SECTION 530
REVETMENT SYSTEMS

530-1 Description.

530-1.1 Riprap: Construct riprap composed of sand-cement or rubble (consisting of broken stone or broken concrete) as shown in the Standard Plans and in the Plans.

530-1.2 Articulating Concrete Block (ACB) Revetment Systems: Furnish and install an ACB revetment system in accordance with this Section and in conformance with the lines, grades, design, and dimensions shown in the Plans. Submit vendor drawings for review and approval by the Engineer. Submit signed and sealed calculations of the block and cable sizing design for approval. Comply with the National Concrete Masonry Association's Design Manual for Articulating Concrete Block Revetment Systems, Second Edition, or the National Highway Institute, Hydraulic Engineering Circular (HEC) No. 23, Publication No. FHWA NHI 09-110. Use a minimum Factor of Safety of 1.5 and 0.5 inch for the block projection.

Blocks must be open cell and non-tapered unless otherwise stated in the Plans. Revetment cabling must be bi-directional or, for mono-directional cabling, the block installation must include a permanent mechanism within the block matrix to prevent lateral displacement of the installed blocks. Cabling must be polyester and free to move within the block.

Use only ACB revetment systems currently listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6, and include certified test reports from an independent test laboratory certifying the ACB revetment system meets the requirements of this Section.

If the ACB revetment system is intended for use as bridge abutment protection, include the following drawings with the APL submittal:

1. At the corner transition between the front and side slopes.
2. For anchorages, geotextile fabric, treatment of voids between adjacent blocks, limits on void size between adjacent blocks and other special details required to successfully install the ACB.
3. For areas adjacent to bridge abutments, detail mat placement aroundopen in curves, connections, protection of mat ends, and splicing of mat.

530-1.3 Gabions: Furnish and install gabions, including gabion baskets and gabion mattresses, filled with rock in accordance with this Section and in conformance with the lines, grades, design, and dimensions shown in the Plans.

530-2 Materials.

530-2.1 Riprap:

530-2.1.1 Filter Fabric: Meet the following requirements:

Type D-2 Geotextile Fabric* .....Section 985

*Use products listed on the Department's APL.

Schedule work so that covering the fabric with the specified material does not exceed the manufacturer's recommendations for exposure to ultraviolet light or five days, whichever is less. If the Engineer determines the exposure time was exceeded, the Contractor shall replace the fabric at no expense to the Department.

Place the filter fabric (fabric) at locations as shown in the Plans, in accordance with the manufacturer's directions. Place the fabric on areas with a uniform slope that are

reasonably smooth, free from mounds, windrows, and any debris or projections which might damage the fabric.

Loosely lay the material. Do not stretch the material. Replace or repair any fabric damaged or displaced before or during placement of overlying layers. Repair in accordance with the manufacturer's instructions.

The Contractor may sew the seams to reduce overlaps as specified in 985-3. Follow the manufacturer's instructions for all seams and overlaps.

530-2.1.2 Prepackaged Sand-Cement Bags: Provide prepackaged sand-cement bags that meet the following requirements:

1. Evenly proportioned sand and cement in the ratio of five cubic feet of sand to 94 pounds of cement. Material proportioned by mass shall use a sand density of 85 pounds per cubic foot.
2. Sealed package of 80 pounds of sand-cement in a bag.
3. Bag made of scrim-reinforced paper capable of holding the sand-cement without leakage.
4. Sand meets requirements of Section 902-3.3
5. Type I/II cement meets requirements of Section 921.

Prepackaged Sand-Cement Bags shall be one of the products listed on the Department's Approved Product List. Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6. Include with the submittal a product data sheet, safety data sheet, product label, and a self-certified statement the product meets the requirements of this Section.

530-2.1.3 Rubble:

530-2.1.3.1 Rubble (Bank and Shore Protection): Provide sound, hard, durable rubble, free of open or incipient cracks, soft seams, or other structural defects, consisting of broken stone with a bulk specific gravity of at least 2.20. Ensure that stones are rough and angular.

For this application, use broken stone meeting the following gradation and thickness requirements:

Weight Maximum Pounds	Weight 50% Pounds	Weight Minimum Pounds	Minimum Blanket Thickness in Feet
670	290	60	2.5
Ensure that at least 97% of the material by weight is smaller than Weight Maximum pounds]. Ensure that at least 50% of the material by weight is greater than Weight 50% pounds]. Ensure that at least 85% of the material by weight is greater than Weight Minimum pounds.			

530-2.1.3.2 Rubble (Ditch Lining): Use sound, hard, durable rubble, free of open or incipient cracks, soft seams, or other structural defects, consisting of broken stone or broken concrete with a bulk specific gravity of at least 1.90. Ensure that stones or broken concrete are rough and angular.

Use broken stone or broken concrete meeting the following gradation and thickness requirements:

Weight Maximum Pounds	Weight 50% Pounds	Weight Minimum Pounds	Minimum Blanket Thickness in Feet
75	30	4	1.5
Ensure that at least 97% of the material by weight is smaller than Weight Maximum pounds. Ensure that at least 50% of the material by weight is greater than Weight 50% pounds]. Ensure that at least 90% of the material by weight is greater than Weight Minimum pounds].			

530-2.1.3.3 Physical Requirements of Broken Stone and Broken Concrete: Use broken stone and broken concrete meeting the following physical requirements:

Absorption (FM 1-T 85)	Maximum 5%
Los Angeles Abrasion (ASTM C535)	Maximum loss 45%*
Soundness (Sodium Sulphate) (AASHTO T 104)	Maximum loss 12%** (after five cycles)
Flat and elongated pieces	Materials with least dimension less than one third of greatest dimension not exceeding 10% by weight.
Dirt and Fines	Materials less than 1/2 inch in maximum dimension accumulated from interledge layers, blasting or handling operations not exceeding 5% by weight.
Drop Test***(EM 1110-2-2302)	No new cracks developed, or no existing crack widened additional 0.1 inch, or final largest dimension greater than or equal to 90% original largest dimension of dropped piece.
* Ensure that granite does not have a loss greater than 55% and that broken concrete does not have a loss greater than 45%. ** The Engineer may accept rubble exceeding the soundness loss limitation if performance history shows that the material will be acceptable for the intended use. The Engineer will waive the soundness specification for rubble riprap (broken stone) when project documents indicate it will be placed in or adjacent to water or soil with a sulfate content less than 150 parts per million and a pH greater than 5.0. Soundness is not required for broken concrete. *** The Engineer will waive the Drop Test unless required to ensure structural integrity. Provide all equipment, labor and testing at no expense to the Department. EM refers to the US Army Corps of Engineer's Specification Engineering Method.	

530-2.1.3.4 Source Approval and Project Control: The Engineer will approve construction aggregate sources in accordance with 6-2.3.

1. The Engineer may perform Independent Verification tests on all materials placed on the project.

2. The Engineer will check the gradation of the riprap by visual inspection at the project site. Resolve any difference of opinion with the Engineer in accordance with the method provided in FM 5-538. Provide all equipment, labor, and the sorting site at no expense to the Department.

3. The Engineer may test components in a blend of rubble processed from different geologic formations, members, groups, units, layers or seams. The Engineer may select components based on like color, surface texture, porosity, or hardness. The Engineer will reject any blend if a component that makes up at least five percent by volume of the blend does not meet these specifications.

530-2.1.4 Bedding Stone: Use Bedding Stone of either a durable quality limestone or other quarry run stone, with a bulk specific gravity of not less than 1.90 and that is reasonably free from thin, flat and elongated pieces. Ensure that the bedding stone is also reasonably free from organic matter and soft, friable particles. Meet the following gradation limits:

Standard Sieve Sizes - Inches	Individual Percentage by Weight Passing
12 inches	100
10 inches	70 to 100
6 inches	60 to 80
3 inches	30 to 50
1 inch	0 to 15

The Engineer will conduct source approval and project control of bedding stone as specified in 530-2.1.3.4. In lieu of limestone or other quarry run stone, the Contractor may substitute non-reinforced concrete from existing pavement that is to be removed and which meets the above requirements for commercial bedding stone.

530-2.2 Articulating Concrete Block (ACB) Revetment Systems: Obtain all precast block, cabling, anchors, and necessary incidental materials from the same manufacturer. ACB revetment systems must meet the requirements of ASTM D6684, ASTM D7276 and ASTM D7277. Submit to the Engineer certification from the manufacturer that the ACB revetment system meets the requirements of this Section.

ACB system components must meet the following requirements:

Concrete .....Section 347, ASTM D6684
Cables and Fittings.....ASTM D6684
Type D-2 Geotextile Fabric * .....Section 985
Granular Underlay .....Section 901
*Use products listed on the Department's APL.

Cables must maintain at least 85% of original tensile strength (ASTM D638) after 1,000 hours exposure to a saturated solution of calcium hydroxide (pH greater than or equal to 11) at 73°F, plus or minus three degrees. Cables must not exceed a maximum of 0.5% moisture absorption at seven days, per ASTM D570. Cable crimps must be aluminum or stainless steel Type 304 or 316.

530-2.3 Gabions:

530-2.3.1 General: Provide gabions meeting the requirements of ASTM A974 and ASTM A975 as modified herein.

Allowable Gabion Wire and Connector Material	Substructure Environmental Classification
Polymeric	Any
Metallic	Slightly Aggressive
Metallic – Galvanized and PVC coated	Slightly Aggressive Moderately Aggressive
Metallic – Type 304 Stainless Steel, Size W1.4 (MW10) or larger	Slightly Aggressive Moderately Aggressive Extremely Aggressive (< 2,000 ppm Chlorides)
Metallic – Type 316 Stainless Steel, Size W1.4 (MW10) or larger	Any

530-2.3.2 Metallic Gabions: The components of metallic gabions must meet the following requirements:

Wire Mesh and Fabric* .....ASTM A974 and A975
Spiral Binders, Lacing Wire, Stiffeners, and Ring Wire Fasteners .....ASTM A974 and A975
Stainless Steel Wire, Wire Fabric, and Lacing Wire .....ASTM A1022
*Wire mesh must be Style 1 or Style 3. Wire fabric must be Style 1 or Style 5.

530-2.3.3 Polymeric Gabions: Polymeric gabions must be constructed in general accordance with ASTM A974 using a single layer of structural geogrid instead of welded wire, and polymeric braid instead of ring wire fasteners. The structural geogrid must be Type R-1, 2, 3, 4, or 5 meeting the requirements of Section 985 and the following:

Tensile Strength @2% strain MD*.....575 lb/ft
Tensile Strength @ 2% strain XD** .....575 lb/ft
Junction Strength (% of Tensile Strength)..... 90%
Min UV Stability..... 85%
Min. Carbon Black Content (by Weight)..... 2%
*MD = machine direction
**XD = cross direction

Polymeric braid for seeming polymeric gabions or connecting metallic gabions must have a minimum tensile strength of 400 pounds for a 36 inch long specimen and contain at least 2% carbon black by weight.

530-2.3.4 Gabion Rock: Use rock meeting the requirements of ASTM D6711 to fill gabions. The rock must be reasonably free from thin, flat or elongated pieces. Rock size must be at least 1.25 times greater than the aperture size of the wire mesh or fabric. Each range of sizes may allow for a variation of 5% oversize rock by weight, 5% undersize rock by weight, or both.

Physical Property Requirements	Acceptable Range
Los Angeles Abrasion and ASTM C535	Maximum loss 40%
Bulk Specific Gravity	Minimum 2.20
Absorption, ASTM C127 and ASTM C128	Maximum 3%

530-2.3.5 Miscellaneous Components: Miscellaneous components for gabion installations must meet the following requirements:

Type D-2 Geotextile Fabric* .....Section 985
Granular Underlay .....Section 901
Anchors ....Section 451 or manufacturer's recommendations
*Use products listed on the Department's APL.

530-3 Construction and Installation.

530-3.1 Geotextile Fabric: Overlap adjacent strips of fabric a minimum of 24 inches, and anchor them with securing pins (as recommended by the manufacturer) inserted through both strips of fabric along a line through the midpoint of the overlap and to the extent necessary to prevent displacement of the fabric.

Place the fabric so that the upstream (upper) strip of fabric overlaps the downstream (lower) strip.

Stagger vertical laps a minimum of 5 feet. Use full rolls of fabric whenever possible in order to reduce the number of vertical laps.

Do not drop bedding stone or riprap from heights greater than 3 feet onto the fabric.

530-3.2 Sand-Cement Bags:

530-3.2.1 Placing: Place the bags with their ends all in the same direction. Lay the bags with broken joints, in a regular pattern. Ram or pack the bags against each other so as to form a close and molded contact. Remove and replace bags ripped or torn in placing with sound, unbroken bags. Then, thoroughly saturate all bags with water.

530-3.2.2 Grouting: Immediately after watering, fill all openings between bags with dry grout composed of one-part Portland cement and five parts sand.

530-3.2.3 Toe Walls: Use sand-cement bags for the toe walls if required. Fill the entire trench excavated for the toe walls with sand-cement bags.

530-3.3 Rubble: Dump rubble in place forming a compact layer conforming to the neat lines and thickness specified in the Plans. Ensure that rubble does not segregate so that smaller pieces evenly fill the voids between the larger pieces.

530-3.4 Bedding Stone: Place a minimum one foot thick layer of bedding stone under all rubble riprap without puncturing or tearing the geotextile fabric. The Engineer will allow an in place thickness tolerance of plus or minus one inch.

Remove and replace geotextile fabric damaged as a result of operations at no expense to the Department.

530-3.5 Articulating Concrete Block (ACB) Revetment System: Install the ACB revetment system in accordance with ASTM D6884 and the manufacturer's recommendations, unless directed otherwise by the Engineer.

Prior to installation, construct the area to be stabilized to an elevation such that, upon completion of stabilizing operations, the completed stabilized subgrade will conform to the lines, grades and cross slope shown in the Plans. Bring the subgrade surface to a plane approximately parallel to the plane of the proposed finished surface, such that, upon placement of the mat, no individual block within the ACB mat will protrude more than one-half inch from any adjacent block. Uniformly compact each subgrade layer to achieve the density required in the Plans. If the Plans do not provide for stabilizing, compact the subgrade in both cuts and fills, to the density specified in ASTM D6884.

Embed anchors at least six feet into the subgrade at a 45 degree angle into the bank with a minimum pullout resistance of 875 pounds. In the presence of the Engineer, perform on-site anchor strength testing to verify the required pull out resistance is achieved. Anchor strength testing must be performed on the first two and final two installed anchors, and randomly throughout the installation operation such that 5% of all installed anchors are tested for pullout resistance. If any anchor fails to meet the pullout resistance requirement, test every subsequent installed anchor until a revised installation plan is proposed and approved by the Engineer. Anchor spacing cannot exceed four feet.

Immediately prior to placing the geotextile fabric and ACB system, inspect the prepared subgrade to ensure it is free of loose material and the surface is smoothly compacted. Place the geotextile fabric directly on the prepared area, in intimate contact with the subgrade and free of folds or wrinkles. Do not glue or physically bond the geotextile fabric to the ACB mat. Install a six inch thick layer of bedding stone under the geotextile fabric, when called for in the Plans.

When installing ACB systems around curves, the mats shall be matched up to the greatest extent possible. Gaps greater than one block size shall be filled with a block and grouted the depth of the block with non-structural grout.

Do not install blocks with chips that result in any block weighing less than 95% of the manufacture specified weight.

530-3.6 Gabions: Install double-twisted wire mesh gabions in accordance with ASTM D7014. Install welded wire fabric gabions and polymeric gabions in accordance with the manufacturer's recommendations.

Prior to installation, complete any required excavation and preparation of the foundation as shown in the Plans or as directed.

Install soil anchors as specified in the Plans.

All adjoining gabion units shall be connected along the perimeter of their contact surfaces to obtain a monolithic structure. If more than one tier, stagger the vertical joints of subsequent rows by one half cell length and adjoin the empty gabions to the top of the lower tier along the front and back edges of the contact surface.

Fill gabions in a manner that minimizes voids, protects against local deformation of the basket or mattress and prevents damage to PVC coating. At no point in the filling process may rock be mechanically placed from a height of over 36 inches from machine to fill area. Uniformly overfill gabions by 1 to 2 inches to compensate for future rock settlements.

Any damage to the basket, mattress, or coatings during assembly, placement, or filling shall be repaired promptly in accordance with the manufacturer's recommendations or replaced with undamaged gabion baskets.

530-4 Method of Measurement.

530-4.1 Sand-Cement Bags: The quantity to be paid for will be the volume, in cubic yards, calculated from the minimum dimensions shown in the Plans or Standard Plans, satisfactorily placed and accepted.

530-4.2 Rubble and Bedding Stone: The quantities to be paid for will be the weight, in tons, in surface dry natural state, by railroad scales, truck scales, or barge displacement. The Contractor shall determine the weights as follows:

1. Railroad Weights: The Contractor shall weigh railroad cars on railroad scales, before and after loading or before and after unloading. If weighed by other than the Engineer, a

certified statement of weights will be required. Certificates of weight, furnished by the railroad company, will be acceptable without further certification.

2. Truck Weights: The Contractor shall weigh trucks on certified scales, loaded and empty, as prescribed above for railroad weights. The Contractor shall weigh trucks in the presence of the Engineer, or submit certificates of weights.

3. Barge Displacement: The Engineer will measure each barge. The Contractor shall fit each barge with gauges graduated in 0.10 foot increments. The Contractor shall locate a gauge at each corner of the barge near the lower end of the rake. The Contractor shall furnish additional gauges amidships if the Engineer deems necessary. The Engineer will compute all weights.

530-4.3 Articulating Concrete Block (ACB) Revetment System: The quantity to be paid for will be the plan quantity, in square yards, completed and accepted, subject to the provisions of 9-3.2. No allowance will be made for ACB placed outside the Plan dimensions, unless the additional placement is ordered by the Engineer.

530-4.4 Gabions: For mattress type applications, the quantity to be paid for will be the plan quantity, in square yards, placed in the final locations.

For stacked basket applications, the quantity to be paid for will be the plan quantity, in cubic yards, placed in the final locations.

530-5 Basis of Payment.

530-5.1 Sand-Cement: Price and payment will be full compensation for all work specified in this Section, including all materials, labor, hauling, excavation, and backfill.

Include the cost of dressing and shaping the existing fills (or subgrade) for placing riprap in the Contract unit price for riprap (sand-cement).

530-5.2 Rubble: Price and payment will be full compensation for all work specified in this Section, including all materials, hauling, excavation, and backfill.

Include the cost of dressing and shaping the existing fills (or subgrade) for placing riprap in the Contract unit price for riprap (rubble).

As an exception to the above, concrete that is shown to be removed from an existing structure and subsequently disposed of by being used in the embankment as riprap will not be paid for under this Section. Include the cost of such work under removal of existing structures.

530-5.3 Bedding Stone: Price and payment will be full compensation for all work specified in this Section, including all materials and hauling.

Include the cost of dressing and shaping the existing fills (or subgrade) for placing bedding stone in the Contract unit price for riprap (rubble).

530-5.4 Geotextile Fabric: Include the cost of materials and installation of the geotextile fabric, including any repairs or replacement, in the Contract unit price for riprap or ACB revetment system.

530-5.5 Articulating Concrete Block (ACB) Revetment System: Price and payment will be full compensation for all work specified in this Section, including all materials, labor, hauling, excavation and backfill.

530-5.6 Gabions: Price and payment will be full compensation for all work specified in this Section, including all materials, labor, hauling, excavation and backfill.

530-5.7 Payment Items. Payment will be made under:

Item No. 530-	1-	Riprap Sand-Cement Bags - per cubic yard.
Item No. 530-	3-	Riprap (Rubble) - per ton.

Item No. 530- 4-	Articulating Concrete Block Revetment System - per square yard.
Item No. 530- 5-	Gabion
Item No. 530- 74-	Bedding Stone - per ton.

SECTION 534
NOISE AND PERIMETER WALLS

534-1 Description.

534-1.1 Precast Concrete Noise Walls:

Furnish and install concrete noise walls with piles, posts and panels constructed in accordance with Standard Plans, Index 534-200, unless the Plans indicate otherwise. Secure joints and connections in a structurally sound manner without openings in the system that would allow transmission of sound.

534-1.2 Perimeter Walls:

Furnish and install perimeter walls and foundations in accordance with Standard Plans, Index 534-250 for either the precast concrete or the masonry option.

534-2 Materials.

Meet the following requirements:

Portland Cement Concrete .....Section 346
Reinforcing Steel .....Section 415
Welded Wire Reinforcement (WWR) .....Section 415
Concrete Masonry Units (CMU) .....ASTM C90
Mortar .....ASTM C270
Grout .....ASTM C476
Horizontal Joint Reinforcing.....
..... ASTM A951* or ASTM A580
Control Joints.....ACI 530.1 Article 2.5 A or B
* Galvanized in accordance with ASTM A153

534-3 Requirements.

Construct concrete components in accordance with Section 400.

534-3.1 Precast Concrete Requirements:

Obtain precast concrete components from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list must meet the requirements of Section 105.

Do not accept products that are not permanently and clearly stamped on the tongue and groove portion of the panel and posted with the type, date cast, project number, and the manufacturer's name or symbol by the Producer.

534-3.2 Masonry Requirements:

Conform to the requirements of Specification for Masonry Structures (TMS 602/ACI 530.1/ASCE6), except as modified by the Plans or this Specification. Submit to the Engineer a certification that materials provided meet the requirements of this Section.

534-4 Shop Drawing Submittal.

Submit shop drawings for precast elements, when required, in accordance with Section 5, showing a plan and elevation with the following project specific information:

1. Begin and end wall stations with offsets
2. Horizontal and vertical alignments of the wall
3. Panel locations
    a. Graphic details and graphic panel locations (noise walls only)

b. Drainage panel locations and Type
c. Location and length of side installed panels (when required)
4. Post locations and lengths
5. Elevations of top of panel, bottom of panel, and panel joints
6. Existing ground and finished grade elevations
7. Non-standard precast component details
8. Non-standard post and pile connection details
9. Lifting devices

534-5 Construction.

Keep to minimum the clearing and grubbing; trim trees and shrubs only to the extent necessary to construct the walls, unless otherwise shown in the Plans. Keep right-of-way fence that is scheduled to be salvaged in place until completing the wall or as otherwise directed by the Engineer.

Prior to beginning earthwork on the project, stake the wall location in the field and establish the finished graded surface elevations at the base of the walls. Use these elevations to develop the shop drawings. Protect the finish graded surface elevations established in the field for the duration of the project, and do not adjust without prior approval of the Engineer. When constructing earthen berms to raise the base elevation of walls, construct the berms of fill material compacted to 95% of the maximum density as determined by AASHTO T99. After erecting the wall, return the disturbed area to preconstruction condition unless otherwise indicated in the Plans.

534-5.1 Precast Construction.

Shimming of wall panels between the pile collar and the bearing pads is permitted, up to a maximum of 1-1/2 inches. Shims must be either stainless steel or engineered copolymer plastic. Copolymer plastic shims must have a minimum compressive strength of 8,000 psi, without any fractures. Stacked shim plates must be bonded together with a compatible epoxy adhesive. Stacking of shims is permitted as follows:

1. For heights of one inch or less, provide up to four 1/4 inch shims.
2. For heights greater than one inch, use a minimum of one 3/4 inch shim.

Erection Tolerances:

1. Variation from plumb: plus or minus 1/4 inch per 10 feet
2. Panel alignment: plus or minus 1/4 inch
3. Top of panel elevation: plus or minus 3/4 inch
4. Elevation difference of adjacent panels: plus or minus 1/2 inch
5. Joint taper over panel length: plus or minus 1/2 inch
6. Top of collar elevation: plus or minus 3/4 inch
7. Post placement:
    a. variation from specified location plus or minus 1 inch
    b. variation from specified elevation plus or minus 1/4 inch
8. Continuity of graphics, fracture fins, etc across joints: 1/4 inch

534-5.2 Concrete Masonry Construction.

Grout all cells that contain horizontal or vertical reinforcing bars.

534-6 Test Wall.

Erect a test wall section not less than 50 feet in length before starting general wall construction at the project site. The Engineer will use the erection of the test wall to verify the

Contractor's methods and equipment are sufficient to produce a wall that meets the requirements of the Contract Documents. Build the test wall at a permanent wall location, as agreed to by the Engineer. If the test wall does not meet construction tolerances, remove and dispose of it at no expense to the Department. Include the cost of the test wall in the cost of the wall.

534-7 Repairs or Rejection.

For precast concrete components that have not been installed, evaluate cracks, spalls and other deficiencies in accordance with 450-12. Repair deficiencies in accordance with 450-13 or with the plant's approved repair methods that are included as part of the Producer Quality Control (QC) Plan. Ensure that the original performance and durability of repaired components are maintained. Use materials for concrete repair that will meet or exceed the strength requirement for the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non-shrink grout when required by 450-13. Precast concrete components are subject to rejection if they fail to conform to any of the requirements after repair. For precast components that have been installed, the disposition of concrete cracks shall be in accordance with 400-21.

534-8 Method of Measurement.

The quantity to be paid for will be the plan quantity, in square feet, measured in place, completed and accepted, of the area bounded by the top of the wall (including wall cap) and the bottom of the wall elements without deductions for openings from the beginning to end limits shown in the control drawings.

534-9 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including but not limited to, furnishing all materials and labor required to construct the wall including caps and foundations.

Payment will be made under:

Item No. 534- 72-	Concrete Noise Wall - per square foot.
Item No. 534- 73-	Perimeter Wall - per square foot.

SECTION 536
GUARDRAIL

536-1 Description.

Construct guardrail, including end treatments, transition connections to rigid barrier, and other associated hardware, as specified in the Plans and in accordance with the Standard Plans, Index 536 series.

Remove existing guardrail as specified in the Plans.

536-2 Materials.

Use components for guardrail, including posts, offset blocks, steel panels, panel components, bolts, foundations, barrier delineators, end delineators, rub rail, pipe rail, and approach terminals, in accordance with Section 967. Prior to installation, submit a list of the APL numbers of all approach terminals, barrier delineators, and composite offset blocks to be used on the project.

536-3 Construction.

536-3.1 Height Tolerance: Install guardrail panels at the height shown in the Standard Plans with a tolerance of 1 inch above and 1/2 inch below the nominal height specified. Where unavoidable surface irregularities, including but not limited to across shoulder gutters, inlets, and roadway surface break lines, are encountered, a tolerance of 3 inches above and 1 inch below the nominal height is permissible.

536-3.2 Station Location Tolerance: Where guardrail feature stationing is called out in the Plans, the longitudinal stationing tolerance is plus or minus 3 feet and 1-1/2 inch, unless otherwise restricted by field conditions as determined by the Engineer.

For transition connections to rigid barrier, install the thrie-beam terminal connector at a 1/4 inch tolerance relative to the end of the rigid barrier as defined in the Plans and Standard Plans.

536-3.3 Setting Posts: Set posts plumb and to the soil depth shown in the Standard Plans. Use the deep post option only where specified in the Plans. Place posts in excavations, backfill the space around the posts, and thoroughly tamp the backfilled soil. As an alternate method, use a post-driving machine meeting the approval of the Engineer.

For guardrail post replacement, backfill and tamp the existing soil hole prior to setting the replacement post.

If driving timber posts, either block out holes in the asphalt pavement during the asphalt paving operation or cut holes through the asphalt mat prior to the post installation. Blocked out or cut holes in the asphalt pavement must be at least 50% larger than the cross-sectional area of the timber post. After driving the posts, patch the area of asphalt around each post with hot bituminous mixture in accordance with Section 339.

If driving steel posts, drive the post directly through the asphalt mat. Fill asphalt depressions or cracks with hot bituminous mixture in a manner meeting the approval of the Engineer.

For post locations where subsurface miscellaneous rock or other solid material is obstructing the post placement, remove such material as follows:

1. If any part of an obstruction is located within 0 and 18 inches in depth, excavate a minimum 24 inch diameter hole around the post location for the full depth of the post,

with the back edge of the excavated hole placed a minimum of 15 inches behind the back face of the post.

2. If an obstruction is only located below 18 inches in depth, excavate a minimum 12 inch diameter hole around the post location, for the full depth of the post, with the back edge of the excavated hole placed a minimum of 3 inches behind the back face of the post.

3. Backfill the holes with soil and thoroughly tamp.

536-3.4 Post Location Conflicts: When the construction of guardrail at the required post spacing results in post(s) conflicting with sidewalks, gutter, underground utilities, or other permanent obstacles which cannot be removed as determined by the Engineer, the following options are permitted with the approval of the Engineer:

1. Additional Offset Blocks – Up to two additional offset blocks (3 total) may be used where the resulting post placement, moved farther behind the face of guardrail, will avoid a post conflict.

Use button-head bolts of added length as needed to secure the panel system with the rear nut and washer. Where bolts greater than 25 inches are required, a 5/8 inch threaded rod meeting the same material requirements may be substituted and secured with steel hex nuts of over 1-1/8 inches in diameter. Use a steel washer against the post and not the panel. The rod is not permitted to extend beyond 3/4 inch from the face of the tightened nut on the panel side; trim the rod as needed and galvanize in accordance with Section 562.

Over a distance of one post spacing, linearly widen the miscellaneous asphalt pavement where required to maintain a minimum of 10 inches of material behind the post.

2. Special Steel Posts – Where post placement atop a concrete structure cannot be avoided, use special steel posts as defined in the Standard Plans and 536-3.6.

3. Encased Posts – Where post placement results in a conflict with an underground utility or obstacle, use the shallower encased post option as defined in the Standard Plans where the concrete encasement will not damage a utility.

4. Frangible Leave-Out – Where post placement results in a conflict with a concrete slab, use the frangible leave-out as defined in the Standard Plans. Do not use posts through concrete slabs deeper than 8 inches.

536-3.5 Deep Post: Mark deep posts on the back face, centered 4 inches below the top edge, with a legible black letter ‘D’ approximately 2 inches vertical by 1 inch horizontal in size. Use a permanent black ink stamp or paint stencil.

536-3.6 Special Steel Post: Mount to concrete structures using the following systems.

536-3.6.1 Adhesive Bonded Anchors: For concrete structures 9 inches deep and greater, mount the base plate to the concrete using steel adhesive-bonded anchor bolts with a minimum tensile strength of 60 ksi and galvanized in accordance with ASTM A153. Stainless steel components may be substituted, but components plated in accordance with ASTM B633 are not acceptable. Use adhesive-bonded anchors in accordance with Section 937 and 416 (Type HSHV) and in accordance with the manufacturer’s specification.

Drill holes in concrete, through reinforcing steel if encountered. Thoroughly clean and dry the holes immediately prior to setting anchors.

At a minimum, meet the following strength capacities in Table 536-1:

Table 536-1 Anchor Strength Capacities		
	Approach Slabs	Other Structures
Min. Tensile Load (Each Anchor)	14,000 lbs	8,000 lbs
Min. Shear Load (Each Anchor)	15,000 lbs	7,800 lbs

536-3.6.2 Hex-Head Bolt: For concrete structures less than 9 inches deep, use a 3/4 inch Hex-Head bolt passing through a 7/8 inch drilled hole in the concrete structure and secured from underneath with a washer and nut. The threaded bolt must not protrude more than 3/4 inches beyond the tightened nut; trim the threaded portion as needed and galvanize in accordance with Section 562.

536-3.7 Steel Panels: Use straight panels to construct radii of 125 feet or greater. Use fabricated shop-bent panels to accommodate radii of less than 125 feet.

536-3.8 Panel Slots and Holes: Use the panel's unaltered, prefabricated slots and holes as shown in the Standard Plans. Do not drill, punch, ream, or otherwise alter the prefabricated slots and holes, except when creating new post bolt slots for reduced post spacing (quarter spacing) and adjusting post spacing to avoid structure edge conflicts as shown in the Standard Plans. Where required, punch new post bolt slots to the dimensions given in the Standard Plans, spaced no closer than 4 inches measured edge to edge from an existing slot. Galvanize new punched slots per Section 562.

536-3.9 Barrier Delineators: Mount barrier delineators on top of the guardrail post by adhesive or mechanical means per the manufacturer's recommendations.

536-3.10 End Delineators: Install the retroreflective sheeting on the approach face (nose) of approach terminals, trailing anchorages, and controlled release terminal (CRT) end treatments where indicated in the Standard Plans. Mount the retroreflective sheeting vertically centered on the approach face by adhesive or mechanical means per the manufacturer's recommendations. Retroreflective sheeting must be a minimum 8 inches in height with a minimum area of 160 square inches for approach terminals and trailing anchorages and 240 square inches for CRT end treatments.

536-3.11 Rub Rail: Treat field drilled holes in accordance with Section 562.

Rub rail must terminate at the nearest post outside of the rub rail stationing range indicated in the Plans.

536-3.12 Pipe Rail: Treat field drilled holes in accordance with Section 562.

Pipe rail must terminate at the nearest post outside of the pipe rail stationing range indicated in the Plans.

536-3.13 Existing Guardrail: Stockpile guardrail, if specified, within the right-of-way at a location approved by the Engineer. Dispose of all remaining guardrail not specified for stockpiling.

536-3.14 Approach Terminal Assemblies: Install approach terminal assemblies as specified in the Plans and APL drawings and in accordance with the geometry and adjacent grading of the Standard Plans. The APL number must be permanently marked on each assembly at a readily visible location using legible lettering at least 3/4 inch in height.

If the Plans call for an approach terminal assembly and do not identify the specific system to be used, the contractor has the option to construct any Department-approved approach terminal assembly identified on the APL that meets the applicable test criteria, subject to the conditions identified in the Plans or the APL drawings.

536-4 Acceptance.

Acceptance of materials and installation of guardrail will be based on conformance with the requirements of this Section and visual inspection by the Engineer.

536-5 Method of Measurement.

536-5.1 Guardrail: The quantity paid for will be the plan quantity, in linear feet, constructed, in place and accepted.

The length of guardrail is measured end-to-end following the centerline of the panels, between the begin/end guardrail stations as defined in the Standard Plans and the Plans, including the full lengths of the adjoining end treatments and transition connections to rigid barrier.

536-5.2 Rub Rail: The quantity paid for will be the plan length, in linear feet, constructed, in place and accepted.

536-5.3 Pipe Rail: The quantity paid for will be the plan length, in linear feet, constructed, in place and accepted.

536-5.4 Special Guardrail Post: The quantity paid for will be the number of each, constructed, in place and accepted. Special guardrail posts include deep posts, special steel posts, encased posts, and frangible leave-outs as defined in the Standard Plans and indicated in the Plans.

536-5.5 Transition Connection to Rigid Barrier: The quantity paid for will be the number of each, constructed, in place and accepted.

536-5.6 Guardrail Post Replacement: The quantity paid for will be the number of each, replaced.

536-5.7 Guardrail End Treatment: The quantity paid for will be the number of each type as designated, constructed, in place, and accepted. Guardrail end treatment types may include approach terminals, trailing anchorages, CRT end treatments, and double faced approach terminals as defined in the Standard Plans.

536-6 Basis of Payment.

536-6.1 Guardrail: Price and payment will be full compensation for all work specified under this Section, except those items specified in 536-6.2 through 536-6.7. Price and payment include furnishing and installing posts, panels, barrier delineators, offset blocks, and all other materials as defined in the Plans and the Standard Plans. The price and payment will include any reduced post spacing, nested panels, shop-bent panels, end unit panels, and CRT posts as required in the Plans.

The type of guardrail specified will be that which comprises the guardrail run between end treatments and transition connections to rigid barrier (including, but not limited to, w-beam general, w-beam double face, w-beam low-speed, modified thrie-beam). For guardrail systems with direct connections between end treatments and transition connections to rigid barrier, the type of guardrail specified will be w-beam for single face guardrail applications or double faced for double face guardrail applications.

536-6.2 Rub Rail: Price and payment will include all components specified in the Plans and Standard Plans.

536-6.3 Pipe Rail: Price and payment will include all components specified in the Plans and Standard Plans. Pipe rail will be shown and tabulated in the Plans for the condition that steel posts are installed at the indicated pipe rail location, however the pipe rail is not required if the timber post option is selected and installed at the indicated pipe rail location.

536-6.4 Special Guardrail Post: Price and payment will include all costs for furnishing and installing special guardrail posts that are in addition to the cost of items included in 536-6.1, where special guardrail posts are installed instead of standard posts.

536-6.5 Transition Connection to Rigid Barrier: Price and payment will include all costs for furnishing and installing all hardware for approach or trailing transition connections to rigid barrier per the Standard Plans that are in addition to the cost of items included in 536-6.1. This includes costs for the concrete transition block or alignment curb where shown in the Standard Plans and barrier delineators for existing post and beam bridge railings. This item applies for connections to concrete barrier, concrete pier protection barrier, and concrete or metal bridge traffic railing, including thrie-beam retrofits.

536-6.6 Removal of Existing Guardrail: Price and payment will include all labor and equipment required for removal and disposition of the existing guardrail as specified in the Plans. No additional payment will be made for the removal of transition connections, double faced guardrail, thrie-beam guardrail, nested panels, pipe rail, rub rail, or end terminals.

536-6.7 Guardrail End Treatment: Price and payment will include all costs for furnishing and installing all guardrail end treatment assemblies specified in the Plans that are in addition to the cost of items included in 536-6.1.

536-6.8 Payment Items: Payment will be made under:

Item No. 536- 1-	Guardrail - per foot.
Item No. 536- 5-	Rub Rail - per foot.
Item No. 536- 6-	Pipe Rail - per foot.
Item No. 536- 7-	Special Guardrail Post - each.
Item No. 536- 8-	Transition Connection to Rigid Barrier - each.
Item No. 536- 73-	Removal of Existing Guardrail - per foot.
Item No. 536- 85-	Guardrail End Treatment - each.

SECTION 538
RESETTING GUARDRAIL

538-1 Description.

Remove the existing guardrail system and reinstall using new and reusable components, at the locations shown in the Plans. Construct the reset guardrail in accordance with the Standard Plans using new and reusable components, excluding components defined as non-reusable in this Section.

Furnish and install end treatment assemblies, approach transition connections to rigid barrier, trailing end transition connections to rigid barrier, and bridge anchorage assemblies as required by the Plans.

538-2 Materials.

538-2.1 Planned Non-reusable Components: The following items are considered planned non-reusable components and must be replaced with new components:

1. Timber posts
2. Timber offset blocks
3. End treatment assemblies
4. Approach transition connections to rigid barrier, including but not limited to panels, posts, hardware, offset blocks, etc.
5. Trailing end transition connections to rigid barrier
6. Bridge anchorage assemblies, including but not limited to panels, posts, hardware, offset blocks, etc.
7. Mounting hardware, including but not limited to nuts, bolts, washers, etc.
8. Any other items specified as non-reusable in the Plans

538-2.2 Unforeseen Non-reusable Components: During construction operations, the Engineer may deem other existing components, excluding planned non-reusable components, as unacceptable for re-use. Such components are considered unforeseen non-reusable components and require replacement with new components. Unforeseen non-reusable components will be compensated in accordance with 4-4.

Components damaged during construction operations are not considered unforeseen non-reusable components and must be replaced with new components at no cost to the Department.

538-3 Construction Methods.

Construct the reset guardrail in accordance with Section 536.

If the reset guardrail is to be placed in the same location as the previous installation, do not use the previous installation's in-ground post holes. Place the reset posts at the approximate midspan location of the previous installation. Backfill and thoroughly tamp the unused, in-ground holes at the previous post locations.

To accommodate the new post locations, field punch new post bolt slots in the reusable guardrail panels where needed. Meet the dimension and treatment requirements of the Standard Plans and Section 536.

538-4 Method of Measurement.

The quantities paid for will be the plan length quantity, in linear feet, constructed, in place and accepted.

The plan length of a run of guardrail is measured end-to-end following the centerline of the panels, from the begin/end guardrail stations as defined in the Standard Plans and specified in the Plans, including the end treatments and transition connections to rigid barrier lengths.

538-5 Basis of Payment.

Price and payment for resetting guardrail will be full compensation for all work specified in this Section, including the furnishing replacements for planned non-reusable components (excluding end treatment assemblies, approach transition connections to rigid barriers, and bridge anchorage assemblies) and installation of all required components as defined in the Standard Plans. The price and payment will include any reduced post spacing, trailing end transition connections, shop-bent panels, and CRT post segments as defined in the Standard Plans and shown in the Plans.

Price and payment for end treatment assemblies, approach transition connections to rigid barriers, and bridge anchorage assemblies will be as specified in Section 536.

Payment will be made under:

Item No. 538- 1- Guardrail - Reset - per foot.

SECTION 544
CRASH CUSHIONS

544-1 Description.

Install redirective crash cushions as shown in the Plans. Redirective crash cushions are safety devices with capabilities to redirect the impacting vehicle along the full length of the device.

544-2 Approved Product List (APL).

Use crash cushions listed on the APL. Manufacturers seeking evaluation of crash cushions for inclusion on the APL must submit the following:

1. Product drawings, which at a minimum include:
    a. Anchorage details for the crash cushion
    b. Tables showing the relevant system information and lengths for all options
    c. Length of need location
    d. Transition details
    e. List of all components
2. Installation manuals
3. Crash testing reports demonstrating that the system meets the requirements of MASH
4. All relevant FHWA Eligibility Letters

544-3 Installation.

Handle and install manufactured materials or articles in accordance with the manufacturer's instructions and the Standard Plans. Transition crash cushions in accordance with the Plans, Standard Plans, Index 544-001 and the APL drawings.

Delineate crash cushion ends with Type IV or better retroreflective sheeting meeting the requirements of Section 994. Install retroreflective sheeting with a minimum surface area of 360 square inches and a minimum height of 15 inches. As an alternative, a Type 1 object marker meeting the requirements of Section 705 may be used to delineate the crash cushion end. Center the object marker 3 feet in front of the crash cushion end.

Perform repairs necessary due to defective material, work, or operations without additional cost to the Department.

Restore crash cushions damaged by the traveling public after the installation is completed, accepted and serving its intended purpose on an open section of bridge or roadway within 24 hours.

544-4 Method of Measurement.

The quantity paid for will be the number of each type as designated, constructed, in place, and accepted. Crash cushion types are designated by Test Level (TL) and include either narrow or wide systems.

544-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including delineation and system transitions to guardrail or rigid barriers.

Relocation of an existing crash cushion to a permanent location called for in the Plans will be paid for at the Contract unit price for relocating existing systems. Price and payment will be full compensation for relocating and reinstalling the system in accordance with the manufacturer's instructions and the Standard Plans.

Payment will be made under:

Item No. 544- 2-	Crash Cushion TL-2
Item No. 544- 3-	Crash Cushion TL-3
Item No. 544- 74-	Relocate Crash Cushion - each

SECTION 546
RUMBLE STRIPS

546-1 Description.

Construct rumble strips in accordance with the details shown in the Plans and Standard Plans, Indexes 546-001, 546-010, and 546-020.

546-2 Materials for Raised Rumble Strips.

546-2.1 Permanent Raised Rumble Strips: Construct permanent raised rumble strips using one of the following:

546-2.1.1 Preformed Thermoplastic: Use only materials listed on the Department's Approved Product List (APL), meeting the following requirements:

Preformed Thermoplastic..... 971-1 and 971-6

Ensure that the material used can be restored to its original dimensions by using a self bonding overlay meeting these requirements. Submit a certified test report to the Engineer indicating that the materials meet all requirements specified.

546-2.1.2 Asphalt: Any plant-mixed hot bituminous asphalt mixture meeting the requirements of a job-mix formula issued by the Department, except open-graded friction course.

546-2.2 Short-Term Raised Rumble Strips: Construct short-term raised rumble strips meeting the requirements of 546-2.1, or by using removable polymer striping tape meeting the requirements of 990-9.

546-3 Application.

546-3.1 Permanent Raised Rumble Strips: Notify the Engineer before the placement of raised rumble strips. Apply raised rumble strips having well defined edges. Remove and replace any raised rumble strips not meeting the requirements of the Contract Documents at no additional cost to the Department.

Before applying raised rumble strips, remove any material that would adversely affect the bond of the raised rumble strips by a method approved by the Engineer.

Apply raised rumble strips only to dry surfaces, and only when the ambient air and surface temperature is at least 55ºF and rising.

Before applying thermoplastic materials on portland cement concrete surfaces, apply a primer sealer recommended by the manufacturer.

Prior to the application of any plant-mixed hot bituminous material, apply a tack coat meeting the requirements of 300-2.3.

The mixture will be accepted on the basis of visual inspection by the Engineer with no further testing required.

546-3.2 Short-Term Raised Rumble Strips: Install short-term raised rumble strips before opening to traffic, and in accordance with 546-3.1. Maintain and remove short-term raised rumble strips until permanent raised rumble strips are installed.

546-3.3 Ground-In Rumble Strip:

546-3.3.1 General: Grind rumble strips that have well-defined edges and smooth interiors without tearing the finished pavement.

On a daily basis, before opening the adjacent lane to traffic, ensure that all debris generated by the grinding process is removed and disposed of by vacuum or a method

approved by the Engineer. Do not dispose of the debris within the right of way. Do not use the debris generated by the grinding process in recycled asphalt (RAP).

Restore any pavement to the satisfaction of the Engineer, at no additional cost to the Department, when ground-in rumble strips do not meet the requirements of the Contract Documents.

546-3.3.2 Inspection: For limited access roadways, measure depth every one mile during the grinding operation to monitor tolerances specified in Standard Plans, Index 546-010. For arterial and collector roadways, measure depth every 500 feet during the grinding operation to monitor tolerances specified in Standard Plans Index 546-020.

If measurements are outside tolerances, immediately stop grinding operations and adjust grinding machine to meet tolerances before continuing the grinding. Measure depth along the rumble strip centerline at the high and low point of the grinding pattern. Measure depth from top of pavement grade to top of ground-in surface. Measure, record and certify on a Department approved form and submit to the Engineer.

546-4 Method of Measurement.

The quantity of raised rumble strip sets to be paid for under this Section will be the Plan quantity per each set per lane, constructed and accepted.

The quantity of ground-in rumble strips to be paid for under this Section will be the plan quantity in gross miles, constructed and accepted. No deduction will be made when the skip array is used.

546-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including all surface cleaning and preparation, all debris disposal, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines, labor, and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 546- 71-	Raised Rumble Strip Sets - each.
Item No. 546- 72-	Ground-In Rumble Strips - per gross mile.

SECTION 548
RETAINING WALL SYSTEMS

548-1 Description.

Construct permanent and temporary retaining wall systems in accordance with this Section and in conformance with the lines, grades, design, and dimensions shown in the Contract or established by the Engineer. Sheet pile walls and cast-in-place walls are not included in this Section. Construct all walls of a specific type (mechanically stabilized earth (MSE), counterfort, etc.), using the same wall system and supplier. If different types of wall systems must be used in such a manner that causes one wall to interact with or influence another wall, coordinate the detailing of these areas of interaction/influence with the assistance of the Contractor's Engineer of Record.

Obtain each reinforced concrete precast concrete retaining wall system from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Ensure that each wall system component is marked in accordance with 548-5.3.

Ensure that each shipment of products to the job site includes a signed or stamped delivery ticket in accordance with the Materials Manual, Section 8.2 Volume II, and the required written certification statement for each product shipped. Submit these tickets and certifications to the Engineer.

When shown in the Plans or approved by the Engineer, a segmental block MSE retaining wall (SBW) system may be provided as a substitute for a reinforced concrete panel MSE wall system. All SBW systems must comprise:

1. Unreinforced dry-cast masonry facing blocks in a running bond pattern meeting the requirements of 548-5.
2. Structural backfill reinforcement:
    a. Type R-3 geosynthetic backfill reinforcement placed in sheets full length without splices normal to the facing blocks and laterally without horizontal gaps, and with a vertical spacing of not more than every other course of blocks or 30 inches, whichever is less.
    b. Metallic reinforcement placed full length without splices normal to the facing blocks and spaced laterally and vertically not more than every other block or 30 inches, whichever is less, with a positive mechanical or shear connection to the facing blocks.
3. A mechanical shear connection to lock adjacent blocks together horizontally or vertically.

548-2 Materials.

Provide a wall system listed on the Department's Approved Product List (APL) based on the wall type shown in the Plans. Purchase components, soil reinforcement, attachment devices, joint filler, filter fabric, and all necessary incidentals for each wall from the same wall supplier.

548-2.1 Concrete: Ensure that concrete utilized for all wall components is consistent with the concrete class, environmental classification and admixture requirements for durability as stated in the Contract Documents. Produce and supply concrete for all reinforced concrete wall components meeting the requirements of Section 346.

Produce and supply concrete for the leveling pad meeting the requirements of Section 347. Use Department approved mix designs.

548-2.2 Reinforcing Steel: Meet the requirements of Section 931 for steel reinforcing and Section 932 for FRP reinforcing, as identified in the Contract Documents and APL drawings.

548-2.3 Backfill Reinforcement: For walls utilizing backfill reinforcement, use reinforcement consisting of steel wire mesh, metal strips or structural geosynthetics as required for the wall system chosen. Use backfill reinforcement of the same length from top to bottom of wall at any section. For tiered walls, use backfill reinforcement of the same length within the height of each tier at any section.

Use plain steel wire mesh and embedded loops shop fabricated from cold drawn steel wire and weld into the finished mesh fabric meeting the requirements of ASTM A1064. Use longitudinal and transverse wires of equal and constant diameter within a given piece of mesh reinforcement. Use steel strips hot rolled from bars to the required shape and dimensions with physical and mechanical properties meeting ASTM A572 Grade 65 or as shown in the Contract. Use shop-fabricated hot rolled steel tie straps meeting the minimum requirements of ASTM A1011/A1011 M, Grade 50, or as shown in the Contract.

Ensure that steel reinforcing strips, tie strips, reinforcing mesh and connectors used in permanent walls are galvanized in accordance with ASTM A123 or ASTM A153, as applicable. For typical applications, punch or drill holes in metal items before galvanizing. Field drilled holes for bin walls are permitted. Repair field drilled holes; field cut ends and other damage to galvanized surfaces in accordance with Section 562.

Use Type R-3 structural geosynthetics made of polypropylene, select high density polyethylene or high-tenacity polyester fibers having cross-sections sufficient to permit significant mechanical interlock with the backfill. Use geosynthetics having a high tensile modulus in relation to the backfill. Use geosynthetics having high resistance to deformation under sustained long term design load while in service and resistant to ultraviolet degradation, to damage under normal construction practices and to all forms of biological or chemical degradation normally encountered in the material being reinforced. Do not use uncoated polyester (PET) reinforcements or reinforcements weakened or damaged by high pH environments within any portion of the flowable fill, or within coarse aggregate backfill below the design high water elevation (DHW) shown in the Plans.

Store the geosynthetics in conditions above 20ºF and not greater than 140ºF. Prevent mud, wet cement, epoxy, and like materials from coming into contact with and affixing to the geosynthetic material. Rolled geosynthetic may be laid flat or stood on end for storage. Cover the geosynthetic and protect from sunlight prior to placement in the wall system.

Carefully inspect all reinforcement, steel and geosynthetics to ensure they are the proper size and free from defects that may impair their strength and durability.

548-2.4 Attachment Devices: Use backfill reinforcement attachment devices as required by the wall system chosen.

548-2.5 Joint Materials and Filter Fabrics:

548-2.5.1 Horizontal Joint Pads: Use elastomeric or polymeric pads in all horizontal joints between precast components as recommended by the wall manufacturer. Ensure that the pads are of sufficient size and hardness to limit vertical stresses on the pad and concrete surface and to prevent concrete to concrete contact at the joints.

548-2.5.2 Joint Covers for Non-SBW Walls: For walls supporting bridge abutments on spread footings, cover joints and other wall openings within a horizontal distance equal to the larger of:

1. the length of the reinforcement under the footing plus 25 feet, or

2. twice the maximum height of the footing above the leveling pad, measured from the nearest edge of the footing, surrounding the reinforced backfill for the abutment with Type D-2 geotextile fabric meeting the requirements of Section 985.

Cover all joints and wall openings in portions of the wall backfilled with coarse aggregate with Type D-2 geotextile fabric meeting the requirements of Section 985. Cover all other joints and wall openings with Type D-2 or D-3 geotextile fabric with a maximum apparent opening size (AOS) equal to US Sieve No. 70 meeting the requirements of Section 985. Apply an adhesive approved by the Engineer to the back of the precast component for attachment of the fabric material.

548-2.5.3 Alignment Pins: Ensure that pins used to align the precast components during construction are of the size, shape and material required for the wall system chosen.

548-2.5.4 Separation Geotextile: Provide a Type D-2, D-3, or D-5 separation geotextile meeting the requirements of Section 985 between the coarse aggregate and the select backfill/embankment at the bottom, top and sides of the coarse aggregate.

548-2.6 Backfill Material:

548-2.6.1 General: Provide compacted select backfill or coarse aggregate backfill within the retaining wall volume as shown in the Plans. For permanent walls, provide coarse aggregate backfill in lieu of compacted select backfill to an elevation at least one foot above the DHW shown in the Plans when the DHW is above the lowest adjacent ground surface. Provide flowable fill within the retaining wall volume in lieu of compacted select backfill or coarse aggregate backfill only when the option for flowable fill is shown in the Plans. The retaining wall volume is defined to extend from the top of the leveling pad or footing, or bottom of walls which do not have footing or leveling pads, to the finish grade line and from the face of the wall to a vertical plane passing through the end of the extreme wall component (straps, counterforts, etc.) plus one foot.

548-2.6.2 Compacted Select Backfill: Meet the requirements of Sections 105 and 120 except as noted within this Section. Have the backfill material tested for every soil type for pH, resistivity, sulfate and chloride content by a Department approved independent testing laboratory prior to placement. Submit a certification, signed and sealed by a Professional Engineer registered in the State of Florida, that the results have met the requirements of this Section.

Use backfill material with a pH between 5.0 and 10.0 as determined by FM 5-550. For polyester geosynthetic reinforcement, use backfill material with a pH between 5.0 and 9.0. Sources of select backfill material having a pH low as 4.5 and 5.0 for walls utilizing metallic reinforcement and pH low as 3.0 for walls utilizing geosynthetic reinforcement, may be used provided the interior face of the MSE wall panels have three inches of concrete cover over the reinforcement, the concrete used in the panels contain either an highly reactive pozzolan or the ternary mix design meets the requirements of Table 346-2 with a surface resistivity equal or greater than 29 kOhm-cm and there are no steel piles and metallic elements/pipes other than metallic reinforcement placed within the backfill.

In addition, for permanent walls utilizing metallic soil reinforcement, use backfill that meets the following electro-chemical test criteria for determining corrosiveness:

Table 548-1 Electro-Chemical Test Criteria	
Criteria	Test Method
Resistivity: > 3,000 ohm -·cm	FM 5-551
Soluble chloride content < 100 PPM	FM 5-552
Soluble sulfate content: < 200 PPM	FM 5-553

For constructing the retaining wall volume, do not use backfill material containing more than 2.0% by weight of organic material, as determined by FM 1-T267 and by averaging the test results for three randomly selected samples from each stratum or stockpile of a particular material. If an individual test value of the three samples exceeds 3%, the stratum or stockpile will not be suitable for constructing the retaining wall volume.

Ensure that the material is non-plastic as determined by AASHTO T 90 and the liquid limit as determined by AASHTO T 89 is less than 15.

For walls using soil reinforcement, use backfill that meets the following gradation limits determined in accordance with AASHTO T 27 and FM 1-T011:

Table 548-2 Gradation Limits	
Sieve Size	Percent Passing
3-1/2 inches	100
3/4 inch	70-100
No. 4	30-100
No. 40	15-100
No. 100	0-65
No. 200	0-12

For walls not using soil reinforcement, use backfill that meets the following gradation limits determined in accordance with AASHTO T 27 and FM 1-T 011:

Table 548-3 Gradation Limits Not Using Soil Reinforcement	
Sieve Size	Percent Passing
3-1/2 inches	100
No. 200	0-12

548-2.6.3 Flowable Fill: Meet the requirements of Section 121 except as noted within this Section and the Plans.

548-2.6.4 Coarse Aggregate Backfill and Drainage Aggregate: Provide coarse aggregate comprised of natural stones meeting the requirements of Section 901 with a size distribution of any of the listed aggregate gradations from Size No 57 through Size No 89, inclusive, except as noted on the Plans. Have all coarse aggregate backfill materials tested for pH, resistivity, sulfate and chloride content by a Department approved independent testing laboratory prior to placement. Submit a certification, signed and sealed by a Professional Engineer registered in the State of Florida, that the results of these tests meet the requirements of 548-2.6.2.

For SBW systems, provide drainage aggregate comprised of coarse aggregate backfill and a drainage geotextile to separate the drainage aggregate from the reinforced backfill as specified for each approved wall system.

548-3 Approved Product List (APL).

All proprietary retaining wall systems shall be listed on the APL. Manufacturers seeking evaluation of products for inclusion on the APL shall submit an application in accordance with Section 6, independently certified test reports, and calculations and drawings in accordance with the latest edition of the AASHTO LRFD Bridge Design Specifications and the Department's Structures Design Guidelines (SDG) signed and sealed by a Professional Engineer registered in the State of Florida. Submit calculations and drawings showing details, notes, materials, dimensions, sizes, and other information as described below for a complete description of the retaining wall system.

1. Soil reinforcement durability and/or corrosion data;
2. Differential settlement the wall system can tolerate without exceeding normal stress range of the soil reinforcement and wall facing, or the construction tolerances in this Section;
3. The effects of water flow;
4. Applicable environmental classifications as outlined in the SDG;
5. Signed and sealed design calculations. Design calculations may be either by hand or by a wall company program with hand calculations verifying the program output. It is only necessary to include sample hand calculations for a 20 foot height for each soil condition.
6. Corrosion and durability design procedures for soil reinforcement elements;
7. Provide 11 inch x17 inch drawings showing:
    a. Notes specific to the wall system;
    b. Panel sizes and reinforcing;
    c. Soil reinforcement connection to wall facings;
    d. Wall panel abutment interfacing;
    e. Slip joints;
    f. Steps in leveling pad;
    g. Soil reinforcing details around all vertical obstructions;
    h. Filter fabric placement at panel joints and around all obstructions;
    i. Details for skewing soil reinforcement (15 degrees maximum) without cutting;
    j. Corner elements (required at all angle breaks greater than 5 degrees);
    k. Bin wall details for acute corners (required at all acute corners where interior corner angle is less than 70 degrees);
    l. Details showing how to accommodate long term (post construction) wall settlement in excess of four inches without attaching soil reinforcement to the abutment; and,
    m. Details of how to ground the wall system.
8. Pull-out test data for the proposed wall/reinforcement connection, and size and type of soil reinforcement for wall system. Testing shall be done by an independent soil testing laboratory or testing agency certified by the Department. Ensure test data includes all sizes and types of soil reinforcement to be utilized on Department projects. Default AASHTO values may be used for conventional soil reinforcement. For soil reinforcement grids, include all various configurations and combinations of longitudinal and transverse wires.

9. Other information pertinent to the design and performance of the wall system as necessary.

10. A field construction manual describing construction requirements and sequencing for the wall system. Submit manual in 8-1/2 inch x 11 inch format in either pdf or MS Word format.

548-4 Shop Drawings.

Submit shop drawings and calculations in accordance with Section 5. Provide calculations and drawings showing details, notes, materials, dimensions, sizes and other information necessary for the complete fabrication and erection of the retaining wall system. As a minimum, provide the following:

1. Elevation view showing the finished graded surface and elevations of the top and bottom of wall at the begin and end of wall, all breaks in vertical alignment and all whole stations and 25 foot station increments.

2. Sections showing the length, size and designation of soil reinforcement.

3. Plan view showing the horizontal alignment and offsets from the horizontal control line to the exterior face of the wall; the location of utilities, drainage structures and other items that impact the wall; the limits of the reinforced soil volume; and, the location of piles within the reinforced earth volume.

4. Details for construction around utilities, drainage structures and other items that impact the wall; for placement of soil reinforcement at acute corners; for addressing conflicts between soil reinforcement and obstructions in the reinforced soil volume; for addressing different wall types intersecting and impacting each other.

5. General notes and design parameters including design soil characteristics; factored bearing resistance and factored bearing pressure for each wall height increment and other notes required for construction of the walls.

6. Design calculations for each wall height increment detailed in the shop drawings.

7. When the friction angle depicted in the shop drawings exceeds 30 degrees for sand backfill or 34 degrees for limerock backfill, provide laboratory test results in accordance with 548-9.5 verifying the backfill to be used for the wall meets the design soil characteristics for the shop drawings.

8. For SBW systems, include details for the placement of drainage aggregate, drainage pipes and separation geotextile. Drawings should be similar to details for Type II or Type III underdrains in Standard Plans, Index 440-001. Do not directly cover perforated drainage pipes with a geotextile filter fabric (such as a filter sock).

9. When SBW systems use friction or semi-friction connections between geosynthetic reinforcement and the facing blocks, include the results of connection capacity testing. Tests must be performed using the materials to be used on the project and tested in accordance with ASTM D6638 to justify the short-term ultimate connection strength reduction factor (CR_u) used to determine the long-term connection strength reduction factor (CR_{cr}) value in the design calculations for each wall height increment detailed in the shop drawings.

548-5 Concrete Component Construction.

Construct reinforced concrete components in accordance with Section 400. Precast wall components are produced using certification acceptance; therefore, assume responsibility for performance of all quality control testing and inspections required by Sections 346 and 400 for

the precast component construction. Perform all quality control (QC) inspection and testing using Construction Training and Qualification Program (CTQP) qualified personnel. Perform compressive strength testing in a laboratory meeting and maintaining at all times the qualification requirements listed in Section 105. The minimum time for form removal is 12 hours. Unless otherwise indicated in the Contract, apply a Class 3 finish to the concrete surface for the front face, and roughly screed the rear face to eliminate open pockets of aggregate and surface distortions in excess of 1/4 inch.

Construct unreinforced concrete SBW components (facing blocks) with a minimum compressive strength of 4,000 psi at 28 days and a maximum absorption of 6.5% in accordance with ASTM C140. Units must have a normal weight density classification meeting the requirements of ASTM C1372, except as modified in this Section.

548-5.1 Curing: Cure reinforced concrete components in accordance with Section 400.

548-5.2 Tolerances: Meet the following manufactured tolerances:

548-5.2.1 Reinforced Concrete Components:

1. Precast component dimensions: lateral position of soil reinforcement attachment devices - within 1 inch. All other dimensions - within 3/16 inch.

2. Precast component squareness: angular distortion of the component must not exceed 0.2 inches in 5 feet.

3. Precast component surface finish: surface defects on smooth formed surfaces measured on a length of 5 feet must not exceed more than 0.1 inches. Surface defects on textured finished surfaces measured on a length of 5 feet must not exceed 5/16 inch.

548-5.2.2 Unreinforced Concrete SBW Components:

1. Length, width and height of each individual block must be within 1/16 inch of the specified dimension. Hollow units must have a minimum wall thickness of 1-1/4 inches.

2. All units must be free of defects that would interfere with proper placing of the unit or impair the integrity of the wall construction. Minor cracks with a width less than 1/32 inch and a length less than 25% of the unit height may be acceptable.

3. Exposed facing blocks must be split face texture with a uniform wheat or tan color, unless shown otherwise in the Plans.

548-5.3 Marking of Precast Components:

548-5.3.1 Reinforced Concrete Components: Permanently and legibly mark the following information on the back of each reinforced precast wall panel by etching: the panel number or type, piece mark, project number (if applicable), date cast and precast manufacturer's name or symbol with the approved producer's QC stamp affixed.

548-5.3.2 Unreinforced Concrete SBW Components: Label each pallet of dry-cast unreinforced concrete SBW facing blocks with the component identification number or type, project number (if applicable), LOT number, date cast, and the manufacturer's name or symbol. Labels must be clearly legible until the component is installed.

548-6 Repairs or Rejection of Precast Components.

548-6.1 Reinforced Concrete Components: For precast concrete wall components that have not been installed, evaluate cracks, spalls and other deficiencies in accordance with 450-12. Repair deficiencies in accordance with 450-13 or the plant's approved repair methods that are included as part of the Producer Quality Control Plan. The original performance and durability of repaired wall components must be maintained. Use materials for concrete repair that meet or

exceed the strength requirement for the class of concrete used. Materials meeting the requirements of Section 930 may be substituted for non shrink grout when required by 450-13.

For precast concrete wall components that have been installed, the disposition of concrete cracks will be determined in accordance with 400-21.

The Department will reject all precast concrete wall components not meeting the quality standard of this Section and referenced Specifications. In addition, any of the following defects will be sufficient cause for rejection by the Department:

1. Defects that indicate unsatisfactory molding.
2. Defects indicating honeycombed or open texture concrete.
3. Defects in the physical characteristics such as:
    a. Signs of aggregate segregation
    b. Broken or cracked corners
    c. Soil reinforcement attachment devices improperly installed/damaged
    d. Lifting inserts not useable
    e. Exposed reinforcing steel
    f. Insufficient cover over reinforcing steel
    g. Cracks at the alignment pipe or pin
    h. Insufficient concrete compressive strength
    i. Precast component thickness in excess of plus or minus 3/16 inch from that shown in the Contract Documents
    j. Stained front face, due to excess form oil or other reasons. If the face of the precast component is stained or discolored to the point of rejection, the stain or discoloration may be removed, or a Department approved stain or a Class 5 finish may be applied to attain a uniform appearance for the entire structure, to the satisfaction of the Engineer.

548-6.2 Unreinforced Concrete SBW Components: The Department will reject all segmental retaining wall blocks not meeting the requirements of this Section and the Contract Documents. In addition, any of the following defects will be sufficient cause for rejection of SBW facing blocks by the Department:

1. Defects that indicate unsatisfactory molding.
2. Defects indicating honeycombed or open texture concrete.
3. Defects in the physical characteristics such as:
    a. Signs of aggregate segregation
    b. Broken or cracked corners
    c. Insufficient concrete compressive strength
    d, Excessive concrete absorption
    e. Exceeding dimensional tolerances, or
    f. Discoloration.

Correct cracks or spalls occurring after installation in accordance with 400-21.

548-7 Handling Storage and Shipping.

Handle, store and ship all components in a manner that prevents chipping, cracks, fractures, excessive bending stresses, mud, dirt and debris. Support precast panel wall and counterfort components in storage on firm blocking located immediately adjacent to the attachment device.

Do not ship precast concrete wall components to the project site prior to the completion of the 72 hour curing period and attainment of the required 28 day strength.

The Contractor is permitted to verify the shipping strength test, before 28 days, by testing compressive strength cylinders that are cured under the conditions similar to the product or by testing temperature match cured cylinders. The shipping strength test is the average compressive strength of two test cylinders. Do not ship reinforced concrete products until accepted and stamped by the QC Manager or the inspectors under the direct observation of the QC Manager.

548-8 Construction Requirements.

548-8.1 General: Due to the unique nature of the structure and concept, procure from the wall supplier fully detailed shop drawings, technical instructions, guidance in preconstruction activities and on-site technical assistance during construction. Closely follow any instructions from the wall supplier, unless otherwise directed by the Engineer. Submit any instructions from the wall supplier to the Engineer. Verify all pertinent retaining wall information (soil parameters, wall alignment, utility locations, conflicting structures) prior to the wall supplier finalizing shop drawings. Bring any conflicts not shown in the Contract to the Engineer's attention.

548-8.2 Wall Excavation: Excavate to the limits shown in the Contract and in conformance with Section 125.

548-8.3 Foundation Preparation: Grade the foundation for the structure level for a width equal to or exceeding the limits of the retaining wall volume or as shown in the Contract. Prepare the foundation in conformance with Section 125.

In addition to the compaction requirements of Section 125, compact the graded area with an appropriate vibratory roller weighing a minimum of eight tons for at least five passes or as directed by the Department's District Geotechnical Engineer. Remove and replace any soft or loose foundation subsoils incapable of sustaining the required compaction to the Engineer's satisfaction.

For permanent MSE wall systems, provide an unreinforced concrete leveling pad as shown in the Contract Documents. Cure the leveling pad a minimum of 12 hours before placement of precast wall components.

For SBW MSE wall systems, a geogrid reinforced, geotextile wrapped, compacted aggregate leveling pad may be used in lieu of the unreinforced concrete leveling pad. The compacted aggregate leveling pad must be at least 24 inches wide and at least 8 inches thick after compacting, and the geogrid must be at least 6 inches below the top of the leveling pad. Wrap the aggregate leveling pad with a D-2, D-3, or D-5 separation geotextile. The geotextile may run up the front and back of the first block course or between the aggregate leveling pad and the first block course.

548-8.4 Wall Erection: Assemble, connect and support wall components as recommended by the wall supplier. As backfill material is placed behind the wall face of MSE wall systems utilizing reinforced concrete panels, maintain the wall in the vertical position or slightly battered into the backfill to provide a final vertical alignment (by means of bracing, temporary wooden wedges placed in the joint at the junction of the two adjacent precast components on the external side of the wall or other alignment aids). Remove wooden wedges as soon as the precast component above the wedged precast component is completely erected and backfilled. External bracing is required for the initial lift of MSE systems.

For SBW systems, carefully place the first course of concrete block units on the leveling pad. Up to 1/2 inch of sand may be placed between the concrete leveling pad and the buried first course of blocks to provide a level and stable base. A one inch gap between the first course of facing units is allowed, provided a suitable filter fabric is placed behind the foundation units as specified for each approved wall system. Each unit must be in full contact with the base

and checked for level and horizontal alignment. Voids must be kept to a minimum to prevent point loading and cracking, unless otherwise indicated in the shop drawings. Place units side by side for the full length of wall alignment. Fill the hollow cores or cells and the space within blocks with drainage aggregate. Sweep away excess material from top of units and install the next course.

Place soil reinforcement normal to the face of the wall, unless otherwise shown in the Contract or as directed by the Engineer. Do not cut or kink soil reinforcement. Do not connect soil reinforcement to piles or allow soil reinforcement to bear against piles. Field cut soil reinforcement only at locations as shown in the approved shop drawings. Prior to placement of the reinforcement, compact the backfill in accordance with 548-8.5.

For SBW systems, shims made of non-degradable materials may be used as specified for each approved wall system. The shim thickness per course of block must not exceed 1/8 inch and must not be installed on reinforcement elevations when the reinforcement connection relies on any friction.

548-8.4.1 Tolerances for Permanent Walls: Walls that do not meet the following tolerances will not be accepted by the Department and must be removed and reconstructed at no cost to the Department.

548-8.4.1.1 Reinforced Concrete MSE Wall Systems: Vertical tolerances (plumbness) and horizontal alignment tolerances must not exceed 3/4 inch when measured with a 10 foot straightedge. The maximum allowable offset in the joint between precast components is 3/4 inch. The final overall vertical tolerance of the completed wall (plumbness from top to bottom) must not exceed 1/2 inch per 10 feet of wall height. Horizontal and vertical joints between precast components must not be less than 1/2 inch or more than 1-1/4 inches.

548-8.4.1.2 SBW Systems: Horizontal alignment tolerances must not exceed 3/4 inch per10 feet of wall length. The maximum allowable gap between segmental retaining wall blocks above the first course must not exceed 1/16 inch. The final overall vertical tolerance of the completed wall (deviation from plumbness from top to bottom or batter shown in the Plans) must not exceed 1/2 inch per 10 feet of wall height.

548-8.4.2 Tolerances for Temporary Walls: Vertical tolerances (plumbness) and horizontal alignment tolerances must not exceed three inches when measured with a 10 foot straightedge. The final overall vertical tolerance of the completed wall (plumbness from top to bottom) must not exceed one inch per three feet of wall height, not to exceed a total of six inches.

548-8.5 Backfill Placement:

548-8.5.1 Compacted Select and Coarse Aggregate Backfill: A LOT is defined as a single lift of finished embankment not to exceed 500 feet in length of continuous or interconnected walls. Backfill within 3 feet from the panels and backfill beyond 3 feet from the panels are separate LOTs. Overlapping retaining wall volumes may be considered one LOT, excluding the 3-foot width behind the panels. Strips up to 8 feet wide between two retaining wall volumes constructed with the same material in a single operation may be considered as one LOT with the retaining wall volumes. Isolated compaction operations will be considered as separate LOTs. For multiple phase construction, a LOT will not extend beyond the limits of the phase. When bridge abutments on spread footings are shown in the Plans, the material within 3 feet behind the wall face and within the limits defined in 548-9.4.2 are considered as separate LOTs.

Remove wrinkles in geosynthetic reinforcement prior to covering with backfill. Place the backfill closely following the erection of each course of precast components or soil reinforcement layers and spread by moving the machinery parallel to the wall face. Do not allow equipment heavier than eight tons closer than three feet behind the wall face. Place backfill in a manner to avoid any damage or disturbance to the wall materials or misalignment of the facing materials. Remove and replace any wall materials which become damaged or disturbed during backfill placement at no cost to the Department, or correct as directed by the Engineer. Remove and reconstruct any misalignment or distortion of the wall facing due to placement of backfill outside the limits of this specification at no cost to the Department.

Compact coarse aggregate backfill with a minimum of three passes of a vibratory compactor weighing between 600 and 1,000 pounds or two passes of vibratory compactor weighing over 1,000 pounds. Use the highest vibration level that does not cause excessive fracture of the aggregate in the opinion of the Engineer. Continue compaction until there is no additional movement. Sheepsfoot, grid rollers or other types of equipment employing a foot are not allowed for any backfill type. Achieve compaction of all backfill types within three feet of the back of the wall face using a power operated roller or plate weighing less than 1,000 pounds. At a distance greater than three feet from the back of the wall, a vibratory roller may be used, provided that the frequency and amplitude combined with bulk weight of the roller has performed satisfactorily at a trial section of the same type of wall. For select backfill, a smooth wheel or rubber tire roller is considered adequate. For walls employing geosynthetic reinforcement, limit the weight of compaction equipment to 25,000 pounds. Ensure that the maximum lift thickness after compaction does not exceed six inches. Decrease the lift thickness if necessary, to obtain specified density.

All transitions from coarse aggregate backfill to select backfill must occur at least six inches above and below any layers of backfill reinforcement. Place a separation geotextile in accordance with 548-2.5.4 between the coarse aggregate backfill and select backfill and embankment.

Perform backfill compaction in a way that the compactor moves in a direction parallel to the wall face and proceeds from a distance not less than three feet behind the wall face toward the end of the soil reinforcement element.

When placing select backfill, the moisture content of the backfill material prior to and during compaction must be uniformly distributed throughout each layer of material. Use backfill material having a placement moisture content at the dry side of the optimum moisture content. To achieve the required compaction moisture content, use water that meets the requirements of Section 923. Do not transport excessively moist backfill materials to the site for any reason. Determine the optimum moisture content in accordance with the test method used to determine maximum density in 548-9.

At the end of each day's operation, shape the last level of backfill to permit runoff of rainwater away from the wall face or provide a positive means of controlling run off away from the wall such as temporary pipe.

548-8.5.2 Thick Lift Option for Compacted Select Backfill: If through field tests, the Contractor can demonstrate that the compaction equipment can achieve density for the full depth of a thicker lift, the backfill may be constructed in successive courses of not more than 10 inches compacted thickness.

Based on the results of a full-height test wall constructed by each Contractor or MSE wall sub-contractor, the Engineer will approve each Contractor's or MSE

wall sub-contractor's specified compaction procedures. The length of the test wall shall be the length required to produce one LOT of 500 feet at the top of the wall. When all individual walls using this option are less than 500-feet long, the test wall may be broken into two segments comprising separate LOTs. Both segments must be accepted to determine the required percent compaction for the remaining walls. For each Contractor or MSE wall sub-contractor, the height of the test wall shall be 20 feet or the highest wall using this option, whichever is less. Lower height walls may be constructed using these procedures until a full height test wall is constructed. Notify the Engineer prior to beginning construction of a test wall.

Perform one set of QC density tests per thick lift of the test wall on the backfill within three feet behind the wall face and one set of QC density tests per thick lift of the test wall on the backfill placed beyond three feet behind the wall face, at random locations within each LOT. At each QC density test, the set will include testing the entire lift thickness and a dig down test of the bottom 6 inches. Excavate materials as needed to allow testing of the bottom 6 inches, at no cost to the Department. Maintain the exposed surface as close to undisturbed as possible; no further compaction will be permitted during the test preparation. The Department will perform verification testing of density for the bottom 6 inches and the entire lift thickness at the frequency indicated in 548-9.6. All QC tests and a Department Verification test must meet the density required by 548-9.4.

Identify the test wall with the required percent compaction effort and thickness in the Earthwork Records System (ERS) portion of the Department's database. For the material within three feet behind the wall face, the minimum density required on the thick lift will be the average of all the passing QC results obtained on the thick lifts of the test wall within the three feet behind the wall face. For the material placed beyond three feet behind the wall face, the minimum density required will be the average of all the passing QC results obtained on the thick lifts of the test wall beyond three feet behind the wall face. If the thick lift density does not meet or exceed the thick lift density results during the test wall, perform dig-down density tests to verify the density of the bottom 6 inches of the lift. The Contractor may elect to place material in 6 inches compacted thickness at any time. Once approved, a change in the source of backfill material will require the construction of a new test wall. Do not change the compaction effort once the test wall is approved. The Engineer will periodically verify the density of the bottom 6 inches during thick lift operations. If unable to achieve the required density, remove and replace or repair the test wall to comply with the specifications at no additional expense to the Department. The Engineer may terminate the use of thick lift construction and instruct the Contractor to revert to the 6 inches maximum lift thickness if the Contractor fails to achieve satisfactory results or meet the requirements of this Section.

548-8.5.3 Flowable Fill: Metallic wall components (including metallic soil reinforcements) must not be in partial contact with the flowable fill. If the metallic components contact the flowable fill, the metallic components must be completely encapsulated by the flowable fill.

548-8.6 Compressible Free Draining Seal: Seal all joints between panels of reinforced concrete panel MSE walls with compressible free draining material (open cell) to prevent plant growth from seeds or spores that may be in the joints or transported to the joints by wind or rain. Install the seal at least 1-1/2-inches from both the front and rear faces of the panel. Protect the free draining seal during the application of coatings and sealants. Should the seal become coated or clogged, remove and replace the coated or clogged free draining seal. The installation must be

secure and free draining to keep the seal securely in place until uninstalled and to prevent hydrostatic forces from building up behind the panel.

548-9 Acceptance Program.

548-9.1 General Requirements: Meet the requirements of 120-10 except delete the requirements of 120-10.1.4.1, 120-10.1.4.3, 120-10.1.6, 120-10.2 and 120-10.3.

548-9.2 Maximum Density Determination: For select backfill, determine the maximum QC density in accordance with FM 1-T180. When compacting A-3 or A-2-4 materials to meet the alternate acceptance criteria in 548-9.4.1, determine the maximum density in accordance with FM 1-T099.

Perform gradation tests on the sample collected in accordance with AASHTO T 27 and FM 1-T011. Classify soils in accordance with AASHTO M 145 to determine compliance with embankment utilization requirements.

548-9.3 Density Testing Requirements: Meet the requirements of 120-10.1.4.2 except as modified herein. Perform these tests at a minimum frequency of one set of tests per LOT.

Determine test locations including stations and offsets, using the random number generator provided by the Engineer. Do not use notepads or worksheets to record data for later transfer to the ERS section of the Department's database. Notify the Engineer upon successful completion of QC testing on each LOT.

548-9.4 Acceptance Criteria: For select backfill, obtain a minimum density of 90% of the maximum dry density as determined by FM 1-T180 within three feet behind the wall face and obtain a minimum density of 95% of the maximum dry density as determined by FM 1-T180 from beyond three feet behind the wall face.

For flowable fill, meet the requirements of 121-6. For coarse aggregate backfill, compact with a minimum of three passes of a vibratory compactor weighing between 600 and 1,000 pounds or two passes of a vibratory compactor weighing over 1,000 pounds. Use the highest vibration level that does not cause excessive fracture of the aggregate in the opinion of the Engineer. Continue compaction until there is no additional movement.

548-9.4.1 Optional Acceptance Criteria for A-3 and A-2-4 Materials: Obtain a minimum density of 95% of the maximum dry density as determined by FM 1-T099 within 3 feet behind the wall face and obtain a minimum density of 100% of the maximum dry density as determined by FM 1-T099 beyond 3 feet behind the wall face.

The combined width from both MSE wall backfill (excluding the 3-foot zone from the panels) and embankment material may be considered the same LOT if the same material is used; the material in both wall backfill and embankment is compacted with the same procedure, equipment and compacting effort; and the maximum lift thickness after compaction in both wall backfill and embankment is 6-inches.

548-9.4.2 Acceptance Criteria for Wall Backfill Supporting Spread Footings: When spread footings at bridge abutments are shown in the Plans, obtain a minimum of 95% of the maximum dry density as determined by FM 1-T180 on the material within 3 feet behind the wall face, and underneath the footing as defined by the following limits:

1. All lifts below the bottom of the footing for a depth equal to at least the footing width
2. A minimum distance of 3 feet beyond the edges of the footing width

If the optional criteria specified in 548-9.4.1 is used, compact the backfill material within the limits specified above to obtain a minimum density of 100% of the maximum dry density as determined by FM 1-T099. Compact the remainder of the backfill in accordance

with 548-9.4 or 548-9.4.1 as applicable. Do not use compaction equipment larger than permitted in 548-8.5 within 3 feet behind the wall face; decrease the lift thickness if necessary.

548-9.5 Friction Angle: When the friction angle depicted in the shop drawings exceeds 30 degrees for sand backfill or 34 degrees for limerock backfill, ensure the friction angle of the backfill material tested in accordance with FM 3-D3080 equals or exceeds the backfill friction angle depicted in the shop drawings.

548-9.6 Frequency: Conduct sampling and testing at a minimum frequency listed in the table below. The Engineer will perform verification sampling and tests at a minimum frequency listed in Table 548-4 below.

Table 548-4
Minimum Frequency Testing

Test Name	Quality Control (QC)	Verification
Maximum Density	One per soil type	One per soil type
Density	One per LOT	One per four LOTs for each type of QC test
Gradation	One per Maximum Density	One per Maximum Density
LL&PI	One per Maximum Density	One per Maximum Density
Soil Classification	One per Maximum Density	One per Maximum Density
Organic Content	One per soil type	One per soil type
pH	One per soil type	One per soil type
Direct Shear	Three per soil type when required by 548-9.5	One per soil type

In addition, for permanent walls utilizing metallic soil reinforcement, test for corrosiveness at a minimum frequency of one test per soil type at point of placement according to the electro-chemical table in 548-2.6. The Engineer will collect enough material to split and create two separate samples and retain one for resolution at point of placement until LOTs represented by the samples are accepted. The Engineer will perform verification tests for corrosiveness at a minimum frequency of one test per soil type.

548-9.7 Verification Comparison Criteria and Resolution Procedures:

548-9.7.1 Maximum Density Determination: The Engineer will collect enough material to split and create two separate samples and retain one for resolution until LOTs represented by the samples are accepted.

The Engineer will meet the requirements of 120-10.4.1 except replace FM 1-T099 with FM 1-T180. If the Contractor selects the Optional Acceptance Criteria, the Engineer will verify the QC results of FM 1-T099 in accordance with 120-10.4.1.

548-9.7.2 Density Testing: Meet the requirements of 120-10.4.2.

548-9.7.3 Soil Classification: The Engineer will meet the requirements of 120-10.4.3 except test the sample retained in 548-9.7.1 instead of taking the additional one.

548-9.7.4 Gradation: The Engineer will verify the QC results if the verification result meets the gradation limits set forth in the gradation table of 548-2.6. Otherwise, the Engineer will test the sample retained in 548-9.7.1. The State Materials Office (SMO) or an

AASHTO accredited laboratory designated by the SMO will perform resolution testing. The material will be sampled and tested in accordance with AASHTO T 27 and FM 1-T011.

If the resolution test result satisfies the required gradation limits, the LOTs will be verified. If the resolution test results do not meet the required gradation limits, reconstruct the LOTs with acceptable material. The Engineer will perform new verification testing.

548-9.7.5 Liquid Limit and Plasticity Index (LL&PI): The Engineer will verify the QC results if the verification result satisfies the plasticity index and liquid limit criteria set forth in 548-2.6. Otherwise, the Engineer will test the sample retained in 548-9.7.1. The SMO or an AASHTO accredited laboratory designated by the SMO will perform resolution testing. The material will be sampled and tested in accordance with AASHTO T 90 and AASHTO T 89, respectively.

If the resolution test result satisfies the required criteria, LOTs of that soil type will be verified. If the resolution test results do not meet the required criteria, reconstruct the corresponding LOTs with acceptable material. The Engineer will perform new verification testing.

548-9.7.6 Corrosiveness: The Engineer will verify the QC results if the verification result satisfies the electro-chemical and pH test criteria set forth in 548-2.6. Otherwise, the Engineer will test the sample retained in 548-9.7.1. The SMO or an AASHTO accredited laboratory designated by the SMO will perform resolution testing. The material will be sampled and tested in accordance with FM 5-550, FM 5-551, FM 5-552 and FM 5-553.

If the resolution test result satisfies the required criteria, material of that soil type will be verified and accepted. If the resolution test results do not meet the required criteria, reject the material and reconstruct with acceptable material.

548-9.7.7 Organic Content: The Engineer will verify the QC results if the verification result satisfies the organic content test criteria set forth in 548-2.6. Otherwise, the Engineer will collect three additional samples. The material will be sampled and tested in accordance with FM 1-T267 and by averaging the test results for three randomly selected samples from at least one lift per soil type. The SMO or an AASHTO accredited laboratory designated by the SMO will perform resolution testing.

If the resolution test result satisfies the required criteria, material of that soil type will be verified and accepted. If the resolution test results do not meet the required criteria, reject the material and reconstruct with acceptable material.

548-9.7.8 Friction Angle: When the friction angle depicted in the shop drawings exceeds 30 degrees for sand backfill or 34 degrees for limerock backfill, the Engineer will take a verification sample at the point of placement to perform a direct shear verification test in accordance with FM 3-D3080. The SMO or a consultant qualified to perform geotechnical specialty lab testing (Type of Work 9.5), per Rule 14-75 of the Florida Administrative Code will perform the verification testing. If the test verifies the material has a friction angle greater than or equal to the friction angle depicted in the shop drawings, the material in the LOTs will be verified. If the verification test does not meet the required friction angle, reconstruct the LOTs with acceptable material.

The Contractor may request to redesign the wall and resubmit the shop drawings with the lower friction angle indicated by the verification test. Employ a Professional Engineer to redesign and submit signed and sealed drawings and computations. Do not begin any

reconstruction until the proposed redesign has been reviewed and approved by the Engineer. The Contractor shall bear the costs of the redesign and any work resulting from the design changes.

548-10 Certification.

Submit all test reports to the Engineer necessary to document compliance with the Specifications, at least ten days prior to wall construction.

Also submit a certificate of compliance certifying that the retaining wall materials, backfill and construction practices comply with this Section.

For SBW systems, the Engineer will randomly select samples of each type of block used in the segmental block retaining wall system and review a copy of the certified test report corresponding the sample at a frequency of one sample per type of block for each wall.

Acceptance of furnished material will be based on the certificate of compliance, accompanying test reports, and visual inspection by the Engineer.

548-11 Method of Measurement.

The quantity to be paid for will be the plan quantity, in square feet, completed and accepted, of the area bounded by the following:

For permanent retaining wall systems: the top of the coping, the top of the leveling pad or top of structural footings and the begin and end wall limits as shown on the wall control drawings.

For temporary retaining wall systems: the top of wall, the ground line and the begin and end wall limits as shown on the wall control drawings.

548-12 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including the design of the wall system, excavation required specifically for wall construction below the finished graded surface, backfill reinforcement, leveling pad, footings, copings, light pole pedestals, fabric material, horizontal joint materials, alignment pins, repairs, labor, equipment, and other materials necessary to complete the wall in an acceptable manner as shown in the Contract. The cost of backfill for the finished graded surface will be included in the cost of embankment or borrow excavation, as applicable.

Payment will be made under:

Item No. 548- 12-	Retaining Wall System (Permanent) - per square foot.
Item No. 548- 13-	Retaining Wall System (Temporary) - per square foot.

SECTION 550
FENCING

550-1 Description.

Furnish, erect and reset metal fence of the type and at the locations shown in the Plans.

550-2 Types of Fence.

The types of fence are designated as follows:

Type A (Farm Fence).
Type B (Chain-Link Fence).
Type R (Chain-Link Fence for Pedestrian Overpass).

550-3 Materials.

550-3.1 Type A Fence (Farm Fence): Meet the requirements of Section 954 for timber posts and braces. For metal posts and braces, and for recycled plastic fence posts, meet the requirements of the Standard Plans.

For the fabric and all other accessories, meet the requirements of the Standard Plans.

550-3.2 Type B Fence (Chain-Link): For the posts, braces, fabric and all accessories other than the concrete for bases, meet the requirements of the Standard Plans.

Use concrete as specified in Section 347, or a premix approved by the Engineer for bases. The requirements contained in 347-2.2, and 347-3 will not apply.

550-3.3 Type R Fence (Chain-Link for Pedestrian Overpass): Use the fabric and accessories specified in the Plans.

550-3.4 Resetting Fence: Use material from the existing fence. For any additional materials required, provide the same type of material as in the existing fence and as specified herein, including gates when applicable.

550-3.5 Optional Use of Materials: For Type A Fence, a combination of steel, aluminum, timber, recycled plastic or concrete posts may be used. Unless otherwise called for in the Plans, line posts of one material may be used with corner, pull and end post assemblies of a different material. The Engineer will permit the use of line posts of only one optional material and pull posts assemblies of only one optional material between corner and end post assemblies. Within individual corner and end post assemblies, the Engineer will allow the use of only one optional material.

For Type B Fence, a combination of zinc-coated steel fence members, aluminum coated fence members and aluminum alloy fence members may be used. Unless otherwise indicated in the Plans, the Engineer will allow the use of only one type of fabric material, one type of line post material and one type of pull assembly material between corner and end post assemblies.

550-3.6 Certification: Provide the Engineer with certified test reports from the manufacturer confirming that all materials (posts, braces, fabric and all other accessories) conform to the requirements of this Section, Section 6 and the Standard Plans. Provide the Engineer a copy of the certification at least ten days prior to fence construction.

Also furnish the Engineer a Certificate of Compliance certifying that the fencing system, materials and construction practices comply with the applicable Standard Plans and Specifications.

Acceptance of furnished material will be based on the Certificate of Compliance, accompanying test reports and visual inspection by the Engineer.

550-4 Construction Methods.

550-4.1 General: Install the fence in accordance with the specific requirements of this Article and with the details shown on the Standard Plans for the particular type of fence called for, except for Type R Fence which shall be detailed in the Plans. Construct the fence in close proximity to the right of way line except as otherwise detailed in the Plans. Assume responsibility for obtaining satisfactory permits or permission from property owners for any encroachments required to perform the work, and for proper scheduling of the fence installation with the removal of existing fence where it is necessary to provide continuous security to adjacent areas already fenced. In order to meet this requirement, where necessary for maintaining security of livestock on adjacent property during construction of the new fence, the Engineer may require the erection and subsequent removal of temporary fencing.

550-4.2 Spacing of Posts: Space posts as shown in the Standard Plans, within a tolerance of 12 inches, except where definite spotting of corner posts is required. Ensure that in any line of fence, the over-spacings and the under-spacings shall approximately compensate. Set additional line posts at abrupt changes in grade.

550-4.3 Clearing: Where the clearing and grubbing for the project includes the area occupied by the fence, clear the area to the limits shown in the Plans. If the limits are not shown in the Plans, clear the area at least 2 feet wide on each side of the fence line. The Engineer may direct that desirable trees be left in place and may restrict clearing where permission from the property owners cannot be obtained.

550-4.4 Construction Over Irregular Terrain and Other Obstructions:

550-4.4.1 Clearance of Bottom of Fence: Install the fence such that the bottom of the fence, in general, follows the contour of the ground. The fence is detailed in the Plans at approximately 3 inches above finished graded surface. Over irregular ground, however, the Engineer will permit a minimum clearance of 1 inch and a maximum of 6 inches for a length not to exceed 8 feet, and, for Type A fence, with the barbed wire spaced midway between ground and bottom of fabric.

550-4.4.2 Grading: Where necessary to secure proper vertical alignment and to meet the clearance requirements, fill depressions (except where filling would obstruct proper drainage) and cut down knolls and ridges. Provide a substantial and permanent foundation for the fence.

550-4.4.3 Use of Extra-Length Posts. At locations where it is impracticable to adjust the ground level, the Engineer may require that posts of additional length be set and that the opening at the bottom be closed by additional barbed wire, stretched taut between poles, with no vertical distance between wires greater than 3 inches. For all such posts requiring a concrete base, extend the concrete downward to the bottom of the extra-length post.

550-4.5 Setting Posts: If rock occurs within the required depth of the post hole, or pavement which is to remain in place exists at the location of a post, drill a hole of a diameter slightly larger than the greatest dimension of the post or footing and grout in the post or footing. Set timber posts either by digging or by driving. Set recycled plastic fence posts in accordance with the Standard Plans.

550-4.6 Placing Fabric: Do not place fabric and barbed wire until the posts have been permanently positioned and concrete foundations have attained adequate strength. Place the fabric by securing one end and applying sufficient tension to remove all slack before making

permanent attachments at intermediate points. Fasten the fabric to all end, corner and pull posts by approved means. Fasten the fabric using tools designed for the purpose, in accordance with the manufacturer's recommendations. Apply the tension for stretching by mechanical fence stretchers or with single-wire stretchers designed for the purpose.

550-4.7 Electrical Grounds:

550-4.7.1 Grounding for Overhead Lines: Wherever an overhead power line crosses over the fence, install a ground rod directly below the point of crossing. Where an overhead power line runs parallel to, and within 100 feet of the fence, install a ground rod at each end of the fence and at intervals of no greater than 1,500 feet. Use copper-clad steel ground rods that are a minimum of 8 feet in length and 1/2 inch in diameter. Drive the rod vertically until the top of the rod is approximately 6 inches below the ground surface. Connect a conductor of No. 6 AWG solid copper wire to the ground rod and each metal fence element directly adjacent to the ground rod using non-corrosive ground rod clamps.

550-4.7.2 Fences with Non-Metal Posts: For all fences using non-metal posts, substitute a metal post for a non-metal post at intervals of no greater than 300 feet with at least one metal post in any length of fence. Tightly fasten a galvanized steel wire to the barbed wire, fence fabric, and metal post.

550-5 Method of Measurement.

550-5.1 General: The quantities to be paid for will be plan quantity for the number of gates and the length of each type of fence constructed and accepted. In addition, extra payment will be made, in accordance with 550-6.2, for additional lengths of post approved by the Engineer for the crossing of depressions in accordance with 550-4.4.3, muck areas, or other areas of inadequate support for a post of standard length.

550-5.2 Measurement of Fence Length, and Payment: The length of fence to be paid for will be plan quantity completed and accepted. Measurement for resetting fence will be the actual length of existing fence reset, including gates when applicable.

550-6 Basis of Payment.

550-6.1 Basic Items of Fencing: The Contract unit price per foot for the item of fencing, will be full compensation for all work and materials necessary for the complete installation, including line posts, corner, end, and pull posts. Such price and payment will include, but not be limited to, the following specific incidental work.

1. Any work required to level and prepare the terrain along the line of the fence.
2. Any additional clearing incidental to construction of the fence.
3. All preparation for post holes, in whatever type of material, as specified herein.
4. Any furnishing and installing of electrical grounds.
5. Any additional work or materials required for special construction over irregular terrain, or terrain of inadequate support for the posts, including the additional barbed wire, but not including the extra lengths of posts ordered by the Engineer.
6. Any cost of erection and removal of any temporary fencing, which may be necessary for maintaining security of livestock, etc., on adjacent property during construction of the new fence.

550-6.2 Payment Rates for Extra-Length Posts: Any extra length posts added to complete installation of the fence will require an invoice. The Contractor will be compensated for invoice price plus 10% as payment for any extra length posts.

The standard length of steel, recycled plastic and aluminum posts will be the required length as indicated in the Plans or Standard Plans for each type and case.

The payment for additional length of post will include the cost of additional concrete to extend concrete bases, as applicable.

550-6.3 Gate Payment: The quantities to be paid for will be full compensation for all labor, materials, posts, and associated hardware for the complete installation of the type gate specified in the Plans, and accepted by the Engineer.

550-6.4 Payment Items: Payment shall be made under:

Item No. 550- 10- Fencing - per foot.

Item No. 550- 60- Gates - each.

SECTION 555
DIRECTIONAL BORE

555-1 Description.

555-1.1 Scope of Work: The work specified in this Section documents the approved construction methods and procedures for directional boring, also commonly called horizontal directional drilling (HDD).

555-1.2 General: HDD is a trenchless method for installing a product that serves as a carrier pipe for transporting solids, liquids or gasses (under pressure or gravity flow), or serves as a conduit, casing, or duct for a carrier pipe, cable, or wire line products. It is a multi-stage process consisting of site preparation and restoration, equipment setup, and drilling a pilot bore along a predetermined path and then pulling the product back through the drilled space. When necessary, enlargement of the pilot bore hole may be necessary to accommodate a product larger than the pilot bore hole size. This process is referred to as back reaming and is done at the same time the product is being pulled back through the pilot bore hole.

Accomplish alignment of the bore by proper orientation of the drill bit head as it is being pushed into the ground by a hydraulic jack and determine orientation and tracking of the drill bit. In order to minimize friction and prevent collapse of the bore hole, introduce a soil stabilizing agent (drilling fluid) into the annular bore space from the trailing end of the drill bit.

Select or design drilling fluids for the site specific soil and ground water conditions. Confine free flowing (escaping) slurry or drilling fluids at the ground surface during pull back or drilling. Remove all residual slurry from the surface and restore the site to preconstruction conditions.

555-2 Construction Site Requirements.

555-2.1 Pedestrian Traffic: When and where installations temporarily disrupt use of a pedestrian way, provide a safe alternate route in accordance with Standard Plans, Indexes 102-600 and 102-660.

555-2.2 Site Conditions:

1. Carry out excavation for entry, exit, recovery pits, slurry sump pits, or any other excavation as specified in Section 120. Sump pits are required to contain drilling fluids if vacuum devices are not operated throughout the drilling operation, unless approved by the Engineer.

2. Within 48 hours of completing installation of the product, clean the work site of all excess slurry or spoils. Take responsibility for the removal and final disposition of excess slurry or spoils. Ensure that the work site is restored to pre-construction conditions or as identified on the plans.

3. Provide MOT in accordance with the Standard Plans and the MUTCD when and where the former is silent.

4. Exposure of product shall be limited to 3 feet and 14 consecutive days unless approved by the Engineer.

555-2.3 Damage Restoration: Take responsibility for restoration for any damage caused by heaving, settlement, separation of pavement, escaping drilling fluid (frac-out), or the directional drilling operation, at no cost to the Department.

555-2.3.1 Remediation Plans: When required by the Engineer, provide detailed plans which show how damage to any roadway facility will be remedied. These details will

become part of the As-Built Plans Package. Remediation plans must follow the same guidelines for development and presentation of the as-built plans. When remediation plans are required, they must be approved by the Engineer before any work proceeds.

555-3 Quality Control.

555-3.1 General: Take control of the operation at all times. Have a representative who is thoroughly knowledgeable of the equipment, boring and Department procedures, present at the job site during the entire installation and available to address immediate concerns and emergency operations. Notify the Engineer 48 hours in advance of starting work. Do not begin installation until the Engineer is present at the job site and agrees that proper preparations have been made.

555-3.1.1 Product Testing: When there is any indication that the installed product has sustained damage and may leak, stop all work, notify the Engineer and investigate the damage. The Engineer may require a pressure test and reserves the right to be present during the test. Perform pressure test within 24 hours, unless otherwise approved by the Engineer. Submit the test results to the Engineer for review and approval. The Engineer is allowed up to 72 hours to approve or determine if the product installation is not in compliance with the specifications. The Engineer may require non-compliant installations to be filled with excavatable flowable fill.

555-3.1.2 Testing Methods: Testing may consist of one of the following methods and must always meet or exceed the Department's testing requirements:

1. Follow the product manufacturer's pressure testing recommendations.
2. Ensure carrier pipes installed without a casing meet the pressure requirements set by the owner. If the owner does not require pressure testing, the Engineer may require at least one test.
3. A water tight pipe and joint configuration where the product is installed beneath any pavement (including sidewalk) and front shoulders is required. The Engineer will determine when and where water tight joint requirements will be applied to the ultimate roadway section for future widening. When a product is located elsewhere, the pipe and joint configuration must meet or exceed soil tight joint requirements. Conduct tests for joint integrity for one hour. The test for a soil tight joint allows up to 0.1 gallon of water leakage at a sustained pressure of 2 psi. The water tight joint criteria allows no leakage at all for a sustained pressure of 5 psi.

555-3.1.3 Failed Bore Path: If conditions warrant removal of any materials installed in a failed bore path, as determined by the Engineer, it will be at no cost to the Department. Promptly fill all voids with excavatable flowable fill.

555-3.2 Product Locating and Tracking: The method of locating and tracking the drill head during the pilot bore will be shown in the Plans. The Department recognizes walkover, wire line, and wire line with surface grid verification, or any other system as approved by the Engineer, as the accepted methods of tracking directional bores. Use a locating and tracking system capable of ensuring the proposed installation is installed as intended. If an area of radio signal interference is expected to exceed 5 feet, the Engineer may specify the use of a suitable tracking system. The locating and tracking system must provide information on:

1. Clock and pitch information
2. Depth
3. Transmitter temperature
4. Battery status
5. Position (x,y)

6. Azimuth, where direct overhead readings (walkover) are not possible (i.e. subaqueous or limited access transportation facility)

7. Ensure proper calibration of all equipment before commencing directional drilling operation.

8. Take and record alignment readings or plot points such that elevations on top of and offset dimensions from the center of the product to a permanent fixed feature are provided. Such permanent fixed feature must have prior approval of the Engineer. Provide elevations and dimensions at all bore alignment corrections (vertical and horizontal) with a minimum distance between points of 100 feet. Provide a sufficient number of elevations and offset distances to accurately plot the vertical and horizontal alignment of the installed product. A minimum of three elevation and plot points are required.

555-3.3 Product Bore Hole Diameter: Minimize potential damage from soil displacement/settlement by limiting the ratio of the bore hole to the product size. The size of the back reamer bit or pilot bit, if no back reaming is required, will be limited relative to the product diameter to be installed as follows:

Table 555-1
Maximum Pilot or Back-Reamer Bit Diameter When Rotated 360 Degrees

Outside Pipe Diameter Inches*	Maximum Bit Diameter Inches
<8	Diameter + 4
8 to 24	1.5 x Diameter
>24	Diameter + 12

*Use manufacturer's recommendation for pipe with restrained joints.

555-3.4 Drilling Fluids: Use a mixture of bentonite clay or other approved stabilizing agent mixed with potable water with a minimum pH of 6.0 to create the drilling fluid for lubrication and soil stabilization. Do not use any other chemicals or polymer surfactants in the drilling fluid without written consent from the Engineer. Certify to the Engineer in writing that any chemicals to be added are environmentally safe and not harmful or corrosive to the facility. Identify the source of water for mixing the drilling fluid. Any water source used other than a potable water source may require a pH test.

555-4 Drilling Operations:

555-4.1 Installation Process: Ensure adequate removal of soil cuttings and stability of the bore hole by monitoring the drilling fluids such as the pumping rate, pressures, viscosity and density during the pilot bore, back reaming and pipe installation. Relief holes can be used as necessary to relieve excess pressure down hole. Obtain the Engineer's approval of the location and all conditions necessary to construct relief holes to ensure the proper disposition of drilling fluids is maintained and unnecessary inconvenience is minimized to other facility users.

To minimize heaving during pull back, the pull back rate is determined in order to maximize the removal of soil cuttings without building excess down hole pressure. Contain excess drilling fluids at entry and exit points until they are recycled or removed from the site or vacuumed during drilling operations. Ensure that entry and exit pits are of sufficient size to contain the expected return of drilling fluids and soil cuttings.

Ensure that all drilling fluids are disposed of or recycled in a manner acceptable to the appropriate local, state, or federal regulatory agencies. When drilling in suspected

contaminated ground, test the drilling fluid for contamination and appropriately dispose of it. Remove any excess material upon completion of the bore. If in the drilling process it becomes evident that the soil is contaminated, contact the Engineer immediately. Do not continue drilling without the Engineer's approval.

When conditions warrant, as determined by the Engineer, back reaming for enlarging the bore diameter shall be accomplished by connecting the reamer to trailing drill stems at the exit pit of the pilot bore. The drill pipe shall remain in the bore hole until the final product is pulled into place. After the pilot bore is established, do not push anything from the entry pit to the exit pit.

The timing of all boring processes is critical. Install a product into a bore hole within the same day that the pre-bore is completed to ensure necessary support exists.

555-4.2 Boring Failure: If an obstruction is encountered during boring which prevents completion of the installation in accordance with the design location and specification, the pipe may be taken out of service and left in place at the discretion of the Engineer. Immediately fill the product left in place with excavatable flowable fill. Submit a new installation procedure and revised plans to the Engineer for approval before resuming work at another location. If, during construction, damage is observed to the FDOT facility, cease all work until resolution to minimize further damage and a plan of action for restoration is obtained and approved by the Engineer.

555-5 Documentation Requirements.

555-5.1 Boring Path Report: Submit a Bore Path Report to the Engineer within seven days of the completion of each bore path. Include the following in the report:

1. Location of project and financial project number including the Permit Number when assigned
2. Name of person collecting data, including title, position and company name
3. Investigation site location (Plans station number or reference to a permanent structure within the project right of way)
4. Identification of the detection method used
5. Elevations and offset dimensions as required in 555-3.2

555-5.2 As-Built Plans: Provide the Engineer a complete set of as-built plans showing all bores (successful and failed) within 30 calendar days of completing the work. As-built plans must be PDF files, in the same scale as the Plans. Ensure that the plans are dimensionally correct copies of the Plans and include roadway plan and profile, cross-section views, boring location and subsurface conditions as directed by the Engineer. The plans must show appropriate elevations referenced to a permanent FDOT feature (mast arm foundation, manhole inlet cover, head wall, etc). Specific plans content requirements include but may not be limited to the following:

1. The Contract plan view shows the center line location of each facility installed, or installed and placed out of service, to an accuracy of 1 inch at the ends and other points physically observed in accordance with the bore path report.
2. As directed by the Engineer, provide either a profile plan for each bore path, or a cross-section of the roadway at a station specified by the Engineer, or a roadway centerline profile. Show the ground or pavement surface and crown elevation of each facility installed, or installed and placed out of service, to an accuracy of within 1 inch at the ends and other exposed locations. On profile plans for bore paths crossing the roadway, show stationing of the crossing on the Plans. On the profile plans for the bore paths paralleling the roadway, show the Plans

stationing. If the profile plan for the bore path is not made on one of the Plans, use a 10 to 1 vertical exaggeration.

3. If, during boring, an obstruction is encountered which prevents completion of the installation in accordance with the design location and specification, and the product is left in place and taken out of service, show the failed bore path along with the final bore path on the plans. Note the failed bore path as “Failed Bore Path - Taken Out of Service”. Also show the name of the utility owner, location and length of the drill head and any drill stems not removed from the bore path.

4. Show the top elevation, diameter and material type of all utilities encountered and physically observed during the subsoil investigation. For all other obstructions encountered during a subsoil investigation or the installation, show the type of material, horizontal and vertical location, top and lowest elevation observed, and note if the obstruction continues below the lowest point observed.

5. Include bore notes on each plan stating the final bore path diameter, product diameter, drilling fluid composition, composition of any other materials used to fill the annular void between the bore path and the product, or facility placed out of service. Note if the product is a casing as well as the size and type of carrier pipes placed within the casing as part of the Contract work.

555-6 Compensation.

No direct payment will be made for directional bore. Include the cost to perform this operation in the Contract price for the item being installed.

No compensation will be made for failed bore paths, injection of flowable fill, products taken out of service, or incomplete installations.

No compensation will be made for the pay item associated with the directional bore until a Bore Path Report has been submitted and accepted by the Engineer.

SECTION 556
JACK AND BORE

556-1 Description.

556-1.1 Scope of Work: The work specified in this Section documents the approved construction methods, procedures and materials for Jack and Bore (J&B), also known as auger boring. Micro tunneling (MT) is also included in the category of J&B for purposes of the Specifications.

556-1.2 General: J&B is a method for installing a product (often called a casing) that may serve as a direct conduit for liquids or gases, or as a duct for carrier (Pipe, cable, or wire line products). It is a multi-stage process consisting of constructing a temporary horizontal jacking platform and a starting alignment track in an entrance pit at a desired elevation. The product is then jacked by manual control along the starting alignment track with simultaneous excavation of the soil being accomplished by a rotating cutting head in the leading edge of the product's annular space. The ground up soil (spoil) is transported back to the entrance pit by helical wound auger flights rotating inside the product. J&B typically provides limited tracking and steering as well as limited support to the excavation face.

MT is conducted similar to J&B with the exception that it is remotely controlled, guided pipe jacking process that provides continuous support to the excavation face. The guidance system usually consists of a laser mounted in the tunneling drive shaft which communicates a reference line to a target mounted inside the MT machine's articulated steering head. The MT process provides the ability to control the excavation face stability by applying mechanical or fluid pressure to counterbalance the earth and hydrostatic pressures.

Removal and disposition of excess material varies, is the responsibility of the boring contractor and is not covered under this Specification. However, the cost of removal or final disposition is included in the cost of the J&B operation.

No J&B conduit may be left open ended without approval of the Engineer.

556-2 Materials.

Select materials approved for installation within the right-of-way based on their suitability for the construction method as defined in Table 556-1. After determining product suitability, individual material standards as contained in Table 556-2 apply.

Table 556-1
Product Suitability by Construction Method

Type	Pipe/Casing Installation Mode	Suitable Pipe/Casing
Jack and Bore	Jacking	Steel, Plastic
Micro tunneling	Jacking	DI, FRPM, PC, PCCP, RCCP, RCP, Steel

Table 556-2 Material Standards Acceptable for J&B and MT Installations		
Material Type	Non-Pressure	Pressure
Ductile Iron (DI)	AWWA C150/C151 ASTM A716	AWWA C150/C151
Fiberglass Reinforced Polymer Mortar (FRPM)	ASTM D3262	ASTM D3517 AWWA C950
Polymer Concrete (PC)	DIN 54815-1 & 2	N/A
Prestressed Concrete Cylinder Pipe (PCCP)	N/A	AWWA C301
Reinforced Concrete Cylinder Pipe (RCCP)	N/A	ASTM C361
Reinforced Concrete Pipe (RCP)	ASTM C76	ASTM C361 AWWA C300/C302
Steel	ASTM A139 Grade B(1) API 2B(2)	AWWA C200 API 2B(2)
Polyvinyl Chloride (PVC)	ASTM D1785	ASTM D1785
Reinforced Thermosetting Resin Pipe (RTRP)	ASTM D2996 or ASTM D2997	ASTM D2996 or ASTM D2997
(1) No hydrostatic test required (2) Dimensional tolerances only		

Unless otherwise tested and approved by the Department, only use encasement pipe or uncased carrier pipe material that is new and has smooth interior and exterior walls.

When the Plans show that the casing is to be used as a drainage carrier pipe, extend the casing the entire length from drainage structure to drainage structure. When using uncased carrier pipe, use pipe meeting the requirements in 556-4.3. Maintain a uniform diameter, wall thickness and material type for the entire length of the casing.

556-2.1 Steel Pipe Casing and Welds: In addition to meeting or exceeding the conditions contained in Table 556-1 and Table 556-2, meet the following requirements:

1. The size of the steel casing must be at least 6 inches larger than the largest outside diameter of the carrier. Casing size must accommodate pressure pipe or carrier pipe joint restraints.

2. The casing pipe must be straight seam pipe, spiral seam pipe, or seamless pipe.

3. All steel pipe may be bare inside and out, with the manufacturer's recommended minimum nominal wall thicknesses to meet the greater of either installation, loading or carrier requirements.

4. All steel casing pipe must be square cut and have dead-even lengths which are compatible with the J&B equipment.

Use steel pipe casings and welds meeting or exceeding the thickness requirements to achieve the service life requirements noted in the Department Drainage Manual Chapter 6. For purposes of determining service life, ensure that casings installed under roadways meet or exceed cross drain requirements and casings under driveways meet or exceed side drain pipe requirements. For pipe used in drainage applications, use pipe meeting the requirements in 556-4.3. For purposes of material classification, consider steel pipe casing structural plate steel

pipe. Ensure that steel pipe casing of insufficient length achieves the required length through fully welded joints. Ensure that joints are air-tight and continuous over the entire circumference of the pipe with a bead equal to or exceeding the minimum of either that required to meet the thickness criteria of the pipe wall for jacking and loading or service life. All welding shall be done in accordance with the American Welding Society Structural Welding Code- Steel D1.1.

556-2.2 Reinforced Concrete Pipe Casing: In addition to meeting or exceeding the conditions contained in Tables 556-1 and Table 556-2, meet the following requirements:

Ensure that concrete pipe complies with the following minimum requirements:

1. 5,000 psi concrete compressive strength
2. Class III, IV, or V as required by load calculations, with a C-wall
3. Full circular inner and/or outer reinforcing cage
4. Multiple layers of steel reinforcing cages, wire splices, laps and spacers are permanently secured together by welding in place
5. Straight outside pipe wall with no bell modification
6. No elliptical reinforcing steel is allowed
7. Single cage reinforcement with a 1 inch minimum cover from the inside wall
8. Double cage reinforcement with a 1 inch minimum cover from each wall
9. Joints are gasket type
10. Additional joint reinforcement
11. For drainage applications, use pipe meeting the requirements in 556 4.3.

Upon installation, the Engineer may, at his discretion, require the Contractor to perform concrete wiping or injection of the joints if it is believed the joints have not maintained their water tightness during the jacking operation. No additional payment will be made for this operation.

556-2.3 Plastic Pipe Casing: Plastic pipe may be jacked and bored if its physical properties meet or exceed the conditions contained in Tables 556-1 and 556-2, and has a sufficient wall thickness to maintain proper alignment without exceeding the deflection requirements in Section 430-9.3. If plastic pipe is Jacked and Bored it may not be used as a pressurized carrier. Plastic pipe casing installed by the jack and bore method requires the use of an auger. Open end jacking without the use of an auger for continuous cleanout of the bore as the pipe is advanced is not permitted. Closed end jacking is not permitted.

For drainage applications, use pipe meeting the requirements in 556-4.3.

556-2.4 Pipe Couplings and Joints: In addition to meeting or exceeding the conditions contained in Tables 556-1 and 556-2, to minimize potential for bore failure, couplings must not project at right angles from the casing diameter by more than 3/4 inch.

1. Steel Pipe Coupling and Joints:
   a. Welds must comply with 556-2.1(4) when couplings are not used or when the coupling thickness is less than the casing thickness.
   b. When couplings are used the casing joint needs only to be tack welded. Couplings must have a full bead weld such that the thickness, when measured at an angle of 45 degrees to the casing and coupling interface, must be no less than the casing thickness.
2. Plastic Pipe Couplings and Joints:

a. Must meet or exceed all ASTM strength and composition standards established for the casing material to which they are being attached.

b. Joints must be made sufficiently strong to withstand the pressures of jacking. All chemical welds must be completely set and cured before any jacking is attempted.

556-3 Construction Site Requirements.

556-3.1 Site Conditions:

1. Carry out excavation for entry, exit, recovery pits, auger slurry sump pits, or any other excavation as specified in Section 120. When using auger fluids, the sump pits must contain auger fluids if vacuum devices are not operated throughout the boring operation.

2. Within 48 hours of completing installation of the boring product, ensure that the work site is cleaned of all excess auger fluids or spoils. Removal and final disposition of excess fluids or spoils is the responsibility of the boring contractor and ensure that the work site is restored to pre-construction conditions or as identified in the Plans.

3. Restore excavated areas in accordance with the Specifications and Standard Plans.

4. Provide MOT in accordance with the Department Standard Plans and the MUTCD when and where the former is silent.

5. Ensure that equipment does not impede visibility of the roadway user without taking the necessary precautions of proper signing and Maintenance of Traffic Operations.

556-3.2 Ground Water Control: Investigate all sites for possibility of having to manage groundwater problems that may occur due to seasonal changes or natural conditions.

When ground water level must be controlled, use a system and equipment that is compatible with the properties, characteristics, and behavior of the soils as indicated by the soil investigation report.

556-3.3 Damage Restoration: Take responsibility for restoring any damage caused by heaving, settlement, separation of pavement, escaping boring fluid (frac-out) of the J&B or MT operation at no cost to the Department.

556-3.3.1 Remediation Plans: When required by the Engineer, submit detailed plans which show how damage to any roadway facility will be remedied. These details will become part of the As-Built Plans Package. Remediation plans must follow the same guidelines for development and presentation of the As-Built Plans. When remediation plans are required, they must be approved by the Engineer before any work proceeds.

556-4 Quality Control.

556-4.1 General: Take control of the operation at all times. Have a representative who is thoroughly knowledgeable of the equipment, boring, and Department procedures present at the job site during the entire installation and available to address immediate concerns and emergency operations. Notify the Engineer 48 hours in advance of starting work. Do not begin the installation until the Engineer is present at the job site and agrees that proper preparations have been made.

556-4.2 Construction Process and Approval: For all installations, submit sufficient information to establish the proposed strategy for providing the following:

1. An indication of where the leading edge of the casing is located with respect to line and grade and the intervals for checking line and grade. Indication may be provided by using a water gauge (Dutch level) or electronic transmitting and receiving devices. Other methods must have prior approval. Maintain a record of the progress at the job site.

2. Equipment of adequate size and capability to install the product and including the equipment manufacturer's information for all power equipment used in the installation.

3. A means for controlling line and grade.

4. A means for centering the cutting head inside the borehole.

5. Provide a means for preventing voids by assuring:

a. The rear of the cutting head from advancing in front of the leading edge of the casing by more than 1/3 times the casing diameter and in stable cohesive conditions not to exceed 8 inches.

b. In unstable conditions, such as granular soil, loose or flowable materials, the cutting head is retracted into the casing a distance that permits a balance between pushing pressure, pipe advancement and soil conditions.

c. Development of and maintaining a log of the volume of spoil material removal relative to the advancement of the casing.

6. Adequate casing lubrication with a bentonite slurry or other approved technique.

7. An adequate band around the leading edge of the casing to provide extra strength in loose unstable materials when the cutting head has been retracted into the casing to reduce skin friction as well as provides a method for the slurry lubricant to coat the outside of the casing.

8. At least 20 feet of full diameter auger at the leading end of the casing. Subsequent auger size may be reduced, but the reduced auger diameter must be at least 75% of the full auger diameter.

9. Water to be injected inside the casing to facilitate spoil removal. The point of injection shall be no closer than 2 feet from the leading edge of the casing.

556-4.3 Testing:

556-4.3.1 Testing Requirements: Ensure all casing joints meet the Department's watertight pressure requirements in accordance with Section 430. Testing may consist of one of the following methods but must always meet or exceed Department testing requirements.

1. Follow the product manufacturer's pressure testing recommendations.

2. Carrier pipes installed without a casing must meet the pressure requirements set by the owner. If the owner does not require pressure testing, the Engineer may require at least one test.

556-4.3.2 Drainage Application Testing (Under Pavement): When under pavement (including sidewalk) and shoulders, all J&B pipe installations must meet or exceed the Department's watertight pipe and joint configuration in accordance with Section 430. The Engineer will determine when and where watertight joint requirements shall be applied to the ultimate roadway section for future widening. For all J&B carrier pipes installed without casing under pavement, perform air pressure testing at 5 psi in the presence of the Engineer as follows.

1. Pressurize pipe to 5 psi (positive and negative) and lock-off outside air source. Record pressure loss for 6 hours. A pressure loss equal to or less than 0.5 psi is acceptable. or,

2. A dragnet type leak detector or equivalent device capable of detecting pressure drops of 1/2 psi for a time period recommended by the manufacturer.

If the pressure loss exceeds 0.5 psi, repair leaks using methods approved by the Engineer and retest.

556-4.3.3 Drainage Application Testing (Not Under Pavement): When J&B pipe installations are not located under the pavement, the pipe and joint configuration must meet or exceed soil tight joint requirements. The test for a soil tight joint allows up to 0.1 gallon of water leakage at a sustained pressure of 2 psi. Conduct test for joint integrity for one hour.

556-4.3.4 Damaged Product Testing: When there is any indication that the installed product has sustained damage and may leak, stop the work, notify the Engineer and investigate damage. The Engineer may require a pressure test in accordance with 556-4.3.2. Perform pressure test within 24 hours unless otherwise approved by the Engineer. Submit the test results to the Engineer for review and approval. The Engineer shall be allowed up to 72 hours to approve or determine if the product installation is not in compliance with Specifications. The Engineer may require non-compliant installations to be filled with excavatable flowable fill at no cost to the Department.

556-4.4 Product Locating and Tracking: Install all facilities such that their location can be readily determined by electronic designation after installation. For non-conductive installations, attach a minimum of two separate and continuous conductive tracking (tone wire) materials, either externally, internally, or integral with the product. Use either a continuous green sheathed solid conductor copper wire line (minimum No. 12 AWG for external placement or minimum No. 14 AWG for internal placement in the conduit/casing) or a coated conductive tape. Ensure that conductors are located on opposite sides when installed externally. Connect any break in the conductor line before construction with an electrical clamp or solder, and coat the connection with a rubber or plastic insulator to maintain the integrity of the connection from corrosion. Clamp connections must be made of brass or copper and of the butt end type with wires secured by compression. Soldered connections must be made by tight spiral winding of each wire around the other with a finished length minimum of 3 inches overlap. Tracking conductors must extend 2 feet beyond bore termini. Conductors must be tested for continuity. Identify each conductor that passes by removing the last 6 inches of the sheath. No deductions are allowed for failed tracking conductors. Failed conductor ends must be wound into a small coil and left attached for future use.

556-4.5 Augering Fluids: Use a mixture of bentonite clay or other approved stabilizing agent mixed with potable water with a minimum pH of 6.0 to create the drilling fluid for lubrication and soil stabilization. Vary the fluid viscosity to best fit the soil conditions encountered. Do not use other chemicals or polymer surfactant in the drilling fluid without written consent of the Engineer. Certify in writing to the Engineer that any chemicals to be added are environmentally safe and not harmful or corrosive to the facility. Identify the source of water for mixing the drilling fluid. Approvals and permits are required for obtaining water from such sources as streams, rivers, ponds or fire hydrants. Any water source used other than potable water may require a pH Test.

556-4.6 Micro-Tunneling (MT) and Micro Tunnel Boring Machine (MTBM) Requirements:

556-4.6.1 Performance Requirements: The MTBM must meet the following minimum performance requirements:

1. Capable of providing positive face support regardless of the MTBM type.
2. Articulated to enable controlled steering in both the vertical and horizontal direction to a tolerance of plus or minus 1 inch from design alignment.
3. All functions are controlled remotely from a surface control unit.

4. Capable of controlling rotation, using a bi-directional drive on the cutter head or by using anti-roll fins or grippers. The Engineer must approve other methods.

5. Capable of injecting lubricant around the exterior of the pipe being jacked.

6. Indication of steering direction.

For slurry systems, the following is also required:

7. The volume of slurry flow in both the supply and return side of the slurry loop.

8. Indication of slurry bypass valve position.

9. Indication of pressure of the slurry in the slurry chamber.

556-4.7 Failed Bore Path: If conditions warrant removal of any materials installed in a failed bore path, as determined by the Engineer, it will be at no cost to the Department. Promptly fill all voids by injecting all taken out of service products that have any annular space with excavatable flowable fill.

556-5 Jack and Bore and Micro-Tunneling Operations.

556-5.1 Installation Process: Provide continuous pressure to the face of the excavation to balance groundwater and earth pressures. Ensure that shafts are of sufficient size to accommodate equipment, the pipe selected and to allow for safe working practices. Provide entry and exit seals at shaft walls to prevent inflows of groundwater, soil, slurry and lubricants. Use thrust blocks designed to distribute loads in a uniform manner so that any deflection of the thrust block is uniform and does not impart excessive loads on the shaft itself or cause the jacking frame to become misaligned.

The jacking system must have the capability of pushing the pipe in J&B operations or MTBM and pipe for MT operations through the ground in a controlled manner and be compatible with the anticipated jacking loads and pipe capacity. Monitor the jacking force applied to the pipe and do not exceed the pipe manufacturer's recommendations.

Ensure that the pipe lubrication system is functional at all times and sufficient to reduce jacking loads. Use pipe lubrication systems that include a mixing tank, holding tank and pumps to convey lubricant from the holding tank to application points at the rear of the MTBM. Maintain sufficient fluids on site to avoid loss of lubrication.

Power Distribution System must be identified in the Plans package or permit provisions as well as any noise constraints. Identity spoil removal capability and method to avoid creating hindrance to other activities which may be necessary in the area.

556-5.2 Excess Material and Fluids: Monitor the pumping rate, pressures, viscosity and density of the boring fluids to ensure adequate removal of soil cuttings and the stability of the borehole. Contain excess drilling fluids, slurry and soil cuttings at entry and exit points in pits until they are recycled or removed from the site.

Ensure that all boring fluids and other materials are disposed of or recycled in a manner acceptable to the appropriate Federal, State, and Local Rules and Regulations. When jacking and boring in known or suspected areas of contaminated groundwater or soil, coordinate with the Engineer and District Contamination Coordinator (DCIC) during the pre-construction meeting and prior to the start of boring to determine the best course of action for J&B activities within the contaminated area. If the J&B operation encounters an unidentified area of contamination or abnormal condition indicating the presence of potentially contaminated material, stop operations and contact the Engineer immediately. Do not continue boring without the Engineer's approval.

556-5.3 Boring Failure: If an obstruction is encountered which prevents completion of the installation in accordance with the design location and Specifications; the pipe may be taken out of service and left in place at the discretion of the Engineer. Immediately fill the product left in place with excavatable flowable fill. Submit a new installation procedure and revised plans to the Engineer for approval before resuming work at another location. If damage is observed to any property, cease all work until a plan of action to minimize further damage and restore damaged property is submitted and approved by the Engineer.

556-6 Documentation Requirements.

556-6.1 Boring Path Report: Submit a bore path report to the Engineer within 14 days of the completion of each bore path. No payment will be made for directional boring work until the bore path report has been delivered to the Department. Include the following information in the report:

1. Location of project and financial project number including the permit number when assigned.
2. Name of person collecting data, including title, position and company name.
3. Investigation site location (Plans station number or reference to a permanent structure within the project right of way).
4. Identification of the detection method used.
5. Spoils removal log.
6. As-built placement plans showing roadway plan and profile, cross-section, boring location and subsurface conditions as defined in bore path plans below. Reference the shown plan elevations to a Department benchmark when associated with a Department project, otherwise to a USGS grid system and datum or to the top of an existing Department head wall.

556-6.2 As-Built Plans: Submit to the Engineer a complete set of as-built plans showing all bores (successful and failed) within 30 calendar days of completion of the work. As-built plans must be PDF files, in the same scale as the Plans. Include notes on the plans stating the final bore path diameter, facility diameter, drilling fluid composition, composition of any other materials used to fill the annular void between the bore path and the facility or facility placed out of service. If the facility is a casing, note this, as well as the size and type of carrier pipes to be placed within the casing as part of the Contract work. Produce the plans as follows:

1. On the Contract plan view, show the centerline location of each facility, installed or installed and placed out of service to an accuracy within 1 inch at the ends and other points physically observed. They show the remainder of the horizontal alignment of the centerline of each facility installed or installed and placed out of service and note the accuracy with which the installation was monitored.
2. As directed by the Engineer, submit either a profile plan for each bore path, or a cross-section of the roadway at a station specified by the Engineer, or a roadway centerline profile. Also show the ground or pavement surface and the crown elevation of each facility installed, or installed and placed out of service, accurately to within 1 inch at the ends and other points physically observed. Show the remainder of the vertical alignment of the crown of each facility installed, or installed and placed out of service and note the accuracy with which the installation was monitored. On profile plans for bore paths crossing the roadway, show the Plans stationing. On the profile plans for bore paths paralleling the roadway show the Plans stationing. If the profile plan for the bore path is not made on one of the Plans, use a 10 to 1 vertical exaggeration.

3. If a bore path is not completed, show on the Plans the failed bore path along with the name of the utility owner and the final bore path. Note the failed bore path as failed bore path. Also show the location and length of the cutting head and any product not removed from the bore path.

4. Show the crown elevation, diameter and material type of all utilities encountered and physically observed during the subsoil investigation. For all other obstructions encountered during subsoil investigation or the installation, show the type of material, horizontal and vertical location, top elevation and lowest elevation observed, and note if the obstruction continues below the lowest point observed.

556-7 Compensation.

No direct payment will be made under this Section. Include the cost to perform this operation in the Contract unit price for the item being installed.

No compensation will be made for failed bore paths, injection of excavatable flowable fill, products taken out of service or incomplete installations.

No compensation will be made for the pay item associated with the jack and bore until a bore path report has been submitted to the Engineer.

SECTION 560
COATING NEW STRUCTURAL STEEL

560-1 Description.

Coat new structural steel in accordance with the requirements of this Section. Apply the coating system designated in the Contract Documents.

560-2 Materials.

560-2.1 Coating System: Use only coating products and systems meeting the requirements of Section 975 and listed on the Department's Approved Product List (APL). All components of coating systems must be from the same manufacturer.

Use Type M coal tar or modified glass flake epoxy coatings meeting the requirements of Section 926. Apply these products over a primer listed on the Department's APL for coating of permanent bulkhead sheet piles and H piles.

560-2.2 Thinners, Solvents and Cleaners: Use thinners, solvents and cleaners listed on the coating manufacturer's product data sheet.

560-2.3 Caulking: Use caulks that are paintable, compatible with the coating system and recommended by the coating manufacturer as part of the coating system.

560-2.4 Soluble Salts Test Kit: Measure the soluble salts using methods in compliance with SSPC-Guide 15, Table 1. Use a fully automated conductivity meter, fiber strip or multi-step patch, cell, or ring. Ensure the test sleeve or cell creates a sealed, encapsulated environment during ion extraction and is suitable for testing all structural steel surfaces.

560-2.5 Abrasives: Use properly sized abrasives to achieve the required cleanliness and anchor profile. Use abrasives meeting the requirements of SSPC-AB 1, Mineral and Slag Abrasives, SSPC-AB 2, Cleanliness of Recycled Ferrous Metallic Abrasives, or SSPC-AB 3, Newly Manufactured or Re-Manufactured Steel Abrasive and do not introduce any contamination that interferes with the coating application and performance.

Submit certification to the Engineer that the abrasives used meet the requirements of this Section and do not contain any chlorides and other salts.

For non- metallic abrasives, verify compliance with the conductivity and cleanliness requirements of SSPC-AB1. For recycled abrasives, verify compliance with the conductivity and cleanliness requirements of SSPC-AB 2 after each recycling or more frequently if required by the Engineer. Select a sample from each recycling machine in use and conduct the water-soluble contaminant and oil content tests outlined in SSPC-AB 2 at least one time each week or more frequently if directed by the Engineer. Conduct the non-abrasive residue and lead content tests as directed by the Engineer. If test results do not meet requirements, notify the Engineer immediately, remove and replace the abrasive, clean the recycling equipment, and conduct tests each day to confirm the equipment is functioning properly. Return to the weekly testing interval as directed by the Engineer.

560-2.6 Rust Preventative Compound: Use a Class 3 rust preventative compound meeting the requirements of Military Specification MIL-C-11796C, Corrosion Preventative Compound, Petrolatum, Hot Applied.

560-2.7 Storage: Store materials in conformance with the manufacturer's recommendations.

560-3 Equipment.

560-3.1 Compressed Air: Use a compressed air system capable of delivering clean, dry, continuous nozzle pressure to achieve the required surface cleanliness and profile or spray pattern. The system must comply with the instructions and recommendations of the manufacturer of the abrasive blasting system or coating application system.

560-3.2 Abrasive Blasting System: Design the blasting system to produce the specified cleanliness and profile.

560-3.3 Coating Application System: Use the coating application equipment approved by and in accordance with the coating manufacturer's technical data requirements.

560-4 Environmental, Health and Safety Requirements.

Isolate the work areas with containment devices, canvasses, tarpaulins or screens during all surface preparation and coating application operations. Dispose of all debris and waste products generated in accordance with all Federal, State and Local regulations.

560-5 Quality Control (QC).

560-5.1 Shop Preparation and Application: Prior to applying coatings, submit a current Corporate Quality Control Plan approved by the American Institute of Steel Construction (AISC) under the Sophisticated Paint Endorsement Program or SSPC under the SSPC-QP3 certification or NACE International Institute Contractor Accreditation Program (NIICAP) AS-1S certification program to the State Materials Office for approval.

560-5.2 Field Preparation and Application: For the surface preparation of steel and application of coatings, submit a current Corporate QC Plan approved by SSPC under the SSPC-QP1 or NIICAP AS-1F certifications and a site specific coating plan to the Engineer at least 14 calendar days prior to beginning coatings work. For the removal of hazardous coatings, submit a current Corporate QC Plan approved by SSPC under SSPC-QP2 and a site specific coating plan to the Engineer at least 14 calendar days prior to beginning coatings work. Do not begin coatings work until the site specific coating plan has been approved by the Engineer.

560-5.3 Inspection: Ensure that all inspection equipment is maintained in accordance with the manufacturer's instructions, calibrated, and in good working condition. Ensure that all activities are observed and approved by a quality control coatings inspector meeting the requirements of this Section. Maintain daily inspection reports at the job site for review by the Engineer. Submit all daily inspection reports upon completion of the project to the Engineer or more frequently as requested by the Engineer.

560-6 Qualifications.

560-6.1 Shop: Submit documentation to the Engineer at least 14 days prior to beginning work that the shop performing any work in accordance with this Section is certified by AISC Sophisticated Paint Endorsement or by SSPC to the requirements of SSPC-QP3.

560-6.2 Field Contractor: Submit documentation to the Engineer at least 14 days prior to beginning work that the field contractor performing any work in accordance with this Section is certified by SSPC to the requirements of SSPC-QP1 and/or SSPC-QP2 as appropriate.

560-6.3 Quality Control (QC) Supervisor in the Shop and Field: Personnel performing inspection of coating activities in the supervisory position must visit the shop at suitable intervals throughout the coating process. Personnel performing inspection of coating activities in the supervisory position must visit the field location at suitable intervals throughout the coating process, as defined in the site specific coating plan. Submit documentation to the

Engineer that all acting as supervisors are certified, at a minimum, to one of the following certifications:

1. AMPP Bridge Coatings Inspector Level 2
2. AMPP Senior Certified Coatings Inspector
3. NACE Coatings Inspector Level 3
4. SSPC Bridge Coatings Inspector Level 2
5. SSPC Protective Coatings Inspector Level 3

560-6.3.1 Certifications: Maintain certifications for the duration of the Contract. If the certifications expire, do not perform any work until certifications are reissued. The QP-1 requirement for a Coating Application Specialist may be waived on a project when there is no media blasting involved in the operations. The request should be identified in the site specific coatings plan.

Notify the Engineer of any change in certification status.

560-7 Surface Preparation.

560-7.1 General: Ensure all surfaces to be coated are clean, dry, and free from oil, grease, dirt, dust, soluble salts, corrosion, peeling coating, caulking, weld spatter, mill scale and any other surface contaminants. Prepare all surfaces that will become inaccessible after fabrication, erection, or installation while accessible. Sequence the surface preparations and coating operations so that freshly applied coatings will not be contaminated by dust or foreign matter. Protect all equipment and adjacent surfaces not to be coated from surface preparation operations. Protect working mechanisms against intrusion of abrasive. In the event that any rusting or contamination occurs after the completion of the surface preparation, prepare the surfaces again to the initial requirements. Perform surface preparation work only when the temperature of the steel surface is at least 5ºF above the dew point temperature.

560-7.2 Mechanical Removal of Surface Defects: Break all corners resulting from sawing, burning, or shearing. In areas where burning has been used, remove the flame hardened surface of the steel to the extent necessary to achieve the required surface profile after abrasive blast cleaning. Remove all weld slag and weld spatter. Conduct all of this work in accordance with AASHTO/NSBA Steel Bridge Collaboration S 8.1.

560-7.3 Cleaning: Clean all steel surfaces in accordance with the requirements of SSPC-SP 1.

560-7.4 Washing: Clean all steel surfaces in accordance with the requirements of SSPC-SP 12 LPWC WJ4.

560-7.5 Soluble Salts Detection and Removal: When using SSPC Guide 15, Table 1 retrieval methods, determine the chloride, sulfate and nitrate concentrations on all steel surfaces using soluble salts test kits meeting the requirements of 560-2.4. Perform the tests after washing and after each applied coat of the coating system. Ensure the non-visible surface contaminant concentration on blast-cleaned surfaces does not exceed the limits in Table 560-1. When quality control documentation at a fixed location indicates 36 months of historical sequential contaminant levels below those specified in Table 560-1, the Department may allow testing frequency to be reduced to one chloride contamination test per day. When any concentration or conductivity measurement exceeds the levels given in Table 560-1, rewash the entire surface area and retest all potentially contaminated steel to the satisfaction of the Engineer. If additional washing does not reduce the concentration to the acceptable level, a surface treatment or water additive may be used. Use a surface treatment or water additive that is approved by the coating system supplier and the Engineer.

Table 560-1 Allowable Surface Contaminants		
Coating Stage	Frequency of Test	Acceptance Criteria
Post-Blast, Pre-Coating	1 test (per 1,000 ft^2)	$\leq$ 17 µg/cm^2 Sulfates $\leq$ 10 µg/cm^2 Nitrates $\leq$ 70 µS/cm^2 Conductivity $\leq$ 7 µg/cm^2 Chlorides
Between Coats	3 tests (first 1,000 ft^2) 1 test (ea. Additional 1,000 ft^2)	$\leq$ 7 µg/cm^2 Chlorides

560-7.6 Abrasive Blast Cleaning: Prepare steel by abrasive blast cleaning to "near-white" metal condition as defined in SSPC-SP 10. Use SSPC VIS 1 as an aid in establishing cleanliness. After abrasive blast cleaning, ensure the surface profile meets the requirements of the coating manufacturer's product data sheet. Determine the surface profile in accordance with ASTM D4417, Method B or C.

Perform all abrasive blast cleaning within a containment system to ensure confinement of all particulates. Design the containment system to comply with all applicable Federal, State, and Local regulations. Ensure the abrasive blast cleaning does not produce holes, cause distortion, remove metal, or cause thinning of the substrate.

560-7.7 Hand and Power Tool Cleaning: Prepare steel by power and hand tool cleaning as defined in SSPC-SP 11, SSPC-SP 15, SSPC-SP 3, and SSPC-SP 2 for touch up and repair when approved by the Engineer. Use SSPC-VIS 3 as an aid in establishing cleanliness.

560-8 Surfaces Not to be Coated.

560-8.1 Galvanized Surfaces: Do not coat galvanized surfaces unless specified in the Contract Documents. When painting is required by the Contract Documents, perform sampling and testing in accordance with Section 649 and 975-4.

560-8.2 Surfaces to be in Contact with Concrete: Do not coat the areas of contact surfaces of steel to be encased or embedded in concrete, or coated with concrete unless specified in the Contract Documents. When specified, prepare the contact surfaces and apply primer.

560-8.3 Faying Surfaces: After application of the primer, protect the contact surfaces of members to be joined by high-strength bolts in friction type joints from all other coatings and foreign material.

560-8.4 Machine Finished Surfaces: Apply a coating of rust preventative compound to all machine finished or similar surfaces that are not to be coated, or will not be coated immediately.

560-8.5 Surfaces to be Welded: Mask off surfaces within 1 inch of field welded connections before the application of any shop coating. Apply a mist coat of primer that is less than 1 mil dry film thickness to surfaces where shear studs will be welded.

560-9 Application.

560-9.1 General: Apply a complete coating system to all structural steel surfaces except surfaces indicated in 560-8. Apply a complete coating system to all surfaces that will become inaccessible after fabrication, erection, or installation.

Apply the prime coat in the shop. Apply the intermediate coat in the shop or field. Only apply the finish coat after erection and after concrete work is complete.

Prior to the application of any coating, inspect the substrate for contamination and defects, and prepare the surface in accordance with 560-7 before application of the next coat.

Apply each coat including a stripe coat in a color that contrasts with the substrate or preceding coat. For exterior surfaces, apply a finish coat color meeting FED-STD-595, Shade 36622, unless otherwise specified in the Contract Documents.

560-9.1.1 Interior Box or Tub Girders: Apply a coat of white amine epoxy directly to the surface of all interior components of steel box or tub girders. Caulk and paint all bolted assemblies and joints in accordance with 560-9.7. When stud welding is specified, apply a mist coat of inorganic zinc-rich primer to the top flange at a dry film thickness no greater than 1 mil. Prevent rust bleeding from the top flange from staining adjacent painted surfaces.

560-9.2 Weather and Temperature Limitations: Do not spray coating when the measured wind speed in the immediate coating area is above 15 miles per hour. Do not apply coatings when contamination from rainfall is imminent or when the ambient air temperature, relative humidity, dew point temperature, or temperature of the steel is outside limits of the coating manufacturer's product data sheet.

560-9.3 Protection of Adjacent Surfaces: Protect all surfaces and working mechanisms not intended to be coated during the application of coatings. Clean surfaces that have been contaminated with coatings until all traces of the coating have been removed. Do not allow material from cleaning and coating operations to be dispersed outside the work site.

560-9.4 Mixing and Thinning: Mix all coatings in accordance with the manufacturer's product data sheet. Only mix complete kits. Use thinners and solvents in accordance with the requirements of the coating manufacturer's product data sheet and confirm that the amount of thinner added does not result in the coating exceeding VOC regulations stated in Section 975.

Perform all mixing operations over an impervious surface with provisions to prevent runoff to grade of any spilled material.

560-9.5 Application Methods: Use coating application equipment and apply coatings per the coating manufacturer's product data sheet. Application with brushes may be permitted for minor touchup of spray applications, stripe coats, or when otherwise approved by the Engineer. Adjust spray equipment to produce an even, wet coat with minimum overspray. Apply coatings in even, parallel passes, overlapping 50 percent. Agitate coatings during application as required by the coating manufacturer's product data sheet.

560-9.6 Stripe Coating: Use an aluminum epoxy mastic that is at least 80% solids by volume and is approved to be compatible with the coating system by the coating system manufacturer. Apply a stripe coat after the prime coat, but prior to applying the intermediate coat. Also, apply a stripe coat after the intermediate coat but prior to the finish coat. Apply the stripe coat per the manufacturers published product data sheet but no less than 3 mils dry film thickness. Apply both stripe coats to achieve complete coverage on welds, corners, crevices, sharp edges, bolts, nuts, rivets, and rough or pitted surfaces. A stripe coat of translucent coatings is not required. Do not apply subsequent coats until the previous stripe coat has cured per the manufacturer's product data sheet for recoating. Stripe coating is not required for the inside surface area of all steel box girders.

560-9.7 Sealing Using Caulk: Apply caulk after the intermediate coat has cured to a condition suitable for recoating in accordance with the manufacturer's product data sheet, and before application of the finish coat. Completely seal the perimeter of all cracks and crevices,

joints open less than 0.5 inch, and skip-welded joints using caulk. Apply the caulk to the joint following the caulk manufacturer's recommendations. Ensure the caulk bead has a smooth and uniform finish and is cured according to the caulk manufacturer's curing schedule prior to the application of the finish coat. Caulking the perimeter of bolted splice plates are not required unless directed by the Engineer. Caulking cracks or crevices less than 0.003 inches in width within the interior surface of box girders is not required.

560-9.8 Thickness of Coats: Apply coatings to the thickness as identified in the manufacturer's product data sheet. After application of each coat, thoroughly inspect the surfaces and measure the dry film thickness (DFT) in accordance with SSPC-PA 2. As an exception to SSPC-PA2, the DFT of the prime coat shall not be less than the minimum specified by the manufacturer's product data sheet. When the DFT is deficient or excessive, correct in accordance with the coating manufacturer's recommendations and retest the area.

560-9.9 Coating Drying, and Curing: Apply coatings within the time specified by the coating manufacturer's product data sheet for drying and recoating. Test the coating for proper cure before handling and shipping. Test for cure in accordance with the manufacturer's recommended method. Meet the requirements of ASTM D4752 for inorganic zinc primers or ASTM D5402 for organic zinc primers when the manufacturer's technical data sheet does not state a specified cure test. Obtain the acceptance criteria from the coating manufacturer and report the results to the Engineer.

Prior to assembling bolted connections, test and verify that the primer coating on the faying surfaces has cured to a resistance rating of 5 in accordance with ASTM D4752, ASTM D5402, or the coating manufacturer's requirements. If cure testing is performed per the coating manufacturer's requirements, submit the test results to the Engineer for approval prior to assembling the bolted connection.

560-9.10 Coating Finish: Apply each coat free of runs, sags, blisters, bubbles, and mud cracking; variations in color, gloss, or texture; holidays; excessive film buildup; foreign contaminants; orange peeling; and overspray.

560-10 Touchup and Repair.

560-10.1 Faying Surfaces: Reapply primer to all damaged surfaces using an approved organic zinc-rich primer. Do not use epoxy mastics on faying surfaces. Maintain a class B slip-critical coefficient by repairing faying surfaces in slip-critical connections in accordance with 560-8.3.

560-10.2 Repairs Other Than Faying Surfaces: Touch up all flaws and damaged areas. Clean and coat all welds, rivets, bolts, and all damaged or defective coating and rusted areas in accordance with 560-7 and 560-9. Repair damaged surfaces using an approved organic zinc-rich primer. Upon approval by the Engineer, aluminum mastic may be used in accordance with the manufacturer's recommendations and approval by the coating manufacturer. Aluminum mastic must contain aluminum pigment and minimum 80% volume solids.

560-11 Coating of Permanent Sheet, Pipe and H-Piles.

560-11.1 Surface Preparation: Prepare the substrate in accordance with 560-7. Provide a depth of anchor profile in accordance with the manufacturer's product data sheet, but in no case less than 2.5 mils. Re-blast piles not coated during the same shift or if the surface to be coated no longer meets the requirements SSPC-SP 10.

560-11.2 Application of Coating: Unless otherwise shown in the Contract Documents, apply the inorganic zinc primer to all surfaces of H and sheet piles and the exterior surface of

pipe piles in accordance with the limitations of 560-8. Unless otherwise shown in the Contract Documents, apply coal tar apply coal tar or modified glass flake epoxy coatings to the exposed side of sheet epoxy coatings to the exposed side of sheet piles from the top of the piles to a depth of five feet below the lower of the design ground surface or the design scour depth in accordance with the limitations of 560-8. Apply the inorganic zinc primer in accordance with this Section. Apply the coal tar or modified glass flake epoxy in accordance with the following specific requirements:

1. Apply the coal tar or modified glass flake epoxy system in strict accordance with the coating manufacturer's published specifications. Coal tar epoxies must attain a total dry film thickness (zinc primer and coal tar epoxy) at a minimum 18 mils (on each side). Modified glass flake epoxies must attain a total dry film thickness (zinc primer and modified glass flake epoxy) at a minimum 10 mils (on each side).

2. Ensure that no area measurements of the coating is less than 80% of the specified minimum film thicknesses, as determined by AMPP Paint Application Standard No. 2 (PA-2). The total minimum film thickness for any combination of coats will be the sum total of the averages of the specified thickness range of the individual coats.

3. After applying the coating on the steel piles, the Engineer will thoroughly inspect the surfaces and make film thickness measurements at the approximate rate of one for each 25 square feet of area unless deficient thickness is found. In this case, the rate of additional measurements will be increased as required to determine the extent of the deficient area.

560-12 Method of Measurement.

For coating all new structural steel in I-girder and box or tub girder superstructures and bent caps, the quantity to be paid for will be the lump sum quantity, completed and accepted.

560-13 Basis of Payment.

For I-girder and box or tub girder superstructures and bent caps, price and payment will be full compensation for all work specified in this Section, including furnishing and applying all materials to complete the coating for the new structural steel.

No separate payment will be made for coating all other structural steel.

Payment for coating all new structural steel in I-girder and box or tub girder superstructures and bent caps will be made under:

Item No. 560- 1- Coating System for New Structural Steel - lump sum.

SECTION 561
COATING EXISTING STRUCTURAL STEEL

561-1 Description.

Coat existing structural steel in accordance with the requirements of this Section by removing and replacing the existing coating or overcoating the existing coating as stated in the Contract Documents.

561-2 Materials.

561-2.1 Coating Systems: For removal and replacement systems, use coating products and systems meeting the requirements of Section 975 and are listed on the Department's Approved Product List (APL).

For overcoating systems, use products and systems as designated in the Contract Documents. Submit product data sheets and product Material Safety Data Sheets (SDS), or in lieu of SDS, submit test reports showing percent weight compositional analysis, Chemical Abstract Number, American Conference of Governmental Industrial Hygienists (ACGIH) time weighted average and ceiling exposure limits for all components, and lower and upper explosive limits, flash point, boiling point, amount of volatile organic compounds by weight, and specific gravity for each component of the coating system.

561-2.2 Thinners, Solvents and Cleaners: Meet the requirements of 560-2.2. In addition, for overcoating systems, use thinners, solvents, and cleaners that do not damage the existing coating system.

561-2.3 Caulking: Meet the requirements of 560-2.3.

561-2.4 Soluble Salts Test Kit: Meet the requirements of 560-2.4.

561-2.5 Abrasives: Meet the requirements of 560-2.5.

561-2.6 Rust Preventative Compound: Meet the requirements of 560-2.6.

561-2.7 Storage: Meet the requirements of 560-2.7.

561-3 Equipment.

561-3.1 Compressed Air: Meet the requirements of 560-3.1.

561-3.2 Abrasive Blasting System: Meet the requirements of 560-3.2.

561-3.3 Coating Application System: Meet the requirements of 560-3.3.

561-4 Quality Control (QC).

561-4.1 Field Preparation and Application: For the surface preparation of steel and application of coatings, submit a current SSPC QP1 or National Association of Corrosion Engineers (NACE) International Institute Contractor Accreditation Program (NIICAP) AS-1F certification with the Corporate QC Plan that was reviewed by SSPC or NIICAP under the current certification and a site specific coating plan to the Engineer at least 14 calendar days prior to beginning coatings work. For the removal of hazardous coatings, submit a current SSPC QP2 certification with the Corporate QC Plan that was reviewed by SSPC under the current certification and a site specific coating plan to the Engineer at least 14 calendar days prior to beginning coatings work. Do not begin coatings work until the site specific coating plan has been approved by the Engineer.

Prepare a traffic control plan for each phase of construction activities signed and sealed by the Contractor's Engineer of Record in accordance with the FDOT Design Manual. Do not begin work until the traffic control plan is approved by the Engineer. Maintain traffic in accordance with Section 102.

For work over navigable waters, submit a work plan to the United States Coast Guard including any scheduled restrictions to navigation channels or marine traffic. Obtain Coast Guard approval at least 30 days in advance of any restrictions.

561-4.2 Inspection: Meet the requirements of 560-5.3.

561-5 Qualifications.

561-5.1 Field Contractor: Meet the requirements of 560-6.2.

561-5.2 Quality Control (QC) Personnel: Meet the requirements of 560-6.3.

561-5.3 Certifications: Meet the requirements of 560-6.4.

561-6 Surface Preparation.

561-6.1 General: When portions of the existing coating are designated in the Contract Documents to be removed and replaced, clean, wash, test and remove soluble salts, and abrasive blast or hand and power tool clean to remove all existing coating and corrosion in the intended locations. Feather back the edges of all existing coating to remain a minimum of 3 inches around the area of existing coating removed to provide a smooth transition. Verify the edges of the existing coating are intact by probing with a dull putty knife in accordance with SSPC SP 2. Roughen the existing coating in the feathered area to ensure proper adhesion of the new coating. Notify the Engineer immediately when any structural steel appears to be defective.

When the existing coating is to remain, clean, wash, and test and remove soluble salts.

Ensure all surfaces to be coated are clean, dry, and free from oil, grease, dirt, dust, soluble salts, corrosion, peeling coating, caulking, weld spatter, mill scale and any other surface contaminants. Sequence the surface preparations and coating operations so that freshly applied coatings will not be contaminated by dust or foreign matter. Protect all equipment and adjacent surfaces not to be coated from surface preparation operations. Protect working mechanisms against intrusion of abrasive. In the event that any rusting or contamination occurs after the completion of the surface preparation, prepare the surfaces again to the initial requirements. Perform surface preparation work only when the temperature of the steel surface is at least 5^{o}F above the dew point temperature.

561-6.2 Mechanical Removal of Surface Defects: Meet the requirements of 560-7.2. In addition, remove all pack rust prior to solvent cleaning.

561-6.3 Cleaning: Meet the requirements of 560-7.3.

561-6.4 Washing: Meet the requirements of 560-7.4.

561-6.5 Soluble Salts Detection and Removal: Meet the requirements of 560-7.5 except test five random locations in the first 1,000 square feet and one random location for each subsequent 1,000 square feet.

561-6.6 Abrasive Blast Cleaning: Meet the requirements of 560-7.6.

561-6.7 Hand and Power Tool Cleaning: Prepare steel by power and hand tool cleaning as defined in SSPC SP 11, SSPC SP 3, and SSPC SP 2 as stated in the Contract Documents. Use SSPC VIS 3 as an aid in establishing cleanliness.

561-7 Surfaces Not to be Coated.

561-7.1 Galvanized Surfaces: Meet the requirements of 560-8.1.

561-7.2 Machine Finished Surfaces: Meet the requirements of 560-8.4.

561-8 Application.

561-8.1 General: Apply a complete coating system to all structural steel surfaces except surfaces indicated in 561-7.

Prior to the application of any coating, inspect the substrate for contamination and defects, and prepare the surface in accordance with 561-6 before application of the next coat.

Apply each coat including a stripe coat in a color that contrasts with the substrate or preceding coat. For exterior surfaces, apply a finish coat color meeting FED-STD-595, Shade 36622, unless otherwise specified in the Contract Documents.

561-8.2 Weather and Temperature Limitations: Meet the requirements of 560-9.2.

561-8.3 Sealing Using Caulk: Meet the requirements of 560-9.7.

561-8.4 Protection of Adjacent Surfaces: Meet the requirements of 560-9.3.

561-8.5 Mixing and Thinning: Meet the requirements of 560-9.4.

561-8.6 Application Methods: Meet the requirements of 560-9.5.

561-8.7 Stripe Coating: Meet the requirements of 560-9.6.

561-8.8 Thickness of Coats: Meet the requirements of 560-9.8.

561-8.9 Coating Drying, and Curing: Apply coatings within the time specified by the coating manufacturer's product data sheet for drying and recoating. Before handling, test for cure in accordance with the manufacturer's recommended method. Meet the requirements of ASTM D5402 for organic zinc primers when the manufacturer's technical data sheet does not state a specified cure test. Obtain the acceptance criteria from the coating manufacturer and report the results to the Engineer.

561-8.10 Coating Finish: Meet the requirements of 560-9.10.

561-9 Touchup and Repair.

Clean and coat all welds, rivets, bolts, and all damaged or defective coating and rusted areas in accordance with 561-6 and 561-8. Upon approval by the Engineer, aluminum mastic may be used in accordance with the manufacturer's recommendations. Aluminum mastic must contain aluminum pigment and minimum 80% volume solids.

561-10 Protection of the Environment, Public, and Workers.

561-10.1 General: Establish plans and programs to protect the environment, public, contractor employees, other workers, and property from overspray, exposure to toxic heavy metals and the release and emission of hazardous materials and nuisance dusts. Include in such plans and programs a procedure for the receipt, processing, evaluation and timely written response for claims by the public for damage resulting from the foregoing work. Submit to the Department any written response which denies such damage claims. Conduct all coating application and removal operations in compliance with EPA, OSHA, and other applicable Federal, State and local regulations. Submit a contingency plan for the remediation of water and land in the event of contamination by solid or liquid paint and contaminated water.

561-10.2 Environmental Protection: Prepare and submit to the Engineer, plans and programs for the protection of the environment and public based on the applicable EPA requirements, the requirements of this Section, and the Contract Documents. Include plans and programs for the protection of the air, soil/ground, and water.

561-10.2.1 Pollution Control: Submit a written pollution control and monitoring plan at the preconstruction meeting or as directed by the Engineer which clearly describes the means for complying with all Local, State and Federal regulations including pollution control provisions specified herein. The written plan must be in accordance with SSPC Project Design: Industrial Lead Paint Removal Handbook, Volume II, Phase 6, Environmental Monitoring, and

specifically include, but not be limited to, providing a scaled map of the work site layout showing the proposed number and location of soil sampling, Total Suspended Particulate (TSP) monitoring sites, waste storage areas, staging areas, temporary waste storage areas, and ambient air and personnel sampling frequency.

Comply with all applicable Federal, State, and Local rules and regulations. Immediately cease all operations in the event a violation of any environmental regulation or a failure to properly execute any pollution control provisions occurs. Resume operations after written proposed corrective procedures have been submitted to and approved by the Engineer and implemented.

561-10.2.2 Permits: Submit all required permits from all applicable regulatory agencies to the Engineer prior to the commencement of any work. Seek permit determination from these regulatory agencies to avoid any potential permit non-compliance issues during work activities. The Contractor is responsible for all liability resulting from non-compliance with pertinent rules and regulations including permit requirements.

561-10.2.3 Ambient Air Quality Compliance and Protection of the Air:

561-10.2.3.1 Visible Emissions: Assess the visible emissions using EPA Method 22, Timing of Emissions as defined by 40 CFR 60, Appendix A, Standards of Performance for New Stationary Sources. During abrasive blasting, do not allow visible emissions from a containment to exceed a random cumulative duration of more than one percent of the workday (SSPC Guide 6, Level 1 Emissions). During pressurized water cleaning, do not allow visible emissions from a containment to exceed a random cumulative duration of more than ten percent of the workday (SSPC Guide 6, Level 3 Emissions).

561-10.2.3.2 Total Suspended Particulate (TSP) Matter: Control emissions from the containment area to prevent exceeding the TSP lead of 1.5 $\mu g/m^3$ over a 90 day period, or the daily and adjusted daily allowances of SSPC-TU 7. Conduct TSP Lead monitoring in accordance with 40 CFR 50, Appendix B, Reference Method for Determination of TSP Matter in the Atmosphere (high volume sampler required), and 40 CFR 50, Appendix G, Reference Method for Determination of TSP Matter Collected from Ambient Air. Position the TSP lead monitoring equipment in general accordance with 40 CFR 58, Ambient Air Quality Surveillance.

When lead is present in the coating, perform TSP Lead background monitoring for a period of 3 days prior to the beginning of abrasive blast cleaning operations. Submit the results from background monitoring and the first week of monitoring during abrasive blast cleaning to the Engineer for review within 5 calendar days after the first week of work. Continue monitoring unless otherwise directed by the Engineer.

561-10.2.3.3 Regulated Area: Establish a regulated area around the work site to prohibit unauthorized persons from areas where exposure to hazardous airborne metals may exceed the following action levels:

Table 561-1
Hazardous Airborne Metals and Action Levels

Airborne Metals	Action Level
Lead	30 $\mu g/m^3$
Cadmium	2.5 $\mu g/m^3$
Arsenic	5 $\mu g/m^3$
Hexavalent Chromium (Cr^{6+})	2.5 $\mu g/m^3$

Conduct monitoring in accordance with the National Institute for Occupational Safety and Health (NIOSH) procedures upon initiation of dust producing operations and submit the test results to the Engineer within 72 hours of sampling. Report sample results as eight-hour Time Weighted Averages (TWA). Reestablish the regulated area and perform additional sampling when the results exceed the action levels or when directed by the Engineer. Record all pertinent data. Position air-sampling pumps around the project perimeter where the public or personnel can approach the work area. Place sampler inlets at breathing height. Clearly mark the regulated area by the use of warning signs, rope, barrier tape, or temporary construction fencing.

561-10.2.4 Soil/Ground Quality: Inspect the ground beneath and in proximity to the structure in the presence of the Engineer for visible paint chips to establish an initial job site cleanliness standard. When heavy metals are in the existing coatings, test soil samples prior to the beginning of operations and after project completion for heavy metals. Document the number and specific locations where the initial samples are taken as outlined in the SSPC Project Design-Industrial Lead Paint Removal Handbook, Volume 2 to ensure the post samples are collected from the same locations. Submit all samples to the Engineer for review. If the project activities increase the heavy metal content in soil to more than 20% above the pre-job geometric mean or 100% at any one location, return the site to the pre-job levels. Conduct additional soil testing as necessary to determine the extent of contamination.

For structures less than 14 feet minimum height, take one sample north, south, east, and west (where soil is present) of the structure. If the structure is longer than 14 feet, take one additional sample for every 14 feet in length.

For structures greater than 14 feet minimum height, take two samples north, south, east, and west (where soil is present) of the structure. Locate the inner row of samples within 14 feet of the structure. Locate the outer row of samples at a distance equal to the height of the structure. If the structure is longer than 14 feet, take one additional sample for every 14 feet in length.

In addition, submit a pre- and post- soil sampling plan for storage areas identifying the sample location, depth, analyses list, lab certification, and turnaround time. Once approved by the Engineer, submit sampling results along with a scaled drawing indicating designated sample locations.

561-10.2.5 Water Quality: Do not release, discharge or otherwise cause hazardous materials, debris, waste, or paint chips to enter the water. Protect against releases due to rain and methods of surface preparation from reaching rivers, streams, lakes, storm drains, or other bodies of water.

561-10.3 Containment System: Submit a written containment system design plan in accordance with this section and the contract documents at the pre-construction conference or as directed by the Engineer which clearly describes the proposed containment system applicable to the intended removal method and in accordance with the requirements outlined herein and SSPC Guide 6, Guide for Containing Debris Generated During Paint Removal Activities. Ensure the plan includes, but is not limited to, removal method; methods for collecting debris; and containment enclosure components. Use fire retardant materials. Submit containment drawings, calculations, assumptions, ventilation criteria if applicable, and a structural analysis that verifies the existing structure can withstand the additional dead, live and wind loads imposed by the containment system, signed and sealed by a Specialty Engineer. However, for more complex structures incorporating cables stayed, suspension, or truss designs, the analysis must be performed by the Contractor's Engineer of Record qualified in Type Work Category 4.3, Complex Bridge Design. Submit a contingency plan addressing natural weather events such as

tropical storms and hurricanes. Ensure the lighting inside the containment is in accordance with SSPC Guide 12, Guide for Illumination of Industrial Painting Projects. Provide lighting to a minimum intensity of 10 ft-cd for general, 20 ft-cd for work, and 50 ft-cd for inspection. All drawings and calculations must be submitted and accepted before any work begins. Include a clear description of the ventilation system components and information including the fan curve and design point on the proposed dust collector. Design to provide ventilation according to the notes provided in SSPC Guide 6: 100 feet per minute for cross draft and 50-60 feet per minute for downdraft.

Isolate the immediate area of the structure to ensure compliance with current and permit requirements for air, water, soil, and pollution prevention. Protect the containment system from vehicular and pedestrian traffic. Ensure paint, paint chips, or other debris will not fall outside of the containment area under any circumstances. Repair any damage created by fastening, bracing, or handling the scaffolding and staging. If a suspended platform is constructed, use rigid or flexible materials as needed to create an air and dust impenetrable enclosure. Verify that the platform and its components are designed and constructed to support at least four times its maximum intended load without failure, with wire cables capable of supporting at least six times their maximum intended load without failure. Strictly comply with all applicable OSHA regulations regarding scaffolding. The category and class of containment shall be as required in the Contract Documents.

561-10.4 Protection of Adjacent Areas: Protect all areas adjacent to abrasive blast cleaning, including machinery and deck grating. Before the commencement of any cleaning and coating operations, submit a control plan for the protection of adjacent surfaces from damage by nearby blasting and coating to the Engineer for review. Repair any damage to adjacent areas. The repair procedure must be submitted to the Engineer for acceptance prior to any remediation.

561-10.5 Worker Protection: Comply with the requirements of OSHA 29 CFR 1926 and applicable portions of 29 CFR 1910. Include specific programs as required by 29 CFR 1926.62 (lead), 29 CFR 1926.1118 (inorganic arsenic), 29 CFR 1926.1126 (hexavalent chromium), and 29 CFR 1926.1127 (cadmium) when these hazardous agents are present. Implement appropriate safety procedures for all hazards on the job site whether specifically identified herein or not.

561-11 Waste Handling and Management.

561-11.1 General: Prepare a waste management program plan which addresses the applicable requirements from EPA regulations for hazardous waste management and the Contract Documents. Include provisions for the handling and disposal of non hazardous waste. Dispose of all waste in accordance with all federal, state, and local laws and regulations.

561-11.2 Collection and Handling of Waste: Properly classify, package, and store all paint removal debris, both solid and liquid in accordance with SSPC Guide 7, Guide for the Disposal of Lead-Contaminated Surface Preparation Debris, the Federal Water Pollution Control Act with amendments, and all other current government regulations and guidelines. Comply with the Resource Conservation and Recovery Act to include, at a minimum, CFR 40 260 through CFR 40 268. Prior to identification and storage, separate solid and liquid waste, and separate individual waste streams.

561-11.3 Testing and Analysis: Laboratory analyses for all waste stream and environmental samples shall be conducted by an EPA certified, independent laboratory with an approved Quality Assurance Plan. Laboratory analyses for worker monitoring and regulated area samples shall be conducted by an American Industrial Hygiene Association (AIHA) metals

accredited laboratory. Submit all sampling and test reports no later than 72 hours after collection of samples.

561-11.4 Waste Identification: Collect samples in accordance with EPA SW 846, Test Methods for Evaluating Solid Waste - Physical/Chemical Methods. Use a random and representative sampling technique. Collect a minimum of four representative samples of each waste stream. These waste streams include, but are not limited to, water, paint chips, dust, and paint chips mixed with disposable abrasives and debris. Complete the initial sampling of each waste stream immediately upon filling the first drum, but do not allow waste to accumulate for longer than 7 days before sampling.

After the representative samples are collected, send them immediately to the EPA certified laboratory for analysis. Unless otherwise directed by the Engineer, required by State regulations, or required by the waste recycling or disposal facility, once each waste stream is sampled, tested, and classified, additional sampling and analysis are not required for subsequent shipments unless the waste stream changes. Submit samples to an approved laboratory to be tested for arsenic, barium, cadmium, hexavalent chromium, lead, mercury, selenium, and silver in accordance with EPA Method 3050 and Method 6010 (content) and EPA Method 1311, Toxicity Characteristics Leaching Procedures (TCLP).Clearly label each sample with sample number, date and time of sampling, name of collector, and location of collection.

Maintain chain of custody forms for each sample. Enter each sample on a sample analysis request form. Record sample numbers, type of waste, amount of each sample, distribution of samples, signature and all other information.

561-11.5 Waste Storage: Collect waste from the control devices, equipment, and all work surfaces on a daily basis. Keep hazardous and non-hazardous waste separate. Do not mix blasting debris with any other type of waste. Place waste in approved storage drums.

Locate all hazardous waste within a regulated area. The maximum weight for each drum, when filled, is 821 pounds. Properly seal and label all drums. Transport waste storage drums to a secured, marked, temporary storage area. Locate the temporary storage area on well-drained ground not susceptible to flooding or storm water run-off. Place drums on a pallet and cover with fiber reinforced, impermeable tarpaulins. Store drums no more than two drums wide and two drums high. Arrange drums so that labels are easily readable. Do not store waste in the temporary storage area longer than 90 days.

561-11.6 Waste Disposal: Transport, treat and dispose of all hazardous and non-hazardous waste. Notify the Engineer a minimum of three weeks prior to the date of shipment of any waste to an off- site facility. Submit to the Engineer documentation that the receiving disposal facilities are properly licensed. Submit manifests for all hazardous and non-hazardous waste shipments. Identify any waste disposal subcontractors and submit verification of their licensing to perform waste disposal and transport operations.

561-11.7 Permits: The Contractor is responsible for all liability resulting from non-compliance with pertinent rules and regulations including permit requirements.

561-12 Method of Measurement.

When a lump sum pay item is provided, the quantity to be paid for coating existing structural steel will be the lump sum quantity for the areas shown in the Plans, completed and accepted.

When a square foot item is provided, the quantity to be paid for coating existing structural steel will be the plan quantity in square feet of surface area as shown in the Plans, completed and accepted.

561-13 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 561- 1- Coating Existing Structural Steel - lump sum.

Item No. 561- 2- Coating Existing Structural Steel - per square foot.

SECTION 562
REPAIR OF GALVANIZED SURFACES

562-1 Description.

Apply a coating of galvanizing compound over welded areas of galvanized structural members and over areas of previously galvanized members on which the galvanizing has become damaged.

562-2 Materials.

562-2.1 Areas 100 Square Inches or Less: Use a cold galvanizing compound containing at least 92% zinc dust in the dry film.

562-2.2 Areas Greater than 100 Square Inches: Use a galvanizing compound as specified in 975-2.4.1 and listed on the Approved Product List (APL).

562-3 Construction Methods.

Prepare surfaces and apply the galvanizing compound according to ASTM A780 and manufacturer's recommendations. Apply additional coats on rough or pitted surfaces, when in the opinion of the Engineer it is necessary to obtain acceptable cover. Follow the manufacturer's recommended dry time between coats.

Re-clean the areas not coated on the same day the cleaning is accomplished, or surfaces that have rusted, prior to coating.

Apply the galvanizing compound to attain a uniform appearance free from all defects or failures. Submit repair procedures to the Engineer for approval. All deficiencies will be corrected at no cost to the Department.

562-4 Basis of Payment.

No direct payment will be made for galvanizing compound coating of welded surfaces or for field repair of damaged galvanized surfaces. Include the cost to perform these operations, in the Contract price for the item which includes the member being so treated.

SECTION 563
ANTI-GRAFFITI COATINGS

563-1 Description.

Apply an anti-graffiti coating in accordance with the requirements of this Section to the areas shown in the Plans.

563-2 Materials.

Use anti-graffiti coating products meeting the requirements of Section 975 that are recommended for the base substrate by the manufacturer and listed on the Department's Approved Product List (APL). Do not use sacrificial coatings on steel structures.

563-3 Application.

563-3.1General: Apply anti-graffiti coatings in accordance with the manufacturer's product data sheet.

563-3.2 Protection of Adjacent Surfaces: Consider wind direction, velocity and geographic location as having a major impact on all cleaning and anti-graffiti coating operations. Use all necessary precautions to prevent cleaning and anti-graffiti coating materials from being dispersed outside the work site. If conditions are such that material is dispersed to areas where vehicles or other property may be damaged, suspend operations until conditions improve and work can continue without affecting adjacent property.

Protect all surfaces not intended to be coated, which are adjacent to, or in close proximity to the surfaces to be coated, during the application of anti-graffiti coating. Clean surfaces that are to be coated, as per the manufacturer's product data sheet.

563-3.3 Surface Preparation: Remove all graffiti from the substrate. Prior to applying any anti-graffiti coatings, prepare all surfaces to be coated in accordance with ASTM D4261 or ASTM D4258 and the manufacturer's product data sheet.

When the anti-graffiti coating or coating system is to be applied over an existing coating, apply a test patch (minimum area of 4 square feet) in accordance with this Section. Allow the test patch to cure a minimum of 7 days without any defects. No time extension will be granted as a result of this test requirement.

563-3.4 Correction of Deficiencies: Remove all applied anti-graffiti coatings identified by the Engineer as damaged, defective, or otherwise not meeting these Specifications, in accordance with the manufacturer's recommendations.

Prepare the surface and reapply the coating in accordance with the manufacturer's recommendations and as specified herein.

Remove and correct all deficiencies at no additional cost to the Department.

563-4 Method of Measurement.

The quantity to be paid for will be plan quantity, in square feet, of the area of anti-graffiti coating completed and accepted.

The area will be based on the surface area shown in the Plans with no allowance for surface texture or variable depth surface profiles.

563-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including furnishing and applying all materials to complete the anti-graffiti coating.

Payment shall be made under:

Item No. 563- 3-	Anti-Graffiti Coating Sacrificial - per square foot.
Item No. 563- 4-	Anti-Graffiti Coating Non Sacrificial - per square foot.

SECTION 570
PERFORMANCE TURF

570-1 Description.

Establish a growing, healthy turf over all areas designated in the Plans. Use sod in areas designated in the Plans to be sodded. Use seed, hydroseed, bonded fiber matrix, or sod in all other areas. Maintain performance turf areas until final acceptance of all Contract work in accordance with Section 5-11 and the establishment requirements of 570-4 have been met.

570-2 Materials.

Meet the following requirements:

Turf Materials .....Section 981
Fertilizer .....Section 982
Water .....Section 983

570-3 Construction Methods.

570-3.1 General: Remove all construction debris in performance turf areas. Install performance turf at the earliest practical time for erosion control and establishment.

Shape the areas to be planted to the plan typical sections and lines and grade shown in the Plans.

Except in areas where the Contract Documents requires specific types of turf to match adjoining private property, any species of turf designated in Section 981 may be used. All of the permanent performance turf material shall be in place prior to final acceptance.

The Department will only pay for replanting as necessary due to factors determined by the Engineer to be beyond control of the Contractor.

Install all performance turf on shoulder areas prior to the placement of the friction course on adjacent pavement.

570-3.2 Seeding: At the Contractor's option, wildflower seed may be included in the performance turf seeding operation or performed separately from the performance turf seeding. Seed must produce visible seedlings within 45 days of planting.

Use of compost meeting the requirements of Section 987 as mulch is acceptable unless otherwise specified.

570-3.3 Sod: Place the sod on the prepared surface, with edges in close contact. Do not use sod which has been cut for more than 48 hours.

Place the sod to the edge of all landscape areas as shown in the Plans and the Standard Plans.

Place rolled sod parallel with the roadway and cut any exposed netting even with the sod edge.

Monitor placed sod for growth of exotic or invasive pest plants and noxious weeds. If exotic or invasive pest plants and/or noxious weeds manifest themselves within 30 days of placement of the sod during the months April through October, within 60 days of placement of the sod during the months of November through March treat affected areas by means acceptable to the Department at no expense to the Department. If pest plants and/or noxious weeds manifest themselves after the time frames described above from date of placement of sod, the Engineer, at his sole option, will determine if treatment is required and

whether or not the Contractor will be compensated for such treatment. If compensation is provided, payment will be made as Unforeseeable Work as described in 4-4.

Remove and replace any sod as directed by the Engineer.

570-3.4 Hydroseeding: Use equipment specifically designed for mixing the mulch, seed, fertilizer, tackifier and dye, and applying the slurry uniformly over the areas to be hydroseeded.

Use mulch that does not contain reprocessed wood or paper fibers. Ensure that 50% of the fibers will be retained on a twenty-five mesh screen.

Mix fertilizer as required into the hydroseeding slurry.

Ensure that the dye does not contain growth or germination inhibiting chemicals.

When polyacrylamide is used as part of hydroseeding mix, only anionic polymer formulation with free acrylamide monomer residual content of less than 0.05% is allowed. Cationic polyacrylamide shall not be used in any concentration. Do not spray polyacrylamide containing mixtures onto pavement. These may include tackifiers, flocculants or moisture-holding compounds.

570-3.5 Bonded Fiber Matrix (BFM): Meet the minimum physical and performance criteria of this Specification for use of BFM in hydroseeding operations or temporary non-vegetative erosion and sediment control methods.

Provide evidence of product performance testing, manufacturer's certification of training and material samples to the Engineer at least 7 calendar days prior to installation.

Provide documentation to the Engineer of manufacturer's testing at an independent laboratory, demonstrating superior performance of BFM as measured by reduced water runoff, reduced soil loss and faster seed germination in comparison to erosion control blankets.

Use only BFMs that contain all components pre-packaged by the manufacturer to assure material performance. Deliver materials in UV and weather resistant factory labeled packaging. Store and handle products in strict compliance with the manufacturer's directions.

When polyacrylamide is used as part of hydroseeding mix, only anionic polymer formulation with free acrylamide monomer residual content of less than 0.05% is allowed. Cationic polyacrylamide shall not be used in any concentration. Do not spray polyacrylamide containing mixtures onto pavement. These may include tackifiers, flocculants or moisture-holding compounds.

Meet the following requirements after application of the formed matrix:

Ensure that the tackifier does not dissolve or disperse upon re-wetting.

Ensure that the matrix has no gaps between the product and the soil and that it provides 100% coverage of all disturbed soil areas after application.

Ensure that the matrix has no germination or growth inhibiting properties and does not form a water-repelling crust.

Ensure that the matrix is comprised of materials which are 100% biodegradable and 100% beneficial to plant growth.

Mix and apply the BFM in strict compliance with the manufacturer's recommendations.

Apply the BFM to geotechnically stable slopes at the manufacturer's recommended rates.

Degradation of BFM will occur naturally as a result of chemical and biological hydrolysis, UV exposure and temperature fluctuations. Re-application, as determined by the

Engineer, will be required if BFM-treated soils are disturbed or water quality or turbidity tests show the need for an additional application.

570-3.6 Watering: Water all performance turf areas as necessary to produce a healthy and vigorous stand of turf. Ensure that the water used for turf irrigation meets the requirements of Section 983.

570-3.7 Fertilizing: Fertilize as necessary to promote turf growth and establishment based on soil testing. Refer to Section 982 for fertilizer rates.

For bid purposes, base estimated quantities on an initial application of 265 lb/acre and one subsequent application of 135 lb/acre of 16-0-8.

570-3.8 Shoulder Treatment: Provide soil for shoulder treatment in accordance with Standard Plans, Index 570-010. Soil needed for these purposes will be included in the corresponding Pay Item.

570-4 Turf Establishment.

Perform all work necessary, including watering and fertilizing, to sustain an established turf, free of noxious weeds, at no additional expense to the Department. Provide the filling, leveling, and repairing of any washed or eroded areas, as necessary.

Established turf is defined as follows:

1. An established root system (leaf blades break before seedlings or sod can be pulled from the soil by hand).
2. No bare spots larger than one square foot.
3. No continuous sod seams running perpendicular to the face of the slope.
4. No bare areas comprising more than 1% of any given 1,000 square foot area.
5. No deformation of the performance turf areas caused by mowing or other Contractor equipment.
6. No exposed sod netting.
7. No competing vegetation, exotic or invasive pest plants or noxious weeds.

Monitor turf areas and remove all competing vegetation, exotic or invasive pest plants, and noxious weeds (as listed by the Florida Exotic Pest Plant Council, Category I “List of Invasive Species”, Current Edition, https://www.fleppc.org). Remove such vegetation regularly by manual, mechanical, or chemical control means, as necessary. When selecting herbicides, pay particular attention to ensure use of chemicals that will not harm desired turf or wildflower species. Use herbicides in accordance with 7-1.7.

If at the time that all other work on the project is completed, but all turf areas have not met the requirements for established turf set forth in 570-4, continuously maintain all turf areas until the requirements for established turf set forth in 570-4 have been met.

During establishment and until the performance turf is established in accordance with this Section, continue the inspection, maintenance, and documentation of erosion and sedimentation control items in accordance with Section 104. Remove and dispose of all erosion and sedimentation control items after the performance turf has been established.

Notify the Engineer, with a minimum of seven calendar days advance notice, to conduct inspections of the performance turf at approximate 90-day intervals during the establishment period to determine establishment. Results of such inspections will be made available to the Contractor within seven calendar days of the date of inspection. Determination of an established turf will be based on the entire project and not in sections.

Upon the determination by the Engineer that the requirements of 570-4 have been met and an established turf has been achieved and all erosion and sedimentation control items have

been removed, the Engineer will release the Contractor from any further responsibility provided for in this Specification.

The Contractor's establishment obligations of this specification will not apply to deficiencies due to the following factors, if found by the Engineer to be beyond the control of the Contractor, his subcontractors, vendors or suppliers:

1. Determination that the deficiency was due to the failure of other features of the Contract.

2. Determination that the deficiency was the responsibility of a third party performing work not included in the Contract or its actions.

The Department will only pay for replanting as necessary due to factors determined by the Department to be beyond the control of the Contractor.

570-5 Responsible Party.

For the purposes of this Specification, the Contractor shall be the responsible party throughout construction and establishment periods.

Upon final acceptance of the Contract in accordance with 5-11, the Contractor's responsibility for maintenance of all the work or facilities within the project limits of the Contract will terminate in accordance with 5-11; with the sole exception that the facilities damaged due to lack of established turf and the obligations set forth in this Specification-for performance turf shall continue thereafter to be responsibility of the Contractor as otherwise provided in this Section.

570-6 Statewide Disputes Review Board.

The Statewide Disputes Review Board in effect for this Contract will resolve any and all disputes that may arise involving administration and enforcement of this Specification related to the remedial work performed during the warranty period. The Responsible Party and the Department acknowledge that use of the Statewide Disputes Review Board is required, and the determinations of the Statewide Disputes Review Board for disputes arising out of this Specification will be binding on both the Responsible Party and the Department, with no right of appeal by either party. Meet the requirements of 8-3.

570-7 Failure to Perform.

Should the Contractor fail to timely submit any dispute to the Statewide Disputes Review Board, refuse to submit any dispute to the Statewide Disputes Review Board, fail to provide an established turf in accordance with 570-4 within six months of final acceptance of the Contract in accordance with 5-11, or fail to compensate the Department for any remedial work performed by the Department in establishing a turf and other remedial work associated with lack of an established turf, including but not limited to, repair of shoulder or other areas due to erosion and removal of sediments deposited in roadside ditches and streams, as determined by the Statewide Disputes Review Board to be the Contractor's responsibility, the Department shall suspend, revoke or deny the Contractor's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, until the Contractor provides an established turf or makes full and complete payment for the remedial work performed by the Department. In no case shall the period of suspension, revocation, or denial of the Contractor's certificate of qualification be less than six months. Should the Contractor choose to challenge the Department's notification of intent for suspension, revocation or denial of qualification and the Department's action is upheld,

the Contractor shall have its qualification suspended for a minimum of six months or until the remedial action is satisfactorily performed, whichever is longer.

570-8 Method of Measurement.

The quantities to be paid for will be plan quantity in square yards based on the area shown in the Plans, completed and accepted.

570-9 Basis of Payment.

Prices and payments will be full compensation for all work and materials specified in this Section.

Payment will be made under:

Item No. 570- 1- Performance Turf - per square yard.

SECTION 571
PLASTIC EROSION MAT

571-1 Description.

Furnish and install plastic erosion mat on areas as shown in the Plans. Conduct this work in conjunction with the performance turf work as specified in Section 570.

571-2 Materials.

Use a plastic erosion mat consisting of continuous or fused synthetic polymer fibers, which are entangled to form a three-dimensional matrix (netting or distorted netting may be included as part of the matrix). Ensure that the mat is capable of maintaining its shape throughout installation. Ensure that the mat is inert to chemicals encountered in a natural soil environment, and meets the requirement of Section 985 according to its application.

571-3 Installation of Plastic Erosion Mat.

Before installing the plastic erosion mat, submit to the Engineer certified test reports from the manufacturer certifying that the geotextile to be incorporated into this project meets the requirements of Section 985. Also, submit the manufacturer's written installation instructions.

Install a plastic erosion mat of uniform thickness, not less than 1/4 inch or more than 3/4 inch on the prepared soil surface in accordance with these Specifications, the manufacturer's recommendations and in conformity with the lines, grades and dimensions as shown in the Plans. Ensure that all joints are shingle lapped such that the bottom of each section fits over the top of the section below to prevent uplift of the ends or edges by water flow. Overlap ends of adjacent rolls a minimum of 3 feet. Overlap edges of adjacent rolls a minimum of 4 inches. Stake all edges at 3 to 5 feet intervals with staples as recommended by the manufacturer unless otherwise directed by the Engineer. Ensure that overlaps and anchor trenches are in conformance with the Plans and the manufacturer's installation recommendations.

Ensure that after installation there are no protrusions, projections or exposures of the plastic erosion mat. Do not compact the installed plastic erosion mat with any type of equipment employing a foot or grid.

The Engineer will reject any material having defects, tears, punctures, flaws, deterioration or other damage before, during or after installation. Remove and replace all rejected plastic erosion mat at no additional expense to the Department.

Fill all voids in the mat with soil meeting the requirements of Section 987. Establish performance turf meeting the requirements of Section 570.

571-4 Method of Measurement.

The quantity to be paid for will be the surface area of plastic erosion mat installed and accepted in square yards with no allowance for overlaps.

Performance turf will be paid for separately in accordance with Section 570.

571-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including furnishing, handling, placement of plastic erosion mat, all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation.

Payment will be made under:

Item No. 571- 1- Plastic Erosion Mat - per square yard.

SECTION 591
LANDSCAPE IRRIGATION SLEEVES

591-1 Description.

Furnish and install landscape sleeves for irrigation pipes and wires in accordance with the Plans and Standard Plans, Index 591-001.

591-2 Materials.

Meet the following requirements:

Schedule 40 Polyvinyl Chloride (PVC) pipe.....Section 630

591-3 Installation Requirements.

591-3.1 General: Construct sleeves along a straight alignment at the location and depth shown in the Plans. Deviations in location or alignment may be made with prior approval of the Engineer. Provide a minimum of 24 inches between irrigation sleeves and other utilities.

591-3.2 Backfill: Backfill in accordance with Section 120.

591-3.3 Coated Conductive Tape: Install coated conductive tape directly above the sleeves with the repeated warning of "CAUTION WATER LINE BURIED BELOW," unless otherwise shown in the Plans.

591.3.4 Pull String: Install a continuous No. 12 American Wire Gauge pull wire or polypropylene cord within the full length of all sleeves. Ensure that a minimum of 36 inches of pull string is accessible at each sleeve termination.

591.3.5 Sleeve Terminations: Terminate the sleeves as shown in Standard Plans, Index 591. Fit sleeve caps at all terminations with a removable PVC threaded or slip cap.

Install a survey marker cap fastened to a 18 inch by 24 inch long permanent marker made of No. 5 rebar, a steel survey stake, or 4 inch square concrete monument above the terminating end of all sleeve pairs. Ensure that the top of cap is flush to grade with message "IRRIGATION SLEEVE" permanently imprinted on the top of monument, and will not peel, fade, or deteriorate.

591-4 Method of Measurement.

The quantity to be paid will be the plan quantity of landscape irrigation sleeve in place and accepted. No separate payment will be made for contractor's choice of installation method.

591-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 591- 1- Landscape Irrigation Sleeve - per foot.

SECTION 603
GENERAL REQUIREMENTS FOR TRAFFIC CONTROL SIGNALS AND DEVICES

603-1 Description.

The provisions contained in this Section include general requirements for all traffic control signals and devices.

603-2 Equipment and Materials.

603-2.1 General: Only use traffic control signals and devices that are listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their products for the APL must submit an application in accordance with Section 6.

Only use new equipment and materials, except as specified in the Contract.

603-2.2 Exceptions: The Department may grant exceptions to the requirements of 603-2.1 by permit to evaluate new technology or for other circumstances that are found to be in the public interest.

603-2.3 Uniformity: Only use compatible units of any one item of equipment, such as signal heads, detectors, controllers, cabinets, poles, signal system or interconnection equipment, etc.

603-2.4 Hardware and Fittings Used for Installation: Ensure that all assembly hardware, including nuts, bolts, external screws and locking washers less than 5/8 inch in diameter, are Type 304 or 316 passivated stainless steel. Use stainless steel bolts, screws and studs meeting the requirements of ASTM F593. Use nuts meeting the requirements of ASTM F594. Ensure all assembly hardware greater than or equal to 5/8 inch in diameter is galvanized. Use bolts, studs, and threaded rod meeting the requirements of ASTM A307. Use structural bolts meeting the requirements of ASTM F3125, Grade A325.

Use high-strength steel anchor bolts and U-bolts, having a minimum yield strength of 55,000 psi and a minimum ultimate strength of 90,000 psi.

603-2.5 Galvanizing: Meet the requirements of Section 962 when galvanizing for fittings and appurtenances for all structural steel (including steel poles).

603-2.6 Environmental Specifications: Ensure system electronics intended for installation outdoors or within a roadside cabinet satisfactorily performs all required functions during and after being subjected to the environmental testing described in National Electrical Manufacturers Association (NEMA) TS 2-2021, Sections 2.2.7, 2.2.8, and 2.2.9.

603-3 Definitions.

Traffic Control Signals and Devices: Any signal or device; manually, electrically, or mechanically operated, by which traffic is alternately directed to stop and permitted to proceed or controlled in any manner. Traffic control signals and devices regulate, warn, or guide traffic on, over or adjacent to a street, highway, pedestrian facility, or bikeway by authority of a public agency having jurisdiction. Traffic control signals and devices include controller assemblies (controller cabinets and their contents); signal heads including their hanging or mounting devices; vehicle detection systems ; pedestrian detection systems; motorist information systems,

video equipment, network devices, electrically powered signs, cameras, and other equipment used within a traffic control system.

603-4 Systems Approval Requirement.

The Engineer will review and approve any system design plan of traffic control signals and devices, that is controlled or operated from a remote location by computers or similar devices, and which affects the movement of traffic on any portion of the State Highway System, prior to installation.

603-5 Submittal Data Requirements.

Prior to the installation of equipment and within 30 days after the preconstruction conference, submit a listing of all traffic control signals, devices, and hardware with Department APL approval numbers to the Engineer for approval on Form 750-010-02, Submittal Data - Traffic Control Equipment. Alternate or modified forms are unacceptable. Submit a separate form for each cabinet location. For non-structural equipment or materials that do not have an APL approval number, submit the manufacturer's descriptive literature and technical data fully describing the equipment to the Engineer for approval. The Engineer will submit forms received from the Contractor to the District Traffic Operations Engineer for concurrence.

Develop shop drawings for all structural support materials and other special designs, such as non-electrical, non-mechanical, or other fabricated items, which may not be specifically detailed in the Plans. Provide a complete operable signal installation as specified in the Contract regardless of any failure of the Department to discover or note any unsatisfactory material.

603-6 Documentation for Electronic Equipment.

Prior to final acceptance, submit the following documentation obtained from the manufacturer for the electronic equipment listed below:

1. Operation Manual
2. Troubleshooting and Service Manual
3. Assembly and installation instructions
4. Diagram of the field installation wiring (as applicable)
5. Warranty information

Submit documentation for the following equipment:

1. Controllers
2. Vehicle detectors
3. Load switches
4. Flasher units
5. Preemption units
6. Conflict monitors
7. Special sequence relays
8. Cameras
9. Dynamic message signs
10. Road weather information systems
11. Any other equipment which has a logic, timing, or communications function
12. Other equipment specified in the Contract Documents

603-7 Department-Furnished Equipment Installed By Contractor.

Where the Contract includes installation of Department-furnished equipment, the Department will turn over such equipment to the Contractor when the construction progress allows or as designated in the Contract. The Department will test and certify the equipment to be in proper condition and ready to use and will bear the costs of correcting any defects in the equipment prior to pick-up by the Contractor. The Engineer will coordinate the pick-up and installation of the equipment. Maintain the equipment in proper operational condition after pick-up at no cost to the Department, until either final acceptance or the equipment is returned to the Department.

SECTION 608
MANUFACTURERS' WARRANTIES FOR TRAFFIC CONTROL SIGNALS AND DEVICES

608-1 Description.

This Section sets forth manufacturers' warranty requirements for traffic control signals and devices furnished to the Department. Manufacturer and Contractor costs associated with transferring, submitting, and delivering equipment warranties, requirements, terms, and conditions are part of the work and are included in the pay item for the equipment or construction feature utilizing the equipment.

608-2 Manufacturers' Warranty Provisions.

608-2.1 General: Submit all warranties provided by the equipment manufacturer for the specific equipment included in the Contract. Ensure that all warranties are fully transferable from the Contractor to the owner of the equipment within the project limits. Ensure that warranties cover defects for at least the duration specified in the Contract Documents from the date of final acceptance in accordance with 5-11. Transfer warranties upon final acceptance in accordance with 5-11. Submit all warranties and warranty transfers to the Engineer.

In accordance with 611-6, the Contractor's responsibility for warranty repairs, warranty replacement, troubleshooting, or other costs associated with repair or replacement of traffic control signals and devices within the contract's project limits will terminate 90 days after final acceptance in accordance with 5-11.

608-2.2 Terms and Conditions: Ensure that the terms and conditions of warranties are documented by the manufacturer for equipment submittals on construction projects. Include terms for a specified service performance with provisions for repair parts and labor, or for replacement.

Ensure warranties require the manufacturer to furnish replacements for any part or equipment found to be defective during the manufacturer's warranty period at no cost to the owner of the equipment within the project limits.

SECTION 611
ACCEPTANCE PROCEDURES FOR TRAFFIC CONTROL SIGNALS, DEVICES, AND INTELLIGENT TRANSPORTATION SYSTEM DEVICES

611-1 Description.

This Section sets forth Contract acceptance procedures for installations of traffic control signals and devices and for equipment purchase contracts.

611-2 Acceptance of Traffic Control Signal and Device Installations.

611-2.1 Partial Acceptance: The Engineer may make inspection for partial acceptance under the Contract in accordance with 5-10 of a complete traffic control signal and device installation upon its completion in accordance with the Contract Documents and at such time that other parts of the total Contract are at a stage of completion that either require or allow the installation to operate in a manner which is in accordance with the Contract Documents. Before inspection for partial acceptance, the Engineer will require the satisfactory completion of all field tests of completed installations in accordance with the requirements of 611-4. The Engineer will make inspection for partial acceptance in accordance with 5-10 in company with a Contractor's representative and, when applicable, a representative of the agency designated to accept maintenance responsibility.

611-2.2 Final Acceptance: The Engineer will make inspection for final acceptance of traffic control signal and device installations as part of all work under the Contract in accordance with 5-11, only after satisfactory completion of all field tests of completed installations and on the basis of a comprehensive field inspection of all equipment installations.

611-2.2.1 Traffic Control Signal and Device Installation: Submit Form 750-010-02, Submittal Data – Traffic Control Equipment for each cabinet location to the Engineer. The Engineer will make the final inspection with a Contractor's representative and a representative of the agency designated to accept maintenance responsibility. The Engineer will submit the approved form to the District Traffic Operations Engineer and place a hard copy in the cabinet at each location. Transfer warranties and guarantees on equipment to the Department in accordance with Section 608. For traffic signal installations, submit form 700-010-22, Final acceptance of Traffic Signal Installation(s), and Transfer of Maintenance, to the Engineer.

611-2.2.2 Intelligent Transportation System Device Installation: The Engineer will make the final inspection with a Contractor's representative and a representative of the agency designated to accept maintenance responsibility. Transfer warranties and guarantees on equipment to the Department in accordance with Section 608. Final acceptance of ITS installation is contingent on successfully completing the ITS Acceptance Test section.

611-2.3 As-Built Documentation: As a condition precedent to acceptance under 611-2.1 or 611-2.2, submit as-built drawings for all installations, signed and sealed by a Professional Engineer or Professional Surveyor and Mapper registered in the State of Florida, along with supplemental as-built information using Feature Import Templates and Attribute Forms used for the Department's ITS Facility Management (ITSFM) System. Feature Import Templates can be found on the Department's web site: https://www.fdot.gov/traffic/itsfm.

611-2.3.1 Submittal Requirements: Submit as-built plans for review by the Engineer. As-built plans must be PDF files, in the same scale and content as the Plans and formatted on 11-inch by 17-inch sheets. Signing and pavement marking plan sheets may be used instead of signalization plan sheets, if a substantial number of changes from the original Plans

must be recorded. If, in the opinion of the Engineer, the changes cannot be clearly delineated on the existing drawings, clearly delineate all changes on 11-inch by 17-inch detail sheets, enlarged 200% from the reproductions.

Submit fiber optic splicing diagrams detailing all cable splices, terminations, equipment port assignments, and optical circuit path names within the communication network. Include cable manufacturer, type, strand count, and cable sequential reading at each pull box entrance/exit, each side of the splice enclosure, and at patch panel terminations.

As-built submittals must include an inventory of all traffic control signals and devices, and support structures. The inventory must include horizontal position geographic coordinate data collected using Differential Global Positioning System (DGPS) equipment. The inventory must include, at a minimum, the manufacturer, model, and serial number for each device or completed assembly. Submit coordinate data for pull boxes as well as conduit and cable at 100-foot intervals including changes in direction. All support structures, equipment cabinets and other fixed location features must be assigned a unique site ID name to create a common association between the as-built plans, inventory forms, and the ITSFM system. Include data for all components listed in 611-2.3.2, except those listed in 611-2.3.2.2 and 611-2.3.2.5.

Aerial photographs may be submitted with as-built plan submittals to provide supplementary information. The aerials should not include extra features such as the right of way, baseline, or roadway edges. The aerials may be used as a base for the as-built plans with mile post and offset dimensions. Make any corrections resulting from the Engineer's review and resubmit as-built plans as a condition precedent to acceptance of the installation. Submit the ITSFM electronic files in any of the following software formats:

1. As-built Plans – Design Files (DGN) and Portable Document Format (PDF)
2. Feature Import Templates – Spreadsheet format (XLSX)
3. Feature Attribute Forms – Portable Document Format (PDF)
4. Differentially Corrected GPS files – (COR)
5. GPS Export Files – Comma-Separated Values (CSV)
6. Photos – Joint Photographic Experts Group (JPG)

611-2.3.2 Components: As a minimum, identify all traffic control devices, poles, support structures, cabinets, pull and splice boxes, hubs, conduit duct banks, access points, and power services, and utility demarcation points.

611-2.3.2.1 Conduit and Cable: Identify all conduit and cable with unique line styles for routing (communication, electrical, and joint-use trenched) that are clearly identified in a legend on each plan sheet. Identify the type of cable (example - 7 conductor signal cable) and label the number of conductors, fiber strands or other identifying features of the cable. For conduit duct banks, clearly note conduit and innerduct size, length, material, and number of runs.

611-2.3.2.2 Loops and Detection Zones: Identify the location of all installed loops (including the distance from the stop bar for the advance loops), the path of each loop to the pull box, the loop window and the path of the loop lead-in to the controller cabinet. Identify the device location and the approximate detection area for detection systems that are not embedded in or under pavement.

611-2.3.2.3 Pull Boxes: Label unused and out of service pull boxes clearly. Show distances to each pull box from the nearest edgeline, stop bar, or other permanent

feature. If an edgeline is not near a pull box or would not clearly identify its location; a fixed monument may be used (example - FDOT pole or structure).

611-2.3.2.4 Poles: Identify poles from the nearest edgeline of both approaches. If an edgeline is not near a pole or would not clearly identify its location, a fixed monument may be used.

611-2.3.2.5 Signal Heads: As-built plans must show the final location of signal heads. Each signal head shall be identified by its corresponding movement number.

611-2.3.2.6 Cabinet: The type of cabinet and inventory of internal components must be documented. Controller manufacturer along with the controller model number shall be submitted for all traffic signal cabinets. A cabinet corner "blow up" shall be submitted detailing pull box locations with all conduit and cable.

611-2.4 Installation Inspection Requirements: Meet the requirements of Section 105.

611-3 Signal Timing.

Set the timing of a traffic signal or system of traffic control devices in accordance with the Contract Documents, unless approved otherwise in writing by the Engineer.

611-4 Field Tests of Installations.

Perform the following tests in the presence of the Engineer and, when applicable, a representative of the agency designated to accept maintenance responsibility.

611-4.1 Traffic Control Signal and Device Installation:

Continuity: Test each signal head circuit, pedestrian detector circuit, vehicle detector loop circuit, and interconnect signal circuit for continuity.

Functional: Perform a functional test that demonstrates that every part of the installation functions as specified.

Induced Voltage on traffic signal connections: Measure the voltage between each signal head indication field terminal and the AC neutral circuit in the controller cabinet during the off (dark) state of each signal head indication. Ensure that the voltage does not exceed 2 $V_{AC, RMS}$. If this value is exceeded, take the following action to reduce the value to 2 $V_{AC, RMS}$:

1. Check for loose or broken connections in the signal head circuit from the controller cabinet to the signal heads.
2. If (1) above does not correct the problem, connect additional neutral circuits between the signal head and the controller cabinet.

Inductive Loop Assembly: An inductive loop assembly is defined as a loop plus the lead-in cable. Measure and record the series resistance of each inductive loop assembly. Ensure that the resistance does not exceed 10 Ω. Perform an insulation resistance megger test, at 500 V_{DC}, for each inductive loop assembly at the cabinet in which the inductive loop assembly is terminated. Do not connect the inductive loop assembly to the cabinet terminal strips during the test, except for the drain wire of a shielded lead-in cable. Insulation resistance is defined as the resistance between one wire of the lead-in cable and a ground rod or bussbar. Record the insulation resistance of each inductive loop assembly. Ensure that the resistance is equal to or greater than 100 MΩ.

Perform the 48-hour test only after achieving acceptable results from the other tests listed in 611-4.

48-Hour Test for Traffic Signal installations:

1. Before beginning the 48-hour test, place all new signal installations (no existing signals) in flash for 48 to 336 hours. The length of the flash period will be determined by the Engineer.

2. Continuously operate each new or modified traffic signal installation or system for not less than 48 hours. If unsatisfactory performance of the system develops, correct the condition, and repeat the test until obtaining 48 hours of satisfactory continuous operation.

3. During the 48-hour test period, the Contractor is fully responsible for the signal or signal systems. Provide a responsible representative (technically qualified) who can monitor signal operation and troubleshoot any malfunctions within a one-hour period.

When coordination is specified in the Contract Documents, provide a two-hour training session on the operation and programming of the coordination features of the controller units during the 48-hour test. Arrange the time and place of the training session with the Engineer.

4. Perform a 48-hour test for flashing beacon installations in the same manner as for traffic signal installations.

5. Start the 48-hour test on a Monday, Tuesday, or Wednesday. Ensure the 48-hour test does not include weekends, Holidays, or Special Events.

6. Start the 48-hour test between 9:00 AM and 2:00 PM.

7. Before the 48-hour test, install and have standing by all equipment specified in the Contract Documents.

611-4.2 Intelligent Transportation System Device Installation: Test all stand-alone functions of the ITS devices as detailed in the Contract Documents and as approved by the Engineer.

For the managed field Ethernet switch (MFES), complete FDOT Form Number 750-040-07 for all installed field switches.

For the closed--circuit television (CCTV) camera, complete FDOT Form Number 750-040-08 for all installed CCTV cameras.

For microwave vehicle detection system (MVDS), complete FDOT Form Number 750-040-09 for all installed MVDS sensors.

For the camera lowering device (CLD), complete FDOT Form Number 750-040-10 for all installed CLDs.

For the dynamic message sign (DMS), complete FDOT Form Number 750-040-11 for all installed DMS.

For the remote power management unit (RPMU), complete FDOT Form Number 750-040-12 for all installed RPMU.

For the ITS cabinet, complete FDOT Form Number 750-040-13 for all installed ITS cabinets.

For ITS devices without official FDOT forms, evaluate ITS devices as per Contract Documents and as approved by the Engineer.

Complete approved data forms and turn them over to the Engineer for approval. Provide a minimum notice of 10 calendar days prior to all tests to permit the Engineer or their representative to observe each test.

If any unit fails to pass its stand-alone test, correct the unit, or substitute another unit in its place, then repeat the test.

If a unit has been modified as a result of a stand-alone test failure, prepare a report describing the nature of the failure and the corrective action taken and submit it to the Engineer prior to re-testing the unit. If a failure pattern develops, the Engineer may direct that

modification be made to all units without additional cost to the Department or an extension of the Contract Time.

611-5 ITS System Acceptance Test.

After the stand-alone tests have been completed and approved by the Engineer, perform the System Acceptance Test in the presence of the Engineer and, when applicable, a representative of the agency designated to accept maintenance responsibility.

Conduct an approved 30-day System Acceptance Test during which all ITS Systems, Sub-Systems and, at a minimum, all control, monitoring, and communication functions of the field equipment are evaluated from a Transportation Management Center (TMC). Complete the System Acceptance Test documentation and turn them over to the Engineer for approval.

During the 30-day test period, limit device outages to 10% or less, a minimum of a single unit if less than 10 devices or the allowable threshold required in the Contract Documents, whichever is less. Should an outage of more than 10% of the total number of devices occur, a single unit or more if less than 10 devices or the allowable threshold in the Contract Documents, then the System Acceptance Test has failed.

Upon the failure of the System Acceptance Test, the 30-day testing window shall pause until all devices are fully functional. In addition to pausing and extending the test period by the number of days lost by failure and repair time, the Engineer has the option of restarting the full 30-day test.

Upon the successful completion of the System Acceptance Test, the Engineer will submit to the Contractor a letter of approval stating the first and last day of the 30-day system test period.

611-6 Contractor's Warranty Period for Installations.

611-6.1 General Requirements: Repair or replace any defective components or work of the installations for a 90-day period after final acceptance.

611-6.2 Contractor's Responsibilities: During the warranty period, the Contractor is responsible for the following:

1. Repair or replacement of equipment that fails to function properly due to defective materials or workmanship.

2. Upon notification by the Engineer of a malfunction, restore the equipment to proper operating condition within 12 hours after notification by the Engineer.

If the Contractor fails to restore the equipment to proper operating condition within 12 hours after notification, the Engineer has the authority to have the remedial work performed by other forces. The Contractor is responsible for all incurred costs of the work performed by other forces. Remedial work performed by other forces does not alter any of the requirements, responsibilities, or obligations of this warranty.

3. If the equipment does not function or malfunctions due to defective materials or workmanship, the Contractor is liable for any impairment to the safety of pedestrian and vehicular traffic resulting from such malfunction.

611-6.3 Department's Responsibilities: During the warranty period, the Department is responsible for the following:

1. Electrical energy costs which are paid for by the local maintaining agency.

2. All adjustments, such as timing, necessary for the normal operations of equipment.

3. Documentation of the individuals involved and the time of Contractor notification upon failure or malfunction of equipment.

4. Repair or replacement of any part of the installation damaged as a result of natural causes or those resulting from vehicular or pedestrian traffic not associated with Contractor activities.

611-7 Manufacturer's Tests and Certifications.

For materials which may not require formal testing, the Engineer reserves the right to require certifications from the manufacturer of such equipment and material, to the effect that they meet all Specification requirements, and, in the event of questionable equipment or material, to require that such material or equipment be tested at no expense to the Department.

The Engineer reserves the right to withhold any payments which may be due; if the Engineer determines that the equipment does not meet the Specifications or evaluation criteria.

611-8 Contracts for Purchase of Equipment.

611-8.1 Acceptance Tests Required: For each unit of equipment furnished under purchase contracts (furnish only), the Engineer will perform the following tests:

1. Visual inspection within 5 days after delivery.

2. Operational tests which determine whether the equipment performs in accordance with the requirements of the Contract Documents. The Engineer will complete such tests within 15 days after delivery. If the equipment is listed on the Department's Approved Product List (APL), the Engineer may verify the APL Certification number in lieu of the operational tests.

611-8.2 Eligibility for Payment: The Department will base payment for equipment furnished under purchase contracts on satisfactory completion of the visual inspection and operational tests required by 611-7.1.

Before any payment will be made for each functional group, deliver to the Engineer, and receive from the Engineer acceptance of all units of each functional group of equipment required to be furnished by the Contract Documents. The Department will make separate payment for a staged delivery of each functional group of equipment only when staged delivery is specified in the Contract Documents.

611-8.3 Equipment Failing to Pass Acceptance Tests: When any unit of equipment fails to pass the acceptance tests, correct the deficiencies (by repair or replacement), at no expense (including all freight costs) to the Department, to attain compliance. If the original Contract Time has expired, the Department will charge and continue to assess liquidated damages in accordance with 8-10 until final acceptance of the equipment. Upon compliance with such correction requirements, the Engineer will perform tests on the equipment as specified above and will determine their eligibility for payment.

The Department will not assess liquidated damages during the acceptance test period in 611-7.1. The Department will allow only one acceptance test exclusion regarding liquidated damages assessment per LOT of units required to be delivered.

611-9 Method of Measurement.

611-9.1 General: Measurement for payment will be in accordance with the following work tasks.

611-9.2 ITSFM Sub-surface Documentation: The Contract unit price per mile of documented conduit, cable, boxes, vaults, enclosures, and all other subsurface utilities will

include furnishing all hardware, tools, and materials and all data collection, verification, and submission as specified in this Section and the Contract Documents, and all labor, travel, MOT, programs, training, equipment, and other requirements necessary for a complete and accepted documentation submission. Payment for facilities located underground will be based on the linear length of the project as stated in the Contract Documents regardless of the length or number of conduits, cables, enclosures, or other subsurface facilities documented. No allowance will be made for sweeps or vertical distances below the ground.

611-9.3 ITSFM Location Documentation: The Contract unit price per location, will include documenting all above ground ITS Facilities at, or associated with, an ITS location as specified in this Section and the Contract Documents, and all labor, travel, training, equipment, programs, MOT, and other requirements necessary for a complete and accepted documentation submission. Payment for location documented will be based on the ITS location including cabinets, poles, utility hardware such as meter cans, utility demarcation sites, disconnects, etc., as well as all ITS devices, auxiliary devices, and other items, attributes, and fields called for in the ITSFM documentation and Contract Documents, regardless of the type or number of devices installed.

611-9.4 As-Built Drawings: All costs incurred in submitting as-built drawings are incidental to the other items of work associated with traffic control signals and devices.

611-10 Basis of Payment.

Price and payment will be full compensation for all work costs incurred in submitting ITSFM requirements including, all data gathering, data entry, transportation, protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Item No. 611- 1- ITSFM Sub-surface Documentation - per mile
Item No. 611- 2- ITSFM Location Documentation - each

SECTION 620
GROUNDING AND LIGHTNING PROTECTION

620-1 Description.

Furnish and install grounding and lightning protection to provide personnel and equipment protection against faults, surge currents and lightning transients. Provide a grounding and lightning protection system in accordance with the details shown in the Standard Plans unless otherwise shown in the Plans.

620-2 Materials.

620-2.1 Ground Rods: Use ground rods meeting the requirements of UL 467 that are listed by an OSHA Nationally Recognized Testing Laboratory (NRTL). Ground rods must be made of copper-clad steel with a nominal diameter of 5/8 inches. Ground rod sections must be a minimum of eight feet in length and manufactured for the sole purpose of providing electrical grounding.

620-2.2 Ground Rod Assembly: Provide a ground rod assembly consisting of one or more ground rods coupled together, such that the total length of the assembly is a minimum of 20 feet, driven into the earth at a single point, without disrupting the electrical continuity of the assembly.

620-2.3 Ground Rod Array: Provide ground rod arrays, as required, consisting of two or more ground rod assemblies, bonded together and spaced a minimum of 40 feet apart.

620-2.4 Grounding Conductors: For installing grounding conductor in conduit, provide an insulated conductor that is stranded in accordance with ASTM B8 and color code the grounding conductor green. For installing grounding conductor without conduit, provide bare solid copper wire meeting the requirements of ASTM B3 for grounding conductors. Connect the grounding conductor from the system ground bus or barrier plates to the ground rod assembly. Size equipment grounding conductors according to NEC Section 250.122. Size grounding electrode conductors according to NEC Section 250.66.

620-2.5 Exothermic Grounding Bond: Make all connections to the ground rod assemblies using exothermic welds.

620-2.6 Air Terminals: Use air terminals that comply with UL 96A and NFPA 780 standards and are listed by a NRTL.

620-2.7 Surge Protective Devices (SPDs): Install SPDs on all power, data, video, and any other conductive circuit. SPD requirements for lighting must meet the minimum requirements of Section 992 and the Standard Plans. Use SPDs that meet the requirements of Section 996 and are listed on the Department's Approved Product List (APL).

Provide primary and secondary surge protection on AC power at traffic control device field sites.

620-2.7.1 SPD for 120 Volt or 120/240 Volt Power: Install a SPD at the utility disconnect to the cabinet.

Ensure an SPD is provided where the supply circuit enters the cabinet. Locate the SPD on the load side of the main disconnect, ahead of electronic devices, and connected in parallel with the AC supply.

620-2.7.2 SPD at Point of Use: Install an SPD at the point the ITS devices receive 120 volt power and connected in series with the circuits.

620-2.7.3 SPDs for Low-Voltage Power, Control, Data and Signal Systems: Install a specialized SPD on all conductive circuits including, but not limited to, data communication cables, coaxial video cables, and low-voltage power cables.

620-2.7.4 Manufacturer's Warranty: Ensure that the SPD has a manufacturer's warranty covering failures for a minimum of 2 years from the date of final acceptance.

The term "failure" for warranty replacement is defined as follows:

Parallel-connected, power-rated SPD units are considered in failure mode when any of the visual indicators shows failure mode when power is applied to the terminals at the unit's rated voltage, or the properly functioning over-current protective device will not reset after tripping.

Series-connected, low-voltage power, data, or signal units are considered in the failure mode when an open circuit condition is created and no data/signal will pass through the SPD device or a signal lead is permanently connected to ground.

If the SPD, including any component of the unit, should fail during the warranty period, the entire SPD must be replaced by the manufacturer at no cost to the Department or maintaining agency.

620-3 Installation.

620-3.1 General: Construct a single-point grounding system. Install the primary ground rod assembly in an electrical pull box so that the top four inches are accessible for inspection, resistance testing, and maintenance. The primary ground rod assembly and electrical pull box shall be installed between 12 inches to 36 inches from the element being grounded. The top of all other ground rod assemblies connected to the primary ground rod assembly in an array must be buried a minimum of 18 inches below grade. Direct bury grounding conductors used to connect ground rod assemblies a minimum of 18 inches below finished grade.

Bond all ground rod assemblies and ground rod arrays together with solid bare tinned copper wire unless otherwise shown in the Plans. Install grounding conductors in a straight path.

Make all bonds between ground wires and ground rod assemblies and ground rod arrays with an exothermic bond with the following exception: do not exothermically bond sections of ground rods to create the ground rod assembly and do not exothermically bond connections within a cabinet. Apply an anti-oxidant compound to all mechanical connections.

Connect primary surge protection for power at the service entrance or main disconnect. Connect secondary surge protection at point of use, unless otherwise shown in the Plans.

Ensure that lightning protection systems conform to the requirements of the National Fire Protection Association (NFPA) Code NFPA 780, Standard for the Installation of Lightning Protection Systems. Install SPDs that have an operating voltage appropriate for the characteristics of the circuits they protect. The NFPA requirements do not apply to lighting systems.

620-3.2 Grounding Resistance:

620-3.2.1 Minimum Resistance Required: Obtain a resistance to ground of not more than 5 ohms for the following grounding applications. Install multiple ground rod assemblies totaling a maximum length of up to 80 feet, as required to achieve minimum grounding resistance.

1. Power service for traffic control devices
2. Signal and ITS cabinets

3. ITS Poles/Structures with electronic equipment
4. DMS and DMS structures

Install a minimum of one primary ground rod assembly. If a grounding and lightning protection system using a single ground rod assembly does not achieve the required resistance to ground, extend the length of the ground rod assembly an additional 20 feet or install an additional ground rod assembly 40 feet away and connect it to the main ground rod assembly to create a ground rod array. Continue installing ground rod assemblies connected in an array until the required resistance is obtained or until the maximum required total length of ground rod is installed.

Grounding systems formed from horizontally constructed conductive radials are permitted if site conditions prohibit the use of vertically driven rods as permitted by the NEC Article 250.53(G). A grounding system consisting of the maximum total length of ground rod required is acceptable in cases where soil conditions prevent the grounding system from achieving the required resistance to ground. Submit the site resistance measurement to the Engineer.

620-3.2.2 Minimum Resistance Not Required: Install a single ground rod assembly for the following applications. No resistance to ground measurements are required.

1. Conventional lighting
2. External lighting for signs
3. Signal cable & span wire
4. Aerial interconnect messenger wire
5. Pedestals for pedestrian signals
6. Pull boxes with metal covers when 120 volts (or greater) AC power is present
7. Splice boxes with wire grounding units.

620-3.3 Grounding Traffic Control Systems at Signalized Intersections: Ensure that all separately grounded elements at an intersection (signal cabinet, power service, mast arms or strain poles, etc.) are bonded together to form an intersection grounding network array.

For traffic signal poles, including pedestals for pedestrian signals, accommodate the ground connection from signal heads and electrically powered signs through span wires to the ground rod assembly or array located at the pole base in accordance with the details in the Standard Plans.

For span wire assemblies, use the span wire to connect the ground rod assemblies or arrays of the poles. Do not use guy wires for grounding purposes, however bond any guy wire to the span wire as part of the intersection grounding network.

620-3.4 Grounding Traffic Control Systems on Highways: Install the primary ground rod assembly at the base of the traffic control device supporting structure. Bond all metal components of the system (such as cabinets, steel poles, and concrete pole grounding wire) to the grounding system using a mechanical connection on the equipment side and an exothermically welded connection at the down cable. Do not use split bolts for grounding system connections.

Connect all ground rod assemblies and any associated grounded electrical system within a 100 foot radius (but not beyond the edge of the roadway) of the primary ground rod assembly. Connect the primary ground rod assembly to a single point main grounding bar inside the equipment cabinet or mount it to the base of the traffic control device supporting structure unless otherwise shown in the Plans.

Place multiple ground rod assemblies, as required, in a ground rod array as depicted in the Standard Plans unless otherwise shown in the Plans. If a required array cannot be placed in the right of way, submit an alternate placement detail for approval.

620-3.5 Grounding Highway Lighting Systems: Ground each metal light pole.

For poles on bridge structures, bring the grounding conductors out to a pull box at each end of the structure and connect them to driven ground rods 20 feet in length.

Ground all high mast poles in accordance with the details for grounding in Standard Plans, Index 715-010.

620-3.6 Grounding Equipment Shelters: Install all grounds for the equipment shelter on the side of the building that utilities, communication cables, and fiber enter. Connect all earth grounds to this point, including the grounding system for SPDs. Make all connections to SPDs according to the manufacturer's recommendations.

Ensure that communication cables, AC power, emergency generator, and equipment frames are connected by the shortest practical route to the grounding system. Protect the lead lengths from each device to the SPD.

Use compression type connection for all interior connections to bond grounding conductors to equipment in the shelter. For connections to bus bars, use mechanical connections having two bolts on a double-lug connector. Install star washers, or another means that accommodates the fasteners used and achieves reliable electrical connections that will not deteriorate. Crimp and solder all wires connected to lugs or clamps. Verify electrical continuity of all connections. Remove all non-conducting surface coatings before each connection is made.

Ensure that ground conductors are downward coursing, vertical, and as short and straight as possible. Ensure that the minimum bending radius for interior equipment shelter grounds is eight inches. Avoid sharp bends and multiple bends in grounding conductors.

620-3.6.1 Interior Grounding: Install a No. 2 AWG solid bare copper wire approximately one foot below the ceiling on each wall and mount it using insulated standoffs. Ensure that the wire encircles the equipment room, forming a ring or continuous loop. Mechanically connect the cable trays to the interior perimeter ground using stranded copper wires with green insulation and bolted terminal connectors at the cable tray ends. Make all points where cable tray sections meet electrically continuous by use of a short jumper wire with terminals attached at each end.

Directly bond all other metallic objects, such as door frames and doors, air conditioners, alarm systems, wall-mounted communication equipment, etc., to the closest interior perimeter ground with the shortest possible stranded copper wire with green insulation. Bond the door to the doorframe using flexible welding cable.

620-3.6.2 Exterior Grounding: Install an exterior grounding system consisting of multiple ground rod assemblies around the exterior perimeter of the equipment shelter. Place the ground rod assemblies a minimum of two feet from the building foundation in a suitable access point. Bond the following items to the shelter's grounding system:

1. Metal building parts such as downspouts and siding.
2. Ground rods provided by power or telephone utilities for grounding of AC power or surge protection devices, as permitted by local codes.
3. Shelter support skids, bases, or foundations, if applicable.
4. Any metal object larger than four square feet.
5. External metal fencing.

620-3.6.3 Punch Block SPD Grounding: Ground Type 66 punchdown blocks in accordance with the manufacturer's recommendations and mechanically connect them to the shelter's interior perimeter ground.

620-3.6.4. Equipment Shelter Fence Grounding: Ensure that the metal Type B fence is grounded to fence perimeter grounding conductors consisting of No. 2 AWG solid bare tinned copper wires that encircle the entire compound to achieve required resistance to ground required in 620-3.2.

Exothermically bond any splices in the grounding conductors. Bury the fence perimeter grounding conductor a minimum of 2.5 feet below finished grade. Bond all fence posts to the fence perimeter ground wire using No. 2 AWG solid bare tinned copper wire. Bond the gate and gatepost together with a flexible ground, such as welding cable wires. Ground the gatepost to the fence perimeter ground wire using No. 2 AWG solid bare tinned copper wire. Exothermically bond all connections to the fence perimeter ground wire.

Connect the fence's top rail to each corner post and in the middle of each side. Ground the fence fabric with No. 2 AWG solid bare tinned copper wire connected to the fence posts. Connect the fence perimeter wires to the ground rod assemblies of the equipment shelter's ground system with No. 2 AWG solid bare tinned copper wire, as shown in the Plans.

Ensure that all ground leads are No. 2 AWG solid bare tinned copper wires for all above- and underground grounding wire installations. Ensure that all exothermic bonds are appropriate for the application. Do not use welding or other forms of bonding without prior written approval.

620-4 Ground Resistance Testing and Inspection.

620-4.1 Testing: Measure the ground resistance with an instrument designed specifically to measure and document earth/ground resistance, soil resistivity, and current flow. Conduct the test by using the fall-of-potential method as described in the Institute of Electronic and Electrical Engineers (IEEE) Standard 81. The fall-of-potential test is used to verify the minimum resistance required in 620-3.2.1. If fall-of-potential tests cannot be performed, it is acceptable to measure resistance at each accessible ground rod using a clamp-on ground resistance tester. Submit to the Engineer certified test results for each testing location. Submit the following information on the test results:

1. The formal name or ID for the location where the test was performed
2. The GPS latitude and longitude for the location where the test was performed
3. The date on which the test was performed
4. The make and model number, serial number, and last date of calibration (by an independent testing facility within the previous 12 months) for the grounding resistance testing device used
5. Contact information (including name, signature, and employer name) for each person conducting, witnessing, or certifying the test
6. Description of the local environmental and soil conditions at the time of testing
7. A rough sketch of the site grounding system; along with the corresponding measured data points
8. Page numbering showing the current page number and total page count (e.g., Page 1 of 3)

Only clamp-on ground resistance testing is required for roadway lighting installations.

620-4.2 Inspection: Do not backfill below-grade grounding installations and grounding connections until inspected and approved. The Engineer will inspect the installation for proper

connection types, tightness, workmanship, and conformance to the Plans. Replace any exothermic bonds that are deemed unsatisfactory with new exothermic bonds. Repair or replace any mechanical connections that are deemed unsatisfactory. Measure the resistance at each accessible ground rod using a clamp-on earth tester. The measurement at any individual rod is the cumulative resistance of all rods in a parallel circuit.

For grounding system inspections, notify the Engineer at least five days prior to completion of the installation. Record all test results in a standardized format approved by the Engineer prior to testing. All recorded test report data shall be dated, witnessed, and signed by at least one representative of the Department and the Contractor. Remedy all deficiencies at no cost to the Department.

620-5 Basis of Payment.

The work specified in this Section will not be paid for directly, but will be considered as incidental work.

SECTION 630
CONDUIT

630-1 Description.

Furnish and install conduit for traffic control signals and devices, highway lighting, and other electrically powered or operated devices as shown in the Contract Documents.

630-2 Materials.

630-2.1 Conduit: Use materials that have been tested and listed by a Nationally Recognized Testing Laboratory to the following industry standards:

Schedule 40 and 80 Polyvinyl Chloride (PVC)[1] ..... UL 651
Fiberglass Reinforced Epoxy[2] (below ground) ..... UL 2420
Fiberglass Reinforced Epoxy[2] (above ground) ..... UL 2515
Intermediate Metal[3] ..... UL 1242
Rigid Galvanized Metal[3,4] ..... UL 6
Rigid Aluminum[4] ..... UL 6A
PVC Coated Intermediate Metal[4] ..... ASTM A135/A135M,
..... ASTM A513, ASTM A568/A568M, NEMA RN1-2005
Liquid Tight Flexible Metal ..... UL 360
High Density Polyethylene (HDPE) Standard Dimension
Ratio (SDR) 9-11[5] ..... ASTM F2160
HDPE SDR 13.5[5] ..... ASTM F2160, NEMA TC-7
Schedule 40 and 80 HDPE ..... UL 651A

1. Use conduit with solvent weld slip-fit plastic couplings unless approved by the Engineer.

2. Use conduit having a minimum stiffness value of 250. Ensure that each section has a duct bell with an integral gasket on one end and a duct spigot on the other end.

3. Use conduit that is hot-dipped galvanized with a minimum coating of 1.24 ounces per square foot on both the inside and outside of the conduit. The weight of the zinc coating shall be determined using ASTM A90.

4. Use conduit with both ends reamed and threaded.

5. Can be used with preassembled cable and rope-in-conduit.

630-2.2 Locate Wire: Ensure that locate wire is a single copper conductor with a minimum gauge of No. 12 AWG. Ensure locate wire is insulated using a 45 mil minimum thickness polyethylene sheath that is orange in color and marked to identify the manufacturer and the conductor size.

630-2.3 Locate Wire Grounding Unit: Ensure that locate wires are attached to a wire grounding unit (WGU) dedicated to safely dissipate high transient voltages or other foreign electrical surges induced into the designated system. Ensure the WGU conforms to the following:

1. Allows signals generated by locate system transmitters to pass through the protection system without going to ground.

2. The protection system automatically resets and passes locate system transmitter signals after the unit has been grounded to dissipate over-voltages.

3. Is intended for below or above grade applications. Ground the WGU to a driven rod within 10 feet of the system using a No. 6 AWG single conductor wire with green insulation.

Ensure that the WGU is enclosed for protection from environmental hazards and is accessible for the connection of portable locate system transmitters.

4. The WGU system meets the minimum standards listed in Table 630-1 for surge protection:

Table 630-1 Minimum Standards for Surge Protection	
Surge Element	3-element maximum duty fail-safe gas tube.
Rating	40,000 A surge capacity (single-cycle, 8 by 20 microsecond waveform).
Life	Minimum 1,000 surges (1000 A to ground).
Fail-Safe	Integral fail-shorted device.
Insulation Resistance	1,000 megohm minimum at 100 volts of direct current (V_{DC}).
Clamp Voltages	a. Impulse at 100 volts per microsecond: Typically 500 volts. b. Direct Current: 300 to 500 volts.

630-2.4 Warning Tape: Ensure that the buried cable warning tape is flexible, elastic material 3 inches wide, 6 mil thick, intended for burial and use as an underground utility warning notice, and that the surface of the warning tape is coated and sealed to prevent deterioration caused by harsh soil elements. Ensure that the warning tape color follows the American Public Works Association color code for underground utilities and has the repeating message "CAUTION: FDOT CABLE BURIED BELOW" or other wording approved by the Engineer, permanently printed on its surface. Ensure that the tape material and ink colors do not change when exposed to acids, alkalis, and other destructive chemical variances commonly found in Florida soils.

630-2.5 Route Markers: Route markers may be either a standard route marker (SRM) type or an electronic route marker (ERM) type. Ensure the SRM is a rigid, tubular, driven post used for location and notification purposes only. Ensure the ERM is physically identical to the SRM, but also includes a termination board to provide aboveground access to locate wire buried alongside conduit and cable runs.

Ensure that each SRM is labeled and identified as an FDOT fiber optic cable marker unless otherwise shown in the Plans. The labels must include the Department's logo, contact information for the local FDOT District, and a telephone number to call prior to any excavation in the area. Ensure that the identification information is permanently imprinted on the top fitting, and will not peel, fade, or deteriorate.

630-2.5.1 Standard Route Marker (SRM): Ensure that SRM posts are white with an orange top fitting cover with black or white lettering and graphics. Ensure that the SRM is a tubular configuration, and both the marker post and the top fitting are made from virgin Type 111 HDPE. Ensure that any fasteners used with the SRM are constructed of stainless steel.

Ensure that all SRMs have a minimum outside diameter of 3.5 inches with a minimum wall thickness of 0.125 inch. Ensure that the top fitting cover is a minimum of 1.5 feet long and has an outside diameter of 3.75 inches with a minimum wall thickness of 0.125 inch. Ensure that each SRM provides a tensile strength of 4,200 pounds per square inch as required in ASTM D638.

Ensure the SRM can withstand an impact force of 70 pounds per foot at 32°F in accordance with ASTM D2444, before and after UV conditioning for 2,000 hours in

accordance with ASTM G154. Ensure that the control sample of any material tested maintains a minimum of 70 percent of its original tensile strength.

Ensure that SRMs installed at the minimum 2 foot depth can withstand at least one impact at 45 miles per hour by a vehicle weighing at least 3,500 pounds and that after impact, post returns to an upright position within 10 degrees of vertical alignment within 30 seconds from the time of impact.

630-2.5.2 Electronic Route Marker (ERM): Ensure ERMs meet the same material and performance requirements as the SRMs with the following exceptions. Equip each ERM with a removable, top-fitting cover that is black with white lettering. Ensure that each ERM contains a terminal board equipped with locate wire and ground connectors.

Ensure that the terminal board is made from corrosion-resistant materials and includes terminal facilities labeled according to function and provides uniform spacing between connection points.

630-3 Installation Requirements.

630-3.1 General: Install the conduit in accordance with NEC or National Electrical Safety Code (NESC) requirements and the Standard Plans. Consider the locations of conduit as shown in the Plans as approximate. Construct conduit runs as straight as possible and obtain the Engineer's approval for all major deviations in conduit locations from those shown in the Plans. Include buried cable warning tape with all trenched conduit. Mark the location of the conduit system with route markers as shown in the Plans and approved by the Engineer. Ensure that all route markers used are new and consistent in appearance.

For conduit installed by directional bore, install in accordance with Section 555. For conduit installed by jack and bore, install in accordance with Section 556.

Use only intermediate galvanized metal conduit, rigid galvanized metal conduit, rigid aluminum conduit or PVC coated intermediate metal conduit for above-ground electrical power service installations and rigid galvanized metal conduit or rigid aluminum conduit for underground electrical power service installations. Meet the requirements of Section 562 for coating all field cut and threaded galvanized pipe.

Use Schedule 80 PVC, Schedule 40 PVC, or fiberglass reinforced epoxy for conduit inside of or embedded within structural elements. Use Schedule 80 PVC or fiberglass reinforced epoxy for conduit that are outside or attached to the exterior of structural elements.

For non-structural, above ground ITS communication and electrical conduit, use intermediate galvanized metal conduit, rigid galvanized metal conduit, or Schedule 80 PVC conduit.

Use HDPE with an SDR number less than or equal to 13.5, Schedule 80 HDPE, Schedule 40 HDPE, Schedule 80 PVC, or Schedule 40 PVC for underground installations of electrical conduit in earth for ITS electrical applications.

Use HDPE with an SDR number less than or equal to 11, Schedule 80 PVC or Schedule 40 PVC for underground installations in earth or concrete for ITS and traffic control signal applications, except, use only HDPE with an SDR number less than or equal to 11 for blown fiber optic cable installations on limited access facilities.

Use Schedule 40 PVC Split Duct Conduit only for temporary repairs or relocation of conduit containing active fiber optic communications for distances less than 100 feet.

Use HDPE with an SDR number less than or equal to 13.5, Schedule 80 PVC, or Schedule 40 PVC for underground installations of electrical conduit in earth for lighting applications and landscape irrigation applications.

Use HDPE with an SDR number less than or equal to 13.5, Schedule 80 PVC, Schedule 40 PVC, or rigid galvanized metal for underground installations of electrical conduit in concrete for lighting applications.

Use the following conduit for toll site applications:

1. HDPE with SDR number less than or equal to 11 for directional bores.
2. Schedule 80 PVC for open trenching of exterior conduits and vertical conduits under the footprint of a toll equipment building/cabinet, except for power service conduits.
3. Rigid steel conduit coated with PVC or a bituminous coating painted up to 6 inches above finished grade for power service conduit and vertical conduits entering or leaving the ground outside the footprint of a toll equipment building/cabinet.
4. Rigid galvanized steel elbows and bends for HDPE and PVC conduit raceways longer than 200 feet in length and 2 inches trade size and larger, except for conduits serving vehicle detection loop pull boxes.
5. Use Electrical Metallic Tubing (EMT) for the portion of conduit that extends greater than 24 inches into the toll equipment building interior.
6. Rigid galvanized steel conduit for exterior above grade conduit and conduit mounted to toll gantries.
7. Do not use Electrical Nonmetallic Tubing (ENT).

Do not place more than the equivalent of three 90 degree bends or a total of 270 degrees of bends, including the termination bends, between the two points of termination in the conduit, without a pull box. Obtain the Engineer's approval to use corrugated flexible conduits for short runs of 6 feet or less.

When a conduit installation changes from underground to above-ground, make the change a minimum of 6 inches below finished grade.

Install a No. 12 AWG pull wire or polypropylene cord inside the full length of all conduits. Ensure that a minimum of 24 inches of pull wire/cord is accessible at each conduit termination.

Ensure the conduit includes all required fittings and incidentals necessary to construct a complete installation.

When earth backfill and tamping is required, place backfill material as per Section 120 in layers approximately 12 inches thick and tamp each layer to a density equal to or greater than the adjacent soil.

When backfilling trenches in existing pavement, use a flowable fill meeting the requirements of Section 121.

Provide a standard clearance between underground control cable and electrical service cable or another parallel underground electrical service cable that meets NESC requirements.

Prevent the ingress of water, dirt, sand, and other foreign materials into the conduit prior to, during, and after construction. Seal the ends of conduit after wiring is complete with a moisture resistant sealant that is designed for this specific application.

630-3.1.1 Fiber Optic Cable Conduit: Install the conduit system so the fiber optic cable maintains a minimum bend radius of 20 times the cable diameter. Use approved methods for connecting inner duct or conduit within or between plowed portions, trenched portions, and bored portions. Submit the conduit manufacturer's coupling method and material to the Engineer for approval.

630-3.2 Conduit Sizes: Size the conduit to be used on all installations, unless otherwise shown in the Contract Documents. Use conduit of sufficient size to allow the conductor to be installed without any damage and meeting NEC requirements. Use conduit that is at least 2 inches in diameter, with the following exceptions:

For conduit protecting the ground wire on the side of a pole, use conduit that is at least 1/2 inch in diameter.

For ITS applications where Contractor chooses to install fiber optic cable by blowing, use conduit that is at least 1-1/4 inch in diameter.

For traffic control signal and device electrical service conduit, use the minimum conduit size required by the local maintaining agency and the electrical service provider.

630-3.3 Conduit Joints: Make conduit joints using materials as specified by the manufacturer. When conduit crosses an expansion joint of a structure and where shown in the Plans, install an expansion or expansion/deflection fitting as specified by the manufacturer. Certify that expansion/deflection fittings are rated to accommodate a minimum rotation of 30 degrees and that both the expansion and expansion/deflection fittings are rated to accommodate the anticipated longitudinal movement (minimum of 2 inches for expansion fittings and 0.7 inches for expansion/deflection fittings). Ensure that all installed joints are waterproof. As an exception to the threaded coupling for intermediate metal conduit, at locations where it is not possible to screw the threaded coupling properly, the Contractor may use a waterproof slip-joint coupling approved by the Engineer. Secure the joint and tighten threaded connections.

Prior to insertion into the coupling, clean, prime and coat the ends of PVC conduit with solvent-type cement as specified by the manufacturer.

For toll site conduit applications: Join lengths of smooth wall HDPE conduit using the Butt Fusion process or universal aluminum couplings. Use PVC to HDPE threaded transition couplings to join PVC conduit to HDPE conduit.

630-3.4 PVC Coating: Apply PVC coating to exposed metal surfaces of the conduit, except for the threads, to attain a nominal thickness of 40 mils. Ensure that the coating is free of sags and drips.

Attach the coupling to the conduit prior to the application of the coating for conduit of 1 inch diameter or less.

Use a coupling with sleeve extensions on conduit larger than 1 inch. Ensure that the sleeve extensions on all threaded female openings have a length equal to the diameter of the conduit up to and including size number 53.

630-3.5 Conduit Terminations: Where conduit enters a box, fitting, or other enclosure, provide a bushing or adapter (end bell, conduit adapter, etc.) to protect the conductor or cable from abrasion unless the box, fitting, or enclosure provides equivalent protection.

For conduit to be encased in concrete, wrap with tape or otherwise protect all terminations to prevent the entrance of concrete.

Connect new underground conduits to existing underground conduits with a pull box.

Install conduit terminating in a concrete strain pole through the cable entry hole and up the center of the pole to a location approximately 6 inches below the handhole.

Seal conduits terminating in a controller base, pole, pull box, junction box, or pedestal base with a moisture resistant sealant approved by the Engineer.

For mast arm poles, high mast poles, and steel strain poles, terminate conduit at least 6 inches above the top of the foundation. For all other poles, controller bases, pedestal bases, and junction boxes, terminate conduit runs into the center of the base or box at least 2 inches above the surface of the base.

630-3.6 Restoration of Trench Areas: Restore the conduit trench construction area to an acceptable condition. Such work includes repair or replacement of all pavement areas, sidewalks, driveways, curbs, structures, landscaping, grass areas (including removal of excavated materials and spoils), removal and disposal of drilling fluids, and backfilling areas disturbed by the conduit installation.

630-3.7 Above-Ground Installation: Use conduit designed and manufactured for use in long-term above-ground applications with UV stabilization to prevent material deterioration. Securely attach above-ground conduit installations to the surface of the supporting structure using conduit straps. As a minimum, use conduit straps located on 5 foot centers. Use galvanized metal conduit straps when installing intermediate galvanized metal conduit, fiberglass reinforced epoxy conduit, rigid galvanized conduit, rigid aluminum conduit or PVC coated intermediate metal conduit above ground.

Use the same PVC coating for the metal straps as the conduit, when using PVC coated intermediate metal conduit.

630-3.8 Elbows: The radius of curvature of the centerline of any bend shall not be less than shown below in Table 630-2:

Table 630-2
Elbow Curvature

Size	Standard Radius
1/2 inch	4 inches
3/4 inch	4-1/2 inches
1 inch	5-1/2 inches
1-1/4 inches	7-1/4 inches
1-1/2 inches	8-1/4 inches
2 inches	9-1/2 inches
2-1/2 inches	10-1/2 inches
3 inches	13 inches
3-1/2 inches	15 inches
4 inches	16 inches
5 inches	24 inches
6 inches	30 inches

630-3.9 Fiber Optic Cable Locate Wire.

630-3.9.1 Fiber Optic Cable Locate Wire Installation: Install locate wire in the trench or bore with all underground conduits to provide end-to-end electrical continuity for electronically locating the underground conduit system. When conduit is placed by trenching, bury locate wire along the centerline of the top outer surface of installed conduit. Do not install locate wire in a conduit with fiber optic cable.

Do not run locate wires into field cabinets. Terminate locate wires at the following locations or as shown on the Plans, nearest pull box to a field cabinet, nearest pull box

to a building, and splice box locations. Ensure that wire termination occurs in a pull box as shown in Standard Plans, Index 635-001.

In a trenching operation, install the locate wire no more than 3 inches above the conduit. Ensure that the locate wire enters all pull and splice boxes, and that a minimum of 10 feet of slack locate wire is coiled and neatly stored in each box.

In a boring operation, install the locate wire in an encasement, install the conduit detection wire external to the conduit with no separation between conduit and wire, or use conduit with integral locate wire. Locate wire may also be placed in the void between the inner wall of conduit and innerducts contained within the conduit as long as no other cables are present within the void.

Make locate wire splices in a flush grade-level box. Ensure that locate wire splices are waterproof and suitable for direct burial. Ensure that locate wire splices at the pull box meet NEC requirements. Ensure that locate wire splices are constructed of and in the following order: a mechanical crimp connection with a butt sleeve, an oxide-preventing aerosol lacquer, mastic electrical splicing tape, and standard electrical tape. At the completion of the installation, provide the Engineer with as-built drawings that document all splice locations.

Install WGUs in pull boxes and splice boxes as shown in the Plans or directed by the Engineer. Mount the device in a location high enough from the bottom of the box to allow access to terminal facilities without disturbing cables present within the box. Terminate the locate wires and connect the WGU to ground in accordance with the manufacturer's instructions.

630-3.9.2 Fiber Optic Cable Locate Wire Testing: Test the locate wire system after installation to ensure that it functions and can be used to accurately locate the conduit system. Perform continuity tests and insulation resistance tests on all locate wires and provide the Engineer with all test results. Replace, or repair defective locate wire at no additional cost.

630-3.10 Route Markers: Install route markers for new fiber optic cable installations, replace route markers as shown in the Plans, and ensure the following:

1. Markers are plumb, level, and the notification information is clearly visible when viewed from the side facing the roadway.
2. Markers are set within the right of way.
3. Markers are placed at a 1 foot offset from the conduit system.
4. The top of the marker post is a minimum of 5 feet and maximum of 6 feet above the finish grade
5. Markers are spaced a maximum of 500 feet apart.
6. A clear line of sight is maintained from one marker to the next.
7. Markers are installed on both sides of the roadway at any crossing point where the conduit system changes to the opposite side of the roadway.
8. Markers are installed at the center point of any conduit run between two pull or splice boxes.
9. Markers are installed at gate locations when the conduit system is adjacent to a fence line.
10. Markers are installed on both sides of a stream, river, or other water crossing, and on both sides of aboveground attachments such as bridges and walls.

Remove and replace all marker posts damaged during installation at no additional cost. Ensure that route marker signs are labeled with a unique identification number, as detailed in the Plans or as approved by the Engineer. Provide as-built documentation at the completion of

installation that includes identification number and location of all installed route markers and correlates the marker to the fiber optic infrastructure that it signifies.

Ensure that installation of ERMs includes connection of the route marker to the locate wire associated with the conduit run that the markers identify. Install locate wire through the base of the marker and terminate the locate wires to connectors mounted on the terminal board inside the marker. Install an underground magnesium anode a minimum of 10 feet away from the marker and perpendicular to the conduit system. Terminate the anode lead on the connector mounted on the terminal board inside the marker. Install the bond straps between the anode connector and all locate wire connectors to provide cathodic protection for the locate wire conductor.

630-4 Method of Measurement.

The Contract unit price per foot of conduit, furnished and installed, will include furnishing all hardware and materials and all testing as specified in this Section and the Contract Documents, and all labor, casings, removal of excavated materials and spoils, removal and disposal of drilling fluids, locate wire, trenching, boring, backfilling, flowable fill and restoration materials necessary for a complete and accepted installation.

Payment for conduit placed underground will be based on the horizontal length of the trench or bore measured in a straight line between the centers of pull boxes, cabinets, poles, etc., in linear feet, regardless of the length or number of conduits installed. No allowance will be made for sweeps or vertical distances below the ground.

Payment for conduit placed aboveground or bridge mounted will be based on the actual length of conduit installed.

Payment for each individual conduit run embedded in concrete barriers or traffic railings, as shown in Standard Plans, Index 630-010, will be based on the length of the concrete barrier or traffic railing section that includes the conduit, regardless of the actual length of conduit installed. This length is limited by the begin and end of the concrete barrier or traffic railing run and includes the portions of the conduit exiting the structure towards the ends of the concrete barrier or traffic railing as shown in the Standard Plans. This includes all expansion and expansion/deflection fittings, but no allowance will be made for sweeps or vertical distances below the ground.

Payment for conduit embedded in miscellaneous concrete structures will be based on the length of each individual conduit run, measured in a straight line between centers of junction boxes, regardless of the length of conduit installed, and will include all expansion and expansion/deflection fittings. Conduit that does not both begin and end at a junction box will be considered incidental to their related items of work.

Payment for replacement of route markers, per each, will be made only for those markers identified in the Plans.

Payment for split duct conduit placed will be based on the actual length of each conduit installed.

630-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment for conduit placed under existing turf will be made as open trench.

Payment for conduit placed under existing pavement (roadway, driveways, or sidewalk) will be made as directional bore, unless specifically identified as open trench. If conduit is being placed under both existing turf and existing pavement between two pull boxes, payment for the

total pull box-to-pull box length will be made as directional bore. Payment for conduit placed by jack & bore will be made as jack & bore, for the total pull box to pull box length.

Payment for conduit embedded in concrete structures or traffic railings will be made as embedded conduit.

No additional payment will be made for multiple conduits in the same trench.

No payment adjustment will be made if the Contractor chooses to use an alternative method approved by the Engineer.

No payment will be made for failed bore paths, injection of excavatable flowable fill, products taken out of service, or incomplete installations.

Payment for replacement of route markers will include all the work, labor, equipment, and materials specified in this Section. No separate payment for route markers will be made for new conduit installation.

Payment will be made under:

Item No. 630-	2-	Conduit - per foot.
Item No. 630-	3-	Replace Route Marker for Existing Conduit - per each.

SECTION 632
SIGNAL CABLE

632-1 Description.

Furnish and install underground and aerial signal cable as shown in the Plans and in accordance with Standard Plans, Index 634-001.

632-2 Materials.

Use only new materials meeting the requirements of this Section.

632-2.1 Signal Cable: Use either polyethylene insulated, polyvinyl chloride jacketed signal cable conforming to the requirements of the International Municipal Signal Association, Inc. (IMSA) Specification No. 19-1 or polyethylene insulated, polyethylene jacketed signal cable conforming to the requirements of IMSA Specification No. 20-1. Use signal cable conductors of stranded copper, No. 14 AWG or larger.

632-2.2 Cable Support Wire: Provide utilities grade zinc-coated support wire meeting the requirements of ASTM A475, whether separate or integral to signal cable, having a minimum nominal diameter of 1/4 inches.

632-2.3 Cable Attachment Hardware: Ensure that all bolts and nuts less than 5/8 inch in diameter are passivated stainless steel, Type 316 or Type 304 and meet the requirements of ASTM F593 and ASTM F594 for corrosion resistance. Ensure that all bolts and nuts 5/8 inch and over in diameter are galvanized and meet the requirements of ASTM A307. Use attachment hardware with sufficient tensile strength for the application. Use stainless steel lashing wire, galvanized or stainless steel lashing rod, cable rings or self-locking cable ties of UV stabilized black plastic having a minimum tensile strength of 100 pounds.

632-3 Installation Requirements.

Except for mast arm assemblies, install signal cable in continuous lengths between the traffic signal controller cabinet and the first disconnect hanger (or traffic signal head) on the span and between the traffic signal controller cabinet and each pedestrian signal head and pedestrian detector.

Do not use the neutral return conductor for pedestrian detectors as a neutral return for any other device. Conductors for the pedestrian signal head and the push button must be separated at the base of the pedestal and routed to the detection panel using separate raceways.

632-3.1 Number of Conductors: Determine the number of conductors required for each signal cable unless specified in the Contract Documents.

Provide three spare conductors for each signal cable used at all signal installations. Install the three spare conductors from the controller cabinet through each disconnect hanger (or traffic signal head) to the furthermost disconnect hanger (or traffic signal head).

Identify all spare conductors in a controller cabinet and ground them to the controller cabinet ground bus bar. Provide spare conductors within the controller cabinet of sufficient length to reach the furthermost field wiring terminals in the cabinet.

632-3.2 Protection of Cable: Ensure cable drawn through conduit, ducts, drilled holes protected by a rubber grommet, or support structures is installed in such a manner as to prevent damage to conductors or insulation.

632-3.3 Cabling for Mast Arm Assembly: Continuous lengths of cable between the traffic signal controller cabinet, signal heads (or disconnect hangers), pedestrian signal heads and pedestrian detectors will be allowed only when specified in Contract Documents.

632-3.4 Cable Terminations: Terminate signal cable in the terminal by inserting the bared conductors into a compression type terminal block.

When barrier terminal blocks are specified in the Contract Documents, crimp insulated fork or ring terminals to the bared conductors using a calibrated ratchet-crimping tool and connect the forks or ring terminals to the barrier terminal block.

Neatly form and tie wrap all cable terminations.

If disconnect hangers are specified in the Contract Documents, terminate spare wires at the terminal strip located inside the disconnect hangers. Individually cap or tape any additional spares in the disconnect hanger.

Connect signal cables for a mast arm assembly in the terminal compartment when provided.

632-4 Method of Measurement.

The Contract unit price for signal cable, furnished and installed, will include furnishing all material, hardware, support wire, cable ties, cable clamps, lashing wire, terminal connectors, cable grounding and labor necessary for a complete and accepted installation.

For intersections where new strain poles, monotubes, or mast arms are installed, payment for signal cable will be based on the number of intersections at which signal cable is furnished and installed.

For all other applications, including repair and replacement of signal cable, payment for signal cable will be based on the linear feet of cable used.

632-5 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 632- 7- Signal Cable

SECTION 633
COMMUNICATION CABLE

633-1 Description.

Furnish and install underground and aerial communication cable as shown in the Plans and Standard Plans.

633-2 Materials.

633-2.1 Fiber Optic Cable and Connections.

633-2.1.1 Single Mode Fiber Optic Cable: Provide all-dielectric, dry-filled, loose-tube, dispersion-unshifted, single-mode fiber (SMF) with low water peak, gel free, and suitable for underground (i.e., in conduit) and aerial outside plant installation. All fiber optic cable shall be splice-compatible with the Department's existing dispersion-unshifted SMF and require no electronic equipment for dispersion compensation between new and existing fiber. Ensure that all components that comprise a single length of cable are continuous and of the same material. Furnish only commercial off-the-shelf materials, equipment, and components.

633-2.1.1.1 Optical Fiber: Ensure that the optical fibers used in the cable meet or exceed the Telecommunications Industry Association (TIA) TIA-492-CAAB specification, U.S. Department of Agriculture Rural Utilities Service (RUS) 7 CFR 1755.902, and International Telecommunication Union ITU-T G.652.D requirements. Use only optical fibers meeting the additional requirements as follows:

Table 633-1
Geometry
Core-to-Cladding Concentricity: ≤0.5 µm
Cladding Noncircularity: ≤0.7%
Mode Field Diameter: 1,550 nm; 10.4 µm, ±0.5 µm
Optical
Cabled Fiber Attenuation: 1,310 nm, ≤0.35 dB/km; 1,550 nm, ≤0.25 dB/km
Dispersion: 1,550 nm ≤18.0 ps/(nm·km)
Polarization Mode Dispersion Link Design Value (PMDQ): ≤0.04 $ps/\sqrt{km}$

Ensure that all fiber in the buffer tube is usable fiber that complies with attenuation requirements. Ensure that fibers do not adhere to each other. Ensure that the fiber is free of surface imperfections and inclusions. Ensure that all fiber optic core glass is from the same manufacturer.

633-2.1.1.2 Buffer Tubes: Ensure that the fiber optic cable includes loose buffer tubes that isolate internal optical fibers from outside forces and provide protection from physical damage as well as water ingress and migration. Ensure that buffer tubes provide freedom of movement for internal optical fibers. Ensure buffer tubes allow for expansion and contraction of the cable without damage to internal optical fiber. Ensure that fiber does not adhere to the inside of the tube. Ensure that buffer tubes permit intentional scoring and breakout

without damage to the fiber. Ensure that each fiber optic cable buffer tube contains 12 fibers per tube unless otherwise shown in the Plans.

633-2.1.1.3 Color Code: Ensure that the marking and color-coding of the fibers and buffer tubes conforms to the TIA-598-D standard.

Ensure that colors are permanent and stable during temperature cycling, and not subject to fading or smearing onto each other or into the water-blocking material. Ensure that fibers are colored with UV curable inks that remain clearly distinguishable as the intended color.

633-2.1.1.4 Strength Member: Ensure that the fiber optic cable contains a dielectric central and outside elements that prevent buckling of the cable and provide tensile strength. Ensure that the fiber optic cable can withstand a pulling tension of 600 lbs. without damage to any components of the fiber optic cable.

633-2.1.1.5 Water Blocking Compound: Ensure that the fiber optic cable contains a dry water-blocking material to prevent the ingress of water within the outer cable jacket. Ensure that water-blocking materials are non-nutritive, dielectric, and homogeneous, and free from dirt and foreign matter. Use dry water-blocking material for fiber optic cables used for either aerial or underground installations. Apply dry water-blocking compound longitudinally around the outside of the central buffer tubes. Construct all cables with water-blocking material that complies with the requirements of the EIA/TIA-455-81B standard and is subjected to water penetration tests as defined in the EIA/TIA-455-82B standard.

633-2.1.1.6 Ripcord: Ensure that the cable contains at least one ripcord under the sheath or alternate method that allows the removal of the sheath by hand or with pliers.

633-2.1.1.7 Filler: Fillers or rods may be included in the cable core to lend symmetry to the cable cross section if required.

633-2.1.1.8 Outer Jacket: Ensure that the fiber optic cable is jacketed with medium density polyethylene (MDPE) that is free of blisters, cracks, holes, and other deformities. Ensure that the nominal jacket thickness is a minimum of 0.03 inches. Ensure the outer jacket provides UV protection and does not promote the growth of fungus.

Mark the jacket with the cable manufacturer's name, fiber type, fiber count, date of manufacture, the words "FDOT FIBER OPTIC CABLE" unless otherwise shown in the Plans, and the sequential cable lengths marked in feet. Ensure that the actual length of the cable is within 1% of the length indicated by the marking. Provide legible marking with contrasting color to that of the cable jacket.

633-2.1.1.9 Performance Requirements:

633-2.1.1.9.1 Operating Temperature: Ensure that the shipping and the operating temperature range of fiber optic cable meets or exceeds minus 40º to 158º F. Ensure that the installation temperature range of fiber optic cable meets or exceeds minus 22º to 158ºF.

633-2.1.1.9.2 Bend radius: Ensure that the fiber optic cable is capable of withstanding a minimum unloaded bend radius of 10 times the cable diameter and a minimum loaded bend radius of 20 times the cable diameter when loaded to pulling tension of 600 pounds. Test the cable as required in the TIA -455-33B standard. Ensure that bending the fiber optic cable up to the minimum bend radius does not affect the optical characteristics of the fiber.

633-2.1.1.9.3 Cable Strength: Ensure that the fiber optic cable is capable of withstanding a pulling tension of 600 pounds during installation . Ensure that optical

fiber is proof-tested by the fiber manufacturer at a minimum of 100 kilo pounds per square inch. Ensure that the cable will withstand 25 impact cycles and the change in attenuation does not exceed 0.2 decibel at 1,550 nanometers when tested according to the requirements as detailed in the TIA-455-25D standard. Ensure that the fiber optic cable can withstand a minimum compression load of 125 pounds per square inch when applied uniformly over the length of the sample at the rate of 0.15 inches to 0.8 inches per minute and maintained for 10 minutes as defined in the TIA/EIA-455-41A standard.

633-2.1.1.9.4 Water Penetration: Ensure that the fiber optic cable is capable of withstanding the tests for water penetration defined in the TIA/EIA-455-82B standard. Ensure that a one-meter length of cable is able to withstand a one-meter static head of water applied at one end for 24 hours without water leaking through the other open cable end.

633-2.1.2 Fiber Optic Connection Hardware: Ensure that all splice enclosures, organizers, cable end preparation tools, and procedures are compatible with the fiber optic cable, and are approved by the Engineer.

633-2.1.2.1 Splice Enclosures: Contain all optical fiber splices within a splice enclosure. Ensure that the enclosures provide storage for splices, fiber, and buffer tubes. Ensure that the splice enclosure restores the mechanical and environmental integrity of the fiber optic cable, encases the sheath opening in the cable, and organizes and stores optical fiber. Ensure all hinges and latching devices are stainless steel. Ensure that the enclosure is airtight and prevents water intrusion. Ensure that the splice enclosure can accommodate pressurization and has the ability to be reentered without requiring specialized tools or equipment. Ensure that the enclosure provides fiber and splice organizers including splice trays and strain relief.

Ensure that splice enclosures are hermetically sealed to protect internal components from environmental hazards such as moisture, insects, and UV light. Fiber optic splice enclosures shall also:

Comply with the Telcordia Technologies' GR-771-CORE standard and all applicable NEC requirements.

Provide space for future expansion equal to 100% of the initial utilization.

Provide fiber optic cable penetration end caps to accommodate a minimum installation of two trunk fiber optic cables and two fiber optic drop cables. Ensure that the enclosure end caps are factory-drilled to the proper diameter to accept and seal the fiber optic cable entries. Ensure that the cable entry locations can accommodate an assortment of cables with outside diameters ranging from 0.45 inch to 0.75 inch, plus 10%, without jeopardizing the waterproof characteristics of the enclosure.

Ensure that splice enclosures are permanently labeled using machine printed, waterproof labels suitable for outside plant applications.

633-2.1.2.2 Splice Trays: Ensure that splice trays are securely attached and accessible, and provide sufficient storage for the fiber cable. Ensure splice trays provide access to individual fibers without disrupting other fibers in the tray. Ensure that splice trays hold the buffer tubes rigidly in place and provide protection for fusion splices. Ensure that the raceway accommodates the minimum bend radius of the fiber. Ensure that splice trays allow visible inspection of the fiber. Ensure that splice trays include a cover with a locking mechanism to hold it in place.

633-2.1.3 Cable Terminations: Use Type LC connectors for all new network installations. Use Type ST, SC, or FC connectors only for connections to existing equipment or as specified in the Plans or by the Engineer. Use ultra physical contact (UPC) pre-terminated cable assemblies with factory-installed connectors for all new network installations. Use UPC field-installed connectors only for connections or temporary repairs to existing equipment as specified in the Plans or by the Engineer. Ensure that all connectors include a ceramic ferrule and provide a strain relief mechanism when installed on a single fiber cable that contains strength elements. Ensure that ST and FC connectors include a metallic body. Ensure that all connectors provide a minimum 11 pound pullout strength. Ensure that the optical fiber within the body of all connectors is mechanically isolated from cable tension, bending, and twisting.

Ensure that all connectors are compliant with the TIA/EIA-604 standards, as applicable, and are tested according to the Telcordia/Bellcore GR-326-CORE standard. When tested according to the TIA and EIA's Fiber Optic Test Procedure (FOTP)-171 (TIA/EIA-455-171B) at the manufacturer, ensure that the connectors have an insertion loss, as reflected on the manufacturer data sheet, less than or equal to 0.30 decibel for pre-terminated cable assemblies with factory-installed connectors and a maximum loss of less than or equal to 0.50 decibel for field-installed temporary connectors. Test the connectors as detailed in FOTP-107 (TIA -455-107A) to reflectance values of less than or equal to minus 45 decibels.

633-2.1.3.1 Pre-terminated Connector Assemblies (Pigtails): Ensure that pre-terminated cable assemblies consist of fiber optic cables with factory-installed connectors on one end of the cable and an un-terminated optical fiber on the other. Ensure that the pre-terminated connector assemblies are installed with fusion splices. Ensure that all buffer tubes and fibers are protected once the attachment of pre-terminated connector assemblies is complete.

633-2.1.3.2 Buffer Tube Fan-out Kits: Ensure that a buffer tube fan-out kit is installed when fiber optic cables are terminated. Use a kit compatible with the fiber optic cable being terminated and that is color-coded to match the optical fiber color scheme. Ensure that the buffer tube fan-out kit supports 12 fiber strands. Ensure that output tubing and the fiber strands contained therein are of sufficient length for routing and attachment of fiber optic cable to connected electronics or as directed by the Engineer. Ensure that the kit and the connectors are supplied by the same manufacturer.

633-2.1.4 Patch Panels: Ensure that the patch panel is compatible with the fiber optic cable being terminated and color coded to match the optical fiber color scheme. Ensure that the patch panel has a minimum of 12 LC-type panel connectors unless otherwise shown in the Plans. Ensure that the patch panel dimensions do not exceed 14 inches x 6 inches x 4 inches for fiber counts of twelve or less. Ensure the patch panel is suitable for mounting within an approved cabinet at the field device location. Ensure patch panels are sized to accommodate specified coupler housings and maintain sufficient bend radius for cables. Ensure the patch panel is sized to occupy the minimum space required for capacity.

633-2.1.4.1 Pre-terminated Patch Panels: Ensure that the pre-terminated patch panel includes a factory installed all-dielectric SMF cable stub. Ensure that the panel includes factory installed and terminated LC-type panel connectors unless otherwise shown in the Plans. Ensure that the cable stub is of sufficient length to splice the stub and provide a fiber connection between the panel and the backbone fiber cable or as directed by the Engineer.

633-2.1.4.2 Field Assembled and Terminated Patch Panels: Ensure that the field-assembled patch panel is a termination panel that includes a connector panel and the

hardware required to mount the patch panel within an approved cabinet at the field device location and connect the panel to the backbone fiber cable.

633-2.1.4.2.1 Connector Panel: Ensure that the connector panel provides 12 LC-type, bulkhead-mount coupling connectors unless otherwise shown in the Plans. Ensure that each coupling connector allows connection of a cable terminated on one side of the panel to a cable on the opposite side.

Ensure that each bulkhead-mount coupling connector includes a locknut for mounting the connector in predrilled or punched holes in the connector panel.

633-2.1.5 Fiber Optic Jumper Cables: Ensure that the fiber optic jumper cables include a factory installed all-dielectric SMF. Ensure that the fiber optic jumper cables include factory installed and terminated LC-type connectors, a connector type shown in the plans, or a connector type directed by the Engineer.

633-2.1.6 Handling:

633-2.1.6.1 Cable End Sealing: Ensure that fiber optic cable ends are capped or sealed to prevent the entry of moisture during shipping, handling, storage, and installation. Equip one end of the fiber optic cable with flexible pulling eyes.

633-2.1.6.2 Protective Wrap: Ensure that the fiber optic cable is shipped and stored with a protective wrap or other approved mechanical reel protection device over the outer turns of the fiber optic cable on each reel. Ensure that the wrap is weather resistant and protects the cable reel from environmental hazards. Ensure that the cable reel remains wrapped until cable is to be installed.

633-2.1.6.3 Packaging, Shipping and Receiving: Ensure that the packaging and delivery of fiber optic cable reels comply with the following minimum requirements:

1. Ensure cable is shipped on reels of marked continuous length.
2. Ensure each cable is shipped on a separate, strongly constructed reel designed to prevent damage to the cable during shipment and installation.
3. Ensure each reel has a minimum of 6 feet on each end of the cable available for testing.
4. Ensure that all fiber optic cable is continuous and free from damage.
5. Ensure no point discontinuities greater than 0.1 decibel per reel.
6. Submit the transmission loss test results as required by the TIA-455-78 standard, as well as results from factory tests performed prior to shipping.
7. Ensure that the manufacturer submits the date of manufacture; product and serial numbers; cable data, including the reel length; refraction index; the project name and location; type of fiber and quantity of strands used; technical product data sheets; and reel numbers.

633-2.1.7 Manufacturer Testing and Certification: Submit documentation of all factory tests performed by the manufacturer for all fiber optic cable, splicing material, cable terminations, and patch panels.

633-2.2 Twisted Pair Cable: Use shielded underground and aerial cable. Underground and aerial cables include telephone cables and multiconductor communication cables.

633-2.2.1 Aerial Cable Support Wire: Meet the requirements of 632-2.2.

633-2.2.2 Aerial Cable Attachment Hardware: Meet the requirements of 632-2.3.

633-2.2.3 Telephone Cable: Use aerial telephone cable with separate support wire conforming to Rural Electrification Administration (REA) Specification PE-39, filled telephone cables. Aerial telephone cable must comply with REA Specification PE-38, aerial telephone cables. Use only No. 22 AWG solid cables for copper connections in traffic signal closed loop systems.

Use underground telephone cable conforming to the United States Department of Agriculture (USDA), Rural Utilities Service (RUS) Bulletin 1753F-205 (PE-39), "REA Specification for Filled Telephone Cables".

633-2.2.4 Multiconductor Cable: Multi-conductor communication cable is used to carry communication and electrical signals between equipment, including Ethernet data or serial data, low voltage power, and may also be used to energize signaling equipment as part of signaling circuits.

633-2.2.4.1 Category 6 Cable: Use polyethylene jacketed Category 6 (CAT 6) cable conforming to the requirement of TIA 568 C.2 with Edison Testing Laboratories (ETL) verification. Cables run outside of equipment enclosures must be shielded cable (F/UTP) using an aluminum foil shield with drain wire and solid copper conductors, and shall be terminated with shielded RJ-45 connectors. Cable which remains within the equipment enclosure where it originates may be un-shielded twisted pair (UTP), include stranded copper conductors, and be terminated with un-shielded RJ-45 connectors. Use straight-through cables when connecting data terminating equipment (DTE) to data communications equipment (DCE), and cross-over cables when connecting DTE to DTE or DCE to DCE. For RJ-45 connector color coding: use TIA T-568B connectors as the standard configuration for straight-through cables and use TIA T-568B on one end and TIA T-568A on the other end for cross over cables.

633-2.2.4.2 Composite Cable: Composite cable consists of multiple conductors and cables housed within a single overall UV resistant polyethylene or polyvinyl jacket. The composite cable must carry communication and power to equipment using the type, number of conductors, and wire gauges as shown in the Plans and recommended by the equipment manufacturer. The cable must include an overall metallic shield with drain wire or individual shields with drain wires for each conductor.

633-3 Installation Requirements.

633-3.1 Fiber Optic Cable Installation: Install all materials and equipment according to the latest version of the manufacturer's installation procedures. Ensure that all materials and installation practices are in accordance with the applicable OSHA requirements as found in 29 CFR Part 1926, Safety and Health Standards for Construction. In addition, perform the following:

1. Ensure conduit and inner-duct is clean and free from damage prior to installing fiber optic cable.

2. Document the sequential cable length markings at each splice box and pull box wall that the cable passes through and include the information with the as-built documentation.

Provide all incidental parts needed to complete the installation, but not specified in the Plans, as necessary for a complete and properly operating system.

633-3.1.1 Cable Identification: Develop a nomenclature plan for identification of fiber optic cable. Submit the nomenclature plan to the Engineer for approval. Use approved

cable nomenclature to create cable tags for the identification of fiber optic cable. Provide cable tag identification on all test results or fiber related documents submitted to the Engineer.

Install cable tags within 1 foot of each splice and/or termination point indicating the cable type, fiber count, and each fiber optic cable origination and termination points. Ensure that the cable tags are machine printed, waterproof, and permanent labels suitable for outside plant applications and are affixed to all fiber optic cables. Ensure that lettering is in permanent ink and displays the phrase “FDOT FIBER OPTIC CABLE”.

633-3.1.2 Pulling: Install the fiber optic cable by hand or by using a mechanical pulling machine. If a mechanical pulling machine is used, equip the machine with a monitored or recording tension meter. Ensure that at no time the manufacturer’s recommended maximum pulling tension is exceeded. Ensure that the central strength member and aramid yarn are attached directly to the pulling eye during cable pulling. Use pulling attachments, such as “basket grip” or “Chinese finger” type, to ensure that the optical and mechanical characteristics are not degraded during the fiber optic cable installation.

Ensure that excess cable is coiled in a figure eight and fed manually when pulling through pull boxes and splice boxes by hand. If pulleys and sheaves will be used to mechanically pull through pull boxes and splice boxes, submit a drawing of the proposed layout showing that the cable will never be pulled through a radius less than the manufacturer’s minimum bend radius. Use large diameter wheels, pulling sheaves, and cable guides to maintain the appropriate bend radius. Provide tension monitoring at all times during the pulling operation. Ensure that cable pulling lubricant used during installation is recommended by the optical fiber cable manufacturer.

633-3.1.3 Blowing: Use either the high airspeed blowing (HASB) method or the piston method. When using the HASB method, ensure that the volume of air passing through the conduit does not exceed 600 cubic feet per minute or the conduit manufacturer’s recommended air volume, whichever is more restrictive. When using the piston method, ensure that the volume of air passing through the conduit does not exceed 300 cubic feet per minute or the conduit manufacturer’s recommended air volume, whichever is more restrictive.

633-3.1.4 Slack Cable Storage: Provide and store fiber optic cable at each pull box and splice box to allow for future splices, additions, or repairs to the fiber network. Store the fiber optic cable without twisting or bending the cable below the minimum bend radius.

Store a total of 200 feet of fiber optic backbone cable in splice boxes, with 100 feet of cable on each side of the cable splice point or as shown in the Plans.

Store a minimum of 100 feet of fiber optic drop cable in splice boxes or as shown in the Plans.

Store 50 feet of spare fiber optic cable in pull boxes.

633-3.1.5 Fiber Optic Connection - Splicing: Perform all optical fiber splicing using the fusion splicing technique, and according to the latest version of the manufacturer’s cable installation procedures; industry accepted installation standards, codes, and practices; or as directed by the Engineer. Ensure that all splices match fiber and buffer tube colors unless shown otherwise in the Plans. Ensure that splice loss does not exceed a maximum of 0.05 db per splice as measured on the fusion splice machine when splicing newly installed fibers together. Ensure that splice loss does not exceed a maximum of 0.1 db per splice as measured on the fusion splice machine when splicing newly installed fibers to existing fibers. Where a fiber cable is to be accessed for lateral or drop signal insertion, only open the buffer tube containing the fiber to be accessed and only cut the actual fiber to be accessed. If a fiber end is not intended for use, cut the

fiber to a length equal to that of the fiber to be used and neatly lay it into the splice tray. Treat any fibers exposed during splicing with a protective coating and place in a protective sleeve or housing to protect the fiber from damage or contaminants. Neatly store all splice enclosures within a splice box. Attach the splice enclosure to the splice box interior wall to prevent the enclosure from lying on the bottom of the splice box. Splices shall be performed only at locations as shown in the plans, or as approved by the Engineer.

633-3.1.5.1 Splice Plan: Submit a splice plan showing the location and configuration of splices in the system for approval by the Engineer. Perform all splicing according to the splice plan. Document each splice location and identify the source and destination of each fiber in each splice tray. Document all fiber colors and buffer jacket colors used during installation, and develop a sequential fiber numbering plan as required in the TIA - 598-D standard for color-coding in the documentation.

633-3.1.5.2 Splice Equipment: Use a fusion splice machine to splice all optical fiber. Ensure that splice equipment is new from the factory, or serviced and certified by the factory or its authorized representative within the previous 12 months from the commencement of its use. Ensure that the calibration certificate is maintained in the splicing equipment case or provided electronically when requested. Submit to the Engineer documentation from the manufacturer or his authorized representative certifying compliance. Clean all splicing equipment and calibrate according to the manufacturer's recommendations prior to each splicing session at each location.

633-3.1.6 Cable Termination Installation: Ensure that fiber optic cables, buffer tubes, and strands are neatly routed, secured, and terminated in a patch panel. Ensure every fiber strand within all fiber drops terminating in field cabinets are terminated in a connector panel using LC connectors unless otherwise shown in the Plans. Ensure all cable termination points include documentation regarding the identification, route, and function of each fiber installed at that location. Ensure that a copy of this information is placed alongside the installed equipment (for instance, in a document pouch or drawer within a field cabinet).

633-3.1.7 Patch Panel Installation: Ensure that patch panels are neatly installed and secured in a weatherproof enclosure. Ensure all patch panel connectors are clearly and permanently labeled using machine printed, waterproof labels suitable for outside plant applications. Ensure all installed patch panels include documentation regarding the identification, route, and function of each patch panel connector at that location. Ensure that a copy of this information is placed alongside the installed equipment in a document pouch or drawer within the cabinet.

633-3.1.8 Installation Testing: Notify the Engineer of cable testing at least 14 calendar days in advance. Submit the testing procedures to the Engineer for approval prior to commencement of testing. Perform all tests at 1,310 and 1,550 nanometer wavelengths and include the last calibration date of all test equipment with the test parameters set on the equipment in the test documentation. Ensure that the last calibration date of all test equipment is within the last 12 months and that the calibration certificate is maintained in the test equipment case or provided electronically when requested. Test all installed fibers (terminated and un-terminated) using methods identified in this Section. All tests must be conducted with a launch box.

Fibers containing splices, fibers terminated on both ends, terminated on one end, or backbone fibers (inside project limits and continuing outside of project limits) must be bidirectionally tested.

Drop fibers without splices (inside project limits and continuing outside of project limits), with only terminations on one end, and bare fiber on the other must be tested unidirectionally at a minimum, unless otherwise specified in the Contract Documents.

Drop fibers without splices which are unterminated on both ends (inside project limits and continuing outside of project limits) must be tested using a bare fiber adapter and tested unidirectionally at a minimum, unless otherwise specified in the Contract Documents.

Present the results of the OTDR testing (i.e., traces for each fiber) and a loss table showing details for each splice and termination tested to the Engineer in an approved electronic format. Ensure all OTDR testing complies with the EIA/TIA-455-78 standard.

633-3.1.8.1 Optical Time Domain Reflectometer (OTDR) Attenuation Testing: Perform testing on all fibers to ensure that attenuation does not exceed allowable loss (0.35 db/km for 1310 nanometer wavelength, 0.25 db/km for 1550 nanometer wavelength, plus 0.5 db for any connectors and 0.1 db for splices). Repair or replace cable sections exceeding allowable attenuation at no cost to the Department.

633-3.1.8.1.1 OTDR Tracing: Test all fibers with an optical time domain reflectometer (OTDR) at wavelengths of 1310 and 1550 nanometer.

633-3.1.8.1.2 Splice Loss Testing: Ensure that the splice loss for a SMF fusion splice does not exceed a maximum bidirectional average of 0.1 decibel per splice when measured using an OTDR. Repair or replace splices that exceed allowable attenuation at no cost to the Department.

633-3.1.8.1.3 Connector Loss Testing: Ensure that the attenuation in the connector at each termination panel and its associated splice does not exceed 0.6 decibel when measured using an OTDR. Repair or replace connectors exceeding allowable attenuation at no cost to the Department.

633-3.2 Twisted Pair Cable Installation: Install all materials and equipment according to the latest version of the manufacturer's installation procedures.

Ensure cable drawn through conduit, ducts, drilled holes is protected by a rubber grommet, and is installed in a manner that prevents damage to conductors or insulation. Ensure all connections to outdoor equipment are weatherproof and prevent water intrusion into equipment, connections, and cable entrances. Cables exposed to the elements must be rated for outdoor use.

633-3.2.1 Cable type and Number of Conductors: Determine the appropriate cable type and conductor count required for each twisted pair communication cable unless specified in the Contract Documents. Identify all spare conductors.

633-3.2.2 Number of Cables: Do not install more than four separate cables at any point on a single support wire.

633-3.2.3 Telephone Cable: Install telephone cables in continuous lengths to and between cabinets and junction boxes. The Contractor may install junctions at intervals less than shown in the Plans; however, the Contractor must provide any additional materials (such as junction boxes, cabinets, risers, and mounting hardware) and labor for additional junctions and terminations at no expense to the Department. Obtain the Engineer's approval for any additional junctions or terminations.

633-3.2.4 Multiconductor Cable: Install multi-conductor communication cable in continuous lengths between cabinets and from cabinets to devices. Separate multi-conductor communication cables from high voltage conductors. Keep cable on the unprotected side of

surge suppression devices separate from cable on the protected side to prevent induction of lightning and other high voltage transient currents.

633-3.2.5 Surge Protective Devices: Install surge protective devices meeting the requirements of Section 620 on cables entering cabinets or enclosures, and as shown in the Plans, prior to connection of Ethernet switches, PoE injectors, or other equipment.

633-4 Warranty.

Ensure that the fiber optic cable, the enclosures, terminations, and twisted pair cables and connectors have a manufacturer's warranty covering defects for a minimum of 2 years from the date of final acceptance. Ensure the warranty includes providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

633-5 Fiber Optic Cable Locator.

Locate and mark all existing Department owned or maintained fiber optic facilities within project limits prior to performing any subsurface work.

Locate and mark as necessary to ensure that all fiber optic facilities are located and visibly marked at all times.

633-6 Method of Measurement.

The quantities to be paid will be: the length, in feet, of fiber optic cable; the number, per each, of fiber optic connections; the number, per each, of fiber optic connection hardware; the number of calendar days from contract time start to final acceptance for fiber optic cable locator; the length, per foot, of telephone cable; and the length, per foot, of multi-conductor communication cable accepted by the Engineer.

The Contract unit price for communication cable, furnished and installed, will include furnishing, placement, and testing of all material, and for all tools, labor, equipment, installation hardware (such as support wire, cable ties, cable clamps, and lashing wire), supplies, support, personnel training, documentation, and incidentals necessary for a complete installation.

Payment for conductive cable terminal connectors and conductive cable grounding is considered incidental and shall be included in the price for twisted pair communication cable.

Fiber optic splices and terminations, as shown in the Plans, shall be measured per each fiber optic connection furnished and installed.

The price per day for a Fiber Optic Cable Locator will include all tools, labor, equipment, locating and marking hardware (such as flags, paint, and shovels), supplies, support, personnel training, documentation, and incidentals.

633-7 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 633- 1	Fiber Optic Cable - per foot.
Item No. 633- 2	Fiber Optic Connection - each.
Item No. 633- 3	Fiber Optic Connection Hardware - each.
Item No. 633- 4	Telephone Cable - per foot.
Item No. 633- 6	Fiber Optic Cable Locator - per day.
Item No. 633- 8	Multi-Conductor Communication Cable – per foot.

SECTION 634
SPAN WIRE ASSEMBLY

634-1 Description.

Install a span wire assembly for supporting traffic signals, signs, and other traffic control devices. Provide fiberglass insulators when required.

634-2 Materials.

634-2.1 General Requirements: For a single point attachment, use only a catenary wire to support the imposed dead and wind load from the attached signs and traffic signals. For a single point attachment, the catenary wire also supports the signal conductor cables and interconnect cables.

For a two point attachment, the catenary wire is used to support the imposed dead load and a portion of the imposed wind load from the attached signs and traffic signals. The two point attachment also includes a messenger wire to resist a significant portion of the imposed wind load and to support the signal conductor cables and interconnection cables.

Use a tether wire for maintaining the alignment of signal heads when specified in the Plans.

634-2.2 Wires: For span wire assemblies, only use wire cables of seven-wire strands manufactured and provided with a Class A zinc coating in accordance with ASTM A475.

Provide utility grade catenary or messenger wires. The Contractor may use Siemens-Martin grade tether wires. Meet the following additional requirements for span wire assembly strands:

Table 634-1
Additional Requirements for Span Wire Assembly Strands

Span Wire Assembly Strand Type	Nominal Diameter Inch	Required Minimum Breaking Strength Pounds
Catenary Wire or Messenger Wire *	3/8 7/16 1/2	11,500 18,000 25,000
Tether Wire	3/16	1,900

*Supply catenary or messenger wire of the nominal diameter as specified in the Contract Documents.

634-2.3 Hardware and Fittings: For utility or Siemens-Martin grade wires, use the connection hardware as specified herein. For installations that use other grades of wire, provide the hardware and fittings indicated in the Plans. Provide only hardware and fittings made of galvanized steel or non-corrosive metal unless the fiberglass insulators specified in 634-2.4 are also required. Provide hardware and fittings of sufficient strength to resist the breaking strength of the wire with which they are used.

Use an alloy steel eyebolt meeting the requirements of ASTM F541, Type 2 and a matching heavy hex nut meeting the requirements of ASTM A563, Grade C or D, to connect the automatic compression dead-end clamp of the catenary wire or messenger wire to the wood or concrete strain poles. Eyebolts and hex nuts must be zinc coated in accordance with ASTM A153, Class C. Sizes of eyebolts, supplied with nuts and washers, are as following: Use a

3/4 inch diameter bolt for maximum of one 7/16 inch diameter catenary or messenger wire, or maximum of two 3/8 inch diameter catenary or messenger wires. Use a 1 inch diameter bolt for maximum of one 1/2 inch diameter catenary or messenger wire, or maximum of two 7/16 inch diameter catenary or messenger wires. Use 1-1/4 inch diameter bolt for maximum of two 1/2 inch diameter catenary or messenger wires. For two point attachments, connect the messenger wire at the lower attachment location. Do not use thimble eye bolts for these connections.

Only use thimble eye and eye bolts, 3/4 inch in diameter, minimum, to connect the automatic compression dead-end clamps of tether wires to wood or concrete strain poles.

Only use "S" hooks, 5/16 inch in diameter, minimum, when connecting the tether wire to all poles.

Ensure that other hardware and fittings, as required for the attachment of a span wire assembly to support poles or structures, are in accordance with the details shown in the Standard Plans.

Furnish and install new catenary and messenger wire clamps for steel strain pole s when existing poles are to remain and the span wire assemblies will be replaced or modified.

634-2.4 Fiberglass Insulators: Install fiberglass insulators of the length specified in the Plans on span wire assemblies located within 6 feet of overhead electric power lines.

Use a fiberglass insulator of a cylindrical shape, fabricated from epoxy-resin impregnated fiberglass strands and having a breaking strength 50% greater than that of the structural support wire to which it is to be attached. Equip the insulator with thimble eye fittings on each end for attachment of the wire. Furnish all fittings and hardware necessary for the complete installation with the insulator and ensure that such fittings and hardware are of at least equal strength to the insulator.

634-2.5 Cable Attachment Hardware: Meet the requirements of 632-2.3.

634-3 Installation Requirements.

634-3.1 Span Wire Assembly Types: Use either of the following span wire assemblies as shown in the Contract Documents:

1. Single Point Attachment Assembly: This type of assembly requires a catenary wire with an optional tether wire if specified in the Plans.

2. Two Point Attachment Assembly: This type of assembly requires a catenary wire, a messenger wire and an optional tether wire if specified in the Plans.

634-3.2 Span Types: Install span wire assemblies on the following span types:

1. Perpendicular Span: Use this type span at an intersection to support a single span wire assembly upon which traffic signals, signs, and other traffic control devices are attached. Attach the span wire assembly to two support poles or structures, located on opposite sides of the roadway, and extend the assembly across the roadway at an angle of approximately 90 degrees to the roadway approach.

2. Diagonal Span: Use this span type at an intersection to support a single span wire assembly upon which traffic signals, signs, and other traffic control devices are attached. Attach the span wire assembly to two poles, located in opposite quadrants of the intersection, and extend the assembly across the intersection at an angle of approximately 45 degrees to the approach lanes of the intersection. Locate traffic control devices for all approaches at appropriate locations on the span wire assembly.

3. Box Span: Use this span type at an intersection to support a perimeter system of four span wire assemblies upon which traffic signals, signs and other traffic control devices for

each approach to the intersection are attached. Attach the span wire assembly to four poles, one located in each quadrant of the intersection, and extend each span wire between two poles at an angle of approximately 90 degrees to the roadway approaches. Place traffic control devices for an approach on the span wire on the far side of the intersection.

4. Special Design Span or Suspended Box Span: Use this span type to support two or more span wire assemblies upon which traffic signals, signs and other traffic control devices for one or more roadway approaches are attached. Attach the span wire assembly to three or more poles.

634-3.3 General Requirements: Provide a span wire assembly with catenary, messenger and tether wires of one continuous length of wire cable with no splices except when an insulator is required by 634-2.4. Connect the insulator, if required, to the cable with automatic compression dead-end clamps.

Attach the span wire assemblies to the support poles or structures by means of automatic compression clamps and accessory hardware.

Assemble the washer and nut on the oval eye bolt with the flat washer next to the pole. Tighten the nut sufficiently to prevent the oval eye bolt from rotating.

For two point attachments, install the messenger wire with the following tensions per 100 feet. Linearly prorate cable tensions for other lengths from these values:

Table 634-2
Two Point Attachment Tension Requirements per 100 Feet

Cable Size Inch	Wire Tension Lbs.
3/8	340.0
7/16	500.0
1/2	645.0

The catenary wire shall be tensioned to provide a 5%, plus or minus 0.5% sag.

Install the span wire assemblies in accordance with Standard Plans, Index 634-001, and at a height on the support poles which will provide a clearance from the roadway to the bottom of the signal head assemblies in accordance with 650-3.

Connect all span wires to the pole grounding system in accordance with Section 620.

Obtain and meet all provisions of the National Electric Safety Code (ANSI-C2) regarding clearance from electric lines, contacting of utility owners, and safety requirements prior to span wire installation.

Prior to installation of the two point attachment span wire assembly, submit the method of providing the required tension in the messenger wire to the Engineer for approval.

634-4 Method of Measurement.

The Contract unit price per intersection for span wire assembly and per foot of fiberglass insulator, furnished and installed, between supporting poles and structures will include furnishing all materials and hardware as required in 634-2, and all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation.

634-5 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section. When a tether wire is specified in the Plans, the payment of the tether wire shall be included in the compensation for the span wire assembly.

Payment will be made under:

Item No. 634- 4- Span Wire Assembly - per intersection.

Item No. 634- 5- Fiberglass Insulator - per foot.

SECTION 635
PULL, SPLICE, AND JUNCTION BOXES

635-1 Description.

Furnish and install pull, splice, and junction boxes as shown in the Plans.

635-2 Materials.

635-2.1 General: Use pull and splice boxes listed on the Department's Approved Product List (APL).

635-2.2 Pull and Splice Boxes:

635-2.2.1 General: Use only boxes that meet the requirements of Section 996 and are listed on the Department's Approved Product List (APL). Ensure box bodies and covers are free of flaws such as cracks, sharp, broken, or uneven edges, and voids.

Ensure in-ground boxes have an open bottom design.

635-2.2.2 Marking: Mark boxes in accordance with 996-5.

635-2.2.3 Dimensions: Unless otherwise shown in the Plans, provide pull and splice boxes with dimensions in accordance with 996-5.

635-2.3 Junction Boxes:

635-2.3.1 Fabrication: Provide galvanized steel, aluminum or NEMA 4X non-metallic junction boxes. Ensure all attachment hardware is Type 316 or 304, passivated stainless steel.

Ensure the outside surface has a smooth, uniform finish. Ensure boxes are free of burrs, pits, sharp corners and dents. Ensure all welds are neatly formed and free of cracks, blow holes, and other irregularities.

635-2.3.1.1 Aerial Junction Boxes: Unless otherwise shown in the Plans, provide aerial junction boxes with minimum inside dimensions of 8 inches wide by 8 inches long and at least 3 inches deep.

635-2.3.1.2 Mounted Junction Boxes: Provide mounted junction boxes fabricated of 5052 sheet aluminum alloy with a minimum thickness of 1/8 inch. Ensure all mounted junction boxes have a hinged door and lock as specified in Section 676.

Unless otherwise shown in the Plans, provide mounted junction boxes for the following installations:

For pole and cabinet mounted installations, provide junction boxes with minimum inside dimensions of 13 inches long by 10 inches wide and at least 3 inches deep.

For base mounted installations, provide junction boxes with minimum inside dimensions of 21 inches long by 10 inches wide and at least 8 inches deep.

635-2.3.1.3 Embedded Junction Boxes: Provide weatherproof embedded junction boxes for use in concrete structures or traffic railings. Include gasketed weatherproof covers made of the same material as the box and stainless steel, tamper resistant screws for securing the cover. Fabricate galvanized steel boxes and their covers from steel meeting the requirements of ASTM A36 and galvanized in accordance with ASTM A123.

For embedded junction boxes not exposed to vehicular impacts, provide the following types of junction boxes. Where the structure's environmental classification is slightly or moderately aggressive, provide a galvanized steel or NEMA 4X (non-metallic) box,

as approved by the Engineer. Where the structure's environmental classification is extremely aggressive, provide a NEMA 4X (non-metallic) box, unless otherwise directed by the Engineer.

For embedded junction boxes exposed to vehicular impacts, provide a galvanized steel box regardless of the structure's environmental classification.

635-2.3.2 Barrier Terminal Blocks: Provide a barrier terminal block with a minimum of ten positions and rated at 600 V_{AC} in all aerial and mounted junction boxes. Ensure each terminal block position has two screws electrically connected by a shorting bar or other Department approved method. Ensure all terminal block positions are numbered sequentially.

635-3 Installation.

635-3.1 General: Do not install power and communication cables in the same box unless otherwise shown in the Plans.

When signal or 120 volt (or greater) power is present, ground all metal covers in accordance with Section 620.

Ensure metal junction boxes are grounded and bonded in accordance with the NEC Section 314.4.

635-3.2 Pull and Splice Boxes: Install pull and splice boxes in accordance with Standard Plans, Index 635-001. Ensure pull and splice boxes are sized for the amount of cable to be placed inside. Ensure that the pull or splice box cover is flush with the concrete apron or sidewalk. Do not install pull or splice boxes in roadways, driveways, parking areas, or public sidewalk curb ramps. Avoid placing pull and splice boxes in low-lying locations with poor drainage. Ensure that pull and splice boxes house fiber optic cable without subjecting the cable to a bend radius less than 14 times the diameter of the cable. Install identification plates according to the box manufacturer's instructions.

635-3.2.1 Placement and Spacing: Place pull and splice boxes as shown in the Plans and at the following locations, unless directed otherwise by the Engineer:

1. At all major fiber optic cable and conduit junctions.
2. Approximately every 2,500 feet for fiber optic cable applications in rural areas with any continuous section of straight conduit if no fiber optic cable splice is required.
3. At a maximum of 1,760 feet for fiber optic cable applications in metropolitan areas.
4. At a maximum of 500 feet for electrical applications.
5. At each end of a tunnel, and on each side of a river or lake crossing.
6. On each side of an aboveground conduit installation, such as an attachment to a bridge or wall.
7. At all turns in the conduit system.
8. Near the base of a service pole or communication cabinet to provide:
    a. A transition point between the fiber optic conduits extending from the fiber backbone and the conduit feeding the communication cabinet.
    b. An assist point for the installation of fiber optic drop cable.
    c. Storage of slack fiber optic drop cable.

635-3.2.2 Electronic Box Marker: Equip all pull and splice boxes buried below finish grade with an electronic box marker inside the pull or splice box to mark the location. Ensure that the electronic box marker is a device specifically manufactured to electronically mark and locate underground facilities. Ensure that the electronic box marker includes circuitry and an antenna encased in a waterproof polyethylene shell. Ensure that the outer shell is

impervious to minerals, chemicals, and temperature extremes normally found in underground plant environments. Ensure that the electronic box marker does not require any batteries or active components to operate. Ensure that electronic box markers used to mark fiber optic cable and general telecom applications are orange in color and operate at 101.4 kHz. Ensure that the electronic box marker's passive circuits produce an RF field when excited by a marker locator to direct the locator to the marker's position. Ensure that the electronic box marker has a minimum operating range of 5 feet from the marker locator.

635-3.3 Aerial Junction Boxes: Install aerial junction boxes in accordance with Standard Plans, Index 634-002.

635-3.4 Mounted Junction Boxes: Install mounted junction boxes in accordance with Standard Plans, Index 676-010. Ensure that the bottom surface of pole mounted junction boxes is a minimum of 4 feet above the finished grade.

635-3.5 Cable Terminations: Make cable terminations in junction boxes in accordance with Section 632. Route and form the cable to allow access to the terminal screws. Do not cover the terminal identification numbers with the cable.

635-4 Relocation of Pull, Splice, and Junction Boxes.

Relocation of pull, splice, and junction boxes shall consist of removing an existing box and installing the box at the location shown in the Plans. Restore the area of the box removal and relocation to the condition of the adjacent area. The costs for restoration will be included in the Contract unit price of the relocation.

Boxes damaged due to the Contractor's operations must be replaced by the Contractor at no cost to the Department. Replacement boxes must be of the same material and size of the existing box, unless directed otherwise by the Engineer.

635-5 Warranty.

Ensure all pull, splice, and junction boxes have a manufacturer's warranty covering defects for a minimum of one year from the date of final acceptance in accordance with 5-11 and Section 608. Ensure the warranty includes providing replacements, within 30 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

635-6 Method of Measurement.

The Contract unit price each for pull, splice, and junction box, furnished and installed, will consist of the pull, splice, and junction box including all required hardware for the type of box and location as specified in the Contract Documents, and all labor and materials necessary for a complete and accepted installation.

635-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, except grounding.

No separate payment will be made for the removal of pull, splice, and junction boxes.

Payment will be made under:

Item No. 635- 2- Pull and Splice Boxes - each.
Item No. 635- 3- Junction Boxes - each.

SECTION 639
ELECTRICAL POWER SERVICE ASSEMBLIES

639-1 Description.

Power service assemblies are utilized for signals, lighting, ITS, and other roadway applications. Install electrical power service assemblies for either overhead service or underground service in accordance with the details shown in Standard Plans, Index 639-001 or 639-002.

Coordinate with the power company to provide electrical service to the locations shown in the Plans. Consult and cooperate with the power company when power is needed at the service point. Furnish and install only those parts of the metering equipment or connections that are required by the power company in the locality involved.

639-2 Definitions.

1. Overhead Service: A service assembly which is supplied electrical power from an overhead power company source. Include with an overhead electrical power service assembly the following components:
    a. Weatherhead
    b. Conduit
    c. Electrical Service wire
    d. Meter base (when required)
    e. Service disconnect
    f. Surge Protective Device
2. Underground Service: A service assembly which is supplied electrical power from an underground power company source. Include with an underground electrical power service assembly the following components:
    a. Conduit
    b. Electrical Service wire
    c. Meter base (when required)
    d. Service disconnect
    e. Surge Protective Device

639-3 Materials.

639-3.1 Weatherhead: Use a weatherhead made of a copper free aluminum alloy with three electrical service wire entrance holes, meeting National Electric Code (NEC) requirements.

639-3.2 Conduit: Use conduit meeting the requirements of Section 630. Meet the requirements of Section 562 for coating all field cut and threaded galvanized pipe.

639-3.3 Electrical Service Wire: For signal and ITS service points, use stranded copper wire with XHHW (cross-linked polyethylene (XLPE) high heat-resistant, water-resistant) insulation, rated at 600 V in dry and wet conditions, no smaller than No. 6 AWG for connections between service disconnect and traffic and ITS cabinets, unless otherwise shown in the Plans.

For lighting service points, use single-conductor cable Type THWN-2 no smaller than No. 6 AWG for connections between service disconnect and load center.

639-3.4 Meter Base: Use meter bases approved by the local electric power company.

639-3.5 Service Disconnect:

639-3.5.1 Enclosure (Cabinet): Use an enclosure conforming to National Electrical Manufacturers Association (NEMA) Standards for Type 3R, Type 3S or Type 4, made of galvanized steel, aluminum, stainless steel or other materials approved by the Engineer. Ensure that the enclosure has a hinged door which can be locked with a padlock. Provide padlock and two keys. Do not use external handles or switches. Ensure that the inside dimensions meet NEC requirements.

639-3.5.2 Circuit Breaker: Use a manually resettable circuit breaker which has a current rating above the current rating of the circuit breaker to which electrical power is provided. Do not use less than a 40A circuit breaker.

639-3.6 Surge Protective Device: Use a lightning arrester rated for a maximum permissible line to ground voltage of 175 V_{AC}.

639-3.7 Electrical Power Transformer: Provide a dry type, air-cooled, factory assembled transformer. All units must be UL listed under the requirements of UL 5085 and UL 1561, IEEE Standard 259, and meet the requirements of NEMA ST-20. Provide transformers for the primary and secondary voltages indicated on the Plans. Provide two 2.5% full capacity below normal taps and two 2.5% above normal taps on the primary side. All taps are full capacity taps.

639-3.7.1 Enclosure: Use an enclosure conforming to NEMA Standards for Type 3R, made of hot-dip galvanized steel, aluminum, stainless steel or other materials approved by the Engineer.

639-3.7.2 Electrical Rating: Transformer electrical ratings may range from 3 KVA to 300 KVA, 120V to 600 V, single phase or three phase, primary or secondary, as shown in the plans.

639-3.7.3 Temperature classifications: Transformers rated less than 15 KVA shall utilize Class 180 or 185 insulation systems, with a 115°C or lower winding temperature rise. Transformers rated 15 KVA and greater shall utilize Class 220 insulation systems, with a 150°C or lower winding temperature rise. The transformer shall utilize an insulation system that has been properly temperature classified in accordance with NEMA ST-20.

Encapsulated transformers rated 15KV A to 25KV A using a Class 180 or 185 insulation system with a 115°C or lower winding temperature rise may be utilized if approved by the Engineer. Transformer windings shall be all aluminum or all copper.

639-3.7.4 Load rating: Furnish and install transformers with load ratings as described in the Plans. Transformers shall be capable of operating continuously at 100 percent of nameplate rating in an ambient temperature not exceeding 40°C. Transformers 5 KVA and above shall be capable of meeting overload requirements per ANSI C57.96 with normal life maintained.

639-3.7.5 Sound rating: Sound levels shall not exceed the following:

Table 639-1

Transformer Rating (KVA)	Average Sound Level Decibels per NEMA ST-20
0-9	40
10-50	45
51-150	50
150-300	55

639-3.8 Attachment Hardware: Use attachment hardware that meets the requirements of Section 603.

639-4 Installation Requirements.

639-4.1 General: Meet the following requirements for the installation of individual components of the electrical power service assembly:

Use extreme care and caution in the installation of all components of the electrical power service assembly.

Follow installation procedures recommended by NEC and National Electrical Safety Code (NESC).

Consider the location of electrical power service assemblies as shown in the Plans to be approximate, and coordinate with the appropriate electrical power company authority to determine the exact locations of each assembly.

Do not use transformers or spliced electrical wire on a traffic signal power service.

639-4.2 Weatherhead: Securely attach the weatherhead to the upper end of the conduit which extends upward from the meter base (or service disconnect if a meter base is not required) to a minimum height of 22 feet above grade.

639-4.3 Conduit: Securely attach all conduit to the pole or cabinet with a maximum distance of 5 feet between conduit attachment hardware.

639-4.4 Electrical Service Wire: Install the electrical service wire in a manner which will ensure that damage to the installation will not occur.

Ensure that the service wire is of sufficient length after installation in the conduit to provide for attachment to the power company service and for termination within the cabinet for which power is required.

Use waterproof gel-filled splices to splice electrical wires in pull boxes only when the length of the cable run prohibits use of continuous wire. Wire nuts and electrical tape splicing are not acceptable.

639-4.5 Meter Base: When a meter base is required, securely fasten the meter base to the pole or cabinet. Install pole mounted meter bases at a minimum height of 5-1/2 feet above grade when measured from the center of the meter base or meet the local electric power company requirement, whichever is greater.

639-4.6 Service Disconnect: Securely fasten the service disconnect to the pole (or cabinet with the Engineers approval), and electrically position the service disconnect between the service meter and the traffic control device cabinet to which electrical service is being supplied. Install pole mounted service disconnects a minimum of 4 feet above grade when measured from the bottom of the disconnect. For cabinet installations, mount the service disconnect at a height approved by the Engineer or as shown in the Plans.

639-4.7 Electrical Power Transformer: Follow installation procedures recommended by NEMA ST-20, National Electric Code (NEC), and National Electrical Safety Code (NESC). Set the ground mount transformer unit level on the pad and secured to the pad with bolts. Pole mount transformers are required to be fastened securely to the pole using bolts, stainless steel straps, or galvanized strut channel.

Conduct field acceptance testing in accordance with Section 611. Perform local field inspection at each site to verify and confirm the following:

1. Check wiring connections for damage and torque, as applicable, prior to energizing the transformer.

2. Check grounding and bonding of transformer enclosure. Ensure that separately derived systems, which are required to be grounded by the NEC 250.30 or the Plans, are fitted with an appropriately installed and sized system bonding jumper in accordance with the NEC 250.30.

3. Measure primary and secondary voltages under normal load conditions.

639-5 Method of Measurement.

639-5.1 General: Measurement for payment will be in accordance with the following work tasks.

Payment for electrical service wire between service disconnect and traffic cabinet is based upon the distance of the cable run and includes payment for all conductors used in the run. For lighting applications, payment for service conductors will be made in accordance with Section 715.

Payment for conduit and electrical service wire which is vertically attached to the electrical power assembly is considered incidental and paid under item 639-1.

639-5.2 Furnish and Install: The Contract unit price per foot of electrical service wire, or the Contract unit price each for electrical service disconnect, furnished and installed, will include furnishing all materials and hardware as specified in the Contract Documents, and all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation.

639-5.3 Furnish: The Contract unit price per foot of electrical service wire, or the Contract unit price each, for electrical service disconnect, furnished, will include the cost of the required materials and hardware as specified in the Contract Documents, plus all shipping and handling costs involved in delivery as specified in the Contract Documents.

639-5.4 Install: The Contract unit price per foot of electrical service wire, or the Contract unit price each, for electrical service disconnect, installed, will include all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation. The Engineer will supply electrical service wire or electrical service disconnect.

639-5.5 Electrical Power Service: The Contract unit price per assembly for electrical power service will include furnishing and installing all material and hardware as specified in the Contract Documents, and all labor and equipment necessary to make a complete and accepted installation.

639-5.6 Electrical Power Transformer: The Contract unit price for each Electrical Power Transformer will include furnishing, installing, and testing all materials and hardware as specified in the Contract Documents, and all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation.

639-6 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 639-	1-	Electrical Power Service - per assembly.
Item No. 639-	2-	Electrical Service Wire - per foot.
Item No. 639-	3-	Electrical Service Disconnect - each.
Item No. 639-	6-	Electrical Power Transformer - each.

SECTION 641
PRESTRESSED CONCRETE POLES

641-1 Description.

Furnish and install prestressed concrete poles as shown in the Plans.

Obtain precast, prestressed concrete poles from a manufacturing plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Ensure that each pole is constructed and permanently and legibly marked in accordance with Standard Plans, Index 641-010, including the date cast. Concrete closed circuit television (CCTV) poles must be constructed and permanently and legibly marked in accordance with Standard Plans, Index 641-020, unless shown otherwise in the Plans. The marking shall be visible after installation.

Ensure that the shipment of the products to the job site meets the requirements of 450-16.3 and Section 105.

641-2 Materials.

641-2.1 Poles: Meet the following requirements:

Portland Cement Concrete*	Section 346
Reinforcing Steel	931-1
Prestressed Strands	933-1
Spiral Reinforcing	ASTM A1064

* Class VI

641-2.2 Camera Lowering Device: Use lowering devices that meet the requirements of Section 996 and are listed on the Department's Approved Product List (APL).

641-2.2.1 Connector Block: Lubricate all components, including the connector block and contacts, in accordance with the manufacturer's recommendations.

641-2.2.2 Lowering Tool: Provide a minimum of one lowering tool and any additional tools as required in the Plans. Deliver the lowering tool to the Department before final acceptance.

641-2.2.3 Wiring: All wiring must meet NEC requirements and be installed in accordance with the equipment manufacturers' recommendations for each device connected on the pole, at the lowering device, and in the field cabinet.

641-2.2.4 External-Mount Lowering System Enclosure for Mounting to Existing Structures: The cabinet must allow for unobstructed operation of the winch, access for servicing and provide sufficient clear area for operation of the winch manually and with an electric drill. Include a pin tumbler lock keyed for use with a No. 2 key and two keys, unless otherwise directed by the Plans. Provide all necessary mounting hardware, conduits, standoffs, and conduit mounts required for a complete and functional system.

641-3 Concrete Pole Construction.

Construct concrete poles in accordance with Section 450. Assume responsibility for performance of all quality control testing and inspections required by Sections 346 and 450; however, the PCI personnel certifications are not required. Plant certification, in accordance with Section 105, is not required for plants that manufacture prestressed concrete poles.

641-4 Installation Requirements.

641-4.1 General: Furnish poles of the type and length shown in the Plans. Provide catenary cable of the size shown in the Plans. Ground poles in accordance with Section 620. Install span wire assemblies in accordance with Section 634.

Do not consider the poles acceptable for use if the camber of the pole, measured as the maximum deviation between the centerline of the pole and a straight line connecting the centroids of the cross-sections at each end of the pole, is greater than the total pole length in inches divided by 140.

641-4.2 Foundations: Provide foundations 3 feet 6 inches in diameter and of the depth specified in the Plans for strain poles used for span wire support of traffic signals. Provide foundations for concrete CCTV poles in accordance with Standard Plans, Index 641-020. Provide foundations for all other pole applications as specified in the Plans. Construct the foundation with concrete as specified in Section 347.

For the excavation and backfill of the foundation, meet the requirements specified in 125-4 and 125-8.2 with the exception of the backfill density. In lieu of the requirements for obtaining the specified density, the Contractor may hand tamp the backfill in 4 inch maximum layers or machine tamp the backfill in 6 inch maximum layers. When performing such operations, ensure that the material is neither dry nor saturated. The Contractor may backfill with concrete.

Use forms, when required, meeting the requirements of 400-5. If the foundation is cast in an oversize hole, place the concrete in the top 6 inches in a form. Trowel all exposed surfaces to a smooth finish.

641-4.3 Orientation of Poles: For poles supporting one catenary wire, orient the pole so that the load face is perpendicular to the catenary wire. For poles supporting two catenary wires, orient the pole so that the load face is perpendicular to a line bisecting the angle between the two catenary wires.

Rake pole back from the span wire as necessary to achieve a final rake of 1/2 inch per foot, plus or minus 1/4 inch.

641-4.4 Camera Lowering Device: Install the lowering device in a manner that does not place the operator directly under the device when it is being raised or lowered. Submit documentation showing connector block pin assignment for approval prior to installation.

The divided support arm and receiver brackets must self-align the contact unit with the pole centerline during installation. Additionally, the lowering device support arm must self-align the disconnect unit and attached device with the pole centerline and remain centered after installation, without moving or twisting.

House the stainless steel lowering cable inside 1.25 inch PVC conduit and provide a conduit mount adapter for the interface between the conduit and the internal back side of the lowering device.

The connection between the lowering device and tenon must be weather resistant. Use conduit straps to secure lowering cable conduit to the pole for externally mounted lowering systems. Stainless steel bands will not be allowed. Ensure that only the lowering cable is in motion inside the pole when the lowering device is operated. All other cables must remain stable and secure during lowering and raising operations. Label all wire leads with their function, label spares as spares. Install the correct length of lowering cable to prevent cable slack and to prevent the cable from jumping off the winch spool. The lowering cable strands must not twist or unwind when the lowering device is operated.

Ensure that crimps and other cable connection hardware associated with the lowering cable do not come in direct contact with the winch tool or guides when operating the system.

Furnish the Engineer with the manufacturer recommended field installation instructions, inspection instructions (including recommended schedules and procedures), and operating instructions.

641-5 Pole Removal.

When removal of the pole and partial foundation removal is specified in the Plans, the remaining pole, foundation and any protrusions, such as pole keys, dead men, guying apparatus, conduit, anchor bolts, or reinforcing steel, must be removed to a minimum depth of 4 feet below existing grade.

When removal of the pole and complete foundation removal is specified in the Plans completely remove each pole including the foundation and all accessories and attachments, such as pole keys, dead men, guying apparatus, conduit, anchor bolts, and reinforcing steel.

Disconnect span wires carefully at the pole, and salvage all usable hardware and attachment devices as determined by the Engineer. Remove all devices supported by the span wire (including wiring) prior to the removal of the span wire.

641-6 Method of Measurement.

641-6.1 General: Measurement for payment will be in accordance with the following work tasks.

641-6.2 Furnish and Install: The Contract unit price for prestressed concrete poles, furnish and install, will consist of the pole plus all labor, concrete for the foundation and other materials necessary for a complete and accepted installation as specified in the Contract Documents.

641-6.3 Pole Removal:

641-6.3.1 Pole Removal Partial: The quantity to be paid for will be the removal of each pole, including the foundation and all accessories and attachments, to a depth of not less than 4 feet below existing grade.

641-6.3.2 Pole Removal Complete: The quantity to be paid for will be the complete removal of the pole, foundation and all accessories and attachments.

641-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 641-	Prestressed Concrete Poles - each.
Item No. 641-	Concrete CCTV Pole - each.

SECTION 646
ALUMINUM POLES, PEDESTALS, AND POSTS

646-1 Description.

The work in this Section consists of furnishing and installing aluminum poles, pedestals, and posts at the locations shown in the Plans and in accordance with the details shown in the Plans and Standard Plans, subject to a five-year warranty period as defined herein. The warranty period will apply only when aluminum poles, pedestals, and posts are painted as called for in the Contract Documents. An aluminum pedestal consists of a pole and a transformer base.

646-2 Materials.

Meet the following requirements:

Portland Cement Concrete* .....Section 346
Anchor Bolts and Shims .....Section 962
Poles and Posts.....Section 965
Transformer Base**.....Section 965
*Class II
**Use products listed on the Department's Approved Products List (APL)

646-2.1 Poles and Posts: Poles used with transformer bases must be threaded with No. 8 NPT threads. Sufficient threads are required to fully seat the pole into the hub of the pedestal base.

646-2.2 Anchor Bolts: Provide Grade 55 anchor bolts, 3/4-inch diameter, 18-inches long, with double nuts. For each bolt, provide two 3/4-inch heavy hex nuts and one 3/16-inch thick by 3-inch round plate washer or one Type 1 washer.

646-2.3 End Caps: Provide end caps sized for nominal 4-inch Schedule 40 4-1/2-inch outside diameter aluminum poles. The cap must be a minimum of 1/4-inch thick and tapped for at least two set screws. Set screws will be provided with the end cap.

646-2.4 Shims: Provide U-shaped galvanized steel shims 2-inches wide by 2-1/2 inches long, shaped to fit around a 3/4-inch anchor bolt.

646-3 Coatings.

646-3.1 Painting:

646-3.1.1 General: When required by the Contract Documents, provide painted aluminum poles, pedestals, and posts. Provide products that will meet specification requirements throughout the warranty period. Meet the color requirement as specified in the Contract Documents. Provide the Engineer with two metal sample coupons, a minimum of 2 inches by 4 inches, painted concurrently and with the same paint as was used on the first LOT of any aluminum poles, pedestals, and posts delivered to the jobsite. Submit sample coupons and manufacturer product data sheets to the Engineer along with the delivery of the first shipment of any painted aluminum poles, pedestals, and posts delivered to the jobsite. At the time of their delivery, the sample coupons described in this paragraph must match the color of the aluminum poles, pedestals, and posts to within 1ΔE measured as specified in 975-4. If the delivered sample coupons exhibit a difference in color from the poles, pedestals, and posts greater than 1ΔE then the sample coupons will be considered unacceptable and no payment shall be made for the materials which the sample coupons represent. Those materials shall not be accepted by the Department until acceptable representative sample coupons in accordance with the requirements of this Section have been submitted to the Engineer.

646-3.1.2 Responsible Party Warranty: When the Contract Documents call for painted aluminum poles, pedestals, and posts, the Contractor shall designate a responsible party to accept responsibility. The responsible party designated by the Contractor must execute and submit to the Department a form, provided by the Department, prior to the first delivery to the jobsite of any painted aluminum poles, pedestals, and posts, stipulating that the responsible party accepts responsibility for ensuring the coating system adhesion and color retention requirements as specified in 975-4 are met for a period of five years after final acceptance in accordance with 5-11. The responsible party shall also bear the continued responsibility for performing all remedial work associated with repairs of any adhesion or color retention failure as defined in Section 975, as to which notice was provided to the responsible party within the five year warranty period. Failure to timely designate the responsible party will result in the Contractor being the responsible party unless otherwise agreed to in writing by the Department. The responsible party shall be either the Contractor or the supplier of the painted aluminum poles, pedestals, and posts. When the responsible party is the fabricator, the responsible party shall be one of the fabricators listed on the Prequalified Painted Galvanized Steel and Aluminum Products Fabricators List. This list may be viewed on the Department's website at the following URL: https://www.fdot.gov/construction/Engineers/PaintedPoleSuppliers.shtm.

Upon final acceptance of the Contract in accordance with 5-11, the Contractor's responsibility to ensure that the coating system adhesion and color retention requirements specified in 975-4 will terminate. The obligations of the responsible party set forth in this Section shall start at final acceptance of the Contract in accordance with 5-11 and continue thereafter until expiration of the five-year warranty period.

646-4 Remedial Work.

During the painting warranty period, the responsible party shall perform all painting remedial work necessary to meet the requirements of this Specification at no cost to the Department. Such remedial work shall be performed within 180 days of notification of a failure by the Department or by the determination of the Statewide Disputes Review Board. Failure to perform such remedial work within the time frame specified will result in the work being performed by other forces at the responsible party's cost.

If the responsible party is the fabricator, the fabricator will be removed from the Prequalified Painted Galvanized Steel and Aluminum Products Fabricators List for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

If the responsible party is the Contractor, the Department will suspend, revoke, or deny the responsible party's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

646-5 Statewide Disputes Review Board.

The Statewide Disputes Review Board in effect for this Contract will resolve any and all disputes that may arise involving administration and enforcement of this Specification related to the painting remedial work performed during the warranty period. The Responsible Party and the Department acknowledge that use of the Statewide Disputes Review Board is required, and the determinations of the Statewide Disputes Review Board for disputes arising out of this Specification will be binding on both the Responsible Party and the Department, with no right of appeal by either party. Meet the requirements of 8-3.

646-6 Installation.

646-6.1 General: Verify the length of the column supports in the field prior to fabrication to permit the appropriate sign or signal height.

646-6.2 Foundations: Construct foundations in accordance with the applicable Standard Plans.

The Contractor may use precast foundations in augered or excavated holes that are a minimum of 12 inches larger than each axis dimension of the precast foundation. The holes must be clean and without loose material. Obtain precast foundations from a manufacturing plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105. Fill the voids around precast foundations with flowable fill meeting the requirements of Section 121 or clean sand placed using hydraulic methods to a level of 6 inches below grade.

646-6.3 Setting Anchor Bolts: Set anchor bolts 90 degrees apart with a bolt circle diameter of 14 inches. Adjust anchor bolts to a plumb line and hold rigidly in position to prevent displacement while pouring concrete.

646-6.4 Installation: Do not erect poles until the concrete strength is at least 2500 psi. Plumb the poles after erection using shims if necessary to obtain precise alignment.

646-6.5 Grounding: Meet the requirements of Section 620 and the applicable Standard Plans.

646-7 Method of Measurement.

The Contract unit price per each for aluminum pedestals and posts, furnished and installed, will include all materials and equipment as specified in the Contract Documents, and all labor and materials necessary for a complete and accepted installation.

Payment for removal of aluminum poles will include the complete removal of the pole and foundation, pedestrian detector and pedestrian signal. Separate payment for the removal of the pedestrian detector and pedestrian signal will be made only when the pole/pedestal is to remain.

Payment for grounding will be incidental to the pedestal or post.

646-8 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 646- Aluminum Poles - per each.

SECTION 649
GALVANIZED STEEL POLES, MAST ARMS, AND MONOTUBE ASSEMBLIES

649-1 Description.

The work in this Section consists of furnishing and installing galvanized steel strain poles, galvanized steel mast arms, galvanized steel monotube assemblies, and galvanized steel CCTV poles in accordance with the details shown in the Contract Documents, subject to a five year warranty period as defined herein. The warranty period will apply only when poles, mast arms or steel monotube assemblies are painted as called for in the Contract Documents.

649-2 Materials.

649-2.1 Pole Assembly: Use pole assemblies as shown in the Standard Plans when standard mast arm assemblies, standard strain pole assemblies, or standard steel CCTV pole assemblies are required by the Contract Documents.

Obtain poles, assemblies from a fabrication facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Obtain poles and mast arms from a fabrication facility that is approved in one of the following fabrication categories:

1. American Institute of Steel Construction, Highway Component Manufacturer
2. American Welding Society, Certified Welding Fabricator
3. Canadian Welding Bureau, Fusion Welding of Aluminum (W47.2)

Use coating products meeting the requirements of Section 975.

Use grouts meeting the requirements of Section 934 and listed on the Department's Approved Product List (APL).

Use water meeting the requirements of Section 923.

Use membrane curing compounds meeting the requirements of Section 925.

649-2.2 Camera Lowering Device: Meet the requirements of 641-2.2.

649-3 Fabrication.

Fabricate poles, mast arm, and monotube assemblies and miscellaneous hardware in accordance with the Contract Documents. Cut all materials to the final dimensions and complete all welding prior to galvanizing. Obtain all components for individual strain poles, mast arm and monotube assemblies from the same fabricator. Obtain the luminaire and bracket from other sources, when necessary.

All welds must be visually inspected for final approval by an actively certified welding inspector, qualified through the American Welding Society. A certifying statement from the welding inspector must be provided with the components. The document must identify the project information, date of inspection, welding inspector name, and inspector certification number.

Affix an aluminum identification tag which will be visible from the handhole or located inside the terminal box containing the information described in the Standard Plans.

Before shipping, assemble monotube assemblies to assure proper fit. Monotube assemblies may be separated for shipment.

For mast arms, use adequate manufacturing controls to assure proper fit, ensuring dimensional tolerances are met and that mast arm to pole connections can achieve a snug-tight condition as defined in 649-7.

Ensure all components are protected from damage during shipping and handling by wrapping or other effective methods. Replace any component, which the Engineer determines is damaged beyond repair, at no additional cost to the Department. If components are wrapped for shipment, remove wrappings no later than five days after receipt of components or immediately if the wrappings become saturated. Post these instructions in brightly colored wording on the wrapper. Failure to comply with these instructions may lead to damage of the coating system and will be cause for the rejection of the component.

649-4 Coatings.

649-4.1 Galvanizing: Galvanize all components in accordance with ASTM A123, except galvanize all fastener assemblies in accordance with Section 962. Use galvanizing methods which provide surfaces suitable for painting.

649-4.2 Surface Preparation: Prepare all galvanized surfaces to be painted in accordance with ASTM D6386 and the manufacturer of the coating system's specifications. Provide a clean and suitable galvanized surface that maximizes coating system adhesion.

Measure the thickness of the zinc coating after completion of surface preparation using a magnetic thickness gage in accordance with ASTM A123. Ensure sufficient galvanizing remains on the substrate to meet the requirements of ASTM A123 and the Contract Documents. Correct any deficient areas to the satisfaction of the Engineer at no additional cost to the Department.

649-4.3 Painting:

649-4.3.1 General: When required by the Contract Documents, provide painted poles, mast arms and monotube assemblies. Provide products from a fabricator on the Department's list of Prequalified Painted Galvanized Steel and Aluminum Products Fabricators List. Provide products that will meet specification requirements throughout the warranty period. Meet the color requirement as specified in the Contract Documents. Provide the Engineer with two metal sample coupons, a minimum of 2 inches by 4 inches, painted concurrently and with the same paint as was used on the first LOT of any poles, mast arms and monotube assemblies delivered to the jobsite. Submit sample coupons and manufacturer product data sheets to the Engineer along with the delivery of the first shipment of any painted poles, mast arms or monotube assemblies delivered to the jobsite. At the time of their delivery, the sample coupons described in this paragraph shall match the color of the poles, mast arms and monotube assemblies to within 1ΔE when measured as specified in 975-4. The Engineer will perform a visual color comparison between the delivered products and sample coupons. The Engineer may evaluate and document any color difference by measuring as specified in 975-4. If the delivered sample coupons exhibit a difference in color from the poles, mast arms and monotube assemblies greater than 1ΔE then the sample coupons will be considered unacceptable and no payment shall be made for the materials which the sample coupons represent. Those materials shall not be accepted by the Department until acceptable representative sample coupons in accordance with the requirements of this Section have been submitted to the Engineer.

649-4.3.2 Responsible Party Warranty: When the Contract Documents call for painted galvanized steel poles, mast arms or monotube assemblies, the Contractor shall designate a responsible party to accept responsibility. The responsible party designated by the Contractor must execute and submit to the Department a form, provided by the Department, prior to the first

delivery to the jobsite of any painted poles, mast arms or monotube assemblies, stipulating that the responsible party accepts responsibility for ensuring the coating system adhesion and color retention requirements as specified in 975-4 are met for a period of five years after final acceptance in accordance with 5-11. The responsible party shall also bear the continued responsibility for performing all remedial work associated with repairs of any adhesion or color retention failure as defined in Section 975, as to which notice was provided to the responsible party within the five-year warranty period. Failure to timely designate the responsible party will result in the Contractor being the responsible party unless otherwise agreed to in writing by the Department. The responsible party shall be either the Contractor or the fabricator. When the responsible party is the fabricator, the responsible party shall be one of the fabricators listed on the Prequalified Painted Galvanized Steel and Aluminum Products Fabricators List. This list may be viewed on the Department's website at the following URL:
https://www.fdot.gov/construction/Engineers/PaintedPoleSuppliers.shtm

Upon final acceptance of the Contract in accordance with 5-11, the Contractor's responsibility to ensure that the coating system adhesion and color retention requirements specified in 975-4 will terminate. The obligations of the responsible party set forth in this Section shall start at final acceptance of the Contract in accordance with 5-11 and continue thereafter until expiration of the five-year warranty period.

649-5 Remedial Work.

During the painting warranty period, the responsible party shall perform all painting remedial work necessary to meet the requirements of this Specification at no cost to the Department. Such remedial work shall be performed within 180 days of notification of a failure by the Department or by the determination of the Statewide Disputes Review Board. Failure to perform such remedial work within the time frame specified will result in the work being performed by other forces at the responsible party's cost.

If the responsible party is the fabricator, the fabricator will be removed from the Prequalified Painted Galvanized Steel Poles and Aluminum Products Fabricators List for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

If the responsible party is the Contractor, the Department will suspend, revoke, or deny the responsible party's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

649-6 Statewide Disputes Review Board.

The Statewide Disputes Review Board in effect for this Contract will resolve any and all disputes that may arise involving administration and enforcement of this Specification related to the painting remedial work performed during the warranty period. The Responsible Party and the Department acknowledge that use of the Statewide Disputes Review Board is required, and the determinations of the Statewide Disputes Review Board for disputes arising out of this Specification will be binding on both the Responsible Party and the Department, with no right of appeal by either party. Meet the requirements of 8-3.

649-7 Installation.

Install foundations in accordance with Section 455. Do not install poles, mast arm poles, or monotubes until the foundation has achieved 70% of the specified 28-day concrete strength

and verifying test results have been submitted to the Engineer. Determine concrete strength from tests on a minimum of two test cylinders prepared and tested in accordance with ASTM C31 and ASTM C39. Before erecting the pole, clean the top of the foundation of any laitance, oils, grease or any other deleterious materials. Erect strain poles in an orientation which considering the rake and the application, cable forces will produce a plumb pole. Erect monotubes plumb at the time of installation. Plumb the pole supporting mast arms after the mast arms, traffic signals or sign panels have been placed.

If the traffic signals and/or sign panels are not in place within two working days after the mast arm is erected, furnish and install a 3 foot x 2 foot blank sign panel on the bottom of each mast arm within 6 feet of the mast arm tip and plumb the pole. Re-plumb the pole supporting mast arms after installation of traffic signals and sign panels.

Install ASTM F3125, Grade A325 bolt, nut, and washer assemblies in accordance with the following. Use bolt, nut and washer assemblies that are free of rust and corrosion and are lubricated properly as demonstrated by being able to easily hand turn the nut on the bolt thread for its entire length. Tighten nuts to a snug-tight condition to bring the faying surfaces of the assembly into firm contact with plies solidly seated against each other, but not necessarily in continuous contact. Snug-tight is defined as the maximum nut rotation resulting from the full effort of a person using an ordinary spud wrench. Visually inspect the connection after snugging all bolts, ensuring firm contact has been achieved at a minimum between faying surfaces beneath bolts within one bolt diameter of bolt hole edges. Re-snug bolts in a connection where faying surfaces are not in firm contact. After bringing the faying surfaces to a snug-tight condition, tighten nuts in accordance with Table 460-7, Nut Rotation from the Snug-Tight Condition. Maintain as close to uniform contact pressure as possible on the faying surfaces during snugging and turn-of-nut process by utilizing suitable erection methods and a bolt tightening pattern that balances the clamping force of each bolt, as closely as possible, with the equal clamping force of a companion bolt.

For this Specification, the retainer nuts (half-height or full-height) are installed on top of the plate washers and below the anchor nuts (full-height). Base plate installation steps are as follows:

1. Clean and lubricate the exposed threads of all anchor bolts. Clean and lubricate the threads and bearing surfaces of all leveling nuts. Re-lubricate the exposed threads of the anchor bolts and the threads of the leveling nuts if more than 24 hours have elapsed since earlier lubrication, or if the anchor bolts and leveling nuts have become wet since they were first lubricated.

2. Verify that the nuts can be turned onto the bolts past the elevation corresponding to the bottom of each in-place leveling nut and be backed off by the effort of a person using an ordinary spud wrench, without employing a pipe extension on the wrench handle.

3. Turn the leveling nuts onto the anchor bolts and align the nuts to the same elevation less than or equal to one bolt diameter from the top of the foundation.

4. Place structural plate washers on top of the leveling nuts; one washer corresponding to each anchor bolt.

5. Install the base plate onto the leveling nut washers, place structural plate washers on top of the base plate; one washer corresponding to each anchor bolt and turn retainer nuts onto the anchor bolts.

6. Tighten retainer nuts against the top of the base plate to a snug-tight condition in a star pattern. A star tightening pattern is one in which the nuts on opposite or near opposite sides of the bolt circle are successively tightened in a pattern resembling a star. For an 8 bolt circle with bolts sequentially numbered 1 to 8, tighten nuts in the following bolt order: (1, 5, 7, 3, 8, 4, 6, 2).

7. Tighten leveling nuts to a snug-tight condition in a star pattern. The distance from the bottom of the leveling nuts to the top of the concrete must not exceed one anchor bolt diameter after tightening.

8. Turn anchor nuts onto the anchor bolts and tighten each until it is in firm contact with the top surface of the retainer nut; then while preventing the retainer nut from rotating, tighten the anchor nut until it is snug-tight using a star pattern. Before final tightening of the anchor nuts, mark the reference position of each snug-tight retainer nut on one flat with a corresponding reference mark on the anchor nut and base plate on each bolt. Assure the retainer nut stays in this final position. Then while preventing the retainer nut from rotating, incrementally turn the anchor nuts using a star pattern until achieving the required nut rotation specified in Table 649-1. Turn the anchor nuts at least two full tightening cycles (passes). After tightening, verify the anchor nut rotation with respect to the retainer nut and verify the retainer nut has not rotated from its snug-tight condition with respect to the plate washer and base plate. Do not exceed the Table 649-1 value by more than 20 degrees. The final condition is a retaining nut that is snug-tight with respect to the plate washer, and an anchor nut that is rotated with respect to the reference mark on the retaining nut, plate washer, and base plate in accordance with Table 649-1.

9. Install a screen over the gap between the base plate and foundation concrete in accordance with 649-8, or place a structural grout pad in accordance with 649-9.

Table 649-1

Anchor Bolt Diameter (inches)	Nut Rotation from Snug-Tight Condition
≤ 1-1/2	1/3 turn
> 1-1/2	1/6 turn

649-7.1 Camera Lowering Device Installation: Meet the requirements of 641-4.4.

649-8 Screen Installation.

On steel strain poles and steel monotube assemblies, install a screen that will prevent vermin and debris from entering the gap between the bottom of the base plate and the top of the concrete foundation. Cover the entire gap with a wire screen, the bottom horizontal wire of which shall be in full contact with the surface of the concrete foundation and the top horizontal wire of which shall not extend beyond the top surface of the base plate. For the screen, use standard grade plain weave galvanized steel wire cloth with 1/2 inch x 1/2 inch mesh and 0.063 inch diameter wires. Vertical screen wires shall not extend beyond the top and bottom horizontal wires of the screen. Use one continuous section of screen with only one overlapping splice where the ends come together and overlap the layers 3 inches minimum. Attach the screen to the vertical side of the base plate with self-tapping stainless steel screws (No. 8, 1/2 inch long) with stainless steel washers (1/4 inch inside diameter). Drill pilot holes into the base plate to facilitate screw installation. Install screws on 9 inch centers maximum and at least one screw shall be installed through the overlapping splice to clamp the layers together. Also clamp the

overlapping splice layers together just above the concrete foundation with an all stainless steel fastener assembly consisting of a machine screw (No. 8, 5/8 inch long), nut and two flat washers (1/4 inch inside diameter) and lock washer. Tightly clamp the screen layers between the flat washers.

649-9 Structural Grout Pads.

On mast arm support structures, install a structural grout pad in accordance with the Standard Plans and manufacturer's instructions. Prior to grout placement, flush the top of the foundation with water to remove any dirt and debris.

Mix grout to a fluid state in accordance with the manufacturer's recommendations. Test the grout fluidity using ASTM C939 Flow Cone Method. Discard any grout with an unacceptable efflux time.

Do not use mechanical means to push or vibrate the grout. Clean any excess grout from the base plate. Verify that water inside the pole will drain freely through the installed drain hole.

649-10 Method of Measurement.

The Contract unit price each for poles, mast arms, and monotube assemblies, furnished and installed, will include all materials specified in the Contract Documents, including the foundation, cover plates, caps, clamps, blank sign panel, luminaire bracket, all labor, equipment, miscellaneous materials and hardware necessary for a complete and acceptable installation.

The Contract unit price for removal of poles, mast arms, and monotube assemblies will include the removal of all attachments (arms, vehicle signals, light fixtures, pedestrian signals, pedestrian detectors and other incidentals).

When removal of the pole and partial foundation removal is called for, remove the pole, foundation, and all accessories or attachments (including pole keys, dead men, guying apparatus, conduit, anchor bolts and reinforcing steel) to a minimum depth of four feet below existing grade.

When removal of the pole and complete foundation removal is called for, completely remove the pole including the foundation and all accessories or attachments as listed above.

649-11 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section. Sign panels and signal assemblies will be paid for separately.

Payment will be made under:

Item No. 649-	Steel Mast Arm Assembly - each.
Item No. 649-	Steel Monotube Assembly - each.
Item No. 649-	Steel Strain Pole - each.
Item No. 649-	Steel CCTV Pole - each.

SECTION 650
VEHICULAR TRAFFIC SIGNAL ASSEMBLIES

650-1 Description.

Furnish and install vehicular traffic signal assemblies as shown in the Plans and Standard Plans. For additional requirements related to mounting and attaching the assemblies, see Section 659.

650-2 Materials.

Use vehicular signal assemblies that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). Vehicular traffic signal assemblies must meet the requirements of Section 603 and the Institute of Transportation Engineers (ITE) Standard for Vehicle Traffic Control Signal Heads.

Provide vehicular traffic signal assemblies as a complete and functioning unit. Components include, but are not limited to, signal housing, light emitting diode (LED) signal modules, visors, backplates, and assembly hardware.

All sections of multi-section assemblies must be from the same manufacturer.

650-3 Installation.

650-3.1 Preassembly: Pre-assemble the signal heads when more than one signal section is required prior to installation at the site. Furnish signal heads with LED modules, backplates, and visors. Use tunnel visors unless otherwise specified in the Contract Documents. Install the LED circular module in the door so that the UP arrow or the word UP or TOP is in the up orientation of the signal housing. Install the LED arrow modules in the signal housing door in the direction of the intended use.

650-3.2 Positioning of Signals: Consider the locations of the installed signals as shown in the Plans as sufficiently flexible as to allow for unanticipated field conditions at the site. The Engineer will direct any variations from the locations shown. Position adjacent signal faces no closer than 8 feet apart measured horizontally at 90 degrees to the traffic flow between centers of faces.

Regardless of the results of any scaled dimensions, consider the location shown in the Plans to be approximate. Position a signal face mounted on a span wire or mast arm as near as practical to the line of the driver's normal view.

Ensure that all sections are of the same manufacturer and the section assemblies are uniform in appearance and alignment.

650-3.3 Clearances: Unless directed otherwise by the Engineer for unusual circumstances at the site, provide a vertical clearance of not less than 17 feet-6 inches and not more than 19 feet for traffic signals placed over the roadway. Measure such clearance for each span directly under the most critical signal assembly (in regards to clearance) for that span. Place signal assemblies on each span as near as practical to the same elevation as the critical signal assembly.

Ensure that the lowest point on pedestal-mounted and side-mounted signal heads is 12 feet above finished grade at the point of their installation.

650-3.4 Aiming of Signal Indication: For proper lateral orientation, aim signals after installing and before locking them in position.

650-3.5 Wiring Connections: Do not splice signal cable. Connect the proper signal cable to the terminals in each signal head in order to provide the proper signal indication display when the cables are connected to the signal controller. Wire a separate neutral circuit and return it to the controller cabinet from each vehicular movement as shown in the Contract Documents.

650-3.6 Special Installation Requirements for Optically Programmed Signals: Install, direct (aim), and conceal optically programmed signals in strict accordance with the instructions of the manufacturer, using the materials furnished by the signal manufacturer, and with the direction of the Engineer.

Position the signals for maximum performance in accordance with the requirements shown in the Plans, and install them with rigid mounting assemblies, using elbows and plumbizers of such type as will provide for stability of the position of the signals. Do not use clevises in the supporting attachments.

Seal the cable routing to the signals to provide permanent water tightness.

650-3.7 Vertically Mounted Plastic Signal Head Assemblies: The top section of all multi-section (5-section, 3-section), vertically mounted, plastic signal assemblies must be constructed of die cast aluminum, unless the entire 3 (or more)-section plastic signal assembly is specifically approved and listed on the APL as a 12 inch plastic 3 (or more)-section vehicle assembly.

Single section signals may be constructed of die cast aluminum or plastic.

650-3.8 Backplates: Install backplates on all signal head assemblies.

650-3.9 Sealing Installed Signal Head Assembly: Ensure that the installed signal head assembly is sealed to exclude dust and moisture. Drill two, 1/4 inch drain holes in the bottom of the installed signal head assembly.

650-3.10 Concealing Signals Not in Use: Where traffic signals are installed and not put into service immediately, or placed out-of-service temporarily, conceal the signal head assembly by securely placing burlap bags or other covering approved by the Engineer over a weather resistant covering of non-transparent material open at the bottom to prevent condensation buildup.

650-3.11 Installation Sequence: Install all traffic signal assemblies at any intersection as a single operation unless a staged operation is approved by the Engineer.

650-3.12 Emergency Signal Heads: For new emergency fire stations signals, install 12 inch signal heads for all three indications. For existing 8 inch emergency fire station signals, retrofit with 8 inch LED modules. The 8 inch LED optical unit must conform to the requirements of the ITE's Performance Specification, Vehicle Traffic Control Signal Heads - Light Emitting Diode (LED) Circular Signal Supplement, dated June 27, 2005.

650-3.13 Transit Signal Heads: For transit signal priority at signalized intersections with bus queue jumper lanes, install 12 inch two-lens signal head assembly per the MUTCD, Figure 8C-3. The 12 inch LED optical unit indications must comply with the MUTCD, Section 8C.11 and as illustrated in Figure 8C-3. The 12 inch LED optical unit must conform to the requirements of the ITE's Performance Specification, Vehicle Traffic Control Signal Heads-Light Emitting Diode (LED) Circular Signal Supplement, dated June 27, 2005, regarding environmental requirements, transient protection, operating voltage range, and electronic noise. The indication (bar symbol) must measure 1-1/2 inches wide by 9 inches long. The indication must be capable of being displayed in any angle of orientation from horizontal to vertical.

650-4 Warranty.

Ensure that the signal housings, backplates, and any other signal assembly components have a manufacturer's warranty covering defects for a minimum of three years from the date of final acceptance in accordance with 5-11 and Section 608. Ensure the warranty includes providing replacements, within 30 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

Ensure that the LED signal modules have a manufacturer's warranty covering defects for a minimum of five years from the date of final acceptance in accordance with 5-11 and 608. Ensure that the warranty includes providing replacements, within 30 calendar days of notification, for any defective parts and equipment (including falling below minimum intensity levels) during the warranty period at no cost to the Department or the maintaining agency.

650-5 Method of Measurement.

The Contract unit price per assembly for vehicular traffic signal, furnished and installed, will consist of the traffic signal and all components necessary to make a complete unit, including mounting assemblies, backplates, visors, LED modules, labor, and materials necessary for a complete and accepted installation.

Separate payment for backplates will only be made for retrofitting existing signal heads, when called for in the Contract Documents.

650-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 650-	1-	Vehicular Traffic Signal - per assembly.
Item No. 650-	2-	Vehicular Signal Auxiliaries - per each.

SECTION 653
PEDESTRIAN SIGNAL ASSEMBLIES

653-1 Description.

Furnish and install pedestrian signal assemblies as shown in the Plans and Standard Plans, Index 653-001. Meet the requirements of Section 603.

653-2 Materials.

Use pedestrian signals that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). Pedestrian signal assemblies must meet the requirements of the latest edition of the Federal Highway Administration's (FHWA) Manual on Uniform Traffic Control Devices (MUTCD) and the Institute of Transportation Engineers (ITE) standard for Pedestrian Traffic Control Signal Indications.

653-3 Installation.

653-3.1 General: Use pedestrian signal assemblies capable of being maintained, adjusted, and disassembled with ordinary hand tools. Pre-assemble the pedestrian signal, with the exception of mounting hardware, prior to installation at the site. Construct the pedestrian signal assembly (including the mounting hardware) to be a weather-tight unit. Conceal all conductors.

653-3.2 Placement: Position pedestrian signals and all mounting assembly members as either plumb or level, and symmetrically arranged. Align signals in the line of the pedestrian's vision for the crosswalk being used.

653-3.3 Installation Sequence: Install all pedestrian signal assemblies at any intersection as a single operation unless a staged operation is approved by the Engineer. Do not install signals at any intersection until all other signal equipment, including the controller, and pedestrian detectors are in place and ready for operation, unless completely covered in accordance with 650-3.10.

653-4 Method of Measurement.

The Contract unit price per assembly for pedestrian signal assembly, furnished and installed, (including mounting hardware but not including poles or pedestals) will include all materials and equipment as specified in the Contract Documents, and all labor and materials necessary for a complete and accepted installation.

Payment for removal of pedestrian signal assemblies will be made only when the pole/pedestal is to remain. Otherwise, the removal of pedestrian signal assemblies are included in the removal of the pole or pedestal.

653-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 653- Pedestrian Signal - per assembly.

SECTION 654
MIDBLOCK CROSSWALK ENHANCEMENT ASSEMBLIES

654-1 Description.

Furnish and install midblock crosswalk enhancement assemblies.

654-2 Materials.

Use In-roadway light assemblies and rectangular rapid flashing beacon (RRFB) assemblies that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). Use hardware that meets the requirements of Section 603.

Pedestrian hybrid beacon assemblies must meet the physical and operational requirements of the latest edition of the MUTCD, Chapter 4F. The cabinet, signals, controller, pedestrian detectors, and other traffic control devices used to create a pedestrian hybrid beacon assembly must be listed on the APL.

654-3 Installation Requirements.

Restore any areas impacted by the installation of the crosswalk enhancement assembly to original condition unless otherwise shown in the Plans. Install crosswalk enhancement assembly in accordance with the Americans with Disabilities Act Standards for Transportation Facilities.

Install post mounted RRFB assemblies in accordance with Standard Plans, Index 654-001. Use sign panel attachment hardware in accordance with Standard Plans, Index 700-010.

Follow manufacturer recommendations on the number of RRFB units that are connected to the timer's output driver. The outside edges of RRFB indications, including any housings, shall not project beyond the outside edges of the associated warning sign.

If installed with highlighted signs or flashing yellow beacons, in-roadway light assemblies shall operate in unison and with an identical flash rate as the signs or beacons.

654-4 Warranty.

Ensure the midblock crosswalk enhancement assembly has a manufacturer's warranty covering defects for two years from the date of final acceptance in accordance with 5-11 and Section 608. Ensure the warranty includes providing replacements within 10 calendar days of notification for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

654-5 Method of Measurement.

654-5.1 General: All midblock crosswalk assemblies will include all materials, equipment, and labor necessary for a complete and accepted installation.

654-5.2 In-Roadway Light Assembly: The in-roadway light assembly includes in-roadway lights, signs, sign support structures, cabinet, electronics, wiring, and pedestrian detectors for a complete crossing. Include solar panels in the cost of the assembly when shown in the Plans.

654-5.3 Rectangular Rapid Flashing Beacon (RRFB) Assembly: Assemblies mounted in accordance with Standard Plan 654-001 includes rectangular beacons and signs for each approach, sign support structure, mounting brackets, attachment hardware, cabinet, electronics, wiring, and pedestrian detector. Include solar panels in the cost of the assembly when shown in the Plans.

654-5.4 Pedestrian Hybrid Beacon Assembly: The Contract unit price for each pedestrian hybrid beacon assembly will consist of all labor and materials necessary for a complete and accepted installation. The assembly includes the 3-section signal, hardware, and backplate. Pedestrian signals, cabinet, signs, mast arms, strain poles or other support structures, and signal cable will be paid under the applicable sections for each item.

654-6 Basis of Payment.

Price and Payment will be full compensation for all work specified in this Section. Payment will be made under:

Item No. 654- 1	Midblock Crosswalk - In-Roadway Light Assembly - per assembly.
Item No. 654- 2	Midblock Crosswalk - Rectangular Rapid Flashing Beacon Assembly - per assembly.
Item No. 654- 3	Midblock Crosswalk - Pedestrian Hybrid Beacon Assembly - per assembly.

SECTION 659
MAST ARM, SPAN WIRE, AND POLE MOUNTING ASSEMBLIES

659-1 Description.

Furnish and install mounting assemblies for vehicular and pedestrian traffic signals, signs, cameras, detectors, and other devices in accordance with the Contract Documents.

659-2 Materials.

659-2.1 General: Use mounting assemblies that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). Meet the requirements of Section 603.

Fastening hardware such as bolts, nuts, washers, set screws, studs, u-bolts, cable and cable swags, must be provided by the mounting assembly manufacturer, must be SAE Type 316 or 304 stainless steel. Hardware (studs, bolts and u-bolts) must be a minimum of 5/16 inch diameter unless otherwise specified in this Section. SAE Grade 8 bolts and nuts are also acceptable.

659-2.2 Mast Arm Mounting Assemblies: Mast arm mounting assemblies must include the following components: mast arm saddle, swivel, attachment cables (with cable clamp mechanism) or bands, support tube, and top and bottom support arms.

659-2.3 Span Wire Mounting Assemblies: Span wire mounting assemblies must include a span wire clamp, a hanging device such as a drop pipe, adjustable hanger, or adjustable pivotal hanger with extension bar, messenger clamp, disconnect hanger, and multi-brackets.

659-3 Installation.

Install all mounting assemblies and torque all fastening hardware in accordance with the manufacturer's recommendations.

When connecting the extension bar to the top and bottom parts of the adjustable hanger, use maximum overlap of the two pieces and use a minimum of two bolts to connect the top and bottom portion of the hanger to the extension bar, separated with one hole between the top and bottom.

659-4 Warranty.

Ensure mounting assemblies have a manufacturer's warranty covering defects for a minimum of three years from the date of final acceptance in accordance with 5-11 and Section 608. The warranty must include providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

659-5 Method of Measurement.

The Contract unit price per assembly for each mounting assembly, furnished and installed, will include all materials specified in the Contract Documents and all labor, equipment, and miscellaneous items necessary for a complete and acceptable installation.

No separate payment will be made for mounting assemblies for new installations. All incidentals required by the Plans for new installations, including mounting hardware, will be included in cost of the new signal, sign, camera, detector, or other traffic control device.

659-6 Basis of Payment.

Price and Payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 659-	1	Mast Arm, Span Wire and Pole Mounting Assemblies - each.

SECTION 660
VEHICLE DETECTION SYSTEM

660-1 Description.

Furnish and install a vehicle detection system in accordance with the Contract Documents and this Section. Meet the requirements of Section 603.

660-2 Materials.

660-2.1 General: Meet the following requirements:

Traffic Data Detection System- Microwave* .....Section 995
Vehicle Detector- Microwave* 995-2.4
Traffic Data Detection System- Video* .....Section 995
Vehicle Detector- Video* 995-2.3
Traffic Data Detection System- LiDAR* .....Section 995
Vehicle Detector- LiDAR* .....Section 995
Vehicle Loop Detector* 995-2.2
Wireless Magnetometer Assembly* 995-2.5
Automatic Vehicle Identification* 995-2.6
Wrong Way Vehicle Detection Systems* 995-2.7
Loop Sealant* 995-3
Highlighted Signs* 995-15
Hardware and Fittings 603-2.4
Galvanizing 962-11
*Use products listed on the Department's APL.

660-2.2 Classification of Types: Vehicle detection and data collection systems are classified by the type of function they perform and the type of technology that they employ.

660-2.2.1 Functional Types: Provide the functional type detailed in the Plans.

660-2.2.1.1 Vehicle Presence Detection Systems: Vehicle presence detection systems produce a corresponding output any time that a vehicle occupies the physical or virtual area of the detector.

660-2.2.1.2 Traffic Data Detection Systems: Traffic data detection systems provide presence, volume, occupancy, and speed data for the lanes they are configured to monitor.

660-2.2.1.3 Probe Data Detection Systems: Probe data detection systems provide speed data and travel times for a road segment. Probe data detectors use automatic vehicle identification (AVI) technologies to establish a unique identifier for each vehicle they detect. This identifier is then transmitted to a central site where it can be matched to past or future detections of the same vehicle at different detector locations.

660-2.2.1.4 Wrong Way Vehicle Detection Systems: Wrong way vehicle detection systems produce an alarm output when a vehicle is detected traveling in the wrong direction and may consist of more than one detection zone and may use any of the technology types. For both mainline and ramp installations, the detection system must monitor all lanes for one direction, including shoulders. The wrong way detection system must not interfere with other vehicle presence or traffic data detection systems.

660-2.2.2 Technology Types: Provide the detection technology type detailed in the Plans. Detection technology types include inductive loop, video, thermal, microwave, wireless magnetometer, and AVI systems.

660-2.2.2.1 Inductive Loop: An inductive loop detection system uses a minimum of one inductive loop and loop detector. The system operates by energizing and monitoring wire embedded in the road surface to detect vehicle presence and provide an output to traffic controllers or other devices that can generate volume, occupancy, and speed data (detection output).

660-2.2.2.1.1 Loop Wire: Use No. 12 AWG or No. 14 AWG stranded copper wire with Type XHHW cross-linked polyethylene insulation and an additional outer sleeve composed of polyvinylchloride or polyethylene insulation that meets the requirements of International Municipal Signal Association (IMSA) 51-7.

660-2.2.2.1.2 Shielded Lead-in Cable: Use No. 14 AWG two conductor, stranded copper wire with shield and polyethylene insulation, meeting the requirements for IMSA 50-2.

660-2.2.2.1.3 Splicing Material: Butt-end connectors may be used for splicing the loop wire to the lead-in cable. Butt-end connectors must be non-insulated. Use resin-core solder for soldered splices. Splicing tape must be self-fusing silicone rubber. Ensure insulated tubing used to cover splice is heat-shrinkable, cross-linked polyethylene with a silicon sealant inside the tubing and an insulation rating of at least 600 V.

660-2.2.2.2 Video: A video vehicle detection system (VVDS) uses one or more cameras recommended by the manufacturer or an integrated thermal sensor and video analytics hardware and software to detect vehicle presence, provides a detection output, or generates volume, occupancy, and speed data.

660-2.2.2.3 Microwave: A microwave vehicle detection system (MVDS) transmits, receives, and analyzes a FCC-certified, low-power microwave radar signal to detect vehicle presence, provide a detection output, or generate volume, occupancy, and speed data.

660-2.2.2.4 Wireless Magnetometer: A wireless magnetometer detection system (WMDS) uses one or more battery-powered wireless sensors embedded in the road surface, which communicates data by radio to a roadside receiver. Wireless magnetometer systems detect vehicle presence and provide a detection output to traffic controllers or other devices that can generate volume, occupancy, and speed data.

660-2.2.2.5 Automatic Vehicle Identification (AVI): An AVI detection system uses one or more different methods to collect information that can be used to establish a unique identifier for each vehicle detected and the time and location that the vehicle was detected. AVI detection systems collect data using radio-frequency identification (RFID), optical character recognition, magnetic signature analysis, laser profiling, Bluetooth®, or other methods to establish vehicle identifier, time, and location.

660-2.2.2.6 Light Detection and Ranging: A light detection and ranging (LiDAR) detection system uses one or more LiDAR sensors and perception hardware and software to detect vehicle presence, provide a detection output, or generate volume, occupancy, and speed data.

660-3 Installation Requirements.

660-3.1 Installation Requirements for all Detectors: Install, configure, and demonstrate a fully functional vehicle detection system as shown in the Plans. Connect all field equipment to the existing communication network, and provide all materials specified in the

Contract Documents. Install all equipment in accordance with this Section and the manufacturer's recommendations.

Install above-ground detectors on poles or sign structures, as shown in the Plans. Furnish and install the power cable and the communication cables in accordance with the manufacturer's recommendation. Ensure that the cables comply with NEC sizing requirements and meet all other applicable standards, specifications, and local code requirements.

Do not install communication cables in the same conduit or pull boxes as power cables carrying voltage greater than 24 V_{DC}/V_{AC} or current in excess of 1.5 amps.

Cut all wires to their proper length before assembly. Do not double back any wire to take up slack. Neatly lace wires into cables with nylon lacing or plastic straps. Secure cables with clamps and provide service loops at all connections. Label all field wiring cables in the cabinet.

In the event that power to the vehicle detection system or a subcomponent thereof is interrupted, ensure that the equipment automatically recovers after power is restored. Ensure that all programmable system settings return to their previous configurations and the system resumes proper operation.

660-3.2 Inductive Loop Detector Installation: Install vehicle loops in accordance with the Contract Documents, the manufacturer's instructions, and Standard Plans, Index 660-001.

660-3.2.1 Inductive Loop-Detector Units: Adjust the operating frequency of each detector unit, if required, to prevent crosstalk of the units.

660-3.2.2 Saw Cuts: Use a chalk line or equivalent method to outline the perimeter of the loop on the pavement and routes for lead-in cables. Do not allow the saw cut in the pavement to deviate by more than 1 inch from the chalked line. Ensure that all saw cuts are free of any dust, dirt, or other debris and completely dry prior to installation of the loop wire, loop wire twisted pair lead, or lead-in cable.

Ensure that the top conductor of the loop wire or lead-in cable is a minimum of 1 inch below the final surface of the roadway.

660-3.2.3 Loop Wire: Ensure that all loops are wound in a clockwise manner and the first turn of the loop wire is placed in the bottom of the saw cut, with each subsequent turn placed on top of the preceding turn. Push the loop wire to the bottom of the saw cut with a non-metallic tool which will not damage the insulation.

Tag and identify the clockwise "lead" of each loop.

Use alternate polarity on adjacent loops.

Ensure that the hold down material is non-metallic, is placed in the saw slot using segments 1 to 2 inches long, spaced 12 inches apart, and that the distance from the top of the hold down material to the final surface of the roadway is not less than 1-1/2 inches.

660-3.2.4 Loop Wire Twisted Pair Lead: Create a loop wire twisted pair lead by twisting the loop wire pair a minimum of 10 turns per foot to form a loop wire twisted pair lead from the edge of the loop to the pull box located adjacent to the roadway. Place only one loop wire twisted pair lead in a saw cut. Ensure that the distance between a twisted loop wire pair lead within the roadway is a minimum of 6 inches from any other twisted loop wire pair lead or loop, until they are within 1 foot of the edge of pavement or curb, at which point they may be placed closer together.

Provide a minimum of 3 feet of twisted loop wire pair lead in the pull box located adjacent to the roadway. Do not route twisted loop wire pair lead directly through conduits to the cabinet, unless otherwise shown in the Plans.

660-3.2.5 Loop Sealant: Do not use expired products. Prepare and apply loop sealant in accordance with the manufacturer's instructions. Ensure that the loop sealant has cured completely before allowing vehicular traffic to travel over the sealant.

660-3.2.6 Shielded Lead-in Cable: Place the lead-in cable in the bottom of the saw cut. Do not damage the insulation.

Install no more than four lead-in cables in a saw cut. Ensure that the hold down material is no longer than 1 inch and that the distance from the top of the hold down material to the final surface of the roadway is not less than 1-1/2 inches.

660-3.2.7 Splicing: Perform the splicing in a pull box located off the roadway, not in the roadway itself.

Splice the black conductor of the lead-in cable to the clockwise "lead" of the loop.

Ensure that the ends of the cable jackets, twisted pair, and lead-in are encased in the loop splice material.

Ensure that each loop has an individual return to the cabinet and series splicing is performed on a separate terminal block in the cabinet.

660-3.2.8 Terminations: Using insulated terminal lugs, terminate lead-in cables or twisted pair loop wire on a terminal strip, which is located in the controller or detector cabinet. Use a calibrated ratchet type crimping tool to attach the lugs to the conductors of the lead-in cable or twisted loop wire.

660-3.2.9 Loop Assembly Identification: Identify and tag each loop assembly in the controller or detector cabinet by lane and movement number.

660-3.2.10 Inductive Loop Detector Testing and Turn-on:

660-3.2.10.1 Series Resistance: Obtain Department of Transportation Traffic Signal Resistance Measurement Data Sheets from the Engineer. Measure and record the series resistance of each loop assembly on these data sheets. Leave a copy in the controller cabinet.

If the series resistance of a loop assembly is greater than 10 Ω, inspect the loop assembly to find the cause of the excessive resistance. Correct the cause of the excessive resistance at no additional cost to the Department.

660-3.2.10.2 Insulation Resistance: Measure and record the insulation resistance of each loop assembly and verify that the resistance is greater than 100 MΩ. Use a 500 V_{DC} insulation tester to measure the resistance. Reference all measurements to a good earth ground (ground rod, metallic water pipe, etc.). Disconnect the transient suppression devices from the loop assemblies before taking any measurements. If the insulation resistance is less than 100 MΩ, determine if the lead-in cable or the loop wire is causing the problem, and replace the defective cable or loop wire at no additional cost to the Department.

660-3.2.10.3 Loop Detector Turn-on: Connect the loop assemblies to the appropriate inductive loop vehicle detectors and tune the detectors in accordance with the manufacturer's instructions. Separate the operating frequencies of vehicle detectors, in adjacent lanes, by at least 2 kHz.

660-3.3 Video Detector Installation: Install cameras and configure detection zones and settings in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer. Submit configuration settings (including, but not limited to, detector names, communication settings, and output assignments) and configuration file backups to the Engineer. Submit a graphical depiction of each camera site, its pole location, mounting height,

the ratio of distance away from the camera versus the mounting height, the camera's mounting type (i.e., pole or structure), camera aiming procedures, and the placement of the proposed detection zone for each lane.

Do not use coaxial cable runs in excess of 500 feet. Mount and aim cameras in a manner that eliminates as much environmentally generated glare as possible.

660-3.4 Microwave Detector Installation: Install detector and configure detection zones and settings in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer. Submit configuration settings (including, but not limited to, detector names, communication settings, and output assignments) and configuration file backups to the Engineer.

660-3.5 Wireless Magnetometer Installation: Install in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer. Ensure that materials used for the installation of magnetometers in the road surface have cured completely before allowing vehicular traffic to travel over them.

660-3.6 AVI Detector Installation: Install in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer.

660-3.7 Wrong Way Vehicle Detection Systems (WWVDS) Installation: Install in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer.

660-3.8 LiDAR Detection System Installation: Install in accordance with the Contract Documents, manufacturer's recommendations, and as directed by the Engineer.

660-4 Acceptance Testing.

660-4.1 Vehicle Presence Detection System:

660-4.1.1 Performance Requirements: Ensure presence detectors provide a minimum detection accuracy of 98%.

660-4.1.2 Field Acceptance Testing: Verify presence detection accuracy at installed field sites using a reduced method in accordance with 995-2.9. Compare sample data collected from the detection system with ground truth data collected by human observation. For site acceptance tests, collect samples and ground truth data for each site for a minimum of five minutes during a peak period and five minutes during an off-peak period. For presence detection at intersections, ensure there are a minimum of three detections for each signal phase. Perform site acceptance tests in the presence of the Engineer.

660-4.2 Traffic Data Detection System:

660-4.2.1 Performance Requirements: Provide a vehicle detection system capable of meeting the minimum total roadway segment accuracy levels of 95% for volume, 90% for occupancy, and 90% for speed for all lanes, up to the maximum number of lanes that the device can monitor as specified by the manufacturer.

660-4.2.2 Field Acceptance Testing: Conduct field acceptance testing in accordance with Section 611.

660-4.3 Probe Data Detection System:

660-4.3.1 Performance Requirements: Ensure that probe data detectors establish a unique and consistent identifier for each vehicle detected and the time and location that the vehicle was detected. Ensure probe data detection systems that match upstream and downstream detection of the same vehicle provide a minimum match rate of 5%. Ensure probe data detection systems meet a minimum total roadway segment speed and travel time accuracy

level of 90%. Verify system performance over several time periods under a variety of traffic conditions as described in 995-2.9.1.

660-4.3.2 Calculation of Speed and Travel Time Accuracy: Verify detector accuracy at installed field sites using a reduced method in accordance with 995-2.11. Calculate speed and travel time accuracy by comparing the speeds and travel times reported by the system against ground truth collected through human observation or another method approved by the Engineer.

660-4.4 Wrong Way Vehicle (WWVDS) Detection System: Submit a test plan for the field acceptance test (FAT) to the Engineer a minimum of 30 calendar days before commencement of testing for review and approval; tests cannot commence or be scheduled until test plans are approved by the Engineer. For each testing phase, test plans must include descriptions of test procedures; test form with areas for test result recording, test conductor, and witness signatures; pass/fail criteria; and test schedule.

Conduct a field acceptance test for each ramp being monitored by a WWVDS. Test all local system functions using the installed WWVDS equipment as detailed in the Plans and as approved by the Engineer. Testing must demonstrate that:

1. All wiring and local configurations are correct.
2. The WWVDS is detecting vehicles driving the wrong way, in all ramp travel lanes and any paved shoulders 8 feet or wider, while ignoring vehicles traveling in the correct direction. A true positive rate of 95% or greater must be achieved. A false positive rate of 1% or less must be achieved.
3. The WWVDS is activating all wrong way highlighted signs on the ramp upon detection of a vehicle traveling in the wrong direction and sign activation occurs before the vehicle reaches the sign.

If any WWVDS fails to pass its field acceptance test, correct the unit, or substitute another unit in its place, then repeat the test.

If a unit has been modified due to a field acceptance test failure, prepare a report describing the nature of the failure and the corrective action taken and submit it to the Engineer prior to re-testing. If a failure pattern develops, the Engineer may direct that design and construction modification be made to all units without additional cost to the Department or extension of the Contract Time.

660-4.4.1 True Positive Testing: Conduct this test on a closed ramp using Contractor-provided test vehicles. Test each lane and paved shoulder 8 feet or wider by driving two types of test vehicles traveling at two travel speed ranges the wrong direction. For this testing, the small vehicle shall be a FHWA Class Group 2 (passenger car) vehicle, and the large vehicle shall be a FHWA Class Group 3 (pick-ups and vans) or Class Group 5 (two-axle truck) vehicle.

Each ramp lane shall be subjected to the following test vehicle runs; each ramp paved shoulder 8 feet or wider must only undergo test runs described in #1 and #2.

1. Five runs of a small vehicle traveling between 10 and 15 miles per hour.
2. Five runs of a large vehicle traveling between 10 and 15 miles per hour.
3. Five runs of a small vehicle traveling 35 miles per hour or greater.
4. Five runs of a large vehicle traveling 35 miles per hour or greater.

Calculate the true positive rate using the following formula:

$$TPR = {}^{TP}/_{N} * 100$$

Where *TPR* = True positive rate %.

TP = Cumulatively for all test runs, the total number of times the WWVDS correctly detected the wrong way vehicle and activated the highlighted signs.

N = Total number of test vehicle runs.

660-4.4.2 False Positive Testing: Conduct this test on a ramp open to the traveling public. Test the WWVDS by monitoring a minimum of 300 total vehicles traveling in the correct direction of travel passing through the WWVDS detection zones. At least 150 vehicles shall be monitored during daylight hours and at least 150 vehicles shall be monitored at night. The Engineer may reduce minimum volume requirements under low volume conditions if necessary.

Calculate the false positive rate using the following formula:

$$FPR = {}^{FP}/_{N} * 100$$

Where:

FPR = False positive rate %.

FP = Total number of times the WWVDS activated for a vehicle traveling in the correct direction.

N = Total number of vehicles traveling in the correct direction.

660-5 Warranty.

Ensure that the detection system has a manufacturer's warranty covering defects for a minimum of 1 year from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608.

Ensure the warranty includes providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

660-6 Method of Measurement.

The quantity to be paid will be the plan quantity for each inductive loop detector and per assembly for loop assembly completed and accepted.

The quantity to be paid will be the plan quantity for each MVDS, VVDS, WMDS, AVI, WWVDS, or LiDAR VDS completed and accepted.

The highlighted signs for a WWVDS will be paid for in accordance with Section 700. Only one WWVDS will be paid per exit ramp, regardless of the number of signs.

660-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section including furnishing, placement, and testing of all materials and equipment, and for all tools, labor, equipment, hardware, operational software packages and firmware, supplies, support, personnel training, shop drawings, warranty documentation, and incidentals necessary for a complete and accepted installation.

Payment will be made under:

Item No. 660-1	Inductive Loop Detector - each.
Item No. 660-2	Loop Assembly – per assembly.
Item No. 660-3	Vehicle Detection System - Microwave - each.
Item No. 660-4	Vehicle Detection System - Video - each.
Item No. 660-5	Vehicle Detection System - Wireless Magnetometer - each.
Item No. 660-6	Vehicle Detection System - AVI - each.

Item No. 660-7	Vehicle Detection System - WWVDS - each.
Item No. 660-8	Traffic Data Detection System - Microwave - each.
Item No. 660-9	Traffic Data Detection System - Video - each.
Item No. 660-10	Vehicle Detection System – LiDAR – each.
Item No. 660-11	Traffic Data Detection System – LiDAR – each.

SECTION 663
SIGNAL PRIORITY AND PREEMPTION SYSTEMS

663-1 Description.

Furnish and install a signal priority and preemption system as shown in the Plans. The signal preemption system must recognize and respond to the priority of each user. Meet the requirements of Section 603.

663-2 Materials.

Use signal priority and preemption system equipment that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). Ensure that all materials furnished, assembled, fabricated, or installed are new products.

Signal priority and preemption system equipment may utilize optical, GPS, and radio frequency based technologies.

Ensure that in-vehicle equipment operates without requiring any action from the vehicle operator or occupants once power is applied.

663-3 Installation.

Installation of materials must be in accordance with the manufacturer's instructions. Install the emergency preemption system including installation of detectors with all necessary hardware and software, mounting hardware, cabling, and all other associated electronics in cabinet necessary to create a fully functional emergency preemption system.

Ensure that status indicators remain unobstructed and visible.

663-4 Field Testing.

Subject the system to field acceptance tests (FATs). Develop and submit a test plan for FATs to the Engineer for approval. The Engineer reserves the right to witness all FATs.

663-5 Warranty.

Ensure that the priority and preemption system has a manufacturer's warranty covering defects for 5 years from the date of final acceptance. Ensure that the manufacturer will furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department or the maintaining agency within 10 calendar days of notification.

663-6 Method of Measurement.

The Contract unit price for each signal priority and preemption system, furnished and installed, will include furnishing, placement, and testing of all equipment and materials, and for all tools, labor, hardware, operational software packages and firmware, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work.

663-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 663- 1- Signal Priority and Preemption System

SECTION 665
PEDESTRIAN DETECTION SYSTEM

665-1 Description.

Install a pedestrian detection system as shown in the Plans. Pedestrian detection systems are classified into three categories: Standard Pedestrian Pushbutton Detectors, Accessible (Audible/Tactile) Pedestrian Pushbutton Detectors, and Passive Detectors. The components of the pedestrian detection system include pushbuttons, pedestrian actuation signs, electronics, wiring, and mounting hardware.

665-2 Materials.

Use pedestrian detection systems that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL). For the pedestrian actuation sign, use Type XI retroreflective sign sheeting meeting the requirements of Section 994 and the Standard Plans, Index 700-102.

665-3 Warranty.

Ensure that pedestrian detection systems have a manufacturer's warranty covering defects for a minimum of 5 years from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608. Ensure the warranty includes providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

665-4 Installation.

Install pedestrian detectors at the locations and in a manner as shown in the Plans and Standard Plans, Index 665-001. Ensure all detectors are the same manufacturer and model.

Pushbuttons mounted on wood poles must be serviced by a conduit riser. Pushbuttons mounted on steel or aluminum (poles, pedestals, or posts) must be serviced by wiring inside the pole. Pushbuttons mounted on existing concrete poles may be serviced by a conduit riser. Pushbuttons mounted on new concrete poles or pedestals must be serviced by wiring on the inside.

A pedestrian actuation sign must be included with each pushbutton assembly. Install pedestrian actuation sign in accordance with the sheeting manufacturer's recommendations. Tactile arrows of accessible pedestrian pushbuttons must align parallel with the direction of the crossing.

When mounting, place the detector housing or saddle in complete contact with the pole or controller cabinet. When a post is required in the installation of the pedestrian detector, restore the area around the post to its original condition or as required by the Plans.

665-5 Method of Measurement.

The Contract unit price for pedestrian detectors, will be paid per each, and will include the pedestrian actuation sign, all mounting hardware, wiring, materials and equipment, and all labor and miscellaneous materials necessary for a complete and accepted installation.

Payment for poles, pedestals, and posts will be made under their respective pay item numbers.

665-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 665- 1- Pedestrian Detector - each.

SECTION 670
TRAFFIC CONTROLLER ASSEMBLIES

670-1 Description.

Furnish and install a traffic controller assembly or flashing intersection control beacon controller assembly as shown in the Plans. Meet the requirements of Section 603.

670-2 Materials.

Use only controller components listed on the Department's Approved Product List (APL). Traffic controller assemblies and intersection control beacon controller assemblies must be permanently marked with manufacturer name or trademark, part number and serial number. Markings must be visible after installation.

Provide a traffic controller assembly consisting of a traffic controller, traffic controller accessories (including monitors, load switches, flasher, flash transfer relay, power supplies), and other equipment wired into a controller cabinet to make a complete and operational assembly. All traffic controller assemblies must provide functionality that meets or exceeds operational characteristics, including NTCIP support, as described in NEMA TS-2-2003.

670-2.1 Traffic Controller: Meet the requirements of Section 671.

670-2.2 Traffic Controller Accessories: Meet the requirements of Section 678.

670-2.3 Controller Cabinet: Meet the requirements of Section 676.

670-2.4 Flashing Intersection Control Beacon Controller Assembly: A flashing intersection control beacon controller assembly must consist of a Type 3 flasher wired into a Type 1 controller cabinet to make a complete and operational assembly.

670-3 Installation Requirements.

670-3.1 Controller Cabinets: Meet the requirements of Section 676.

670-3.2 Field Wiring: Meet the requirements of Sections 632 and 676.

670-3.3 Grounding: Meet the requirements of Sections 620 and 676.

670-3.4 Equipment Placement: Install all equipment in the cabinet in accordance with the manufacturer's recommendations.

670-4 Method of Measurement.

The Contract unit price per assembly for traffic controller assembly or intersection control beacon controller assembly will include all labor, equipment, and miscellaneous materials necessary for a complete and accepted installation.

No separate payment will be made under this item for wiring, programming, signal operating plan, or other modifications needed to complete the installation of new signal cables or auxiliary equipment.

670-5 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 670-	4-	Intersection Control Beacon Controller Assembly - per assembly.
Item No. 670-	5-	Traffic Controller Assembly - per assembly.

SECTION 671
TRAFFIC CONTROLLERS

671-1 Description.

Furnish and install a traffic controller unit as shown in the Plans. Meet the requirements of Section 603.

671-2 Materials.

Use traffic controllers that meet the requirements of Section 995 and are listed on the Department's Approved Product List (APL).

If shown in the Plans, new installations must include controllers that will deactivate the dimming circuit of LED street lighting during pedestrian activations. Pedestrian detector diagnostics must be activated when this feature is used.

671-3 Installation Requirements.

Install and configure traffic controllers in accordance with the Plans and the manufacturer's recommendations.

671-4 Method of Measurement.

The Contract unit price each for traffic controller, furnished and installed, will include all materials specified in the Contract Documents, and all labor, equipment, and miscellaneous materials necessary for a complete and acceptable installation.

No separate payment will be made for a traffic controller when included with the Traffic Controller Assembly per Section 670.

671-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item 671- 2- Traffic Controller - each

SECTION 676
TRAFFIC CABINETS

676-1 Description.

Furnish and install traffic cabinets as shown in the Plans. Meet the requirements of Section 603.

676-2 Materials.

676-2.1 General: Use traffic signal controller cabinets, ITS cabinets, and small equipment enclosures that meet the requirements of Section 995-11 and are listed on the Department's Approved Product List (APL). Provide the cabinet with an automatic transfer switch if shown in the Plans. New signal installations must include controller cabinets that will interface with the dimming circuit of LED street lighting with an auxiliary relay if shown in the Plans. Provide cabinets with No. 2 locks unless otherwise shown in the Plans.

676-3 Installation Requirements.

676-3.1 General: Ground all cabinets in accordance with the requirements of Section 620. Keep the ground wire from the cabinet ground busbar to the ground rod assembly or array as short as possible. Ensure the ground wire is not in contact with any other part of the cabinet. All field drilled conduit entrance holes or other holes must be reamed and free of burrs. All conduit connections to cabinets and small equipment enclosures must be weatherproof. Ensure cabinet doors do not pinch or damage interior cables or displace equipment when doors are open, closed, or in motion.

Construct cabinet bases and maintenance service slabs as shown in Standard Plan 676-010 unless otherwise shown in the Plans. Construct cabinet bases and maintenance service slabs without risers using concrete in accordance with Section 347. Construct cabinet bases and maintenance service slabs with risers using concrete in accordance with Section 346. Make the concrete base and maintenance service slab level, free of honeycombs, and with a broomed finish. Temporarily seal the end of conduit risers located in the base before placing the concrete. Ensure conduit remains clear of debris. Position the end of the conduit risers a minimum of 2 inches above the finished surface of the concrete base.

676-3.2 Controller Cabinet Installation: Install traffic signal controller cabinets and concrete risers in accordance with Standard Plans, Index 676-010. Wire controller cabinets in accordance with the signal operating plan specified in the Contract Documents. If phases are omitted for future use, the cabinet must be wired for these future phases. Load switches for the future phases do not have to be furnished.

676-3.2.1 Pole Mounted Cabinets:

(a) Fasten the pole mounted hardware furnished with the cabinet to the cabinet using bolts no less than 1/2 inch threaded diameter. Ensure all connections are watertight.

(b) Use stainless steel bands for mounting cabinets onto steel strain poles.

(c) Use stainless steel bands or lead anchors (or equivalent) for mounting cabinets onto concrete strain poles.

(d) Use stainless steel bands or lag bolts for mounting cabinets onto wood poles.

676-3.2.2 Ground Mounted Cabinets:

(a) Use anchor bolts to fasten ground mounted cabinets to the concrete base.

(b) Seal the joint between the bottom of the cabinet and the concrete base (inside and outside of cabinet) with a clear silicone rubber sealant.

676-3.2.3 Field Wiring:

(a) Terminate signal cable, interconnect cable, and loop lead-in wires on the appropriate terminal strips in the controller cabinet with insulated terminal lugs. Use a calibrated ratchet type crimping tool to install the insulated terminal lugs onto the field wires.

(b) Label spare circuits of the signal and interconnect cables and connect them to the cabinet ground busbar.

(c) Neatly bundle and identify all field wiring cables in the controller cabinet.

676-3.3 Intelligent Transportation System Cabinet Installation: Mount the cabinet as shown in the Plans and provide the cabinet with the necessary base or pole mount hardware. Ensure that pole and structure-mounted field cabinets have mounting brackets on the side so that both cabinet doors are fully functional. Provide an adapter bracket for pole mounted cabinets that is designed to allow banding straps to be installed without obstructing pole handholes.

Make provisions for all data, control, and confirmation connections between the ITS device and field cabinet and for any required wiring harnesses and connectors.

Place a heavy-duty resealable plastic bag on the backside of the main cabinet door for storing a list of terminal block connections and other cabinet documentation.

Place all equipment in the cabinet according to the recommendations of the manufacturer. Maintain a minimum clearance of 6 inches between the top of the cabinet and the top of any equipment placed on the top shelf of the cabinet and a minimum clearance of 2 inches between each side of the cabinet and any equipment placed on the cabinet shelves.

676-3.4 Small Enclosure Installation: Mount the enclosure on a pole or support structure as shown in the Plans and provide any hardware necessary for a complete and accepted installation.

676-4 Warranty.

Ensure cabinets, enclosures, and risers have a manufacturer's warranty covering defects for a minimum of 2 years from the date of final acceptance. The warranty must include providing replacements, within 10 calendar days of notification, for defective parts and equipment during the warranty period at no cost to the Department or maintaining agency.

676-5 Method of Measurement.

The Contract unit price each for cabinet, enclosure, or riser, furnished and installed, will include all materials specified in the Contract Documents, and all labor, equipment, and miscellaneous materials necessary for a complete and acceptable installation.

No separate payment will be made for a traffic signal controller cabinet when included with the controller assembly as per Section 670.

676-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 676- 1- Traffic Signal Controller Cabinet - each.

Item No. 676- 2- ITS Cabinet - each.

Item No. 676- 3- Small Equipment Enclosure - each.

SECTION 677
EQUIPMENT SHELTER

677-1 Description.

Furnish and install an equipment shelter as shown in the Plans. Ensure that all materials furnished, assembled, fabricated, or installed are new products.

677-2 Materials.

677-2.1 General: Ensure that the shelter includes a secure door; power distribution panels; a heating, ventilation, and air conditioning (HVAC) system; lightning protection, grounding, and any other components necessary for a completely integrated communication building. Ensure that the shelter is constructed and installed according to local building codes.

Provide a shelter designed for the following loads: wind: 170 MPH; floor: 200 pounds per square foot; slab: 200 pounds per square foot; roof: 100 pounds per square foot. Submit design drawings that meet all minimum standards and are signed and sealed by a registered Professional Engineer in the State of Florida.

The shelter's exterior shall have an exposed concrete aggregate finish. The shelter must have a bullet-resistant exterior surface in accordance with UL 752. The shelter's exterior color is to be earth tone. Alternative exterior finishes or colors may be approved by the Engineer.

677-2.2 Shelter Floor and Foundation: The floor is to be constructed of concrete or concrete composite material.

The foundation is a monolithic slab with appropriate footings and the final top of slab elevation is set a minimum of 2 feet above final grade, or as shown in the Plans. Concrete is to be Class II for extremely aggressive environments and in accordance with Section 346. Perform concrete structures work in accordance with Section 400.

The equipment shelter must not bend or break during moving, towing, or hoisting.

The equipment room's interior floor covering is to be industrial-grade vinyl flooring fastened to the shelter floor with waterproof adhesive. Provide an air gap between the equipment shelter floor and the foundation slab, or alternatively, construct the foundation slab with a vapor barrier to prevent moisture penetration. Insulate the floor to provide a minimum insulating factor of R-11.

677-2.3 Door: The exterior door is to be 36 inches wide by 78 inches tall, insulated, bullet-resistant, corrosion-resistant steel door with a door check and doorstop secured with a mortised deadbolt security lock keyed as directed. The door is to have a lever type handle on both the inside and outside. Provide the Department with four keys to each door lock.

677-2.4 Walls: Vapor shield the walls to prevent moisture penetration and install rigid board insulation for a minimum insulating factor of R-14. Attach the vapor shield and insulation directly to the concrete wall avoiding any air gap. Interior surfaces are to have a white textured finish wall covering with molding on all corners. All floor and wall intersections are to have 4 inch vinyl baseboards installed using waterproof adhesive.

677-2.5 Ceiling and Roof: The interior room height is to be no less than 9 feet above the floor and capable of supporting the proposed electrical fixtures and cable trays. The roof section shall have a 1/8 inch per foot minimum pitch for drainage. Fill all voids between the ceiling and roof with a vapor shield and install rigid board insulation for a minimum Type insulating factor of R-21 insulation. Attach the vapor shield and insulation directly to the concrete ceiling avoiding any air gap.

677-2.6 Entrance: The entrance steps shall be concrete with ADA approved hand rail. The maximum distance from the final grade or final step to the shelter floor must not exceed 8 inches.

677-2.7 Lighting: Fluorescent light fixtures are to provide a uniform initial light level of 125 to 150 foot candles at 4 feet above the floor with a 3:1 ratio of maximum to minimum light levels as measured throughout the shelter's interior. Mount a light switch inside the shelter, adjacent to the entry door, for the interior lighting.

Install one 2250 lumen floodlight that is vandal resistant and mounted on the outside near the entrance door with a photocell and interior light switch. Install an auxiliary powered interior emergency light that illuminates when primary power fails.

677-2.8 HVAC System: Install appropriately sized exterior wall-mounted air conditioners. Ensure the system has a dry contact closure alarm output for failure monitoring and has an installed adjustable start time delay, initially set to 5 minutes.

The HVAC unit must be capable of operating when the outside temperature falls below 60ºF and have sufficient capacity to cool from a 95ºF ambient temperature to 75ºF, including the equipment heat load, providing continuous interior equipment cooling and dehumidification. The unit shall have a device installed to reduce the starting current required during a cold start or under high-head pressure conditions.

Provide an IP addressable thermostat which provides a secure web based interface that displays the current thermostat settings and allows remote adjustments.

677-2.9 Cable Trays: Cable trays are to be 12 inches wide capable of supporting the transmission lines, control and data wires, and alarm wires associated with communication equipment. Use cable trays constructed of aluminum or painted steel fabricated in an open ladder type arrangement that are suspended from the ceiling. Electrically bond by mechanical means, on non-painted surface areas, all rack and cable tray units together. After bonding all rack and cable tray units, cover these areas with an antioxidant compound. Cable trays and rack frames are to be connected to the shelter interior ground.

The clearance height between the floor and bottom of the cable tray is to be no less than 86 inches.

Equip the cable trays with overhead receptacles as shown in the Plans.

677-2.10 Equipment Rack: Include at least one standard 19 inch EIA/TIA equipment rack capable of mounting and supporting all devices indicated in the Plans. Include provisions for vertical and horizontal cable management and for power strips. Secure the top of each rack to the cable tray above using C channel or J hook hardware and to the floor in the location shown in the Plans or as directed by the Engineer.

677-2.11 Fire/Smoke Detection and Suppression: Install at least one smoke detector that operates on alternating current. Mount the smoke detector on the ceiling 1 foot clear of all obstructions and ensure that it includes a dry contact closure that will activate during prescribed conditions.

Where the equipment shelter is to be furnished with an automatic fire protection system, it is to be an FM-200 waterless, residue-free fire suppression system that conforms to NFPA and ISO 14520 standards.

Mount a hand-held carbon dioxide ABC fire extinguisher on the wall near the door. Verify that the extinguisher has a valid inspection tag and is rechargeable.

677-2.12 Alarm Specification: Wire, label and terminate all alarms on a Type 66 block. Provide the following shelter alarms:

1. A magnetic dry contact door alarm.
2. A dry contact air conditioner failure alarm for each installed unit.
3. Dry contact fire alarms.
4. Dry contact high- and low-temperature alarms with thresholds adjustable between 50 and 90ºF.
5. A power failure alarm that is wired from a dedicated circuit breaker.
6. A main fuse alarm that is wired from the main fuse disconnect.

Provide provisions on each exterior side of the shelter that can be used for installation of security cameras. Provide these weatherproof conduit entries at locations near the corner of the shelter just below the roofline to allow wiring for cameras and other security devices to pass into the shelter.

677-2.13 Electrical: The standard electrical configuration is single-phase 120/240 V_{AC} at 60 Hz with a 150 A minimum service and a 42 circuit distribution panel. Provide power service drop and site-specific power needs in accordance with Section 639.

677-2.13.1 Primary AC Surge Protective Device: Install a primary AC surge protective device (SPD) that meets the requirements of Section 620, wired to protect the system while utilizing either utility or emergency power.

677-2.13.2 SPDs at Point of Use: Install SPDs that meet the requirements in Section 620 so that all outlets are protected.

677-2.14 Communication Cable Wall Entry: Install four, 4 inch diameter exterior wall penetrations with weather-sealed boots as shown in the Plans.

677-2.15 Circuit Termination Backboard: Install a backboard for the termination of communication circuits of 3/4 inch AC-grade plywood no less than 48 inches square and painted with two coats of gray, flame-retardant paint. All ground wires and conductors are to be insulated from the backboard, which must be securely mounted to the wall and capable of supporting the hardware fastened to it.

677-2.16 Warranty: The equipment shelter, its components, and hardware must have a manufacturer's warranty covering defects for a minimum of one year.

677-3 Installation Requirements.

677-3.1 General: Provide and detail the equipment shelter installation, including site layout, fencing, and all other features. Submit this drawing for approval prior to the start of construction.

Concrete is to be Class II in accordance with Section 346. Perform concrete structures work in accordance with Section 400. Obtain precast products from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105. Submit to the Engineer all permit documents for approval prior to starting the work.

Complete construction of the shelter foundation prior to delivery of the equipment shelter. Provide primary electrical power service, or generator power, to the site prior to delivery of the equipment shelter.

Begin shelter installation on the foundation within two days of shelter delivery to the jobsite. Complete the grounding and electrical connections to the shelter.

Upon completion of shelter installation dehumidify the shelter. Keep the shelter door closed for a period of 15 minutes and cycle the heat with the HVAC thermostat set on 85°F. The vendor shall return the HVAC units to normal operation mode once the dehumidification process is complete.

In the event that shelter installation and primary or back up power connections to the shelter are delayed, then a portable dehumidifier shall be installed and operated until the shelter installation and power connection is complete. Install the portable dehumidifier with minimum performance capability, at 80°F and 60% relative humidity, of 30 pints per day water removal rate. Install a drain to route water away from the shelter.

677-3.2 Electrical: Install and connect electrical power to the equipment shelter and install all wires and cables in a neat, orderly fashion. Provide underground power service unless otherwise specified in the Plans.

Make all electrical connections from the service drop to the equipment shelter's receptacles. Use a minimum of No. 12 AWG copper wires to install the receptacles, switches, and light fixtures. Run all wire in a minimum 0.75 inch inside diameter electrical metallic conduit. Divide the electrical loads among as many load centers as necessary to contain the quantity of circuit breakers required to protect the equipment shelter facility.

Load centers must contain separate, appropriately sized circuit breakers for the HVAC units, each major branch as is necessary, each receptacle, and each remaining location in the 42 circuit panel. Each interior side of the four walls will have a duplex receptacle 18 inches above the floor, or as shown in the Plans. Protect receptacles with an individual 20 A circuit breaker. Install a separate 20 A single-pole circuit breaker to protect the lighting circuits.

677-3.3 Provision for Backup Power: The equipment shelter must be capable of utilizing a mobile emergency generator during power outages. The emergency generator connection shall allow Department personnel to power the site from a portable generator in the event that both the utility power and emergency power is lost.

Install a primary power switch to allow for the disconnection of commercial power at the main power entrance that is interconnected to an automatic transfer switch to facilitate a switch to emergency generator power in the event utility power is lost. Emergency generator power must route through a manual power switch on the outside of the shelter prior to connection to the automatic transfer switch panel.

677-3.4 Grounding: Meet the requirements of Section 620.

677-3.5 Site Preparation: Meet the requirements of Section 110. Coordinate the extent and schedule for all land clearing activities with the Engineer.

677-3.6 Fencing: Furnish Type B chain-link perimeter fencing and gates according to the requirements of Section 550 and Standard Plans, Index 550-002 with barbed wire attachment. Install the fence to form a rectangle or square shape, unless otherwise specified in the Plans. Allow for a minimum clearance of 5 feet between the fence and any enclosed item.

Construct sliding gates in accordance with Standard Plans, Index 550-003 with barbed wire, configure as shown in the Plans. Provide a hardened, four digit combination gate lock with the combination set as directed.

677-3.7 Weed Prevention: As necessary, treat the fenced area with a Department-approved herbicide used in accordance with 7-1. Install a woven plastic weed barrier in accordance with manufacturer's recommendations prior to gravel installation with a minimum 10% overlap for each barrier section and secure the edges of the mat with stakes.

677-3.8 Compound Gravel: Place gravel or crushed rock covering all unimproved areas within the limits of the fenced area to a depth of 6 inches. Gravel or crushed rock shall not exceed 3 inches in diameter.

677-3.9 Site Restoration: Provide performance turf in accordance with Section 570.

677-4 Inspection and Verification.

677-4.1 General: The Department may perform an inspection witnessed by the Engineer at completion of the work. Notify the Engineer at least 10 days prior to completion of the installation to schedule the inspection. The inspection will verify that all equipment is correctly installed and functional.

Submit all test results in a format approved by the Engineer prior to testing. All recorded test report data shall be signed and dated, witnessed, and validated by signature from a Department representative. Remedy all noted deficiencies at no cost to the Department.

677-4.2 Mechanical Inspection: Test all equipment associated with the shelter. Test and verify the HVAC system performance for heating, cooling, and dehumidification. Inspect the building for the proper sealing of all wall penetrations. Correct any deficiencies at no cost to the Department.

677-4.3 Electrical Inspection: Verify and submit a report to the Engineer prior to acceptance that all shelter lights and smoke detectors operate properly, and proper electrical power load balances are realized. Correct any deficiencies at no cost to the Department.

677-4.4 Site Inspection: The site is to be free of debris and all excavations backfilled and restored to natural grade conditions.

677-4.5 Performance Period: Following the completion of all acceptance testing and inspections, subject the installed site to a minimum 20 day performance period, or alternately, the operational test period for the project, whichever is greater.

For the purpose of a successful performance period, failure of operation is defined as the failure of a major site component (i.e., HVAC systems, lighting, alarms, fire or smoke detection, etc.). Conduct the performance verification inspection with the Engineer present.

Complete performance testing within 45 days of shelter installation and inspection.

677-5 Method of Measurement.

The Contract unit price for each equipment shelter, furnished and installed, will include furnishing, placement, and testing of the shelter, all its materials and equipment, and for all tools, labor, equipment, hardware, site preparation, site restoration, fencing, supplies, shop drawings, permit documents, utility connections, documentation, and incidentals necessary to complete the work.

677-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 677- 1 Equipment Shelter, per each.

SECTION 678
TRAFFIC CONTROLLER ACCESSORIES

678-1 Description.

Furnish and install traffic controller accessories as shown in the Plans. Meet the requirements of Section 603.

678-2 Materials.

Meet the following requirements:

Conflict Monitor*	Section 995
Malfunction Management Unit*	Section 995
Power Supply*	Section 995
Load Switch*	Section 995
Flasher*	Section 995
Flash Transfer Relay	NEMA TS2-2021, Section 6.4
Model 206L Power Supply Unit*	Section 995
Model 208 Monitor Unit*	Section 995
Model 210 Monitor Unit*	Section 995
Power Distribution Assembly*	Section 995
Input File*	Section 995
Model 430 Flash Transfer Relay	CALTRANS TEES 2020, 6.4.5.1.5
Time Switch*	Section 995

*Use products listed on the Department's APL.

678-3 Installation Requirements.

678.3.1 General: Install all traffic controller accessories in accordance with the manufacturer's recommendations. Terminate wires on the appropriate terminal strips in the controller cabinet with insulated terminal lugs. Neatly bundle, secure, and identify all wiring and cables.

678-3.2 Time Switch: Mount time switches on the inside wall of the controller cabinet to allow easy access for programming the switch. Ensure that the load current on the output circuits of the time switch does not exceed 3 A at 115 $V_{AC.}$ Whenever time switches are used for transferring a controller assembly to and from flashing operation, wire the controller cabinet for uniform code flashing as specified in Section 676.

678-4 Basis of Payment.

No separate payment will be made for traffic controller accessories. Include the cost in the Contract unit price for the traffic controller assembly.

SECTION 680
SYSTEM CONTROL EQUIPMENT

680-1 Description.

Furnish and install system control equipment as shown in the Plans. Meet the requirements of Section 603.

680-2 Materials.

680-2.1 General: Use system control equipment and components listed on the Department's Approved Product List (APL).

680-3 Installation.

Install all system control equipment in accordance with the manufacturer's recommendations. Terminate wires on the appropriate terminal strips in the controller cabinet with insulated terminal lugs. Neatly bundle, secure, and identify all wiring and cables.

680-4 Warranty.

Ensure system control equipment has a manufacturer's warranty covering defects for a minimum of 3 years from the date of final acceptance. The warranty must include provisions for providing replacements within 10 calendar days of notification for defective parts and equipment during the warranty period at no cost to the Department or the maintaining agency.

680-5 Method of Measurement.

The Contract unit price for system control equipment, furnished and installed, will include all materials, equipment, hardware labor and miscellaneous materials necessary for a complete and accepted installation.

680-6 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 680 1 System Control Equipment - each.

SECTION 682
VIDEO EQUIPMENT

682-1 CCTV Camera.

682-1.1 Description: Furnish and install a closed-circuit television (CCTV) camera at the locations shown in the Plans. The installed equipment must provide video images of the roadway, traffic, and other current conditions around a roadside CCTV field site; respond to camera control signals from the operator; and transmit video images to remote locations for observation.

682-1.2 Materials: All equipment shall be permanently marked with manufacturer name or trademark, part number, and date of manufacture or serial number. Meet the requirements of Section 603. Provide a CCTV camera that is compatible with any camera operating software indicated in the Contract Documents. Cameras are classified by camera type and video type. Provide the appropriate type for the locations shown in the Plans. Use only equipment and components that meet the requirements of Section 996 and are listed on the Department's Approved Product List (APL).

All CCTV cameras must support the communication links shown in the Plans. Unshielded twisted pair/shielded twisted pair network cables must be compliant with the TIA-568 Standard.

682-1.3 Installation: Install the CCTV camera on a pole in accordance with Standard Plans, Indexes 641-020, 649-020, and 659-020, and as shown in the Plans.

Furnish and install the power supplies and any other camera-related field electronic equipment and transient voltage surge suppressors within a pole- or base-mounted lockable cabinet. The cabinet must meet the requirements of Section 676.

Furnish and install all power, video, and data cables necessary to provide connection points for camera video and PTZ control signals within the cabinet. Furnish and install any and all ancillary equipment required to provide a complete and fully operational CCTV camera. Verify that all wiring meets National Electric Code (NEC) requirements where applicable.

Route the data and video cables from the pole or support structure to the camera inside the mounting hardware and protect from exposure to the outside environment.

Coat the exterior of the dome-type enclosure's lower half with a clear, rain repellant product prior to final acceptance.

682-1.4 Field Acceptance Testing: Conduct field acceptance testing in accordance with Section 611.

Perform local field inspection at each local CCTV field site to verify and confirm the following:

1. Physical construction has been completed as specified in the Plans and all existing and proposed lanes are clearly visible with no line of site obstructions.
2. The quality and tightness of ground and surge protector connections.
3. Proper voltages for all power supplies and related power circuits.
4. All connections, including correct installation of communication and power cables.

682-2 Video Display Equipment.

682-2.1 Description: Furnish and install video display equipment as shown in the Plans.

682-2.2 Materials: Video display equipment must have the capability to display analog, digital, and other images associated with the operation of the transportation management center (TMC).

Provide equipment, mounting hardware, cabling, and other video display components that are compatible with each other. All equipment and materials furnished and installed must be reviewed and approved by the Engineer.

682-2.2.1 Video Display Control System: Furnish a video display control system that meets the requirements of Section 996.

Provide the video display control system with a minimum configuration of 4 composite video inputs, 4 component (red, green, and blue (RGB)) video inputs, and 4 DVI inputs as well as network connections, decoders, and associated hardware and software required to display 32 inputs simultaneously at a minimum resolution of 720 pixels x 480 pixels and a frame rate of 30 fps, or as shown in the Plans.

Provide the video display control system with a minimum configuration of 4 composite video outputs, 2 component (RGB video outputs), and 4 DVI outputs, or as shown in the Plans. If the projection device requires an analog signal, then breakout cables may be used to convert the DVI output connector to a HD15 analog RGB connector.

682-2.2.2 Video Wall Display: Furnish and install a video wall display consisting of display devices described below arranged in a wall, as shown in the Plans, together with a video display control system.

The video wall display must produce, at a minimum, a large-scale, high-resolution video image having accurate color rendition, sufficient image brightness, and a high contrast ratio, as described in 682-2.2.8. The display system must provide access to serviceable components for repair and replacement of electronics, lamps, and optical components without removing the device from service for a period longer than 30 minutes.

Integrate the individual display units in a single, seamless display that provides a continuous image across the entire active display area provided, under the complete control of the TMC operators from their individual shared workstations.

Source all major wall display components from a single provider or manufacturer to ensure that the various devices are compatible with each other and able to function together as an integrated display.

The individual video images must exhibit a uniformity of color quality across the multiple displays. Colors must be displayed evenly across the video wall and the video wall must maintain uniform brightness characteristics from one video display unit to the next in the tiled display, with no degradation in color or brightness uniformity over time. The video wall display must provide features that allow physical and electronic alignment of the separate high-resolution display units that comprise the wall.

682-2.2.3 Video Wall Support Structure: Furnish and install an aluminum or steel-frame structure that supports the video display units as mounted and stacked to form the matrix for the video wall display. The support structure must consist of stackable display units that maintain a consistent maximum horizontal and vertical spacing of 0.04 inches between adjacent display units in the video wall matrix.

Fabricate the support structure specifically to ensure that a continuous, accurate image is provided on the screens without any distortion or unused screen space and that no observable distortions are present in the installed video wall display due to normal building

vibration. Each completed structure must be enclosed such that there is no ambient light effect on the screen from behind the display.

Ensure that the components of the individual video displays can be serviced without disturbing the integrity of the entire video wall display.

682-2.2.4 Rear Projection Video Display: Use rear projection video displays that are suitable for digital video wall applications in mission-critical TMCs where video wall image quality, operational reliability, and serviceability objectives as stated in this Specification can be achieved.

Use rear projection video displays that display a minimum of a single or quad-split, four-paned CCTV camera video image. Each video display must be able to be independently controlled from any of the central operator or shift supervisor workstations, and that each video display can be integrated with additional video units to form a single video display, or a virtual desktop where video windows can be positioned and resized by the operator.

Ensure that the rear projection video display facilitates lamp replacement without the need to readjust the image being projected on the screen.

The rear projection video display intensity must be sufficient for effective and comfortable viewing by TMC operations personnel under normal lighting conditions, subject to approval by the Department. The unit's display engine must produce a minimum light output of 550 ANSI lumens.

The rear projection video units must have the following minimum features and characteristics:

1. Screen brightness achieved by a combination of projection techniques and screen materials, so that the video display has a minimum brightness measurement of 130 candelas per square meter (cd/m2) across the outside viewing surface of the projection screen.

2. Brightness uniformity that meets or exceeds 80 percent across the display unit, as measured using a photometer.

3. A multi-lamp optical engine must be provided for rear projection video units that do not use light-emitting diodes (LEDs) for illumination. Multi-lamp optical engines must provide a failover feature whereby a second lamp can be automatically activated when the first lamp fails. Ensure displays with multi-lamp optical engines provide indication of lamp status.

4. Multi-lamp optical engines must include both a "hot standby" mode in which failover to the second lamp takes no more than two seconds and a "cold standby" mode in which failover and the time for the display to return to full light output does not exceed 30 seconds.

5. A display module that uses modular component architecture to permit service or replacement of serviceable parts without removing the projection engine.

6. Each unit must be completely enclosed and light tight, with fixed panels for access to the lamp, power supply, and projection engine.

682-2.2.5 Flat Panel Display: Furnish and install a flat panel display unit to reproduce video and computer graphics information. The device must display, at a minimum, a high-resolution, distortion-free image and maintain a consistent level of illumination across the entire screen area. Ensure that it has the following minimum features and characteristics:

1. Dimensions of 24 inches high by 41 inches wide by 4 inches deep, or as shown in the Plans.

2. Ability to be installed on the face of a standard wall or flush mounted within the wall system.

682-2.2.6 Cabling: Furnish each video display component with all required appurtenances, including all the necessary cables, with proper length and connectors for power and communication, as defined by the manufacturer. Ensure that cabling conforms to applicable EIA/TIA standards. Size the power cables to meet NEC requirements. Provide communication cables from each video display component to the network communication devices that are appropriate for and compatible with the technology employed (e.g., fiber optic, twisted pair, or coaxial), and meet the minimum size and bandwidth specifications the manufacturer requires.

Provide all cabling of adequate length, along with the compatible connectors and any ancillary equipment necessary to fully interconnect the video components and display control systems needed to achieve the functions required. Label all cables at both ends, as approved by the Engineer.

682-2.2.7 Electrical: Provide equipment that operates on 120 V_{AC} at a frequency of 60 Hz. Furnish a transformer or other necessary means of power conversion for any device that requires another voltage or frequency.

Conduct TMC field reviews to examine the electrical distribution panels allocated for various equipment items and the electrical schedules for each. Make any changes, additions, or corrections to the electrical panels, wiring, outlets, and connectors that may be deemed necessary to adequately power all of the equipment proposed for a video display project at the intended location, subject to the approval of the Engineer. Make any changes to the building's electrical wiring in accordance with applicable codes and permits, and with the NEC. Modifications to an existing building's wiring or the video wall electrical wiring plans must be signed and sealed by a Specialty Engineer, and submitted for approval.

682-2.2.8 Performance: Use only display devices meeting the following minimum requirements.

Table 682-1 Minimum Requirements for Display Devices				
	Flat Panel Display			Rear Projection Video Display
Type	Direct View LCD			DLP or LCD
Size	(dependent on TMC design, as shown in the Plans)			
Aspect Ratio	(dependent on TMC design, as shown in the Plans)			
Resolution	1600 x 1200 / 1280 x 768 pixels; 16.7 million colors			1024 x 768 pixels
Viewing Angle	170 degrees horizontally and vertically	160 degrees horizontally and vertically		160 degrees horizontally and vertically
Half Gain Angle	—	—		±40 degrees horizontally and vertically
Contrast Ratio	500:1	600:1		600:1
Screen Brightness *	250 cd/m2	450 cd/m2		130 cd/m2
Lamp Life	—	—		8,000 hrs. (avg.)
Video Inputs	Analog/digital via 15-pin D-sub (HD-15) connector; DVI-D connector.	Composite video (NTSC) on RCA connector; analog/digital via 15-pin D-sub (HD-15) connector; DVI-I connector; HDMI.		Composite video (NTSC) on BNC; RGB via 15-pin D-sub (HD-15) connector; DVI-D connector.
Operating Temperature and Humidity	32° to 95°F. 20 to 80%.	32° to 95°F. 20 to 80%.		32° to 95°F. 20 to 80%.
Power Requirements	120 V_{AC} at 60 Hz	120 V_{AC} at 60 Hz		120 V_{AC} at 60 Hz
* Measured using a photometer.				

682-2.3 Installation: Do not proceed with any part of the procurement, construction, or installation of the video display equipment until the construction plans and materials are approved by the Engineer. Submit to the Engineer documentation, including the manufacturers' product specification sheets and a detailed description of each item's function as well as a compliance matrix that confirms all equipment meets or exceeds the requirements of these Specifications.

Configure each video display unit to provide individual, independent control from each operator workstation.

Create the video wall display by arranging individual video display units in a framework or apparatus that creates the video wall configuration as shown in the Plans. The finished video wall must provide a single, apparently seamless display area. The adjacent individual display units must be aligned physically and electronically so that image content stretched across multiple monitors align within plus or minus 2 lines of horizontal and vertical resolution.

All rear projection video unit controls must be accessible at all times when the devices are permanently installed. Ensure that installation and positioning does not conceal or limit access to any display unit controls at any time during active use.

Follow proper ventilation and cooling procedures for the equipment installed, as determined by the equipment manufacturers. Provide electrical requirements and power distribution units and power supplies for the video display components as-needed.

682-2.4 Testing: Submit a detailed system acceptance test plan to the Engineer for review and approval. Prepare a test plan that covers all areas of system function described in this Section, and that is developed according to the various equipment manufacturers' recommendations.

Check and test the satisfactory operation of all video display components upon completion of the equipment's installation. At minimum, include in the video display system test the testing of each color video monitor type, each secondary display output at workstations, each rear projection video display unit, and the video wall display's image alignment and control functions.

Subject the video wall display to a 90 day operational observation period. During this time, perform any and all maintenance, recalibration, system checking, and display modifications required by the Engineer. The Engineer has the option to require a restart of the observation period if a major system flaw or failure occurs.

682-3 Warranty.

Ensure that CCTV cameras and video display equipment have a manufacturer's warranty covering defects for a minimum of one year from the date of final acceptance. Ensure that the warranty requires the manufacturer to furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department or the maintaining agency within 10 calendar days of notification.

Warranty repairs of the video display control system and related TMC display equipment must commence within 24 hours after notification by the Department.

682-4 Method of Measurement.

The Contract unit price for each CCTV camera or video display device or system, furnished and installed, will include furnishing, placement, and testing of all equipment and materials, and for all tools, labor, operational software packages and firmware, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work. The cabinet will be paid for in accordance with Section 676.

The video display equipment will be measured as each major system component is furnished, installed, made fully operational, and tested in accordance with this Specification or as directed by the Engineer.

682-5 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 682- 1- CCTV Camera - each.

Item No. 682- 2- Video Display Equipment - each.

SECTION 684
NETWORK DEVICES

684-1 Description.

Furnish and install network devices as shown in the Plans. Meet the requirements of Section 603.

684-2 Materials.

684-2.1 General: Meet the following requirements:

Managed Field Ethernet Switch*.....Section 996
Managed Hub Ethernet Switch.....Section 996
Device Server*.....Section 996
Digital Video Encoder*.....Section 996
Digital Video Decoder*.....Section 996
Media Converter*.....Section 996
*Use products listed on the Department's APL.

684-2.2 Managed Field Ethernet Switch: Ensure that the managed field Ethernet switch (MFES) provides Ethernet connectivity between devices, systems, and locations as required by the Contract Documents.

Ensure that the ITS network administrator will be able to manage each MFES individually and as a group for switch configuration, performance monitoring, and troubleshooting.

Ensure that the MFES is fully compatible and interoperable with connected Ethernet devices and the traffic control system network.

Ensure the MFES provides a switched Ethernet connection for each connected device and at least one open RJ45 Ethernet port for technician access.

684-2.2.1 Optical Ports: Ensure that all fiber optic link ports operate at 1,310 or 1,550 nanometers in single mode. Ensure that the optical ports are Type ST, SC, LC, or FC only, as specified in the Plans or by the Engineer. Do not use mechanical transfer registered jack (MTRJ) type connectors.

Provide an MFES having a minimum of two optical 100 Base FX ports capable of transmitting data at 100 megabits per second unless otherwise shown in the Plans. Ensure the MFES is configured with the number and type of ports detailed in the Contract Documents. Provide optical ports designed for use with a pair of fibers; one fiber will transmit (TX) data and one fiber will receive (RX) data. The optical ports must have an optical power budget of at least 15 dB, or as detailed in the Contract Documents.

684-2.2.2 Copper Ports: Provide an MFES that includes a minimum of four copper ports unless otherwise shown in the Plans.

Ethernet over very high speed digital subscriber line (EoVDSL) ports are permitted for use in applications where fiber optic cable is not available.

684-2.3 Managed Hub Ethernet Switch: Ensure that the managed hub Ethernet switch (MHES) provides wire-speed Ethernet connectivity at transmission rates of up to ten gigabits per second to and from adjacent MHES within the traffic control network.

Ensure that the ITS network administrator will be able to manage each MHES individually and as a group for switch configuration, performance monitoring, and troubleshooting.

Ensure that the MHES is fully compatible and interoperable with field devices and the traffic control system network.

Ensure the MHES includes any license(s) required to utilize all Layer 3 features.

Ensure the MHES provides a switched Ethernet connection for each connected device and at least one open RJ45 Ethernet port for technician access.

684-2.3.1 Optical Ports: Ensure that all fiber optic link ports are modular SFP/SFP+ ports that operate at 1310 or 1550 nanometers in single mode and support 100Base-FX, 1000Base-X, and 10GBase-X. Ensure that the optical ports are Type LC unless otherwise shown in the Plans. Do not use mechanical transfer registered jack (MTRJ) type connectors.

Provide an MHES having a minimum of six optical Gigabit Ethernet ports as required to interface adjacent network devices. Optical ports must be capable of 100M, 1G, and 10Gbps data rates unless otherwise shown in the Plans. Ensure the MHES is configured with the number and type of ports detailed in the Contract Documents. Furnish hot-swappable fiber optical transceivers. Provide optical ports designed for use with a pair of fibers; one fiber will transmit (TX) data and one fiber will receive (RX) data. The optical ports must have an optical power budget of at least 15 dB, or as detailed in the Contract Documents.

684-2.3.2 Copper Ports: Provide an MHES that includes a minimum of twelve gigabit Ethernet copper ports unless otherwise shown in the Plans. All copper ports must be Type RJ-45 and auto-negotiate speed (e.g., 10/100/1000 Base) and duplex (i.e., full or half).

684-2.4 Device Server: Ensure that the device server provides Ethernet connectivity to devices with serial data interfaces as required by the Contract Documents. The device server must operate using a nominal input voltage of 120 V_{AC}. If the device requires nominal input voltage of less than 120 V_{AC}, furnish the appropriate voltage converter.

684-2.5 Digital Video Encoder and Decoder: Ensure that the complete video and data transmission system, defined as the combination of digital video encoder (DVE) and digital video decoder (DVD) hardware together with the existing or planned network infrastructure, simultaneously transports video and data from multiple remote field locations to multiple monitoring locations for roadway surveillance and traffic management.

Provide a software decoding and control package that allows the viewing of any video source connected to the network through a DVE, and which allows the pan-tilt-zoom (PTZ) control of any PTZ camera on the network, the discovery of DVE and DVD devices on the network, and the control and adjustment of programmable parameters in the DVE and DVD equipment, including the network addresses of these devices, at no additional cost.

684-2.5.1 Digital Video Decoder: Provide a DVD that is either a hardware-based network device or a software application that resides on a workstation PC. Ensure that the software application provides PC desktop display of IP network video streams.

Provide all setup, control programs, and diagnostic software related to the DVE or DVD.

Provide all equipment licenses, where required for any software or hardware in the system.

Ensure that any software-based decoder applications do not interfere with SunGuide® software operating when installed and used together on a shared hardware platform. Ensure that the software-based decoder offers an open Application Programming Interface (API) and software development kit available to the Department at no cost for integration with third party software and systems.

684-2.5.2 Interoperability: Provide DVE and DVD devices and software that are interoperable and interchangeable with DVE and DVD devices and software from other manufacturers.

684-2.5.3 Network Interface: Ensure that fiber ports are single mode with a minimum link budget of 30 dB or the type and power detailed in the Contract Documents.

684-2.6 Media Converter: The media converter must allow transition between the transmission media shown in the Plans or required to construct a functional system, such as conversion from twisted pair to optical fiber or from twisted pair to coaxial cable.

Ensure that fiber ports are single mode with a minimum link budget of 30 dB or the type and power detailed in the Contract Documents.

Media converters must operate on a nominal voltage of 120 V_{AC} if POE is unavailable. Supply an appropriate voltage converter for devices that require operating voltages of less than 120 V_{AC}.

684-3 Installation.

684-3.1 General: Install network devices at the locations shown in the Plans. Ensure that network devices are mounted securely and are fully accessible by field technicians. Ensure that all unshielded twisted pair/shielded twisted pair Ethernet network cables are compliant with the EIA/TIA-568-B standard.

684-4 Field Acceptance Testing.

684-4.1 General: Conduct field acceptance testing in accordance Section 611.

684-4.2 MFES Field Acceptance Testing: Conduct inspection and testing at the installed equipment location according to the approved test plan. Perform the following:

1. Verify that physical construction has been completed as detailed in the Plans.
2. Inspect the quality and tightness of ground and surge protector connections.
3. Verify proper voltages for all power supplies and related power circuits.
4. Connect devices to the power sources.
5. Verify all connections, including correct installation of communication and power cables.
6. Verify network connection and MFES configuration using a laptop PC.

684-4.3 MHES Field Acceptance Testing: Conduct inspection and testing at the installed equipment location according to the approved test plan. Perform the following:

1. Verify that physical construction has been completed as detailed in the Plans.
2. Inspect the quality and tightness of ground and surge protector connections.
3. Verify proper voltages for all power supplies and related power circuits.
4. Connect devices to the power sources.
5. Verify all connections, including correct installation of communication and power cables.
6. Verify network connection and MHES configuration using a laptop PC.

684-4.4 Device Server Field Acceptance Testing: Conduct inspection and testing at the installed equipment location according to the approved test plan. Perform the following:

1. Verify that physical construction has been completed as specified in the Plans.
2. Verify the quality and tightness of ground and surge protector connections.
3. Verify proper voltages for all power supplies and related power circuits.
4. Connect devices to the power sources.

5. Verify all connections, including correct installation of communication and power cables.

6. Verify network connection and device server configuration using a laptop PC.

7. Verify serial data transmission through the device server.

684-4.5 DVE and DVD Field Acceptance Testing: Conduct inspection and testing at the installed equipment location according to the approved test plan. Perform the following:

1. Verify that physical construction has been completed as detailed in the Plans.
2. Inspect the quality and tightness of ground and surge protector connections.
3. Verify proper voltages for all power supplies and related power circuits.
4. Connect devices to the power sources.
5. Verify all connections, including correct installation of communication and power cables.
6. Verify video image is present and free from oversaturation and any other image defect in both color and monochrome mode.
7. Verify network connection to the DVE and DVD through ping and telnet session from a remote PC.
8. Verify serial data transmission through the DVE and DVD serial ports.
9. Verify support of unicast, multicast, and SAP.

684-5 Warranty.

684-5.1 General: Ensure that network devices have a manufacturer's warranty covering defects for 1 year from the date of final acceptance. Ensure that the manufacturer will furnish replacements for any part or equipment found to be defective during the warranty period at no cost to the Department or the maintaining agency within 10 calendar days of notification.

684-6 Method of Measurement.

The Contract unit price for each network device, furnished and installed, will include furnishing, placement, and testing of all equipment and materials, and for all tools, labor, hardware, operational software packages and firmware, supplies, support, personnel training, shop drawings, documentation, and incidentals necessary to complete the work.

Provide software-based decoders at no additional cost when furnished in conjunction with DVEs.

A software-based DVD provided individually must be paid under the pay item below.

684-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 684- 1-	Managed Field Ethernet Switch-each.
Item No. 684- 2-	Device Server-each.
Item No. 684- 3-	Digital Video Encoder with Software Decoder-each.
Item No. 684- 4-	Digital Video Decoder-each.
Item No. 684- 5-	Media Converter-each.
Item No. 684- 7-	Managed Hub Ethernet Switch-each

SECTION 685
TRAFFIC CONTROL SYSTEM AUXILIARIES

685-1 Description.

Furnish and install traffic control system auxiliaries as shown in the Plans.

685-2 Materials.

685-2.1: General: Meet the following requirements:

Uninterruptible Power Supply* .....Section 996
Remote Power Management Unit* .....Section 996
*Use products listed on the Department's APL.

685-2.2 Uninterruptible Power Supply (UPS): Use a line interactive or online/double-conversion UPS as shown in the Plans. UPS assemblies must be designed for installation in a roadside NEMA 3R enclosure to provide battery backup functionality for traffic control systems, including traffic signal and intelligent transportation system (ITS) devices. UPS assemblies must include batteries provided by the UPS manufacturer or in accordance with manufacturer's requirements. Batteries must be sealed and require no maintenance, cause no corrosion, and be capable of maintaining 80% of original capacity and performance for a minimum of five years.

Loss of utility power, transfer from utility power to battery power, and transfer back to utility power must not interfere with normal operation of connected equipment. In the event of UPS failure or battery depletion, connected equipment must be energized automatically upon restoration of utility power.

Removal and replacement of the UPS must not disrupt the operation of the equipment being protected.

All harnesses necessary to connect and operate the system must be included.

685-2.2.1 Electrical: UPS assemblies used to provide backup power in an ITS cabinet must provide a minimum of 350 watts (at 120 V_{AC}) of continuous backup power for a minimum of two hours unless otherwise shown in the Plans.

UPS assemblies used to provide backup power in a traffic signal controller cabinet must provide a minimum 400 watts (at 120 V_{AC}) of continuous power for a minimum of 6.5 hours unless otherwise shown in the Plans.

685-2.2.2 Traffic Signal UPS Cabinet: Cabinets used to house traffic signal UPS assemblies must be designed to be mounted to the side of a traffic cabinet or base mounted. Cabinets must meet the requirements of Section 676 and must include shelves and rack rails to house all UPS system components including the UPS, batteries, harnesses, switches, surge protective device, power terminal block and a generator hookup with transfer switch. The UPS cabinet must allow a maintenance technician to safely insert power for traffic signal operation while the UPS or associated equipment is serviced or replaced.

A surge protective device must be installed where the supply circuit enters the cabinet in accordance with 620-2.7.1.

685-2.2.2.1 Transfer Switch and Generator Access Panel: The cabinet must include an automatic transfer switch and generator access panel in accordance with Section 676. The generator access door must not protrude more than 1 inch when closed.

685-2.3 Remote Power Management Unit (RPMU): Use a RPMU as shown in the Plans. The RPMU must be designed for installation in a roadside Traffic Cabinet to provide remote control of electrical receptacles.

685-3 Installation.

Install UPS assemblies in accordance with the manufacturer's recommendations. All equipment used to keep the intersection signalized must be backed up and protected by the UPS. Include a UPS operation and maintenance manual in the cabinet where the UPS is installed that includes cabinet wiring schematics, electrical interconnection drawings, parts layout and parts lists.

Install the RPMU in accordance with the manufacturer's recommendations. Include a RPMU operation and maintenance manual in the cabinet where the RPMU is installed that includes cabinet wiring schematics, electrical interconnection drawings, parts layout and parts lists.

685-4 Testing.

Provide a field acceptance test plan to the Engineer for approval at least 14 days prior to commencement of testing. After approval of the acceptance test plan, perform testing of the installed UPS and RPMU equipment. Furnish all equipment, software, and supplies necessary for conducting the test.

685-5 Warranty.

Ensure the UPS includes a manufacturer's warranty covering defects for a minimum of 3 years (5 years for the batteries in accordance with 685-2.2) from the date of final acceptance in accordance with 5-11 and Section 608. The warranty must include provisions for providing a replacement UPS within 10 calendar days of notification for any UPS found to be defective during the warranty period at no cost to the FDOT or the maintaining agency.

Ensure the RPMU includes a manufacturer's warranty covering defects for a minimum of 3 years from the date of final acceptance in accordance with 5-11 and Section 608.

685-6 Method of Measurement.

The Contract unit price for each UPS or RPMU, will include furnishing, placement, and testing of all equipment and materials as specified in the Contract Documents, and all tools, labor, operational software packages and firmware, supplies, support, documentation (including the field acceptance test plan), and incidentals necessary for a complete and accepted installation.

685-7 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 685- 1-	Uninterruptible Power Supply - each
Item No. 685- 2-	Remote Power Management Unit - each

SECTION 695
TRAFFIC MONITORING SITE EQUIPMENT

695-1 Description.

Furnish or furnish and install a complete, operable traffic monitoring site (TMS) as shown in the Plans and Standard Plans. The Department uses TMS to monitor the volume, speed, number of axles, weight of wheels, axles or vehicles, or vehicular axle classification types.

695-2 General.

695-2.1 Materials: Meet the following requirements:

Poles	Section 646
Transformer Base*	Section 646
Wire for Inductive Loop*	Section 997
Class II Piezoelectric Axle Sensor*	Section 997
TMS Vehicle Non-Weight Axle Sensors*	Section 997
TMS Vehicle Microwave Radar Vehicle Sensors*	Section 997
TMS Vehicle Video Sensors*	Section 997
TMS Vehicle Strain Gauge Sensors*	Section 997
TMS Vehicle Quartz Piezoelectric Sensors*	Section 997
TMS Non-Motorized Axle Sensor*	Section 997
TMS Non-Motorized Infrared Sensor*	Section 997
TMS Non-Motorized Video Sensor*	Section 997
TMS Solar Power Unit For Vehicle Data Collection*	Section 997
TMS Solar Power Unit For Non-Motorized Data*	Section 997
TMS System Communications Modem*	Section 997
TMS Modem Antenna*	Section 997
TMS Vehicle Speed/Classification Unit*	Section 997
TMS Vehicle Weigh-In-Motion (WIM) Unit*	Section 997
TMS Non-Motorized Data Collection Unit*	Section 997
Adhesive Bonding Agent*	Section 997
Loop Sealant*	Section 997
TMS Cabinets*	Section 997
TMS Suppression Devices (power, sensor)*	Section 997
TMS Managed Field Ethernet Switch*	Section 997
Patch Panel	Section 633

*Use products listed on the Department's APL.

695-2.2 Traffic Monitoring Site Component Approval: Submit forms in accordance with 603-5. Any electronics unit or software submitted for approval must be compatible with or convert the data into a format compatible with the Department's polling and processing software and be compatible with the existing and new equipment. Remove and replace any new equipment that fails the operational test at no cost to the Department.

695-2.3 Notification: Notify the Engineer 10 working days prior to beginning work in the area of the TMS to coordinate the removal of existing TMS equipment.

A TMS Inspector must be onsite during TMS installation. Notify the Engineer 10 working days prior to installation of the TMS to coordinate the scheduling of a TMS Inspector.

For the Weigh-In-Motion (WIM) electronics sensor and unit, notify the Engineer for final acceptance inspection after the completion of a 30 day operational period with no deficiencies. For all other equipment, notify the Engineer for final acceptance inspection after the completion of a 14 day operational period with no deficiencies.

695-2.4 Poles: Install the weather head in accordance with Standard Plans, Index 695-001. Ground the pole in accordance with Section 620.

695-2.5 Manufacturer's Warranty : Ensure that the terms and conditions of warranties are documented when submitting equipment submittal for approval. Furnish replacements within 10 calendar days of notification for any part or equipment found to be defective during the manufacturer's warranty period at no cost to the Department. Transfer warranties upon final acceptance in accordance with 5-11. Document all warranties and warranty transfers and submit to the Engineer.

Leave a copy of the warranty in the cabinet once it is installed and submit the warranty to the Engineer. The Engineer will submit warranty forms received from the Contractor to the TDA TMS Manager.

695-3 Vehicle Sensor (Non-Weight) Applications.

695-3.1 General: The vehicle classification site consists of axle sensors and inductive loop sensors. Furnish and install TMS vehicle sensors of the type and at the location shown in the Plans.

695-3.2 Axle Sensor:

Section, Contract Documents, and Standard Plans, Index 695-001. Ensure axle sensors are installed in the roadway and secured using an adhesive bonding agent as listed on the APL.

Allow newly applied friction course to cure for a minimum of 30 days prior to the installation of in-road sensors.

Install axle sensors in the right-hand wheel-path midway between the leading and trailing loops as detailed in Standard Plans, Index 695-001. Install axles sensors in the left-hand wheel-path when no paved shoulder exists and sensor lead exit windows are installed at the right-hand edge of the roadway surface or in a lane which is to the left of and adjacent to an open lane of traffic.

Install the axle sensor such that the cable end is closest to the pull box to which the sensor lead cable will be routed. Install the end of the sensor mid-way into the edge line stripe or lane line stripe. Ensure that the axle sensor being installed has lead-in cables of sufficient length to reach the cabinet without splicing. Do not splice axle sensor lead-in cables.

Route the sensor leads to the pull box then to the TMS cabinet. Mark the sensor leads at the pull box and at termination in the cabinet. Submit lane numbering information as specified in Standard Plans, Index 695-001.

Cut the slot the length of the sensor plus an additional 3 to 4 inches. Ensure the depth and width of the slot is installed as recommended by the sensor manufacturer, typically 0.75 inch wide by 1.5 to 2 inches deep.

Use clips or jigs provided by the manufacturer to suspend the sensor at a uniform depth in the slot. Mix and apply the adhesive bonding agent ensuring the slot is completely full with no voids beneath the sensor.

695-3.2.2 Test Requirements: Perform the manufacturer's recommended on-site pre-installation test to determine the sensor's condition using an Inductive Capacitance Resistance meter. Replace any sensors that fail the pre-installation test.

Record all test results by lane on the warranty form provided by the manufacturer and leave a copy in the cabinet.

Repeat the test at the termination point in the cabinet after installation. Use an oscilloscope to view and record typical waveforms and signal intensity measurements for the axles of passenger cars and large trucks. Remove and replace any sensor that fails the test at no additional charge to the Department.

Perform an operational test to meet final acceptance requirements. The operational test requires the equipment to operate without deficiencies for a minimum of 14 days prior to final acceptance. The sensor shall be operating without deficiencies at the time of final acceptance. Remove and replace any sensor that fails the operation test at no additional charge to the Department. Final inspection will be completed by FDOT TDA staff for final acceptance.

695-3.3 Non-Intrusive Vehicle Sensors:

695-3.3.1 General: Install motorized (radar, microwave, or video) vehicle sensors on a pole as shown in the Plans, Contract Documents, and Standard Plans, Index 695-001.

695-3.3.2 Installation Requirements: Install the sensor on a pole perpendicular to the target lanes of traffic with room to perform horizontal and vertical aiming adjustments.

Ensure that the wireless vehicle sensor has sufficient cable length to reach the cabinet without splicing. Fasten the cable to the pole so wind does not move it or route the cable within the pole cavity to the cabinet termination point. Provide 18 to 24 inches of slack in the cable at the connections to the sensor and in the cabinet to ensure the cable is stress-free. Include the appropriate mounting hardware and the manufacturer's recommended surge suppression as a part of the installation.

Set up the lane detection zones using the manufacturer's instructions and software and verify that the sensor's orientation is perpendicular to the roadway.

Configure the wireless vehicle sensor for vehicle volume unless otherwise specified in the Plans.

695-3.3.3 Test Requirements: Conduct a visual test to determine that all detection zones are being counted accurately.

Connect a personal computer (PC) to the electronics unit and observe traffic in every lane, verifying that each vehicle is displayed on-screen. A minimum of 20 vehicles should be observed for each lane of traffic with all vehicles counted; assuming a clear line of sight between the sensor and the vehicle being observed is maintained.

If any vehicles are not counted, reconfigure the wireless vehicle sensor and repeat the visual observation test until all lanes count correctly. If the sensor fails to provide accurate counts after three test attempts, it must be replaced with a new unit at no expense to the Department.

Submit a 48 hour verification (class, speed and volume) report for all TMS to the Engineer and leave a copy in the cabinet.

Perform an operational test to meet final acceptance requirements. The operational test requires the equipment to operate without deficiencies for a minimum of 14 days prior to final acceptance. The sensor shall be operating without deficiencies at the time of final acceptance. Final inspection will be completed by FDOT TDA staff for final acceptance.

695-4 Vehicle Speed/Classification Unit.

695-4.1 General: Furnish and install TMS vehicle speed/classification unit (electronics unit) in the TMS cabinet at the locations shown in the Plans.

Ensure that the vehicle speed/classification unit and equipment cables are compatible and constructed in accordance with the Standard Plans.

Ensure that the vehicle speed/classification unit markings are visible after installation.

695-4.2 Installation Requirements: Furnish and install the electronics unit and equipment cables in accordance with the manufacturer's recommended installation procedure, Standard Plans, Index 695-001, and the Contract Documents.

Ensure that the cables are properly terminated for the prescribed use without further modification by the Department.

Furnish one serial port cable for interconnecting each electronics unit with a PC.

695-4.3 Test Requirements: The electronics unit must collect and distribute vehicle speed and classification data during the 14 day operational testing period and at final acceptance.

695-5 Weigh-In-Motion Electronic Unit.

695-5.1 General: Furnish and install the vehicle weigh-in-motion (WIM) unit in the TMS cabinet at the locations shown in the Plans.

Ensure that the WIM unit and equipment cables are compatible and constructed in accordance with the Standard Plans.

Ensure that the WIM unit markings are visible after installation.

695-5.2 Installation Requirements: Furnish and install the electronics unit and equipment cables in accordance with the manufacturer's recommended installation procedure, Standard Plans, Index 695-001, and the Contract Documents.

Ensure that the cables are properly terminated for the prescribed use without further modification by the Department.

695-5.3 Test Requirements: The electronics unit must collect and distribute weigh-in-motion data during the 30 day operational testing period and at final acceptance.

695-6 Non-Motorized Data Collection Unit.

695-6.1 General: Furnish and install the non-motorized data collection unit in the TMS cabinet at the locations shown in the Plans.

Ensure that the non-motorized data collection unit and equipment cables are compatible and constructed in accordance with the Standard Plans.

Ensure that the data collection unit markings are visible after installation.

695-6.2 Installation Requirements: Furnish and install the electronics unit and equipment cables in accordance with the manufacturer's recommended installation procedure, Standard Plans, Index 695-001, and the Contract Documents.

Ensure that the cables are properly terminated for the prescribed use without further modification by the Department.

695-6.3 Test Requirements: The electronics unit must collect and distribute non-motorized data during the 14 day operational testing period and at final acceptance.

695-7 Weigh-In-Motion Electronic Sensor.

695-7.1 General: The weigh-in-motion (WIM) lane consists of WIM sensors and inductive loops sensors. The first type of WIM sensor, strain gauge sensor, is described in 695-7.3. The second type of WIM sensor, quartz piezoelectric weigh-in-motion sensor, is described in 695-7.4. The inductive loop assembly is described in 695-10. Furnish and install the Traffic

Monitoring Site (TMS) Weigh-In-Motion Electronic Sensor in the configuration shown on the Standard Plans, Index 695-001. Install in accordance with Manufacturer's instructions.

695-7.2 Installation Requirements: The installer must have a valid certification from the manufacturer for installing the Weigh-In-Motion Electronics Sensors. Use a chalk line or equivalent method to outline the perimeter of the sensor on the pavement and routes for lead-in cables. Do not allow the saw cut in the pavement to deviate more than 1.0 inch from the chalk line. Ensure that all saw cuts are free of any dust, dirt, or other debris and completely dry prior to the installation.

695-7.3 Strain Gauge Sensor: Install two strain gauge sensors in line with each other in each wheel path to cover a 12-foot lane in the roadway. Connect the strain gauge sensors to an interface processor.

Install the strain gauge sensor frames into concrete slabs of 6 inches or more without constructing a special foundation socket. The frames, including strain gauge sensor embedded in it, have an average depth of 1.5 inches.

If the concrete slab is less than 6 inches or if the roadway material is asphaltic concrete, install a special foundation socket of concrete under the frame, just as wide as the frame. Bore 1-inch diameter anchors to a minimum of 8 inches into the base course.

Install the manufacturer provided drain pipe from lower side of the foundation frame towards the slope into the drain water shaft. Ensure that water does not accumulate in the frame and properly drains the frame.

Install the strain gauge sensors in accordance with the manufacturer's installation procedures and in the presence of the manufacturer's representative. Ensure that the procedures are approved by the Engineer.

695-7.4 Quartz Piezoelectric Weigh-In-Motion Sensor: Install two quartz piezoelectric sensors in line with each other in each wheel path to cover a 12-foot lane in the roadway.

Install the quartz piezoelectric sensor by sawing slots into the pavement perpendicular to the flow of traffic, equal to the length of the sensor plus 1 inch, by 2.875 inches wide, and by 2.125 inches deep. Sawcut a 1 inch wide by 2 inches deep cable run slot from the end of the sensor slot to the edge of the pavement shoulder.

Install the quartz piezoelectric sensor into the slot, properly aligned and positioned using specially constructed installation and leveling beams. Pour the manufacturer recommended adhesive bonding agent into the cavity until it is at the proper height above the road surface and allow it to set. After the adhesive bonding agent hardens, grind it to be level with the road surface. The top of the sensor must not deviate more than 1/24 inch above the height of the pavement surface over the length of the sensor.

Route the sensor lead-in cables to the pull box and through the conduit to the traffic monitoring site cabinet. Mark the sensor lead-in cables at the pull boxes and at the point of termination within the traffic monitoring site cabinet, in accordance with Standard Plans, Index 695-001. Connect the cable to the interface card installed in the traffic monitoring cabinet.

695-7.5 Weigh-In-Motion Electronics Sensor Test Requirements: Perform the manufacturer's recommended on-site pre-installation test to determine the Weigh-In-Motion electronics sensor's condition. Install only those Weigh-In-Motion electronics sensors that pass the pre-installation test.

Repeat the test, following installation, at the lead-in point of connection in the traffic monitoring site cabinet. Remove and replace any Weigh-In-Motion electronics sensor which fails the test at no additional cost to the Department. Prior to post-installation acceptance,

the Contractor shall demonstrate in the presence of the Engineer that the equipment supplied and installed for the system is in full compliance with the Plans and Specification herein.

The Department will operate the complete system for 30 consecutive days without failures prior to Final Acceptance. The Department will poll the site and statistically check data from historical data, field collected data and field observations. In the event of failures, the Contractor shall correct the problem(s) and restart the 30-day test. Any equipment or labor that is found to be defective during the operation test and prior to Final Acceptance shall be replaced or corrected at no expense to the Department. Final Acceptance will be made upon the successful completion of the 30-day test.

Place a copy of the final test results, including the date of installation, manufacturer's name, model number for each Weigh-In-Motion electronics sensor, laboratory calibration sheet provided by the manufacturer, and type of adhesive bonding agent used in a waterproof package in the cabinet and furnish one copy to the Engineer.

695-8 Non-Motorized Sensor Applications.

695-8.1 General: The non-motorized site uses axle sensors, inductive loops sensors, and infrared sensors. The inductive loop assembly is described in 695-10. Furnish and install TMS non-motorized sensors of the type and at the location shown in the Plans and Index 695-001.

695-8.2 Non-motorized Axle Sensor:

695-8.2.1 Installation Requirements: Allow newly applied friction course to cure for a minimum of 30 days prior to the installation of in-path sensors.

Ensure axle sensors are installed in the pathway and secured using an adhesive bonding agent as listed on the APL.

Cut the slot the length of the axle sensor plus an additional 3 to 4 inches. Ensure the depth and width of the slot is installed as recommended by the sensor manufacturer. Ensure that all saw cuts are free of any dust, dirt, or other debris and completely dry prior to the installation.

Use clips or jigs provided by the manufacturer to suspend the sensor at a uniform depth in the slot. Mix and apply the adhesive bonding agent ensuring the slot is completely full with no voids beneath the sensor. Once cured, grind down excess adhesive bonding agent to be level with the road surface, sidewalk, side path, or shared-use path.

695-8.2.2 Test Requirements: Perform the manufacturer's recommended on-site pre-installation test to determine the sensor's condition using an Inductive Capacitance Resistance meter. Install only those sensors that pass the pre-installation test. Record all test results on the warranty form provided by the manufacturer and leave a copy in the cabinet.

Repeat the test at the termination point in the cabinet after installation. Use an oscilloscope to view and record typical waveforms and signal intensity measurements for the axles of non-motorized vehicles.

Connect a personal computer (PC) to the electronics unit and observe bicycles and pedestrians in the pathway, verifying the detection of each non-motorized vehicle on-screen. A minimum of 20 non-motorized vehicles shall be observed with all non-motorized vehicle manually counted.

If any non-motorized vehicles are not counted by the sensor, reconfigure the sensor and repeat the visual observation test until all are counted correctly. If the sensor fails to provide accurate counts after 3 test attempts, it must be replaced with a new unit at no expense to the Department.

The sensor shall operate without any deficiencies for two weeks after installation and at final acceptance. Remove and replace any sensor that fails the 14 day operation test at no additional charge to the Department.

Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-8.3 Infrared Sensors:

695-8.3.1 Installation Requirements: For grade level applications, install the sensor perpendicular to the pathway and pointed parallel to the ground. The sensor shall not point towards the vehicular traffic lane, reflective surfaces, direct sunlight exposure, or moving infrastructure. Ensure that the sensor has sufficient cable length to reach the cabinet without splicing.

For overhead applications, route the cable within the pole cavity or conduit to the cabinet termination point. Provide 18 to 24 inches of slack in the cable at the connections to the sensor and in the cabinet to ensure the cable is stress-free. Include the appropriate mounting hardware as a part of the installation.

Set up the detection zones using the manufacturer's instructions and software and verify that the sensor's orientation is perpendicular to the pathway.

Configure the sensor for pedestrian and bicycle traffic.

695-8.3.2 Test Requirements: Conduct a visual test to determine that all detection zones are being counted accurately.

Connect a personal computer (PC) to the electronics unit and observe traffic in the pathway, verifying that each non-motorized vehicle or pedestrian is displayed on-screen. A minimum of 20 non-motorized vehicles and 20 pedestrians shall be observed with all non-motorized vehicles and pedestrians counted.

If any non-motorized vehicles or pedestrians are not counted, reconfigure the infrared sensor and repeat the visual observation test until all are counted correctly. If the sensor fails to provide accurate counts after 3 test attempts, it must be replaced with a new unit at no expense to the Department.

The sensor shall operate without any deficiencies for two weeks after installation and at final acceptance. Remove and replace any sensor that fails the 14 day operation test at no additional charge to the Department.

Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-9 TMS Solar Power Unit.

695-9.1 General: Furnish and install TMS solar power units at the locations and as shown in the Plans and Standard Plans. Solar power units are used to power TMS that collect vehicular data and non-motorized data on a continuous basis. The solar power unit consists of the following components: solar panel(s) and mounting hardware; 12 V storage battery; and voltage regulator with wiring and associated mounting hardware.

695-9.2 Testing Requirements: Solar panels must be tested by setting the multi-meter to volts setting and connecting the positive lead to the solar panel's positive wire. Then connect the multi-meter's negative lead to the solar panel's negative wire. The volt reading on the multi-meter should be no less than 20 volts. If the volts are less, then there is a problem with the solar panel output. Go back and check all connections of the solar panel and check for cracks in the solar cells. Next test the solar panel for amperage by setting the multi-meter to amps setting and follow the above-mentioned steps. The amp reading should be no less than 4.25 amps. If the

amperage is less, then there is a problem with the solar panel output. Go back and check all the connections of the solar panel and check for cracks in the solar cells.

The panels shall operate without any deficiencies for two weeks after installation and at final acceptance. Remove and replace any panels that fail the 14 day operation test at no additional charge to the Department.

Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-10 Inductive Loop Assembly.

695-10.1 General: Install TMS motorized inductive loop assembly and non-motorized inductive loop assembly at the locations shown in the Plans. Ensure that all materials furnished, assembled, or installed are new products.

Install loop wire in accordance with Standard Plans, Index 695-001. Install the inductive loops such that the loop leads reach the cabinet. Do not splice loop leads.

695-10.2 Installation Requirements:

695-10.2.1 Saw Cuts: Perform saw cuts across concrete pavement expansion joints as detailed in Standard Plans, Index 695-001.

For pavement thickness greater than or equal to 2 inches deep, make saw cuts deep enough to allow 1 to 1-1/2 inch of sealant cover over the installed loop wire.

For pavement thickness less than 2 inches, make the saw cut depth to 1 inch.

695-10.2.2 Loop Wire: Ensure that all motorized vehicular loops have four complete turns of wire and all non-motorized vehicle loops have eight complete turns of No. 14 AWG stranded copper wire that meet the requirements of International Municipal Signal Association (IMSA) 51-7, wound in a clockwise manner. Do not damage the insulation.

For roadways, ensure that the hold down material is non-metallic; placed in the saw slot using segments 1 to 2 inches long, spaced 12 inches apart; and the distance from the top of the hold down material to the final roadway surface is not less than 1-1/2 inches.

For sidewalks, side paths, or shared use paths, the distance from the top of the non-metallic hold down material to final surface elevation must be 1/2 inch or greater.

Install inductive loops in the pathway and secure using loop sealant listed on the APL. Avoid installation of inductive loops in areas that have electromagnetic interference from power lines (overhead or underground) or buried telecommunication equipment or in the proximity of other inductive loops.

695-10.2.3 Loop Wire Twisted Pair Lead: For motorized vehicular loops, create a loop wire twisted pair lead by twisting the loop wire pair a minimum of 8 to 16 twists per foot from the edge of the loop to the termination point in the cabinet. Provide a minimum of 3 feet of twisted loop wire pair lead in the pull box located adjacent to the roadway. For non-motorized vehicle loops, create a loop wire twisted pair lead by twisting the loop wire pair 10 twists per foot from the edge of the loop to the termination point. Splicing of the loop wire is not permitted.

695-10.2.4 Loop Sealant: Use loop sealant in accordance with Section 997. Prepare and apply the sealant in accordance with the manufacturer's instructions. Remove excess sealant from the roadway surface. Ensure that the loop sealant has cured completely before allowing vehicular traffic to travel over the sealant.

695-10.3 Testing: Conduct all testing with the leads disconnected from the backplane. The loops shall operate without any deficiencies for two weeks after installation. Remove and

replace any loop that fails the 14 day operation test at no additional charge to the Department. Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-10.3.1 Motorized Vehicular Loop Resistance: Ensure new loops have a resistance reading of 3.0 Ω or less.

695-10.3.2 Motorized Vehicular Loop Inductance: Ensure new loops have a minimum inductance reading of 100 μH.

695-10.3.3 Motorized Vehicular Loop Insulation Resistance (Megging): Ensure new loops have a minimum reading of 200 MΩ at 500 V.

695-10.3.4 Non-Motorized Vehicular Loop Resistance: Ensure new loops have a resistance reading of 3.0 Ω or less.

695-10.3.5 Non-Motorized Vehicular Loop Inductance: Ensure new loops have an inductance reading of 100 to 150 μH.

695-10.3.6 Non-Motorized Vehicular Loop Insulation Resistance (Megging): Ensure new loops have a minimum reading of 200 MΩ at 500 V.

695-11 TMS Cabinet.

695-11.1 General: Furnish and install Type III, IV or V TMS cabinets in accordance with Section 676 and Standard Plans, Index 695-001.

695-11.2 Materials:

695-11.2.1 General: Only use TMS cabinets and components currently listed on the Department's APL. Ensure that the cabinet and components are compatible with the other components installed at the location.

695-11.2.2 Shelf: Ensure that the cabinet has an adjustable shelf, constructed of 0.08 inch thick aluminum, that is adjustable to within 15 inches of the top of the cabinet and to within 26 inches of the bottom of the cabinet in 2 inch increments.

695-11.2.3 Backplane and Cabinet Cable: Furnish and install as specified in the Standard Plans, Index 695-001.

695-11.2.4 Suppression Devices: Furnish and install suppression devices per manufacturers recommendation.

695-11.3 Installation Requirements: Install the TMS cabinet in accordance with the Plans, Standard Plans and manufacturer's recommended installation procedure. Ensure that all conduit entrance holes or field drilled holes are reamed and free of burrs. Use clear silicone rubber sealant to make all conduit connections to the cabinet watertight. Perform all excavation and backfill in accordance with 125-4 and 125-8.2.

695-11.3.1 Pole Mounted Traffic Monitoring Site Cabinets (Types III and IV): Install pole mounted traffic monitoring site cabinets in accordance with Standard Plans, Index 676-001 and 695-001.

695-11.3.2 Base Mounted (Type IV and V) and Pedestal Mounted (Type III) Traffic Monitoring Site Cabinets: Install base and pedestal mounted traffic monitoring site cabinets in accordance with Standard Plans, Index 676-001 and 695-001.

Ensure that the end of the conduit riser is a minimum of 2 inches above the finished surface of the concrete base.

695-12 TMS System Communications Modem.

695-12.1 General: Furnish and install the TMS modem and antenna in the cabinet at the TMS location shown in the Plans.

Furnish and install all cables required to connect the modem to the electronics unit. Furnish and install all antenna cables.

695-12.2 Commercial Software Registration: Ensure that the Department is registered as the end-user of software installed on the system communications.

695-12.3 Installation Requirements: Install the TMS modem and antenna in accordance with the manufacturer's recommended installation procedure.

695-12.4 Test Requirements: The modem and antenna shall operate without any deficiencies for two weeks after installation. The modem and antenna must transmit and receive TMS data during the 14 day operational testing period and at final acceptance. Remove and replace any modem and antenna that fails the operation test at no additional charge to the Department. Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-13 TMS Managed Field Ethernet Switch.

695-13.1 General: Furnish and install the Managed Field Ethernet Switch (MFES) in the cabinet at the TMS location shown in the Plans. Furnish and install all cables required to connect the MFES to the cabinet equipment. Furnish and install all fiber optic jumpers required to connect the MFES to the patch panel.

695-13.2 Installation Requirements: Install the MFES in accordance with the manufacturer's recommended installation procedure.

695-13.3 Test Requirements: The MFES must transmit and receive TMS data over the Department's fiber network. The MFES shall communicate with the TMS central data repository. The MFES must operate within the TMS solar site power and battery backup system constraints. All MFES functions shall be operational during the operational testing period and at final acceptance.

The MFES shall operate without any deficiencies for two weeks after installation. The MFES must transmit and receive TMS data during the 14 day operational testing period and at final acceptance. Remove and replace any MFES that fails the operation test at no additional charge to the Department. Submit all documents to the Engineer and leave a copy of the report in the cabinet.

695-14 Method of Measurement.

The Contract unit price for each vehicle axle sensor will include the vehicle sensor, lead-in cables, adhesive bonding agent; and all equipment, materials, testing and labor necessary for a complete and accepted installation.

The Contract unit price for each non-intrusive vehicle sensor will include the vehicle sensor, cables, conduit, conduit accessories such as the weatherhead and couplings; and all equipment, materials, testing and labor necessary for a complete and accepted installation.

The Contract unit price per assembly for the vehicle speed/classification unit includes the electronics unit and equipment cable, all equipment, materials and labor necessary for a complete and accepted installation.

The Contract unit price per assembly for the weigh-in-motion unit includes the electronics unit and equipment cable, all equipment, materials and labor necessary for a complete and accepted installation.

The Contract unit price per assembly for the non-motorized data collection unit includes the electronics unit and equipment cable, all equipment, materials and labor necessary for a complete and accepted installation.

The Contract unit price for each Weigh-In-Motion Electronics Sensor, furnished and installed, will consist of the Weigh-In-Motion sensor, lead-in cable(s), adhesive bonding agent, loop sealant, all equipment, materials, and labor necessary for a complete and accepted installation.

The Contract unit price for each non-motorized axle sensor will include the sensor, lead-in cables, adhesive bonding agent, loop sealant; and all equipment, materials, testing and labor necessary for a complete and accepted installation.

The Contract unit price for each non-motorized infrared sensor will include the infrared sensor, mounting hardware, cabling; and all equipment, materials, testing and labor necessary for a complete and accepted installation.

The Contract unit price for each solar power unit includes the solar power unit as specified in the Contract Documents, all equipment, materials (weatherhead, conduit, conduit accessories), and labor necessary for a complete and accepted installation.

The Contract unit price for each inductive loop assembly includes loop wire, loop sealant, all equipment, materials, testing, and labor necessary for a complete and accepted installation.

The Contract unit price for each TMS cabinet includes the TMS cabinet, shelf, suppression device, and backplane components as specified in the Contract Documents, all equipment, materials, and labor necessary for a complete and accepted installation. The cost of the base or pedestal, as shown in the Standard Plans, is included in the cost of the cabinet. The cost of the pole for pole mounts will be paid in accordance with Section 646.

The Contract unit price for each TMS modem will include the modem and all equipment, materials, and labor necessary for a complete and accepted installation.

The Contract unit price for each TMS antenna will include the antenna and all equipment, materials, and labor necessary for a complete and accepted installation.

The Contract unit price for each TMS Managed Field Ethernet Switch (MFES) will include the MFES and all equipment, materials, and labor necessary for a complete and accepted installation.

695-15 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section.

Payment will be made under:

Item No. 695- 1-	TMS Vehicle Axle Sensor - Non-Weight Applications- each.
Item No. 695- 2-	TMS Vehicle Non-Intrusive – Non-Weight Applications – each.
Item No. 695- 3-	TMS Vehicle Speed/Classification Unit - per assembly.
Item No. 695- 5-	TMS Solar Power Unit - each.
Item No. 695- 6-	TMS Inductive Loop Assembly – each.
Item No. 695- 7-	TMS Cabinet - each.
Item No. 695- 8-	TMS System Communications Modem – each.
Item No. 695- 9-	TMS Weigh-In-Motion Axle Sensor – each.
Item No. 695- 10-	TMS Weigh-In-Motion Unit – per assembly.
Item No. 695- 11-	TMS Non-Motorized Data Collection Unit – per assembly.
Item No. 695- 12-	TMS Non-Motorized Axle Sensor – each.
Item No. 695- 13-	TMS Non-Motorized Infrared Sensor – each.
Item No. 695- 14-	TMS Non-Motorized Inductive Loop Assembly – each.
Item No. 695- 15-	TMS Non-Motorized Solar Power Unit – each.

Item No. 695- 16- TMS Surge Suppressor – each.
Item No. 695- 17- TMS Patch Panel – each.
Item No. 695- 18- TMS Managed Field Ethernet Switch – each.

SECTION 700
HIGHWAY SIGNING

700-1 Description.

Furnish and install roadway signs in accordance with the details in the Standard Plans and as shown in the Plans.

Erect ground traffic signs as signs on the shoulders, slopes, or medians. Signs are classified as single column(post), multi-column, or In-Street signs.

Erect overhead traffic signs partially or completely over the traveled roadway or mounted on bridges. Overhead traffic signs are classified as span wire mounted, mast arm mounted, overhead cantilever structure, or overhead span structure traffic signs.

The sign face(s) may be a single or combination of static sign panels, illuminated sign panels, dynamic message signs, or electronic display signs.

Fabricate standard sign panel messages in accordance with details included in the Standard Highway Signs (SHS) manual published by the U.S. Department of Transportation, the Plans, or Standard Plans. Submit shop drawings to the Department for approval, as specified in Section 5.

All Traffic Control Signals and Devices must meet the requirements of Section 603.

700-2 Materials.

700-2.1 General Requirements: Meet the following requirements:

Flowable Fill for precast foundation.....Section 121
Structural Concrete .....Section 346
Non-Structural Concrete .....Section 347
Reinforcing Steel .....Section 415
Structural Steel Welding.....Section 460
Repair of Galvanized Surfaces.....Section 562
Transformer Base.....Section 965
Structural Steel and Miscellaneous Metal Items
(other than aluminum).....Section 962
Aluminum Items .....Section 965
Retroreflective Sign Sheeting* .....Section 994
Sign Panel Fabrication .....Section 994
Internally Illuminated Signs*..... Section 995-14
Highlighted Signs*..... Section 995-15
Dynamic Message Signs* ..... Section 995-16
Electronic Display Signs
(ERS, ESFS, BOS)*..... Section 995-17
Sign Beacon* ..... Section 995-18
In-street Sign* ..... Section 995-19

*Use products listed on the Department's Approved Products List (APL).

700-2.2 Static Sign Assembly Requirements:

700-2.2.1 Static Sign Panels: Provide aluminum sheets for sign panels meeting the requirements of Section 965 and Section 994. Meet the minimum thickness requirements of Table 700-1.

For flip signs, use continuous hinges constructed of ANSI grade 316 stainless steel.

For In-Street signs, see 700-7.

Table 700-1 Static Sign Panel Requirements	
Type	Minimum Thickness
Single column ground sign	0.08 inch
All other sign panels	0.125 inch

700-2.2.2 Sign Panel Mounting Hardware: Provide aluminum materials (plates, bars, shapes, bolts, nuts, and washers) in accordance with Section 965. Stainless steel mounting hardware meeting Table 962-6 (ASTM F593 for bolts and ASTM F594 for nuts) may be substituted. Steel plates, shapes and hardware must meet Section 962.

700-2.2.3 Retroreflective Sign Sheeting: Sign sheeting must meet the requirements of Section 994 and Table 700-2.

Table 700-2 Retroreflective Sign Sheeting*		
Application	Sheeting System Type	Notes
All signs and retroreflective strips, except as otherwise noted below	Type XI	
School: S1-1, S3-1, S3-2, S4-5, S4-5a, S5-1 (SCHOOL portion) Bicycle: W11-1 Pedestrian: R1 6, R1 6a, R1 6b, R1 6c, R1 9, R1 9a, R10 15, W11 2 Shared Use Path (trail): W11 15, W11 15a	Type XI fluorescent yellow green sheeting**	Includes supplemental panels
* All digitally printed signs and red silkscreen inks require a clear overlay for UV protection. **Do not mix signs having fluorescent yellow green sheeting with signs having yellow retroreflective sheeting.		

700-2.3 Galvanized Bolt Assemblies (Bolts, Nuts, Washers): Provide galvanized bolt assemblies meeting Section 962 for high-strength steel fastener assemblies. Provide galvanized anchor rods, plate washers, U-bolts, and shims meeting the requirements of Section 962 for hardware not designated as high strength.

700-2.4 Sign Support Structure:

700-2.4.1 Single Column Ground Signs and Single Post Barrier Mounted Signs: Use aluminum tubing meeting the requirements of Section 965. For top-mounted single post barrier mounted signs use galvanized steel pipe meeting the requirements of Section 962. Steel shapes and welding must meet 962-10.

700-2.4.2 Multi-Column Ground Signs: Multi-column signs must be galvanized steel W or S beams steel columns meeting Section 962.

700-2.4.3 Overhead Signs: Obtain overhead sign structures from a facility that is listed on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

Meet the requirements for overhead signs in accordance with Section 962.

Repair galvanized surfaces in accordance with Section 562. Galvanizing materials used for repair must meet the requirements of Section 975.

700-2.4.4 Enhanced Highway Sign Assemblies: Use aluminum pedestal posts, transformer bases, anchors, caps, and shims meeting the requirements of Section 646.

700-2.5 Storage, Handling and Labeling: If signs are stored prior to installation, store them in accordance with the manufacturer's recommendations. Properly package signs to protect them during storage, shipment and handling to prevent damage to the sign face and panel.

Install a label on all permanent roadway signs on the back bottom edge with the date of installation, APL number of the base sheeting, and Name of Fabricator. Make the labels unobtrusive, but legible enough to be easily read by an observer on the ground when the sign is in its final position. Apply the label in a manner that is at least as durable as the sign face.

700-2.6 Acceptance of Signs:

700-2.6.1 Sign Inspection: Submit certification that the sign assembly meets the material and installation requirements of the Contract Documents. The Engineer will inspect the signs upon delivery to the storage or project site and again at the final construction inspection. Repair and replace damaged signs at no expense to the Department.

700-2.6.2 Imperfections and Repairs: Repair or replace signs containing imperfections or damage regardless of the kind, type, or cause of the imperfections or damage. For sign panels exceeding 30 square feet, the Contractor may make one patch, if necessary, to each sign panel not to exceed two square inches. Make repairs according to the manufacturer's recommendations. Ensure that completed repairs provide a level of quality necessary to maintain the service life of the sign and are satisfactory in appearance to the Engineer.

700-3 Static Signs.

700-3.1 Single Column and Multi-Column Ground Sign Assemblies: Furnish and install single column and multi-column ground signs in accordance with the Plans and Standard Plans, Indexes 700-010, 700-011, and 700-020.

700-3.1.1 Foundation: Construct foundations in accordance with the applicable Standard Plans. The Contractor may use precast foundations in augured or excavated holes a minimum of 12 inches larger than each axis dimension of the precast foundation. Obtain precast foundations from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.The holes must be clean and without loose material. Temporary casing will be required if the soil is unstable. Fill the void around the precast foundation with flowable fill meeting the requirements of Section 121 or use clean sand placed using hydraulic methods.

700-3.1.2 Breakaway Support Mechanisms for Ground Traffic Signs:

700-3.1.2.1 Frangible Supports: Provide support posts for all frangible sign assemblies consisting of aluminum tubes up to 3-1/2 inches outside diameter with 3/16-inch wall thickness in accordance with the requirements in the Standard Plans.

700-3.1.2.2 Slip Bases: Slip base assemblies for single column signs will use aluminum sleeves and base plates. The slip base stub (the lower base plate assembly) may be galvanized steel in accordance with the Standard Plans.

Slip base assemblies for multi-column signs will use galvanized steel bases. All slip bases must be fabricated in accordance with the requirements of the Standard Plans.

700-3.1.3 Fabrication: Fabricate the supports and wind beams in accordance with the Standard Plans. Weld joints in accordance with Section 460.

Drill or sub-punch and ream holes in multi-column fuse plates and hinge plates.

Hot dip galvanize after fabrication. Remove all drips, runs or beads on base plate within washer contact areas (including saw cuts).

700-3.1.4 Installation: Verify the length of the column supports in the field prior to fabrication to permit the appropriate sign mounting height. Columns must be plumb and panels must be level with the proper orientation.

700-3.1.5 Retroreflective Strips for Signs: Use with static Wrong-Way Signs in accordance with Standard Plans, Index 700-101 and on other signs where retroreflective strip is called for in the Plans. The retroreflective strip must be 2 inches in width and 5 feet in height for all signs, except for signs mounted at a height of 4 feet, then use a retroreflective strip 2 feet in height. For the back of Railroad Crossbuck signs, the retroreflective strip will be 2 inches wide for the full length of the blade. Match the color of the retroreflective strip to the background color of the sign (per the SHS), except for YIELD signs and DO NOT ENTER signs, where the color must be red. Install retroreflective strips directly to a panel attached to the column in accordance with the manufacturer's instructions. Use a 0.040-inch minimum aluminum plate or other material approved by the sheeting manufacturer. Use stainless steel attachment hardware for the installation. Install retroreflective strips in a manner that does not require drilling holes through the column (post). A set screw no larger than 1/4 inch may be used with band attachments

700-3.1.6 Flip Signs: Install in accordance with the Plans and Standard Plans Index 700-010.

700-3.2 Single Post Barrier Mounted Signs: Meet the requirements of the Standard Plans, Indexes 700-012 and 700-013. Snap-in post cap is UV and weather-resistant glass-filled polyester cap.

700-3.3 Overhead Signs: Meet the requirements of the Plans and Standard Plans for overhead sign structures, including those for walk-in dynamic message signs (DMS).

700-3.3.1 Fabrication: Weld joints in accordance with Section 460.

Structural bolt hole diameters: Bolt diameter plus 1/16 inch.

Anchor bolt hole diameters: Bolt diameter plus 1/2 inch.

Upright splices are not allowed. Sign trusses may be fabricated in sections that fit into available galvanizing vats. Provide magnetic particle testing on 100% of upright fillet welds after galvanizing.

Shop assemble the entire structure after galvanizing to validate proper fit for all bolted connections. Complete necessary repairs prior to shipping. Assemblies may be separated for shipment.

700-3.3.2 Foundations: Meet the requirements of Section 455. Use Class IV concrete for spread footings and IV (Drilled Shaft) for drilled shaft foundations.

700-3.3.3 Installation: Install nuts on anchor bolts in accordance with Section 649 with the following exception. For cantilever overhead sign structures, after placement of the upright and prior to installation of the truss, adjust the leveling nuts beneath the

base plate to achieve the back rake shown on the Camber Diagram. If the top surface of the base plate has a slope that exceeds 1:40, use beveled washers under the top nuts. Split-lock washers are not permitted.

Install screens or grout pads in accordance with the Standard Plans, and as required by Section 649.

Install ASTM F3125, Grade A325 bolt, nut and washer assemblies in accordance with 460-5, except that 460-5.4.2 Preparation of Faying Surfaces is not required.

700-3.3.4 Erection of Signs and Sign Supports: Do not erect overhead sign supports until the concrete strength in the support footing is at least 2,500 psi. Determine concrete strength from tests on a minimum of two test cylinders sampled and tested in accordance with ASTM C31 and ASTM C39 and verifying test results have been submitted to the Engineer.

Erect the signs and sign structures in accordance with the details shown in the Plans. Re-galvanize damaged parts as specified in Section 562. Record the as-built anchor locations and submit to the Engineer prior to erecting the sign supports. Place backfill above spread footings prior to installation of the sign panels. Do not remove or reduce backfill without prior approval of the Engineer.

700-4 Enhanced Highway Sign Assemblies.

700-4.1 Description: Furnish and install enhanced highway sign assemblies in accordance with the Plans and Standard Plans, Index 700-120.

700-4.2 Materials: Use flashing beacons, highlighted signs, electronic display signs (EDS), and associated mounting hardware that meet the requirements of Section 995 and are listed on the APL. EDS are specialized electronic signs that include dynamic display components. The term EDS refers to a general category of electronically enhanced road signs (ERS) with warning regulatory, or guide legends; electronic speed feedback signs (ESFS); and blank-out signs (BOS).

For new roadside sign assemblies, provide support structure in accordance with Section 646. Meet all static sign requirements for the static portion of the highlighted sign (i.e., sign panel, reflective sheeting, etc.).

700-4.2.1 Warranty: Ensure that beacons, highlighted signs, and EDS have a manufacturer's warranty covering defects for three years from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608.

700-4.3 Foundations: Construct foundations in accordance with the Standard Plans and Specification 646.

700-4.4 Installation: Install sign assembles based on Alpha-Numeric Type designation shown in the Plans. Assembly Type is based on Power Configuration "Alpha" Identification and Numerical Identification shown in Standard Plans, Index 700-120. Install sign panel and wind beam meeting the requirements of this Section and Standard Plans, Index 700-110. For roadside sign assemblies, construct foundation and install support structure in accordance with 646-3 and the Standard Plans, Index 700-120. Install enhanced highway sign assembly components in accordance with the manufacturer's recommendations.

700-5 Internally Illuminated Signs.

700-5.1 Description: Furnish and install internally illuminated signs in accordance with the details specified in the Contract Documents.

700-5.2 Materials: Use internally illuminated signs and associated mounting hardware listed on the Department's Approved Product List (APL).

Use clamp-on cantilever arms for internally illuminated signs which meet all design and wind loading requirements as specified in the Contract Documents. Ensure the clamp is adjustable to accommodate various size poles.

700-5.2.1 Acceptance of Internally Illuminated Signs: Certify that signs and clamp-on cantilever arms provided meet the criteria in this Section and Section 995.

700-5.2.2 Warranty: Ensure that internally illuminated signs have a manufacturer's warranty covering defects for five years from the date of final acceptance by the Engineer in accordance with 5-11 and Section 608.

700-5.3 Installation of Internally Illuminated Signs: Secure the brackets to the sign housing in accordance with the manufacturer's instructions.

700-5.3.1 Double Sided Sign Assembly: Use a free swinging mounting method.

700-5.3.2 Two Point Support Assembly: Use a two point support assembly when the sign assembly is attached to a mast arm that is perpendicular to the street on which the sign is viewed.

Use a two point mast arm mounting assembly consisting of the following:

1. Stainless steel band or cable type clamp,
2. Clevis,
3. Span wire adapter,
4. Tri-stud hanger body.

Ensure one of the hangers has a mechanism for the horizontal adjustment of the sign.

700-5.3.3 One Point Support Assembly: Use a one point support assembly consisting of an articulated horizontal stainless steel band or cable type mast arm clamp, sign bracket and mounting hardware, when the sign assembly is attached to a mast arm that is diagonal to the street on which the sign is viewed. Do not use a one point support assembly for internally illuminated sign assemblies exceeding four feet in width.

Ensure the band or cable clamp is capable of horizontal rotation of 360 degrees.

700-5.3.4 Clamp-On Cantilever Arm: Attach the arm perpendicular to the street on which the sign assembly is viewed. Use a clamp and arm that are galvanized in accordance with ASTM A123 unless otherwise shown in the Plans. Ensure the arm has a cap secured in place.

700-5.3.5 Electrical Wiring: Unless otherwise shown in the Plans, install dedicated 14 AWG conductors to supply power to the sign and connect the conductors to a dedicated 15 amp circuit breaker located either inside the controller cabinet or inside the electrical service disconnect. Using the same conduit system for both signal cables and internally illuminated sign conductors is permitted, unless otherwise shown in the Plans.

Install conductors in such a manner as to prevent damage to conductors or conductor insulation. Remove and replace all damaged conductors /insulation at no additional cost to the Department.

Ensure drilled holes through which conductors pass through are fitted with a weather tight rubber grommet fitting.

Install continuous lengths of conductors between the dedicated circuit breaker and internally illuminated signs.

Do not splice conductors unless otherwise shown in the Plans.

Provide one photoelectric cell for all internally illuminated signs at each intersection. Use an L bracket to mount the photoelectric cell as specified in the Contract Documents. Connect the photoelectric cell to a contactor assembly inside the controller cabinet to provide switching of the internally illuminated signs.

700-6 Dynamic Message Signs.

700-6.1 General: Provide monochrome, tri-color, or full-color signs as shown in the Plans.

700-6.2 Sign Housing Requirements for all DMS: Ensure that the sign housing design and appearance is approved by the Engineer.

700-6.3 Characters, Fonts, and Color: Submit a list of the character fonts to the Engineer for approval.

700-6.4 Main Power Supply and Energy Distribution Specifications: Provide Type XHHW power cables sized as required by the NEC for acceptable voltage drops while supplying alternating current to the sign.

700-6.5 Uninterruptible Power Supply (UPS): The UPS system must be capable of displaying the current messages on a sign when a power outage occurs. Signs with an UPS must be able to operate on battery power and display text messages for a minimum of two hours.

700-6.6 Operational Support Supplies: Furnish the operational support supplies listed in Table 700-3. Promptly replace any of the supplies used to perform a warranty repair prior to final acceptance.

For every group of 10 or fewer DMSs provided or required, provide one set of supplies as follows:

Table 700-3
DMS Operational Support Supplies

1 each	Sign controller and I/O board(s)
1 per DMS	LED display modules
1 each	Display power supply
1 each	Uninterruptible power supply
2 each	Surge suppression sets
1 each	Fan assembly

700-6.7 Message and Status Monitoring: Ensure that the sign can perform the following functions:

1. Control Selection – Ensure that local or remote sign control can be selected.
2. Message Selection – Ensure that the sign controller can select a blank message or any one of the messages stored in the sign controller's nonvolatile memory when the control mode is set to local.
3. Message Implementation – Ensure that the sign controller can activate the selected message.

Ensure that each font may be customized, and modifications to a font may be downloaded to the sign controller from the TMC or a laptop computer at any time without any software or hardware modifications.

Ensure that there is no perceivable flicker or ghosting of the pixels during sign erasure and writing periods.

700-6.8 TMC Communication Specification for all DMS:

Provide communications line circuits that are point-to-point or multipoint, and that provide full duplex asynchronous data transmissions at the rate shown in the Contract Documents or directed by the Engineer.

Assign each sign controller a unique address.

700-6.9 Sign Control Software: Ensure that the laptop computer and sign can communicate when connected directly by an EIA-232 cable and via Ethernet. Ensure that the software allows communication between multiple users and multiple signs across the same communication network.

700-6.10 Sign Support Structure: Meet the requirements of 700-2.3.

700-6.11 Installation Requirements: Provide a walk-in DMS for locations over interstate travel lanes. Verify that any ventilation system incorporated within the sign is operational per the manufacturer's recommendations.

Install the DMS in accordance with the manufacturer's recommendations and Standard Plans, Index 700-090.

Ensure that the location of the lifting eyebolts, left in place or removed, is sealed to prevent water entry after installation.

Load the initial message libraries on both the sign control software and the sign controller. The Engineer will furnish the messages to be placed in these libraries.

700-6.12 Documentation: Submit documentation for electronic equipment in accordance with 603-6.

700-6.13 Licensing: Ensure that the manufacturer grants the Department a license that allows the Department to use and internally distribute any and all sign communications protocols, operating systems, drivers, and documentation.

700-6.14 Technical Assistance: Ensure that a manufacturer's representative is available to assist the Contractor's technical personnel during pre-installation testing and installation.

Do not provide initial power to the signs without the permission of the manufacturer's representative.

700-6.15 Pre-installation Field Testing: Conduct pre-installation tests on all units at a Contractor-provided facility within the appropriate District. Perform the tests on each unit supplied to verify that no damage was done to any sign during the shipment and delivery process. Notify the Engineer a minimum of 10 calendar days before the start of any tests. Conduct all tests according to the approved test procedures detailed in this Section. Each DMS must pass the individual tests detailed below prior to installation.

700-6.15.1 Material Inspection: Examine each DMS carefully to verify that the materials, design, construction, markings, and workmanship comply with all applicable standards, specifications, and requirements.

700-6.15.2 Operational Test: Operate each DMS long enough to permit equipment temperature stabilization, and to check and record an adequate number of performance characteristics to ensure compliance with applicable standards, specifications, and requirements.

700-6.15.3 Pre-Installation Test Failure Consequence: If any unit fails, the unit shall be corrected or another unit substituted in its place and the test repeated.

If a unit has been modified as a result of a failure, a report shall be prepared and submitted to the Engineer. The report shall describe the nature of the failure and the corrective action taken.

If a failure pattern develops, the Engineer may direct that design and construction modifications be made to all units without additional cost to the Department or an extension of the Contract Time.

700-6.16 Installed Site Tests: Conduct Intelligent Transportation System Device Installation testing in accordance with Section 611.

700-6.17 System Testing: Conduct Intelligent Transportation System Device Installation testing in accordance with Section 611.

700-7 In-Street Sign Assemblies.

700-7.1 Description: In-Street signs consist of the R1-6a or R1-6c In-Street Pedestrian Crossing Sign assemblies including the sign base.

700-7.2 Fabrication of Panel Messages: Fabricate standard sign panel messages in accordance with the Standard Plans. Sign panels of 9 inches in width x 27 inches in height or 12 inches x 36 inches are acceptable. See Standard Plans Section 700-102.

700-7.3 Installation: Install a fixed base connection in accordance with the manufacturer's instructions. Install portable base connections only for temporary applications at school crossings where a crossing guard is present during school arrival and departure times or when children are present.

700-8 Warranty.

Refer to Section 608 for Contractor Requirements. Transfer all warranties from the Manufacturer to the Department.

700-9 Method of Measurement.

700-9.1 Single Column Ground Sign Assembly: Measurement will be made per each and will consist of all signs mounted on a single column (post). Area measurement for an assembly will include the total sheeting area, excluding any reflective sign strips.

700-9.2 Multi-Column Ground Sign Assembly: Measurement will be made per each and will consist of all sign panels and columns for a multi-column ground sign. Area measurement for an assembly will include the total sheeting area, excluding any reflective sign strips.

700-9.3 Sign Panel: Measurement for each sign panel will be the width times height of the sheeting area. No separate payment will be made for any panels on a new sign assembly.

700-9.4 Overhead Static Sign Structure: Sign panels will be paid separately from the overhead static support structures. For signs mounted on a span wire or mast arm, payment for the structure will be paid under the applicable items in Section 634 or Section 649. Measurement for all other overhead static sign structures will be made per each.

700-9.5 Enhanced Highway Sign Assembly: Measurement for Enhanced Highway Sign Assembly will be made per each.

700-9.5.1 Sign Beacon: No separate measurement will be made for a sign beacon mounted on a new Enhanced Sign Assembly. Separate measurement for retrofit, per each sign beacon, will be made for installation on an existing sign panel or sign assembly.

Separate payment for removal will be made only when the sign panel or sign assembly is to remain.

700-9.5.2 Highlighted Signs: No separate measurement will be made for a highlighted sign as part of a new Enhanced Sign Assembly. Separate measurement for retrofit, per each highlighted sign, will be made for installation on an existing post or other structure. Measurement for Highlighted Sign will be made per each sign completed.

700-9.5.3 Electronic Display Sign: No separate measurement will be made for an EDS as part of a new Enhanced Sign Assembly. Separate measurement for retrofit, per each EDS, will be made for installation on an existing post or other structure. Measurement for EDS will be made per each sign completed.

700-9.6 Internally Illuminated Signs: Measurement for Internally Illuminated Sign will be made per each completed sign, regardless of whether the sign has one or more illuminated faces.

700-9.7 Embedded Dynamic Message Sign: Measurement for Embedded Dynamic Message Sign will be made for each completed sign, regardless of the number of embedded sign messages or housings mounted on a single or multi-post foundation.

700-9.8 Front Access Dynamic Message Sign: Measurement for Front Access Dynamic Message Sign will be made for each completed sign, regardless of the number of sign messages or housings mounted on a single or multi-post foundation.

700-9.9 Walk-in Dynamic Message Sign: Measurement for Embedded Dynamic Message Sign will be made for each completed sign.

700-9.10 Dynamic Message Sign Support Structure: Measurement for Dynamic Message Sign Support Structure will be made for each completed sign structure, regardless of the number of static and/or dynamic message signs supported.

700-9.11 Retroreflective Strip: Measurement for the retroreflective sign strip will be per each.

700-9.12 In Street Sign Assembly: Measurement will be made per each.

700-9.13 Removal and Relocation Operations: Measurement for removal or relocation operations of single column and multi-column signs will be made per each. Measurement for overhead sign structure will be made per each.

Measurement, per each, for removal of sign panels will only be made for signs not on an assembly.

700-10 Basis of Payment.

700-10.1 Single Column Ground Sign Assembly: The Contract unit price per each for single column ground mounted signs will include the sign panels, sheeting, support structure, foundation, hardware, and labor necessary for a complete and accepted installation. For flip-up signs, the assembly includes the hinge and any additional hardware.

700-10.2 Multi-Column Ground Sign Assembly: The Contract unit price per each for multi-column ground mounted signs will include the sign panels, support structure, foundation, hardware, and labor necessary for a complete and accepted installation.

700-10.3 Sign Panel: The Contract unit price per each sign panel will include the aluminum panel, sheeting, support structure, foundation, hardware, and labor necessary for a complete and accepted installation.

700-10.4 Overhead Static Sign Structure: The Contract unit price for each overhead static sign structure will include the support structure, foundation, hardware, and labor necessary for a complete and accepted installation.

700-10.5 Enhanced Highway Sign Assembly: The Contract unit price per each will include sign, electronics, cabinet, support structure, foundation, hardware, power system, and labor necessary for a complete and accepted installation.

700-10.5.1 Sign Beacon: The Contract unit price per each for sign beacon will consist of the flashing beacons, cabinet, housing, controller, hardware, and labor necessary for a complete and accepted installation. Signal cable from the cabinet to the signs will be paid separately under the applicable item for signal cable.

When solar power is specified in the Contract Documents, the Contract unit price will include the solar panel, auxiliary pole, batteries, and electronics.

700-10.5.2 Highlighted Signs: The Contract unit price per each for highlighted signs, furnished and installed, will include furnishing the sign, electronics, cabinet, support structure, foundation, hardware, and labor necessary for a complete and accepted installation. When solar power is specified in the Contract Documents, the Contract unit price will include the solar panel, auxiliary pole, batteries, and electronics.

Highlighted Signs used for Wrong Way sign installations do not include the Wrong Way Detection System; measurement and payment for the detection system will be made in accordance with Section 660.

700-10.5.3 Electronic Display Sign: The Contract unit price per each for electronic display sign will include static sign panels as required, electronic display, support structure, foundation, housing, cabinet, controller, speed detector, hardware, electrical connection, and labor necessary for a complete and accepted installation.

When the electronic display sign is ground mounted, the Contract price will include the support structure and foundation. All other mounting will include the hardware necessary to complete the attachment to the support structure; the span wire, monotube, or mast arm structure will be paid separately.

When solar power is specified in the Contract Documents, the Contract unit price will include the solar panel, auxiliary pole, and batteries.

700-10.6 Internally Illuminated Signs: The Contract unit price for each Internally Illuminated Sign will include the sign, housing, hardware, electrical connection, and labor necessary for a complete and accepted installation. All other mounting will include the hardware necessary to complete the attachment to the support structure; the span wire, monotube, or mast arm structure will be paid separately.

700-10.7 Embedded Dynamic Message Sign: The Contract unit price per each for Embedded DMS will include the sign, all hardware and software, testing, and warranty for a completed installation.

700-10.8 Front Access Dynamic Message Sign: The Contract unit price per each for Front Access DMS will include the sign, all hardware and software, testing, and warranty for a completed installation.

700-10.9 Walk-in Dynamic Message Sign: The Contract unit price per each for Walk-in DMS will include the sign, all hardware and software, testing, and warranty for a completed installation. When shown in the Contract Documents, payment for the Walk-in DMS will also include the Uninterruptible Power Supply.

700-10.10 Dynamic Message Sign Support Structure: The Contract unit price for each support structure will include posts and supports, catwalks, handrails, footings, foundation, excavation, site grounding, painting, and incidentals necessary for a complete and accepted installation.

700-10.11 Retroreflective Sign Strip: The Contract unit price per each will include the retroreflective sign strip, hardware, and labor necessary for a complete and accepted installation.

700-10.12 In Street Sign Assembly: The Contract unit price per each will include the vertical panel, retroreflective sign sheeting, rebounding boot support, and a base, for a complete and accepted installation.

700-10.13 Removal and Relocation Operations: The Contract unit price for removal of signs will include the removal of the support and footing. Restore the area to the condition of the adjacent area.

The Contract unit price for relocation of signs will consist of removing the existing sign assembly, including foundation removal and area restoration, and installing the sign at the new location shown in the Plans.

For the relocation of existing ground-mounted signs to be relocated or removed, after removing the sign panel from the assembly, remove supports and footings.

For the removal of overhead static sign structures, the Contract unit price will include the removal of the foundation: when partial foundation removal is called for, remove the support structure, and foundation to a minimum depth of four feet below existing grade; when complete foundation removal is called for, completely remove the support structure including the foundation.

700-10.14 Payment Items: Payment will be made under:

Item No. 700- 1-	Single Column Ground Sign Assembly, each.
Item No. 700- 2-	Multi-Column Ground Sign Assembly, each.
Item No. 700- 3-	Sign Panel, each.
Item No. 700- 4-	Overhead Static Sign Structure, each.
Item No. 700- 5-	Internally Illuminated Signs, each.
Item No. 700- 7-	Embedded Dynamic Message Sign - each.
Item No. 700- 8-	Front Access Dynamic Message Sign - each.
Item No. 700- 9-	Walk-in Dynamic Message Sign - each.
Item No. 700- 10-	Dynamic Message Sign Support Structure - each.
Item No. 700- 13-	Retroreflective Sign Strip, each.
Item No. 700- 14-	Enhanced Highway Sign Assembly, each.
Item No. 700- 15-	In Street Sign Assembly, each.

SECTION 701
PROFILED THERMOPLASTIC PAVEMENT MARKINGS

701-1 Description.

Profiled thermoplastic pavement markings consist of thermoplastic material with raised thermoplastic bumps creating a raised profile marking. Apply profiled thermoplastic pavement markings in accordance with the Contract Documents.

701-2 Materials.

Use only materials listed on the Department's Approved Product List (APL) as an approved system and meeting the following requirements:

Profiled Thermoplastic..... 971-1 and 971-9
Retroreflective Elements*..... 971-1.7
Glass Spheres* ..... 971-1 and 971-2
*Use retroreflective elements or glass spheres recommended by the manufacturer.

The Engineer will take random samples of the materials in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

701-3 Equipment.

Use equipment capable of providing continuous, uniform heating of the pavement marking material to temperatures exceeding 390ºF, mixing and agitating the material in the reservoir to provide a homogenous mixture without segregation. Use equipment that will maintain the pavement marking material in a plastic state, in all mixing and conveying parts, including the line dispensing device until applied. Use equipment which is capable of producing a consistent pattern of bumps with a longitudinal distance between bumps of approximately 30 inches center-to-center intervals. Use equipment which meets the following requirements:

1. Capable of traveling at a uniform, predetermined rate of speed, both uphill and downhill, to produce a uniform application of pavement marking material and capable of following straight lines and making normal curves in a true arc.

2. Capable of applying retroreflective elements or glass spheres to the surface of the completed pavement marking by automatic dispensers attached to the pavement marking machine such that the retroreflective elements or glass spheres are dispensed closely behind the installed line. Use retroreflective element or glass sphere dispensers equipped with an automatic cut-off control that is synchronized with the cut-off of the thermoplastic material and applies the retroreflective elements or glass spheres uniformly on the entire pavement marking surface with 50 to 60% embedment.

3. Equipped with a special kettle for uniformly heating and melting the pavement marking material. The kettle must be equipped with an automatic temperature control device and material thermometer for positive temperature control and to prevent overheating or scorching of the thermoplastic material.

4. Meets the requirements of the National Fire Protection Association (NFPA), State and Local authorities.

701-4 Application.

701-4.1 General: Remove existing thermoplastic pavement markings and raised bumps using a method approved by the Engineer such that pavement surface scars or traces of the

removed thermoplastic pavement markings will not conflict with new pavement markings. Do not use paint to blackout, hide, or disguise existing pavement markings.

Before applying pavement markings, remove any material that would adversely affect the bond of the pavement markings by a method approved by the Engineer.

Before applying pavement markings to any portland cement concrete surface, apply a primer, sealer or surface preparation adhesive of the type recommended by the manufacturer. Offset longitudinal lines at least 2 inches from construction joints of portland cement concrete pavement.

Apply thermoplastic material thickness according to 701-4.2. Application on open graded friction surfaces may require more thermoplastic material to achieve the required thickness above the pavement surface.

Apply pavement markings to dry surfaces only, and when the ambient air and surface temperature is at least 50°F and rising for asphalt surfaces and 60°F and rising for concrete surfaces.

Apply pavement markings to the same tolerances in dimensions and in alignment specified in 710-5. When applying pavement marking over existing markings, ensure that no more than 2 inches on either end and not more than 1 inch on either side of the existing line is visible.

Conduct field tests in accordance with FM 5-541, Part A. Take test readings representative of the pavement marking performance. Remove and replace pavement markings not meeting the requirements of this Section at no additional cost to the Department.

701-4.2 Thickness: Apply flat base lines having a minimum thickness of 0.100 inches or 100 mils and not exceeding a thickness of 0.150 inches or 150 mils, exclusive of the bumps, when measured above the pavement surface.

Measure, record and certify on a Department approved form and submit to the Engineer, the thickness of white and yellow pavement markings in accordance with FM 5-541, Part A.

The Engineer will verify the thickness of the pavement markings in accordance with FM 5-541, Part A within 30 days of receipt of the Contractor's certification.

701-4.3 Dimensions of Raised Bumps: Apply the raised bumps with a profile such that the leading and trailing edges are sloped at a sufficient angle to create an audible and vibratory warning.

Bumps on edge line and centerline markings shall be at least 0.45 inches at the highest point of the bump, above the pavement surface, including the base line. The height shall be measured after application of drop-on retroreflective elements or glass spheres. Bumps shall have a minimum baseline coverage dimension of 2.5 inches in both transverse and longitudinal directions. The bumps may have a drainage channel, the width of each drainage channel will not exceed 1/4 inch at the bottom of the channel. The longitudinal distance between bumps shall be approximately 30 inches.

701-4.4 Retroreflectivity: Apply white and yellow profiled thermoplastic markings that will attain an initial retroreflectance of not less than 300 $mcd/m^2/lx$ and not less than 250 $mcd/m^2/lx$, respectively. Measure, record and certify on a Department approved form and submit to the Engineer, the retroreflectivity of white and yellow pavement markings in accordance with FM 5-541, Part A.

701-4.5 Color: Use pavement marking materials that meet the requirements of 971-1.

701-4.6 Retroreflective Elements or Glass Spheres: Apply retroreflective elements or drop on glass spheres to all markings as identified on the APL and at the rates determined by the manufacturer's recommendations.

701-4.7 Loss: If more than 1% of the bumps or more than three consecutive bumps are missing or broken (less than half a bump remaining) within the first 45 days under traffic, replace all failed bumps at no expense to the Department. If more than 2% of the bumps fail within the first 45 days under traffic, the replacement period will extend an additional 45 days from the date all replacement bumps were installed. If, at the end of the additional 45 days, more than 2% of all bumps (initial and replacement) fail, replace all failed bumps at no expense to the Department. Measure, record and certify on a Department approved form and submit to the Engineer, the loss of bumps.

701-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the materials. At the time of notification, submit a certification to the Engineer with the APL number and the batch or LOT numbers of the thermoplastic materials and retroreflective elements or glass spheres to be used. Packaging labels that contain the information required by 971-1.1 will be accepted in lieu of a certification.

701-6 Protection of Newly Applied Profiled Thermoplastic Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

701-7 Observation Period.

Longitudinal pavement markings, with the exception of bumps, are subject to a 180 day observation period under normal traffic. The observation period will begin with the satisfactory completion and acceptance of the work. The observation period for bumps will be in accordance with the requirements of 701-4.7.

The longitudinal pavement markings shall show no signs of failure due to blistering, excessive cracking, chipping, discoloration, poor adhesion to the pavement, loss of retroreflectivity or vehicular damage. The retroreflectivity shall meet the initial requirements of 701-4.4. The Department reserves the right to check the retroreflectivity anytime prior to the end of the observation period.

Replace, at no expense to the Department, any longitudinal pavement markings that do not perform satisfactorily under traffic during the 180 day observation period.

701-8 Corrections for Deficiencies.

Correct all deficiencies by removal and reapplication of a one-mile section centered around the deficiency, at no cost to the Department.

701-9 Method of Measurement.

701-9.1 Profiled Thermoplastic Markings: The quantities of 6 inch solid and 10'-30' skip lines to be paid will be the plan quantity length, in gross miles, subject to 9-1.3.2. The gross mile measurement will be taken as the distance from the beginning of the profiled thermoplastic line to the end of the profiled thermoplastic line and will include the unmarked gaps for skip lines. The gross mile will not include designated unmarked lengths at intersections, turn lanes, etc.

701-9.2 Removal of Existing Thermoplastic Markings: The quantity to be paid for removal of existing thermoplastic pavement markings will be the area, in square feet, acceptably removed. Payment for removal of thermoplastic pavement markings will only be made for locations where the existing pavement surface is to remain.

701-10 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 701	Profiled Thermoplastic Pavement Markings.	
	Solid - per gross mile	
	Skip - per gross mile	
	Remove - per square foot	

SECTION 704
TUBULAR MARKERS

704-1 Description.

Furnish and install tubular markers at the locations called for in the Standard Plans or in the Plans.

704-2 Materials.

Meet the following requirements:

Tubular Markers.....Section 991

***** Use tubular markers listed on the Department's Approved Product List (APL).

704-3 Installation Requirements.

Install tubular markers in accordance with the manufacturer's installation instructions posted on the APL. Use the same color as the pavement marking being emphasized.

704-4 Method of Measurement.

The quantity to be paid will be the plan quantity of the number of tubular markers furnished, installed, and accepted.

704-5 Basis of Payment.

Prices and payments will be full compensation for work specified in this Section, including the cost of labor, materials, and incidental items required to complete the work.

Payment will be made under:

Item No. 704 - 1 Tubular Marker - each.

SECTION 705
OBJECT MARKERS AND DELINEATORS

705-1 Description.

Furnish and install object markers to mark obstructions within or adjacent to the roadway of the types and at the locations called for in the Standard Plans or in the Plans.

Furnish and install delineators along the side of the roadway to indicate the alignment of the roadway as indicated in the Standard Plans or in the Plans.

705-2 Materials.

705-2.1 General: Meet the following requirements:

Flexible Post Delineators*.....Section 993
Barrier Delineators* .....Section 993
Retroreflective Sign Sheeting*.....Section 700
*Use products listed on the Department's Approved Product List (APL).

705-2.2 Flanged U-Channel Posts: Meet the mechanical requirements of ASTM A499, Grade 60. Galvanize after fabrication in accordance with ASTM A123, to produce a smooth uniform finish free from defects affecting strength, durability, and appearance. Punch or drill 3/8-inch diameter holes on 1-inch centers through the center of the post, starting approximately 1 inch from the top and extending the full length of the post. Punching or drilling operations shall be completed prior to galvanization. The weight per foot of a manufacturer's U-channel size shall not vary more than plus or minus 3.5% of its specified weight per foot. Machine-straighten the U-channel to a tolerance of 0.4% of the length.

705-2.3 Round Aluminum Posts: Meet the requirements of Standard Plans, Index 700-010.

705-2.4 Retroreflective Sheeting: Use Types IV, V or XI sheeting. The retroreflective area shall be in accordance with the MUTCD.

705-2.5 Aluminum Panel: For Object Markers and Nonflexible Delineators, adhere retroreflective sheeting to 6061 T6 aluminum meeting ASTM B209. Use 0.040-inch sheet aluminum for Type 2 markers and nonflexible delineators. Use 0.080-inch sheet aluminum for Type 1, Type 3, and Type 4 markers. Prepare aluminum in accordance with recommendations of the sheeting manufacturer.

705-3 Installation Requirements.

Install delineators and object markers in accordance with the MUTCD, Standard Plans and Plans.

705-3.1 Object Markers: For uniformity, all Type 1 markers shall be OM1-3 style markers, all Type 2 markers shall be OM2-2V style markers, and all Type 4 (end of road) markers shall be OM4-3 style markers. Install object markers at a mounting height of 4 feet measured in accordance with Standard Plans, Index 700-101.

Attach Type 1 and Type 4 object markers to round aluminum posts in accordance with Standard Plans, Index 700-010. Install Type 2 and Type 3 object markers directly to 3 lb/ft flanged U-Channel posts using two 1/4-inch bolts spaced to fit holes on the post.

Use attachment hardware (nuts, bolts, clamps, brackets, braces, etc.) of aluminum or galvanized steel.

705-3.2 Flexible Post Delineators: Install in accordance with the manufacturer's instructions.

705-3.3 Nonflexible Post Delineators: Install nonflexible post delineators on 1.1 lb/ft flanged U-Channel. The retroreflective sheeting shall have a minimum width of 4 inches and have a minimum area of 32 square inches.

705-3.4 Barrier Delineators: Install barrier delineators by adhesive or mechanical means as per the manufacturer's recommendations and in accordance with the details shown in the Plans and the Standard Plans. Install barrier delineators at a spacing of 25 feet for the first 100 feet of barrier and at 100 feet spacing thereafter. For installations with guardrail, install barrier delineators in accordance with Standard Plans, Index 536-001. Orient barrier delineators as detailed in the manufacturer's instructions.

705-4 Method of Measurement.

The quantity to be paid will be the number of delineators or object markers furnished, installed and accepted, with the exception of barrier delineators on new barriers, which are included in the cost of the barrier.

705-5 Basis of Payment.

Prices and payments will be full compensation for work specified in this Section, including the cost of labor, materials, and incidental items required to complete the work.

Payment will be made under:

Item No. 705- 10	Object Marker - each.
Item No. 705- 11	Delineator - each.

SECTION 706
RAISED PAVEMENT
MARKERS AND MARKER ADHESIVE

706-1 Description.

Raised pavement markers (RPMs) and adhesive provide a positive guidance system to supplement other reflective pavement markings.

706-2 Materials.

Use only Class B markers, except as follows:

For center line rumble strip installations where RPMs are in conflict with the grinding, install Class D RPMs with the first application of standard paint. Remove Class D RPMs prior to grinding, then install Class B RPMs in an unground area after grinding.

Install Class F RPMs only when shown in the plans.

Meet the requirements of Section 970.

706-2.1 Product Acceptance on the Project: Use only RPMs and adhesive that are listed on the Department's Approved Product List (APL). For Class F RPMs, provide a warranty assigned to the Department in accordance with Section 970.

706-3 Bituminous Adhesive Equipment.

Use equipment having either thermostatically controlled double boiler type units utilizing heat transfer oil or thermostatically controlled electric heating pots to install hot applied bituminous adhesive. Use a melter/applicator unit suited for both melting and pumping the bituminous adhesive through heated applicator hoses.

Heat the bituminous adhesive to between 375°F and 425ºF and apply directly to the bonding surface from the melter/applicator by either pumping or pouring. Maintain the application temperature between 375°F and 425ºF. The bituminous adhesive may be reheated. However, do not exceed the manufacturer's recommendations for pot life at application temperatures.

706-4 Application.

Install RPMs in accordance with the Plans and Standard Plans, Indexes 706-001 and 711-003, prior to opening the road to traffic.

Apply RPMs to the bonding surface using bituminous or epoxy adhesives in accordance with the manufacturer's instructions. Use epoxy adhesives when applying RPMs on concrete pavement.

For Class F RPMs, installation may include the removal of roadway surface material to recess a portion of the RPM housing.

Prior to application of adhesive, clean the portion of the bonding surface of any material which would adversely affect the adhesive.

Apply the adhesive to the bonding surface (not the RPM) so that 100% of the bonding area of the RPM will be covered, in accordance with adhesive manufacturer's recommendations. Apply sufficient adhesive to ensure that when the marker is pressed downward into the adhesive, adhesive will be forced out around the entire perimeter of the RPM.

Immediately remove excess adhesive from the bonding surface and exposed surfaces of the RPMs. Soft rags moistened with mineral spirits meeting Federal Specifications TT-T-291 or kerosene may be used to remove adhesive from exposed faces of the RPMs. Do not use any other

solvent. If any adhesive, pavement marking materials or other foreign matter adheres to the traffic face of the RPM, replace the RPM at no cost to the Department.

Restore any areas impacted by the installation of Class F RPMs to original condition.

Ensure that all final RPMs are in place prior to opening the road to traffic.

If more than 2% of the RPMs fail in adhesion or alignment within the first 45 days under traffic, replace all failed RPMs at no expense to the Department. If more than 5% of the RPMs fail in adhesion and or alignment during the initial 45 day period, the Engineer will extend the replacement period an additional 45 days from the date that all replacement RPMs have been installed. If, at the end of the additional 45 day period, more than 2% of all RPMs (initial installation and 45 day replacements combined) fail in adhesion or alignment, replace all failed RPMs at no expense to the Department.

706-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of RPMs. At the time of notification, submit the APL number and the batch or LOT numbers of RPMs and adhesive to be used.

706-6 Method of Measurement.

The quantity of RPMs to be paid for under this Section will be the quantity per each, furnished and installed, completed and accepted.

706-7 Basis of Payment.

706-7.1 Class B RPMs: Price and payment for Class B RPMs will be full compensation for all work and materials in this Section.

706-7.2 Class D RPMs: Payment will be made in accordance with Section 102.

706-7.3 Class F RPMs: Price and payment for Class F RPMs will be full compensation for all work and materials in this Section.

706-7.4 Payment Items: Payment will be made under:

Item No. 706- 1- Raised Pavement Marker - per each.

SECTION 709
TWO REACTIVE COMPONENTS PAVEMENT MARKINGS

709-1 Description.

Apply two reactive components pavement markings in accordance with the Contract Documents.

709-2 Materials.

Use only materials listed on the Department's Approved Product List (APL) as an approved system and meeting the following requirements:

Two Reactive Components ..... 971-1 and 971-8
Retroreflective Elements* 971-1.7
Glass Spheres* ..... 971-1 and 971-2
*Use only retroreflective elements or glass spheres recommended by the manufacturer.

The Engineer will take random samples of the materials in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

709-3 Equipment.

Use equipment that will produce continuous uniform dimensions of pavement markings of varying widths and meets the following requirements:

1. Capable of traveling at a uniform, predetermined rate of speed, both uphill and downhill, to produce a uniform application of the two reactive components material and capable of following straight lines and making normal curves in true arcs.

2. Capable of applying retroreflective elements or glass spheres to the surface of the completed line by an automatic retroreflective element dispenser attached to the pavement marking machine such that the retroreflective elements or glass spheres are dispensed closely behind the installed line. Use a retroreflective element or glass sphere dispenser equipped with an automatic cut-off control that is synchronized with the cut-off of the material and applies the retroreflective elements or glass spheres in a manner such that the retroreflective elements or glass spheres appear uniform on the entire pavement markings surface.

3. Capable of providing the manufacturer's recommended mixing ratio between the components in a thorough and consistent manner.

709-4 Application.

709-4.1 General: Remove existing pavement markings, such that scars or traces of removed markings will not conflict with new pavement markings by a method approved by the Engineer.

Before applying pavement markings, remove any material by a method approved by the Engineer that would adversely affect the bond of the pavement markings.

Offset longitudinal lines at least 2 inches from construction joints of portland cement concrete pavement.

Apply pavement markings to dry surfaces only, and when the ambient air and surface temperature is at least 40ºF and rising.

Do not apply two reactive components pavement markings when winds are sufficient to cause spray dust.

Apply two reactive components pavement markings to the same tolerances in dimensions and in alignment specified in 710-5. When applying two reactive components pavement marking over existing markings, ensure that not more than 2 inches on either end and not more than 1 inch on either side of the existing line is visible.

Apply the two reactive components pavement markings to the pavement in accordance with the manufacturer's instructions or as directed by the Engineer.

Conduct field tests in accordance with FM 5-541, Part A. Take test readings representative of the pavement marking performance. Remove and replace two reactive components pavement markings not meeting the requirements of this Section at no additional cost to the Department.

Apply all final pavement markings prior to opening the road to traffic.

709-4.2 Thickness: Apply two reactive components pavement markings to attain a minimum wet film thickness in accordance with the manufacturer's recommendations as identified on the APL.

Measure, record and certify on a Department approved form and submit to the Engineer, the thickness of white and yellow pavement markings in accordance with FM 5-541, Part A. **709-4.3 Retroreflectivity:** Apply white and yellow two reactive components pavement markings that will attain an initial retroreflectivity of not less than 450 mcd/m^2/lx and not less than 350 mcd/m^2/lx, respectively for all longitudinal lines.

Measure, record and certify on the Department approved form and submit to the Engineer, the retroreflectivity of white and yellow two reactive components pavement markings in accordance with FM 5-541, Part A.

709-4.4 Color: Use materials that meet the requirements of 971-1.

709-4.5 Retroreflective Elements or Glass Spheres: Apply retroreflective elements or glass spheres type and rates to all two reactive components pavement markings as identified on the APL based on manufacturer's recommendations.

709-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the materials. At the time of notification, submit a certification to the Engineer with the APL number and the batch or LOT numbers of the materials and retroreflective elements or glass spheres to be used. Packaging labels that contain the information required by 971-1.1 will be accepted in lieu of a certification.

709-6 Protection of Newly Applied Pavement Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

709-7 Observation Period.

Longitudinal pavement markings are subject to a 180 day observation period under normal traffic. The observation period shall begin with the satisfactory completion and acceptance of the work.

The longitudinal pavement markings shall show no signs of failure due to blistering, excessive cracking, chipping, discoloration, poor adhesion to the pavement, loss of retroreflectivity or vehicular damage. The retroreflectivity shall meet the initial requirements of 709-4.3. The Department reserves the right to check the retroreflectivity any time prior to the end of the observation period.

Replace, at no additional expense to the Department, any longitudinal pavement markings that do not perform satisfactorily under traffic during the 180 day observation period.

709-8 Corrections for Deficiencies.

Correct all deficiencies by removal and reapplication of a one mile section centered around the deficiency, as determined by the Engineer, at no additional cost to the Department.

709-9 Method of Measurement.

709-9.1 Two Reactive Components Markings: The quantity of solid, 10'-30' skip, and 3'-9' dotted, 6'-10' dotted, 2'-2' dotted, and 2'-4' dotted lines to be paid will be the plan quantity length, in gross miles, subject to 9-1.3.2.

The gross mile measurement will be taken as the distance from the beginning of the two reactive component line to the end of the two reactive component line and will include the unmarked gaps for skip and dotted lines. The gross mile measurement will not include designated unmarked lengths at intersections, turn lanes, etc.

709-9.2 Removal of Existing Thermoplastic Markings: The quantity to be paid for removal of existing thermoplastic pavement markings will be the area, in square feet, acceptably removed. Payment for removal of thermoplastic pavement markings will only be made for locations where the existing pavement surface is to remain.

709-10 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 709	Two Reactive Components
	Solid - per gross mile.
	Skip - per gross mile.
	Remove - per square foot.

SECTION 710
PAINTED PAVEMENT MARKINGS

710-1 Description.

Apply painted pavement markings, in accordance with the Contract Documents.

710-2 Materials.

Use only materials listed on the Department's Approved Product List (APL) meeting the following requirements:

Standard Paint	971-1 and 971-3
Durable Paint	971-1 and 971-4
Glass Spheres	971-1 and 971-2

The Engineer will take random samples of all material in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

710-3 Equipment.

Use equipment that will produce continuous uniform dimensions of pavement markings of varying widths and meet the following requirements:

1. Capable of traveling at a uniform, predetermined rate of speed, both uphill and downhill, in order to produce a uniform application of paint and capable of following straight lines and making normal curves in a true arc.

2. Capable of applying glass spheres to the surface of the completed line by an automatic sphere dispenser attached to the pavement marking machine such that the glass spheres are dispensed closely behind the installed line. Use a glass spheres dispenser equipped with an automatic cut-off control that is synchronized with the cut-off of the paint and applies the glass spheres in a manner such that the spheres appear uniform on the entire pavement markings surface.

3. Capable of spraying the paint to the required thickness and width without thinning of the paint. Equip the paint tank with nozzles equipped with cut-off valves, which will apply broken or skip lines automatically.

710-4 Application.

710-4.1 General: Remove existing pavement markings, such that scars or traces of removed markings will not conflict with new pavement markings, by a method approved by the Engineer.

Before applying pavement markings, remove any material that would adversely affect the bond of the pavement markings by a method approved by the Engineer.

Apply standard paint to dry surfaces only, and when the ambient air and surface temperature is at least 40ºF and rising.

Apply durable paint to dry surfaces only. Do not apply durable paint when the ambient air and surface temperature is below 50°F, relative humidity is above 80% or when the dew point is within 5°F of the ambient air temperature.

Do not apply painted pavement markings when winds are sufficient to cause spray dust.

Apply painted pavement markings, having well defined edges, over existing pavement markings such that not more than 2 inches on either end and not more than 1 inch on

either side is visible. When stencils are used to apply symbols and messages, the areas covered by the stencil reinforcing will not be required to be painted.

Mix the paint thoroughly prior to pouring into the painting machine. Apply paint to the pavement by spray or other means approved by the Engineer.

Conduct field testing in accordance with FM 5-541 Part A. Remove and replace painted pavement markings not meeting the requirements of this Section at no additional cost to the Department.

Apply all pavement markings prior to opening the road to traffic.

710-4.1.1 Painted Pavement Markings (Final Surface): On concrete surfaces or newly constructed asphalt, the painted pavement markings (final surface) will include one application of standard paint applied to the final surface, except as noted herein.

For center line and edge line rumble strip installations where the pavement marking is placed within the grinding, apply a second application of standard paint within 24 hours of each day's grinding operation.

Do not apply final surface paint where preformed thermoplastic is required in 711-4.2.3.

Do not apply final surface paint where permanent tape will be applied.

710-4.2 Thickness: Apply standard paint to attain a minimum wet film thickness of 0.015 inches or 15 mils . Apply durable paint to attain a minimum wet film thickness of 0.025 inches or 25 mils. Measure, record, and certify on a Department approved form and submit to the Engineer, the thickness of white and yellow durable paint pavement markings in accordance with FM 5-541 Part A.

710-4.3 Retroreflectivity: Apply white and yellow standard paint that will attain an initial retroreflectance of not less than 300 mcd/m^2/lx and not less than 250 mcd/m^2/lx, respectively. Apply white and yellow durable paint that will attain an initial retroreflectance of not less than 450 mcd/m^2/lx and not less than 300 mcd/m^2/lx, respectively. Black pavement markings must have a retroreflectance of less than 20 mcd/m^2/lx.

Measure, record and certify on a Department approved form and submit to the Engineer, the retroreflectivity of white and yellow pavement markings in accordance with FM 5--541 Part A.

The Department reserves the right to test the markings within three days of receipt of the Contractor's certification. Failure to afford the Department opportunity to test the markings will result in non-payment. The test readings should be representative of the Contractor's pavement marking performance. If the retroreflectivity values measure below values shown above, reapply the pavement marking at no additional cost to the Department.

For standard paint, ensure that the minimum retroreflectance of white and yellow pavement markings are not less than 150 mcd/m^2/lx. If the retroreflectivity values for standard paint fall below the 150 mcd/m^2/lx value within 180 days of initial application, the pavement marking will be reapplied at the Contractor's expense. If the retroreflectivity values for durable paint fall below the initial values of 450 mcd/m^2/lx value for white and 300 mcd/m^2/lx for yellow within 180 days of initial application, the pavement marking will be reapplied at the Contractor's expense.

710-4.4 Color: Use paint material that meets the requirements of 971-1.

710-4.5 Glass Spheres: Apply glass spheres on all pavement markings immediately and uniformly following the paint application. The rate of application shall be based on the manufacturer's recommendation.

For longitudinal durable paint markings, apply a double drop of Type 1 and Type 3 glass spheres. For transverse durable paint markings, apply a single drop of Type 3 glass spheres.

The rate of application shall be based on the manufacturer's recommendation.

710-5 Tolerances in Dimensions and in Alignment.

Establish tack points at appropriate intervals for use in aligning pavement markings, and set a stringline from such points to achieve accuracy.

710-5.1 Dimensions:

710-5.1.1 Longitudinal Lines: Apply painted skip line segments with no more than plus or minus 12 inches variance, so that over-tolerance and under-tolerance lengths between skip line and the gap will approximately balance. Apply longitudinal lines at least 2 inches from construction joints of portland cement concrete pavement.

710-5.1.2 Transverse Markings, Gore Markings, Arrows, and Messages: Apply paint in multiple passes when the marking cannot be completed in one pass, with an overall line width allowable tolerance of plus or minus 1 inch.

710-5.1.3 Contrast Lines: Use black paint to provide contrast on concrete or light asphalt pavement, when specified by the Engineer. Apply black paint in 10 foot segments following each longitudinal skip line.

710-5.2 Alignment: Apply painted pavement markings that will not deviate more than 1 inch from the stringline on tangents and curves one degree or less. Apply painted pavement markings that will not deviate more than 2 inches from the stringline on curves greater than one degree. Apply painted edge markings uniformly, not less than 2 inches or more than 4 inches from the edge of pavement, without noticeable breaks or deviations in alignment or width.

Remove and replace at no additional cost to the Department, pavement markings that deviate more than the above stated requirements.

710-5.3 Correction Rates: Make corrections of variations in width at a maximum rate of 10 feet for each 0.5 inch of correction. Make corrections of variations in alignment at a maximum rate of 25 feet for each 1 inch of correction, to return to the stringline.

710-6 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the materials. At the time of notification, submit a certification to the Engineer with the APL number and the batch or Lot numbers of the paint and glass spheres to be used.

710-7 Protection of Newly Applied Pavement Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

710-8 Corrections for Deficiencies to Applied Painted Pavement Markings.

Reapply a 1.0 mile section, centered around any deficiency, at no additional cost to the Department.

710-9 Submittals.

710-9.1 Submittal Instructions: Prepare a certification of quantities, using the Department's current approved form, for each project in the Contract. Submit the certification of

quantities and daily worksheets to the Engineer. For Lump Sum pay item 710-90, document the quantity as an estimated percentage (in decimal form) of the total lump sum amount on the daily worksheet. The Department will not pay for any disputed items until the Engineer approves the certification of quantities.

710-9.2 Contractor's Certification of Quantities: Request payment by submitting a certification of quantities no later than Twelve O'clock noon Monday after the estimate cut-off date or as directed by the Engineer, based on the amount of work done or completed. Ensure the certification of quantities consists of the following:

1. Contract Number, FPID Number, Certification Number, Certification Date and the period that the certification represents.

2. The basis for arriving at the amount of the progress certification, less payments previously made and less any amount previously retained or withheld. The basis will include a detailed breakdown provided on the certification of items of payment.

710-10 Method of Measurement.

The quantities, authorized and acceptably applied, under this Section will be paid as follows:

1. The length, in gross miles, of solid, 10'-30' skip, 3'-9' dotted, 6'-10' dotted, 2'-2' dotted, and 2'-4' dotted lines.

2. The length, in linear feet, of transverse lines, diagonal lines, chevrons, and parking spaces.

3. The number of pavement messages, symbols, and arrows. Each arrow is paid as a complete marking, regardless of the number of "points" or directions.

4. Lump Sum, as specified in 710-4.1.1 (final surface) and 710-9.1.

5. The area, in square feet, for removal of existing markings acceptably removed. Payment for removal of conflicting markings will be in accordance with 102-11.20. Payment for removal of non-conflicting markings will be paid separately.

The gross mile measurement will be taken as the distance from the beginning of the painted line to the end of the painted line and will include the unmarked gaps for skip and dotted lines. The gross mile measurement will not include designated unmarked lengths at intersections, turn lanes, etc. Final measurement will be determined by plan dimensions or stations, subject to 9-1.3.1.

710-11 Basis of Payment.

710-11.1 General: Price and payment will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

710-11.2 Painted Pavement Markings (Final Surface): Price and payment for painted pavement markings (final surface) will be full compensation for all applications of painted pavement markings in accordance with 710-4.1.1 and 710-9.1.

710-11.3 Payment Items: Payment will be made under:

Item No. 710	Painted Pavement Markings.	
		Solid - per gross mile.
		Solid - per linear foot.
		Skip - per gross mile.

Dotted - per gross mile.
Message or Symbol -each.
Arrows - each.
Yield Line - per linear foot.
Island Nose – per square foot

Item No. 710- 90 Painted Pavement Markings (Final Surface) - lump sum.

SECTION 711
THERMOPLASTIC PAVEMENT MARKINGS

711-1 Description.

Apply new thermoplastic pavement markings, or refurbish existing thermoplastic pavement markings, in accordance with the Contract Documents.

711-2 Materials.

Use only materials listed on the Department's Approved Product List (APL) meeting the following requirements.

Hot-Applied Standard and Refurbishment Thermoplastic .... 971-1 and 971-5
Preformed Thermoplastic..... 971-1 and 971-6
Glass Spheres ..... 971-1 and 971-2

The Engineer will take random samples of all material in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

711-3 Equipment.

Use equipment capable of providing continuous, uniform heating of the pavement marking material to temperatures exceeding 390ºF, mixing and agitation of the material in the reservoir to provide a homogeneous mixture without segregation. Use equipment that will maintain the pavement marking material in a plastic state, in all mixing and conveying parts, including the line dispensing device until applied. Use equipment which can produce varying line widths and which meets the following requirements:

1. Capable of traveling at a uniform, predetermined rate of speed, both uphill and downhill, to produce a uniform application of pavement marking material and capable of following straight lines and making normal curves in a true arc.

2. Capable of applying glass spheres to the surface of the completed pavement marking by a double drop application for standard thermoplastic pavement markings and a single drop application for recapping and refurbishment thermoplastic pavement markings. The bead dispenser for the first bead drop shall be attached to the pavement marking machine in such a manner that the beads are dispensed closely behind the installed line. The second bead dispenser bead shall be attached to the pavement marking machine in such a manner that the beads are dispensed immediately after the first bead drop application. Use glass spheres dispensers equipped with an automatic cut-off control that is synchronized with the cut-off of the thermoplastic material and applies the glass spheres uniformly on the entire pavement markings surface with 50 to 60% embedment.

3. Equipped with a special kettle for uniformly heating and melting the pavement marking material. The kettle must be equipped with an automatic temperature control device and material thermometer for positive temperature control and to prevent overheating or scorching of the thermoplastic material.

4. Meet the requirements of the National Fire Protection Association, state, and local authorities.

711-4 Application.

711-4.1 General: Remove existing thermoplastic pavement markings using a method approved by the Engineer such that pavement surface scars or traces of the removed

thermoplastic pavement markings will not conflict with new pavement markings. Do not use paint to blackout, hide, or disguise existing pavement markings.

Before applying pavement markings, remove any material that would adversely affect the bond of the pavement markings by a method approved by the Engineer.

Before applying pavement markings to any portland cement concrete surface, apply a primer, sealer, or surface preparation adhesive of the type recommended by the manufacturer. Offset longitudinal lines at least 2 inches from any longitudinal joints of portland cement concrete pavement.

Apply thermoplastic material thickness according to 711-4.2. Application on open graded friction surfaces may require more thermoplastic material to achieve the required thickness above the pavement surface.

Apply pavement markings to dry surfaces only, and when the ambient air and surface temperature is at least 50ºF and rising for asphalt surfaces and 60°F and rising for concrete surfaces.

Apply pavement markings to the same tolerances in dimensions and in alignment specified in 710-5. When applying pavement markings over existing markings, ensure that no more than 2 inches on either end and not more than 1 inch on either side of the existing line is visible.

Apply thermoplastic material to the pavement by extrusion or other means approved by the Engineer.

When thermoplastic pavement markings are to be removed and replaced, apply new thermoplastic pavement markings prior to opening to traffic.

Conduct field tests in accordance with FM 5-541 Part A. Take test readings representative of the pavement marking performance. Remove and replace pavement markings not meeting the requirements of this Section at no additional cost to the Department.

With the exception of short-term raised rumble strips, wait at least 14 days after constructing the final asphalt surface course to place thermoplastic pavement markings. Installation of thermoplastic on concrete requires a clean, dry surface. Follow the manufacturer's recommendations for surface preparation for thermoplastic on concrete. Provide temporary pavement markings during the interim period prior to opening the road to traffic.

711-4.1.1 Preformed Thermoplastic: Apply markings to dry surfaces only and when ambient air temperature is at least 32°F. Prior to installation, follow the manufacturer's recommendations for pre-heating. For railroad dynamic envelopes, keep all equipment and personnel out of the foul area.

711-4.2 Thickness:

711-4.2.1 Hot-Applied Standard Thermoplastic Markings: Apply or recap standard thermoplastic pavement markings for longitudinal lines to attain a minimum thickness of 0.10 inch or 100 mils and a maximum thickness 0.15 inch or 150 mils when measured above the pavement surface.

Markings other than longitudinal lines, wherever located, will have a thickness of 0.09 inch or 90 mils to 0.12 inch or 120 mils when measured above the pavement surface.

Measure, record and certify on Department approved form and submit to the Engineer, the thickness of white and yellow pavement markings in accordance with FM 5-541.

The Engineer will verify the thickness of the pavement markings in accordance with FM 5-541 within 30 days of receipt of the Contractor's certification.

711-4.2.2 Hot-Applied Refurbishment Thermoplastic Markings: Apply a minimum of 0.06 inch or 60 mils of thermoplastic material. Ensure that the combination of the existing marking and the overlay after application of glass spheres does not exceed the maximum thickness of 0.150 inch or 150 mils for all lines.

Measure, record and certify on Department approved form and submit to the Engineer, the thickness of white and yellow pavement markings in accordance with FM 5-541 Part A.

The Engineer will verify the thickness of the pavement markings in accordance with FM 5-541 Part A within 30 days of receipt of the Contractor's certification.

711-4.2.3 Preformed Thermoplastic Markings: Apply 0.125 inch or 125 mils of preformed thermoplastic material.

Use preformed thermoplastic for bicycle markings, shared use path markings, 24-inch markings on special emphasis crosswalks, route shields, ramp exit numbers, railroad dynamic envelopes, white dotted lines (2'-4') with trailing black contrast, 12-inch transverse crosswalk lines with black contrast, 24-inch stop line with black contrast, and black contrast arrows, messages, and symbols.

Measure, record and certify on Department approved form and submit to the Engineer, the thickness of the pavement markings in accordance with FM 5-541 Part A.

711-4.3 Retroreflectivity:

711-4.3.1 General: Measure, record and certify on Department approved form and submit to the Engineer, the retroreflectivity of white and yellow pavement markings in accordance with FM 5--541 Part A.

711-4.3.2 Longitudinal Lines: Apply hot-applied standard and refurbishment thermoplastic pavement markings that will attain an initial retroreflectivity of not less than 450 mcd/m^2/lx and not less than 350 mcd/m^2/lx for white and yellow, respectively.

711-4.3.3 Markings Other Than Longitudinal Lines: Apply hot-applied standard and refurbishment thermoplastic markings that will attain an initial retroreflectivity of not less than 300 mcd/m^2/lx and 250 mcd/m^2/lx for white and yellow, respectively.

711-4.3.4 Preformed Markings: Apply white preformed thermoplastic markings that will attain an initial retroreflectivity of not less than 200 mcd/m^2/lx. Black pavement markings must have a retroreflectance of less than 20 mcd/m^2/lx.

711-4.4 Glass Spheres:

711-4.4.1 Longitudinal Lines: For hot-applied standard thermoplastic markings, apply the first drop of Type 4 or larger glass spheres immediately followed by the second drop of Type 1 glass spheres. For hot-applied refurbishment thermoplastic markings, apply a single drop of Type 3 glass spheres. Apply retroreflective glass spheres to all markings at the rates provided in the manufacturer's installation instructions.

711-4.4.2 Markings Other Than Longitudinal Lines: For hot-applied standard and refurbishment thermoplastic markings, apply a single drop of Type 1 glass spheres and sharp silica sand at the rates provided in the manufacturer's installation instructions. Use sharp silica sand materials meeting the requirements of 971-5.4. For hot-applied high friction thermoplastic markings, apply retroreflective and friction elements at the rates provided in the manufacturer's installation instructions.

711-4.4.3 Preformed Markings: These markings are factory supplied with glass spheres and friction elements. Apply additional glass spheres and friction elements in accordance with the manufacturer's instructions.

711-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the materials. At the time of notification, submit a certification to the Engineer with the APL number and the batch or LOT numbers of the thermoplastic and glass spheres to be used. Packaging labels that contain the information required by 971-1.1 will be accepted in place of a certification.

711-6 Protection of Newly Applied Thermoplastic Pavement Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

711-7 Observation Period.

Longitudinal pavement markings are subject to a 180 day observation period under normal traffic. The observation period shall begin with the satisfactory completion and acceptance of the work.

The longitudinal pavement markings shall show no signs of failure due to blistering, excessive cracking, chipping, discoloration, poor adhesion to the pavement, loss of retroreflectivity or vehicular damage. The retroreflectivity shall meet the initial requirements of 711-4.3. The Department reserves the right to check the retroreflectivity any time prior to the end of the observation period.

Replace, at no additional expense to the Department, any longitudinal pavement markings that do not perform satisfactorily under traffic during the 180 day observation period.

711-8 Corrections for Deficiencies.

Recapping applies to conditions where additional pavement marking material is applied to new or refurbished pavement markings to correct a thickness deficiency. Correct deficiencies by recapping or removal and reapplication of a 1 mile section centered around the deficiency, as determined by the Engineer, at no additional cost to the Department.

711-9 Method of Measurement.

711-9.1 Thermoplastic Pavement Markings: The plan quantity, acceptably applied and subject to 9-1.3.2, under this Section will be paid as follows:

1. The length, in gross miles, of solid, 10'-30' skip, 3'-9' dotted, 6'-10' dotted, 2'-2' dotted, and 2'-4' dotted lines.

2. The length, in linear feet, of transverse lines, diagonal lines, chevrons, parking spaces, special emphasis crosswalk markings, and railroad dynamic envelope markings.

3. The number of pavement messages, symbols, and arrows. Each arrow is paid as a complete marking, regardless of the number of "points" or directions.

The gross mile measurement will be taken as the distance from the beginning of the thermoplastic line to the end of the thermoplastic line and will include the unmarked gaps for skip and dotted lines. The gross mile measurement will not include designated unmarked lengths at intersections, turn lanes, etc.

711-9.2 Removal of Existing Thermoplastic Markings: The quantity for removal of existing thermoplastic pavement markings to be paid will be the area, in square feet, acceptably removed. Payment for removal of thermoplastic pavement markings will only be made for locations where the existing pavement surface is to remain.

711-10 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 711	Thermoplastic Pavement Markings
	Solid - per gross mile.
	Solid - per linear foot.
	Skip - per gross mile.
	Dotted - per gross mile.
	Message or Symbol - each.
	Arrows - each.
	Yield Line - per linear foot.
	Railroad Dynamic Envelope - per linear foot.
	Remove - per square foot.

SECTION 713
PERMANENT TAPE PAVEMENT MARKINGS

713-1 Description.

Apply permanent tape pavement markings, in accordance with the Contract Documents.

713-2 Materials.

Use only materials listed on the Department's Approved Product List (APL) meeting the following requirements:

Permanent Tape ..... 971-1 and 971-7

The Engineer will take random samples of all material in accordance with the Department's Sampling, Testing and Reporting Guide schedule.

713-3 Equipment.

Use equipment that is mobile and maneuverable to the extent that straight lines can be followed, and normal curves can be made in a true arc.

Ensure the mechanical applicator is equipped with film cut-off device and a measuring device that automatically and accumulatively measures the length of each line placed with an accuracy tolerance of plus or minus 2 percent. Tape may be placed by hand on short sections, 500 feet or less if the tolerances in dimensions and in alignment specified in 710-5 are met.

713-4 Application.

713-4.1 General: Remove existing pavement markings, such that scars or traces of removed markings will not conflict with new pavement markings by a method approved by the Engineer.

Before applying permanent tape, remove any material by a method approved by the Engineer that would adversely affect the bond of the tape.

Apply a primer, sealer or surface preparation adhesive of the type recommended by the manufacturer. Ensure the permanent tape adheres to the pavement surface.

Offset longitudinal lines at least 2 inches from construction joints on portland cement concrete pavement.

Apply permanent tape to dry surfaces only, and when the ambient air and surface temperature is at least 55ºF and rising.

Apply permanent tape to the same tolerances in dimensions and in alignment specified in 710-5.

Apply permanent tape to the pavement by means approved by the Engineer.

Conduct field testing in accordance with FM 5-541, Part A. Take test readings representative of the pavement marking performance. Remove and replace permanent tape not meeting the requirements of this Section at no additional cost to the Department.

Apply all pavement markings prior to opening the road to traffic.

713-4.2 Thickness: Apply permanent tape pavement markings that have a thickness as designated on the APL for the particular product used.

Measure, record and certify on a Department approved form and submit to the Engineer, the thickness of white and yellow pavement markings in accordance with FM 5-541, Part A.

713-4.3 Retroreflectivity: Apply white and yellow pavement markings that will attain an initial retroreflectivity of not less than 450 mcd/m^2/lx for white markings and not less than

350 mcd/m^2/lx for yellow markings. Black pavement markings must have a retroreflectance of less than 20 mcd/m^2/lx.

Measure, record and certify on Department approved form and submit to the Engineer, the retroreflectivity of white and yellow pavement markings in accordance with FM 5-541, Part A.

713-4.4 Color: Use material meeting the requirements of 971-1.

713-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the material. At the time of notification, submit the APL number and the batch or LOT numbers of tape to be used.

713-6 Protection of Newly Applied Pavement Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently bonded. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

713-7 Observation Period.

Longitudinal pavement markings are subject to a 180 day observation period under normal traffic. The observation period shall begin with the satisfactory completion and acceptance of the work.

The longitudinal pavement markings shall show no signs of failure due to blistering, excessive cracking, chipping, discoloration, poor adhesion to the pavement, loss of retroreflectivity or vehicular damage. The retroreflectivity shall meet the initial requirements of 713-4.3. The Department reserves the right to check the retroreflectivity any time prior to the end of the observation period.

Replace, at no additional expense to the Department, any longitudinal pavement markings that do not perform satisfactorily under traffic during the 180 day observation period.

713-8 Corrections for Deficiencies.

Correct all deficiencies by removal and reapplication of a one mile section centered around the deficiency, as determined by the Engineer, at no additional cost to the Department.

713-9 Method of Measurement.

713-9.1 Permanent Tape Markings: The quantities of 6 inch solid, 10'-30' skip, and 3'-9' dotted lines to be paid will be the plan quantity length, in gross miles, subject to 9-1.3.2.

The gross mile measurement will be taken as the distance from the beginning of the permanent tape line to the end of the permanent tape line and will include the unmarked gaps for skip and dotted lines. The gross mile measurement will not include designated unmarked lengths at intersections, turn lanes, etc.

713-9.2 Removal of Existing Markings: The quantity paid for removal of existing permanent tape pavement markings will be the area, in square feet, for removal of existing markings acceptably removed. Payment for removal of existing permanent tape pavement markings will only be made for locations where the existing pavement surface is to remain.

713-10 Basis of Payment.

Price and payment will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing

and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 713- 1- Permanent Tape.

Solid – per gross mile.
Skip – per gross mile.
Dotted – per gross mile.
Remove – per square foot.

SECTION 714
GREEN-COLORED PAVEMENT MARKINGS

714-1 Description.

Apply new green-colored pavement markings in accordance with the Contract Documents.

714-2 Materials.

Use materials meeting the following requirements:

Green-Colored Pavement Marking Materials ..... Section 974

*Use products on the Department's Approved Products List (APL).

714-3 Equipment.

Use equipment in accordance with the manufacturer's installation instructions.

714-4 Application.

714-4.1 General: Remove existing pavement markings using a method approved by the Engineer such that pavement surface scars or traces of the removed pavement markings will not conflict with new pavement markings. Do not use paint to blackout, hide, or disguise existing pavement markings.

For installation on new asphalt roadways, apply pavement markings a minimum of 14 days after placement of the final asphalt surface course.

Before applying pavement markings, remove any material that would adversely affect the bond of the pavement markings by a method approved by the Engineer. Follow the manufacturer's recommendations for surface preparation.

For each green-colored pavement marking location, produce and provide a video record of the pavement before and after installations. Video records with timestamp will be provided to the Department within one week after installation. Provide video files via digital media (DVD, flash drive, or other) or by online digital distribution with a minimum standard resolution of 720 x 480 and at a speed not greater than 6 feet per second. The video image shall be clear, focused, and relatively free from roll, static, or other image distortion qualities that would prevent the reviewer from evaluating the condition of the roadway surface.

714-4.2 Preformed Thermoplastic: Apply a primer, sealer, or surface preparation adhesive as recommended by the manufacturer's recommendations prior to installation. Perform mechanical blasting or abrading and subsequent surface cleaning as recommended.

Apply markings to dry surfaces only and when ambient air temperature is at least 32°F. Prior to installation, follow the manufacturer's recommendations for pre-heating. Apply 0.125 inch or 125 mils of preformed thermoplastic material. Apply skid resistant material in accordance with the manufacturer's instructions.

714-4.3 Two Reactive Component System: Install two reactive component pavement markings in accordance with manufacturer's recommendations.

Install two reactive component pavement markings in areas subject to vehicular traffic to a thickness meeting manufacturer recommended thickness requirements.

714-5 Contractor's Responsibility for Notification.

Notify the Engineer prior to the placement of the materials. At the time of notification, submit a certification to the Engineer with the Product name and the batch or Lot numbers of the preformed thermoplastic or two component reactive pavement markings to be used.

714-6 Protection of Newly Applied Pavement Markings.

Do not allow traffic onto or permit vehicles to cross newly applied pavement markings until they are sufficiently dry. Remove and replace any portion of the pavement markings damaged by passing traffic or from any other cause, at no additional cost to the Department.

714-7 Method of Measurement.

The quantity to be paid for will be the plan quantity area, in square feet, of green-colored pavement markings acceptably applied, subject to 9-1.3.2.

714-8 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including, all cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

Payment will be made under:

Item No. 714- 10- Green-Colored Pavement Markings – per square foot.

SECTION 715
HIGHWAY LIGHTING SYSTEM

715-1 Description.

Install a highway lighting system in accordance with the details shown in the Plans. Use pole assemblies as shown in the Standard Plans when standard aluminum pole assemblies or standard high mast light assemblies are required by the Contract Documents. Include in the system the light poles, bases, luminaires, drivers, cable, conduit, protective devices, and control devices; all as specified or required for the complete facility.

Obtain conventional light pole and high mast light pole assemblies from a fabrication facility that is approved in one of the following fabrication categories:

1. American Institute of Steel Construction, Highway Component Manufacturer
2. American Welding Society, Certified Welding Fabricator
3. Canadian Welding Bureau, Fusion Welding of Aluminum (W47.2)

Provide metal lighting poles, excluding high mast lighting, with internal vibration damping devices in accordance with Standard Plans, Index 715-002 in all installations on bridges, walls, and median concrete barriers.

715-2 Painting.

715-2.1 General: When required by the Contract Documents, provide painted conventional light pole assemblies. Provide products that will meet specification requirements throughout the warranty period. Meet the color requirement as specified in the Contract Documents. Provide the Engineer with two metal sample coupons, a minimum of 2 inches by 4 inches, painted concurrently and with the same paint as was used on the first LOT of any conventional aluminum light poles assemblies delivered to the jobsite. Submit sample coupons and manufacturer product data sheets to the Engineer along with the delivery of the first shipment of any painted conventional aluminum light pole assemblies delivered to the jobsite. At the time of their delivery, the sample coupons described in this paragraph must match the color of the conventional light pole assemblies to within 1ΔE measured as specified in 975-4. If the delivered sample coupons exhibit a difference in color from the conventional light pole assemblies greater than 1ΔE then the sample coupons will be considered unacceptable and no payment shall be made for the materials which the sample coupons represent. Those materials shall not be accepted by the Department until acceptable representative sample coupons in accordance with the requirements of this Section have been submitted to the Engineer.

715-2.2 Responsible Party Warranty: When the Contract Documents call for painted conventional light pole assemblies the Contractor shall designate a responsible party to accept responsibility. The responsible party designated by the Contractor must execute and submit to the Department a form, provided by the Department, prior to the first delivery to the jobsite of any painted conventional light pole assemblies stipulating that the responsible party accepts responsibility for ensuring the coating system adhesion and color retention requirements as specified in 975-4 are met for a period of five years after final acceptance in accordance with 5-11. The responsible party shall also bear the continued responsibility for performing all remedial work associated with repairs of any adhesion or color retention failure as defined in Section 975, as to which notice was provided to the responsible party within the five-year warranty period. Failure to timely designate the responsible party will result in the Contractor being the responsible party unless otherwise agreed to in writing by the Department. The

responsible party shall be either the Contractor or the supplier of the painted conventional light pole assemblies. When the responsible party is the fabricator, the responsible party shall be one of the fabricators listed on the Prequalified Painted Galvanized Steel and Aluminum Products Fabricators List. This list may be viewed on the Department's website at the following URL: https://www.fdot.gov/construction/Engineers/PaintedPoleSuppliers.shtm

Upon final acceptance of the Contract in accordance with 5-11, the Contractor's responsibility to ensure that the coating system adhesion and color retention requirements specified in 975-4 will terminate. The obligations of the responsible party set forth in this Section shall start at final acceptance of the Contract in accordance with 5-11 and continue thereafter until expiration of the five-year warranty period.

715-3 Remedial Work.

During the painting warranty period, the responsible party shall perform all painting remedial work necessary to meet the requirements of this Specification at no cost to the Department. Such remedial work shall be performed within 180 days of notification of a failure by the Department or by the determination of the Statewide Disputes Review Board. Failure to perform such remedial work within the time frame specified will result in the work being performed by other forces at the responsible party's cost.

If the responsible party is the fabricator, the fabricator will be removed from the Prequalified Painted Galvanized Steel Poles and Aluminum Products Fabricators List for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

If the responsible party is the Contractor, the Department will suspend, revoke, or deny the responsible party's certificate of qualification under the terms of Section 337.16(d)(2), Florida Statutes, for a minimum of six months or until payment in full for the correction of the deficiencies or defects has been made, whichever is longer.

715-4 Statewide Disputes Review Board.

The Statewide Disputes Review Board in effect for this Contract will resolve any and all disputes that may arise involving administration and enforcement of this Specification related to the painting remedial work performed during the warranty period. The Responsible Party and the Department acknowledge that use of the Statewide Disputes Review Board is required, and the determinations of the Statewide Disputes Review Board for disputes arising out of this Specification will be binding on both the Responsible Party and the Department, with no right of appeal by either party. Meet the requirements of 8-3.

715-5 Shop Drawings and Working Drawings.

Submit shop drawings and working drawings with descriptive specifications and engineering data for the service main, control panel enclosure, control panel main disconnect, lighting contactor, electrical panel, transformer, in-line fuse holders, surge protective devices, non-standard light poles (including brackets), luminaires, LED drivers, photo-electric cell, conduit and cable or any other item requested by the Engineer as specified in Section 5.

715-6 Materials and Equipment to be Installed.

715-6.1 General: All welds must be visually inspected for final approval by an actively certified welding inspector, qualified through the American Welding Society. Meet the materials and equipment requirements of Section 992.

715-6.2 Luminaires: Use the make and model of the luminaire(s) shown in the Plans. Luminaires other than those shown in the Plans may be substituted if the Contractor proves photometric and electrical equivalence per the approval of the lighting EOR.

Use only luminaires listed on the Department's Approved Product List (APL).

715-6.3 Criterion Designation of Materials and Equipment: Where a criterion specification is designated for any material or equipment to be installed, by the name or catalog number of a specific manufacturer, understand that such designation is intended only for the purpose of establishing the style, quality, performance characteristics, etc., and is not intended to limit the acceptability of competitive products. The Engineer will consider products of other manufacturers which are approved as similar and equal as equally acceptable.

715-7 Furnishing of Electrical Service.

Provide service point in accordance with Section 639.

715-8 Excavation and Backfilling.

715-8.1 General: For excavation and backfilling, meet the requirements of Section 125, except that when rock is encountered, carry the excavation 3 inches below the required level and refill with sand or with selected earth material, 100% of which passes the 1 inch sieve.

715-8.2 Trenches for Cable: Construct trenches for cable or conduit no less than 6 inches in width and deep enough to provide a minimum cover in accordance with the Standard Plans.

715-8.3 Placing Backfill for Cable: For installation of the cable, place an initial layer of 6 inches thick, loose measurement, sand or selected earth material, 100% of which passes a 1 inch sieve. Place and compact the remaining material in accordance with 125-8.

715-9 Foundations for Light Poles.

715-9.1 Concrete Foundations: Provide foundations for light poles of the sizes and shapes shown in the Plans. Construct precast or cast-in-place concrete foundations in accordance with the Standard Plans. Obtain precast foundations from a plant that is currently on the Department's Production Facility Listing. Producers seeking inclusion on the list shall meet the requirements of Section 105.

715-9.2 Setting Anchor Bolts: Set anchor bolts according to manufacturer's templates and adjust to a plumb line, check for elevation and location, and hold rigidly in position to prevent displacement while pouring concrete.

715-9.3 Installation: Do not erect roadway light poles or high mast light poles until the concrete strength in the cast-in-place foundation is at least 2,500 psi. Determine concrete strength from tests on a minimum of two test cylinders sampled and tested in accordance with ASTM C31 and ASTM C39 and verifying test results have been submitted to the Engineer.

Fill the voids around precast concrete foundations under roadway light poles with flowable fill meeting the requirements of Section 121 or clean sands placed using hydraulic methods to a level 6 inches below grade.

715-10 Pulling Conductors.

Leave at least 3 feet of conductor where the cable enters and leaves conduit. Protect conductors pulled into conduit or ducts against abrasion, kinking, and twisting. Locate pull boxes so that the conductors are not subjected to excessive pulling stresses.

715-11 Splicing.

Make all conductor splices in the bases of the light poles, or in pull boxes designed for the purpose. Do not make underground splices unless specifically authorized by the Engineer, and then only as directed by him.

Unless otherwise shown in the Standard Plans or authorized by the Engineer, splices shall be made with split bolt connectors. The connector shall be sealed in silicone gel that easily peels away leaving a clean connection. The gel will be contained in a closure that when snapped around the split bolt will provide a waterproof connection without the use of tools or taping. This closure will be UV resistant, impact resistant and abrasion resistant.

715-12 Conduit.

Install conduit at the locations shown in the Plans and in accordance with Section 630.

715-13 Erecting Light Poles.

715-13.1 General: Install the light poles at the locations and in accordance with the details shown in the Plans. Unless otherwise specifically approved by the Engineer, fasten bracket (truss) arms to the pole prior to erection. Erect light poles with the orientation of the access door on the opposite side of approaching traffic. Do not field weld on any part of the pole assembly. Plumb the poles after erection and use metal shims or leveling nuts if necessary to obtain precise alignment. Use a thin cement grout where necessary to eliminate unevenness or irregularities in the top of the base.

715-13.2 Adjusting Anchor Bolts and Installing Nuts on Anchor Bolts: Where poles are to be placed on existing foundations or bases with anchor bolts in place, furnish poles with a base which fits the anchor bolt spacing. Include the cost of any necessary extension of existing anchor bolts in the price bid for the lighting system. For high mast light pole bases, install nuts on anchor bolts in accordance with 649-5.

715-13.3 Installation of Luminaire: Make primary LED driver connections in accordance with manufacturer's instructions. Install sufficient cable to allow all connections to be made outside the light pole base. Connect the ground conductor to the ground stud provided.

715-13.4 Electrical Connections: Make primary ballast connections in accordance with manufacturer's instructions. Install sufficient cable to allow all connections to be made outside the light pole base. Connect the ground conductor to the ground stud provided.

715-13.5 Pole Identification Plates: Furnish and install a 2 inch by 8 inch aluminum identification plate on each light pole. Attach plates to the pole as approved by the Engineer. Attachment methods requiring screws, bolts, or rivets must be approved by the pole manufacturer. Install plates five feet above grade on the exterior traffic lane side of the pole. Use 3/4-inch black text on white or yellow background. Orient the text vertically on the plate with the following information: load center designation, circuit number, and the pole number. Number the poles as shown in the Plans.

715-13.6 Screen Installation for High Mast Light Pole Bases: Install a screen in accordance with 649-6.

715-14 Grounding.

Ground in accordance with the NEC, and local codes which exceed these Specifications.

Ground each metal light pole, not on a bridge structure, with an approved rod, 20 feet in length and at least 5/8 inch in diameter.

For poles on bridge structures, bring the grounding conductors out to a pull box at each end of the structure and connect them to driven ground rods, 20 feet in length and at least 5/8 inch in diameter.

The 20 feet length of rod may be either two rods 10 feet in length connected by a threaded coupling and driven as a single rod or two rods 10 feet in length separated by at least 6 feet.

Make all bonds between ground wires and grounding electrode assemblies or arrays with an exothermic bond with the following exception: do not exothermically bond grounding electrode to grounding electrode connections.

The work specified in this Section will not be paid for directly, but will be considered as incidental work.

Ground all high mast poles in accordance with the details for grounding in the Standard Plans, Index 715-010.

715-15 Labeling.

Stencil labels on the cases of transformer and panel board with white oil paint, as designated by the Engineer. Also, mark the correct circuit designations in accordance with the wiring diagram on the terminal marking strips of each terminal block and on the card holder in the panel board.

715-16 Tests of Installation.

Upon completion of the work, test the installation to ensure that the installation is entirely free of ground faults, short circuits, and open circuits and that it is in satisfactory working condition. Furnish all labor, materials, and apparatus necessary for making the required tests. Remove and replace any defective material or workmanship discovered as a result of these tests at no expense to the Department, and make subsequent re-tests to the satisfaction of the Engineer.

Make all arrangements with the power supplier for power. Pay all costs, excluding energy charges, required for the test period.

Not less than 48 hours prior to the beginning of the test period, give the power supplier the schedule for such test.

Test the installation under normal operating conditions during the seven-day test period specified in 715-14, rather than as a continuous burn test period.

If the work is not open to traffic at the end of the seven-day test period, de-energize the lighting system until the work is opened.

715-17 Acceptance of Highway Lighting.

715-17.1 Partial Acceptance: The Engineer may make partial acceptance of the highway lighting based on satisfactory performance of all highway lighting for seven consecutive days. The seven-day evaluation period may commence upon written authorization by the Engineer that highway lighting is considered ready for acceptance evaluation. Contract Time will be charged during the entire highway lighting evaluation period. Correct any defects in materials or workmanship which might appear during the evaluation period at no expense to the Department.

Provide a certification from the welding inspector identifying the project information, date of inspection, welding inspector name, and inspector certification number.

715-17.2 Final Acceptance: Upon acceptance of as-built drawings, transfer manufacturers' warranties to the Department upon final acceptance in accordance with 5-11. Submit all warranties and warranty transfers to the Engineer.

715-18 Method of Measurement.

The quantities to be paid for will be as follows, completed and accepted:

1. Conduit: Payment will be made in accordance with Section 630.

2. Luminaire and Truss Arm: The Contract unit price will include the truss arm, luminaire with lamp, and all necessary mounting hardware as indicated in the Plans and Standard Plans.

3. Service Point: Payment will be made in accordance with Section 639.

4. Load Center: The Contract unit price will include the enclosure, panel boards, breakers, lightning arrestor, contactors, photo electric switch, grounding, and the concrete pad as shown in the Plans and Standard Plans.

5. Luminaire: The Contract unit price will include the luminaire with lamp and necessary mounting hardware as indicated in the Plans and Standard Plans.

6. Pull Box: Payment will be made in accordance with Section 635.

7. High Mast Lighting Pole Complete: The Contract unit price will include the pole, luminaires with lamps, lowering system, breakers and anchor bolts with lock nuts and washers, and foundation as indicated in the Plans and Standard Plans.

When partial foundation removal is called for, remove the pole and foundation to a minimum depth of four feet below existing grade.

When complete foundation removal is called for, completely remove the pole and foundation.

8. Conductor: The quantity to be paid for will be the plan quantity, in feet, completed and accepted. Measurement will be based on the horizontal distance between pull boxes, or between pull boxes and luminaire poles, plus 8 feet for each conductor entering and 8 feet for each conductor leaving the pull box and 8 feet for each conductor entering the luminaire pole.

9. Lighting Pole Complete: The Contract unit price will include the pole, internal vibration damping device, truss arm, luminaire with lamp, anchor bolts with lock nuts and washers, frangible base, and foundation.

10. Pole Cable Distribution System: The Contract unit price will include the surge protector, fuse holders with fuses, waterproof connectors, and the waterproof wiring connection to the luminaires.

715-19 Basis of Payment.

Prices and payments will be full compensation for all work specified in this Section, including all materials, equipment, and tests.

DIVISION III

Materials

AGGREGATES

SECTION 901
COARSE AGGREGATE

901-1 General.

901-1.1 Composition: Coarse aggregate shall consist of naturally occurring materials such as gravel, or resulting from the crushing of parent rock, to include natural rock, slags, expanded clays and shales (lightweight aggregates) and other approved inert materials with similar characteristics, having hard, strong, durable particles, conforming to the specific requirements of this Section.

Materials substantially retained on the No. 4 sieve, shall be classified as coarse aggregate.

Approval of mineral aggregate sources shall be in accordance with 6-2.3.

901-1.2 Deleterious Substances: All coarse aggregates shall be reasonably free of clay lumps, soft and friable particles, salt, alkali, organic matter, adherent coatings, and other substances not defined which may possess undesirable characteristics. The weight of deleterious substances shall not exceed the following percentages:

Coal and lignite (AASHTO T 113)	1.00
Soft and friable particles (AASHTO T 112)*	2.00
Clay lumps (AASHTO T 112)*	2.00
Plant root matter (visual inspection in AASHTO T 27)****	0.005
Wood and wood matter (visual inspection in AASHTO T 27)****	0.005
Cinders and clinkers	0.50
Free shell**	1.00
Total Material passing the No. 200 sieve (FM 1-T011)	
At Source with Los Angeles Abrasion less than or equal to 30	2.50
At Source with Los Angeles Abrasion greater than 30	1.75
At Redistribution Terminal for Aggregates Certified for Concrete Products Only	2.50
At Point of Use	3.75
Fine-Grained Organic Matter (AASHTO 194)	0.03
Chert (less than 2.40 specific gravity SSD) (AASHTO T 113)***	3.00

* The maximum percent by weight of soft and friable particles and clay lumps together shall not exceed 3.00.

** Aggregates to be used in asphalt concrete may contain up to 5% free shell. Free shell is defined as that portion of the coarse aggregate retained on the No. 4 sieve consisting of loose, whole, or broken shell, or the external skeletal remains of other marine life, having a ratio of the maximum length of the particle to the shell wall thickness exceeding five to one. Coral, molds, or casts of other shells, and crushed clam and oyster shell indigenous to the formation will not be considered as free shell.

*** This limitation applies only to coarse aggregates in which chert appears as an impurity. It is not applicable to aggregates which are predominantly chert.

**** Plant root matter, and wood and wood matter shall be considered deleterious when any piece exceeds two inches in length or 1/2 inch in width.

The weights of deleterious substances for reclaimed Portland cement concrete aggregate shall not exceed the following percentages:

Bituminous Concrete 1.00
Bricks 1.00
Wood and other organic substances (by weight)***** 0.1
Reinforcing Steel and Welded Wire Reinforcement 0.1
Plaster and gypsum board 0.1
Joint Fillers.....0.1

***** Supersedes requirement for other coarse aggregate

901-1.3 Physical Properties: Coarse aggregates shall meet the following physical property requirements, except as noted herein:

Los Angeles Abrasion (FM 1-T096).....maximum loss 45%
Soundness (Sodium Sulfate) AASHTO T 104 .....
.....maximum loss 12%*
Flat or elongated pieces** .....maximum 10%

* For source approval - aggregates exceeding soundness loss limitations will be rejected unless performance history shows that the material will not be detrimental for portland cement concrete or other intended usages.

** A flat or elongated particle is defined as one having a ratio between the maximum and the minimum dimensions of a circumscribing prism exceeding five to one.

901-1.4 Gradation: Coarse aggregates shall conform to the gradation requirements of Table 901-1, when the stone size is specified. However, Table 901-1 is waived for those aggregates intended for usage in bituminous mixtures, provided the material is graded on sieves specified in production requirements contained in 6-2.3, and meets uniformity and bituminous design requirements.

Table 901-1 Standard Sizes of Coarse Aggregate								
Amounts Finer than Each Laboratory Sieve (Square Openings), weight percent								
Size No.	Nominal Size Square Openings	4 inches	3-1/2 inches	3 inches	2-1/2 inches	2 inches	1-1/2 inches	1 inch
1	3-1/2 to 1-1/2 inches	100	90 to 100	-	25 to 60	-	0 to 15	-
2	2-1/2 inches to 1-1/2 inches	-	-	100	90 to 100	35 to 70	0 to 15	-
24	2-1/2 inches to 3/4 inch	-	-	100	90 to 100	-	25 to 60	-
3	2 inches to 1 inch	-	-	-	100	90 to 100	35 to 70	0 to 15
357	2 inches to No. 4	-	-	-	100	95 to 100	-	35 to 70
4	1-1/2 inches to 3/4 inch	-	-	-	-	100	90 to 100	20 to 55
467	1-1/2 inches to No. 4	-	-	-	-	100	95 to 100	-
5	1 inch to 1/2 inch	-	-	-	-	-	100	90 to 100
56	1 inch to 3/8 inch	-	-	-	-	-	100	90 to 100
57	1 inch to No. 4	-	-	-	-	-	100	95 to 100
6	3/4 inch to 3/8 inch	-	-	-	-	-	-	100
67	3/4 inch to No. 4	-	-	-	-	-	-	100
68	3/4 inch to No. 8	-	-	-	-	-	-	-
7	1/2 inch to No. 4	-	-	-	-	-	-	-
78	1/2 inch to No. 8	-	-	-	-	-	-	-
8	3/8 inch to No. 8	-	-	-	-	-	-	-
89	3/8 inch to No. 16	-	-	-	-	-	-	-
9	No. 4 to No. 16	-	-	-	-	-	-	-
10	No. 4 to 0	-	-	-	-	-	-	-

Table 901-1 (Continued) Standard Sizes of Coarse Aggregate								
Amounts Finer than Each Laboratory Sieve (Square Openings), weight percent								
Size No.	Nominal Size Square Openings	3/4 inch	1/2 inch	3/8 inch	No. 4	No. 8	No. 16	No. 50
1	3-1/2 inches to 1-1/2 inches	0 to 5						
2	2-1/2 inches to 1-1/2 inches	0 to 5						
24	2-1/2 inches to 3/4 inch	0 to 10	0 to 5					
3	2 inches to 1 inch	-	0 to 5					
357	2 inches to No. 4	-	10 to 30	-	0 to 5			
4	1-1/2 inches to 3/4 inch	0 to 15	-	0 to 5				
467	1-1/2 inches to No. 4	35 to 70	-	10 to 30	0 to 5			
5	1 inch to 1/2 inch	20 to 55	0 to 10	0 to 5				
56	1 inch to 3/8 inch	40 to 85	10 to 40	0 to 15	0 to 5			
57	1 inch to No. 4	-	25 to 60	-	0 to 10	0 to 5		
6	3/4 inch to 3/8 inch	90 to 100	20 to 55	0 to 15	0 to 5			
67	3/4 inch to No. 4	90 to 100	-	20 to 55	0 to 10	0 to 5		
68	3/4 inch to No. 8	90 to 100	-	30 to 65	5 to 25	0 to 10	0 to 5	
7	1/2 inch to No. 4	100	90 to 100	40 to 70	0 to 15	0 to 5		
78	1/2 inch to No. 8	100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5	
8	3/8 inch to No. 8	-	100	85 to 100	10 to 30	0 to 10	0 to 5	
89	3/8 inch to No. 16	-	100	90 to 100	20 to 55	0 to 30	0 to 10	0 to 5
9	No. 4 to No. 16	-	-	100	85 to 100	10 to 40	0 to 10	0 to 5
10	No. 4 to 0	-	-	100	85 to 100	-	-	-

The gradations in Table 901-1 represent the extreme limits for the various sizes indicated which will be used in determining the suitability for use of coarse aggregate from all sources of supply. For any grade from any one source, the gradation shall be held reasonably uniform and not subject to the extreme percentages of gradation specified above.

901-2 Natural Stones.

Coarse aggregate may be processed from gravels, granites, limestones, dolomite, sandstones, or other naturally occurring hard, sound, durable materials meeting the requirements of this Section.

901-2.1 Gravels: Gravel shall be composed of naturally occurring quartz, free from deleterious coatings of any kind. The minimum dry-rodded weight AASHTO T 19 shall be 95 pounds per cubic foot.

Crushed gravel shall consist of a minimum of 85%, by weight, of the material retained on the No. 4 sieve, having at least three fractured faces.

901-2.2 Granites: Coarse aggregate produced from the crushing of granites shall be sound and durable. For granites to be used in bituminous mixtures and surface treatments, the Los Angeles Abrasion requirement of 901-1.3 is modified to permit a maximum loss up to 50 (FM 1-T096). Maximum amount of mica schist permitted is 5% (FM 5-584).

901-2.3 Limestones, Dolomite and Sandstone: Coarse aggregates may be produced from limestone, dolomite, sandstones, and other naturally occurring hard, durable materials meeting the requirements of this Section. When used as a friction course, crushed limestone shall have a minimum acid insoluble content of 12% (FM 5-510). Other materials must meet the approval requirements for friction course determined by Rule 14-103.005(1), Florida Administrative Code (FAC).

Pre-Cenozoic limestones and dolomite shall not be used as coarse crushed stone aggregates for asphalt concrete friction courses, or any other asphalt concrete mixture or surface treatment serving as the final wearing course. This specifically includes materials from the Ketone Dolomite (Cambrian) Newala Limestone (Mississippian) geologic formations in Northern Alabama and Georgia.

901-2.4 Cemented Coquina Rock: For cemented coquina rock to be used in bituminous mixtures, the Los Angeles Abrasion requirement of 901-1.3 is modified to permit a maximum loss up to 50 (FM 1-T 096) provided that the amount of material finer than No. 200 generated during the Los Angeles Abrasion test is less than 18%.

901-3 Manufactured Stones.

901-3.1 Slags: Coarse aggregate may be produced from molten nonmetallic by-products consisting essentially of silicates and aluminosilicates of calcium and other bases, such as air-cooled blast-furnace slag or phosphate slag, provided it is reasonably uniform in density and quality, and reasonably free from deleterious substances as specified in 901-1.2. In addition, it must meet the following specific requirements:

Sulphur content ..... not more than 1.5%
Dry rodded weight AASHTO T 19 ..... minimum 70 lb/ft^3
Glassy Particles ..... not more than 10%

Slag shall not be used as an aggregate for Portland cement concrete.

For air-cooled blast furnace slag, the Los Angeles Abrasion requirement of 901-1.3 is modified to permit a maximum loss up to 50 (FM 1-T096) provided that the amount of material finer than No. 200 sieve generated during the Los Angeles Abrasion test is less than 18%.

901-4 Lightweight Aggregates.

901-4.1 Lightweight Coarse Aggregate for Bituminous Construction: Lightweight coarse aggregate may be produced from naturally occurring materials such as pumice, scoria and

tuff or from expanded clay, shale or slate fired in a rotary kiln. It shall be reasonably uniform in quality and density, and free of deleterious substances as specified in 901-1.2, except that the term cinders and clinkers shall apply to those particles clearly foreign to the extended aggregate in question.

In addition, it must meet the following specific requirements:

Material passing the No. 200 Sieve
.....maximum 3.00%, (FM 1-T011)
Dry loose weight (AASHTO T 19)*..... 33-55 lb/ft^3
Los Angeles Abrasion (FM 1-T096). maximum 35%
Ferric Oxide (ASTM C641)..... maximum 1.5 mg

* Source shall maintain dry-loose unit weight within plus or minus 6% of Quality Control average. Point of use dry-loose unit weight shall be within plus or minus 10% of Source Quality Control average.

901-4.2 Lightweight Coarse Aggregate for Structural Concrete: The requirements of 901-4.1 are modified as follows:

Aggregates shall not be produced from pumice and scoria.

Los Angeles Abrasion (FM 1-T096, Section 12) shall be 45%, maximum.

Gradation shall meet the requirements of AASHTO M 195 for 3/4 inch, 1/2 inch and 3/8 inch.

901-5 Recycled Concrete Aggregate (RCA).

RCA shall be crushed and processed to provide a clean, hard, durable aggregate having a uniform gradation free from adherent coatings.

RCA can be used as coarse aggregate in pipe backfill under wet conditions, underdrain aggregate, or concrete meeting the requirements of Section 347. RCA can only be used in bituminous mixtures if the RCA originated from a concrete mix which was produced and placed in accordance with Section 346. RCA shall be asbestos free.

The Contractor's (Producer's) crushing operation shall produce an aggregate meeting the applicable gradation requirements. The physical property requirements of 901-1.3 for soundness shall not apply and the maximum loss as determined by the Los Angeles Abrasion (FM 1-T096) is changed to 50.

The sources of reclaimed portland cement concrete will be treated as a mine and subject to the requirements of Section 6 and Section 105.

901-6 Exceptions, Additions and Restrictions.

Pertinent specification modifications, based on material usage, will be found in other Sections of the specifications.

SECTION 902
FINE AGGREGATE

902-1 General.

902-1.1 Composition: Fine aggregate shall consist of natural silica sand, screenings, local materials, or subject to approval, other inert materials with similar characteristics, or combination thereof, having hard, strong, durable particles, conforming to the specific requirements of this Section.

Approval of construction aggregate sources shall be in accordance with 6-2.3.

902-1.2 Deleterious Substances: All fine aggregate shall be reasonably free of lumps of clay, soft or flaky particles, salt, alkali, organic matter, loam or other extraneous substances. The weight of deleterious substances shall not exceed the following percentages:

Shale.....1.0
Coal and lignite.....1.0
Cinders and clinkers.....0.5
Clay Lumps.....1.0

902-2 Silica Sand.

902-2.1 Composition: Silica sand shall be composed only of naturally occurring hard, strong, durable, uncoated grains of quartz, reasonably graded from coarse to fine, meeting the following requirements, in percent total weight.

Table 902-1

Sieve Opening Size	Percent Retained	Percent Passing
No. 4	0 to 5%	95 to 100%
No. 8	0 to 15%	85 to 100%
No. 16	3 to 35%	65 to 97%
No. 30	30 to 75%	25 to 70%
No. 50	65 to 95%	5 to 35%
No. 100	93 to 100%	0 to 7%
No. 200	minimum 96%	maximum 4%

Silica sand from any one source, having a variation in Fineness Modulus greater than 0.20 either way from the Fineness Modulus of target gradations established by the producer, may be rejected.

902-2.2 Organic Impurities: Silica sand shall be subject to the colorimetric test for organic impurities. If the color produced is darker than the standard solution, the aggregate shall be rejected unless it can be shown by appropriate tests that the impurities causing the color are not of a type that would be detrimental to portland cement concrete. Such tests shall be in accordance with AASHTO T 21 and AASHTO T 71. When tested for the effect of organic impurities on strength of mortar, the strength ratio at seven and 28 days, calculated in accordance with Section 11 of AASHTO T 71, shall not be less than 95%.

902-3 Sands for Miscellaneous Uses.

902-3.1 Anchor Bolts and Pipe Joints: Sand for setting anchor bolts, pipe joints or other similar uses shall meet the quality requirements of 902-2, except that gradation requirements are waived.

902-3.2 Brick Masonry: Sand for brick masonry shall meet the quality requirements of 902-2, except for gradation requirements. All the materials shall pass the No. 8 sieve, and be well graded from coarse to fine.

902-3.3 Sand-Cement Riprap: Sand for sand-cement riprap shall meet the quality requirements of 902-2, except for gradation requirements. The material shall meet the following gradation limits:

Table 902-2	
Sieve Size	Percent Passing
No. 4	minimum 97%
No. 100	maximum 20%
No. 200	maximum 5%

902-4 Filter Material for Underdrains.

Silica sand for use as filter material for Types I through IV underdrains shall meet the requirements of 902-2, except that the requirements of 902-1.2 and 902-2.2 shall not apply. The aggregate shall be reasonably free of organic matter and other deleterious materials. The gradation requirements of 902-2.1 shall apply except no more than 2% shall pass the No. 200 sieve.

Filter material for Type V underdrain shall meet the above requirements except that there shall be no more than 1% of silt, clay and organic matter, that the aggregate shall have a Uniformity Coefficient of 1.5 or greater, and that 10% diameter shall be No. 70 to 35 sieve. The Uniformity Coefficient shall be determined by the ratio D60 divided by D10, where D60 and D10 refer to the particle diameter corresponding to 60% and 10% of the material which is finer by dry weight.

902-5 Screenings.

902-5.1 Composition: Screenings shall be composed of hard, durable particles, either naturally occurring, such as gravel screenings, or resulting from the crushing or processing of the parent rock, to include natural rock, slags, expanded clays or shales (lightweight aggregates), or other approved inert materials with similar characteristics.

Aggregates classified as screening shall conform to the following gradation requirements:

Table 902-3	
Sieve Size	Percent Passing
3/8 in.	100%
No.4	75 to 100%

902-5.2 Specific Requirements:

902-5.2.1 Screenings from Department Approved Sources of Coarse Aggregate: Processed screenings from fully approved sources of coarse aggregate are subject to

gradation. Should coarse aggregate source approval status change, or unsatisfactory in-service history develop, additional control requirements may be implemented.

Screenings for use in hot bituminous mixture may consist of screenings from the processing of reclaimed portland cement concrete pavement to produce coarse aggregate.

902-5.2.2 Screenings from Other Sources: Screenings, from sources other than Department Approved Sources of Coarse Aggregate, must meet the following additional general requirements:

Modified Los Angeles Abrasion: 95% statistical probability of meeting maximum loss of 23%.

Specific Gravity*
Absorption*
Soundness*
Sulfur*
Phosphate*
Extraneous Substances*

*Specific specification requirements based on material usage found in appropriate Bituminous or Portland Cement Sections.

Based on specific material characteristics, processing techniques and in-service history on Department projects, specific source requirements may be assigned.

902-5.2.3 Screenings for Use in Portland Cement Concrete: Screenings produced from either the Miami Oolite, Miami Ft. Thompson, or Loxahatchee Ft. Thompson Formations may be substituted for silica sand for use in concretes, except for concrete pavements, approach slabs, bridge decks and precast superstructure segments. (However, screenings will be permitted in the concrete when the bridge deck or approach slab is to be covered with an asphalt concrete surface course.)

These screenings must meet the gradation requirements of AASHTO M 6, Section 6.1, as well as the maximum percent passing the No. 200 sieve, Fineness Modulus, and Organic requirements of 902-2 Silica Sand. In addition, the saturated, surface dry specific gravity shall be at least 2.48.

902-6 Local Materials.

Local materials shall be composed of hard, strong, durable particles, either naturally occurring, such as natural sands, or resulting from the crushing or processing of parent rock, to include natural sand and rock, slags, expanded clays or shales (lightweight aggregate), or other approved inert materials with similar characteristics.

Aggregates classified as local material shall conform to the following gradation requirements:

Table 902-4	
Sieve Size	Percent Passing
3/8 in.	100%
No. 10	85 to 100%
No. 200	maximum 15%

In addition to meeting the requirements of 902-1.2, the material shall not contain excessive quantities of other deleterious substances, such as roots, cans, debris, etc. If clay size material is present, it shall not exceed 7%, as determined by AASHTO T 88, and it shall be of a type which will not produce clay balls when used. The aggregate must be suitable for designated use, as determined by laboratory tests. If the deposit consists of stratified layers of varying characteristics and gradation, the producer shall employ such means as necessary to secure a uniform material.

Local materials will not be required to be produced under the requirements of 6-2.3, provided they can meet the above requirements.

902-7 Lightweight Fine Aggregate for Internal Curing.

Fine lightweight aggregate suitable for internal curing shall meet the requirements of ASTM C1761.

902-8 Exceptions, Additions and Restrictions.

Other specification modifications, based on material usage may be found in the appropriate sections of the Specifications.

SECTION 911
BASE AND STABILIZED BASE MATERIALS

911-1 Description.

This Section governs materials to be used in the construction of base and subgrade stabilization including limerock, shell, shell-rock, cemented coquina shell, and recycled concrete aggregate (RCA).

911-2 Materials.

911-2.1 General:

911-2.1.1 Approval of Material: Approval of mineral aggregate sources shall be in accordance with 6-2.3.

911-2.1.2 Deleterious Substances: Materials shall not contain deleterious substances that would result in: prevention of the bituminous prime coat from adhering to the base course; a detriment to the finishing, strength, or performance of the base; or a surface which is susceptible to distortion under construction traffic. Such substances include, but are not limited to: cherty or other extremely hard pieces, lumps, balls or pockets of sand or clay size material, organic matter, loose sand, loose, free shells, corals or skeletal remain of other marine invertebrates retained on the No. 4 sieve, or water sensitive clay minerals.

911-2.2 Limerock Composition: Limerock material shall consist of unconsolidated or partly consolidated limestone of marine origin.

911-2.3 Shell Material: Composition: Shell materials shall consist of naturally occurring deposits formed essentially of broken mollusk shell, corals and the skeletal remains of other marine invertebrates. Live or steamed shell, or man-made deposits as a by-product of the shellfish industry will not be permitted.

911-2.3.1 Bank Run Shell: Shell materials meeting the requirements of this Section which are presently found as “dry land” deposits.

911-2.3.2 Dredged Shell: Shell materials meeting the requirements of this Section which are dredged from ocean, bay or lake deposits.

911-2.4 Shell-Rock Material Composition: Shell-rock materials shall consist of naturally occurring heterogeneous deposits of limestone with interbedded layers or lenses of loose and cemented shell, to include cemented sands (calcitic sandstone). This material shall be mined and processed in a manner that will result in a reasonably homogenous finished product.

911-2.5 Cemented Coquina Shell Material Composition: Cemented coquina shell materials to be used as cemented coquina base or stabilized base, shall be defined as naturally occurring deposits formed essentially of broken mollusk shell, corals and the skeletal remains of other marine invertebrates, which are presently found as “dry land” deposits and which have been cemented together by carbonates or other natural cementing agents.

911-2.6 Recycled Concrete Aggregate (RCA) Composition: RCA shall consist of concrete material derived from the crushing of hard portland cement concrete. In addition to the deleterious materials noted in 911-2.1.2, RCA shall be asbestos free. The following limits shall not be exceeded:

Bituminous Concrete ..... 1% by weight
Bricks ..... 1% by weight
Glass and Ceramics ..... 1% by weight
Wood and other organic substances ..... 0.1% by weight
Reinforcing steel and welded wire fabric .... 0.1% by weight
Plaster and gypsum board ..... 0.1% by weight

911-3 Material Requirements.

911-3.1 Limerock Bearing Ratio (LBR): Materials shall meet the requirements in Table 911-1 in accordance with FM 5-515:

Table 911-1 Limerock Bearing Ratio (LBR)	
Material	Requirement
Limerock	Average Results per LOT - 100, minimum Individual Results - 90, minimum
Shell	
Shell-Rock	
Cemented Coquina Shell	
RCA	Individual Results - 150, minimum

911-3.2 Liquid Limit and Plasticity: Materials shall meet the requirements in Table 911-2 in accordance with AASHTO T 89 and AASHTO T 90:

Table 911-2 Liquid Limit and Plastic Properties			
Material		Liquid Limit	Plastic Properties
Limerock	Base	Not to exceed 35	Non-Plastic (NP)
	Stabilized Base		Plasticity not to exceed 10
Shell		-	NP
Shell-Rock			
Cemented Coquina Shell		-	NP
RCA		-	NP

911-3.3 Carbonates: Materials shall meet the carbonate requirements in Table 911-3 in accordance with FM 5-514:

Table 911-3 Percentage of Carbonates (Calcium and Magnesium)	
Material	Requirement
Limerock	minimum - 70%
Shell	minimum - 50%
Shell-Rock	minimum - 50%
Cemented Coquina Shell	minimum - 50%
RCA	Not Applicable

911-3.4 Gradation and Size Requirements: Materials shall meet the gradation and size requirements in Table 911-4 in accordance with FM 1-T27 and FM 1-T11:

Table 911-4[1] Gradation Requirements			
Material		Requirement	
Limerock	Base	At least 97% shall pass a 3-1/2 inch sieve[2]	
	Stabilized Base	At least 97% shall pass a 1-1/2 inch sieve[2]	
Shell	Dredged shell	Passing 3-1/2 inch sieve - 97% Passing No. 4 sieve - 50%, maximum Passing No. 200 sieve - maximum 7.5% (washed)	
	Bank-run shell	Passing 3-1/2 inch sieve - 97% Passing No. 4 sieve - 80%, maximum Passing No. 200 sieve - 20%, maximum (washed)	
Shell-Rock		Passing 3-1/2 inch sieve - 97%, minimum Passing No. 4 sieve - 70%, maximum Passing No. 200 sieve - 20%, maximum (washed)	
Cemented Coquina Shell			
RCA		Sieve Size	Percent by Weight Passing
		2 inch	100
		3/4 inch	65 to 95
		3/8 inch	40 to 85
		No. 4	25 to 65
		No. 10	20 to 50
		No. 50	5 to 30
		No. 200	0 to 10
(1) The maximum dimension shall not exceed six inches. (2) The material shall be well graded down to dust. The fine material shall consist entirely of dust of fracture.			

911-4 Exceptions, Additions, and Restrictions.

Approved materials shall not be mixed with other approved or non-approved materials.

SECTION 914
STABILIZATION MATERIALS

914-1 General.

This Section governs materials to be used in subgrade stabilization. Meet the following requirements:

Table 914-1	
Plasticity Index (AASHTO T 90)	Maximum 10
Liquid Limit (AASHTO T 89)	Maximum 40
Passing a 3-1/2 inch screen (AASHTO T 27)	Minimum 97%
LBR	No Requirement

914-2 Materials for Stabilizing (Limerock Bearing Ratio-LBR).

914-2.1 Commercial Materials: Materials may be either limerock, shell rock, cemented coquina or shell base sources approved in accordance with 6-2.3.

914-2.2 Local Materials: Local materials used for stabilizing may be soils or recyclable materials such as crushed concrete, roof tiles and asphalt coated base, reclaimed asphalt pavement (RAP) or Fossil Fuel Combustion Products (FFCPs) provided the following limits for organic content are met.

Table 914-2	
Average Organic Content* (FM 1-T267)	Maximum 2.5%
Individual Organic Content Sample (FM 1-T267)	Maximum 4%
*Note: A minimum of three samples per source.	

FFCPs may be used provided they meet the requirements of 403.7047, F.S., are not used outside the paved area and are not less than 3 feet above the design high groundwater table. All materials for stabilizing must meet all applicable air or water quality standards or criteria in Florida Department of Environmental Protection (FDEP) rules.

SECTION 916
BITUMINOUS MATERIALS

916-1 General.

All products supplied under this Specification shall be one of the products included on the Approved Product List (APL). Producers seeking evaluation of a product for inclusion on the APL shall submit an application in accordance with Section 6.

Any marked variation from the original test values for a material below the established limits or evidence of inadequate quality control or field performance of a material will be considered sufficient evidence that the properties of the material have changed, and the material will be removed from the APL.

916-2 Superpave PG Asphalt Binder.

916-2.1 Requirements: Superpave Performance Graded (PG) asphalt binders, identified as PG 52-28, PG 58-22, PG 67-22, polymer modified asphalt (PMA) binders, PG 76-22 (PMA) and High Polymer, and asphalt rubber binders (ARB), PG 76-22 (ARB), shall meet the requirements of 916-2 and AASHTO M 332. When the Contract Documents specify either a PG 76-22 (PMA), PG 76-22 (ARB), or PG 76-22 binder, either binder can be used interchangeably at no additional cost to the Department. All PG asphalt binders shall meet the following additional requirements:

1. The intermediate test temperature at 10 rad/sec. for the Dynamic Shear Rheometer (DSR) test (AASHTO T 315) shall be 26.5ºC for PG grades PG 67 and higher.
2. An additional high temperature grade of PG 67 is added for which the high test temperature at 10 rad/sec for the DSR test (AASHTO T 315) shall be 67ºC.
3. All PG asphalt binders having a high temperature designation of PG 67 or lower shall be prepared without modification.
4. All PMA binders having a high temperature designation higher than PG 67 shall only be produced with a styrene-butadiene-styrene (SBS) or styrene-butadiene (SB) elastomeric polymer modifier and the resultant binder shall meet all requirements of this Section.
5. Polyphosphoric acid may be used as a modifier not exceeding 0.75% by weight of asphalt binder for PG 76-22 (PMA) and PG 76-22 (ARB) binders. Polyphosphoric acid may not be used in High Polymer binder.
6. PG 76-22 (ARB) shall meet the additional requirements of 916-2.1.1.
7. All PG asphalt binders having a high temperature designation of PG 67 or lower shall not have a high temperature true grade more than 5.9°C higher than the specified PG grade, (for example, if a PG 58-22 is specified, do not supply a PG 64-22 or higher).
8. The use of waste oil is prohibited in the modification of any PG binder grade. Waste oil shall be defined as recycled oil products that have not been processed through a vacuum tower and have an initial boiling point of 385°C (725°F) or lower when tested in accordance with ASTM D6352.
9. Re-refined engine oil bottoms (REOB)/vacuum tower asphalt extenders (VTAE) may be used as a modifier not exceeding 8.0% by weight of asphalt binder. REOB/VTAE are materials as defined in Asphalt Institute document IS-235.

For all PG binder used in all hot mix asphalt, silicone may be added to the PG binder at the rate of 25 cubic centimeters of silicone mixed to each 5,000 gallons of PG binder. If a disbursing fluid is used in conjunction with the silicone, the resultant mixture containing the full

25 cubic centimeters of silicone shall be added in accordance with the manufacturer's recommendation. The blending of the silicone with the PG binder shall be done by the supplier prior to the shipment. When the asphalt binder will be used with a foaming warm mix technology, refer to the technology supplier's guidance on the addition of silicone.

Where an anti-strip additive is required, the anti-strip additive shall meet the requirements of 916-4. The anti-strip additive shall be introduced into the PG binder by the supplier during loading.

916-2.1.1 Additional Requirements for PG 76-22 (ARB): The following additional requirements apply only to PG 76-22 (ARB):

1. The asphalt binder shall contain a minimum of 7.0% ground tire rubber (GTR) by weight of asphalt binder.
2. The GTR shall meet the requirements of Section 919.
3. Polymer modification is optional for PG 76-22 (ARB).

916-2.1.2 High Polymer Binder Blending: Existing high polymer binder may be blended in an asphalt producer's storage tank to make a PG 76-22 binder provided the following requirements are met:

1. Notify the State Materials Office (SMO) and the local District Materials Office prior to blending.
2. Follow the blending instructions of the high polymer binder supplier.
3. Submit a sample of the blended binder to a SMO approved laboratory for testing. Provide test results to the SMO.
4. Use the newly blended binder only after approval from the SMO.

916-2.2 Compliance with Materials Manual: Producers of Superpave PG binders shall meet the requirements of Section 3.5, Volume II of the Department's Material Manual, which may be viewed at the following URL: https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section35V2.shtm.

916-2.3 Reporting: Specification compliance testing results shall be reported for the tests in Table 916-1 below, unless noted otherwise. Quality control (QC) testing results shall be reported for original binder DSR (G/sin δ and phase angle, as applicable).

Table 916-1 SUPERPAVE PG ASPHALT BINDER		
Test and Method	Conditions	Specification Minimum/Maximum Value
Superpave PG Asphalt Binder Grade		Report
APL Number		Report
Modifier (name and type)	Polymer, Ground Tire Rubber with Approved Product List (APL) number, Sulfur, PPA, REOB, and any Rejuvenating Agents	Report
Original Binder		
Solubility, AASHTO T 44	in Trichloroethylene	Minimum 99.0% (Not applicable for PG 76-22 (ARB))
Flash Point, AASHTO T 48	Cleveland Open Cup	Minimum 450ºF
Rotational Viscosity, AASHTO T 316	275ºF	Maximum 3 Pa·s[(a)]
Dynamic Shear Rheometer [(b)], AASHTO T 315	$G^*/\sin\delta$	Minimum 1.00 kPa
	Phase Angle, δ[(c)] PG 76-22 (PMA) and PG 76-22 (ARB)[(d)]	Maximum 75 degrees
Separation Test, ASTM D7173 and Softening Point, AASHTO T 53	163±5°C 48 hours	Maximum 15°F (PG 76-22 (ARB) only)
Rolling Thin Film Oven Test Residue (AASHTO T 240)		
Rolling Thin Film Oven, AASHTO T 240	Mass Change %	Maximum 1.00
Multiple Stress Creep Recovery, $J_{nr,\ 3.2}$ AASHTO T 350	Grade Temperature (Unmodified binders only)	"S" = 4.50 kPa^{-1} max
Multiple Stress Creep Recovery, $J_{nr,\ 3.2}$[(d, e, f)] AASHTO T 350	67°C (Modified binders only) 76°C (High Polymer binder only)	"V" = 1.00 kPa^{-1} max Maximum $J_{nr,diff}$ = 75% 0.10 kPa^{-1} max
Multiple Stress Creep Recovery, %Recovery[(d, e)] AASHTO T 350	67°C (Modified binders only) 76°C (High Polymer binder only)	$\%R_{3.2} \geq 29.371\ (J_{nr,\ 3.2})^{-0.2633}$ $\%R_{3.2} \geq 90.0$

Table 916-1 SUPERPAVE PG ASPHALT BINDER		
Pressure Aging Vessel Residue (AASHTO R 28)		
Dynamic Shear Rheometer, AASHTO T 315	$G^*\sin\delta$, 10 rad/sec.	Maximum 6,000 kPa [g,h]
Creep Stiffness, AASHTO T 313	S (Stiffness), @ 60 sec. m-value, @ 60 sec.	Maximum 300 MPa Minimum 0.300
ΔTc, ASTM D7643	20 hours PAV aging S (Stiffness), @ 60 sec. m-value, @ 60 sec.	ΔTc ≥ -5.0°C

(a) Binders with values higher than 3 Pa·s should be used with caution and only after consulting with the supplier as to any special handling procedures, including pumping capabilities.
(b) Dynamic Shear Rheometer (AASHTO T 315) shall be performed on original binders for the purposes of QC testing only. The original binder G*/sin δ shall be performed at grade temperature. Grade temperature for High Polymer binder is 76°C.
(c) The original binder phase angle (AASHTO T 315) shall be performed at grade temperature.
(d) AASHTO T 315 and AASHTO T 350 will be performed at a 2-mm gap for PG 76-22 (ARB).
(e) All binders with a high temperature designation >67 will be tested at 67°C. PG 76-22 (PMA) and PG 76-22 (ARB) shall pass a "V" grade per AASHTO M 332.
(f) A maximum Jnr diff = 75% does not apply for any Jnr value ≤ 0.50 kPa-1.
(g) For 5000 kPa ≤ G*sin δ ≤6,000 kPa, the phase angle, δ, shall be a minimum of 42°.
(h) For PG 67 or higher grades, perform the PAV residue testing at 26.5°C.

916-3 Asphalt Emulsions.

916-3.1 Compliance with Materials Manual: Producers of asphalt emulsions shall meet the requirements of Section 3.4, Volume II of the Department's Material Manual, which may be viewed at the following URL:
https://www.fdot.gov/programmanagement/Implemented/URLinSpecs/Section34V2.shtm.

916-3.2 Requirements: Use a prime coat meeting the requirements of AASHTO M 140 for anionic emulsions, AASHTO M 208 or AASHTO M 316 for cationic emulsions, or as specified in the Producer's QC Plan. For anionic emulsions, the cement mixing test will be waived. For tack products, the minimum testing requirements shall include percent residue, naphtha content (as needed), one-day storage stability, sieve test, Saybolt Furol viscosity, original DSR, re-emulsification (FM 5-624), and solubility (on an annual basis). Residue testing shall be performed on residue obtained from distillation, AASHTO T 59 or low-temperature evaporation (AASHTO R 78).

At the direction of the Engineer, sample tack from the distributor used on the project at a minimum frequency of once per project per product. The sample shall be tested by the Department for the following specified material properties: percent residue, contaminants, and the residue property G*/sin δ. Should any of the test results fail the specification requirements, the tack material will be considered defective and shall not to be used on Department projects unless waived by the Engineer. Should a tack sample fail specifications, the Engineer may require three 6-inch diameter roadway cores be obtained from the day of production from which the tack sample was obtained. The roadway cores shall be tested for bond strength in accordance with FM 5-599. Individual bond strength results less than 80 psi will require removal and replacement. Failing bond strength results may result in bond strength testing for additional areas represented by the failing tack material.

916-4 Liquid Anti-strip Agents.

916-4.1 Requirements: Liquid anti-strip agents shall be tested by the Department in accordance with FM 1-T 283. A minimum tensile strength ratio of 0.80 must be obtained when testing the liquid anti-strip with various aggregate sources and two nominal maximum aggregate size mixtures for approval to be placed on the APL.

916-4.2 Mix Design Verification: Particular aggregate sources may require moisture susceptibility testing per FM 1-T283 for each mix design. Results from this testing may meet the Department's requirement of minimum tensile strength ratio of 0.80 or may indicate the need for a larger dosage rate of anti-strip agent (up to 0.75% maximum) or may require a different anti-strip agent to meet the specification requirements.

SECTION 917
MINERAL FILLER

917-1 Composition.

Mineral filler shall consist, in general, of limerock dust, portland cement, slag dust, hydrated lime, or any other inert mineral matter from sources approved by, the Engineer. The mineral filler shall be thoroughly dry and free from lumps consisting of aggregations of fine particles. Ground phosphate will not be allowed as a mineral filler.

Stone or slag screenings may also be used as filler material for asphalt concrete mixtures, under the provisions specified in 917-3, below.

917-2 Gradation.

The mineral filler shall meet the following gradation requirements:

Total passing No. 30 sieve 100%
Total passing No. 80 sieve ..... 95% (minimum)
Total passing No. 200 sieve ..... 65% (minimum)

917-3 Provision for Use of Coarser Filler Material.

Process screenings from stone or slag, having a coarser gradation than as specified above, may also be used as filler material provided the particular product, and the source thereof, are approved by the Engineer and that the material meets the following requirements.

1. All of the material shall pass the No. 10 sieve, and not more than 35% shall pass the No. 200 sieve.

2. The material passing the No. 200 sieve shall be free from organic impurities, and not more than 4.0% of such shall consist of clay minerals. The plasticity index of the material passing the No. 200 sieve shall not exceed 4.

3. For the stone or slag material from which the screenings are produced the loss, when subjected to the Los Angeles Abrasion Test, shall not exceed 45%.

SECTION 919
GROUND TIRE RUBBER

919-1 Description.

This Section specifies the requirements for ground tire rubber (GTR).

919-2 General Requirements.

919-2.1 General: The GTR shall be produced from tires and shall be substantially free from contaminants including fabric, metal, mineral, and other non-rubber substances. Up to 4% (by weight of rubber) of talc or other inert dusting agent, may be added to prevent sticking and caking of the particles.

919-2.2 Ground Tire Rubber (GTR) for Use in Asphalt Rubber Binder: GTR shall be sufficiently dry so as to be free flowing and to prevent foaming when mixed with asphalt cement.

The use of pelletized asphalt rubber is permitted provided the components of the pelletized rubber particles meet the requirements of this Section. Additionally, the pelletized particles must disassociate once blended with asphalt cement.

919-2.3 Ground Tire Rubber (GTR) for Use in Flowable Fill: GTR may replace up to 20% of the fine aggregate.

919-2.4 Approved Product List (APL): GTR and pelletized rubber used shall be one of the products listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6.

919-3 Physical Requirements.

The physical properties of the ground tire rubber shall be determined in accordance with FM 5-559, and shall meet the following requirements:

Specific Gravity	1.02 to 1.20
Moisture Content	Maximum 0.75%
Metal Contaminants	Maximum 0.01%
Gradation	Minimum 98% Passing the No. 30 Sieve

919-4 Chemical Requirements.

The chemical composition of the ground tire rubber shall be determined in accordance with ASTM D297-13 and shall meet the following requirements:

Acetone Extract	Maximum 25%
Rubber Hydrocarbon Content	40 to 60%
Ash Content	Maximum 8%
Carbon Black Content	20 to 40%
Natural Rubber	16 to 45%

919-5 Packaging and Identification Requirements.

The ground tire rubber shall be supplied in moisture resistant packaging such as either disposable bags or other appropriate bulk containers. Each container or bag of ground tire rubber shall be labeled with the manufacturer's designation for the rubber and the specific type, maximum nominal size, weight and manufacturer's batch or LOT designation.

919-6 Certification Requirements.

The Contractor shall submit to the Engineer a certification conforming to the requirements of Section 6 from the manufacturer, confirming that the ground tire rubber meets the requirements of this Section.

SECTION 921
PORTLAND CEMENT AND BLENDED CEMENT

921-1 General.

Cement shall conform to the requirements of AASHTO M 85 or AASHTO M 240, as applicable, except as provided in this Section.

921-1.1 Type of Cement: Cement may be Types I, II, III, V (as defined by AASHTO M 85), or IL, IP, IS, IT (as defined by AASHTO M 240). Cement type shall be selected based on component and environmental conditions in accordance with Section 346. Different brands of cement, cement of the same brand from different facilities, or different types of cement shall be stored separately, identified, and shall not be mixed.

921-1.2 Heat of Hydration: The cement heat of hydration for Type II, Type IT, Type IL, Type IP, and Type IS shall be tested in accordance with ASTM C1702 and reported at three days.

921-2 Definitions.

The following definitions are applicable to the production and Quality Control (QC) of cement:

1. Approved Laboratory: A laboratory that is currently inspected by the Cement and Concrete Reference Laboratory (CCRL), is actively participating in the CCRL proficiency program, and which has all deficiencies noted at the time of inspection corrected. The laboratory must also authorize CCRL to submit their inspection reports to the State Materials Office (SMO).

2. Producer: A cement supplier, including but not limited to a plant, a terminal, or a transfer facility, that has been qualified by the SMO. The Cementitious Materials Production Facility Listing will be maintained by the SMO.

3. Test Report: A certification from the Producer showing that the cement meets the requirements of Section 921.

The test report must include, at a minimum, the following information:

a. The type of cement.
b. The production period.
c. Chemical and physical analysis of the cement.
d. The silo identification where the cement is stored.
e. The base cement phase composition, except for blended cements.
f. Amount of limestone and/or inorganic processing additions used, expressed as a percentage of the cement mass.
g. The oxide composition of the limestone and/or inorganic processing additions.
h. The specific gravity of cement reported as an average of the last twelve monthly tests, updated every six months.
i. The heat of hydration at three days.
j. The approved laboratory that performed all tests.

Acceptable test reports are available in the appendices of AASHTO M 85 for portland cement and AASHTO M 240 for blended cement, except as modified by the requirements of this Section.

4. Purchaser: The term "purchaser" in the AASHTO requirements shall be taken as the Department.

921-3 Quality Control Program.

921-3.1 General: Develop a Producer QC Program as specified in Section 105.

Producers shall submit a proposed QC Plan to the SMO for acceptance. Complete the Cementitious Materials Producer QC Plan Checklist (Appendix B02) and submit it along with the QC Plan, in a separate file. The checklist can be found on the SMO website: https://www.fdot.gov/materials/quality/programs/qualitycontrol/checklists/index.shtm. In addition to the QC Plan, the Producer must submit monthly test reports from an approved laboratory which certifies that the cement in current production or supply conforms to the requirements of this Section.

Producers with an accepted QC Plan will appear on the Cementitious Materials Production Facility Listing.

QC test data that does not comply with this Section will not be a reason for rejection of the material if the Producer's QC Plan indicated that material will be diverted and not used for Department work.

921-3.2 Sampling and Testing: An approved laboratory shall perform one QC test per day. Test reports representing no more than one month's production shall be submitted to the SMO on a monthly basis, for foreign cement, refer to 921-5.

Representatives from the Department may take verification samples at the Producer's plant, terminal, distribution facility, or the concrete production facility. Samples shall be obtained by one of the methods described in FM 5-503. Sample size shall be a minimum of one gallon. At the concrete production facility, cement samples shall be jointly obtained by the Department inspector and the concrete producer's representative.

Upon request of the Department, the Producer shall provide split samples of the cement collected for QC testing. Split samples shall be delivered to the SMO and shall be identified as representing a designated LOT of cement.

Notification of failing verification sample test results will be distributed to the Producer and concrete producer, if applicable. Split samples of the initial sample may be provided to the Producer and concrete producer upon request, as available.

921-3.3 Limestone and Inorganic Processing Additions: Producers intending to use limestone and/or inorganic processing additions as component materials in the production of cement shall describe the type, source, and the target amount, expressed as a percentage of cement mass. In addition, the Producer shall display the information required in 921-2 on the test report. Samples of any pulverized limestone and/or inorganic processing additions shall be provided to the SMO for evaluation upon request.

921-4 Shipping and Storage.

Cement shall be delivered in bags or in bulk. Portland cement from a Producer on the Cementitious Materials Production Facility Listing shall be shipped on the basis of test reports meeting the requirements of this Section. Ensure that each shipment is accompanied by a delivery ticket that is traceable to the test report and includes, at a minimum, the following information:

1. FDOT Facility Identifier
2. Type of cement
3. Date shipped
4. Silo Identification

The storage building, bin or silo shall be weatherproofed.

921-5 Foreign Cement Acceptance.

Cement being imported from a foreign source shall conform to all requirements of this Section and will be subject the following process:

1. The proposed QC Plan and the QC Plan Checklist (Appendix B02) referenced in 921-3.1 shall be sent to the SMO and will include information regarding the QC, sampling, storage, and handling of the cement at the arrival terminal as well as the shipping control to and from the arrival terminal. In addition, the QC Plan from the foreign source shall be translated to English and will be included with the proposed QC Plan for the arrival terminal.

2. An initial one-gallon sample of the imported cement shall be sent to the SMO for chemical and physical verification testing.

3. When the first ship is being loaded from foreign source, a one-gallon verification sample will be obtained and shipped to the SMO for chemical and physical property testing.

The material will be accepted for use on Department projects provided that the QC Plan has been accepted, and the results of the initial and verification samples have been confirmed to meet the requirements of this Section.

Upon receiving the shipment of cement at the arrival terminal, the Department will be notified, and a Department representative may obtain another verification sample.
Test reports representing each shipment shall be sent to the SMO.

921-6 Rejection of Material:

Reject the entire container of cement if it does not meet the requirements of this Section, including cement that has been damaged, is partially set, lumpy or caked.

Reject bagged cement if it varies more than 5% from the designated weight, or if the average weight of 50 randomly selected sacks is less than the designated weight.

SECTION 923
WATER FOR CONCRETE

923-1 General Requirements.

Water for use with cement shall be clear and free from oil, and injurious amounts of acid, alkali, chlorides, organic matter, and other deleterious substances. It shall not be salty or brackish. Water that contains quantities of substances which makes it discolored or smell unusual or objectionable, shall not be used unless approved by the Department. Water sources permitted include potable water supplies that are approved by a public health department, open bodies of water, well water, reclaimed water, and recycled water. Reclaimed water shall be as defined in Chapter 62-610, F.A.C. Open bodies of water are defined as naturally occurring rivers, lakes, and ponds. Recycled water includes wash water from mixer washout operations and stored in a lined settling pond. Water sources that meet the requirements of Table 923-1, Table 923-2 or from a public health department may be used alone or blended in a storage tank for use in batching structural or non-structural concrete. All other sources of water not listed above shall be considered recycled and reclaimed water.

923-2 Evaluation of Water for Concrete.

923-2.1 General: Water from potable water supplies approved by a public health department may be used without additional testing. The concrete producer shall submit test data of water samples from other sources. To determine chemical properties, the concrete producer shall use a laboratory accredited by the Construction Materials Engineering Council Accreditation Program including accreditation on referred chemical tests on Table 923-1 and 923-2.

923-2.2 Initial Sampling and Testing Frequency: Open bodies of water and well water shall be initially sampled once prior to use. Recycled and reclaimed water shall be tested once per week for four weeks initially, and thereafter once per month for four months prior to its use, provided that the results of the test samples comply with all the applicable limits. Failing test results will result in restarting initial sampling and testing.

923-2.3 Production Sampling and Testing Frequency: Open bodies of water and recycled water shall be tested monthly. Well water and reclaimed water shall be tested once every three months. If the last eight consecutive well water and reclaimed water samples meet the requirements, then the sample frequency may be reduced to one sample every six months, as approved by the Department. If a well water or reclaimed water sample fails once the frequency has been reduced, then the sampling frequency shall revert to once every three months.

923-3 Chemical Requirements.

923-3.1 Testing: All chemical analysis shall be performed in accordance with the test methods listed in Tables 923-1 and 923-2 or equivalent Standard Methods for the Examination of Water and Wastewater (SM). Inorganic Anions (Chlorides and Sulfates) shall be determined simultaneously using SM 4110B Ion Chromatography or separately using SM 4500 Cl^- B and SM 4500 SO_4^{2-} E. ASTM D516 may be used as an alternative method for sulfates. The test method used shall be included in the concrete producer report.

923-3.2 Recycled and Reclaimed Water: Recycled and reclaimed water shall be tested before use and shall not exceed the limits in Table 923-1:

Table 923-1		
Chemical Test	Test Method	Maximum (%)
Total Solids	SM 2540 B	5.00
Total Chlorides as Cl^-	SM 4500 Cl^- B or SM 4110 B	0.05
Total Sulfates as SO_4^{2-}	ASTM D516	0.30

923-3.3 Open Bodies of Water and Well Water: Open bodies of water and well water shall be tested before use and shall not exceed the limits of Table 923-2:

Table 923-2		
Chemical Test	Test Method	Maximum (%)
Alkalinity Calculated in terms of Calcium Carbonate	SM 2320 B	0.05
Total Organic Solids	SM 2540 E	0.05
Total Inorganic Solids	SM 2540 E	0.08
Total Chlorides as Cl^-	SM 4500 Cl^- B or SM 4110 B	0.05

923-4 Physical Requirements for Mortar.

923-4.1 General: To determine physical properties, use a laboratory accredited by the Construction Materials Engineering Council Accreditation Program or inspected by the Cement and Concrete Reference Laboratory.

923-4.2 Testing: Mortar shall be tested in accordance with ASTM C109 with the following exception: the mortar shall not be tested for flow. The mortar, composed of the sampled water, shall have a compressive strength of not less than 90% when compared to a mortar prepared using distilled water and tested at seven days.

Water of a questionable quality, as determined by the Department, shall be subject to the acceptance criteria for time of set as required by ASTM C1602, Table 1.

SECTION 924
ADMIXTURES FOR CONCRETE

924-1 General.

This Section covers admixtures for specific concrete applications. Admixtures shall comply with applicable ASTM specifications and the requirements of this Section. Admixtures that have been previously qualified for Department use are listed on the Department's Approved Product List (APL).

924-2 Acceptance of Admixtures.

924-2.1 Approved Product List (APL): All admixtures must be listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of their products shall submit an application is accordance with Section 6 and include product data sheets, certified independent test data showing the product meets the requirements of this Section, safety data sheet (SDS), and a certification of the average solids content and specific gravity.

Admixtures shall meet the following requirements:

Air-Entraining - ASTM C260
Type A Water-Reducing - ASTM C494
Type C Accelerating - ASTM C494
Type D Water-Reducing and Retarding - ASTM C494
Type E Water-Reducing and Accelerating - ASTM C494
Type F High Range Water Reducing - ASTM C494
Type G High Range Water-Reducing and Retarding - ASTM C494
Type I - Plasticizing - ASTM C1017
Type II - Plasticizing and Retarding - ASTM C1017
Type S Specific Performance - ASTM C494 and the performance requirements of this Section.
Corrosion Inhibitors – ASTM G109 and the requirements of this Section.

The inclusion of any specific product on the APL, as specified in 6-1, indicates that the product has been given contingent approval, as evidenced by previous tests and apparent effectiveness under field conditions.

Unless otherwise specified, no further testing will be required for any product on the APL unless there is indication in actual field use of inadequate or unreliable results.

924-2.2 Additional Requirements for Corrosion Inhibitors: Calcium nitrite is a chemically reactive admixture used in concrete to inhibit the corrosion of embedded reinforcing steel and other metallic components. The calcium nitrite supplier shall submit to the Engineer test certificates from an independent laboratory indicating compliance with this Specification. The test certificate shall include corrosion inhibiting properties per ASTM G109 and results of physical tests included in this section. Calcium nitrite shall be supplied by the same manufacturing source throughout the project. If a single primary source of calcium nitrite cannot be maintained throughout the project, new test certificates shall be submitted. The Engineer will determine specification compliance of a new supplier's product, and evaluate the effectiveness of the new calcium nitrite product before approving the source.

The active ingredient shall be calcium nitrite $Ca(NO_2)_2$.

The calcium nitrite shall be furnished in solution containing not less than 29% calcium nitrite solids. The concentration of the calcium nitrite solution shall be verified by

spectrophotometric analysis or other comparable methods. The nitrite concentration shall be measured in accordance with Standard Methods for the Examination of Water and Waste Water, 18th Edition.

A volume of one gallon of calcium nitrite solution shall weigh within the range of 10.40 to 11.92 lb.

The calcium nitrite solution shall be added to the concrete mixture at a rate of 4.50 to 4.60 gal/yd^3 of concrete.

The addition of calcium nitrite to the concrete mix shall not adversely affect the properties of fresh and hardened concrete.

Calcium nitrite concrete shall meet the following physical requirements when mixed and tested in accordance with ASTM C494:

Table 924-1	
Water Content, % of control	95 to 100
Time of setting, allowable deviation from control, h:min:	
Initial: at least not more than	1:00 earlier nor 1:30 later
Final: at least not more than	1:00 earlier nor 1:30 later
Compressive Strength, min. % of control:	shall be 100 for all ages
Flexural strength, min, % of control:	shall be 100 for all ages
Length change, max Shrinkage (alternative requirements): % of control	135
Increase over control	0.010
Relative durability factor, min	80

The following table lists the corrosion inhibiting test result limits for calcium nitrite concrete tested in accordance with ASTM G109:

Table 924-2	
Maximum Allowable Test Results of Calcium Nitrite Concrete	
Measured average macrocell current any time during the test	10 µA
Average macrocell current at test completion	2 µA
Average visible corrosion measured as percent corroded area of control	85%

924-2.3 Type S (Specific Performance): Trial batches shall use concrete meeting the requirements of ASTM C494. Additional trial batches may be required. Dosage rate shall be the same for all testing.

924-2.3.1 Workability Retention: Workability retention admixtures are used to extend workability and slump life without retarding the setting time. The dosage rate used shall be capable of maintaining 80% of the initial measured slump after 60 minutes. Perform an initial slump test, hold the trial batch in the mixer for 60 minutes, remix for 30 seconds and perform a second slump test. Workability retention shall be calculated as the percent difference in the initial slump and the slump at 60 minutes.

924-2.3.2 Shrinkage Reducing: Shrinkage reducing admixtures are used to minimize the shrinkage of plastic and hardened concrete. The dosage rate used shall reduce shrinkage a minimum of 50% after dry curing for 28 days. Shrinkage shall be determined in accordance with ASTM C157, except omit curing period in ASTM C157(10.3). Air storage for

the 28-day curing period shall be in accordance with ASTM C157(11.1.2). Shrinkage reduction shall be calculated as the percent difference in the control mix length change and the test mix length change.

924-2.3.3 Viscosity Modifying: Viscosity modifying admixtures are used primarily in flowing and self-consolidating concrete to maximize the rheology of plastic concrete and reduce segregation. The dosage rate used shall reduce static segregation to a minimum of 10%. A flowing concrete control mix shall be established by adding a compatible high range water-reducing or plasticizing admixture to increase the slump to 10 inches, plus or minus 0.5 inches. To establish the test mix, the control mix shall be reproduced with the addition of the viscosity admixture. The static segregation for both mixes shall be determined in accordance with ASTM C1610. Static segregation shall be calculated as the percent difference of the control mix static segregation to the test mix static segregation.

924-2.3.4 Rheology Modifying: Rheology modifying admixtures are used to maximize the rheology of plastic concrete. The dosage rate used shall be based on the manufactures recommendation and may vary for a specific application.

924-3 Retesting.

The approved admixtures are required to be tested for their uniformity and equivalence whenever there is an indication of erratic results. The tests shall be performed in accordance with the following procedure. The admixture shall be checked for comparison between infrared spectrophotometry, pH value, specific gravity, and solids content. Any marked variation from the original curve, pH value, specific gravity, or solids content will be considered sufficient evidence that the chemistry of the original material has been changed and, therefore, the use of this material will be rejected and the material will be removed from the APL.

SECTION 925
CURING MATERIALS FOR CONCRETE

925-1 Burlap.

Burlap for curing concrete shall consist either of two layers, each weighing 10 to 18 ounces/10 square feet, or of four layers, each weighing 6 to 7 ounces/10 square feet. Burlap which has been used as a container for sugar shall not be used. Burlap that is being used for the first time shall be thoroughly washed in order to remove starches used in sizing the material. Burlap shall be furnished in strips of at least 3 feet wide and shall be at least 3 feet longer than the width of surface to be covered.

925-2 Membrane-Forming Curing Compound.

925-2.1 General: Membrane-forming curing compound shall conform to requirements of ASTM C309 and the following requirements:

Table 925-1

Requirement	Test Method	Test Value
Water Loss@72 hours	ASTM C156	0.55 kg/m^2
Deleterious Reaction with Concrete	ASTM C309	None
Reflectance	ASTM E1347	60% minimum*
Drying Time	ASTM C309	4 hours maximum
Non-Volatile Content	ASTM D1644 (Method A)	(informational)
Density, lbs/gal	ASTM D1475	(informational)

*Type 2 (White) compounds only.

The membrane-forming curing compound shall be of a consistency suitable for spraying at temperatures prevalent at the time of application, and which forms a continuous, uniform film. It shall be free from precipitated matter caused by conditions of storage or temperature. Thoroughly agitate the curing compound in accordance with the manufacturer's recommendations prior to shipment from manufacturer's plant and prior to use at job site.

Curing compound delivered to the jobsite shall be in the manufacturer's original container and clearly labeled with the following information:

1. manufacturer's name
2. product name (trade name)
3. type
4. batch or LOT number
5. date of manufacture

925-2.2 Product Acceptance: Acceptance of membrane-forming curing compound shall be based on the product being listed on the Department's Approved Product List (APL).

925-2.2.1 Approved Product List: Manufacturers seeking evaluation of their product must submit an application in accordance with Section 6 and include product data sheets, material safety data sheets (SDS) and certified test reports from an independent laboratory showing the product meets the requirements of this Section. Testing in accordance with the

AASHTO Product Evaluation & Audit Solutions Project Work Plan for the Laboratory Testing of Liquid Membrane-Forming Compounds for Curing Concrete shall be acceptable as independent laboratory data. Include an Infrared Spectrophotometry (IR) Scan and a certification stating the nominal minimum percentage of non-volatile material for the product formulation. Deviation of the non-volatile material below this certified value shall be considered a change in formulation and shall be grounds for removal from the APL.

925-2.2.2 Certification: Prior to use, the Contractor shall submit to the Engineer a certification from the manufacturer conforming to the requirements of Section 6 that the requirements of this Section are met.

925-2.3 Product Life: Store the curing compound in accordance with the manufacturer's recommendations. Curing compounds not used within one year of the date of manufacture shall not be incorporated into the work.

925-3 Sheet Materials.

925-3.1 General: Waterproof paper, polyethylene film and white burlap-polyethylene sheet, for curing concrete shall meet the requirements of ASTM C171, with the additional requirements for waterproof paper and for polyethylene film as shown below.

925-3.2 Additional Requirements for Waterproof Paper: The paper as prepared for use shall be in such dimensions that each unit as laid will extend at least 18 inches beyond the edges of the slab. If laid longitudinally, paper not manufactured in sizes which will provide this width shall be securely sewed or cemented together; the joints being sealed in such manner that they do not open up or separate during the curing period.

At the option of the Contractor, instead of the single longitudinal strip specified above, the blanket may be furnished in three strips; one strip being the neat width of the pavement, with two side strips.

925-3.3 Additional Requirements for Polyethylene Sheeting: The sheets, as prepared for use, shall be of such dimensions that each unit as laid will extend beyond the edges of the slab by at least twice the thickness dimension of the pavement edge, and the sheets shall overlap by at least 18 inches.

No sheet may be reused except after individual inspection and approval by the Engineer. Any sheets determined by the Engineer to be so damaged as to not afford the protection to the concrete in preventing moisture loss during the curing period will be rejected.

925-4 Certification.

For burlap or white burlap-polyethylene, the Contractor shall submit to the Engineer a certification conforming to the requirements of Section 6 from the manufacturer confirming that the requirements of this Section are met. Each certification shall cover only one type of burlap or white burlap-polyethylene sheeting.

SECTION 926
EPOXY COMPOUNDS

926-1 Types of Compounds.

Epoxy resin-based compounds for application to portland cement concrete, bituminous cement concrete, metals and other type surfaces shall be applicable for the following types as designated. Products may only be used for applications recommended by the manufacturer.

Table 926-1

Type	Description
AB*	An epoxy resin, for bonding fresh or hardened concrete to hardened concrete and constructing doweled splices in precast prestressed concrete piles.
E*	A fluid epoxy for crack injection in the repair of old structures.
F F-1* F-2**	An epoxy for repairing spalled areas on concrete bridge structures with these subtypes: A non-sagging gel type for vertical surfaces. A pourable type for repairs where forms are to be used.
H**	An epoxy for structural bonding where asphalt overlays are to be in contact with the hardened compound.
K*	An epoxy for underwater sealing of the bottom of the jacket of an integral pile jacket system.
M***	A coal tar or modified glass flake epoxy coating for steel sheet piles and H piles (water immersion) and hot applied coal tar epoxy tape.
PSE*	A two-part epoxy system to match the cast faces of joints between precast segmental concrete superstructure and/or substructure segments.
Q*	An epoxy for use in post tensioning anchorage protection systems.

*Accepted by APL
**Accepted by certified test report
***Accepted by certification

926-2 Epoxy Design Requirements.

926-2.1 General: All types of compounds, except for Type M, shall be thermosetting containing no volatile solvent, and be pure reactive material. All types of compounds except for Type M shall have simple mix ratios of one to one, two to one, or shall be supplied in pre-proportioned containers in which all the contents are to be mixed.

All types of compounds shall be labeled with the manufacturer's name, brand name, component type (resin, hardener or filler), mix ratio, mixing directions, date manufactured, shelf life, and the manufacturer's LOT number. Potential hazards shall be stated on each package in accordance with the Federal Hazardous Products Labeling Act.

Certain terms used in this specification shall have these meanings:

low modulus - the stress-strain property for which ultimate tensile strength is attained at over 10% elongation.

high modulus - the stress-strain property for which ultimate tensile strength is attained at under 6% elongation.

non-sagging gel - grades of mixed compounds which will not perceptibly flow under their own weight on a vertical surface in the unhardened state.

pourable - grades of mixed compound sufficiently fluid that they (either neat or filled) can be cast into and will take the shape of a mold.

Fillers for mixing mortars and grouts shall be recommended by the manufacturer of the epoxy compound and supplied as packages accompanying the epoxy or premixed.

926-2.2 Approved Product List (APL): All epoxy materials shall be one of the products listed on the Department's Approved Product List (APL) unless an alternative acceptance is identified in this Specification. Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6 and identify the epoxy type. Include with the submittal product data sheets, safety data sheets (SDS), and certified test reports from an independent laboratory showing the product meets the requirements of this Section. Manufacturers may submit performance test reports from the AASHTO Product Evaluation & Audit Solutions as acceptable independent laboratory data.

Upon request, submit product samples to the Department for confirmatory testing and Infrared (IR) analysis.

926-3 Specific Requirements for Type AB Epoxy Compounds.

926-3.1 Mixing and Application: Type AB epoxy compounds are used for bonding fresh or hardened concrete to harden concrete and constructing doweled splices in precast prestressed concrete piles.

926-3.2 Performance Tests: Meet the requirements of ASTM C881 Type IV and V, Class C, when tested at 73° ± 2° F.

926-4 Specific Requirements for Type E Compounds.

Epoxies for crack injection shall meet the requirements of ASTM C881 Type IV compound with these additional requirements:

Table 926-2	
Viscosity five minutes after mixing	300 to 600 cps at 77°F by ASTM D2556
Wet bond strength to concrete, minimum	250 psi at seven days by FM 5-518

926-5 Specific Requirements for Type F Compounds.

926-5.1: Repairing Spalled Areas: Epoxies for repairing spalled areas shall meet the requirements in this Section.

926-5.2: Subtype F-1: Subtype F-1 epoxy is used for repairing vertical and other surfaces and shall be a trowelable low modulus, non-sagging gel epoxy compound capable of bonding to wet surfaces with these properties:

Table 926-3	
Color	Shall match gray color No. 36622 of FED-STD-595
Consistency	Gel
Maximum sand loading	Recommended by the manufacturer
Elongation in tension minimum	10% by ASTM D638, seven-day cure
Wet bond to Steel and Concrete minimum	250 psi by Florida Test Method FM 5-518

926-5.3: Subtype F-2: Subtype F-2 epoxy is used for filling larger spalls where a form is required to build back to the original surface. Materials shall be a pourable low modulus type compound capable of bonding to wet surfaces with these properties:

Table 926-4	
Color	Shall match gray color No. 36622 of FED-STD-595-
Maximum sand loading	Recommended by the manufacturer
Elongation in tension, minimum	10% by ASTM D638, seven-day cure
Exotherm	110°F by ASTM D2471, 1 pint sample
Wet bond strength	250 psi at seven days by FM 5-518

Type F-2 epoxy compounds will be accepted by certified test report. Submit to the Engineer testing from the manufacturer of the product for each LOT of material to be incorporated in the project. The test results will indicate that the material is in conformance with the Specifications, and will include actual values from the required tests. Obtain approval from the Engineer before incorporating material into the project.

926-6 Specific Requirements for Type H Compounds.

Type H epoxies for structural bonding where bituminous pavement overlays will come in contact with the hardened compound shall meet the requirements for Types AB compounds above. Submit from the manufacturer test data showing that cutback and emulsified asphalts, asphalt cement, and bituminous mixes shall bond to but not soften or otherwise damage the epoxy after a curing period of four days.

Type H epoxy compounds will be accepted by certified test report. Submit to the Engineer testing from the manufacturer of the product for each LOT of material to be incorporated in the project. The test results will indicate that the material is in conformance with the Specifications and will include actual values from the required tests. Obtain approval from the Engineer before incorporating material into the project.

926-7 Specific Requirements for Type K Compounds.

Type K epoxies are used for sealing the bottom of integral pile jackets in the repair of concrete piles. These epoxies will be extended with the aggregate supplied by the manufacturer. The epoxy shall be factory pre-proportioned including factory supplied aggregate and meet the following requirements:

Table 926-5	
Compressive strength at seven days, minimum by ASTM C579B	4,500 psi
Bond Strength by FM 5-518	
to wet concrete, minimum	250 psi
to wet pile jacket, minimum	150 psi
Viscosity of mixed epoxy component at 77°F, five minutes by ASTM D2556	1,000-2,000 cps

The epoxy shall be capable of flowing through water in the void area of the jacket and hardening under water so as to provide a water tight seal of the depth indicated in the Plans or approved shop drawings and to maintain this seal during subsequent construction steps.

926-8 Specific Requirements for Type M Compounds.

Type M Coal Tar epoxy coatings for steel sheet and H piles used in bridges, fender systems and other structures subject to immersion in water shall comply with the requirements of SSPC Paint 16 with Type 1 pitch. Modified glass flake epoxies must be designed for immersion service and include a passivator. Application of the epoxy coating shall meet the requirements of Section 560 for a coal tar epoxy coating.

Hot applied coal tar epoxy tape used to protect tie back rods on sheet pile walls and bulkheads shall comply with the requirements of American Water Works Association standard C203. Application shall be according to the manufacturers published recommendations.

Submit to the Engineer a manufacturer certification, confirming that the coal tar or modified glass flake epoxy meets the requirements of this Section. The certification shall conform to the requirements of Section 6. Do not incorporate these materials into the project until the Engineer has accepted and approved the certification for the material. Submit such certification for each LOT of material delivered to the project. In each certification, identify the serial or LOT numbers of the containers certified.

926-9 Specific Requirements for Type PSE Epoxy Compounds.

Precast Segmental Epoxy (PSE) compounds are used for match-cast joints between precast concrete segments. Normal set PSE shall remain workable for a short open time (about one hour) and meet the requirements of ASTM C881, Type VI Grade 3. Slow set PSE shall remain workable over an extended open time (about eight hours), meet the requirements of ASTM C881, Type VII Grade 3, and have a compressive yield strength of 6,000 psi at 14 days.

PSE compounds shall be factory pre-proportioned and formulated to provide application temperature ranges which are suitable for the erection of match cast segments with substrate temperatures between 40°F and 105°F with a minimum of at least two, but preferably three, formulations dividing the range into approximately equal subranges which overlap by at least 5ºF.

926-10 Specific Requirements for Type Q Compounds.

Type Q epoxy compounds are used to protect the anchorages of post-tensioning tendons or bars and other uses indicated in the Plans. The material shall produce a low exothermic reaction and have flow and fill characteristics suitable for machine base plate applications. The material shall be factory pre-proportioned including factory supplied aggregate. Mix with the full aggregate loading unless the use of less aggregate is approved by the Engineer.

The epoxy grout plus aggregate mix shall meet or exceed the specified physical properties stated herein as determined by the following standard ASTM test methods.

Table 926-6		
Property	Test Value	Test Method
Compressive Strength at 7-day Cure at 77°F	> 10,000 psi	ASTM C579B
Tensile Strength at 7 days, Cure at 77ºF	> 2,100 psi	ASTM C307
Flexural Strength at 7days Cure at 77ºF	> 3,600 psi	ASTM C580
Modulus of Elasticity 7 days Cure at 77ºF	< 2,100,000 psi	ASTM C580
Coefficient of Thermal Expansion at 74° to 210°F	< 20 x 10^{-6} in/in/ºF	ASTM C531
Peak Exotherm, Specimen 12 x 12 x 3 in.	< 150ºF	ASTM D2471
Slant Shear at 7 days (Bond Strength to Concrete)	> 3000 psi	FM 5-587
Thermal Compatibility	90% of control	FM 5-609
Linear Shrinkage at 7 days	0.025%	ASTM C531
Flowability and Bearing Area	90% Contact area	ASTM C1339
Gel Time, Specimen 12 x 12 x 3 in.	< 4:00 (hr.)	ASTM D2471

SECTION 929
SUPPLEMENTARY CEMENTITIOUS MATERIALS

929-1 General.

Supplementary cementitious materials (SCMs) shall conform to the requirements of this Section. SCMs shall be used in concrete mix designs in accordance with Section 346.

Repulpable bags may be accepted by the Engineer, provided a successful demonstration by the producer has indicated complete degradation of the repulpable bags during the mixing operation and before the mix is discharged.

The Engineer may require additional testing beyond the requirements of this Section prior to the acceptance of any SCM sources.

929-1.1 Definitions.

The following definitions are applicable to the production and quality control (QC) of SCMs:

1. Approved Laboratory: A laboratory that is currently inspected by the Cement and Concrete Reference Laboratory (CCRL), is actively participating in the CCRL proficiency program, and has corrected all deficiencies noted at the time of inspection. The laboratory must authorize the CCRL to send a copy of the final inspection report and proficiency sample results to the State Materials Office (SMO).

2. SCM Producer: Indicates an SCM supplier, including but not limited to a plant, a terminal, or a transfer facility, that has been qualified by the SMO. The Cementitious Materials Production Facility Listing will be maintained by the SMO.

3. Test Report: A certification from the SCM Producer showing that the SCM meets the requirements of this Section. The test report must include, at a minimum, the following information:

   a. The type of SCM.
   b. The production period.
   c. Chemical and physical analysis of the SCM.
   d. The silo numbers where the SCM is stored.
   e. The specific gravity of the SCM reported as an average of the last twelve monthly tests, updated every six months.
   f. The approved laboratory that performed all tests.

4. Purchaser: The term “purchaser” in the ASTM requirements shall be taken as the Department.

929-2 Quality Control Program.

929-2.1 General: Develop a Producer QC Program as specified in Section 105.

SCM Producers shall submit a proposed QC Plan to the SMO for acceptance.

Complete the Cementitious Materials Producer QC Plan Checklist (Appendix B02) and submit it along with the QC Plan, in a separate file. The checklist can be found on the SMO website: https://www.fdot.gov/materials/quality/programs/qualitycontrol/checklists/index.shtm. In addition to the QC Plan, the SCM Producer must submit monthly test reports from an approved laboratory which certifies that the SCM in current production or supply conforms to the requirements of this Section.

SCM Producers with an accepted QC Plan will appear on the Cementitious Materials Production Facility Listing.

QC test data that does not comply with the Specification will not be reason for rejection of the material if the SCM Producer's QC Plan indicates that material will be diverted and not used for Department projects.

929-2.2 Sampling and Testing: Representatives from the Department may take verification samples at the SCM Producer's plant, terminal, distribution facility or the concrete production facility. Samples shall be obtained by one of the methods described in FM 5-503. Sample sizes shall be a minimum of one gallon by volume.

Upon request of the Department, the SCM Producer shall provide split samples of the SCM collected for QC testing. Split samples shall be delivered to the SMO and shall be identified as representing a designated LOT of the SCM.

Notification of failing verification sample test results will be distributed to the SCM Producer and concrete producers (if applicable). Split samples of the initial sample may be provided to the SCM Producer and concrete producer upon request, as available.

929-3 Coal Ash.

929-3.1 General: Sampling and testing of coal ash shall follow the requirements of ASTM C311. Coal ash shall not include the residue resulting from the burning of municipal waste or any other refuse with coal, or the burning of industrial or municipal waste in incinerators. The Engineer may accept sources of coal ash containing bottom ash on a case-by-case basis. The SCM Producer shall report:

1. If the material is fly ash or harvested coal ash.
2. If harvested coal ash is combined with any other material.

929-3.1.1 Fly Ash (Class F or Class C): Coal ash derived from the combustion of ground or powdered coal meeting the requirements of ASTM C618 Class F or Class C coal ash, and this Section.

929-3.1.2 Harvested Coal Ash (Class F or Class C): Coal ash derived from the combustion of ground or powdered coal that has been stored in a landfill or surface impoundment and subsequently excavated and processed to meet the requirements of ASTM C618 Class F or Class C coal ash, and this Section.

929-3.2 Acceptance Testing of Coal Ash: Coal Ash derived from the combustion of ground or powdered coal shall meet the requirements of ASTM C618 Class F or Class C coal ash.

Acceptance of coal ash from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class F or Class C, and this Section. When the loss on ignition exceeds 6.0%, the Supplementary Optional Physical Requirements shall be mandatory.

Class C coal ash may be used if the concrete test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements, when compared to concrete containing Class F fly ash.

929-3.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with Class C coal ash, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Use a Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of Class C coal ash sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

The following testing shall be performed on each concrete mix, as appropriate.

Table 929-1
Concrete/Mortar Testing Requirements

Test Description	Standard Test Method	Test Age
Surface Resistivity	AASHTO T 358	28, 56, 91, and 180 days
Compressive Strength	ASTM C39	28, 56, 91, and 180 days
Chloride Diffusion	ASTM C1556 or NT Build 443	6 and 12 months
Length Change	ASTM C157	Per ASTM C157 (1)
Sulfate Resistance (2)	ASTM C1012	6, 12, and 18 months

(1) Follow both the Water and Air Storage procedures.
(2) Prepare a mortar mix using a fixed water/cementitious materials ratio of 0.485.

Upon completion of the 6-month concrete and mortar testing, the SCM Producer may present the data to the SMO for acceptance. The 12 and 18-month data shall be provided to the SMO upon completion.

929-4 Slag Cement.

Slag cement (ground granulated blast furnace slag, GGBFS) is the quenched, ground by-product of the iron ore refinement process conducted in blast furnaces. It is primarily an amorphous material of calcium aluminosilicate constituents.

929-4.1 General: Slag cement and reference cement used for determination of slag activity tests shall meet the requirements of ASTM C989. Sampling and testing procedures shall follow the requirements of ASTM C989.

929-4.2 Acceptance Testing of Slag Cement: Acceptance of slag cement from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C989 and this Section. The test report shall include:

1. For slag granules, provide X-ray Fluorescence (XRF) elemental analysis of the granules, presented in oxide form. Include CaO, SiO_2, Al_2O_3, MgO, Mn_2O_3, TiO_2, Fe_2O_3, and sulfur (as sulfide).
2. For slag cement, provide XRF elemental analysis, presented in oxide form. Include CaO, SiO_2, Al_2O_3, MgO, Mn_2O_3, TiO_2, Fe_2O_3, sulfur as sulfide (S), sulfate sulfur (SO_3), and total sulfur as sulfate (SO_3).
3. The results of all testing listed under Test Methods section of ASTM C989.

4. Indicate the amount of any additions introduced during grinding of the slag granules and report compliance with Section 6 of ASTM C989.

a. Amount of limestone added and its $CaCO_3$ content.

b. Amount of other inorganic processing addition.

5. For calcium sulfate additions, indicate:

a. Amount of calcium sulfate added.

b. Form of calcium sulfate.

c. SO_3 content.

d. Method used to determine the amount of calcium sulfate that was added.

929-4.2.1 Assessment of Sulfate Resistance: Following guidance in ACI 233R-17 Guide to the Use of Slag Cement in Concrete and Mortar, slag cements with Al_2O_3 contents greater than 11% should be interground with calcium sulfate to avoid an undersulfated cementitious system. Provide ASTM C1012 data with a 50:50 cement-slag cement blend, using a Type II or Type IL cement on the Department's Cementitious Materials Production Facility Listing, with an alkali content of no more than 0.6%, when any of the following conditions occur:

1.The Al_2O_3 content of the slag cement is equal to or greater than 12%.

2. The slag cement is a blend of slag granules from more than one source that are interground during production of the slag cement and for which one or more of the following are true:

a. The Al_2O_3 contents of both slag sources are equal to or greater than 12%.

b. The average Al_2O_3 content of the blend is equal to or greater than 12%.

c. One of the slag sources has an Al_2O_3 content that is equal to or greater than 14%.

The Department will consider the ASTM C1012 data acceptable when the results indicate no more than 0.10% expansion at 12 months.

The Department may grant provisional acceptance if the expansion does not exceed 0.05% at 6 months.

For any slag cements with Al_2O_3 content equal to or greater than 12%, perform a retest of ASTM C1012 if the monthly test report indicates that any of the following conditions have occurred:

1. The Al_2O_3 content increases by greater than or equal to 1.0% of the content measured during qualification of the sulfate resistance.

2. The sulfate sulfur (SO_3) content decreases by 0.25% less than that measured during qualification of the sulfate resistance.

3. The Blaine fineness increases by 50 m^2/kg greater than that measured during qualification of the sulfate resistance.

The Department may grant provisional acceptance of the slag cement source if ASTM C1012 data is required for any of the above retesting conditions.

929-5 Calcined Clay.

929-5.1 General: Sampling and testing of calcined clay shall follow the requirements of ASTM C311. Calcined clay shall meet the requirements of ASTM C618 Class N.

929-5.2 Acceptance Testing of Calcined Clay: Acceptance of calcined clay from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N and this Section.

Calcined clay may be used in concrete if the test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing Class F coal ash.

929-5.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with the calcined clay, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Use a Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of calcined clay sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

929-6 Ground Glass.

929-6.1 General: Sampling and testing of ground glass shall follow the requirements of ASTM C311. Ground glass shall meet the requirements of ASTM C1866. Sampling and testing procedures shall follow the requirements of ASTM C1866.

929-6.2 Acceptance Testing of Ground Glass: Acceptance of ground glass from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C1866 and this Section.

Ground glass may be used in concrete if the test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing Class F coal ash.

929-6.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with the ground glass, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used in the mixes must be obtained from FDOT approved sources. Use a Class IV (5,500 psi) Conventional binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of ground glass sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

929-7 Natural Pozzolan.

929-7.1 General: Sampling and testing of natural pozzolans shall follow the requirements of ASTM C311. Natural pozzolans shall meet the requirements of ASTM C618 Class N.

929-7.2 Acceptance Testing of Natural Pozzolans: Acceptance of natural pozzolans from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N and this Section.

Natural pozzolans may be used in concrete if the test results provide improved or comparable compressive strength, sulfate resistance, corrosion protective properties, and other durability requirements of concrete, when compared to concrete containing Class F coal ash.

929-7.2.1 Concrete/Mortar Testing: Six concrete mixes shall be prepared by an accredited laboratory, three control batches using Class F coal ash and three comparison batches with the natural pozzolan, while all other constituents remain the same except for small adjustments to get the mix to yield. Concrete constituents used must be obtained from FDOT approved sources. Use a Class IV Conventional (5,500 psi) binary concrete mix design meeting the requirements of Section 346, with the following attributes:

1. Type II or Type IL cement.
2. Size No. 57 coarse aggregate.
3. Control batches: Replace 18 to 22% of the cement with Class F coal ash.
4. Comparison batches: Replace a portion of cement with a quantity of natural pozzolan sufficient to produce properties comparable to those of the control batches.
5. Water/cementitious materials ratio of 0.41.

Testing shall be performed in accordance with Table 929-1.

929-8 Highly Reactive Pozzolans.

929-8.1 Silica Fume:

929-8.1.1 General: Silica Fume shall meet the requirements of ASTM C1240 using the referenced test methods and frequencies.

929-8.1.2 Acceptance Testing of Silica Fume: Acceptance of silica fume from sources operating under an accepted QC Plan shall be based on monthly test reports that the material meets the requirements of ASTM C1240 and this Section.

929-8.2 Metakaolin:

929-8.2.1 General: Metakaolin shall meet the requirements of ASTM C618 Class N and the following:

1. The sum of $SiO_2 + Al_2O_3 + Fe_2O_3$ shall be at least 85%.
2. The loss on ignition shall be less than 3.0%.
3. The available alkalis, as equivalent Na_2O, shall not exceed 1.0%.
4. The strength activity index, at 7 days, shall be at least 85%.

929-8.2.2 Acceptance Testing of Metakaolin: Acceptance of metakaolin from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class N, as modified herein, and this Section.

929-8.3 Ultra-Fine Fly Ash:

929-8.3.1 General: Sampling and testing of the ultra-fine fly ash shall follow the requirements of ASTM C311. Ultra-fine fly ash derived from the combustion of ground or

powdered coal shall meet the requirements of ASTM C618 as a Class F fly ash with the following modifications:

1. The strength activity index, at 7 days, shall be at least 85% of the control and the strength activity index, at 28 days, shall be at least 95% of the control.
2. The amount of material retained when wet-sieved on a 45-µm sieve shall be less than 6.0%.
3. The moisture content shall be less than 1.0%.
4. The loss on ignition shall be less than 2.0%.

929-8.3.2 Acceptance Testing of Ultra-Fine Fly Ash: Acceptance of fly ash from sources operating under an accepted QC Plan shall be based on the monthly test reports meeting the chemical and physical requirements of ASTM C618 Class F fly ash, as modified herein, and this Section. When the loss on ignition exceeds 2.0%, the Uniformity Requirements in the Supplementary Optional Physical Requirements shall be mandatory.

929-9 Shipping and Storage.

SCMs may be delivered in bags or in bulk. SCMs from an SCM Producer on the Cementitious Materials Production Facility Listing shall be shipped on the basis of test reports meeting the requirements of this Section. Ensure that each shipment is accompanied by a delivery ticket that is traceable to the test report and includes, at a minimum, the following information:

1. FDOT Facility Identifier
2. Type of material (e.g., Class F coal ash or Grade 120 slag)
3. Date shipped
4. Silo Identification

The storage building, bin or silo shall be weatherproofed.

929-10 Foreign SCM Acceptance.

SCMs being imported from a foreign source shall conform to all requirements of this Section and will be subject to the following process:

1. The proposed QC Plan shall be sent to the SMO and will include information regarding the QC, sampling, storage, and handling of the material at the arrival terminal as well as the shipping control to and from the arrival terminal. In addition, the QC Plan from the foreign source shall be translated to English and will be included with the proposed QC Plan for the arrival terminal.
2. An initial one gallon by volume sample of the imported SCM shall be sent to the SMO for chemical and physical testing.
3. When the first ship is being loaded from the foreign source, a one gallon by volume verification sample will be obtained and shipped to the SMO for chemical and physical property testing.

The material will be accepted for use on Department projects provided that the QC Plan has been accepted, and the results of the initial and verification samples have been confirmed to meet the requirements of this Section.

Upon receiving the shipment of SCM at the arrival terminal, the Department will be notified, and a Department representative may obtain another verification sample.

Test reports representing each shipment shall be sent to the SMO.

SECTION 930
MATERIALS FOR CONCRETE REPAIR

930-1 Description.

This Section covers cementitious materials used to repair concrete including defects or purposely placed openings in concrete elements. Materials containing organic compounds, such as bitumen and epoxy resin as the principal binder are not included. The requirements for epoxy resin materials are covered in Section 926. Any depth larger than the manufacturer's recommendation for the specific material shall be repaired with portland cement concrete meeting the requirements of Section 346.

930-2 Product Acceptance on the Project.

930-2.1 Product Acceptance: Use only products listed on the Department's Approved Product List (APL). Manufacturers seeking evaluation of products must submit an application in accordance with Section 6 and include independently certified test reports that the material meets the requirements of this Section. The application package must describe detailed quality control requirements for installation including, but not limited to: maximum water to cementitious material ratio, formulation for two or more component systems, special materials and/or equipment, recommendations for all surface preparation, and curing requirements.

Provide the Engineer certification conforming to the requirements of Section 6 from the manufacturer confirming that the materials used meets the requirements of this Section and is the appropriate product for the intended use.

When specified in the Contract Documents, submit a report of test results from an independent laboratory on samples taken from material shipped. Ensure the test was performed within 45 days prior to the shipping date of the material.

930-2.2 Material Supply, Storage, and Marking: The material shall be pre-proportioned including aggregate. Deliver products in original, unopened containers with manufacturer's name, date of manufacture, and clearly marked with all information described below. Store the material in an elevated dry and weather protected enclosure in full compliance with the manufacturer's recommendations. Material must be used within manufacturer's recommended shelf life.

The material from which the containers are made shall have water vapor transmission not greater than 100 g/m^2 in 24 hours as determined in accordance with Procedure B of ASTM E96.

All containers shall be marked with the following information:

1. LOT identification number and material expiration date
2. Directions for use shall include but are not limited to the following:
    a. The type and kind of adhesive recommended (if any) to bond fresh repair material to the concrete or mortar being repaired.
    b. The recommended amount of resin, other liquid component, or both, to be mixed with the package contents.
    c. The recommended length of mixing time or sequence of mixing and resting times in minutes.
3. Date the material was packaged.
4. The yield in cubic feet or yield in ft^2/in. thickness when mixed with the recommended amount of liquid.

5. The net weight in each container. The contents of any container shall not vary by more than 2% from the weight stated in the declarations. The average weight of filled containers in a LOT shall be not less than the individual weight stated in the declarations.

6. Instructions for the maximum and minimum water (or solutions) to cementitious material ratio.

7. State the approximate working time.

930-2.3 Sampling, Mixing, and Additional Testing: A LOT is the packaged repair material normally placed on a pallet. A unit sample is a single container or package of material randomly selected from the LOT. Mix and install the materials in accordance with the manufacturer's recommendations. Manufacturers will be required to provide field representation upon request by the Engineer. The Department reserves the right to conduct further field testing on any approved material.

930-2.4 Rejection: All broken containers will be rejected. Material that fails to meet any of the requirements of this Specification will be rejected. Report all materials failing to meet this specification and state the reasons for rejection in writing to the Engineer and the producer or supplier. Material in local storage in the hands of a vendor for more than six months after testing will be retested before use, except for the scaling resistance test and length change immersed in sulfate solution test for magnesium ammonium phosphate concrete. Retested material will be rejected if it fails to conform to any of the requirements of this Specification.

930-3 Laboratory Specimen Preparation.

930-3.1 Mixing and Fabrication: Mechanically mix the dry packaged materials with liquid components in accordance with the manufacturer's recommendations.

930-3.2 Length Change: Make and cure the test specimens in accordance with ASTM C157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period.

930-3.3 Manifestly Faulty Specimens: Visually examine each group of specimens representing a given test or a given age of test, including tests of freshly mixed concrete, before or during the test, or both, whichever is appropriate. Discard any specimen found to be manifestly faulty by such examination without testing. Visually examine all specimens representing a given test at a given age after testing, and should any specimen be found to be manifestly faulty the test results thereof shall be disregarded. Should more than one specimen representing a given test at a given age be found manifestly faulty either before or after testing, the entire test shall be disregarded and repeated. The test result reported shall be the average of the individual test results of the specimens tested or, in the event that one specimen or one result has been discarded, it shall be the average of the test results of the remaining specimens.

930-4 Materials for Repair of Predominately Horizontal Surfaces.

930-4.1 General: This material is intended to be used to repair concrete where the area to be treated will be on a horizontal surface. Examples of the type of locations for these materials are bridge decks, portland cement concrete pavements and other locations required by the Contract Documents. Follow the manufacturer's recommendations for preparing the surfaces, mixing, placing, and curing the repair material unless otherwise directed in the Contract Documents.

930-4.2 Classification: The materials to be considered under this classification shall meet the following requirements:

930-4.2.1 Rapid Hardening: Moderate compressive strength for repairing concrete with an in-place compressive strength less than or equal to 4,000 psi.

930-4.2.2 Very Rapid Hardening: High compressive strength for repairing concrete with an in-place compressive strength greater than 4,000 psi. This material may be used in lieu of rapid hardening materials.

930-4.3 Physical Properties: The repair material shall meet or exceed the physical properties stated in Table 930-1 as determined by the specified test methods.

Table 930-1 Physical Properties of Repair Materials for Horizontal Surfaces			
Requirement	Test Method	Rapid Hardening	Very Rapid Hardening
Minimum Compressive Strength, psi			
3 hours	ASTM C39* or ASTM C109*	N/A	2,000
24 hours		2,000	4,000
7 days		4,000	6,000
28 days		Greater than or equal to strength at 7 days.	
Maximum Length Change, %			
Allowable expansion at 28 days when water cured compared to length at one day	ASTM C157**	0.12	0.12
Allowable shrinkage at 28 days when air cured compared to length at one day		-0.12	-0.12
Allowable difference between increase in water and decrease in air		0.20	0.20
Minimum Slump (Concrete), inches	ASTM C143***	3	3
Minimum Flow (Mortar), %	ASTM C1437***	100	80
Time of Setting (Initial), minutes	ASTM C191* or ASTM C403*	Minimum 30	10 to 29
Coefficient of Thermal Expansion, in/in/°F	ASTM C531* or AASHTO T 336	3.0×10^{-6} to 9.0×10^{-6}	3.0×10^{-6} to 9.0×10^{-6}
Minimum Bond Strength by Slant Shear, psi			
24 hours	FM 5-587	400	450
7 days		Greater than or equal to strength at 24 hours.	
Maximum Allowable Total Chlorides lb/yd^3	FM 5-516	0.40	

* as applicable
** Make and cure the test specimens in accordance with ASTM C157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period.
*** Testing for flow/slump will be completed in 15 plus or minus 1/2 minute after the start of mixing liquid with the rapid hardening materials or 5 plus or minus 1/2 minute after mixing the liquid with the very rapid hardening materials.

930-4.4 Specimen Preparation:

930-4.4.1 Flow/Slump: Testing for flow/slump will be completed in 15 minutes, plus or minus 1/2 minute, after the start of mixing liquid with the rapid hardening materials or 5 minutes, plus or minus 1/2 minute, after mixing the liquid with the very rapid hardening materials.

930-5 Materials for Repair of Predominately Vertical Surfaces.

930-5.1 General: This material is intended to be used to repair concrete where the area exposed in the field to be treated will be on a vertical surface. If an element has both horizontal and vertical surfaces, then the repair used will be for vertical surfaces. If it is not apparent which material is to be used, the vertical application will prevail. Examples of the type of locations for these materials are columns, caps, beams, piles, incidental concrete products, drainage structures and other locations required by the Contract Documents. Follow the manufacturer's recommendations for preparing the surfaces and for mixing, placing and curing the repair material.

930-5.2 Classification: The materials to be considered under this classification shall meet the following requirements:

930-5.2.1 High Performance: Moderate compressive strength for repairing concrete with a designed compressive strength greater than or equal to 5,000 psi.

930-5.2.2 Ultra-high Performance: High compressive strength for repairing concrete with a designed compressive strength greater than 5,000 psi. These materials may be used in lieu of high performance vertical materials.

930-5.3 Physical Properties: The repair material shall meet or exceed the physical properties stated in Table 930-2 as determined by the specified test methods.

Table 930-2 Physical Properties of Repair Materials for Vertical Surfaces*			
Requirement	Test Method	High Performance	Ultra-high Performance
Minimum Compressive Strength, psi			
24 hours	ASTM C39** or ASTM C109**	1,000	2,000
7 days		N/A	5,000
28 days		5,000	Greater than or equal to strength at 7 days
Maximum Length Change, %			
Allowable expansion at 28 days when water cured compared to length at one day	ASTM C157**	0.12	0.12
Allowable shrinkage at 28 days when air cured compared to length at one day		-0.08	-0.08
Maximum Slump (Concrete), inches	ASTM C143	3****	3****
Maximum Flow (Mortar), %	ASTM C1437	100****	100****
Time of Setting (Initial), minutes	ASTM C191** or ASTM C403**	10 to 180****	10 to 180****
Coefficient of Thermal Expansion, in/in/°F	ASTM C531*** or AASHTO T 336***	3.0×10^{-6} to 9.0×10^{-6}	
Minimum Bond Strength by Slant Shear, psi,			
24 hours	FM 5-587	450	750
7 days		750.	750
Minimum Flexural Strength (at 7 days), psi	ASTM C580	500	700
Maximum Absorption (Mortar at 7 days), %	ASTM C413	4	4
Minimum Surface Resistivity (Concrete at 28 days), kohm-cm	AASHTO T 358	N/A	22
Maximum Allowable Total Chlorides lb/yd^3	FM 5-516	0.40	

* Use cement-based materials modified with polymers and silica fume for extremely aggressive environments
** Make and cure the test specimens in accordance with ASTM C157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period.
*** As applicable
**** For pump and pour applications, the maximum flow, slump and time of setting can be adjusted according to the manufacturer's recommendation.

930-6 Material for Repair of Concrete in High Stress Concentration Areas.

930-6.1 General: This material is intended to be used to repair block-outs and voids in post-tensioned elements, load bearing area of a beam, and other locations required by the Contract Documents. This material may be used for the repair of horizontal or vertical surfaces. Follow the manufacturer's recommendations for preparing the surfaces and for mixing, placing and curing the concrete. This material shall be a magnesium ammonium phosphate based concrete (MAPC) or a magnesium potassium phosphate based concrete (MPPC).

930-6.2 Physical Properties: The MAPC and MPPC materials shall meet or exceed physical properties stated in Table 930-3 as determined by the specified standard test methods.

Table 930-3
Physical Properties of Repair Material in High Stress Areas

Requirement	Test Method	Test Value
Minimum Compressive Strength (at 28 days), psi	ASTM C109*	8,500
Minimum Flexural Strength (at 28 days), psi	ASTM C348*	600
Minimum Slant Shear Bond (at 14 days), psi	FM 5-587*	2,500
Time of Setting (Initial), minutes	ASTM C191**	15 to 60
Maximum Scaling Resistance	ASTM C672	No scaling
Maximum Length Change, %		
Allowable expansion at 28 days when water cured compared to length at one day	ASTM C157***	0.03
Allowable shrinkage at 28 days when air cured compared to length at one day		-0.03
Maximum Allowable Total Chlorides lb/yd^3	FM 5-516	0.40

* The test methods for compressive strength (ASTM C109), flexural strength (ASTM C348), and Slant Shear Bond (FM 5-587) shall be modified so that the specimens are air cured instead of moist cured. All of these samples shall be air cured until the time of testing.

** Initial time of set for MAPC or MPPC will be tested in accordance with ASTM C191 with the following modification. The initial time of set shall be tested at 95° plus or minus 5°F.

*** Make and cure the test specimens in accordance with ASTM C157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period.

930-6.3 Curing of Compressive Strength, Flexural Strength and Slant Shear Bond Specimens: The test methods for compressive strength (ASTM C109), flexural strength (ASTM C348), and Slant Shear Bond (FM 5-587) shall be modified so that the specimens are air cured instead of moist cured. All of these samples shall be air cured until the time of testing.

930-7 Special Fillers.

930-7.1 General: This material is intended to be used as filler material and for rapid repairs to pile jacket structures and other locations specified in the Plans. Meet the requirements of the contract documents for preparing the surfaces, placing, sampling, testing, and curing the concrete. Mix the material in accordance with the manufacturer's recommendations.

930-7.2 Classification: The materials to be considered under this classification shall meet the following requirements:

930-7.2.1 Cathodic Protection (CP) Filler: Provide cementitious based materials with a minimum cement content of 900 pounds of cement per cubic yard of mix. Material formulation must not contain coal ash, slag, silica fume or other mineral admixtures which may produce increased electrical resistance. The material shall not contain any substances corrosive to metals.

930-7.2.2 Non-Cathodic Protection (Non-CP) Filler: Provide cementitious based materials with a minimum cement content of 650 pounds of cement per cubic yard of mix. The material shall not contain any substances corrosive to metals.

930-7.2.3 Extended Materials: Where concrete filler materials are specified, approved mortar materials may be extended using size number 89 gradation aggregates from a certified FDOT approved source.

930-7.3 Physical Properties: The repair material shall meet or exceed the physical properties stated in Table 930-4 as determined by the specified standard test methods. If extended, materials shall meet the minimum requirements of Table 930-4.

930-7.4 Constructability: Submit to the Engineer for approval shop drawing as may be required to complete repairs in compliance with the design shown in the Plans and the manufacturer's recommended repair system.

Table 930-4
Physical Properties of Special Fillers

Requirement	Test Method	Cathodic Protection	Non-Cathodic Protection
Minimum Compressive Strength, psi			
24 hours	ASTM C39* or ASTM C109*	1,500	2,000
28 days		5,000	5,000
Maximum Length Change, %			
Allowable expansion at 28 days when water cured compared to length at one day	ASTM C157**	0.12	0.12
Allowable shrinkage at 28 days when air cured compared to length at one day		-0.12	-0.12
Allowable difference between increase in water and decrease in air		0.20	0.20
Slump (Concrete), inches	ASTM C143	7-9	7-9
Minimum Flow (Mortar), %	ASTM C1437	100	100
Time of Setting (Initial), minutes	ASTM C191* or ASTM C403*	200 to 400	200 to 400
Minimum Bond Strength by Slant Shear (at 7 days), psi	FM 5-587	450	450
Minimum Flexural Strength (at 7 days), psi	ASTM C580	700	700
Minimum Tensile Strength (at 7 days), psi	ASTM C307	200	200
Surface Resistivity (at 28 days), kohm-cm	AASHTO T 358	15 or less	22 or greater
Maximum Allowable Total Chlorides lb/yd^3	FM 5-516	0.40	

* as applicable

** Make and cure the test specimens in accordance with ASTM C157, except omit the curing period in Section 10.3; however both 11.1.1 and 11.1.2 shall apply for 28 day curing period.

SECTION 931
METAL ACCESSORY MATERIALS FOR CONCRETE PAVEMENT AND CONCRETE STRUCTURES

931-1 Reinforcement Steel (for Pavement and Structures).

931-1.1 Steel Bars:

931-1.1.1 Carbon Steel Bars: Carbon steel bars for concrete reinforcement shall conform to the requirements of ASTM A615 Grades 60 or 80.

931-1.1.2 Stainless Steel Bars: Stainless steel bars for concrete reinforcement shall conform to the requirements of ASTM A955, Grades 60 or 75; or ASTM A276, UNS S31653 or S31803.

931-1.1.3 Low-Carbon Chromium Steel Bars: Low-carbon chromium steel bars for concrete reinforcement shall conform to the requirements of ASTM A1035 Grade 100.

931-1.1.4 Special Requirements: The following special requirements shall apply:

1. Unless otherwise specified or shown in the Plans all reinforcing bars No. 3 and larger shall be deformed bars.
2. Twisted bars shall not be used.
3. Wherever in the Specifications the word “purchaser” appears it shall be taken to mean the Department.

931-1.1.5 Acceptance of Steel Bars: Acceptance of reinforcing steel shall be based on the manufacturer being on the AASHTO Product Evaluation & Audit Solutions list of compliant producers, samples taken by the Department, and manufacturer’s certified mill analysis. The test results shall meet the specification limits of the ASTM or AASHTO designation for the size, grade, and any additional requirements. The manufacturer’s certified mill analysis for each heat, size, and grade per shipment of reinforcing steel shall be provided to the Engineer prior to use.

The Engineer will select samples representing each LOT of reinforcing steel. A sample is defined as the reinforcing steel and the certified mill analysis corresponding to the sample. A LOT is defined as the weight of all bars, regardless of size, grade or pay item in consecutive shipments of 100 tons or less. Samples shall be cut from bundled steel that is shipped to the jobsite.

Projects with less than two tons of bars do not require Department sampling.

931-1.2 Wire Reinforcement:

931-1.2.1 Carbon Steel Wire Reinforcement: Plain and deformed carbon steel wire reinforcement shall meet the requirements of ASTM A1064. Deformed carbon steel wire shall be Grade 75.

931-1.2.2 Stainless Steel Wire Reinforcement: Plain and deformed stainless steel wire reinforcement shall meet the requirements of ASTM A276, UNS S30400.

931-1.2.3 Acceptance of Wire Reinforcement: Acceptance of wire reinforcement shall be based on the manufacturer’s certified mill analysis certifying that the test results meet the specification limits of the ASTM designation for the sizes and any additional

requirements. Prior to use, submit to the Engineer the manufacturer's certified mill analysis for each heat and size per shipment.

931-1.3 Carbon Steel Welded Wire Reinforcement:

931-1.3.1 Carbon Steel Welded Wire Reinforcement: Welded wire reinforcing steel shall meet the requirements of ASTM A1064.

931-1.3.2 Acceptance of Carbon Steel Welded Wire Reinforcement: Acceptance of welded wire reinforcement shall be based on the manufacturer's certified mill analysis certifying that the test results meet the specification limits of the ASTM designation for the sizes and any additional requirements. Prior to use, submit to the Engineer the manufacturer's certified mill analysis for each heat and size per shipment.

931-1.4 Couplers for Steel Bars:

931-1.4.1 Approved Product List (APL): The couplers used shall be a product included on the Department's APL.

Manufacturers seeking approval of their product shall demonstrate the performance of their product in accordance with the requirements in 931-1.4.2 through 931-1.4.4 as applicable and 931-1.4.5.

931-1.4.2 Couplers for Carbon Steel Bars: Couplers for use with carbon steel bars shall be fabricated from an alloy that is electrochemically compatible with bars that meet the requirements of 931-1.1.1.

931-1.4.3 Couplers for Stainless Steel Bars: Couplers for use with stainless steel bars shall be fabricated from an alloy that is electrochemically compatible with bars that meet the requirements of 931-1.1.2.

931-1.4.4 Couplers for Low-Carbon Chromium Steel Bars: Couplers for use with low-carbon chromium steel bars shall be fabricated from an alloy that is electrochemically compatible with bars that meet the requirements of 931-1.1.3.

931-1.4.5 Special Requirements: Couplers shall develop at least 125% of the specified yield strength of the bar being spliced.

931-2 Metal Materials for Joints in Concrete Pavement.

931-2.1 Sheet Metal Bottom Strips: For concrete pavement using the special select soil base option, the sheet metal strip for protecting the bottom and side edges of transverse expansion joints shall be composed of galvanized sheet metal of 0.0157 inches minimum thickness and shall conform to the requirements of ASTM A653.

The sheets shall be furnished in accordance with the dimensions shown in the Plans. They may be in one continuous piece, or spliced. When splicing is used the metal shall be lapped not less than 3 inches and securely fastened, by welding or otherwise, in such manner as to leave the spelter undamaged and produce a smooth sliding surface in contact with the pavement slab. The splices shall be spaced not less than 10 feet apart and not less than 5 feet from either end. The complete sheet shall not vary from a straight line by more than 1 inch from end to end.

The Contractor shall submit to the Engineer a certified mill analysis from the manufacturer of the sheet metal bottom strips including test results for thickness, dimension, grade, length, size, and spacing. Each certified mill analysis shall cover only one type of metal material for joints.

931-2.2 Bars and Chairs for Longitudinal Joints: Transverse reinforcing steel across the joint shall be deformed steel bars conforming to the requirements of 931-1.1 except that the bars may be any grade shown in ASTM A615.

These bars, and the chairs to hold them in place, shall be of the type and spacing as indicated in the Plans.

931-2.3 Dowel Bars: Dowel bars must meet the requirements of Table 931-1. They shall be of the length, size and spacing as shown in the Plans.

The Contractor shall submit to the Engineer a certified test report from the manufacturer of the dowel bars confirming that the requirements of this Section are met. The certified test report shall conform to the requirements of Section 6 and include metallurgical mill analysis, grade, length and size. Each certification shall cover only one LOT for dowel bars.

931-2.4 Chairs and Metal Expansion Caps: The chairs and metal expansion caps shall be of an approved type as shown in the Plans.

Dowel bars for expansion joints shall have a metal cap on one end so placed to provide ample space for movement of the slab. Continuous sleeves covering one half of the length of the bar will not be permitted. Other fasteners may be approved. Dowel bars shall be coated with an approved material to break the bond.

931-3 Metal Dowel Bar Assemblies for Joints in Concrete Pavement.

931-3.1 Approved Product List (APL): The dowel bars and basket assembly must meet the requirements of Table 931-1 and shall be a product included on the Department's APL.

Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6 and shall submit product photo and drawings, technical data sheets, and certifications that demonstrate the performance of their products in accordance with the requirements in 931-3.1 thru 931-3.5.

Table 931-1 Material Requirement for Dowel Bar and Basket Assemblies

Component	Base Metal	Coating
Dowel Bar	ASTM A615	ASTM A775 or SSPC Paint 20 or Epoxy ≥ 1.25% self-healing microcapsules (by weight)
Wire Basket Assembly	ASTM A1064	ASTM A775 or SSPC Paint 20 or Primer with ≥ 40% Solids (by weight) or Asphaltum Protective Coating or Modified Wax Coating or Corrosion Preventative Compound

Produce dowel bars coated in the shop. Wire basket assemblies may be coated in the shop or the field. For welded wire basket assemblies fabricated after coating, apply touch-up coating in the shop or field over all welded connections. All field applied coatings must have a volatile organic compound (VOC) content ≤ 420g/L.

931-3.2 Rigidity: The dowel bars shall be supported by an approved welded assembly possessing sufficient rigidity to hold the dowel bars in position to such accuracy that error or deviation from its required position in any bar in the entire installation after the pavement has been finished shall be no greater than 1/2 inch.

The assembly shall have continuous parallel spacer bars and two continuous parallel bearing members of no less than 1/4 inch diameter wire. One spacer bar shall be located

at or near each end of the dowel. Alternate ends of dowels shall be welded to a spacer bar in such a manner as to maintain the dowels parallel to each other and permit sliding movement in the joint.

The free ends of each dowel shall be retained securely in place by means of wire loops or metal tubes welded to the other spacer bar. An expansion cap shall be installed on one end of each bar if the dowels are being used in an expansion joint.

Suitable struts or ties shall be provided to hold the assembly in correct position during installation.

The assembly shall have an upright support welded to the spacer bar and continuous bearing member at the end of each dowel and a continuous bearing member.

If the upright support consists of a single vertical wire, the support shall be no less than 5/16 inch diameter wire. Otherwise, the support shall be no less than 1/4 inches in diameter.

931-3.3 Sand Plates: Sand plates, if required, shall be made from no less than 3/8 inch sheet steel. Each plate shall have no less than 0.1 square feet of bearing area. The plates shall be furnished in sufficient number to provide uniform support for the complete assembly. They may be furnished separate from the assembly units or attached thereto by welding, suitable clips, or other approved means.

931-3.4 Welds: The welds of the assembly shall be made securely. A broken weld will be cause for rejection of the length of section of the assembly where it occurs.

931-3.5 Assembly Placement: When the dowel bar assembly is in place, it shall act as a rigid unit with each component part securely held in position relative to the other member of the assembly.

The entire assembly shall be held securely in place during placing, consolidating, and finishing the concrete by means of metal pins. Pins used on granular subbase or cold mixed bituminous stabilized subbase shall penetrate at least 12 inches below the dowel bar assembly. The pins shall be of no less than 1/4 inch diameter wire and shall be provided with a hook or arm welded to the pin in such a manner that it shall secure the assembly in place.

Nail securing systems may be used as an anchoring device on hot bituminous stabilized subbase. The nail shall be no less than 1/8 inch in diameter, no less than 2 inches in length and the nail head or attached washer shall be not less than 1/2 inch outside diameter. The nail shall be driven through both ends of a metal strap after it has been placed around one of the lower transverse bars on the dowel bar assembly.

At least eight pins or nails shall be used for each 12 foot section (a lane width) of assembly. Sand plates, if required, shall be drilled to receive the pins.

The Contractor shall provide the equipment and personnel necessary to verify dowel bar location after the concrete is placed and has received the initial screeding.

931-4 Wire for Site Cage Machines.

The wires for site cage machines shall meet the requirements of ASTM A1064 or ASTM A706.