# INVITATION FOR BID (IFB)

# IFB NO.: FQ15155/WJG

## WASHINGTON METROPOLITAN AREA

## TRANSIT AUTHORITY

## BUS BAY, SAFETY AND ACCESS IMPROVEMENTS AT FRANCONIA SPRINGFIELD METRO RAIL STATION

## DATE: APRIL 9, 2015

## VOLUME 2

## TECHNICAL SPECIFICATIONS

**SECTION 00012**
**TABLE OF CONTENTS**



**END OF SECTION**

# SECTION 02220

# DEMOLITION

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section specifies demolition work.
   1. Related Work Specified Elsewhere:
      a. Removal of concrete and masonry walls and foundations 12 inches below existing grade: Section 02320, Grading, Excavating and Backfilling.
      b. Removal and restoration of miscellaneous facilities: Section 02320, Grading, Excavating and Backfilling.

B. Definitions:
   1. Demolition: Complete removal and disposal of existing facilities from areas to be cleared and grubbed and from other areas shown.
   2. Existing facilities include, but are not restricted to, buildings, sheds, streetcar tracks, pavements, sidewalks, curbs and gutters, signs, posts, fences, drainage, sewage, and other utility facilities located in the area to be cleared and grubbed.
   3. Salvage: Section 02320, Grading, Excavating and Backfilling.

### 1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Certification:
      a. Submit copy of request to utility companies owning or agency controlling services and appurtenances affected by demolition work for discontinuance of services along with certificates of severance.
   2. Documentation:
      a. Demolition permit from the jurisdictional agency or owner.
      b. Permits and releases from each owner of property where demolition debris will be deposited absolving the Authority of responsibility in connection with such disposal.

### 1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.

### 1.04 JOB CONDITIONS:

A. Maintenance of Traffic:
   1. Keep traffic areas free from debris and spillage of materials.
   2. When demolition work interferes with bus loading facilities, provide and maintain surfaced areas at alternative locations or arrange rerouting with appropriate authorities for duration of work.

B. Protection and Restoration:

1. Prevent damage to pipes, conduits, wires, cables and structures above and below ground which are not designated for removal. Repair or replace damaged items.

C. Exterior Dust Control:
1. To prevent unnecessary spread of dust during performance of exterior demolition work, thoroughly moisten the work surfaces and debris as required to prevent dust being a nuisance to the public, neighbors, and concurrent performance of other work on the site. Water for use in dust control shall be provided by the Contractor.

D. Protection During Demolition: Exercise care during demolition work to confine demolition operations to the areas as indicated on the Drawings. The physical means and methods used for protection are at the Contractor's option. However, the Contractor shall be completely responsible for replacement and restitution work of whatever nature at no increase in Contract Price.

E. Public Safety: If public safety is endangered during the progress of the demolition work, provide adequate protective measures to protect public pedestrian and vehicular traffic on streets and walkways.

F. Barriers: Signs, signals and barricades used shall conform to requirements of Federal, State and local laws, rules, regulations, precautions, orders, and decrees.

G. Explosives and Blasting: Not allowed in performance of demolition work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Temporary Barriers: Materials needed or required for temporary protection in the form of barricades, fences, enclosures, etc., may be pre-used construction materials of sound condition and reasonably clean. However, the condition of these materials shall meet or exceed the requirements of governing agencies or approving bodies as may be involved with the work.

B. Equipment: Equipment, machinery and apparatus, motorized or otherwise, used to perform the demolition work may be as chosen at the Contractor's discretion, but which will perform the work within the limits of the Contract requirements.

PART 3 EXECUTION

3.01 PRESERVATION OF REFERENCES:

A. Prior to removal, record location and designation of survey markers and monuments located within demolition area. Store markers and monuments during period of work. Restore survey markers and monuments upon completion of work.

3.02 REMOVAL OF PAVEMENTS, SIDEWALK, CURBS, AND GUTTERS:

A. Demolish pavement, sidewalks, curbs, and gutters within demolition area shown to underside of pavement and dispose of resulting debris. Remove and salvage stone curbing where shown.

B. Fill resulting excavations, holes and depressions to existing grade or alternative grade as shown, using fill material conforming to requirements of Section 02320, Grading, Excavating and Backfilling.

C. Adequately drain resulting surfaces.

3.03 DISPOSAL:

A. Remove debris resulting from demolition work to locations outside Authority's right-of-way.

B. Dispose of debris off site only with permission of property owner where such debris is to be deposited and in accordance with codes and regulations of the jurisdictional authorities.

C. Do not burn debris at demolition site.

3.04 BACKFILLING

A. General Requirements: Perform backfilling in the area of demolished structures (and removed items) in accordance with Section 02320, Grading, Excavating and Backfilling.
   1. Placement and Compaction: Using material specified as Backfill in Section 02320, Grading, Excavating and Backfilling; place and compact such material as specified therein.

END OF SECTION

# SECTION 02230

# SITE CLEARING

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This Section includes the following:
1. Protecting existing trees and vegetation to remain.
2. Removing trees and other vegetation.
3. Clearing and grubbing.
4. Topsoil stripping.
5. Removing above-grade site improvements.
6. Disconnecting, capping or sealing, and abandoning site facilities in place.
7. Disconnecting, capping or sealing, and removing site facilities.

B. Related Sections include the following:
1. Demolition: Section 02220.
2. Topsoil, Seeding and Sodding: Section 02920.
3. Landscaping: Section 02930.

C. Definitions
1. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than *2 inches* in diameter; and free of weeds, roots, and other deleterious materials.
2. Facility: Utility structures and system components belonging to utility company including service lines which are used to provide service to utility's customers and product which these facilities convey.
3. Utility: Company, agency, owner, or operator of facility concerned.

### 1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Documentation:
a. Permits and releases from each owner of property where debris will be deposited absolving the Authority of responsibility in connection with such disposal.

### 1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.

## PART 2 PRODUCTS

### 2.01 MATERIALS:

A. Requirements for satisfactory soil materials are specified in Section 02320, Grading, Excavating and Backfilling.

1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available onsite.

B. Standard Wood Tree Guards: As shown on W.M.A.T.A. Standard Drawing ST-C-16, consisting of the following:
   1. Wood posts: Two inches square.
   2. Wood stringers: Two inches by four inches.

C. Standard Chain-Link Tree Guards: As shown on W.M.A.T.A. Standard Drawing ST-C-16, consisting of the following:
   1. Chain-link fencing: Nine gauge, two-inch mesh.
   2. Posts: 2.7 lbs. per foot “H” or 1-1/2 inches inside diameter.
   3. Brace rails: 1-5/8 inches outside diameter.
   4. Stretcher bars: 1/4-inch by 3/4-inch.

D. Temporary Enclosures and Wrapping: Contractor's option.

E. Tree Wound Paint: Standard bituminous product.

PART 3 EXECUTION

3.01 PREPARATION:

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Provide erosion-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways

C. Locate and clearly flag trees and vegetation to remain or to be relocated.

D. Protect existing site improvements to remain from damage during construction.
   1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.02 TREE PROTECTION:

A. Erect and maintain temporary enclosures or wrappings around drip line of individual trees or around perimeter drip line of groups of trees to remain. Remove enclosures or wrapping when construction is complete.
   1. Do not store construction materials, debris, or excavated material within drip line of remaining trees.
   2. Do not permit vehicles, equipment, or foot traffic within drip line of remaining trees.

B. Protect trees shown on the drawing with standard wood or chain link tree guards.

C. Nurture protected and replaced trees, shrubs and plants during the period of this Contract.

D. Do not excavate within drip line of trees, unless otherwise indicated.

E. Where excavation for new construction is required within drip line of trees, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
   1. Cover exposed roots with burlap and water regularly.

2. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.
3. Coat cut faces of roots more than 1-1/2 inches in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
4. Cover exposed roots with wet burlap to prevent roots from drying out. Backfill with soil as soon as possible.

F. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.
1. Employ a qualified arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
2. Replace trees that cannot be repaired and restored to full-growth status, as determined by the qualified arborist.

3.03 UTILITY FACILITIES:

A. Locate, identify, disconnect, and seal or cap off facilities indicated to be removed.
1. Owner will arrange to shut off indicated facilities when requested by Contractor.

B. Existing Facilities: Do not interrupt facility service to building connections occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
1. Notify Engineer not less than two days in advance of proposed facility interruptions.
2. Do not proceed with facilities interruptions without Engineer's written permission.

C. Excavate for and remove underground facilities indicated to be removed.

3.04 CLEARING AND GRUBBING:

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal includes digging out stumps and obstructions and grubbing roots.
1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
3. Completely remove stumps, roots, obstructions, and debris extending to a depth of 18 inches below exposed subgrade.
4. Use only hand methods for grubbing within drip line of remaining trees.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated
1. Place fill material in horizontal layers not exceeding 8-inch loose depth, and compact each layer to a density equal to adjacent original ground.

3.05 TOPSOIL STRIPPING:

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.
1. Strip surface soil of unsuitable topsoil, including trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
   1. Limit height of topsoil stockpiles to 72 inches.
   2. Do not stockpile topsoil within drip line of remaining trees.
   3. Stockpile surplus topsoil and allow for respreading deeper topsoil.

3.06 REMOVAL OF TREE BRANCHES:

A. Remove tree branches which extend over structure neat lines and are less than 20 feet above top of rail or existing surface, whichever is higher.

B. Remove tree branches which create a hazardous condition.

C. Remove branches so as to present balanced appearance of tree.

D. Treat scars resulting from removal of tree branches with heavy coat of tree wound paint

3.07 SITE IMPROVEMENTS:

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.

3.08 DISPOSAL:

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials, including trash and debris, and legally dispose of them off Owner's property.

B. Dispose of debris off site only with permission of property owner where such debris is to be deposited and in accordance with codes and regulations of the jurisdictional authorities.

C. Burning and burying debris on site is prohibited.

END OF SECTION

# SECTION 02320

# GRADING, EXCAVATING, AND BACKFILLING

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section specifies grading, excavating and backfilling for structures and utility facilities.

B. Related Work Specified Elsewhere:
1. Demolition: Section 02220.
2. Erosion and Sediment Control: 02370.
3. Cast-in-Place Structural Concrete: Section 03300.

C. Definitions:
1. Grading: Shaping earth and rock through the removal or filling of earth and rock materials.
2. Earth Excavation: Excavation of materials of whatever nature, except rock as defined below.
3. Rock Excavation: Excavation of material in place which cannot be loosened or broken down by ripping using earth excavating equipment and which requires blasting or rock excavating equipment for its removal.
4. Approved Material: Earth which meets specified measurable requirements for use as embankment, fill or backfill.
5. Surplus Excavated Material: Approved excavated material which is not used in embankments or as fill on site.
6. Unsuitable Material: Material which does not meet specified requirements for use in situ or as embankment, fill, or backfill and is prohibited for use in the work.
7. Authorized Excavation: Excavating to neat lines and limits shown and specified; excavating unsuitable material.
8. Unauthorized Excavation: Excavating materials which would otherwise be left in place; excavation which is not specified as authorized excavation, such as excavation beyond neat lines and bottoms of footings as shown.
9. Excess Excavation: Excavating materials beyond or below cross section shown, as well as unavoidable over breakage in rock.
10. Controlled Low Strength Materials (CLSM): Fill.

D. Salvage:
1. Materials shown to be salvaged in accordance with the General Requirements.

### 1.02 SUBMITTALS:

A. Testing Agency Approval: Submit experience qualification of the proposed independent testing agency for approval.

B. Submit the following for approval in accordance with the General Requirements and the additional requirements as specified for each:
1. Samples:
a. Submit sample 21 days in advance of desired date of approval. Two one-cubic-foot samples are required of each material proposed for fill, backfill, and embankments.

b. Obtain, identify, and ship soil and aggregate samples in accordance with ASTM D75.

2. Documentation:
   a. Permits for disposal of excavated material:
      1) Obtain written permits and releases from owners of property where material will be deposited.
      2) Each permit and release from each property owner will absolve the Authority from responsibility in connection with such disposal of the material.
3. Certification:
   a. With samples of materials proposed for fill, backfill and embankment, submit certified test reports of tests performed by an approved Independent Testing Agency for all tests required to demonstrate compliance with specified requirements.

C. Test Reports:
1. Aggregate Material Tests: Submit testing laboratory aggregate test reports based on requirements stated under the Quality Assurance Article.
2. Compaction Density Tests: Submit compaction density test reports based on method of density determination as specified in Reference Standards and the method as approved by the Engineer.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. American Association of State Highway and Transportation Officials (AASHTO):
   a. AASHTO M147 – Standard Specification for Materials for Aggregate and Soil-Aggregate Subbase, Base, and Surface Courses.
3. ASTM International (ASTM):
   a. ASTM C33 – Standard Specification for Concrete Aggregates.
   b. ASTM D75 – Standard Practice for Sampling Aggregates.
   c. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft lbf/ft$^3$ (600 kN m/m$^3$))
   d. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (United Soil Classification System).
   e. ASTM D2922 – Standard Test Methods for Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth).
   f. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
   g. ASTM D3740 – Standard Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
   h. ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

B. Testing Agency: An agency meeting or exceeding the evaluation criteria of ASTM D 3740, Practice for Evaluation of Agencies Engaged in Testing and/or Inspection of Soil and Rock as used in Engineering Design and Construction. Additionally, the Testing Agency shall have the following required qualifications.
1. Laboratory and field testing shall be performed under the general supervision of a Registered Professional Engineer.

2. The independent testing agency shall have experience in quality control of earthwork structural fills.

C. Aggregate Material Tests: Conduct aggregate quality tests in accordance with the requirements of appropriate Referenced Standard for such materials.
1. The Engineer reserves the right to accept aggregate materials based on certification from supplier that the aggregate originates from a source approved by VDOT and that the aggregate complies with specified VDOT requirements.

1.04 JOB CONDITIONS:

A. Existing Drainage:
1. Preserve, protect, and maintain existing operable drains and sewers during grading operations.
2. Keep excavations dry.

B. Blasting:
1. Not permitted on this project.

C. Accident Prevention and Safety:
1. Perform work in accordance with specified safety requirements and PROTECTIVE DEVICES article of the General Requirements.

D. Location of Underground Facilities and Structures:
1. Locations shown for utility facilities are approximate.
2. Utility facility locations and site investigations are listed in the General Requirements.
3. Contact Miss Utility to have utilities located before beginning excavation.

E. Toxic and Combustible Substances:
1. During excavation, provide detection and testing equipment and carry out necessary tests to detect the presence of toxic and combustible substances.
2. Take action to safeguard persons and property in accordance with the rules and regulations of the jurisdictional agencies and utility owners.
3. Promptly notify utility owners when problems concerning their facilities become apparent.

PART 2 PRODUCTS

2.01 MATERIALS

A. Embankment, Fill, or Backfill Materials:
1. Composition:
a. Well-graded soil-aggregate mixture, as defined by ASTM D2487, comprised of stone, gravel, sand, silt, clay, or combinations of such materials.
b. Prohibited material: Organic matter, debris, cinders, and frozen material.
2. Additional requirements:
a. Particle size: Four inches maximum, but not exceeding one inch within one foot of finished grade.
b. Liquid limit: Forty maximum, determined in accordance with ASTM D4318.

c. Plasticity index: Ten maximum, determined in accordance with ASTM D4318.
d. Maximum dry density: Not less than 100 pounds per cubic foot.

B. Select Material: AASHTO M147, with the following gradation requirements:

| Sieve Designation | Percentage Passing By Weight |
|---|---|
| Two inch | 100 |
| One inch | 70 - 95 |
| 3/8 inch | 35 - 75 |
| Size 4 | 25 - 60 |
| Size 10 | 15 - 45 |
| Size 40 | 10 - 30 |
| Size 200 | 0 - 15 |

C. Pervious Material:
1. Natural, clean, free draining sand conforming to the requirements of ASTM C33 except the following:
a. Material passing Size 100 sieve not to exceed eight percent.
b. Material passing Size 200 sieve not to exceed five percent.
2. Drainage Material: Clean, crushed, rock, gravel, with 1-1/2 inch maximum particle size and maximum two percent by weight passing Size 4 sieve.
3. Below concrete walks and slabs: ASTM C33, Size No. 67, except maximum two percent by weight passing Size 4 sieve.

D. Impervious Material:
1. Silt-clay material minimum 35 percent by weight passing Size 200 sieve.
2. Plasticity index: 11 minimum, determined in accordance with ASTM D4318.

2.02 SOURCE OF MATERIALS:

A. Use materials for embankment, fill, or backfill from this Contract if they meet specified requirements. If sufficient material meeting these requirements is not available from this Contract, obtain material meeting specified requirements.

B. Use only material whose quality, source, and zone of placement in the fill have been approved.

C. Dress and shape borrow areas provided by the Authority to ensure positive drainage when borrow operations are completed.

PART 3 EXECUTION

3.01 EQUIPMENT:

A. Use appropriate equipment in sufficient quantity and sizes to perform the work as specified and shown.

3.02 EARTH EXCAVATION:

A. Excavate in sequences and stages as specified, and in a manner which will not impair permanent or temporary structures, installations, or surfaces.

B. Excavate to neat lines or set back lines for mixed face conditions and grades shown. If approved, slopes may be flattened as a matter of expediency.

C. Protect, support, and maintain utility facilities as specified in Section 31 34 00.

D. Proceed with caution in areas of utility facilities; expose them by hand excavation or other methods acceptable to the facility owner.

E. Control runoff so that water does not run through excavation area. Keep excavation free of water.

F. Remove excavated materials to fill, embankment, stockpile or disposal locations. Keep haul routes clean in accordance with the General Requirements.

G. Fill excess excavations with approved materials and compact as specified.

H. Unauthorized excavation for the purpose of obtaining materials for resale or for use at another job site is prohibited unless otherwise approved by the Engineer.

Fill excess excavation with concrete or other approved material.

3.03 EMBANKMENT, FILL, AND BACKFILL:

A. Place embankment, fill, and backfill in eight-inch loose layers, unless otherwise shown, for entire width so that each layer can be uniformly and properly compacted.

B. Avoid accumulation of large pieces of material at one location. Fill voids and interstices with finer materials.

C. In confined areas, use approved power-actuated compactors to achieve required density.

D. Prior to compaction, adjust moisture content of material within required limits by drying or watering either at material source or on fill.

E. Where utility facilities and structures are supported in place, use special equipment and techniques as required to achieve specified compaction under and around them.

F. When backfilling against structures, place material approximately simultaneously on both sides of structures to equalize opposing horizontal pressures.

G. When backfilling on tops of structures, place material in six-inch lifts over full area.

H. Under concrete floor and other slabs on grade, place drainage material directly on prepared subgrade which meets density and elevation requirements. Compact with hand-operated plate-type vibratory compactor.

I. Maintain embankment, fill, and backfill in stable, well-drained condition.

J. Where approved, dispose of surplus excavated material by widening embankments and flattening slopes.

K. Where pervious material will be exposed to erosion, cover it with 12-inch layer of approved impervious material compacted in place.

L. One field density determination is required for each layer of material placed.

3.04 COMPACTION ADJACENT TO STRUCTURES:

A. Compact embankment, fill, or backfill materials within five feet of retaining walls, abutments or other structures using lightweight compactors.

B. Do not overstress structures.

C. Backfilling against new structures without approval is prohibited.

3.05 EXCAVATION OF UNSUITABLE MATERIALS:

A. Remove unsuitable materials from the site.

B. Replace unsuitable material with approved material and compact as specified.

3.06 PREPARATION OF GROUND AS SUBGRADE:

A. General Requirements: Remove and replace soft, loose, and disturbed materials. Perform compaction as directed by Engineer.
   1. Do not place fill materials on surfaces that are muddy, frozen, or contain frost.
   2. Trim bottoms to indicated lines and grades to leave solid base to receive other work.

B. Where the subgrade is on original ground or in cut or where embankment or fill is less than one foot, fulfill compaction requirement for 12 inches minimum below final subgrade.

C. If necessary, scarify original ground and adjust moisture content prior to compacting.

3.07 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
   1. Construct finished subgrade to vary not more than 0.05-foot above or 0.10-foot below elevation shown.
   2. Complete embankment slopes to plus-or-minus 0.5 foot of slope line shown.
   3. Maintain moisture content of embankment, fill, or backfill material within plus- or minus three percent of optimum moisture content of material.
   4. Compact each layer of embankment, fill, or backfill to 95 percent of maximum dry density as determined in accordance with ASTM D698, at moisture content within tolerance specified, except the following:
      a. From upper surface of fill or backfill to a plane 12 inches below subbase level of vehicular pavement, sidewalks, trackbeds,, and structural foundations to 100 percent of maximum dry density at moisture content within tolerance specified.

b. In areas of 95-percent compaction where utility facilities are located in fill and are not supported on concrete cradles, compact material for a depth of one foot directly below bottom of facility to 100 percent of maximum dry density at moisture content within tolerance specified.

B. Test Method:
1. Determine the maximum dry density and the optimum moisture content in accordance with ASTM D698.
2. Determine in-place density and moisture content in accordance with ASTM D2922 and ASTM D3017 respectively, or other test methods acceptable to the Engineer.

C. Corrective Measures: Whenever tests indicate that the field moisture or density does not meet specified requirements, take corrective action as approved by the Engineer.
1. Corrective measures may include loosening the soil and wetting or drying it prior to recompaction, additional compaction, or removing and replacing the material.
2. Retest material that did not meet the moisture and density requirements after corrective measures have been performed.

D. Retesting: The Engineer may require retesting of material, whether in stockpiles or being placed, if it appears that the material differs from that which has previously been approved for use.
1. Differences that may result in retesting include, but are not limited to, differences in grain size, color, texture, plasticity, or workability.
2. In the event that such retesting indicates that the material does not meet the specified requirements, the material represented by the retest shall be removed from the work and replaced with approved material.
In the interim period between taking a retest sample and receiving the results, placement of additional material is at the Contractor's risk.

3.08 FINISHING:

A. On completion of work, clean ditches and channels.

B. Slope and shape borrow areas to provide positive drainage.

C. Remove unsuitable and surplus excavated materials to locations outside the Authority's right-of-way.

D. Leave site in neat, presentable condition.

END OF SECTION

# SECTION 02370

# EROSION AND SEDIMENT CONTROL

## PART 1 GENERAL

### 1.01 SUMMARY:

A. Section Includes: The work specified in this Section consists of the erosion and sediment control (E&S) measures for the earthwork activities as specified in various other Sections of the Project Manual.
   1. Work is fully described with applicable details on the drawings.
   2. The E&S protection measures for the Project are presented in Narrative form on the Drawings and also illustrated in Details on the Drawings.

B. Section Includes: Provisions for soil erosion and sedimentation control work as indicated on Drawings. Work is fully described with applicable details in the Soil Erosion and Sedimentation Control Plan (SE&SCP) prepared for this Project.

C. Related Sections:
   1. Demolition: Section 02220.
   2. Grading, Excavating, and Backfilling: Section 02320.
   3. Topsoil, Seeding and Sodding: Section 02920.

### 1.02 REFERENCES:

A. ASTM International (ASTM):
   1. ASTM A82; Specification for Cold-Drawn Steel Wire for Concrete Reinforcement.
   2. ASTM A615, Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   3. ASTM C97; Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone.
   4. ASTM D3776, Standard Test Method for Mass Per Unit Area (Weight) of Woven Fabric.
   5. ASTM D3786, Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics – Diaphragm Bursting Strength Tester Method.
   6. ASTM D4355, Standard Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water.
   7. ASTM D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
   8. ASTM D4533, Test Method for Trapezoid Tearing Strength of Geotextiles.
   9. ASTM D4632, Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).
   10. ASTM D4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.
   11. ASTM D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
   12. ASTM D4884, Standard Test Method for Seam Strength of Sewn Geotextiles.

B. Fairfax County Public Facilities Manual (PFM).
   1. Erosion and Sediment Control Chapter.

C. Virginia Department of Conservation and Recreation (DCR)
   1. Erosion and Sediment Control Handbook.

1.03 SUBMITTALS:

A. Furnish certificates from manufacturers of following materials, certifying their products meet requirements of these Specifications. Submit material samples if requested by the Engineer.
   1. Matting/Geotextile for Erosion Control.
   2. Filter Fabric Fence.
   3. Filter Sock Barrier.
   4. Rip-rap and bedding.
   5. Aggregates.
   6. Seeding mixtures.
   7. Precast concrete products.
   8. Filter bag pumped sediment removal and inlet protection devices.
   9. Piping

B. E&S Plan for Off-Site Spoil Area: If an off-site spoil area for excess materials is required, prepare and submit for approval a Contractor prepared E&S Plan for the off-site spoil area. Submit the plan to the Fairfax County, VA Department of Conservation and Recreation. The Contractor shall have an approved E&S Plan prior to the start of earthmoving activities.

C. Submit Erosion and Sedimentation Controls Contractor's Inspection Report as required under Project Conditions.

1.04 PROJECT CONDITIONS:

A. Environmental Requirements:
   1. The contractor is responsible for executing the form attached to the end of this Section and provide it to the Resident Project Representative on a regular basis as indicated on the form.
   2. Conform to VA DCR's Clean Fill Policy.

1.05 QUALITY ASSURANCE:

A. Conduct work in complete compliance with all rules, regulations, and requirements of the Fairfax County, VA Department of Conservation and Recreation (DCR). Assume obligation for fines and related costs resulting from failure to comply with these requirements.

B. Preconstruction Conference: Be prepared at preconstruction conference to submit for review, schedules and methods for accomplishing the approved soil erosion and sedimentation control plan. No work will be started until soil erosion and sedimentation control schedules, methods and materials have been submitted to the Engineer.

C. In case of repeated failure on part of Contractor to control erosion, pollution, or siltation, Owner reserves the right to employ outside assistance or to use own forces to provide necessary corrective measures. Such incurred direct costs plus related engineering costs will be charged to Contractor and appropriate deductions made from any moneys due or to become due him under Contract.

1.06 DELIVERY, STORAGE, AND HANDLING:

A. Delivery and Handling: Transport and handle Products, specified herein, in a manner recommended by the respective manufacturers of such, to prevent damage and defects.

B. Storage: Store Products in accordance with manufacturer's recommendations to prevent damage and contamination.

PART 2 PRODUCTS

2.01 STONE FOR RIPRAP:

A. Do not use stone for riprap protection containing boulders, or cobbles from soil or gravel deposits, earth, roots, debris or similar material. Each stone's density not to be less than 162 pounds per cubic foot, based on saturated dry specific gravity, determined in accordance with ASTM C97.

B. Provide stone that is predominantly angular and blocky in shape rather than elongated, with sharp clean edges at intersection of relatively flat faces. Following shape limitations are specified for stone used for riprap protection.
1. Not more than 25 percent of stones reasonably well distributed throughout gradation to have a length more than 2.5 times breadth or thickness.
2. Do not use stone having a length exceeding 3.0 times its breadth or thickness.

C. Stone for riprap protection obtained from an offsite source to conform to gradation requirements for Rock Lining as specified in the DCR's Erosion and Sediment Control Manual. Stone protection material may contain up to 5 percent, by weight of air dried rock, fragments, spalls, and dust with each particle weighing less than permissible minimum stone size and be defined as a stone in stone protection material. In computing percentages by weight of stones in required gradation, do not include weight of a particle weighing less than permissible minimum stone size in total weight.

2.02 BEDDING MATERIAL FOR RIPRAP:

A. Aggregate Bedding Material for Corresponding "R" Classification of Riprap is as follows:

| "R" Class | Max. Size | Avg. Size (d50) | Min. Size (d15) |
|---|---|---|---|
| R-3 | 2" | No. 4 | No. 100 |
| R-4 | 2" | No. 4 | No. 100 |
| R-5 | 2" | No. 4 | No. 100 |
| R-6 | 6.5" | 2.5" | No. 16 |
| R-7 | 6.5" | 2.5" | No. 16 |
| R-8 | 6.5" | 2.5" | No. 16 |

2.03 MATTING FOR EROSION CONTROL:

A. Erosion Control Matting: A 70 percent straw, 30 percent coconut fiber matrix sewn between a heavyweight UV stabilized top net and a lightweight bottom net with bio-degradable cotton thread. Material composition shall have the following minimum properties:
1. Material Composition: .35 lb./sq. yd. straw; .15 lb./sq. yd. Coconut
2. Acceptable Manufacturers:
a. North American Green; SC150.

b. Or equal.

B. Short Term Erosion Control Matting: A 100 percent straw fiber stitched with photodegradable thread to a lightweight, photodegradable polypropylene top net.
1. Acceptable Manufacturers:
   a. North American Green; S75.
   b. Or equal.

C. Permanent Erosion Control Matting: A 70 percent straw, 30 percent coconut fiber matrix, and a corrugated ultra heavy duty UV stabilized polypropylene netting sewn between a heavy-duty UV-stabilized polypropylene net (top and bottom). The material shall be able to withstand velocities up to 9.5 feet per second and shear stresses of 6.0 lbs per square foot without failure. Material composition shall have the following minimum properties:
1. Material Composition: 0.35 lb./sq. yd. straw; 0.15 lb./sq. yd. coconut matrix
2. Top and Bottom Netting: Heavy duty UV stabilized polypropylene
3. Middle Netting: Corrugated ultra heavy duty UV stabilized polypropylene
4. Thread: UV stabilized polypropylene
5. Acceptable Manufacturers:
   a. North American Green; SC250.
   b. Or approved equal.

D. Staples: For anchoring soil stabilizing materials provide staples of No. 11 gauge wire or heavier. Their length shall range from six to ten inches, with the longer staples used on loose, unstable soils.

2.04 EROSION AND SEDIMENT CONTROL DEVICES:

A. Straw Bale Barriers:
1. Bales: Straw stalks of threshed grain or tall hay grass stalks commercially available locally.
2. Stakes: Wood Stakes. Sound, rough sawn, red or white cedar or hardwood measuring two inches by two inches; of required length, with tapered point.
3. Reinforcement Bars: ASTM A615 (S1), Grade 60, Deformed.

B. Wire: ASTM A82.

C. Filter Fabric Fence: Fabric conforming Conform to Fairfax County PFM, DCR Erosion and Sediment Control Handbook for Notes and Detail Drawings.
1. Standard Silt Fence.
2. Reinforced Silt Fence:
3. Super Silt Fence.

D. Compost Filter Socks: Compost filter socks conforming to Fairfax County PFM, DCR Erosion and Sediment Control Handbook for Notes and Detail Drawings.

E. Rock Construction Entrance:
1. Crushed Stone - AASHTO No. 1.

F. Pumped Water Sediment Removal Pond: Materials in accordance with the Fairfax County PFM, DCR Erosion and Sediment Control Handbook for Notes and Detail Drawings.

G. Pumped Water Sediment Control Device (PWSCD):
1. Nonwoven geotextile fabric sewn with double needle machine using high strength thread.

2. Provide PWSCD with opening large enough to accommodate a 4 inch discharge hose with attached strap to tie off the hose preventing pumped water from escaping from PWSCD without being filtered.
3. Properties:

| PROPERTY | TEST METHOD | TEST RESULT |
|---|---|---|
| Weight | ASTM D3776 | 10 oz./yd. |
| Grab Tensile | ASTM D4632 | 270 lbs. |
| Puncture | ASTM D4833 | 150 lbs. |
| Flow Rate | ASTM D4491 | 70 gal./min./ft.$^2$ |
| Permittivity | ASTM D4491 | 1.3 $sec^{-1}$ |
| UV Resistance | ASTM D4355 | 70% |
| AOS % Retained | ASTM D4751 | 100 |
| Seam Strength | ASTM D4884 | 100 lbs./in. |
| All properties are minimum average roll value except the weight of the fabric which is given for information only. | | |

4. Manufacturer:
   a. ACF Environmental, Dirtbag.
   b. Or approved equal.

H. Inlet Sediment Control Device (ISCD):
1. Woven geotextile fabric sack sewn with double needle machine using high strength thread. Geotextile fabric sack to have an average wide width strength of 100 lb/in per ASTM D4884.
2. Provide ISCD manufactured to fit openings of the inlets.
3. Provide ISCD with integral dump straps, lifting loops and restraining strap.
4. Properties:

| PROPERTY | TEST METHOD | TEST RESULT |
|---|---|---|
| Grab Tensile | ASTM D4632 | 300 lbs. |
| Grab Elongation | ASTM D4632 | 20 Percent |
| Puncture | ASTM D4833 | 120 lbs. |
| Mullen Burst | ASTM D3786 | 80 psi |
| Trapezoid Tear | ASTM D4533 | 120 lbs |
| UV Resistance | ASTM D4355 | 80% |
| Apparent Opening Size | ASTM D4751 | 40 US Sieve |
| Flow Rate | ASTM D4491 | 40 Gal/Min/Sq. Ft. |
| Permittivity | ASTM D4491 | 0.55 sec-1 |

| PROPERTY | TEST METHOD | TEST RESULT |
|---|---|---|
| All properties are minimum average roll values. | | |

5. Manufacturer:
   a. ACF Environmental, Siltsack.
   b. Or approved equal.

I. Catch Basin Oil-Debris Hood: Provide hood of appropriate size and shape to cover the storm sewer pipe and conform to the interior of the drainage structure as recommended by the manufacturer. Mounting surface of the drainage structure shall be finished smooth and free of voids and/or loose material. Hood shall be constructed of a glass reinforced resin composite with iso gel coat exterior finish with a minimum 0.125 laminate thickness. Hood shall be provided with the following features:
   1. Provide watertight removable access port, 6" minimum diameter, for maintenance and inspection purposes.
   2. Provide anti-siphon vent that extends above the Hood a minimum of 3" to a maximum of 24" depending on the structure configuration.
   3. Securely attach Hood to drainage structure wall with 3/8" stainless steel bolts and oil-resistant gasket supplied by the Manufacturer.
   4. Acceptable Manufacturers:
      a. Best Management Products, Inc., The Snout
      b. Or equal.

J. Channel Inlet Protection: Materials in accordance with the Fairfax County PFM, DCR Erosion and Sediment Control Handbook for Notes and Detail Drawings.

K. Curbed Roadway Inlet Protection: Materials in accordance with the Fairfax County PFM, DCR Erosion and Sediment Control Handbook for Notes and Detail Drawings.

L. Rock Filters:
   1. Aggregate Rock - AASHTO No. 57.
   2. Rip-Rap Rock – Per paragraph 2.01.

2.05 TEMPORARY SEEDING MIXTURES:

A. As indicated on the Drawings.

| Variety of Seed | Spring<br>Mar. 1-May 15 | Summer<br>May 15-Aug. 15 | Fall & Winter<br>Aug. 15-Mar. 1 |
|---|---|---|---|
| | lb. per acre | lb. per acre | lb. per acre |
| Annual rye grass | 20 | | 40 |
| Barley or Oats<br>(local seed) | 96 | | |
| Millet (Japanese) | | 35 | |
| Annual rye grass | | 40 | |
| Winter rye or | | | 168 |

| Variety of Seed | Spring<br>Mar. 1-May 15 | Summer<br>May 15-Aug. 15 | Fall & Winter<br>Aug. 15-Mar. 1 |
|---|---|---|---|
| | lb. per acre | lb. per acre | lb. per acre |
| Winter wheat | | | 180 |

2.06 SOIL SUPPLEMENT MATERIALS:

A. As specified in Section 02920, Topsoil, Seeding, and Sodding.

2.07 MULCHING MATERIALS:

A. Mulches: As specified in Section 02920, Topsoil, Seeding, and Sodding.

B. Mulch Binding: As specified in Section 02920, Topsoil, Seeding, and Sodding.

C. Wood Chips: Wood chips, recovered from clearing and grubbing operations is acceptable as mulch for seeding and used at a rate of 35 cubic yard per acre.

PART 3 EXECUTION

3.01 INSTALLATION:

A. Bedding Material for Riprap: Place bedding material uniformly on prepared base, in a satisfactory manner, over areas to receive riprap and to a minimum thickness of 6 inches. Repair damage to surface of bedding base during placement of bedding material or riprap before proceeding with work. Compaction of bedding is not required, but finish to present a reasonably even surface, free from wounds or windows.

B. Riprap: Firmly bed each stone abutting against other stones to form a layer, with interstices filled with suitably sized spalls. Take care in placing stone so that its weight is carried by underlying material and not by adjacent stones. Surface of each stone is not to vary more than four inches from surface plane. Depths of abutting stones are not to differ by more than 4 inches. Progress by fitting additional and abutting stones with well broken joints so that most compact mass of riprap is developed.

C. Erosion Control Devices: Provide in place prior to start of construction in any area.
1. Diversion Terraces and Interceptor Terraces:
a. Provide diversion and interceptor terraces consisting of low ridges of compacted soil or earth-filled burlap bags installed in series to prevent erosive velocities from developing on long, uninterrupted slopes and to direct surface runoff away from critical, disturbed areas. Intercept runoff at each terrace, then filter through a sediment barrier and direct into a stable, non-erosive or vegetated area. Outlet ends of successive interceptor terraces should alternate from side to side of exposed Right-of-Way. Install diversion terraces prior to excavation and earth moving activities. Install interceptor terraces on sloping terrain during construction, after backfill and final grading, and prior to seeding. Construct diversion and interceptor terraces in accordance with details indicated on Drawings. Spacing and location of interceptor terraces are governed by onsite conditions in accordance with following guidelines.

| Typical Spacing for Diversion Terraces | |
|---|---|
| Slope Above Terrace (%) | Spacing (Ft.) |
| 5 - 15% | 150 |
| 15 - 30% | 100 |
| 30% or greater | 50 and provide diversion above area to divert runoff |

2. Trench Plugs:
   a. Provide temporary trench plugs at intersections between interceptor terraces and open pipeline trench to prevent unconsolidated soils from being washed down trench during periods of rainfall. Temporary trench plugs consist of eight foot long dams of compacted earth.
   b. Provide permanent trench plugs on critical slopes and on each side of creek crossings to form a solid barrier against subsurface water movement. Permanent trench plugs consist of earth filled sacks packed tightly around pipe.
3. Rock Filter: Provide where indicated on Drawings or as directed by Engineer and as indicated on the Drawings to remove sediment. Place rock to produce an even distribution of rock pieces, with minimum voids. Remove rock filter material when clogged with sediments. Filter materials shall be washed completely free of sediment, or new rock used to rebuild the filter.
4. Compost Filter Socks: Install and maintain in accordance with the Fairfax County PFM, DCR Erosion and Sediment Control Handbook.
5. Silt Barrier Fence: Install fence near limits of excavation or fills where indicated on Drawings or as directed by Engineer to control erosion until disturbed areas are permanently stabilized.
   a. Construct silt barrier fencing with Class 3 geotextile material with wire or plastic mesh support fencing fastened to support posts. Overall height of fabric above ground to be as indicated on the Drawings. Provide geotextile material of width required including a 12 inch section for embedment.
   b. Excavate a trench 6 inches wide by 6 inches deep on fabric side of barrier and along inside of post line.
   c. Install posts a minimum of 18 inches deep, by an approved method, on downstream edge of trench at a maximum spacing of 10 feet.
   d. Provide wire or plastic mesh support fence when used, of sufficient height to extend from top of fabric to ground or into excavated trench and be securely fastened to posts. Provide staples for wood posts and tie wires for steel and plastic posts, with a minimum of three fasteners per post.
   e. Secure geotextile fabric material by fasteners to top of wire mesh and posts, keeping sag to a minimum, and at a maximum spacing of 30 inches. Extend fabric 12 inches into excavated trench for embedment. Backfill and compact over geotextile material to prevent water from flowing under fabric. Overlap fabric roll ends a minimum of 6 inches at post locations.
   f. Preassembled silt barrier fence systems to be approved by Engineer. Install preassembled fence systems in accordance with manufacturer's recommendations.
   g. Construct silt barrier fence across a ditch or swale area of sufficient length to eliminate end flow, with ends pointing upstream and upslope.

h. Maintain silt barrier fence satisfactorily to keep functional. This includes removal of trapped sediment and cleaning fabric of trapped sediment by tapping fabric material when dry. Replace fabric not functioning due to clogging, damage, or deterioration as directed by Engineer.

i. Remove fencing when no longer required, as determined by Engineer. Dispose of fencing materials in a suitable manner and restore area where fence had been erected at no additional cost to Owner.

6. Pumped Water Sediment Control Device (PWSCD):
   a. Install the PWSCD on a slope. It should be placed so the incoming water flows into the bag and will flow through the PWSCD and then flow off the site without creating more erosion. The neck of the PWSCD should be tied off tightly to stop the water from flowing out of the PWSCD without going through the walls of the bag. To increase the surface area being used, the PWSCD may be placed on a gravel bed to allow water to flow in all directions.
   b. The PWSCD is considered full and should be disposed when it is impractical for the bag to filter the sediment out at a reasonable flow rate and should be replaced with a new PWSCD.
   c. Disposal may be accomplished as directed by the Engineer. If the site allows, the PWSCD may be buried on site and seeded, visible fabric removed and seeded or removed from site to a proper disposal area.
7. Inlet Sediment Control Device (ISCD):
   a. Installation and emptying instructions in accordance with manufacturers printed instructions.
8. Temporary Seeding and/or Mulching:
   a. General: Engineer reserves right to direct temporary seeding and/or mulching of disturbed areas in event permanent grading and seeding cannot be immediately performed. Include cost of temporary erosion control measures in appropriate pay item.
   b. Liming: Lime application rates will be determined on basis of tests performed by Contractor or apply a minimum of 800 pounds of agricultural lime stone per 1000 square yards.
   c. Fertilizer: Apply fertilizer at a rate of 140 pounds per 1000 square yards of 10-20-20 fertilizer or in conformance with results of soil tests performed.
   d. Tilling: Till seedbed to a depth of 3 inches prior to seeding. Lime (if required) and fertilizer may be applied during tilling operation.
   e. Seeding: Type of temporary seed mixture to be used is determined by Engineer. Sow seed at rate indicated in Temporary Seeding Mixtures Article. Cover seed with 1/2 inch of topsoil and lightly roll seeded area.
   f. Mulching: Apply hay or straw mulch at rate of three tons per acre on slopes of 1.5 to 1 or flatter. Apply asphalt material to anchor mulch at rate of 50 gallons per ton on straw or hay mulch. Apply wood cellulose fiber mulch on slopes steeper than 1.5 to 1 at a rate of 1500 pounds per acre. Wood chips, recovered from clearing and grubbing operations, is acceptable as mulch for temporary seeding. Use at a rate of 35 cubic feet per acre in lieu of straw or hay.
9. Mulching Alone: For embankments or cuts 1.5 to 1 or flatter, susceptible to critical erosion during periods of cold weather or other site conditions, Engineer may require a three ton per acre application of straw or hay mulch for temporary erosion control and later seeding. Apply asphalt for anchoring mulch at a rate of 50 gallons per ton. Straw or hay may be rolled immediately with a sheepsfoot roller to anchor mulch in lieu of using asphalt. When weather becomes favorable, seed areas provided with a mulch cover alone using normal

application rates of seed, fertilizer, and lime. If additional mulch is needed, rate of application and area to be mulched will be as determined by Engineer.

10. Matting for Erosion Control: Provide matting in lieu of mulch on slopes 3:1 and steeper or when directed by Engineer.
    a. Prepare area to be covered as a fine seedbed, fertilized and seeded. Place matting immediately and water to give a firm bond to soil and start germination of seed. Either jute or excelsior matting may be used.
    b. Jute Matting: Lay jute matting snugly to ground with a 4 inch overlap on edges and a 12 inch overlap on ends. Make check slots from a 2 foot wide strip of jute matting folded and buried in a 6 inch deep trench with a 6 inch flap extending on each side of trench. Place check slots perpendicular to water flow, tamped and stapled in place before jute matting is laid. Use check slots for jute matting when slope exceeds a 5 percent grade. On grades or slopes steeper than 5 percent, Engineer will determine spacing of check slots.
    c. Excelsior Matting: Lay excelsior matting with netting on top and fibers in contact with soil over entire area. Butt ends and sides of excelsior blanket snugly and staple. It is not necessary to dig check slots, anchor ditches, or bury ends of excelsior matting.
    d. Staples: Hold matting in place by means of wire staples driven at a 90 degree angle to soil surface. Space staples not more than 3 feet apart in three rows for each strip, with one row along each edge and one row alternately spaced in middle. Space staples 6 inches apart across matting ends and check slots width.

3.02 MAINTENANCE:

A. Begin maintenance operations immediately and continue throughout construction period until Contract is completed. Inspect sediment control structures and repair after each storm.

3.03 SOIL EROSION AND SEDIMENTATION PLAN:

A. An approved Erosion and Sedimentation Control Plan is indicated on Drawings. Should Contractor desire to modify this Plan, obtain necessary approvals prior to implementing any provisions at no additional cost to Owner.

END OF SECTION

# SECTION 02465

# AUGER CAST PILES (DRILLED SHAFT)

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section specifies the construction of auger cast-in-place pile (ACIP) piles as shown on the contract plans and as specified herein. The Contractor is responsible for furnishing all design, materials, products, accessories, tools, equipment, services, transportation, labor, and supervision, and manufacturing techniques required for design and installation ACIP piles for this project.

The Contractor shall install ACIP piles to the minimum diameter and length shown on the Drawings, utilizing methods that will provide the load capacities indicated on the project plans, without damage to existing nearby structures.

A Geotechnical Report has been prepared for this project (Geotechnical Report for WMATA Springfield – Franconia Bus Canopy Project, Springfield VA, by HSA, Inc., Project No. 11-103W, dated October 2014.

B. Definitions:
1. Auger Cast-in-Place Pile: Any foundation that is made by rotating a hollow-stem auger into the ground to the specified pile depth. Grout or concrete is injected through the auger shaft under continuous positive pressure, as the auger is being withdrawn, in order to exert a positive upward pressure on the earth-filled auger flights as well as lateral pressure on the soil surrounding the placed grout or concrete column. Reinforcing steel, as specified, is inserted into the column of fluid grout or concrete following the completion of grout or concrete placement.

C. Related Sections:
1. Concrete Reinforcement: Section 03200.
2. Cast-in-Place Structural Concrete: Section 03300.

### 1.02 REFERENCES:

A. ASTM International (ASTM):
1. ASTM C31; Standard Practice for Making and Curing Concrete Test Specimens in the Field.
2. ASTM C33; Standard Specification for Concrete Aggregates.
3. ASTM C39; Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
4. ASTM C87; Standard Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar.
5. ASTM C109; Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. [or 50 mm] Cube Specimens).
6. ASTM C143; Standard Test Method for Slump of Hydraulic-Cement Concrete.
7. ASTM C150; Standard Specification for Portland Cement.
8. ASTM C227; Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).

9. ASTM C289; Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method).
10. ASTM C295; Standard Guide for Petrographic Examination of Aggregates for Concrete.
11. ASTM C494; Standard Specification for Chemical Admixtures for Concrete.
12. ASTM C586; Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks as Concrete Aggregates (Rock-Cylinder Method).
13. ASTM C618; Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
14. ASTM C937; Specification for Grout Fluidifier for Preplaced-Aggregate Concrete.
15. ASTM C939; Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
16. ASTM C942; Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.
17. ASTM C1017; Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
18. ASTM C1090; Standard Test Method for Measuring Changes in Height of Cylindrical Specimens of Hydraulic-Cement Grout.
19. ASTM D1143; Standard Test Methods for Deep Foundations Under Static Axial Compressive Load.

1.03 PROJECT SITE SURVEY:

A. Before beginning work, the Contractor shall review the available subsurface information and visit the project site to assess the site geometry, equipment access conditions, and locations of existing structures and above-ground facilities.

B. The Contractor is responsible for field locating and verifying the locations of all utilities shown on the plans prior to starting the Work. The Contractor shall notify the Engineer of any utility locations different from those shown on the plans that may require relocation of foundation elements or modification to the structure design.

1.04 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications
   1. Special Inspections as required.

1.05 SUBMITTALS:

A. Submit the following for the Engineer's approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Qualifications:
      a. The Contractor shall be experienced in the construction and load testing of ACIP piles or shall employ a qualified Subcontractor. The Contractor shall provide documentation of a minimum of three projects performed in the three-year period preceding the bid date in which ACIP piles were installed successfully under subsurface and project conditions similar to those of the current project. The Contractor shall also provide documentation that the designated foreman or crew chief for the pile construction has had a minimum of three years of experience in supervision of the installation of ACIP piles. Drill rig operators shall be documented to have a minimum of three years experience installing ACIP piles.

b. Five copies of the completed project reference list and personnel list shall be submitted by the Contractor within 7 calendar days of receipt of award of Contract. The project reference list shall include a brief project description with the project Owner's name and current phone number. The personnel list shall identify the Contractor or Subcontractor, drill rig operator, and job site supervisor or crew chief to be assigned to the project. The personnel list shall contain a summary of each individual's experience and be complete enough for the Engineer to determine whether each individual satisfies the required qualifications. The Engineer will approve or reject the Contractor's qualifications within 7 calendar days after receipt of a complete submission.

2. Documentation:

The Contractor shall prepare a Pile Installation Plan to demonstrate, to the satisfaction of the Engineer, the dependability of the equipment, techniques, and source of materials to be used on the project. The components of the plan shall meet the requirements contained in this specification. This plan shall include, but not be limited to, the following items:

a. List and sizes of proposed equipment, including drilling rigs, augers and other drilling tools, pumps for grout or concrete, mixing equipment, automated monitoring equipment, and similar equipment to be used in construction, including details of procedures for calibrating equipment as required.
b. Step-by-step description of pile installation procedures.
c. A plan of the sequence of pile installation.
d. Target drilling and grouting parameters (along with acceptable ranges) for pile installation, including auger rotation speed, drilling penetration rates, torque, applied crowd pressures, grout pressures, and grout volume factors.
e. Details of methods of reinforcement placement, including support for reinforcing cages at the top of the pile and methods for centering the cages within the grout or concrete column.
f. Mix designs for all grout or concrete to be used on the project, including slump loss vs. time curves and strength development vs. time curves for mixes with fly ash and/or slag.
g. Equipment and procedures for monitoring and recording auger rotation speed, auger penetration rates, auger depths, and crowd pressures during installation.
h. Equipment and procedures for monitoring and recording grout or concrete pressures and volumes placed during installation.
i. Contingency plans for equipment failures during drilling or grouting operations (grout pump, monitoring equipment, etc.);
j. Other required submittals shown on the plans or requested by the Engineer.

## PART 2 PRODUCTS

### 2.01 MATERIALS:

A. Cast-in-Place concrete for Auger Cast-in-Place Piles:
1. Cast-in-Place Structural Concrete: See Section 03300
2. Portland Cement (Types I, II, & III): ASTM C150
3. Fine and Coarse Aggregate: ASTM C33, ASTM C87, ASTM C227, ASTM C289, ASTM C295, ASTM C586.
4. Mineral Admixtures (Fly Ash): ASTM C618, Class C or F

5. Water Reducing Admixtures: ASTM C494, ASTM C1017
6. Fluidifier (Fluidizer): ASTM C937
7. Reinforcing Steel: See Section 03200, Concrete Reinforcement
8. Grout Flow Testing (Flow Cone): ASTM C939
9. Grout Cube Samples: ASTM C109
10. Grout Cube Testing: ASTM C109. ASTM C942
11. Concrete Slump Testing: ASTM C143
12. Concrete Cylinder Samples: ASTM C31
13. Concrete Cylinder Testing: ASTM C39

B. Concrete Material Exceptions:
1. Type III Portland cement shall not be used when the air temperature for the 12 hours following batching will exceed 60ºF.
2. Type B fly ash shall not be used in conjunction with Type II Portland cement.

PART 3 EXECUTION

3.01 CONSTRUCTION REQUIREMENTS:

A. This specification covers the construction of 24” diameter auger cast-in-place concrete piles. The minimum capacity shown below and on the Contract drawings must be met or exceeded, without exception.
1. Allowable Pile Capacity shall at minimum, meet or exceed 30 kips compression, 15 kips uplift, +/-5 kip lateral and +/-15 kip-ft bending moment at the base of the structural steel canopy.The 24” diameter ACIP is utilized to support they canopy system. .

B. Site Preparation and Protection of Adjacent Structures:
1. Protection of Adjacent Structures: The Contractor shall be solely responsible for evaluating the need for, design of, and monitoring of measures to prevent damage to adjacent structures or underground utilities. These measures shall include, but are not limited to, selection of construction methods and procedures that will prevent over-excavation, as well as monitoring and controlling the vibrations from construction activities.

C. Grout:
1. The grout or concrete property requirements listed to follow in this section shall be determined from samples taken during ACIP pile construction.
2. Grout Mix Design: The grout shall consist of a mixture of Portland cement, fly ash, water, fine aggregate (sand), fluidifier, and if necessary, retarder, which shall be proportioned and mixed so that the grout will exhibit the following properties:
a. All solids shall remain in suspension in the grout without excessive bleed-water.
b. The grout shall be tested for fluid consistency (using a flow cone) in accordance with the modifications made to either ASTM C939, and shall be obtained as described in this specification. Flow cone outlet shall be modified from a ½ in. diameter outlet to a ¾ in. diameter outlet. A range of acceptable fluid consistency (expressed as efflux time per standard volume) shall be established, and must meet the approval of the Engineer.
c. The grout shall not exhibit shrinkage in excess of 0.15% in the vertical direction, as tested in accordance with ASTM C1090, and shall be housed in a 100 % humidity room at a temperature of 68ºF to 74ºF, or as otherwise specified by the Engineer.

d. Grout samples recovered for strength testing, as described herein, shall exhibit a minimum compressive strength 4000 psi 28 days after casting. The submitted mix design shall include curves of viscosity loss versus time. In addition, grout shall be designed so as to maintain the range of acceptable fluid consistency for a period of at least 2 hours or longer, if required by the project-specific pile installation plan.
e. Strength development versus time curves/data shall be provided, with data beyond 28 days as required for mixes that include fly ash, silica flume, or slag.

D. Concrete:
1. Concrete Mix Design: The concrete shall consist of a mixture of Portland cement, fly ash, water, coarse aggregate, fine aggregate (sand), water reducers, and if necessary, retarder, which shall be proportioned and mixed so that the concrete will exhibit the following properties:
a. All solids shall remain in suspension in the concrete mix without excessive bleed-water.
b. Concrete samples recovered for slump testing, shall exhibit a slump of 8 in ± 1 in when tested in accordance with ASTM C143.
c. Concrete samples recovered for strength testing, shall exhibit a compressive strength 4000 psi 28 days after casting.
d. The submitted mix design shall include curves of slump loss versus time.
e. Strength development versus time curves/data shall be provided for mixes that include fly ash, silica flume, or slag.

E. Field Operations:
1. All oil, rust inhibitors, residual drilling slurries, and similar foreign materials shall be removed from holding tanks/hoppers, stirring devices, pumps and lines, and all other equipment in contact with the grout or concrete before use.
2. All grout or concrete used shall be batched at an approved facility, and delivered to the project site. The addition of water at the project site is permitted only with prior approval by the Engineer and only to the extent that the water-cementitious material ratio does not exceed the ratio of the approved design mix.
3. If agitated continuously, the grout or concrete may be held in the ready mix truck for up to 2.5 hours if the air temperature is not greater than 68ºF, or up to 2 hours if the air temperature is between 68ºF and 100ºF if other than Type III Portland cement is used. Grout or concrete shall not be placed if the air temperature exceeds 100ºF or is less than 39ºF unless approved procedures for hot (over 100ºF) or cold weather (less than 39ºF) placement are followed. Grout or concrete designed with retarders to extend the holding time or placement temperature range shall be placed in accordance with the mix design parameters.
4. A screen with a mesh with openings no larger than ¾ in. for grout, or 4 in. for concrete shall be used between the delivery point from a ready mix truck and the pump, to remove large particles or cement clumps that can clog the grout or concrete injection system.
5. The grout or concrete pump shall be a positive displacement pump with a known volume per stroke that is capable of developing peak pressures of at least 350 psi at the pump. The pump shall be sized appropriately to the pile size such that a smooth, continuous delivery of grout or concrete can be

maintained while limiting the pressure variations (particularly the pressure drop) felt by the pile due to the pump strokes. The ACIP Pile Contractor shall provide the Engineer with the value of the volume of grout or concrete delivered by each stroke of the pump and shall demonstrate to the Engineer that the actual volume delivered by each stroke of the pump is within 3% of the value provided. The volume per stroke shall be recalibrated when the Engineer suspects that the grout or concrete delivery performance has changed.

6. Automatic measurements shall be made and recorded during the pile construction process. All inspection records shall be maintained.
7. The minimum value of grout pressure at the pump outlet or at the top of the auger that is required on the approved working drawings or approved pile installation plan shall be maintained for all grout or concrete placement operations throughout the project.

F. Grout or Concrete Sampling and Testing:

1. Grout or concrete samples for strength testing shall be taken from the discharge at the delivery trucks prior to pumping. Concrete samples shall be cylinders 6 in. diameter by 12 in. high, or sized appropriately for maximum aggregate size according to ASTM C39. Grout samples shall be 2 in. cubes and shall be subjected to a 10% increase in required compressive strength as compared to cylinder samples.
2. The Contractor, Testing Agency, or qualified party specified in the contract documents shall make no less than six (6) samples per working day, or less than six (6) such samples for each mix of grout or concrete produced by the supplier. Concrete or grout cylinders (or alternatively cubes for grout) shall be cured and tested in accordance with the standard specifications.
3. The samples will be tested by a certified laboratory for unconfined compressive strength. As a minimum, two (2) samples shall be tested at seven days after sampling; two (2) samples shall be tested at 28 days after sampling; and two (2) samples will be held in reserve. Those samples tested at 28 days after casting shall exhibit a minimum compressive strength as specified above for grout and concrete.
4. A grout sample shall be obtained from every truck, and shall be tested for fluid consistency (flow cone) and temperature prior to discharging into the pump hopper. The grout sample shall exhibit the fluid consistency as specified. Alternatively, if a concrete mix is used, a concrete sample shall be obtained from every truck, and shall be tested for slump and temperature prior to discharging into the pump hopper. The concrete sample shall exhibit the slump as specified. Additional samples may be required at the discretion of the Engineer at any time during the grout or concrete placing process to ensure that consistent fluidity/slump is being achieved.

G. Auger Equipment:

1. The auger flights shall be continuous from the top of the auger to the bottom tip of the cutting face of the auger, with no gaps or other breaks. Gaps in the flighting are allowed only where auger sections are joined and may not exceed 1 in. The length of any auger brought to the project site shall be such that the auger is capable of installing a pile to a depth that is 20% greater than the depth of the pile shown on the approved working drawings. The auger flighting shall be uniform in diameter throughout its length, and the outside diameter of the auger shall be at least 97% of the design diameter of the pile. Only single helix augers shall be used. The hollow stem of the auger shall be maintained in a clean condition throughout the construction operation. In order to facilitate inspection, the leads shall be clearly marked

every 1 ft along its length so that such marks are visible to the unaided eye from the ground.

2. The bottom of the auger flights and the cutting teeth attached thereto shall be constructed geometrically so that the bottom of the pile will be as flat as feasible. The grout or concrete injection port shall be fitted with a means of sealing it against ingress of water and soil during drilling.
3. The auger shall be guided at the ground surface by a guide connected to the leads of the ACIP piling rig. Where ACIP piles are installed with hydraulic, fixed mast installation platforms, and the stem to which the auger is fixed has an outside diameter 10 in. or greater, a guide above the ground surface is not required. The leads that carry the rotary unit that power the auger should be restrained against rotation by an appropriate mechanism.
4. The piling rig shall be capable of penetrating the ground without drawing surrounding soils laterally into the pile bore. It shall be capable of installing a pile to a depth at least 20% greater than the depth of the piles shown on the approved working drawings.

H. Automatic Measurement and Recording Equipment

1. As a minimum, the following automatic measurements shall be made and recorded during the drilling operation:
   a. Auger rotation;
   b. Depth of the auger injection point;
   c. Torque delivered to the auger; and
   d. Crowd force (downward thrust on auger).
2. All measurements shall be referenced to (or plotted against) the depth of the auger injection point. This shall be accomplished with a rotational position indicator on the auger head system and an electronic position indicator on the crane line or boom holding the auger. Torque and thrust load cells shall be positioned on the auger head system.
3. As a minimum, the following automatic measurements shall be made and recorded during the grouting or concreting operation:
   a. Volume of grout or concrete;
   b. Maximum and minimum grout or concrete pressure;
   c. Auger rotation (if rotated); and,
   d. Depth of the injection point.
4. All measurements shall be referenced to (or plotted against) the depth of the auger injection point. This shall be accomplished with electronic flow meters and electronic pressure transducers placed in the grout or concrete pressure line, an electronic position indicator on the crane line or boom holding the auger, and a rotational position indicator on the auger system.
5. Calibration shall be made on all measuring and recording equipment at the beginning of the project that will demonstrate that the values indicated by the measuring and recording equipment are within 3% of the values indicated. Calibrations shall be performed in accordance with the equipment manufacturer's specifications. All measuring and recording equipment shall also be recalibrated when the Engineer suspects that the drilling and grouting or concreting performance has changed.

I. Drilling:

1. The Contractor shall perform the drilling required for the piling, through whatever materials are encountered, to the dimensions and elevations required by the design, as shown on the approved working drawings. Drilling shall not commence until sufficient supply of grout or concrete is present on the project site to complete the pile.

2. The center of any pile shall be within 3 in. of the location shown on the approved working drawings in a horizontal plane (i.e., plan-view). The completed pile shall be plumb to within 2%.
3. Any pile in violation of these tolerances will be subject to review by the Engineer and may be rejected or replaced at the Contractor's expense.
4. The auger shall not be extracted from the ground at any time during the construction of a pile in such a way that would result in an open unsupported borehole or inflow of water into the pile borehole. It should become necessary to raise the auger and subsequently re-insert the auger during the pile construction process, the depth of the pile shall be increased and/or other additional measures shall be required as directed by the Engineer.
5. The auger shall be advanced into the ground at a continuous rate and at a rate of rotation that prevents excess spoil from being transported to the ground surface.
6. Pile shall be terminated at the minimum depth designated on the Contract Drawings. If refusal is encountered before planned depth is achieved, rotation of the auger shall be stopped, and the Contractor shall inform the Engineer. A penetration of less than 1ft/minute will be established as refusal. The Contractor and Engineer shall evaluate the installation data and determine if the established termination criteria have been met, or if other action is required to complete the pile. If an obstruction is encountered and it does not allow the pile to be completed in the planned location, the Contractor shall notify the Engineer in order for the Engineer to determine remedial action.
7. All earth spoils that are pushed out from the augered hole during concrete injection shall be gathered up and containerized in 55 gallon polyethylene drums, with waterproof lids. Spoils shall be considered contaminated (from exposure to petroleum-based materials), until tested. It will not be the Contractor's responsibility to test the soil. Drums will be filled and stored in a location designated by the Engineer.

J. Placement of Grout or Concrete:
1. The placement of grout or concrete shall commence within 5 minutes after the auger has achieved the planned depth. Grout or concrete shall be pumped through the hollow-stem auger with sufficient pressure (as measured at the top of the auger) as the auger is withdrawn to completely form the pile and fill any soft or porous zones surrounding the pile.
2. At the beginning of grout or concrete placement the sealing device (plug, or bottom cover plate at the tip of the auger) shall be removed by the application of grout or concrete pressure, or with a central reinforcing bar. As pumping begins, the auger shall be lifted from 6 to 12 in. to facilitate removal of the sealing device. Care shall be taken to ensure that the auger is lifted only within this specified range to initiate the flow of grout or concrete, and that water inflow and soil movement at or near the base of the auger are minimized. After withdrawing the auger to initiate the flow of grout or concrete, the tip of the auger should be re-inserted to at least the original depth.
3. The technique and equipment used to initiate and maintain the grout or concrete flow shall be such that a pile of the full design cross-section is obtained from the maximum depth of boring to the final pile cut-off level. The grout or concrete shall be supplied to the pile at a rate during auger withdrawal that ensures that a continuous monolithic shaft of at least the full specified cross-section is formed, and is free from soil inclusions or any grout or concrete segregation.

4. The auger shall be extracted at a smooth, steady rate while continuously pumping. If rotation of the auger occurs during auger extraction, it shall be positive, i.e. in the same direction as during drilling.
5. Satisfactory coordination of auger withdrawal with pumping is indicated by maintaining a positive pressure in the grout at the auger tip, and a sufficient volume or pressure of grout or concrete to fill the pile (with a small oversupply of volume). Satisfactory coordination shall be verified using automated monitoring equipment.
6. The volume of grout or concrete placed as a function of depth shall be measured and recorded at intervals not exceeding 2 ft using automated monitoring equipment. The magnitude of minimum oversupply (or grout volume factor) appropriate for the site conditions shall be established, and maintained during production pile construction. Inadequate volume pumped over a depth interval of 5 ft is a basis for rejection of the pile.
7. If placement of grout or concrete is suspended for any reason, such as equipment failure, the pile will need to be re-drilled. The pile may be re-drilled in the same location if the grout or concrete is still fluid enough for the drill rig to penetrate. If the concrete or grout has set, the pile will need to be re-drilled in a new location. The Pile Installation Plan and working drawings will need to be revised by the Contractor to reflect the changes and submitted to the Engineer for approval prior to re-drilling the pile. If the change in pile location requires a modification of the restraining anchor, such work will be at the Contractor's expense.

K. Pile Head Finishing and Protection:
1. Immediately upon completion of placement of the fluid grout or concrete, the Contractor shall remove all excess grout or concrete and spoil from the vicinity of the top of the excavation and place a suitable temporary device within the top of the excavation, extending both above and below the ground surface by at least 1 ft to keep surface spoil from entering the grout or concrete column before it sets. Immediately upon placement of this temporary device, the Contractor shall remove any and all loose soil that has fallen into the grout or concrete column, and before the grout or concrete begins its initial set. The temporary device shall be removed without disturbing the natural soil surrounding the top of the pile once the grout or concrete has set.

L. Reinforcing Steel Placement:
1. Any required reinforcing steel shall be placed as shown on the plans by lowering the steel into the grout or concrete column while it is in a fluid state. The reinforcing steel shall be free of oil, soil, excessive rust or other deleterious material.
2. The reinforcing steel shall not be spliced except at locations that are shown on the plans, and the reinforcing steel shall be free of any permanent distortion, such as bars bent by improper pickup.
3. The reinforcing steel shall be placed in the grout column immediately after screening the grout or concrete and before the grout or concrete begins to set. The steel may be lowered into the grout or concrete by gravity or pushed gently to final position by hand. The reinforcing steel shall not be vibrated, driven, or otherwise guided into position by mechanical means. The reinforcing shall be embedded to a minimum depth as shown on the Contract Drawings.
4. The reinforcing steel and associated bars to secure the piles to the future foundation shall be held in position within the fluid grout column by supports

appropriate for the reinforcement used, which shall remain in place until the grout reaches its initial set, or 24 hours, whichever is longer.

M. Pile Cut-Off:

1. Pile cut-off will not be required provided the top of the pile concrete is relatively level, free of debris such that the restraining anchor concrete will bond, and the top of the pile does not interfere with the reinforcing in the restraining anchor.

N. Inspection and Records:

1. The Contractor shall maintain accurate records for each pile constructed. Similar records will be maintained by the Engineer. These records shall show:
   a. Pile location;
   b. Ground surface elevation (reference grade for pile length);
   c. Pile toe (bottom) depth and elevation;
   d. Elevation of top of grout or concrete;
   e. Pile length;
   f. Auger diameter;
   g. Details of the reinforcing steel (number, size, and grade);
   h. Flow cone efflux time and volume of grout placed or slump and volume of concrete placed
   i. Theoretical volume of drilled hole (theoretical diameter = diameter of auger);
   j. Depth to which reinforcing steel was placed;
   k. Date/Time of beginning of drilling;
   l. Date/Time of completion of drilling;
   m. Date/Time grout or concrete was mixed;
   n. Date/Time ready-mix grout or concrete truck arrived at project site, and copies of all grout or concrete batch tickets used for the pile construction;
   o. Date/Time of beginning of grout or concrete pumping;
   p. Date/Time of completion of grout or concrete pumping;
   q. Date/Time of placement of reinforcing steel;
   r. Weather conditions, including air temperature, at time of grout or concrete placement;
   s. Identification of all grout or concrete samples taken from the pile;
   t. All other pertinent data relative to the pile installation; and
   u. All readings made by the automated measuring and recording equipment to include as a minimum:
      1) Auger rotation verses depth for every 2 ft increment, or less, of pile advancement during the drilling process, and during placement of grout or concrete (if auger is rotated during this placement);
      2) Volume of grout or concrete placed versus depth of outlet orifice for every 2 ft increment, or less, of pile placed;
      3) Average maximum and minimum pump stroke pressures at ground level for every 2 ft increment, or less, of pile placed;
      4) Average maximum and minimum pump stroke pressure at or near the auger head for every 2 ft increment, or less, of pile placed, if directed by the Engineer; and
      5) Additionally, the Engineer may also specify that torque and crowd force (downward thrust on auger) measurements be made for every 2 ft increment, or less, of pile advancement during the drilling process.

2. These data shall be provided to the Engineer within 24 hours of the completion of the pile. Data collected by automated measuring and recording equipment shall be provided in numerical or graphical form.

O. Unacceptable Piles:
1. Unacceptable piles are defined as piles that do not meet the project performance criteria with regard to load carrying capacity and deflections. The following items constitute construction conditions would be considered a basis for pile rejection:
   a. Piles for which the data from the automated measuring and recording equipment, other recording methods, or the Inspector's records indicate that a defective pile has been installed due to an inadequate penetration rates, grout/concrete volume factors or pressures, or other pile installation parameters that do not meet the criteria established by the pre-production test program.
   b. Piles out of position at the ground surface or not within the plumbness.
   c. Piles in which the top of pile elevation is outside the limits shown on the approved working drawings.
   d. Piles in which the grout or concrete strength, and/or grout or concrete factor is less than as designed.
   e. Piles in which the reinforcing steel was not inserted as designed.
   f. Piles that exhibit any visual evidence of grout or concrete contamination, excessive settlement of grout/concrete, structural damage, or inadequate consolidation of grout/concrete (honeycombing).
2. Unacceptable piles shall be replaced or repaired at the Contractor's expense, as directed by the Engineer.

P. Allowable Loads on Piles:
1. Test Piles:
   a. A minimum of 2 test piles shall be installed prior to the installation of the production piles in manner utilizing identical equipment, methods, and materials for all piling.
   b. Test piles shall be used by the Contractor to refine the operations of the equipment and shall not be installed at production pile locations.
   c. The location of the test piles shall be submitted to the Resident Engineer prior to their installation. If, in the opinion of Resident Engineer, the test pile locations shown are not representative of the area, alternate locations will be provided by Engineer.
2. Load test piles:
   a. Load tests will be performed on two (2) test piles. The data from the load test will be used to verify pile design load.
   b. Contractor shall conduct load tests in accordance with ASTM D1143 standard loading procedure. These tests will be conducted at no additional cost to the Owner. No additional piles shall be installed until test reports of test piles are received and approved by Engineer.
   c. Additional load tests or an increase in production pile length may be required if the test pile fails the load test.

END OF SECTION

# SECTION 02585

# ELECTRICAL UNDERGROUND DUCTS AND MANHOLES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes: Requirements for underground electrical work, materials and products and raceway systems.

B. Related Sections:
1. Division 02 and 03 Sections as included
2. Section 16050 Common Work Results for Electrical
3. Section 16060 Grounding and Bonding for Electrical Systems
4. Section 16082 Acceptance of Electrical Systems
5. Section 16112 Conduits for Electrical Systems
6. Section 16119 Low Voltage Electrical Power Conductors and Cables

### 1.02 REFERENCES

A. Reference Standards:
1. U. S. Government:
   a. Federal Transit Administration (FTA):
      1) 49 CFR 661 Buy America Requirements.
   b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities
   c. Codes, Regulations, Reference Standards and Specifications:
      1) Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. Federal Specifications (Fed. Spec.):
   a. Fed. Spec. FF-S-107C(2), Screws, Tapping and Drive.
   b. Fed. Spec. FF-S-325, Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry) Group II (Shield, Expansion Bolt Anchor) Type 4 (Wedge expansion anchors) Class 1 (one piece steel expander with cone taper integral with stud).
4. American Standards of Testing and Materials (ASTM): ASTM A 36, Specification for Structural Steel.

### 1.03 GENERAL REQUIREMENTS

A. Factory Tests:
1. Determine applicable soil-density relationships for underground electrical installation bedding per applicable soil tests as defined in Division 02 of the Specifications.
2. Determine soil-density relationships for compaction of backfill material as defined in Division 02 of the Specifications.

### 1.04 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of the :
1. Catalog information:
   a. Conduit. (All Types)

b. Precast Concrete Manhole and Handhole.
c. Precast Polymer Concrete Handhole
d. Manhole Frame and Cover.
e. Handhole Frame and Cover.
f. Sump Pumps.

1.05 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
1. Buy America Act :
a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

B. Regulatory Requirements:
1. Perform the Work of this Section in accordance with the requirements specified in NFPA 70, and to all other applicable state, local, and national governing codes and regulatory requirements.

C. Certifications:
1. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) for the location installed in, and the application intended, unless products meeting the requirements of these testing laboratories are not available or unless standards do not exist for the products.
2. Material and Equipment: Provide manufacturer's statement certifying that the product supplied meets or exceeds contract requirements.
a. Precast Concrete Manhole and Handhole and accessories.
b. Manhole frame and cover.
c. Precast Polymer Concrete Handhole

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Basic Electrical Materials: Those products such as building wire, connectors, fittings and similar devices as required for work of this Section are as specified in other Sections of these Specifications.

B. Provide materials and equipment listed by UL, when such equipment is listed or approved.

C. Conduit and Conduit Spacers: Conform to Section 16112, Conduits for Electrical Systems.

D. Wire and Cable: Conform to Section 16119, Low Voltage Electrical Power Conductors and Cables.

E. Grounding Material: Conform to Section 16060, Grounding and Bonding for Electrical Systems.

2.02 WATERPROOFING OF CONDUIT JOINTS

A. General: Ensure that equipment and materials for waterproofing conduit joints complies with the following manufacturers for quality, installation procedures and guaranteed end results.
   1. Rigid Metal Conduit:
      a. Thread sealant: As recommended and approved by the conduit manufacturer.
      b. Cleaning solvent: As recommended and approved by the conduit manufacturer.
   2. Non-Metallic Conduit:
      a. All weather, quick-set joint cement: Approved by the conduit manufacturer.
      b. Cleaning solvent: As recommended and approved by the conduit manufacturer.

2.03 CAST JUNCTION BOXES

A. Provide weatherproof and watertight junction boxes for flush in-ground installation where indicated on the Contract Drawings.
   1. Construction: Cast iron type with necessary boxes, checkered cover and neoprene gasket for flush mounting.
   2. Install junction box in concrete pad as detailed on the Contract Drawings.
   3. Provide box of minimum size of 8-inches x 8-inches; larger as required by the
   4. National Electrical Code, or as indicated on the Contract Drawings and/or required by the field conditions.
   5. Acceptable Manufacturers:
      a. Appleton.
      b. Crouse Hinds.
      c. Killark.

2.04 PRECAST CONCRETE MANHOLE & HANDHOLES

A. Provide precast concrete, watertight manholes/handholes as indicated on the Contract Drawings. Provide manholes/handholes complete with necessary, required and specified appurtenances such as watertight locking type covers, cable racks, pulling-in irons, ground rods and ladder and water drainage provisions.

B. Acceptable manholes/handholes manufactures as indicated on Contract Drawings or as approved equal.

2.05 PRECAST POLYMER CONCRETE HANDHOLES

A. Provide precast polymer concrete, handholes as indicated on the Contract Drawings. Provide handholes complete with necessary, required and specified appurtenances such as watertight locking type covers, cable racks, ground rods and water drainage provisions.

B. Provide precast polymer concrete handholes constructed of sand-gravel aggregate bonded together with a matted fiberglass-reinforced polymer concrete. In no assembly can the cover design load exceed the design load of the box. All covers are required to have a minimum coefficient of friction of .50 in accordance with ASTM C 1028 and the corresponding Tier Level embossed on the top surface.

C. Provide handhole a heavy duty cover suitable for driveway and parking lot application with occasional non-deliberate heavy vehicular traffic and a service load of 6800 kg over a (15,000 pounds over a 10-inch) square.

D. [Provide enclosures, boxes and covers to conform to all test provisions of the latest version of the ANSI/SCTE 77 “Specification For Underground Enclosure Integrity” for Tier 22].

E. Provide handhole with the following identification cast into the cover as appropriate for the service: "Electric", "Lighting","Telephone", "Communications", "Fiber Optics".

F. Acceptable Manufactures
1. Quazite
2. CDR Systems
3. Strongwell
4. Hubbell Enclosures

2.06 WATERPROOFING PRECAST CONCRETE MANHOLES

A. Provide asphalt compound coating of either the solvent type or the emulsion type. However, mixtures of the two types in the Project is not permitted.
1. Solvent Type: Brush or spray-on asphalt compound, cold-applied.
2. Emulsion-Type: Brush or spray-on asphalt-base, clay emulsion with fibers, cold-applied.
3. Acceptable Manufacturers:
a. W. R. Meadows, Inc.; SEALMASTIC.
b. Coopers Creek; Coopers Black.
c. Tnemec; 46-465.
d. Or Approved Equal.

2.07 SUPPORTS AND FASTENERS

A. Supporting Devices: Carbon steel angles, channels, and bars meeting material requirements of ASTM A36. Pre-engineered UL Listed supporting systems of electrogalvanized steel or electrogalvanized steel PVC coated products may be used in lieu of field fabricated support systems.

B. Fasteners: Provide anchoring devices to anchor conduit or raceway, and supporting devices or pre-engineered supporting systems, to the structure, of the type designed for the specific purpose of anchoring into structure materials at intended point of installation. RAWL PLUGS NOT PERMITTED.
1. Toggle and Expansion Bolts: Fed. Spec. FF-B-588C.
2. Self-Tapping Screws: Fed. Spec. FF-S-107C(2).
3. Conform anchoring devices for fastening into solid masonry or concrete to Fed Spec. FF-S-325 Group II, Type 4, Class 1 for expansion type anchors.

2.08 UNDERGROUND WARNING TAPE

A. Metal detectable polyester material, with minimum one-inch high lettering. Overcoated graphics to read, "CAUTION-BURIED ELECTRIC LINE" for electric lines and/or “CAUTION - BURIED TELEPHONE” for telephone lines. APWA color to be red for electric lines and orange for telecommunication or fiber-optic lines.

B. Acceptable Manufacturers:
1. Brady #91600 Series

2. Presco
3. Seton
4. Or Approved Equal

2.09 GROUNDING

A. Ground rods are to be copper clad steel with diameter adequate to permit driving full length of the rod minus 6 inches, which extends above the finished concrete slab. Conform to Section 16060, Grounding and Bonding for Electrical Systems of these Specifications.

B. Ground Wires: 600Volt, size as indicated or required by code minimum #6.

PART 3 EXECUTION

3.01 INSTALLATION

A. General Requirements: (For Underground Work)
1. Install underground conduit systems in accordance with Article 300-5 of the NEC, in accordance with previous requirements of this Section, and the following requirements exceeding NEC:
a. Perform earthwork for buried conduit as specified previously for electrical work under Division 02.
b. Install Concrete Encasement as indicated and detailed. Concrete as previously specified in Section 03300, Cast-in-Place Structural Concrete.
c. Where detailed on the Contract Drawings, underground conduits, both single and banked, concrete encase and reinforce using 5/8-inch steel reinforcing rods as indicated on the Contract Drawings.
d. Bank conduits to the extent indicated and secure same in place with install separators at 5-foot intervals. Provide separators with sufficient strength to prevent displacement of conduits when placing backfill or pouring concrete encasement.
e. Lay conduit lines to grade a minimum of three inches per 100 feet. Grade conduit lines away from buildings, except conduit lines running between buildings, without intervening handholes or manholes shall be level.
f. Where conduit lines run to manholes, handholes or similar underground structures, grade conduits to drain to such.
g. Construct underground conduit lines to be watertight. Stagger conduit couplings in banks of conduits.
h. Unless otherwise indicated on drawing or details, where conduits change direction or turn up at equipment, transformers, buildings, terminal poles, etc., use long sweep PVC coated rigid galvanized steel conduit elbows.
i. Provide two and one half feet minimum cover over conduits and over concrete encasement of conduit, unless indicated otherwise or specified.
j. Where conduits are to be turned up into equipment or transformer pads, extend the concrete encasement for the conduits up to the top of the concrete pad and provide a 3/4" chamfer around exposed top edges. Isolate the concrete encasement for the conduits from the concrete pad for the equipment or transformer pad. Provide 2" high crushable fiber materials around duct bank encasement.
k. Extend conduits 6 inches above concrete slab surface. Install insulating grounding bushing on all conduits. Perform concrete work as specified in Section 03300, Cast-In-Place Structural Concrete.

l. Where conduits are to be turned up at terminal poles, extend the concrete encasement for the conduits up pole to a height of 24 inches above finished grade and be provided with a 3/4" chamfer around all exposed top edges. Perform concrete work as specified in Section 03300, Cast-In-Place-Structural Concrete.

B. Underground Duct Bank with Concrete Encasement: Construct underground duct bank lines of individual conduits encased in concrete as indicated. Except where rigid galvanized steel conduit is indicated or specified, use only one kind of conduit in any one duct bank. Use ducts no smaller than 4 inches in diameter unless otherwise indicated. Provide concrete encasement rectangular in cross-section surrounding the bank and provide at least 3 inches of concrete cover for ducts. Separate conduit by a minimum concrete thickness of 2-inches, and maintain a separation, between conduit centerlines, of seven and one-half inches. Separate power conduits from telephone, communication and/or data highway conduits a minimum of 24 inches of earth or concrete thickness of 8 inches, unless otherwise indicated.

C. Place duct bank lines with a continuous slope downward toward manholes, handholes and away from buildings with a pitch of not less than 3 inches in 100 feet. Except at conduit risers, change direction of bends in runs exceeding a total of 10 degrees, either vertical or horizontal, by long sweep bends having a minimum radius of curvature of 25 feet. Sweep bends may be made up of one or more curved or straight sections or combinations thereof. Use only manufactured bends with a minimum radius of 18 inches for use with conduits of less than 3 inches in diameter and a minimum radius of 36 inches for conduits of 3 inches in diameter and larger. Terminate conduits in end-bells where duct bank lines enter manholes and handholes as indicated on the Contract Drawings.

D. Provide separators compatible with the conduit utilized and conforming to those specified in other Sections of these Specifications. Stagger the joints of the conduits by rows and layers so as to provide a duct bank line having the maximum strength. During construction, protect partially completed duct bank lines from the entrance of debris such as mud, sand, and dirt by means of suitable conduit plugs. As each section of a duct bank line is completed from manhole to manhole, from manhole to building or structure and/or from handhole to handhole, draw a testing mandrel not less than 12 inches long with a diameter 1/4 inch less than the size of the conduit, through each conduit, after which draw a brush having the diameter of the duct bank and stiff bristles through until the conduit is clear of particles of earth, sand, and/or gravel; immediately install conduit plugs. Provide a plastic pull rope, having a minimum of 3 additional feet at each end, in telephone and spare duct banks.

E. Backfilling: Provide a continuous plastic warning tape about 12 inches below the top of the trench directly over each underground duct bank. Conform concrete to that specified in Division 03 of this Contract. Progress backfilling as rapidly as the construction, testing and acceptance of the work permits. Ensure backfill is free from roots, wood, scrap material, and other vegetable matter and refuse. Install and compact backfill as specified in Division 02.

3.02 CONDUIT WATERPROOFING

A. Non-Metallic Conduit:

1. Plastic PVC Conduit (Schedule 40): Liberally coat the end of the conduit with an approved all weather, quick-set clear cement before joining. Insert joint into the coupling, pushing firmly and rotating conduit until it reaches the pre-formed stopping ridge within the coupling.

3.03 PRECAST CONCRETE MANHOLES & HANDHOLES

A. Provide steel bar pulling-in irons bent in the configuration of a deformed "Z" and cast in the walls and floors. Pocket pulling-in irons in the floor and center directly under the manhole cover. Locate pulling-in irons in the wall not less than 6 inches above or below, and opposite the conduits entering the manhole. Locate the pulling-in-irons such as not to interfere with the cable distribution racks. Project pulling-in-irons into the manhole approximately 4 inches. Zinc-coat irons after fabrication.

B. Ensure cable racks, including hooks and insulators, are sufficient to accommodate the cables and spaced not more than 24 inches horizontally. Provide wall bracket of glass reinforced nylon channel. Provide support brackets of glass reinforced nylon and of the removable type. Provide insulators of dry-process glazed porcelain.

C. Provide aluminum step: aluminum alloy AA designation 6061-T6. Coat that portion of aluminum step being embedded in concrete with heavy bodied bituminous paint.

3.04 MANHOLE/HANDHOLE INSTALLATIONS

A. Where openings into manholes are below final finished grade, extend openings to the required elevation with either concrete or brick suitably arranged to support or anchor the frames and covers. Obtain engineer approval of the construction method and procedure before any work is done.

B. Where required for pulling cables, furnish and install in the walls of the manholes and handholes, a sufficient number of inserts for the proper attachment of cable supports.

C. In general, properly dress and rack cable/or wire on the support arms and insulators around the walls of the manholes and handholes, providing slack where required for future rearrangements. Install cable support brackets, along with the support arms and porcelain insulators, on each wall of the manhole and handhole. Secure cables within manholes and handholes to the insulators by marlin rope. Use proper regard for neat and orderly appearance and location, and provide accessibility for future connections. Take care not to damage the walls of the manholes and handholes during cable pulling.

D. Provide each manhole with a 1 inch diameter hole in the floor for a ground rod. Provide a 3/4 inch diameter by 10 foot long copper clad ground rod installed in one corner with 6 inches of the ground rod left extended above finished floor. Ground metal work to the ground rod.

E. Conform manhole frames and covers to requirements as outlined above in these Specifications; and ensure Engineer approval.

F. Provide a manhole drainage system as indicated on the Contract Drawings.

3.05 PRECAST CONCRETE MANHOLE & HANDHOLE FRAME AND COVER INSTALLATION

A. Where required, make final adjustment of frame to elevation using materials grade rings.
   1. Set precast grade rings in Waterproof Mortar. Do not exceed 3/4-inch maximum and 3/8-inch minimum mortar thickness. Wet, but do not saturate precast grade rings immediately before laying.
   2. Precast grade ring: Pre-set to proper plane and elevation using wedges or blocks of cementation material not exceeding one spare inch wide on each side. Permit no more than four wedges or blocks per grade ring. Incorporate wedges or blocks in fresh mortar in a manner to completely encase each. Crown fresh

mortar to produce squeeze-out between grade rings. Tool exposed joints with appropriately shaped tool and compact mortar edge into joints. Clean off excess mortar prior to initial mortar set.

3. Bolt manhole frames in place on manhole top section, or on leveling units if required, after installing 2 inch thick preformed plastic sealing compound on bearing surface of manhole frame. Remove excess sealing compound squeeze-out after manhole frame is bolted in place.
4. Use bolts of sufficient length to properly pass through leveling units, if used, engage full depth of manhole top section inserts and allow enough threaded end to pass through manhole frame to properly tighten nut and washer. Tighten manhole frame bolts after mortar has cured.

3.06 PRECAST CONCRETE HANDHOLES & MANHOLES FIELD COATING

A. Clean cast-iron or steel frames, covers and gratings not buried in masonry of mortar, rust, grease, dirt and other deleterious materials by an approved blasting process, and give a coat of bituminous coating material. Clean surfaces that cannot be cleaned satisfactorily by blasting to bare metal, by wire brushing, or other mechanical means. Wash surfaces contaminated with rust, dirt, oil, grease or other contaminants with solvents until thoroughly cleaned. Immediately after cleaning, coat surface with a pretreatment coating or give a crystalline phosphate coating. As soon as practicable after the pretreatment coating has dried, prime treated surfaces with a coat of zinc chromate primer and coat with synthetic exterior gloss enamel.

3.07 WATERPROOFING PRECAST CONCRETE HANDHOLES & MANHOLES

A. Apply a specified protective coal-tar-based coating of two applied coats, minimum, to surfaces in direct contact with in ground cover to obtain a minimum 12.0 dry mil total applied surface thickness. Apply coating in strict conformance with manufacturer's requirements.

B. Application: The coating may be either shop or field applied. Apply coating to the exterior of manhole components.

3.08 CONNECTIONS TO MANHOLES/HANDHOLES

A. Construct concrete encased duct bank lines connecting to manholes or handholes to have a tapered section adjacent to the manhole or handhole to provide shear strength. Construct manholes and handholes to provide for keying the concrete envelope of the duct bank line into the wall of the manhole or handhole. Use vibrators when this portion of the envelope is poured to assure a seal between the envelope and the wall of the manhole or handhole.

3.09 CABLE DUCT BANK SHIELDS

A. Provide shields of a suitable type manufactured for the purpose where cables enter and leave manholes and handholes and other duct bank entrances.

3.10 EARTHWORK

A. Excavate to depths as required for manholes and handholes. Excavation for manholes and conform handholes to the requirements stipulated in Division 02 – Site Construction.

B. Remove waste excavated materials not required or suitable for backfill on the project from the site as directed. Provide sheeting and shoring as necessary for projection of

work and safety of personnel. Remove water from excavation by pumping or other approved method.

3.11 GROUNDING

A. Provide non-current carrying metallic parts associated with electrical equipment with a maximum resistance to solid "earth" ground not exceeding the values indicated in Section 16082, Acceptance of Electrical Systems of these Specifications.

3.12 DISSIMILAR SURFACES ISOLATION

A. Paint aluminum surfaces at point of contact with wood, concrete or masonry construction with one coat (minimum dry mil thickness - 5.0 mils) of bituminous paint.

B. Clean away excess or misplaced paint materials from aluminum surfaces and adjoining construction materials.

3.13 TEST

A. Field Tests: Field test of electrical equipment and conform systems to those specified in Section 26 05 53 of these Specifications.

END OF SECTION

SECTION 02720

BASE FOR PAVEMENTS

PART 1 GENERAL

1.01 DESCRIPTION:

A. This section specifies providing base for pavements as shown, complete in place on previously constructed subgrades.

B. Related Work Specified Elsewhere:
1. Grading, Excavating, and Backfilling: Section 02320.
2. Concrete Pavement: Section 02750.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. American
a. AASHTO M147, Standard Specification for Materials and Aggregate and Soil-Aggregate Subbase, Base, and Surface Courses.
b. AASHTO T180, Standard Specification for Moisture-Density Relations of Soils Using a 2.5 kg (5.5) Rammer and a 305 mm (12 in.) Drop.
c. AASHTO T191, Density In-Place by the Sand Cone Method.

B. Source Quality Control:
1. Not less than 10 days prior to the beginning of work, inform the Engineer of proposed source of supply of materials, for testing by the Engineer.
2. Once approved, do not change source of supply.
3. Do not construe approval as approval of the entire location but as approval only insofar as material continues to conform to specified requirements.
4. Cooperate with the Engineer so that the Engineer may take samples and make tests as often as he deems necessary.
5. The Engineer has the right to reject material at the job site by visual inspection, pending sampling and testing.

C. Certifications:
1. Buy America Act Certification:
a. In accordance with Solicitation Instruction 17 and Certification RC-114 in the Contract Specifications for this Contract, provide written certification that the products provided under this Section meet the requirements of 49 CFR 661 Buy American Act.
b. Submit the Buy America Act Certification to the Authority Representative (AR) for approval.

PART 2 PRODUCTS

2.01 MATERIALS:

A. Aggregate Base Material, General: AASHTO M147, Materials for Aggregate and Soil-Aggregate Base and Surface Courses, as amended in this section.

B. Use material which is free from frozen material.

C. Grading requirements:

| Sieve Designation | Percentage By Weight Passing Square Mesh Sieves |
|---|---|
| 2 inches | 100 |
| 1 inch | 70 - 100 |
| 3/4 inch | 60 - 95 |
| No. 4 | 40 - 75 |
| No. 10 | 25 - 65 |
| No. 40 | 10 - 45 |
| No. 200***** | 2 - 15 |

***** Fraction passing the No. 200 sieve to be not greater than 2/3 of the fraction passing the No. 40 sieve.

PART 3 EXECUTION

3.01 EQUIPMENT:

A. Place material using equipment designed for the purpose. Use equipment of size and weight necessary to shape material as shown and to compact material to specified minimum density.

B. Provide sufficient equipment to achieve specified compaction at rate consistent with rate of placement of base material.

C. Obtain approval of equipment prior to use on the work.

D. Maintain equipment in first class operating condition while in operation.

E. At the Engineers discretion, the Engineer may permit the use of graders for touching up and for working materials into areas not amenable to placing by other equipment, providing there is continuing conformance to the requirements.

F. Use approved mechanical tampers to compact material to the required density in areas that are not accessible to rollers.

3.02 PLACING MATERIAL:

A. Subgrade Preparation: In accordance with Section 02320, Grading, Excavating, and Backfilling.

B. Prior to placing the material, check the subgrade, make necessary repairs, and secure the Engineer's approval of the subgrade. Do not place on frozen subgrade. Do not dump the material directly on the subgrade.

C. Place material in its final location so as to provide uniformity of grading throughout work.

D. Use graders for touching up and for working materials into areas which do not permit use of other equipment providing there is continuing conformance to specified requirements and providing approval is obtained.

E. Place material in uniform layers so that each layer has compacted lift thickness of six inches maximum and three inches minimum.

F. Where thickness is shown or specified is more than six inches, place material in two or more layers of equal thickness so that specified requirements are met.

3.03 COMPACTION:

A. During placing and compacting, obtain moisture content and dry density within the allowable tolerances specified.

B. Compact each layer to required density before placing next layer.

C. Compact areas not accessible to rollers to required density by means of approved mechanical tampers.

D. Puddling or jetting is prohibited.

E. Density:
1. Compact material under curbs and gutters, gutters, curbs and pavement to 100 percent of maximum density at proper moisture content.
2. Compact material under sidewalks to 95 percent of maximum density at proper moisture content.

3.04 FIELD QUALITY CONTROL

A. Allowable Tolerances:
1. Construct base to the following tolerances:
   a. Thickness of base: Plus zero or minus 3/8 inch.
   b. Surface of base:
      1) Plus 1/8 inch or minus 3/8 inch of elevation shown.
      2) Deviation not more than 3/8 inch from steel straightedge.
2. Maintain moisture content within one percent of optimum moisture content.

B. Tests: Determine optimum moisture content and maximum density in accordance with AASHTO T180, Moisture-Density Relations of Soils Using a 2.5 kg (5.5) Rammer and a 305 mm (12 in.) Drop, and tested in accordance with AASHTO T191, Density of Soil In-Place by the Sand-Cone Method.

3.05 MAINTENANCE:

A. Throughout placing and compacting, and until the placing of the succeeding pavement course, maintain base for pavement in specified condition.

3.06 DEFICIENT BASES:

A. Where directed, repair or remove and replace, with new material, pavement base that does not meet requirements.

END OF SECTION

# SECTION 02750

# CONCRETE PAVEMENT

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section specifies providing Portland cement concrete pavements complete in place as shown.

B. Related Work Specified Elsewhere:
1. Base for Pavements: Section 02720.
2. Concrete Formwork: Section 03100.
3. Concrete Reinforcement: Section 03200.
4. Cast-in-Place Structural Concrete: Section 03300.

### 1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements with the additional requirements as specified for each:
1. Shop Drawings:
   a. Joint devices.
2. Certification: As specified in Section 03300, Cast-in-Place Structural Concrete, including design mixes.
3. Certifications:
   a. Buy America Act Certification

### 1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. American Association of State Highway and Transportation Officials (AASHTO): M33, M74, M81, M148, M153, M171, M182, M194, M220, M227, T51 T148.
3. FS: SS-S-164, SS-S-195, TT-P-86, TT-S-00227.
4. ASTM International (ASTM):
   a. ASTM A185, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   b. ASTM A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
   c. ASTM A615, Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
   d. ASTM C33, Standard Specification for Concrete Aggregates.
   e. ASTM C294, Standard Descriptive Nomenclature for Constituents of Concrete Aggregates.
   f. ASTM C920, Standard Specification for Elastomeric Joint Sealants.
5. Buy American Act:
   a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy American Act.

B. Concrete: Conform to quality assurance requirements as specified in Section 03300, Cast-in-Place Structural Concrete and this section.

C. Testing: Subject concrete for pavements to test procedures specified in Section 03300, Cast-in-Place Structural Concrete.

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Aggregates and Cement: As specified in Section 03300, Cast-in-Place Structural Concrete.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Do not place concrete on frozen soil base.
2. Apply joint sealer when the air temperature is 50ºF or higher.

B. Refrain from placing concrete while the temperature is lower than 40F or when by the National Weather Service forecast it may be expected to reach 40F or lower during the 24-hour period following placement of concrete.

PART 2 PRODUCTS

2.01 MATERIALS:

A. Subgrade Paper: AASHTO M74.

B. Polyethylene sheet and tape: AASHTO M171, white opaque for curing.

C. Welded Wire Fabric: Welded steel-wire fabric, ASTM A185.

D. Bituminous Paint: AASHTO M81, Grade RC-250.

E. Joint Devices: Use joint devices which are so designed that, when under the load of fresh concrete, the parts will deviate no more than 1/4 inch from the position shown and not more than 1/8 inch from the specified tolerances, and that the finish joints can be constructed to these same tolerances. Provide joint devices complete with accessories, approved supporting devices, and installing devices and equipment.
1. Tie bars: ASTM A615, Grade 60.
2. Tie rod assemblies: Tensile requirements of AASHTO M227, Grade 80 based on measured cross-sectional area of unthreaded portion of bar when tested in assembled condition in accordance with ASTM A370.
3. Dowels:
   a. Plain round bars, AASHTO M227, Grade 80 coated with paint, FS TT-P-86, Type I.
   b. Dowel sleeves in accordance with the following:
      1) Snug fit with dowel bar.
      2) Closed end.
      3) Limit stop for dowel approximately one inch from closed end.
      4) Sufficient rigidity to prevent entry of fresh concrete and collapse during construction.
4. Grease for Dowels: Approved water-resistant graphite grease.
5. Preformed joint fillers: AASHTO M153, Type II.
6. Preformed Plank: Rigid plank of asphalt hardboard or similar material approved by the Engineer.

F. Joint Sealer Materials:

1. Joint sealing compound: Materials so proportioned that joints will be satisfactorily sealed from moisture and other foreign matter. Add appropriate tinting during manufacture, if necessary, to produce a black color.
    a. Hot-poured joint sealing compound for joints in concrete pavement: FS SS-S-164 except the use of ground rubber scrap is prohibited. Ductility of not less than 40 centimeter in accordance with AASHTO T51; flow at 140F not greater than 1.0 centimeter.
    b. Cold-applied joint sealing compound for joints in concrete pavement: FS SS-S-195.
    c. Joint sealing compound for joints between concrete pavement and other structures: FS TT-S-00227.

G. Preformed joint seals: AASHTO M220.

H. Burlap: AASHTO M182, Class 3.

I. Waterproof paper: AASHTO M171.

J. White burlap-polyethylene sheet shall conform to AASHTO Designation M171.

K. Liquid Membrane Forming Curing Compounds: AASHTO M148, Type 1, resin base, wax-free.

L. Concrete: Section 03300, Cast-in-Place Structural Concrete, Class 3500, air-entrained, amended as follows:
1. Portland cement: Type I.
2. Minimum cement content: Six bags per cubic yard of concrete.
3. Maximum water content: 0.45 maximum water cement ratio.
4. Air content: 6-1/2 percent plus-or-minus 1-1/2 percent by volume.
5. Slump: 2-1/2 inches plus-or-minus 1/2 inch.
6. Water reducing admixture: AASHTO M194, Type A or D as directed.
7. Coarse aggregate:
    a. Size: ASTM C33 Size No. 67 or a combination of Size No. 4 and Size No. 67.
    b. Deleterious materials: Maximum amount of soft fragments, 2.0 percent by weight; maximum amount of coal and lignite 0.25 percent by weight; and material passing Size 200 sieve 0.5 percent by weight.
    c. Maximum abrasion loss: 40 percent by weight.
8. Fine aggregate:
    a. Deleterious material: Maximum amount of friable particles, 0.5 percent by weight; maximum amount of coal and lignite 0.25 percent by weight; material passing Size 200 sieve three percent maximum by weight.

M. High-Early-Strength Concrete: As specified for concrete and modified to produce high-early-strength concrete by one or a combination of the following methods.
1. Substitution of Type III or Type I cement in approved mix.
2. Addition of Type I cement to the approved mix, but so that the total cement does not exceed eight bags per cubic yard of concrete.
3. Addition of an approved accelerating admixture to approved mix as specified in Section 03300, Cast-in-Place Structural Concrete.

PART 3 EXECUTION

3.01 EQUIPMENT:

A. General: See General Provisions Article on equipment.
1. Provide suitable equipment in sufficient quantity and sizes to perform work as specified and shown.
2. Maintain machinery and equipment on site in first class working condition. Provide necessary tools and supplies for maintenance.
3. The term EQUIPMENT includes such specialized devices and tools that are customarily used in the construction of concrete pavements. The requirements for equipment given are not intended to be complete; rather, the intent is that characteristic equipment be used to produce certain of the required results. The suitability of the equipment is a determination made by the Engineer that the equipment will produce the required results.

B. Concrete Spreading Machines: Power driven spreaders capable of spreading concrete to the full width and depth specified as it is delivered and as follows:
1. Standard-width machines with adjustments up to five feet.
2. Controls conveniently grouped in easy reach of the operator.
3. Multiple speeds in both reverse and forward gear.
4. Capable of spreading concrete to both the depth specified for reinforcement and the full thickness of the slab, without segregation and without interfering with the joints or reinforcement.
5. Not disturbing the forms due to lateral pressure of the spreading operation; the weight of the machines of such amount and so distributed as not to cause settlement of the forms.
6. Equipped with dismountable rims to be used when operating on concrete.
7. Provided with suitable means to keep material off the wheel and the top of the forms or slab.
8. Spreading accomplished by either a screw, blade, or other suitable device of the reversing type, followed by a strike-off screed; the strike-off screed adjustable to the specified crown and section.

C. Internal Vibrators Operated Independently of Spreading or Finishing Machines: Use approved type of internal vibrators such as the spud-type, for compacting pavement concrete at joints and edges, operating at a frequency capable of producing at least 5,000 pulsations per minute, and with sufficient cable to permit being moved to any location directed by the Engineer. Do not use vibrators of such weight as to be unwieldy in application.

D. Concrete Finishing Machines:
1. Power-driven and of the transverse-screed type.
2. Equipped with traction wheel or wheels with dismountable rims to be used when operating on concrete.
3. Equipped with two screeds, maintained in the best possible condition and adjustment throughout their use: Front screed used for striking off excess concrete to exact grade and crown; the rear screed used for finishing and smoothing operation.
4. Screeds constructed of steel, be capable of being adjusted to the specified cross section, and be of such rigidity as to produce the specified crown and cross section.
5. Each screed of the floating or suspended type, at least 1-1/2 feet longer than the width between the forms, and easily and quickly adjustable to the width required.

6. Both machine and screeds are to have variable speeds and independently controlled.
7. The weight of the machines of such amount and so distributed as not to cause settlement of the forms upon which operated.
8. Provided with suitable means to keep material off the wheel and the top of the forms or slab.

E. Straightedges: Ten feet long, made of metal with handles suitable for ease of use, and rigidly constructed so that there will be no deflection exceeding 1/32 inch.

F. Templates: Constructed to extend from form to form and to ride on the form, equipped with adjustable tines spaced at six-inch intervals, and rigidly constructed that there will be no deflection exceeding 1/32 inch.

3.02 BASE:

A. Base Preparation: In accordance with Section 02720, Base for Pavements.

B. Check previously placed base for grade and crown with templates and straightedges for compliance with tolerances specified in Section 02720, Base for Pavements.

C. Correct deficiencies in grade, contour and compaction.

D. Obtain approval of base prior to placing forms and impervious material.

3.03 SETTING FORMS:

A. Unless concrete is placed against abutting structures, use steel forms to maintain concrete within required tolerance and to support paving equipment.

B. Use flexible steel forms for curve radii less than 250 feet. For small radius curves and non-standard closures, use approved wood forms. Provide properly drilled forms to accommodate tie rod assemblies.

C. Set forms accurately and firmly to line and grade throughout entire length of approved base.

D. Set forms sufficiently ahead of other work to avoid conflict during operations.

E. Concurrent with setting of forms, cover base with layer of impervious material of either subgrade paper or polyethylene sheet.
1. Subgrade paper: Overlap adjacent strips at least four inches and ends not less than 12 inches.
2. Polyethylene sheet: Overlap sides at least 12 inches.
3. Maintain cover intact until concrete is placed.

F. Apply one coat of bituminous paint to contact areas of abutting structures and previously placed slabs.

3.04 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
1. Joints and joint devices: Maximum deviation of 1/4 inch from position shown and 1/8 inch from ten-foot steel straightedge.
2. Dowels: Aligned to tolerance of not more than 1/8 inch in 12 inches.

3. Fabric reinforcement:
   a. Clearance from vertical surfaces and joints: Minus 1/4 inch or plus 1/2 inch.
   b. Clearance from top and bottom surfaces: Plus-or-minus 1/4 inch.
   c. Clearance from top surface of additional reinforcing at penetrating structures: Plus-or-minus 1/8 inch.
4. Top surface of concrete: Maximum deviation of 1/8 inch from ten-foot steel straightedge and within plus-or-minus 1/8 inch of the required elevation.
5. Grooves for joints: Within minus 1/16 inch or plus zero inch of dimensions shown.
6. Thickness of concrete pavement: Within minus 1/8 inch of the thickness shown, in accordance with AASHTO T148.

B. Testing of Concrete:
1. Conform to requirements specified in Section 03300, Cast-in-Place Structural Concrete.

3.05 JOINT DEVICES:

A. General:
1. Place and secure joint devices to ensure that deviation does not exceed specified tolerances. Finish joints to such tolerances.
2. Provide acceptable means of splicing.
3. Provide satisfactory gages for checking position of joint devices.
4. Where joints are to be completed after placing concrete, mark location of joint devices so as to permit installation of joint to tolerances specified.
5. Where options for construction are permitted, use approved method.
6. Do not disturb joint devices. Do not permit workers to step on joint devices. Realign devices immediately if displaced.
7. Hold initial installation of devices firmly in place by tap bolts installed in holes drilled in forms. If holes in forms have been formed by method other than drilling, use steel washers in addition to tap bolts. After removal of forms replace tap bolts until adjoining subgrade is ready for concrete placement. Remove tap bolts and install remainder of tie devices prior to placing adjoining slab. Apply heavy coating of bituminous paint prior to placing concrete for adjacent slab.

B. Construction.
1. Longitudinal: The longitudinal joint at a previously placed slab and the joint between a slab and abutting curb and gutter are longitudinal construction joints.
   a. For these joints, with the exception of the ones at the curb and gutter sections, use a tongue-and-groove joint of an isosceles trapezoidal section one inch in height with the bases two inches and 2-1/2 inches, respectively; with the groove located as shown.
   b. Tie the separately constructed slab sections together by the installation of longitudinal tie devices.
   c. The groove for concrete pavement for surface course may be made by forming or sawing as specified below, or by preformed plank left in place.
   d. Coat edges of the slab first constructed with heavy coat of bituminous paint prior to placing concrete for the adjacent slab.
2. Transverse joints: Make transverse construction joints only at a planned transverse expansion or contraction joint. Accordingly, have transverse construction joint devices conform to the requirements for the particular type of joint.

C. Contraction Joints:
1. Provide longitudinal contraction joints between previously placed slabs and new slabs and between slabs and abutting curbs and gutters.
a. Tie longitudinal contraction joints together by installation of 1/2-inch tie rods or tie-rod assemblies 30 inches long placed across longitudinal contraction joint and spaced as shown. Do not install tie rods or tie-rod assemblies closer than 18 inches to transverse joints.
b. Make groove for contraction joints by formwork, sawing or leaving filler in place.

D. Expansion Joints and Joint Filler:
1. Make grooves for expansion joints by forming. Where grooves are made by device, use approved device of such design that work can be properly performed.
a. Prepare preformed expansion joint filler in greatest length possible and no less than ten feet.
b. Cut filler for joints transverse to the slab in a single piece of the required shape.
c. Cut pieces for curb and gutter as directed to exact size, from larger pieces.
d. When splicing joint filler, butt tightly to prevent penetration of concrete between adjacent strips of joint filler.
e. For longitudinal joints, except at curb and gutter sections, use preformed tongue and groove filler as shown.
f. Where dowels or other approved load-transfer devices have to penetrate joint filler, properly locate and drill holes of correct size or diameter through filler at required intervals to receive bars and to achieve tight fit.
g. Make groove for cement pavement for surface course by forming, sawing, or leaving preformed joint in place.
h. Protect preformed joint filler during placing of concrete.

3.06 PLACING REINFORCEMENT:

A. Install welded steel wire fabric in flat sheets where shown in accordance with Section 03200, Concrete Reinforcement.

B. Unless otherwise noted, use wire fabric as follows:

| Slab Thickness (Inches) | Roadway Width | |
|---|---|---|
| | Equal to or less than 24'-0" | Greater than 24'-0" |
| | Pounds/100 Square Feet | Pounds/100 Square Feet |
| 6 | 44 | 46 |
| 8 | 51 | 54 |
| 10 | 61 | 69 |

C. Place wire fabric to clear vertical surfaces and joints by two inches and within tolerances specified. Lap sheets distance equal to spacing of wires and tie securely.

D. Place two layers of wire fabric in concrete pavements over trench cuts, each layer to be of weight and type as specified for thickness of concrete. Position each layer two inches clear of top and bottom surfaces of slab and within tolerance specified. Extend each layer nine inches beyond sides of trench.

E. Where other structures, such as manholes, penetrate concrete pavements, place wire fabric on one inch centers in each direction so that there is a minimum of two feet of fabric extending horizontally around perimeter of structure. Install layer of fabric one inch clear of top surface of slab and within tolerance specified.

F. In surface courses, place wire fabric two inches clear of top surface of slab and within tolerance specified.

G. Install layer of wire fabric to serve as top layer over trenches. Install additional fabric around penetrations.

H. Except for pavements over trench cuts and around penetrations, do not place wire fabric in base course.

3.07 PLACING CONCRETE:

A. Supply and place Portland cement concrete as specified in Section 03300, Cast-in-Place Structural Concrete, with the following additional requirements:
1. Place concrete only during daylight unless otherwise approved. If placement is authorized during darkness, provide adequate lighting system.
2. Do not place concrete at temperatures below 40F unless otherwise approved; nor place concrete on a frozen base.
3. Prior to placing concrete around poles, manholes or other structures projecting through pavement, coat such structures heavily with bituminous paint.
4. Place concrete to the full thickness, deposited in successive batches for full width of slab by means of discharging device which does not cause segregation of materials.
5. Compact concrete thoroughly during placement.
6. Place concrete mechanical spreaders except where hand methods for spreading are approved. When spreading by hand, employ sufficient work force for leveling, spading and spreading concrete in front of screed. Do not use rakes for handling concrete.
7. Deposit concrete as near as practicable to joints but not touching expansion and contraction joint devices. Shovel concrete to height approximately two inches more than depth of the joint. As soon as forms are removed, clean ends of expansion joints of concrete and expose full width of preformed joint filler for full depth of slab. Place concrete against previously constructed slabs only after ends of preformed joint filler have been so cleaned and ends of performed joint filler in slab being poured have been neatly and firmly butted.
8. Where wire fabric is required, place concrete in layers so that wire fabric may be properly placed. Requirements for machine placing and for vibration apply for each layer. Place layers and wire fabric, large wires running in longitudinal direction in such rapid sequence that monolithic slab will result.
9. Compact concrete both by internal and surface vibration. Vibrators may be combined with spreading and finishing machines. Compact concrete adjacent to forms, joints, existing concrete or other structures by use of spud vibrator. Insert vibrator in concrete and work along entire length. Avoid contact with joint devices or underlying base. Evidence of honeycomb or lack

of compaction constitute basis for rejection of concrete pavement as deficient.

10. Construction Joints:
    a. Form construction joints where it is necessary and approved to stop concreting for 30 minutes or longer, by staking in a bulkhead and finishing the concrete to the bulkhead.
    b. If, due to an emergency, concreting must be stopped within less than ten feet of a previously formed joint of any type, remove the concrete to the joint prior to resuming the placing of the slab.

3.08 INITIAL FINISHING, FLOATING, AND FINAL FINISHING:

A. Give concrete initial finish by use of finishing machines operated so as to minimize formation of laitance and to give required uniformity of surface and compaction. Remove laitance in approved manner.

B. Avoid prolonged operation over a given area. Operate the machine over each area of pavement as directed and only as many times and at such intervals as required to give the proper compaction and uniformity of surface.

C. Keep tops of forms clean to permit true and accurate movement of machine.

D. On completion of screeding, bring surface to smooth finish by use of floats, eight inches wide and a minimum of four feet long, with handles at least four feet longer than width of slab and not less than 16 feet long.

E. Operate float transversely with combined longitudinal and transverse motion for sufficient number of passes to smooth ridges and fill depressions.

F. On completion of floating operations, screed top surface of concrete with deviation not exceeding 1/8 inch from straightedge and within tolerance specified for required elevation. Correct deficiencies by handwork if approved.

G. After floating and verifying that surface is within specified tolerances, drag surface in longitudinal direction with longitudinal and crosswise motions using burlap so to prevent edges digging into surface of concrete or working crown out of pavement.

H. Brooming:
    1. Upon completion of burlap dragging, broom finish top surface of pavement. Use street brooms made for the purpose with split bamboo bristles or metal bristles.
        a. Broom width: 14 inches.
        b. Broom handle: At least one-half slab width.
    2. In general make brooming perpendicular to centerline of paving unless otherwise shown. Prior to brooming, obtain the Engineer's approval of the direction of brooming for each area.
    3. Pull broom gently over surface of pavement from edge to edge walking back and forth on bridge over pavement, holding handle almost vertical and allowing broom to drag lightly over surface without interruption, leaving slight ridges in concrete perpendicular to centerline of pavement.
    4. Overlap ridging. Ridging not more than 1/8 inch in depth with corrugations of uniform character and width.
    5. Complete brooming before rounding edges of pavement and joints.

I. Round joints and edges to ¼-inch radius unless shown otherwise on the drawings.

J. To form flow line for gutters, trowel smooth 12-inch width of pavement adjacent to curbs unless otherwise shown.

K. Joint Work and Edging: Where there is an option of method for doing joint work, secure approval for the method elected and use only that method.
1. Perform joint work and edging when condition of concrete permits.
2. Ensure that joints are within tolerances specified and that there is no perceptible lip or depression other than rounding.
3. Prepare clean grooves rounded to 1/4-inch radius with smooth even walls.
4. Make grooves for expansion joints by forming. See requirements above for expansion joints.
5. For joints to be sealed with poured sealer, prepare grooves with dimensions as shown and within tolerance specified. For joints to be sealed with preformed elastomeric seals, leave grooves of dimensions and within tolerances shown. Provide suitable gauges for checking dimensions.
6. Where joints in surface course are sealed with cold-poured joint sealer, break bottom bond by placing polyethylene tape full width of groove, laid flat along top of preformed joint filler prior to joint sealing.
7. When using hot-poured or cold-applied joint sealer, use only equipment designed for purpose. Hand-pouring pots are prohibited. Maintain material within temperature range recommended by manufacturer. Apply sealer when air temperature is as specified. Construct so that resulting stripe is straight, neat, of uniform width and joint is filled to 1/4 inch from top surface of pavement.
8. When placing elastomeric joint seals, use equipment and methods recommended by manufacturer.

3.09 CURING:

A. Allow finished concrete to cure by one of the following methods for seven days or until concrete has developed flexural strength of 500 psi:
1. Wet burlap: Cover pavement with double thickness of thoroughly wet burlap, overlapping adjacent sheets by at least six inches. Maintain burlap in saturated state by sprinkling until it is removed. Use only clean material free from holes.
2. Waterproof paper, polyethylene sheet or white burlap-polyethylene sheet: Place material so that adjacent sheets overlap by at least 12 inches. Secure material alongside and ends so as to maintain reasonably airtight seal.
3. Use approved liquid-membrane curing compounds as recommended by manufacturer, using equipment designed for purpose.

B. Obtain approval of the Engineer for the curing method elected and use only that method.

3.10 REMOVAL OF FORMS:

A. Remove forms as soon as condition of concrete permits, but in no case sooner than 12 hours after placement.

B. When the temperature is below 40F, leave forms in place for at least 48 hours or as directed.

3.11 COLD WEATHER CONSTRUCTION:

A. Whenever, by the National Weather Service forecast for the locality, the temperature may be expected to reach 50F or lower during the 24-hour period following placement concrete mix, include a Type C accelerating admixture in the concrete mix as specified in Section 03300, Cast-in-Place Structural Concrete. The accelerating admixture shall comply with AASHTO M 194, Type C, except that it shall contain no more than 500 parts per million chloride ion.

B. Place concrete when temperature conditions are as specified, unless otherwise directed. If placing of concrete is so directed, in addition to adding an accelerator heat aggregates, water or both, so that mix when laid is not less than 55F nor more than 90F. Do not exceed 140ºF for mixing water and 150F for aggregates.

C. As soon as concrete has hardened sufficiently to prevent marring, cover pavement surface and edges with dry burlap, building paper or other approved material and subsequent layer of at least six inches of dry hay, straw, or other approved material. Maintain such protection for at least three days or until field tests indicate that concrete has attained required strength.

D. During low temperatures, install truck-mixed concrete immediately upon delivery.

E. When temperature by National Weather Service forecast will be 40F or lower during the 72-hour period following placement of concrete, do not use membrane curing compound.

3.12 HOT WEATHER CONSTRUCTION

A. When by National Weather Service forecast, temperature will be 90F or higher during the 24-hour period following placement of concrete, cover pavement by wet-burlap method for first 24 hours, after which curing may be completed by one of the specified methods.

3.13 PROTECTION OF CONCRETE PAVEMENT

A. Obtain approval prior to permitting use of completed pavement by public and construction traffic.

3.14 DEFICIENT PAVEMENT

A. Where directed, remove and replace with new materials or correct concrete pavement that does not meet requirements.

END OF SECTION

SECTION 02760

PAVEMENT MARKINGS

PART 1 GENERAL

1.01 DESCRIPTION:

A. This section specifies providing pavement markings and striping.

1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Samples:
      a. Paint: One quart of each color.
      b. Spheres: Two pounds.
      c. Thermoplastic compound: Ten pounds of each color.
      d. Preformed plastic markings: Five each of plain and reflective, each three inches wide by one-foot long.
   2. Certification.
      a. Buy America Act Certification

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. American Association of State Highway and Transportation Officials (AASHTO):
      a. AASHTO M249-79.
   3. U.S. Department of Transportation (USDOT)/Federal Highway Administration (FHWA):
      a. Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD).
   4. Federal Test Method Standard 141.
   5. FED STD: 595.
   6. FS: TT-P-85, TT-B-1325.
   7. ASTM International (ASTM):
      a. ASTM D638, Standard Test Method for Tensile Properties of Plastics.

B. Buy America Act:
   1. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Deliver materials in factory-sealed containers plainly marked as follows:
   1. Manufacturer's name and address.
   2. Location of plant.
   3. Material.
   4. Color of material.
   5. Amount of contents.
   6. Date of manufacturer and lot number.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Traffic zone paint:
a. Apply only when ambient air temperature is above 40F and temperature of surface to be painted is above 45F.
b. If pavement is wet, allow surface to dry for eight hours minimum after surface appears dry.
c. Do not apply glass spheres in strong windy conditions.
2. Extruded thermoplastic compound:
a. Apply by extrusion at 400F minimum, 440F maximum, when air temperature is more than 35F and pavement temperature is above 50F.
b. If pavement is wet, delay application until the pavement has been exposed to at least two hours of direct sunlight after surface appears dry.
3. Preformed plastic traffic markings:
a. Apply on dry pavement when ambient temperature and temperature of pavement surface is above 60F.
b. When temperature of pavement surface is less than 60F and when approved, apply surface heating to degree necessary for application of plastic marking.

B. Protection:
1. Provide traffic protective devices and methods of protection to comply with requirements of the jurisdictional authorities.
2. Provide and maintain traffic cones, barricades, lights and other protective devices necessary to protect traffic, workmen and completed pavement marking and striping. Remove such devices when marking and striping, including painted sections of curbing and raised traffic bars, have sufficiently cured for intended use.

PART 2 PRODUCTS

2.01 MATERIALS:

A. Traffic Zone Paint:
1. Primer: If recommended by paint manufacturer or required by jurisdictional authorities, type as recommended by paint manufacturer.
2. Paint: Traffic, FS TT-P-85, white and yellow.

B. Glass Beads: Retroreflective glass spheres, FS TT-B-1325, with the following additional gradation requirements:

| US Sieve Size | Percentage Passing |
|---|---|
| 40 | 100 |
| 50 | 80 - 100 |
| 80 | 35 - 80 |
| 100 | 20 - 50 |
| 200 | 0 - 15 |

C. Extruded Thermoplastic Compound: Hot-applied alkyd thermoplastic per AASHTO M249-79 and as follows:

1. Thermoplastic compound:
   a. Mixture of thermoplastic resins and other substances compounded for use in traffic markings which, when extruded hot in place and cooled to ambient temperature, will produce stark white or yellow reflective marking stripe.
   b. Permanently white or yellow, without blemish or discoloration, with straight, clean cut, sharply defined, parallel edges and of uniform cross section.
   c. Shaped to minimize tire impact and adhere permanently to road.
   d. Set to solid, non-tacky, non-slippery line of sufficient elasticity to resist cracking and chipping caused by weather and temperature changes, traffic action, as well as pavement crawl and lift in freezing weather.
   e. After curing, does not react with nor deteriorate in contact with snow removal chemicals, oil and other substances common to roadway surfaces.
   f. Chemically stable and emitting no dangerous fumes.
   g. Especially compounded for traffic markings, with no change in color and brightness characteristics after prolonged exposure to sunlight.
   h. No breakdown or deterioration when held at plastic temperature for extended periods of time nor when repeatedly reheated to plastic temperature.
   i. No change in temperature versus viscosity characteristics through repeated reheatings and from batch to batch.
2. White thermoplastic compound:
   a. Pure white, free from dirt or tint after drying.
   b. Maximum allowable compound deviations from magnesium oxide standard when tested by standard color difference meter, Gardner Color Difference Meter, Gardner Laboratories, Inc. Bethesda, Maryland or equal, with the following minimum requirements:

| Scale | Definition | Magnesium Oxide Standardized | Sample |
|---|---|---|---|
| Rd | Reflectance | 100 | 70 minimum |
| A | Redness – Greenness | 0 | Minus 5 to plus 5 |
| b | Yellowness – Blueness | 0 | Minus 10 to plus 10 |

   c. The white compound pigment containing not less than six-percent titanium dioxide ($TiO_2$).
3. Yellow thermoplastic compound:
   a. After drying, yellow, FED STD 595, Color 33538, tested in accordance with Federal Test Method Standard 141, Method 4252.
   b. Pigmented binder well dispersed and free from skins, dirt, foreign objects, or ingredients that will cause bleeding, staining, or discoloration, and consisting of mixture of non-drying synthetic resins, at least one of which is solid at room temperature.
   c. Total binder content of thermoplastic compound: 15-percent minimum, 35-percent maximum by weight.
   d. Filler incorporated with resins or binder: White calcium carbonate with compressive strength of 5,000 psi.

D. Preformed Plastic Traffic Markings:
1. Composed of preformed plastic, smooth on top surface, undersurfaces factory-coated with pressure-sensitive adhesive coating overlaid with protective paper, polyethylene, or other suitable material which remains in place until plastic is ready for application to pavement.
2. Plain or reflectorized.
3. White or yellow.
4. Composition:
   a. Non-reflectorized plastic material: Consisting of basic plastic and plasticizers, 50-percent minimum by weight.
   b. Reflectorized plastic material: Consisting of 40-percent minimum by weight of basic plastic and plasticizer and 30-percent minimum by weight of clear, reflective glass spheres, thoroughly and uniformly dispersed throughout plastic.
5. Pigmentation:
   a. White plastic markings: Pure white, free from tint, and containing not less than six-percent titanium dioxide.
   b. Yellow plastic markings: Yellow, FED STD 595, Color 33538, Federal Test Method 141, Method 4252.
   c. Uniform coloring throughout cross section of plastic.
6. Low-temperature stress resistance: No indication of breaking, chipping or cracking when sample of specified thickness is abruptly bent to right angle after being immersed in water at 32F for 30 minutes.
7. Resistance to wear: Endure not less than 2,500 cycles of a Taber Abraser, using CS-17 wheels under a load of 1,000 grams, when each 0.001-inch thickness of plastic is tested at 21 C.
8. Tensile strength: Non-reflectorized markings not less than 1500 psi; reflectorized markings not less than 750 psi when tested in accordance with ASTM D638.
9. Bond strength: Withstand 50-pound static shear load for 15 seconds average at 21 C before complete parting of bond when pair of two-inch wide strips are overlapped two inches and adhesive faces placed together.

## PART 3 EXECUTION

### 3.01 FIELD QUALITY CONTROL:

A. Layout of Work:
1. Lay out lane widths, parking spaces, and crosswalks in accordance with regulations of jurisdictional authorities and as shown.

B. Letters and Symbols:
1. Unless otherwise shown or specified, apply letters, directional arrows, and other pavement markings of size and configuration in accordance with referenced USDOT/FHWA Manual on Uniform Traffic Control Devices for Street and Highways.
2. Apply letters, directional arrows, and other markings in color shown.

C. Width and Color of Lines for Pavement Striping:
1. Apply lines for pavement striping as follows:
   a. Width:
      1) Continuous centerline striping and parking space markings: Four inches.
      2) Dashed lane striping: Four inches.
      3) Solid crosswalk lines: Six inches.
      4) Solid stop lines: Twelve inches.

b. Lines:
   1) Dashed lane lines: White stripes nine feet in length separated by 15 feet of unmarked surface.
c. Color:
   1) Stripes:
      a) Solid centerline stripe: White or yellow as shown.
      b) Lane striping, parking space marking, crosswalk, and stop lines: White, unless otherwise shown.

D. Allowable Tolerances:
1. Traffic-zone paint:
   a. Width of lines not to vary from specified width by more than 1/8 inch in each linear foot.
   b. Lengths of skip or lane lines and unpainted surface between skip lines not to vary by more than three inches from specified length.
   c. Coverage rate maximum: 100 square feet minimum and 110 square feet maximum of surface coverage per gallon of paint, yielding wet-film thickness of 0.015 inches minimum.
   d. Coverage rate of glass spheres: Ten pounds per gallon of paint minimum.
2. Extruded thermoplastic compound:
   a. Thickness of stripe: 90 to 125 mils.
   b. Rate of application of binder-sealer: Between 800 linear feet and 1,000 linear feet per gallon for four-inch wide lines. For lines of other widths, apply in proportion based on such rate.
3. Preformed plastic traffic markings:
   a. Thickness: 0.095 inch, minus 0.005 inch or plus 0.010 inch.
   b. Width: Four inches, plus-or-minus 1/8-inch per 12-inch length.
4. Painting of curbing and raised traffic bars:
   a. Wet-film thickness: 0.015 inches minimum.

3.02 APPLICATION:

A. Traffic Zone Paint:
1. Equipment:
   a. Use equipment suitable for mechanical application of paint and glass spheres.
   b. Apply paint with atomizing spray machines designed for striping to apply stripes of uniform cross section, and thickness, at specified coverage with clean-cut edges permitting easy and accurate adjustment of width and rate of application as well as immediate shutoff.
   c. Use automatic mechanical equipment designed and constructed to distribute glass spheres in uniform pattern and at prescribed coverage regardless of variation in speed of travel. Equipment may be integral part of striping machines or self-contained unit designed for attachment to striping machines, so that glass spheres will be applied immediately following application of paint. Use equipment designed and constructed to permit adjustment of coverage rate.
2. Method of application:
   a. Schedule marking and striping operations to permit paint to set and harden before roadway is opened to traffic.
   b. Allow hot laid bituminous material to cool, prior to beginning striping operations.
   c. Remove foreign matter from surfaces prior to painting.

d. Apply pigmented binder and glass spheres, mix and thin pigmented binder in accordance with manufacturer's recommendations.
e. Apply glass spheres uniformly, immediately following application of paint. Do not premix paint and spheres.
f. Apply pavement markings accurately with straight, clean-cut, sharply defined parallel edges and of uniform cross section.
g. Clean striping machines as often as necessary to ensure application of markings of specified quality and physical requirements.

B. Extruded Thermoplastic Compound:
1. Equipment:
a. Master kettle:
1) Minimum capacity: 800 pounds of melted compound.
2) Double oil jacket.
3) Thermostatic controls.
4) Approved heating device.
5) Temperature gauges for oil and compound.
6) Integrally mounted chopping device to chop and drop solid compound into kettle.
b. Liner:
1) Use liners with self-contained heat source, such as propane heater, capable of maintaining compound at drawing temperature of not less than 420F as well as radiant heater installed over die for same purpose.
2) For installation of crosswalk lines, stop lines and solid center lines, use liner with capacity of approximately 150 pounds and automatic sphere dispenser capable of distributing reflective spheres on surface of line while still plastic.
3) For centerline and lane line installation, use mobile unit equipped to automatically install dashed lines in combinations of line and skip up to 40 feet and for application of reflective spheres as specified for smaller liner.
4) Provide for varying die widths in liner to produce specified line widths, including shaping die cutoff device to provide clean, square ends at beginnings and ends of lines.
2. Application of binder-sealer:
a. Before applying binder-sealer or thermoplastic com pound, prepare roadway surface by buffing and cleaning or other appropriate method.
b. Where thermoplastic stripe is to be installed, spray surfaces with binder sealer consisting of two parts epoxy and one-part hardener-catalyst immediately prior to installation of compound.
c. Mix binder-sealer fresh each day. Do not premix.
3. Application of thermoplastic compound:
a. Apply compound in colors shown and at locations shown.
b. Do not use pans and aprons to control width of lines.
c. Use equipment including extrusion dies capable of maintaining compound at specified extrusion temperature and density and capable of producing stripe of specified width.
4. Application of glass spheres:
a. Perform reflectorizing of thermoplastic compound by immediate application of glass spheres to specified density.
b. Perform reflectorizing so that completed line registers not less than 55 on Hunter Nite Visibility Meter.

C. Preformed Plastic Traffic Markings:

1. Prepare roadway surface by removing dirt, dust, oily substances, and other foreign matter before installing plastic markings.
2. Do not install plastic marking on wet or damp pavement.
3. Make installations in neat, workmanlike manner with ends and edges of successive strips of material even.
4. Position center and lane markings using chalk as guides.
5. Installation on sheet-asphalt surfaces:
   a. When plastic markings are to be installed on new sheet-asphalt surfaces, install while asphalt is still hot and immediately before final rolling is performed.
   b. As part of final rolling operation, position and embed plastic marking into surface.
   c. To install plastic markings on existing sheet asphalt, accurately locate and press marking into place and obtain final bond by at least two longitudinal passes of ten-ton roller.
6. Installation on asphaltic-concrete surfaces:
   a. Install as specified for sheet-asphalt surfaces except apply prime coat recommended by manufacturer of plastic markings to pavement surface prior to installation of markings.
7. Installation on Portland-cement concrete pavement:
   a. Seal surface of concrete pavement with quick-setting primer to reduce capillary action and improve bond between marking and pavement surface.
   b. Otherwise install as specified for sheet-asphalt pavement.

D. Painting of Curbing and Raised Traffic Bars:
1. Paint curbing and raised traffic bars with traffic-zone paint.
2. Clean surfaces to be painted of dirt, dust, laitance, oil or other foreign substances.
3. Allow 14 days minimum after installation of Portland cement concrete before painting.
4. Curbing:
   a. Paint top and front of curbing in locations shown with one coat of non-reflectorized traffic-zone paint as specified.
5. Raised traffic bars:
   a. Paint surfaces, except bottom of raised traffic bars with one coat of white traffic-zone paint and apply glass spheres before paint has hardened.
   b. Apply paint and glass spheres as specified.

END OF SECTION

# SECTION 02772

# CURBS, GUTTERS, AND WALKS

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section specifies providing walks, curbs, gutters, curb and gutters, coping curbs and integral curbs.

B. Related Work Specified Elsewhere:
1. Section 02320: Grading, Excavating, and Backfilling.
2. Section 02720: Base for Pavements.
3. Section 02750 Concrete Pavement.
4. Section 03200: Concrete Reinforcement.
5. Section 03300: Cast-in-Place Structural Concrete.

### 1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Working Drawings indicating: Expansion joint layout and openings.
2. Mix design for each change of ingredients and ingredient sources, including admixtures.
3. Certificates of Compliance to specifications of materials provided as work of this Section.

### 1.03 REFERENCES:

A. Codes, Regulations, Reference Standards, and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM International (ASTM):
   a. ASTM C920, Standard Specification for Elastomeric Joint Sealants.
   b. ASTM: C979 – Standard Specification for Pigments for Integrally Colored Concrete.
   c. ASTM D6690, Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

### 1.04 BUY AMERICA ACT CERTIFICATION QUALITY ASSURANCE:

A. Buy America Act:
1. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

## PART 2 PRODUCTS

### 2.01 MATERIALS:

A. Concrete: Section 02750, Concrete Pavement and as specified in this section.

B. Carbon Black:
1. Emulsified: At least 25 percent by weight standard carbon-gas black colloidally dispersed in liquid medium so that when one part of product is

stirred into ten parts of water, resulting liquid, after standing undisturbed for 72 hours, is uniformly colored and contains no fillers or other material that would adversely affect quality or appearance of concrete.

2. Powder:
   a. Concrete grade carbon black, meeting the requirements of ASTM C979.
   b. Carbon black powder to disperse in water without floating and to be capable of uniform dispersion in plastic concrete.

C. Joint Devices:
1. In accordance with Section 02750, Concrete Pavement, with the following additional requirements:
   a. Dowels: 14 inches long, 3/4-inch diameter for curb and gutter and 1/2-inch diameter for sidewalk.
   b. Plates for construction joints and planes of weakness: 14-gauge galvanized sheet metal cut to section as necessary.

D. Expansion Joint Materials:
1. In accordance with Section 02750, Concrete Pavement, with the following additional requirements:
   a. Preformed joint filler, 1/2-inch thick, subject to specified construction requirements.

E. Polyethylene Tape: Section 02750, Concrete Pavement.

F. Joint Sealer:
1. Hot-applied: Rubberized joint sealing material, ASTM D6690.
2. Cold-applied: Elastomeric type, ASTM C920.

2.02 MIXES:

A. Mix exposed aggregate surface course concrete comprising by volume, one part Portland cement to three parts granite aggregate or gravel, crushed gravel, or crushed stone aggregate as shown, with sand added to form workable mix.

B. Where concrete walks are shown to be darkened, add 1/2 pound of emulsified carbon black or 1/3 pound of carbon powder per bag of Portland cement.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL:

A. Allowable Dimensional Tolerances:
1. Concrete surfaces constructed in accordance with the following:
   a. Plus-or-minus 3/16 inch of elevation shown.
   b. Deviation: 1/8-inch maximum from steel straightedge as specified in Section 02750, Concrete Pavement.

3.02 BASE:

A. Ensure that previously placed base is satisfactorily compacted and free from loose material.

B. Have base approved prior to placing forms and base covering.

C. Correct deficiencies in grade, contour, and compaction.

3.03 FORMS:

A. Place forms as specified in Section 02750, Concrete Pavement.

3.04 JOINT DEVICES AND CONTRACTION JOINTS:

A. General Requirements:
   1. Place joint devices and contraction joints as specified in Section 02750, Concrete Pavement.
   2. Where work abuts concrete pavement, adjust spacing of joints so that joints of same type coincide with transverse joints of concrete pavement.
   3. Width of preformed expansion joint filler: Same as thickness of concrete pavement minus 3/4 inch.
   4. Concrete curb, gutter and curb and gutter:
      a. Place two dowels in each joint between eight and twelve inches apart; for curb and gutter place one of the dowels four inches from back of curb. For curb and gutter abutting concrete pavements, complete partial tie rod assemblies in slab. Place preformed expansion joint filler in single piece depressed 1/2-inch below finished surface.
      b. For curves of 100 feet radius or less, space expansion joints equally at intervals of approximately 15 feet; for radii greater than 100 feet space expansion joints at intervals of 45 feet, with contraction joints at intervals of 15 feet. Form contraction joints, with plates left in place, depressed 1/2-inch below finished surface.
      c. Where placed in curves of 100 feet radius or less, stop reinforcing steel two inches clear of expansion joints.
   5. Sidewalk:
      a. Place 1/4-inch preformed expansion joint material between sidewalks and curb where sidewalks are constructed between permanent structure and curb.
      b. Place transverse expansion joints at intervals of 45 feet, unless otherwise shown.
      c. Provide dowels in expansion joint spaced at two-foot intervals, clearing edges of sidewalk by one foot. Where sidewalks intersect, place expansion joints in each sidewalk for full width along extension of back edges.
   6. Uniform Joint Spacing: For the entire length of each straight or curved run of sidewalk or curb to be placed, lay out the work and adjust joint spacing to provide intervals of equal dimension between joints, including grooves, unless otherwise shown.

3.05 CONCRETE AND WIRE FABRIC:

A. Place concrete and wire fabric in accordance with applicable requirements of Section 02750, Concrete Pavement except that top layer of fabric over trench-cuts to clear top surface by 1-1/2 inches, plus-or-minus 1/4-inch tolerance.

B. Place pipe for weep holes through curbs for rain leaders from building downspouts where shown.

3.06 FINISHING CONCRETE CURB, GUTTER AND CURB AND GUTTER:

A. Remove curb and face forms as soon as condition of concrete permits and perform finishing work on exposed surfaces.

B. Finish face edge of curb to one-inch radius. Finish other edges to 1/4-inch radius.

C. Provide steel troweled finish followed by brushing with fine-hair brush.

D. Remove other forms when condition of concrete permits, but no sooner than 12 hours after placing. Rub surfaces with carborundum stone where necessary.

3.07 FINISHING SIDEWALK:

A. Work on Authority Property:
1. Strike off and screed top surfaces so that resulting surface is smooth and within specified tolerances.
2. As soon as condition of work permits, perform joint work, edging, and marking.
3. Finish edges to 1/4-inch radius.
4. Scoring pattern: Unless otherwise shown, as follows:
   a. Expansion joints: Install on 45-foot centers. For the entire length of each straight or curved run of sidewalk to be placed, layout the work and adjust joint spacing to provide intervals of equal dimension between joints, including grooves, unless otherwise shown.
   b. Contraction joints: Make transverse grooves 1/3 depth of the concrete at approximately nine-foot equal intervals between expansion joints perpendicular to longitudinal grooves.
   c. Control joints: Make transverse grooves 1/2-inch deep at approximately three foot equal intervals between contraction joints perpendicular to longitudinal grooves.
   d. Make longitudinal grooves 1/2-inch deep at approximately three foot equal intervals between and parallel to sides of sidewalk.
5. Finish surface with final light broom finish with fine-hair broom.
6. Construct wheel chair ramps at locations shown.
7. Remove forms when condition of concrete permit, but no sooner than 12 hours after placement. Rub surfaces with carborundum stone where necessary.

B. Non-Authority Work:
1. In accordance with codes and regulations of the jurisdictional authorities.

3.08 CURING:

A. In accordance with Section 02750, Concrete Pavement, except that liquid membrane curing compounds not to be used on curb of curb and gutter when temperatures tend to go lower than 40F within 24 hours after application.

B. Do not use liquid membrane curing compounds on exposed aggregate concrete or darkened concrete surfaces.

3.09 SEALING JOINTS:

A. Immediately prior to sealing joints, place polyethylene tape width of groove flat on preformed expansion joint filler.

B. Seal expansion joints in concrete curb, gutter and curb and gutter with poured joint sealer in conformance with Section 02750, Concrete Pavement. Do not seal expansion joints in sidewalk and stone curb.

3.10 HIGH EARLY STRENGTH CONCRETE:

A. Use high-early-strength concrete in accordance with Section 02750, Concrete Pavement when approved.

3.11 CORES:

A. Where directed, provide test cores in accordance with Section 02750, Concrete Pavement.

3.12 PROTECTION OF THE WORK:

A. Protect new work in accordance with Section 02750, Concrete Pavement.

3.13 DEFICIENT WORK:

A. Remove and replace with new materials or correct as directed work which does not meet specified requirements.

3.14 INTEGRAL CURBS:

A. Pour integral curbs with the pavement slab.

END OF SECTION

# SECTION 02830

# MECHANICALLY STABILIZED EARTH (MSE) RETAINING WALLS

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section specifies furnishing materials and placement for mechanically stabilized earth walls conforming to the lines, grade and dimensions shown on the contract drawings. The mechanically stabilized earth wall will consist of a non-structural levelling pad, concrete facing panels and soil reinforcement elements mechanically connected to each facing panel. The soil reinforcement elements, some of which are proprietary, employ either strip or grid type metallic or geosynthetic reinforcements in the soil mass. Soil reinforcement will have sufficient length, strength and frictional resistance as required by the specifications and WMATA Design Guidelines. All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other appurtenances shown on the plans, shall be accounted for in the stability design of the wall. All designs must conform to WMATA Design Guidelines. A geotechnical report has been prepared for the project (Geotechnical Report for WMATA Springfield-Franconia Bus Canopy Project, Springfield, VA, by HSA, Inc., Project No. 11-103W, Dated: October 2014).

B. Related Work Specified Elsewhere:
   1. Grading, Excavating, and Backfilling: Section 02320.
   2. Cast-in-Place Structural Concrete: Section 03300.

### 1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. American Association of State Highway and Transportation Officials (AASHTO):
      a. AASHTO Standard Specifications for Highway Bridges.
   3. ASTM International (ASTM):
      a. ASTM A82, Standard Specification for Wire, Plain, for Concrete Reinforcement.
      b. ASTM A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
      c. ASTM A153, Standard Specification for Zinc (Hot-Dip) on Iron and Steel Hardware.
      d. ASTM A325, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
      e. ASTM A572, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
      f. ASTM A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
      g. ASTM A706, Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.
      h. ASTM A775, Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
      i. ASTM A1064, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
      j. ASTM A1011, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

B. Allowable Tolerances:
   1. Cut and bend reinforcing steel to conform to dimensions shown within the following tolerances:

a. Sheared length: Plus-or-minus one inch.
b. Depth of truss bars: Plus zero or minus 1/2 inch.
c. Stirrups, ties and spirals: Plus-or-minus 1/2 inch.
d. All other bends: Plus-or-minus one inch.

1.03 DESIGN REQUIRMENTS

A. The mechanically stabilized earth wall design shall follow the dimensions of the wall envelope shown in the contract plans. The top of leveling pad shall be located a minimum of 30" below grade. Where coping or barrier is utilized, the wall face panels shall extend up into the coping or barrier a minimum of 2 inches. The top of the face panels may be level or sloped to follow the top of wall line noted.

B. Where walls or wall sections intersect with an angle of 130 degrees or less, a special vertical corner element panel shall be used. The corner element panel shall cover the joint of the panels that abut the corner, and allow for independent movement of the abutting panels. Corner elements shall have at least two levels of earth reinforcements.

C. Standard facing panels shall have at least two levels of earth reinforcements to stabilize the panels against rotation and are to be constructed of reinforced concrete. Top and bottom half panels shall have at least one level of earth reinforcements. The wall facing shall be designed to accommodate differential settlement of 1 foot in 100 feet (0.5 feet in 100 feet for large rectangular panels). The spacing between adjacent panels shall be designed to be 3/4 inch ± 1/4 inch. Joints between panels shall have a shiplap configuration to protect the joint materials from vandalism. There shall be no openings through the wall facing except for utilities to pass through the wall.

D. A geotechnical report has been developed for the project. This report is to be used as the basis of design (Geotechnical Report for WMATA Springfield-Franconia Bus Canopy Project, Springfield, VA, HSA Project No. 11-103W Dated October 2014). Any additional information required for design, detailing and installation of the MSE wall and it appurtenances is the responsibility of the contractor and his engineer.

E. The design by the wall system supplier shall consider the external and internal stability of the wall mass as outlined below. The external stability of the structure, including slope stability, bearing capacity, and total and differential settlement, is to be included in the design calculations for the overall submittal package.
1. Failure Plane: The reinforced soil mass shall be analyzed so that the soil stabilizing components extend sufficiently beyond the failure plane to stabilize the material. External loads which affect the internal stability, such as those applied through piling, footings, traffic (both temporary construction and permanent loads), slope surcharge, and hydrostatic and seismic loading shall be accounted for in the design.
2. Hydrostatic Forces: Unless specified otherwise, when a design high-water surface is shown on the plans at the face of wall, the design stresses calculated from that elevation to the bottom of wall must include a 3 foot minimum differential head of saturated backfill. In addition, the buoyant weight of saturated soil shall be used in the calculation of pullout resistance.
3. Backfill: For internal stability design of the wall, the friction angle of the select backfill used in the reinforced fill zone shall be assumed to be 34° unless shown otherwise on the Plans. The friction angle shall be determined by the standard direct shear test, AASHTO T-236, utilizing a sample of the material compacted to 95 percent of AASHTO T-99, Methods C or D at optimum moisture content. Before construction begins, the selected backfill material shall be subject to approval to show conformance with this frictional requirement. The friction angle of the foundation soils and the random backfill shall be assumed to be 30 unless otherwise shown on the Plans.
4. Factors of Safety: The minimum factors of safety shall be as follows:

a. 1.5 against pullout of the reinforcements based on pullout resistance at 1/2 inch deformation for a representative backfill (i.e., the resulting deformation should not exceed 1/2 inch at 1.5 times the design load).
b. 1.5 against sliding of the reinforced soil mass
c. 2.0 against overturning of the reinforced soil mass
d. 2.0 against panel connection pullout or rupture, and
e. 1.5 against panel connection deformation of 1/2 inch under the maximum allowable reinforcement tension (i.e.,the resulting deformation should not exceed 1/2 inch at 1.5 times the design load).

5. Connections: All connections shall be positive, structural connections subject to the same metal loss rates and allowable tension requirements as outlined Allowable Reinforcement Tension Section of this specification. Adequacy and capacity of panel connections is to be demonstrated by providing connection test data.
6. Reinforcement Length: The soil reinforcement length shall be the same from top to bottom of each wall section. The reinforcement length defines the width of the entire reinforced soil mass and may vary with wall height along the length of wall. For walls with level or sloped surcharge, the minimum length embedded in the soil shall be 70 percent of the facing height, H, or 8 feet, whichever is greater.
7. State of Stress and Pullout Resistance : The lateral earth pressure to be resisted by the reinforcements shall be calculated using the appropriate coefficient of earth pressure, K, based on the type of reinforcement used, multiplied by vertical soil stress at each reinforcement layer. Vertical soil stress shall be calculated. The soil reinforcement length shall be sufficient to satisfy the above requirements, to meet the sliding, overturning and pullout factors of safety, and to meet any minimum reinforcement lengths required for external stability.
8. The actual applied bearing pressures under the stabilized mass for each reinforcement length shall be clearly indicated on the design drawings. Passive pressure in front of the wall mass shall be assumed to be zero for design purposes.
9. Calculations for stresses and factors of safety shall be based on assumed conditions at the end of the design life. The design life shall be 100 years.
10. Allowable Reinforcement Tension: For determination of the allowable reinforcement tension, the following metal loss rates shall be assumed:
    a. Zinc (first 2 years): 15 microns/year/side
    b. Zinc (subsequent years to depletion): 4 microns/year/side
    c. Carbon Steel (after depletion of zinc): 12 microns/year/side
    d. Carbon Steel (75 to 100 years): 7 microns/year/side
11. For ladder strips, bar mats and welded wire mesh reinforcements, the gauge of the wires or bars shall be the same in both the longitudinal and transverse directions. Fy used for design shall not exceed 65 ksi. The maximum allowable tension in the reinforcements shall consider any reduction in cross sectional area of reinforcements due to punching and corrosion losses and shall not exceed 50%of the pullout capacity of the connection devices embedded in the facing panels.
12. A guardrail (stainless steel railing) is to be placed at the top of the wall. The top of the wall is to be designed for forces from the guardrail (railing) described in the WMATA Design criteria and current applicable building code (whichever is stricter). The guardrail and its attachment to the wall are WMATA standard.

1.04 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
    1. Shop Drawings: The Contractor shall submit design calculations and design drawings signed and sealed by a Professional Engineer in the Commonwealth of Virginia knowledgeable in the work for approval by the Owner prior to beginning construction. The proposed design shall satisfy the design parameters and requirements in the plans and specifications. Complete design calculations shall include the most critical geometry

and loading combination for each design section that exists during construction and 'in-place'. The design drawings shall include all details, dimensions, quantities and cross-sections necessary to construct the wall. Information presented shall include, at a minimum, the following:

a. An elevation view for each wall, including the top of wall elevation at all horizontal and vertical break points and at least every 50 feet along the face of wall, the elevation of all steps in the leveling pads, the designation as to the type of panel, the length of soil reinforcing elements, the distance along the face of the wall to where changes in length of the soil reinforcing elements occur, the final ground line, and maximum calculated bearing pressures.
b. A typical cross section or cross sections showing the elevation relationship between ground conditions and proposed grades.
c. General notes pertaining to design criteria and wall construction. A listing summarizing the quantities for each wall.
d. All panel details shall show all dimensions necessary to construct the panel, all reinforcing steel in the panel, and the location of soil reinforcing
e. connection devices embedded in the panel. Clearly indicated details for wall construction around drainage facilities. Details of the architectural treatment. Details for diverting soil reinforcements around obstructions such as piles, catch basins and other utilities.
f. Details for connections between concrete panels and soil reinforcements.

2. Product Data: Manufacturers materials specifications, installation instructions, and recommendations:
   a. Manufacturer's certificates.
   b. Concrete certifications and mix design with test breaks per ACI 318. Slump, Air content and admixtures are to be provided.
   c. Mill tests on each heat showing chemical and physical analyses performed in accordance with ASTM A615, as modified by ACI 318.
   d. Record of mill tests traceable to individual reinforcement bars supplied to the project.

1.05 QUALITY ASSURANCE

A. Construction – Contractor performing work in this section shall have a minimum of 5 years' experience and have constructed at least 50,000 square feet of segmental concrete retaining walls on projects of like scope. When requested, evidence of experience, noting project, owner, and design professional shall be furnished to the Owner.

B. Testing – An independent testing lab shall be required to test the select fill material to determine suitability of material for the project and shall conduct compaction tests for each layer of fill material at the rate of at least 1 test per 1000 square feet per lift. The contractor is required to have full time construction observation. The observation will include daily reporting of the work progress and final certification of the MSE construction conforms to the approved shop drawings. A letter is to be issued to the owner stating the MSE wall and its appurtenances are in conformance with the approved shop drawings. The letter is required to be signed and sealed by a professional engineer.

1.06 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. The Contractor shall inspect the materials upon delivery to assure that proper type and grade of material has been received.

B. The Contractor will ship, store and handle materials in accordance with manufacturer's recommendations and in a manner to prevent deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breaking, chipping or other causes. Panels are to be shipped in stacks, front face down. Blocking is to be installed to prevent the attachment devices from contacting the panel above and is to be located immediately adjacent to the

attachment lifting devices. Lifting inserts are to be cast into the top edges of the panels to permit lifting at the project site. Reinforcement connection inserts (tie strip or loop inserts) are not to be used for lifting or handling the panels.

C. The Contractor shall protect the materials from damage. Damaged material shall not be incorporated into the MSE wall.

D. The date of manufacture, the production lot number and piece mark are to be clearly marked on the side of each panel.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Proprietary Mechanically Stabilized Earth retaining wall suppliers.
   1. Reinforced Earth; The Reinforced Earth Company, 12001 Sunrise Valley Drive Suite 400, Reston VA, 20191, Tel (703) 547-8797 Email: Info@reinforcedearth.com.
   2. EarthTec, Inc.; 413 Browning Court, Purcellville, VA, 20132, Tel (703) 771-7305.
   3. Or Approved Equal.

2.02 MATERIALS:

A. Concrete Facing Panels: Facing panels are to have a minimum thickness of 5 1/2 inches and minimum concrete cover of the reinforcing steel of 1 ½ inches. Concrete shall follow specification 03 30 00. Panels will have a minimum concrete compressive strength of 4000 psi at 28 days. Prior to casting, attachment devices shall be set in place to the dimensions and tolerances shown on the shop drawings.
   1. Unless otherwise noted, the concrete surface for the front (exposed) face will have an ordinary steel form finish and for the rear (unexposed) an unformed finish. The rear face shall be free of open pockets of aggregate and surface distortions in excess of ¼ inch.
   2. All units shall be manufactured within the following tolerances with respect to the dimensions shown on the shop drawings:
      a. Attachment Device Locations and Alignment – The lateral position of reinforcing strip attachment devices shall be within 1 inch and embedment measured from the back face of the panel shall be within +1/4 inch, -1/2 inch. For attachment devices having multiple bearing surfaces for a single reinforcement, the bearing surfaces shall align within 1/16 inch.
      b. Panel Dimensions -- All panel dimensions shall be within ¼ inch. All hardware embedded in the panel with the exception of attachment devices shall be within 1/4 inch.
      c. Panel Squareness --, as determined by the difference between the two diagonals, shall not exceed 1/2 inch.
      d. Panel Surface Finish -- Surface defects on smooth-formed surfaces, measured on a length of 5 feet, shall not exceed 1/4 inch. Surface defects on textured-finished surfaces, measured on a length of 5 feet, shall not exceed 5/16 inch.
   3. Reinforcing Steel Bars:
      a. ASTM A615, Grade 60, modified in accordance with ACI 318.
      b. Wire Reinforcement: ASTM A82 or ASTM A615, Grade 60.
      c. Welded Steel-Wire Fabric: ASTM A1064.
      d. Metal Accessories: As recommended by CRSI Manual of Standard Practice. Where concrete surfaces will be exposed to public view in finish structure, use supports with plastic-protected legs or stainless steel legs.

B. Soil Reinforcing and Attachment Devices: All reinforcing and attachment devices shall be carefully inspected to insure they are true to size and free from defects that may impair their strength and durability.
   1. Ribbed Reinforcing Strips. Ribbed Reinforcing Strips shall be hot rolled from bars to the required shape and dimensions. ASTM A-572 grade 65 (AASHTO M-223) or equivalent. Galvanizing shall conform to the requirements of ASTM-A123 (AASHTO M-111). The minimum galvanizing coating thickness shall be 2ounces/square feet.
   2. Ladder Reinforcing Strips. ASTM A-82 and welded into the finished ladderstrip configuration in accordance with ASTM A-185. The longitudinal and transverse wires shall be of the same size. Galvanizing shall be applied after the ladder strips are fabricated and shall conform to the minimum requirements of ASTM A-123 (AASHTO M-111). The minimum galvanizing coating thickness shall be 2 ounces/square foot.
   3. Reinforcing Mesh and Bar Mats. Reinforcing Mesh and Bar Mats fabricated of cold drawn steel wire conforming to ASTM A-82 and ASTM A-185. The longitudinal and transverse wires shall be of the same size. Galvanizing shall be applied after the mesh is fabricated and shall conform to the minimum requirements of ASTM A-123 (AASHTO M-111). The minimum galvanizing coating thickness shall be 2 ounces/square foot.
   4. Tie Strips. hot rolled steel conforming to the minimum requirements of ASTM A-1011, Grade 50 or equivalent. Galvanizing shall conform to the minimum requirements of ASTM A-123 (AASHTO M-111) or ASTM A-153 (AASHTO M-232). The minimum galvanizing coating thickness shall be 2 ounces/square foot.
   5. Wire Tie Strips and Loop Inserts: Cold drawn steel wire conforming to the minimum requirements of ASTM A-82. Galvanizing shall conform to the minimum requirements of ASTM A-123 (AASHTO M-111). The minimum galvanizing coating thickness shall be 2 ounces/square foot.
   6. Fasteners: Hexagonal cap screw bolts and nuts conforming to the minimum requirements of ASTM A-449 (AASHTO M-164) or equivalent. Galvanizing shall conform to the minimum requirements of ASTM A-153 (AASHTO M-232).
   7. Connector Bars and Pins:cold drawn steel wire conforming to the minimum requirements of ASTM A-82 and shall be galvanized in accordance with the requirements of ASTM A-123 (AASHTO M-111). The minimum galvanizing coating thickness shall be 2 ounces/square foot.
   8. Structural Plate Connectors and Fasteners. Structural Plate Connectors used for yokes to connect reinforcements to wall panels around pile or utility conflicts shall conform to the minimum requirements of A36 structural steel and shall be galvanized. Galvanizing of Structural Plate Connectors shall conform to the minimum requirements of ASTM A-123 (AASHTO M-111). The minimum galvanizing coating thickness shall be 2 ounces/square foot. Fasteners for Plate Connectors shall consist of hexagonal cap screw bolts and nuts conforming to the minimum requirements of ASTM A-325 (AASHTO M-164) or equivalent. Galvanizing of Fasteners for Structural Plate Connectors shall conform to the minimum requirements of ASTM A-153 (AASHTO M-232).

C. Geosynthetic Soil Reinforcing and Connection Devices
   1. Geogrids shall be structural geogrids formed by uniaxially drawing a continuous sheet of high density polyethylene material. Geogrids shall be a regular network of integrally connected polymer tensile elements with aperature geometry sufficient to permit significant mechanical interlock with the surrounding rock or soil. Structure of the geogrid reinforcement shall be dimensionally stable and able to retain its geometry under manufacture, transport and installation.
      a. Tensar Geogrid BX1100
      b. Or approved equal.
   2. Connection devices, such as bars, pins, plates etc, shall consist of non-degrading polymer and be made for the express use with the geogrids supplied.

D. Joint Materials

1. Joint materials shall be installed to the dimensions and thicknesses in accordance with the plans or approved shop drawings.
2. Bearing Pads: Bearing pads for panels with shiplap joints shall be EPDM rubber conforming to ASTM D-2000 M2AA 807, having a durometer hardness of 80 ± 5. Bearing pads for panels with tongue and groove shall be preformed high density polyethylene (HDPE) conforming to ASTM D1505 and having a minimum density of 0.946 g/cm3.
3. Joint Cover: Where required, as shown on the plans, horizontal and vertical joints between panels shall be covered by a geotextile. The geotextile may be either a non-woven needle punched polyester geotextile or a woven monofilament polypropylene geotextile as approved by the wall supplier. Adhesive used to hold the geotextile filter fabric material to the rear face of the panels prior to backfill placement shall be approved by the wall supplier.

E. Select Granular Backfill Material
1. Provide crushed or natural sand, crushed or uncrushed gravel, blasted limestone, blasted sandstone or a standard size course aggregate meeting the following gradation
   a. Seive Size Percent Passing

| | |
|---|---|
| 3 INCHES | 100 |
| 1 ½ inch | 100 |
| ¾ inch | 20-100 |
| ½ inch | 25-60 |
| No. 40 | 15-30 |
| No. 200 | 0-5 |

2. Furnish material exhibiting an angle of internal friction of not less than 34 degrees as determined, in accordance with AASHTO-T236, on the portion finer than the No. 10 sieve compacted to 95% of PTM No. 106, Method B, at optimum moisture content. Direct shear testing may be performed on samples containing material larger than the No. 10 sieve, if the shear device conforms with AASHTO-T236, Sections 5.4 and 5.5.
3. Plasticity Index -- The Plasticity Index (P.I.), as determined by AASHTO T90,shall not exceed 6.
4. The select granular backfill material used in MSE structure will be reasonably free from organic and deleterious materials. In addition, the backfill shall conform to all of the following requirements.
   a. Soundness -- The material shall be substantially free of shale or other soft, poor durability particles. The material shall have a magnesium sulfate soundness loss of less than 30 percent after four (4) cycles, as determined by AASHTO T-104.

Electrochemical Requirements -- The backfill material shall conform to the following electrochemical requirements:

| Property | Requirement | Test Methods |
|---|---|---|
| Resistivity(1) | >5000 ohm-cm – no chloride Or sulfate testing is required. 2000-5000 ohm-cm perform Chloride and sulfate test at 100% saturation | AASHTO T-288-91(1) ASTM G-57-78 |
| pH | 6-10 | AASHTO T-288-91(1) ASTM G-51-77 |
| Soluble Chlorides(2) | ≤ 100 ppm | ASTM D-512-88 AASHTO T-291-91(1) |
| Soluble Sulfates(2) | ≤ 200 ppm | ASTM D-516-88 AASHTO T-290-91(1) |

1) Resistivity testing shall be performed up to and including, but not exceeding, 100 % soil saturation. Note 6 of AASHTO T-288 (Note 5 in older editions) shall not be used.

2) If the minimum resistivity exceeds 5000 ohm-cm, at 100% saturation, the need for testing of chlorides and sulfates is waived.

5. The Contractor shall furnish to the Engineer a Certificate of Compliance certifying that the select granular backfill material complies with this section of the specifications. A copy of all test results performed by the Contractor, which are necessary to assure compliance with the specifications, shall also be furnished to the Engineer.
6. If the material sampled fails to meet the specified requirements, immediately discontinue its use, and remove and replace all material placed since the last passing acceptance or verification sample was obtained. Do not continue backfilling until new backfill material has been sampled and approved.
7. Backfill not conforming to this specification shall not be used without the written consent of both the Engineer and the wall supplier.

## PART 3 EXECUTION

### 3.01 QUALIFICATION

A. Contractor and site supervisor must have proven qualified experience to complete the installation of the MSE wall system.

### 3.02 WALL EXCAVATION

A. Unclassified excavation shall be in accordance with the requirements of the general specification and the limits shown on the construction documents.

### 3.03 FOUNDATION PREPARATION

A. The foundation for the MSE wall structure is to be graded level for a width equal to or exceeding the length of the reinforcement as shown on the shop drawings. The subgrade material is to be compacted as directed by the project Geotechnical Engineer. Any unsuitable soils found to be unsuitable shall be replaced as directed by the project Geotechnical Engineer.

B. At each panel foundation level a concrete levelling pad is to be cast as shown on the shop drawings. Allowable elevation tolerances are +1/8 inch and -1/4 inch from the design elevation.

### 3.04 WALL ERECTION

A. Concrete panels shall be placed vertically with the aid of a light crane.

B. For erection, panels shall be handled by means of lifting devices set into the upper edge of the panels. Panels shall be placed in successive horizontal lifts in the sequence shown on the plans as backfill placement proceeds.

C. As backfill material is placed behind the panels, the panels shall be maintained in a vertical position by means of shoulder clamps to adjacent panels and temporary wooden wedges placed in the joint at the junction of the two adjacent panels on the external side of the wall. External bracing is required for the initial lift.

D. Vertical and horizontal alignment tolerances shall not exceed 3/4 inch in 10 feet. The overall vertical tolerance of the wall (plumbness from top to bottom) shall not exceed 3/4 inch per 10 feet of wall height.

3.05 REINFORCEMENT PLACEMENT

A. Prior to placing the first layer of reinforcements (strips, mats or grids), backfill shall be placed and compacted in accordance with this specification.

B. Bending of reinforcements in the horizontal plane which results in a kink in the alignment of the reinforcements shall not be allowed. Gradual bending in the vertical direction that does not kink the reinforcements is permitted.

C. Connection of reinforcements to piles, or bending of reinforcements around piles, shall not be allowed. Cutting of reinforcement longitudinal bars to avoid conflicts with piles or utility obstructions shall not be allowed. A structural connection (yoke) from the wall panel to the reinforcement shall be used whenever it is necessary to avoid cutting or to avoid excessive skewing of reinforcements due to pier, pile or utility conflicts.

D. Soil reinforcements shall be placed normal to the face of the wall, unless otherwise shown on the shop drawings or directed in writing by the MSE wall engineer. If skewing of the soil reinforcements is required due to obstructions in the reinforced fill, rotatable connections shall be used and the maximum skew angle shall not exceed 15 degrees from the normal position unless specifically addressed in design calculations justifying skewed connections are adequate.

3.06 CUTTING AND BENDING:

A. Perform cutting and bending in the shop. Bend steel cold. Do not bend or straighten bars so as to damage material.

B. Do not bend bars in the field except to correct minor errors and damage occurring during shipping and handling.

3.07 BACKFILLING

A. Backfill placement shall closely follow erection of each course of panels. Backfill shall be placed in such a manner as to avoid any damage or disturbance to the wall materials or misalignment of the facing panels. Any wall materials which become damaged or disturbed during backfill placement shall be either removed and replaced at the Contractor's expense or corrected, as directed by the Engineer.

B. Any backfill material placed within the reinforced soil mass which does not meet the requirements of this specification shall be corrected or removed and replaced at the Contractor's expense, as directed by the Engineer.

C. Backfill shall be compacted to 95 percent of the maximum density as determined by AASHTO T-99, Method C or D.

D. The moisture content of the backfill material prior to and during compaction shall be uniform throughout each layer. Backfill material shall have a placement moisture content less than or equal to the optimum moisture content. Backfill material with a placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniform and acceptable throughout the entire lift. The optimum moisture content shall be determined in accordance with AASHTO T-99, Method C or D.

E. The frequency of sampling of select granular backfill material, necessary to assure gradation control throughout construction, shall be as directed by the Engineer. If 30 percent or more of the select granular backfill material is greater than 3/4 inch in size, AASHTO T-99 is not applicable. For such a material, the acceptance criterion for control of compaction shall be either a minimum of 70 percent of the relative density of the material as determined by ASTM D-4253 and D-4254, or a method specification, based on a test compaction section which defines the type of equipment, lift thickness, number of passes of the specified equipment, and placement moisture content.

F. The maximum lift thickness after compaction shall not exceed 8 inches, regardless of the vertical spacing between layers of soil reinforcements. The Contractor shall decrease this lift thickness, if necessary, to obtain the specified density. Prior to placement of the soil reinforcements, the backfill elevation, after compaction, shall be 2 inches above the attachment device elevation from a point approximately 12 inches behind the back face of the panels to the free end of the soil reinforcements, unless otherwise shown on the plans.

G. Compaction within 3 feet of the back face of the panels shall be achieved by at least three (3) passes of a lightweight mechanical tamper, roller or vibratory system. The specified lift thickness shall be adjusted as warranted by the type of compaction equipment actually used, but no soil density tests need be taken within this area. Care shall be exercised in the compaction process to avoid misalignment of the panels or damage to the attachment devices. Heavy compaction equipment shall not be used to compact backfill within 3 feet. of the wall panels.

H. At the end of each day's operation, the Contractor shall slope the last level of backfill away from the back of the panels to direct runoff of rainwater away from the wall face. In addition, the Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

END OF SECTION

# SECTION 02920

# TOPSOIL, SEEDING, AND SODDING

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section specifies providing and maintaining seeding and sodding, including grass.

B. Related Work Specified Elsewhere.
   1. Removal and restoration of existing landscaping: Section 02230, Site Clearing.
   2. Site grading: Section 02320, Grading, Excavating, and Backfilling.

C. Definitions:
   1. UMPC: University of Maryland, College Park
   2. Numerical fertilizer analysis: Three-digit number indicates nitrogen, phosphoric acid and potash percentages by weight. Thus, 3-25-25 means three-percent nitrogen, 25-percent phosphoric acid and 25-percent potash by weight.

### 1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications: Keep always available at the work site a copy of each of the cited references.
   1. Codes and regulations of the jurisdictional authorities.
   2. USDA-SCS.
   3. UMPC: Current publication of Agronomy Mimeo #77 (Turfgrass Cultivar Recommendations for Maryland).
   4. ASTM International (ASTM):
      a. ASTM C51, Standard Specification for Gypsum Keene's Cement.
   5. Buy America Act.

B. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.
   1. Personnel Qualifications:
      a. Superintendent: Use a Superintendent with previous knowledge and verifiable experience in supervising seeding and sodding work of similar size and scope. Have the Superintendent present whenever work is being performed and have the Superintendent responsible for controlling the quality of work and inspecting completed work to ensure that Contract requirements are met. The Superintendent is the primary contact person with the Engineer regarding seeding and sodding work.
      b. Workers: Have the work performed only by experienced workers, who through related training and verifiable previous on-the-job experience, are familiar with the technical aspects of seeding and sodding, and with the materials and equipment used for each operation. Have each worker abide by the code of ethics or professional conduct established by the Landscape Contractors Association MD-DC-VA.

### 1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Samples and Certification:

a. Submit in accordance with Table 02920-1 and as follows:
   1) Seed: Each seed bag bearing the following upon delivery:
      a) Analysis tag.
      b) Certification tag.
      c) Maryland or Virginia State tags where applicable.
   2) Inoculant: Sample packet of inoculant, viable bacteria, true to legume strain required and listing source.
   3) Sod: Maryland or Virginia State-Certified, each delivery bearing a Maryland or Virginia certification tag and label as required by law.
   4) Topsoil: Submit supplier's name and address and source of topsoil. Submit certified report of soil laboratory test results listing textures, pH, P and K nutrients, soluble salt, organic matter and mechanical analysis as to percentage of sand, silt and clay. Do not deliver topsoil to site until approved. Approval does not constitute final acceptance.
   5) Fertilizer: Labeled with manufacturer's name and address, guaranteed analysis, including nutrient and its derived source and listing of potential acidity.
   6) Limestone and acidifying agent: Labeled with manufacturer's name and address, chemical analysis, oxide content and size gradation of each used.
   7) Mulch and mulch binder: Labeled with manufacturer's name and address, material components, trademark, chemical analysis, species, size, age and source.
   8) Herbicide: Labeled with manufacturer's name and address and chemical analysis. Include in submittal the Material Safety Data Sheet, with copies to the Engineer and Contractor's Safety Officer.

b. Usable samples will be returned.

2. Documentation:
   a. Personnel qualifications: A list of the qualifications and experience of the workers, and qualifications and experience of the Superintendent, as attested by knowledge and experience in supervising contracts of similar size and scope in the past.
   b. Soil tests for planting areas: Submit certified report of soil tests made by a local state agricultural experiment station or agricultural laboratory recommended by U.S. Department of Agriculture. Test for pH, P and K nutrients, soluble salt, organic matter, and mechanical analysis as to percentage of sand, silt and clay; and include recommended quantities of soil amendments to be added to produce the target pH value and to produce optimal growing conditions for the target crop.
   c. Furnish one test for each 500 square feet of each planting area, and not less than one test for each area.
   d. Equipment list: A list of the equipment anticipated for use, including the make and model, year manufactured.
3. Certifications:
   a. Buy America Act Certification.

1.04 PRODUCT INSPECTION, DELIVERY, STORAGE, AND HANDLING:

A. General: Materials and supplies are subject to inspection and sampling for testing. Allow no seed, sod, fertilizer, straw or other agronomic materials or supplies on site other than those for the project.

B. Seed: Deliver with labels and tags.

C. Inoculants: Store inoculant containers below 70F until used. Keep containers sealed until contents are used in their entirety. Use inoculants before expiration date shown on packet. Using inoculants exposed to temperatures of 70F or greater is prohibited.

D. Sod: Deliver sod with labels and tags.
1. Deliver sod to job within 24 hours after being cut; place sod within 36 hours after being cut.
2. Prior to and after delivery during wet weather, allow sod to dry to the extent that will prevent tearing during handling and laying. During dry weather, water sod to ensure its vitality and prevent dropping of the soil in handling.

E. Topsoil: During hauling operations, keep walkway and roadway surfaces clean. Promptly remove fallen material.

1.05 JOB CONDITIONS:

A. Conduct seeding and sodding only under favorable seasonal conditions throughout the period of the Contract as determined by the Engineer. Install no work during adverse weather or during periods when soil conditions are unfavorable as determined by the Engineer. Do not plant or lay sod during freezing weather, when planting area is muddy or frozen, nor when sod is frozen.

B. Protection: During progress of operations, protect walls, walks, curbs, benches, established lawn areas, plant material, and other site improvements by adequate means acceptable to the Engineer.
1. Weight Restrictions: Do not overload entrance paving, sidewalks, and curbs.
2. Pollution: Take necessary and adequate measures to prevent soil erosion, air pollution, and water pollution by the materials and equipment used during construction.
3. Repairs: If damage by the Contractor should occur, it is the Contractor's responsibility to repair or replace per the Engineer's direction, as acceptable to concerned parties, and at no additional cost to the Authority. Perform work so that damaged areas make smooth, satisfactory, and imperceptible transitions to existing adjacent work. Use materials and methods conforming to current standards for the area damaged, matching adjacent materials in appearance, and meeting approval of jurisdictional authorities and the Engineer.

C. If, at any time, the Engineer determines that work is unsatisfactory or being conducted in an unsafe manner, immediately cease such work activities upon notification.

PART 2 PRODUCTS

2.01 MATERIALS:

A. Seed: Free of quack grass, timothy, bentgrass, clover, dock, annual bluegrass, cheat, chess, chickweed, crabgrass, plantain, black medic, and, except where specified in Table 32 92 19-2, Canada Bluegrass. Kentucky bluegrass and red fescue free of tall fescue.
1. Grass Seed: Dated material from last available crop, with date of test not more than nine months before date of sowing; listed as Proven Cultivars in the latest Agronomy Mimeo #77 (Turfgrass Cultivar Recommendations for Maryland), published by UMPC; and as specified in Table 02920-2 below.

B. Inoculant: Adaptable culture of live nitrogen-fixing bacteria true to legume strain used.

C. Sod:

1. Well-rooted Maryland or Virginia State-Certified sod, at least 18 months old. Varieties, identical to one of the following, or as approved:
   a. Seed mixture specified in Table 02920-3.
   b. Proven Cultivars in the latest Agronomy Mimeo #77, published by UMPC, certified 90-percent Turf-type Tall Fescue and 10-percent Kentucky Bluegrass.
2. Sod and attached soil free from noxious weeds such as Bermuda grass, quack grass, garlic, Johnson grass, Canada thistle and other turf weeds.
3. Mowed in production field to height of not more than 2-1/2 inches within five days prior to lifting.
4. Machine cut in sections not less than 2-1/2 feet in length nor less than 12 inches in width and to a depth equal to growth of fibrous roots, uniform soil thickness of 3/4 inch, plus-or-minus 1/4 inch. Measurement for thickness to exclude top growth and thatch.
5. Cut in sections or strips strong enough to support its own weight and retain size and shape when suspended vertically from firm grasp on upper 10 percent of section. Small, irregular or broken pieces of sod are prohibited. Sod on Beck Roll is permitted.

D. Topsoil: Weathered surface soils or natural friable loam obtained from approved sources, free of subsoil, hard fragments and stones larger than one-inch across greatest dimension, objectionable salts, noxious weeds and plants, debris and other materials inferior to surface soils or that would be toxic or harmful to growth; containing not less than 1.5-percent organic matter as determined by Walkley-Black Method; capable of sustaining normal, healthy growth and development of seed and sod scheduled and specified. Seed shall not be placed in topsoil which has been treated with soil sterilants until sufficient time has elapsed to allow for the dissipation of toxic materials.
1. Grading analysis:

| Sieve | Minimum Percent Passing |
|---|---|
| 2 inches | 100 |
| 1/2 inch | 90 |
| 1/4 inch | 80 |
| No. 10 | 70 |

2. Test and analysis of proposed topsoil material: Performed by local state agricultural experiment station or agricultural laboratory recommended by the U.S. Department of Agriculture, including recommendations for fertilizer and pH adjustment for target crop, and meeting the following requirements.
   a. Acidity range: pH 5.5 to pH 7.5, inclusive. When topsoil pH is not within pH 5.5 - pH 7.5, modifications to correct topsoil pH shall be made according to the recommendations of the soil test lab, or the applicable State Cooperative Agricultural Extension Service.
   b. Salinity by electrical-conductivity measurement: 500-ppm soluble salt maximum.
   c. Fertility: Rated high in natural nutrients in pounds per acre based on the standard soil test in laboratory.
   d. Texture: Classification consisting of 5-percent to 25-percent clay, 20-percent to 60-percent sand and 15-percent to 45-percent silt as determined by hydrometer or pipette method. Sand, silt and clay as defined by USDASCS.

E. Fertilizer:
1. For grass seeded and sodded areas: Commercial fertilizer of standard quality, recommended by approved soil test report; 10-22-22.

F. Limestone: ASTM C51, Dolomitic, Agricultural Grade.
1. Capable of neutralizing soil acidity and containing not less than 85 percent calcium and magnesium carbonates.
2. Sieve analysis: 95-percent passing No. Eight sieve and 40-percent passing a No. 100 sieve. For hydroseeding, use pulverized limestone.
3. Containers labeled to show chemicals.

G. Acidifying Agent: As approved per soil analysis recommendations and seeding method.

H. Mulch:
1. Wood-cellulose fiber: Containing no growth or germination-inhibiting factors and dyed green.
   a. Properties:
      1) Fiber length: Approximately 3/8 inch.
      2) Diameter: Approximately 1/32 inch.
      3) Acidity range: pH 4.0 to 8.5, inclusive.
      4) Ash content: 1.6-percent maximum.
      5) Water-holding capacity: 90-percent minimum.
   b. Packaging: Furnish fibers air-dry in packages not exceeding 50 pounds gross, with net weight shown on package.
   c. Source: Conwed Hydro Mulch by Conwed Corp., St. Paul, MN 55101 or equal.
2. Straw: Wheat, barley, oat or rye straw, threshed, air-dried, and free from Canada thistle, dock, Johnson grass and other foreign matter.
3. Mulch blanket: Knitted construction of biodegradable yarn with uniform openings, Gulf States Paper Corporation, Tuscaloosa, AL 35401 or equal.
   a. 150-foot lengths or greater.
   b. U-shaped staples: As standard with mulch-blanket manufacturer.

I. Mulch Binders: Non-asphaltic only.
1. Synthetic binder for use with the following:
   a. Wood-cellulose fiber: Terra Tack 1 by Grass Growers, Plainfield, NJ 07061; Soil-Gard by Alco Chemical Company, Philadelphia, PA 1913, or equal.
   b. Straw: Terra Tack 1 by Grass Growers, Plainfield, NJ 07061 or equal.
2. Biodegradable netting for use with straw: Conwed Erosion Control Netting by Conwed Corporation, St. Paul, MN 55101 or equal.

J. Herbicides:
1. Broadleaf weed control: Trimec by P.B.I. Gordon Corporation, Kansas City, KS 66118 or equal.
2. Pre-emergent crabgrass control: Balan by Elanco Products Company, Division of Eli Lilly Corporation, Indianapolis, IN 46206 or equal.
3. Post-emergent crabgrass control: A.M.A., D.S.M.A., M.A.M.A. or Calcium Methyl Arsenate by W.A. Cleary Company, Somerset, NJ 08873 or equal.
4. Perennial bunch-grass control: Round-up by Monsanto Agricultural Products Company, Wilmington, DE 19810 or equal.

K. Stakes (for pegging sod): Wood or other biodegradable stakes suitable for the purpose, measuring 1/2-inch by one-inch by 12 inches.

L. Water: Potable.

2.02 SEED MIXTURES:

A. Grass Seed: Tables 02920-2 and 02920-3.

2.03 EQUIPMENT:

A. Dry-Type Seeder: Brillion seeder, drill seeder, or other approved mechanical seeder.

B. Spraying Equipment for Hydroseeding: Use water tank equipped with liquid-level gauge calibrated in increments not larger than 50 gallons over entire range of tank capacity with gauge visible to nozzle operator. Use tank equipped with agitation system capable of maintaining solids in complete suspension until used.

PART 3 EXECUTION

3.01 PLACING TOPSOIL:

A. After completion of construction work in the area, prepare surface of subsoil. Finish to lines shown and parallel to proposed finished grade, as approved. Remove rocks and other foreign materials 1-1/2 inches or greater in any dimension. Immediately prior to covering with topsoil, loosen prepared subsoil surface to a minimum depth of four inches. Leave no depressions.

B. Place and spread topsoil over areas to be seeded and sodded, to depth which will produce four-inch depth after natural settlement and will conform to finish lines, grades and elevations.

C. When placing topsoil on slopes, work topsoil into subsoil to minimum depth of four inches to eliminate slip-plane between the two materials. Leave topsoil at surface to ensure germination of seed.

D. After spreading topsoil, rake up and remove large stiff clods, hard lumps, large rocks, roots, stumps, litter and other foreign matter.

E. Maintain specified depth of topsoil from time placed until specified seed or sod is established.

F. If soil or weather conditions are unsuitable, cease topsoil operations. Resume topsoil operations when proper conditions prevail.

3.02 SEEDING GRASS:

A. Dry Seeding: After placing topsoil, proceed as follows:
   1. Seed bed preparation:
      a. pH adjustment: Adjust topsoil pH to raise it by applying limestone or approved acidifying agent or elemental sulfur to lower the topsoil pH at per-acre rate recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations. Work into the top three inches of soil.
      b. Fertilizing: After acidity adjustment and within 24 hours before seeding, apply fertilizer at per-acre rate recommended by approved soil test report. Use machine spreader and lightly drag or rake fertilizer into top 1/4 inch of soil.
   2. Seeding: Clean seeders as approved prior to applying seed. Apply seed mixture directly after fertilizing.

a. Sow specified grass seed mixture from March 1 to April 30 and from August 15 to October 15. Extend or reduce specified periods as approved and as required by weather and soil conditions.
b. Sow at minimum rate as specified in Table 02920-3.
c. Work seed in to depth of 1/4-inch maximum.
d. Finish as follows:
1) Lawn areas with slopes up to 3:1: Raked surface.
2) Roadside areas with slopes up to 3:1: Scarified surface.
3) Slopes over 3:1: Leave surface in irregular condition with ridges running parallel to contour of slope to prevent erosion.

3. Rolling: Directly after seeding, roll lawn areas with slopes up to 3:1 using approved lawn roller, weighing 40 to 60 pounds per foot of width, unless intervening precipitation would cause such rolling to be detrimental.

B. Hydroseeding: After placing topsoil, proceed as follows:
1. Seed bed preparation:
a. Clean hydroseeders as approved prior to coming on site.
b. pH adjustment: Adjust soil pH by either applying limestone or approved acidifying agent or elemental sulfur at per-acre rate recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations.
1) Use only pulverized limestone to raise soil pH.
2) Apply not more than 300 pounds of limestone for each 100 gallons of water.
3) After applied limestone mixture has dried, work into the top three inches of soil.
c. Apply elemental sulfur as recommended, and incorporate into top three inches of soil.
d. After pH adjustment, again grade and dress seed beds for lawn areas to raked surface.
2. Fertilizing and seeding: After seed bed preparation, apply fertilizer-seed mixture.
a. Apply fertilizer at per-acre rate recommended by approved soil test report.
b. Apply seed at same rates and times specified for dry seeding. Mix seed and fertilizer together in proportions to meet required application rates.
c. If mulching with wood-cellulose fiber on areas with slopes up to 3:1, add mulch to seed and fertilizer mixture.
3. Application method:
a. Apply mixtures by means of high-pressure spray directed upward into air so that mixtures fall to ground in uniform spray. Do not direct nozzle of hand-held hose toward ground in manner that would produce erosion or runoff.
b. Make uniform applications at required rate, with two passes at 90 degrees to each other, to ensure uniformity and prevent misses.
c. Agitate mixtures constantly from time mixed until application to seed bed.
d. Use mixtures within eight hours after mixing.

3.03 MULCHING:

A. General:
1. Mulch according to the following slope limitations.
2. Mulch within two hours after seeding as follows:
3. Immediately replace displaced mulching.

B. Slopes up to 3:1:
1. Wood-cellulose fiber:

a. Apply at a net dry weight 1,500 pounds per acre.
b. Apply hydraulically with seed and fertilizer at rate of 50 pounds per 100 gallons of water.

2. Straw:
a. Methods of application:
1) Hand spreading: 4,000 pounds per acre (100 pounds per 1,000 square feet). Cover areas uniformly to depth of not less than two inches of loose material.
2) Blowing: Use of cutters is permitted in blowing equipment if at least 95-percent of mulch is six inches or more in length. For cut mulches applied by blowing method, achieve uniform distribution and loose in-place depth of not less than two inches.
3) Mulch-binder application:
a) Synthetic binder: Apply according to manufacturer's instructions.
b) Biodegradable netting: Apply according to manufacturer's instructions.

C. Slopes 2:1 to 3:1: Straw as specified above.

D. Slopes over 2:1: Mulch blanket, applied and stapled according to manufacturer's instructions.

3.04 SODDING:

A. Sod Bed Preparation: After placing topsoil, proceed as follows:
1. pH adjustment: Adjust soil pH by applying limestone or approved acidifying agent, or elemental sulfur at per-acre rate recommended by approved soil test report so as to obtain a 6.5 pH. Mix into soil to a depth of four inches minimum.
2. Fertilizing: After pH adjustment, apply fertilizer at per-acre rate recommended by approved soil test report. Mix into soil to a depth of four inches minimum.
3. Compact topsoil with lawn roller or tractor roller to three inches of final compacted thickness as approved.

B. Laying Sod:
1. Lay sod between September 15 and June 1, grown from seed varieties identical to grass seed mixture in Table 02920-3, or sod which is Blue-Tag certified.
2. Extend or reduce specified period as approved and as required by weather and soil conditions.
3. When soil surface is hot or dry, wet soil to a depth of two inches, six to eight hours before sodding. Do not accept or lay dried sod.
4. Place sod by hand with butted joints and no overlapping. When Beck Roll of sod is used, lay also in accordance with the supplier's instructions.
5. Lay first row of sod in straight line. Place subsequent rows parallel to and tightly against each other. Stagger perpendicular joints to promote more uniform growth and strength. Do not stretch sod. On slopes, lay sod parallel to contour of slope.
6. Peg sod placed on slopes 2:1 or greater. Peg each strip or section of sod with at least two stakes not more than two feet apart. Drive stakes flush with top of sod so that roots are in contact with topsoil.
7. Water sod immediately to prevent excessive drying during progress of work. Sod which dries out will be rejected.
8. Roll entire area as sodding is completed in each section so that sod is without surface irregularities, such as depressions and high spots.
9. Irrigate immediately after rolling, enough to wet underside of sod and one inch of soil immediately below.

3.05 MAINTENANCE AND REPLACEMENT:

A. Maintenance: Maintain seeding, sodding and incidental work during seeding and sodding and thereafter for a period of 120 days for work performed in the spring and for 90 days of subsequent growing weather for work performed in the fall. Perform the following and other operations of care appropriate for promotion of healthy growth, so that work is in an approved condition throughout maintenance period; uniform in color, quality and coverage; and free of weeds, insects, diseases, surface damage and other imperfections:
   1. Watering:
      a. First week: Perform watering daily to keep soil and sod pads continuously moist, maintaining moist topsoil to a depth of at least four inches. Water prior to heat of the day as necessary to prevent wilting or as approved.
      b. Subsequent weeks: Water seeded and sodded areas to maintain moisture in upper four inches of soil for promotion of deep root growth.
   2. Mowing: Mow only when seed or sod has firmly rooted, is securely in place and has grown to height of six inches. Mow to height of three inches at first cutting. Thereafter, do not remove more than 1/3 of grass leaf at any cutting. Maintain Kentucky Bluegrass between height of two and 2-1/2 inches and tall fescue at height of three inches, unless otherwise directed.
   3. Edging: Edge walks during alternate mowings.
   4. Rolling: Roll to maintain uniform surface.
   5. Applying herbicides: Apply in spray form. Do not apply when temperature exceeds 80F or during periods of drought. Have workers wear personal protective equipment appropriate for the submitted MSDS.
   6. Clean-up: Remove rubbish and debris caused by this work. Keep site clean during maintenance period.

B. Replacing Seeding and Sodding: During maintenance period and until Final Acceptance, replace seeded and sodded areas that are dead, unhealthy, unsightly or badly impaired. Replace as soon as possible during the specified planting seasons. Make such replacements in the same manner as required for original seeding and sodding.

3.06 SUBSTANTIAL COMPLETION INSPECTION (SCI):

A. Substantial Completion Inspection will be held by the Engineer after completion of seeding and sodding to verify that the work was performed as defined in the Contract Documents.

B. The Contractor will not be held responsible or liable for damage by animals, by malicious or careless human agencies over which the Contractor has no control, by fire or storm, or by vehicular accidents by others that occur after the Substantial Completion Inspection.

3.07 FINAL ACCEPTANCE:

A. Request inspection for final acceptance at least 10 days before end of maintenance period.

B. Replace rejected seeded and sodded areas as specified so that repair or replacement plantings are rooted and established prior to final acceptance.

| TABLE 02920-1: MATERIALS SUBMITTAL CHART | | | |
|---|---|---|---|
| This chart indicates minimum length of time required for the approval process before intended use and by which submittals must be made, as well as the minimum quantity for each sample. Useable samples will be returned. | | | |
| **ITEM** | **TIME** | **QUANTITY** | **COMMENT** |
| SEED | 40 days | 10 pounds or 5 kilograms<br>5 pounds or 3 kilograms | If seed is purchased as a mixture.<br>Per component prior to blending if Contractor blends mixture. |
| INOCULANT | 7 days | 1 packet | Keep temperature of inoculants below 70F (21 C). |
| SOD | 7 days | - - | Notification of source. |
| FERTILIZER | 14 days | 50 pounds (25 kilograms) | Provide sample of each type of fertilizer used. Unopened container. |
| LIMESTONE | 14 days | 50 pounds (25 kilograms) | As specified. Unopened container. |
| MULCH | 7 days | 10 pounds (5 kilograms)<br>1 unbroken bale<br>1 square yard (1 square meter) | Wood-cellulose fiber mulch.<br>Straw mulch.<br>Mulch blanket including staples. |
| MULCH BINDER | 14 days | 1 quart (1 liter)<br>1 square yard (1 square meter) | Synthetic binder.<br>Biodegradable netting including staples. |
| TOPSOIL | 28 days | 25 pounds (15 kilograms) | - - |
| HERBICIDE | 7 days | 1 quart (1 liter) | Unopened container. Include MSDS |
| OTHER MATERIAL | 7 days | As directed and as approved | - - |

| TABLE 02920-2: GRASS SEED FOR SEED MIXTURES | | | |
|---|---|---|---|
| **SPECIES** | **MINIMUM GUARANTEED PURITY** | **MAXIMUM WEED SEED AND OTHER CROP** | **MINIMUM GUARANTEED GERMINATION** |
| Certified Turf-Type Tall Fescue Festuca elatior arundinacea (Cultivars from current Agronomy Mimeo #77) | 98 percent | 0.2 percent | 85 percent |
| Certified Kentucky Bluegrass Poa pratensis | 95 percent | 0.2 percent | 85 percent |

**Superseded recommendation of approved soil test report

END OF SECTION

# SECTION 03100

# CONCRETE FORMWORK

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section specifies formwork for concrete structures and other facilities.

B. Related Work Specified Elsewhere:
1. Concrete Reinforcement: Section 03200.
2. Cast-in-Place Structural Concrete: Section 03300.

### 1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:

B. Comply with codes and regulations of the jurisdictional authorities.

C. American Concrete Institute (ACI):
1. ACI 347, Publication # 4

D. Western Woods Products Association (WWPA):
1. Western Lumber Grading Rules.

E. U.S. Army Corps of Engineers (USACE):
1. CRD-C 572.

F. American Association of State Highway and Transportation Officials (AASHTO):
1. AASHTO M153.

G. APA – The Engineered Wood Association:
1. HDO Plywood Exterior Grade.

H. U.S. Product Standard : PS 1

I. Responsibilities:
1. Design and construction of formwork is the responsibility of the Contractor, subject to review by the Engineer.
2. Design Criteria: Design the formwork and falsework in accordance with ACI 347 and with the following:
   a. Design, include assumed values of live load, dead load, weight of moving equipment operated on the formwork, temporary construction material, foundation pressures, stresses, lateral stability, and such other factors pertinent to safety of the structure during construction.
   b. Design the formwork to be readily removable without impact, shock, or damage to cast-in-place concrete surfaces and adjacent construction.
3. Design formwork system which is adequately braced and has adequate strength and stability to ensure finished concrete within the specified tolerances.
4. When necessary to maintain the specified tolerances, design camber into the formwork to compensate for anticipated deflection and creep due to the weight and pressure of the fresh concrete, prestressing forces and construction loads.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
   1. Working Drawings:
      a. Include details of form types, methods of form construction and erection, design computations and location of form joints and form ties, location and dimensions of blockouts and openings in structure, and embeds.
   2. Samples:
      a. Each type of waterstop proposed for use, each one foot long: Two.
      b. Each type of premolded expansion-joint filler proposed for use, each six inches by 12 inches: Two.
      c. Proposed dovetail anchor slot, each twelve inches long: Two.
      d. Snap-off form ties: Two.
   3. Certification:
      a. Manufacturer's certificates.
      b. Certified test reports of specified concrete tests.
   4. Documentation:
      a. Calculations: Early form removal calculations as specified certified by a professional engineer registered in the area where the work is to be performed. Submit in advance for obtaining approval prior to form removal.

PART 2 PRODUCTS

2.01 MATERIALS:

A. General:
   1. Wood forms:
      a. All framing lumber stress-graded.
      b. Lumber in direct contact with concrete, dressed on at least the contact side, with dressed or tongue-and-groove edges; other lumber may be dressed or rough.
      c. Where vertical board finish is shown or specified, use the following:
         1) Form board: Tongue-and-groove, Number 1 Common or better, Ponderosa or White pine, in accordance with the Western Lumber Grading Rules book published by WWPA (not the Southern Pine Inspection Bureau grading rules), one-inch nominal thickness, four-inch nominal width, groove S2S milled or beveled one side only and center matched with 45-degree beveled edges to produce sharp V-shaped 3/8-inch wide in concrete. Four-inch tongue-and-groove boards to be toenailed at edge or face-nailed to backer board.
         2) Smooth concrete: Tongue-and-groove, square cut unturned edges, Number 1 Common or better, Ponderosa or White pine, in accordance with the Western Lumber Grading Rules book published by WWPA (not the Southern Pine Inspection Bureau grading rules), one-inch nominal thickness, four inches nominal width, S2S and center-matched.
   2. Plywood forms:
      a. APA grade-marked:
         1) B-B Plyform Exterior grade Group I or II for unexposed finished concrete.
      b. APA High-Density Overlay (HDO) plywood;

1) B or better face veneer Exterior grade Group I for exposed to public view finished concrete..

c. USPS : PS 1

3. Tubular fiber forms:
   a. Spirally constructed of laminated plies of fiber.
   b. Wall thickness as recommended by the manufacturer to meet load requirements of various uses and sizes.
   c. Outside surface wax-coated for moisture resistance.
   d. Inside surface of column forms coated with bond-breaker compound and fabricated so that finish concrete surfaces are smooth and free of spiral and seam marking.
4. Fibrous-glass reinforced plastic forms:
   a. One-piece dome system forms, fabricated of plastic reinforced with fibrous glass.
   b. Molded under heat and pressure using matched metal dies.
   c. Special sizes and cross sections with thickness, reinforcement and surface finish as necessary to form concrete surfaces that are smooth and free of irregularities.
5. Steel forms:
   a. One-piece dome system forms.
   b. Special sizes and cross sections as shown, with metal gauges, reinforcement, stiffeners and surface finish as necessary to form concrete surfaces that are smooth and free of irregularities and concrete stain.
6. Hardboard:
   a. For concrete not exposed to public view: tempered, smooth-one-side (S1S) panels not less than 3/16-inch thick, in accordance with AHA IS 1.
7. Form ties:
   a. Factory-fabricated, snap-off metal type, of adequate design to minimize form deflection and preclude concrete spalling upon removal.
   b. Fabricated so that set-back in concrete is such that portion of tie remaining after snap-off and removal of exterior portions is at least 1-1/2 inches below concrete surface.
8. Form release agent: Chemically reactive liquid product that will not bond with, stain, or impair concrete surfaces. Follow form panel manufacturers approved product and recommendations for application. Agents containing castor oil are prohibited
9. Preformed expansion joint filler: AASHTO M153.
   a. Type I: Sponge rubber.
   b. Type II: Cork.Type III: Self-expanding cork.
10. Waterstops: PVC, CE CRD-C 572.
11. Dovetail-anchor slots: 22-gauge electrogalvanized steel, with removable felt filler.
12. Chamfer strips: Except where other sizes are shown, 3/4-inch by 3/4-inch triangular fillets milled from clear, straight-grain pine, surfaced-each-side, or extruded-vinyl tape.
13. Miscellaneous preformed strips for reveals, rustications, and similar joints: Fabricated of wood, metal, plastic or other approved material formed to cross sections shown.

PART 3 EXECUTION

3.01 CONSTRUCTION AND WORKMANSHIP:

A. Concrete finishes and usage locations of various types of forms and form lining: As shown or specified.

B. Unless otherwise shown for concrete surfaces exposed to public view, use HDO Plywood in largest practicable continuous panels to produce plane, smooth surface free from grain imprint, patchmarks, and discoloration.

C. Construct adequately braced formwork so that resulting concrete surfaces conform to specified tolerances.

D. Brace forms, falsework, and centering adequately to retain forms in position as shown on approved working drawings.

E. Provide mortar-tight forms of wood, plywood, fibrous-glass-reinforced plastic, steel or other approved materials which conform to shapes, lines and dimensions shown and produce smooth surface without fins and projections.

F. Where shown or directed because of lagging or form irregularity, and where concrete surfaces will not be exposed to public view, line inner form surfaces with hardboard as follows:
1. Use widest available width of hardboard.
2. Line areas less than four feet wide with single-width piece of hardboard.
3. Offset lining joints from those in backing.
4. Fasten securely to backing with galvanized or aluminum nails driven flush.

G. Forms shall be clean of any rust, molds, concrete scale..etc.

3.02 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
1. Construct elements except concrete linings of tunnels to meet allowable tolerances of dimensions, elevations and positions shown and specified in Section 03300, Cast-in-Place Structural Concrete.
2. Prior to installation, test hydraulic cylinder well casing assembly hydrostatically at 60 psi pressure for two hours in the presence of the Engineer.

3.03 COATING FORMS:

A. Lightly coat form panels with chemically reactive release agent prior to initial concrete placement and before each subsequent placement.

B. Do not allow excess coating material to stand in puddles in forms nor to come into contact with concrete against which fresh concrete is to be placed.

C. Coat with release agent bolts and rods that are to be completely removed or to be free to move

3.04 EMBEDDED ITEMS:

A. Ensure that items to be embedded in concrete are free from oil and foreign matter that would weaken bond of concrete to such items.

B. Install in formwork inserts, anchors, sleeves and other items specified elsewhere. Close ends of conduits, piping and sleeves embedded in concrete with caps or plugs.

C. Install continuous dovetail-anchor slots where shown.

D. Complete tests on piping and other items before starting concrete placement.

E. Before depositing concrete, check location and support of piping, electrical conduits and other items which are to be wholly or partially embedded.

3.05 OPENINGS AND RECESSES IN CONCRETE:

A. Provide openings and recesses; place sleeves furnished by other trades.

3.06 JOINTS:

A. Unless otherwise directed, make contraction, expansion and construction joints only where shown. Where concrete will be exposed to public view, use largest practicable size sheets to minimize joints.

B. Continue reinforcing steel and wire fabric across joints unless they are shown as being free to move.

C. Install pre-molded joint filler at locations shown. Extend filler from bottom of concrete up flush to finish concrete surface or hold down below finish surface as shown.

D. Make splices in pre-molded filler in manner to preclude penetration of concrete between joint faces.

3.07 REMOVAL OF FORMS, FALSEWORK, AND CENTERING:

A. Maintain forms, falsework, and centering in place until the concrete has attained minimum percentage of specified design strength in accordance with Schedule 1:

| **Structural Member** | **Minimum Percentage of Specified Design Strength** | |
|---|---|---|
| | **Schedule 1** | **Schedule 2** |
| Footings; inverts; sides of beams; slabs and girders; slabs and beams on grade | 25 | 20 |
| Free-standing walls, columns and piers | 40 | 30 |
| Cantilevers | 90 | 70 |

B. Early removal of forms, falsework, and centering will not be allowed for concrete strength values below Schedule 2, but will be allowed for concrete strength values between Schedule 1 and Schedule 2 only after:
1. The Engineer has approved calculations showing anticipated concrete strengths at time of proposed early removal based on:

a. Ratio of dead load over live load.
b. Span, height and shape.
c. Ratio of rise over span.
d. Reshoring.
e. Loads, resultant stresses and deformations to which concrete and reinforcing steel will be subjected at time of removal, subsequent to removal and until concrete has attained design strength.
f. Prevailing site conditions.

2. Concrete strength attained prior to form removal has been determined by analysis of quality-assurance data in accordance with Section 03300, Cast-in-Place Structural Concrete.

C. Do not remove wood board forms within 48 hours of pouring concrete.

D. Do not alter loading conditions on concrete subsequent to removal of forms if it results in exceeding permissible stresses and deformations at attained concrete strengths.

E. The Engineer may permit early removal of concrete support without submittal of calculations prior to attainment of specified design strength if he considers such submittals to be unnecessary.

END OF SECTION

SECTION 03200

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.01 DESCRIPTION:

A. This section specifies reinforcement for concrete structures and other facilities.

B. Related Work Specified Elsewhere:
1. Concrete Formwork: Section 03100.
2. Cast-in-Place Structural Concrete: Section 03300.

C. Definitions:
1. Cover: Thickness of concrete between outside surface of reinforcement and outside face of concrete.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. American Concrete Institute (ACI):
a. ACI SP-66, Detailing Manual.
b. ACI 318, Building Code Requirements for Structural Concrete.
3. Concrete Reinforcing Steel Institute (CRSI):
a. Manual of Standard Practice; Placing Reinforcing Bars.
4. American Association of State Highway and Transportation Officials (AASHTO):
a. AASHTO Standard Specifications for Highway Bridges.
5. ASTM International (ASTM):
a. ASTM A82, Standard Specification for Wire, Plain, for Concrete Reinforcement.
b. ASTM A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
c. ASTM A706, Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement.
d. ASTM A775, Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
e. ASTM A1064, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

B. Allowable Tolerances:
1. Cut and bend reinforcing steel to conform to dimensions shown within the following tolerances:
a. Sheared length: Plus-or-minus one inch.
b. Depth of truss bars: Plus zero or minus 1/2 inch.
c. Stirrups, ties and spirals: Plus-or-minus 1/2 inch.
d. All other bends: Plus-or-minus one inch.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings:
a. Detail reinforcing in accordance with ACI SP-66.

b. Bar lists showing the individual weight of each bar, total weight of each bar size and total weight of bars on list. Base calculated weights on theoretical unit weights shown in ASTM A615, Table 1.

2. Certification:
   a. Manufacturer's certificates.
   b. Mill tests on each heat showing chemical and physical analyses performed in accordance with ASTM A615, as modified by ACI 318.
   c. Record of mill tests traceable to individual reinforcement bars supplied to the project.

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Ship reinforcing steel in bundles limited to one size and length.

B. Tag each bundle at mill with waterproof tag showing name of mill, heat number, grade, and size of bars, and identifying number.

C. Protect reinforcing steel and wire fabric from damage; foreign matter such as dirt, oil and grease; and rust-causing conditions.

PART 2 PRODUCTS

2.01 MATERIALS:

A. Reinforcing Steel Bars:
   1. ASTM A615, Grade 60, modified in accordance with ACI 318.
   2. ASTM A706, for all welding reinforcing bars, except for electrical bonding.
   3. Epoxy Coating: ASTM A775, as shown.

B. Spiral Reinforcement: ASTM A82 or ASTM A615, Grade 60.

C. Welded Steel-Wire Fabric: ASTM A1064.

D. Metal Accessories: As recommended by CRSI Manual of Standard Practice. Where concrete surfaces will be exposed to public view in finish structure, use supports with plastic-protected legs or stainless steel legs.

PART 3 EXECUTION

3.01 CUTTING AND BENDING:

A. Perform cutting and bending in the shop. Bend steel cold. Do not bend or straighten bars so as to damage material.

B. Do not bend bars in the field except to correct minor errors and damage occurring during shipping and handling.

3.02 BAR SUPPORTS AND SPACERS:

A. Support bars by means of bolsters or chairs with no less than minimum required by ACI SP-66.

B. Reinforcing steel in bottom of slabs resting on earth may be supported by concrete brick or mortar blocks.

C. In walls, columns, piers, and abutments hold reinforcing steel in position by means of mortar blocks, bar supports, or spacers wired to reinforcing steel.

D. Do not use stones, clay bricks, wood blocks, or pieces of broken concrete to support reinforcing steel.

E. Do not place bars or fabricated mats on layers of fresh concrete as work progresses.

3.03 PLACING AND FASTENING:

A. Arrange and place reinforcing steel as shown.

B. Secure reinforcement positively against displacement during placing of concrete.

C. Wire or clip bars together as recommended in CRSI Placing Reinforcing Bars.

D. Before placement, ensure that reinforcement is free from dirt, mill scale, rust scale, oil, grease, and other foreign matter.

3.04 SPLICING:

A. Furnish reinforcing bars in full lengths as shown on the Contract Drawings and approved shop drawings.

B. Do not splice bars unless approved in writing.

C. Make splices when authorized, in accordance with ACI 318, except make all butt splices by mechanical connector with a capacity of not less than 125 percent of minimum yield strength of bar.

3.05 INSPECTION:

A. Placement of concrete prior to approval of reinforcement and electrical bonding work is prohibited.

END OF SECTION

# SECTION 03300

# CAST-IN-PLACE STRUCTURAL CONCRETE

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section specifies providing Portland-cement cast-in-place concrete.

B. Related Work Specified Elsewhere:
1. Section 02750: Concrete Pavement.
2. Section 02772: Curbs, Gutters, and Walks.
3. Section 03100: Concrete Formwork
4. Section 03200: Concrete Reinforcement

### 1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. American Concrete Institute (ACI):
   a. ACI 201.2R, Guide to Durable Concrete.
   b. ACI 211.1, Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
   c. ACI 304, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
   d. ACI 309, Guide for Consolidation of Concrete.
   e. ACI 318, Building Code Requirements for Structural Concrete and Commentary.
   f. ACI 318.1, Building Code Requirements for Structural Plain Concrete.
3. American Association of State Highway and Transportation Officials (AASHTO):
   a. AASHTO M182, T26.
4. NBS: Handbook 44.
5. USBR: Concrete Manual.
6. FS: A-A-341A, HH-I-521, K-P-146.
7. ASTM International (ASTM):
   a. ASTM C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   b. ASTM C33, Standard Specification for Concrete Aggregates.
   c. ASTM C39, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   d. ASTM C40, Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
   e. ASTM C42, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   f. ASTM C87, Standard Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar.
   g. ASTM C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   h. ASTM C94, Standard Specification for Ready-Mixed Concrete.
   i. ASTM C131, Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   j. ASTM C150, Standard Specification for Portland Cement.
   k. ASTM C171, Standard Specification for Sheet Materials for Curing Concrete.

l. ASTM C172, Standard Practice for Sampling Freshly Mixed Concrete.
m. ASTM C260, Standard Specification for Air-Entraining Admixtures for Concrete.
n. ASTM C295, Standard Guide for Petrographic Examination of Aggregates for Concrete.
o. ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
p. ASTM C311, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete.
q. ASTM C494,
r. ASTM C535, Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
s. ASTM C586, Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks as Concrete Aggregates (Rock-Cylinder Method).
t. ASTM C595, Standard Specification for Blended Hydraulic Cements.
u. ASTM C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
v. ASTM C665, Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.
w. ASTM C685, Standard Specification for Chemical Admixtures for Concrete.
x. ASTM C989, Standard Specification for Slag Cement for Use in Concrete and Mortars.
y. ASTM C1107, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
z. ASTM C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).

8. Concrete Plant Manufacturer's Bureau (CPMB):
   a. Concrete Plant Standards.
9. National Institute of Standards and Technology (NIST).

B. Testing Laboratory:
1. Furnish the services of an independent testing laboratory. Employment of an independent laboratory does not relieve the Contractor of the obligation to perform the work in accordance with requirements of the Specifications and Drawings. Submit certified results of the tests performed.
2. Furnish proof that the laboratory satisfies the requirements of the American Council of Independent Laboratories' Recommended Requirements for Independent Laboratory Qualification. Laboratory need not be a member of the American Council of Independent Laboratories.
3. Certify that testing equipment has been calibrated by an accredited calibration agency at not more than 12-month intervals using devices of accuracy traceable to the National Institute of Standards and Technology (NIST) or accepted values of material physical constants

C. Properties of Concrete:
1. General:
   a. Design mixes to produce concrete of proper workability, durability, strength, maximum density, minimum shrinkage, and permeability.
   b. Design mixes to have minimum water content per cubic yard of concrete, cement content corresponding to appropriate water-cement ratio, largest permissible maximum size specified of coarse aggregate available and optimum percentage of fine aggregate.
   c. Use maximum size of coarse aggregate in accordance with ACI 211.1.
   d. Use same brand from same source throughout the work.

e. Use aggregates from same source throughout the work.
f. Use ground-iron blast-furnace slag and fly ash from the same sources respectively throughout the work.

2. Durability:
   a. Maximum water cementitious materials ratio as per ACI 318, Chapter 4 and ACI 201.2R.
   b. Use a suitable combination of approved air-entraining admixture and water reducer to reduce water content and permeability of the concrete, provided such admixtures do not adversely affect other specified properties of concrete.
3. Workability:
   a. Use approved chemical admixtures as needed for workability so that concrete can be placed, consolidated, and finished without segregation or excessive bleeding.
4. Strength:
   a. Design mix for each class and type of concrete of each specified strength based on overdesign factor in accordance with ASTM C94. Unless otherwise shown, working-stress method applies to structures.
   b. Design each class of concrete in accordance with the following:
      1) Not more than the following percentages of strength tests to have values less than specified strength:
      2) Working-stress method: 20 percent.
      3) Ultimate-strength method: 10 percent.
      4) Prestressed structures: 10 percent.
      5) Average of the following numbers of consecutive strength tests to be equal to or greater than specified strength:
         a) Working-stress method: Six.
         b) Ultimate-strength method: Three.
         c) Prestressed structures: Three.
   c. When number of tests totals six or less, average to be in accordance with Note 21 of ASTM C94.
5. Appearance:
   a. Cured concrete exposed to public view shall be uniform in color, texture and finish with no discernible form or patch marks, grain imprint, joint irregularities or discoloration. Use only manufacturer approved chemically reactive release agents on HDO plywood forms.
   b. Final selection and approval for color shall be made by the Engineer.

D. Method of Proportioning:
1. Proportion mixes as described in ACI 211.1.
2. Approximate mixing-water and air-content requirements for mixes of different slumps and nominal maximum sizes of aggregates as specified in ACI 211.1, Table 5.3.3.
3. Do not vary proportions of ingredients of approved mixes without written approval.

E. Ready-Mixed Concrete: ASTM C94.

1.03 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Product Data: Manufacturer's literature completely describing each material, standard, test data, installation instructions and special instructions or safety precautions applicable to the materials.
   a. Samples:
      1) Concrete surface sealer: Two, each one pint.

2) Membrane-forming curing compound: Two of each type, each one pint.

2. Certification:
   a. Ingredients:
      1) Submit with mix design, laboratory test reports and mill or manufacturer's certificates verifying that ingredients conform to specified requirements. Use ingredients in design mix which are representative samples of materials to be used in the work.
      2) Submit test results whenever the aggregates, cement or other additives to be used in the concrete come from a different lot, source, other area of the quarry, different quarry or from other than the representative stockpile or batch from which the original material was tested and approved.
   b. In case the source, brand or characteristic properties of ingredients need to be varied during the term of the Contract, submit revised laboratory-mix report in accordance with procedures specified for original mix design.
   c. Batch tickets:
      1) Before unloading at the site, submit certification or delivery ticket from concrete supplier with each batch delivered to the site bearing the following information:
         a) Name of supplier.
         b) Name of batching plant and location.
         c) Serial number of ticket.
         d) Date.
         e) Truck number.
         f) Specific job designation: Contract number and location.
         g) Volume of concrete in cubic yards.
         h) Class and type of concrete.
         i) Time loaded.
         j) Type and brand of cement.
         k) Weight of cement and fly ash or ground-iron blast-furnace slag.
         l) Maximum size of aggregates.
         m) Weights of coarse and fine aggregates.
         n) Maximum amount of water to be added and amount of water added at the site.
         o) Kind and amount of admixtures.
3. Documentation:
   a. Proposed methods for controlling concrete temperature and plans for placing concrete taking into account sun, heat, wind, ambient air temperature or other limitations of facilities that will prevent proper finishing or curing.
   b. Quality control reports. Submit as specified after installation.
   c. Design mixes:
      1) Prior to placing concrete, submit design mixes for each class and type of concrete, certifying that proposed concrete ingredients and proportions will result in concrete mix meeting specified requirements.
      2) Include for each class and type of concrete as many mix designs as there are combinations of different ingredients or types of ingredients anticipated to cover requirements of the work.
      3) Establish mix designs through an approved design laboratory.
      4) Design concrete mix for protection against alkali-aggregate reactivity.
      5) The Contractor may present for approval a concrete mix previously approved for Authority work provided such mix is made

with proposed ingredients that meet requirements and provided that concrete has complied with compressive-strength requirements based on control record of at least 30 consecutive-strength tests recently obtained.

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Aggregates:
1. Transport and stock pile aggregate separately according to sources and gradations. Handle so as to prevent segregation, loss of fines and contamination by earth or other foreign materials.
2. If aggregates show segregation or if different grades become mixed, rescreen before placing in proportioning bins.
3. Do not combine aggregate from different sources or of different gradations except to obtain different gradations.
4. Do not transfer aggregates directly from trucks, railroads cars or barges to proportioning bins when moisture content is such that it will affect accurate proportioning of concrete mixture. In such cases, stockpile aggregate until excess moisture drains off.

B. Packaged Cement:
1. Deliver to project site in original sealed packages labeled with weight, name of manufacturer, brand, and type.
2. Store packages in watertight building.
3. Do not use cement which has been reclaimed by cleaning bags.
4. Do not use cement which has been exposed to moisture or contaminated.
5. Deliver packages conforming to weight specified.
6. Packaged cement will be subject to testing.

C. Bulk Cement:
1. Store bulk cement separately from other cement and protect to prevent exposure to moisture and contamination.
2. In ready-mix plant, provide facilities to maintain separation of cement meeting specified requirements from other cement.
3. Provide in cement manufacturer's plant, facilities for sampling cement at weighing hopper or in feed line immediately before entering hopper.

D. Ready-Mixed Concrete: ASTM C94.

E. Blast-Furnace Slag or Fly Ash for use with Portland Cement:
1. Transport in covered carriers.
2. Store in watertight bins or silos to provide protection from dampness and contamination. When compartmented bins are used, conduct periodic, but not less than weekly checks between adjacent bins to avoid contamination of either of the stored materials.

F. Concrete Additives. As required by the manufacturer.

PART 2 PRODUCTS

2.01 MATERIALS:

A. Cementitious Materials:
1. Portland Cement: ASTM C150, Types I and II. Use Type II only for underground structures.

a. Alkali content not to exceed 0.6 percent.

2. Blended Hydraulic Cement: ASTM C595 Type IS and IP.

B. Ground-Iron Blast Furnace Slag: ASTM C989, Grade 100 or 120.

C. Fly Ash: ASTM C311 and ASTM C618, Class F:

1. Loss on ignition not to exceed 4 percent.
2. Maximum available alkalis (for combination of cement and fly ash) not to exceed 0.6 percent based on proportions to be used and alkalinity measurements for cement and fly ash individually or in combination.
   a. Fly ash used to be qualified for each source.
3. Uniform color when used in concrete exposed to public view.

D. Aggregates:

1. Aggregates for normal concrete and shotcrete: ASTM C33 with the following additional requirements:
   a. Coarse aggregate: Gravel, crushed gravel or crushed stone.
      1) Deleterious substances:
         a) Maximum allowable amounts:

| Substance | | Maximum Allowable Percentage by Weight |
|---|---|---|
| (1) | Soft particles: | 5.0 |
| (2) | Coal and lignite particles: | 0.5 |
| (3) | Friable particles: | 0.25 |
| (4) | Material passing Size 200 sieve: | 1.0 |
| (5) | Thin or elongated pieces: | 15.0 |
| (6) | Other local deleterious substances: | 1.0 |

         b) Soft particles: Higher percentage may be approved where concrete is not subject to abrasion, provided concrete strength is achieved without the use of excess cement.
         c) Crushed aggregates: If material finer than Number 200 sieve consists of dust of fracture essentially free from clay or shale, percentage may be increased to 1.5.
         d) Thin or elongated pieces: Length of pieces to be greater than five times the smallest dimensions of a circumscribing rectangular prism.
      2) Percentage of wear: 45 maximum when tested in accordance with ASTM C131 and ASTM C535.
      3) Weighted percentage of loss: 15-percent maximum by weight when subjected to five cycles of magnesium sulphate soundness test in accordance with ASTM C88.
      4) Gradation: In accordance with ASTM C33, Table 2, and represented by a smooth gradation curve within required limits.
   b. Fine aggregate:
      1) Washed natural sand or washed stone sand. Stone sand may be subject to special gradation requirements as directed.
      2) Gradation in accordance with ASTM C33.

a) Minimum percentages of material passing Size 50 and Size 100 sieves may be reduced to five and zero, respectively, if aggregate is to be used in concrete with three percent minimum air entrainment, or in concrete containing more than 517 pounds of cement per cubic yard.

3) Weighted percentage of loss not more than 12 percent by weight when subjected to five cycles of magnesium sulphate soundness test in accordance with ASTM C88.

4) Deleterious Substances:

| Substance | | Maximum Allowable Percentage by Weight |
|---|---|---|
| a) | Friable particles: | 1.0 |
| b) | Coal and lignite: 0.5 | |
| c) | Material passing the Size 200 sieve: | 5.0 |
| d) | Other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles: | 2.0 |

5) Free from injurious amounts of inorganic impurities as determined by ASTM C40. Should materials fail to pass test for organic impurities in sand for concrete, retest in accordance with ASTM C87. If fine aggregate shows by colorimetric test a darker color than that of sample originally approved for the work, stop using such aggregate until approved tests have been made to determine whether change in color is indicative of injurious amount of deleterious substances.

c. Evaluate for potential alkali aggregate reactivity:

1) Perform a petrographic examination in accordance with ASTM C295. The petrographic analysis will identify the constituents of the fine and coarse aggregate and will also identify aggregate found to be potentially alkali-carbonate reactive. Fine and coarse aggregate containing more than the following quantities of constituents is unacceptable:

a) Optically strained, microfractured or microcrystalline quartz exceeding five percent (a common constituent or granite and granite gneiss).

b) Chert, Metaquarzite, Chalcedony or combination thereof exceeding three percent. However, fine aggregate may contain up to eight percent provided that mortar bar test results are acceptable.

c) Tridymite or cristobalite exceeding one percent.

d) Opal exceeding five percent.

e) Natural volcanic glass in volcanic rocks exceeding three percent.

2) Test aggregate for alkali-silica reactivity in accordance with ASTM C1260. Aggregate sources that exhibit a C1260 mean mortar bar expansion at 16 days greater than 0.08 percent are unacceptable.

3) Aggregate identified by the petrographic analysis to be potentially alkali-carbonate reactive is to be further evaluated in accordance with ASTM C586. Expansion of test specimen cylinders not to exceed 0.10 percent after 28 day immersion in NaOH solution.

4) Aggregate which fails the evaluation criteria for potential alkali aggregate reactivity may be reclassified as acceptable if prior field performance demonstrates that the aggregate is nonreactive. Include service records (material records, batch quantities, exposure conditions, and petrographic evaluation) demonstrating the aggregate to be nonreactive in the mix design submittal.

E. Water:
1. Natural potable water with no pronounced taste or odor.
2. Containing no impurities, suspended particles, algae or dissolved natural salts in quantities that will cause:
   a. Corrosion of reinforcing steel.
   b. Volume change that will increase shrinkage cracking.
   c. Efflorescence.
   d. Excessive air entraining.
3. pH: Not less than five.
4. When tested in accordance with AASHTO T26, standard mortar-briquette tests to show no indication of unsoundness, no change in setting time in excess of plus-or-minus 30 minutes and no reduction in strength in excess of 10 percent.

F. Ready-Mixed Concrete: ASTM C94, Option C.

G. Admixtures:
1. In accordance with the following:
   a. Air-entraining admixtures: ASTM C260.
   b. Chemical admixtures: ASTM C494.
2. Approved brands: Chlorides may be present in admixtures provided total chloride in mixing water of proposed concrete mixture, including chloride ions contributed by admixture or admixtures, aggregate, and mixing water is not in excess of 150 ppm.
3. Meeting requirements of reference standards or documented to have five-year minimum history of demonstrably satisfactory performance for similar structures under equivalent conditions.
   a. .

H. Curing Materials:
1. Plastic sheeting: Polyethylene, ASTM C171.
   a. Curing sheet: Type 1.1.1 and 1.1.2.
   b. Vapor barrier: Clear 10-mils thickness.
2. Burlap sheet: AASHTO M182, Class 3 or 4.
3. Tarpaulin: FS K-P-146.
4. Blanket insulation: FS HH-I-521.
5. .

I. Chairs for Reinforcement: Plastic or stainless steel.

2.02 SAMPLING:

A. Sample concrete ingredients prior to use and have them tested by an approved laboratory in accordance with methods specified. Subsequently test materials as often as necessary to verify that materials conform to specified requirements and that quality of product is maintained.

B. Make arrangements for the Engineer to witness sampling and testing. Submit record of test results.

C. Ready-Mixed Concrete: ASTM C94.

2.03 GROUT MIXES:

A. Portland-cement grout:
1. Prepare grout composed of Portland cement, sand and water.
2. Use Portland-cement grout under bearing plates, in recesses, holes and surfaces under structural members and at other locations shown.
3. Do not use staining ingredients in grout exposed to view.
4. Formulation: Two parts sand and one-part cement measured by volume.
5. Mix grout with sufficient water to permit placing and packing, approximately 45 minutes prior to use.

B. Nonshrink grout: ASTM C1107.

C. Shrinkage-compensating grout:
1. Use shrinkage-compensating grout for setting structural members, anchor bolts, embedded items, or items of equipment and machinery on hardened concrete.
2. Prepare non-staining shrinkage-compensating grout with Portland cement, sand and aluminum powder and use in accordance with manufacturer's recommendations.
3. Prepare shrinkage-compensating grout for use up to two inches thick as follows, measured by volume:
a. One-part Portland cement, Type I or II.
b. One-part fine natural-sand aggregate, graded as specified.
c. One-part ferrous aggregate, graded as specified, combined with Type-A chemical admixture, oxidation agent and water in sufficient amount to permit placing and packing.

D. Premixed shrinkage-compensating grout:
1. In lieu of specified shrinkage-compensating grout, use premixed ready-to-use formulation when approved. Approval will be based on manufacturer's certification that:
a. Material will perform as specified.
b. Composition and proportioning of grout materials is essentially as specified for shrinkage-compensating.
c. Formulation has been used successfully in like applications for at least five years.
2. Proportion ingredients in accordance with the manufacturer's recommendations.

E. Mixing water:
1. Proportion mixing water in accordance with grout manufacturer's recommendation or to produce flowable mixture without segregation or bleeding.

F. Curing:
1. After grout has attained initial set, keep damp for 24 hours minimum.

PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL:

A. Classes of Concrete:
1. Classes of concrete are designated by numerals corresponding to their specified 28-day compressive strength in pounds per square inch as determined by ASTM C94.

2. Concrete classes used in this project are specified. Unless otherwise indicated, use Class 4000.
3. Each class of concrete may comprise one or more mixes determined by maximum size of aggregate, cement factor and types of admixtures used.
   a. Portland cement may be used alone or mixed with either ground-iron blast-furnace slag or fly ash. Do not use fly ash in architectural concrete exposed to public view.
   b. Maximum allowable ground-iron blast-furnace slag: 50 percent of the total weight of the Portland cement and ground-iron blast-furnace slag mixture.
   c. Maximum allowable fly ash: 20-percent of the total weight of the Portland cement and fly-ash mixture.
4. Concrete with fly ash or ground-iron blast-furnace slag may be used at locations shown on the drawings.

B. Minimum Cement Factor:
1. Observe minimum cement factor for various classes of concrete, as follows:

| Class of Concrete | Minimum Cement Factor Bags Per Cubic Yard Of Concrete |
|---|---|
| 5,000 | 6.5 |
| 3,500 - 4,000 | 6.0 |
| 2,500 - 3,000 | 5.0 |

* one bag of cement = 94 lbs. of cement

2. If a mix of Portland cement and ground-iron blast-furnace slag or portland cement and fly ash is used, the mix is the basis of determining the bags per cubic yard of concrete.

C. Air Entrainment:
1. Determine air content of concrete in accordance with ASTM C94.

D. Testing of Concrete:
1. General:
   a. Provide the Engineer with molds and concrete, and cast specimens for testing. In addition, furnish necessary testing equipment and tools to perform sampling, slump tests and yield tests. Furnish boxes for shipping samples.
2. Perform strength tests by making not less than one set of standard cylindrical test specimens for each 100 cubic yards of concrete or any portion thereof for each structure.
   a. For each work shift, when concrete is delivered, make at least one set of specimens. A set of test specimens consists of at least three standard cylinders from a batch.
   b. Perform slump tests, unit weight and air content tests with no less frequency than that of strength-specimen sets.
3. Concrete strengths:
   a. Determine strengths from standard test specimens according to ASTM C31 and ASTM C172 and cured and tested in accordance with ASTM C39 by the testing laboratory. Core drilling and testing in accordance with ASTM C42.Consider the effects of corrosion-inhibiting admixture and other admixtures on the strength of the concrete, in the concrete mix design. The corrosion-inhibiting admixture and other admixtures must be present in the concrete used for the test of the proposed mix strength.
   b. Compute and evaluate in accordance with ASTM C94.

E. Variability of Constituents in Concrete:
1. Take representative samples of concrete mortar.
2. Maximum allowable unit-weight variation of air-free mortar taken from consecutive batches as discharged from mixer:
   a. Average of two mortar weights: 0.8-percent maximum.
   b. Average of six mortar weights: 0.5-percent maximum.
3. Maximum allowable weight variation of coarse aggregate per cubic foot of concrete taken from consecutive batches as discharged from mixer.
   a. Average of two weights: Five-percent maximum.

F. Allowable Concrete Finish Tolerances:
1. Finish concrete elements to dimensions, elevations and positions shown within the tolerances specified for each:
   a. Formed surfaces such as walls, piers , and columns: Plus-or-minus 1/4 inch.
   b. Invert slabs and floating slabs:
      1) Maximum deviation from profile grade: Plus zero or minus 1/2 inch.
      2) Maximum deviation from 10-foot steel straightedge: Plus-or-minus 1/8 inch, noncumulative.
      3) Verify adequacy of finish for draining by hosing area. Ponding or obstructions to flow toward invert drains constitute defects.
   c. Invert under floating slabs:
      1) Maximum deviation from profile grade: Plus zero, minus 1/2 inch.
      2) Maximum deviation from 10-foot steel straightedge: Plus-or-minus 1/8 inch, noncumulative.

3.02 MATERIAL PREPARATION:

A. Mixing Concrete:
1. Operations:
   a. Provide concrete mixers that discharge concrete of uniform composition and consistency.
   b. Combine coarse aggregates of different gradation and identical sources, provided corresponding concrete mix has been approved. The use of alternate batches of gravel, crushed gravel or crushed stone of a single size is prohibited.
   c. Adequacy of mixing will be determined by the Engineer by means of mixer performance tests in accordance with USBR Concrete Manual, Designation 26, Variability of Constituents in Concrete, in the appendix.
   d. The Engineer may reduce size of batch to be mixed or increase mixing time when charging and mixing operations fail to produce concrete which conforms to specified requirements and which has uniform coloration and consistency.
   e. Add water prior to, during and following mixer-charging operations. Do not overmix or add water to maintain consistency.
   f. Use of concrete to which water in excess of amount permitted by approved design mix has been added to overcome conditions caused by excessive retention in mixer is prohibited.
2. Central-mixed concrete:
   a. Arrange mixers in centralized mixing plant so that mixing action in mixers can be conveniently observed by the Engineer and plant operator.
   b. Do not load mixers in excess of rated capacity. Mix concrete ingredients in batch mixer for not less than period of time specified for various mixer capacities after each ingredient except full amount of water is in mixer.

Reduce mixing time if thorough mixing as specified can be obtained in less time and if approved.

c. Mixing time:

| Cubic-Yard Capacity of Mixer | Mixing Time |
|---|---|
| 2 or less | 1½ minutes |
| 3 | 2 minutes |
| 4 | 2½ minutes |
| More than 4 | To be determined per ASTM C94 tests by the Engineer |

d. Equip each mixer with mechanically operated batch counter and timing and signaling device to indicate completion of mixing period.

3. Truck-mixed concrete: Use equipment and procedures that conform to the requirements of ASTM C94 and ACI 304, Chapter 5, with the following additional requirements:
   a. Introduce materials, including water and mixtures, into the mixing drum only at the central batching plant, or
   b. Transport aggregates from the central plant to the jobsite in the mixing drum and add measured and recorded cement, admixtures, and water into the drum prior to mixing at discharge point.
   c. When ice is used, add it with the water and counted as part of the water-cement ratio.
   d. Place concrete within 90 minutes after cement is introduced into the mixing drum.
   e. Accomplish initial mixing by 70 to 100 revolutions with drum rotating at the manufacturer's recommended speed. 30 revolutions at mixing speed will be required, if the addition of water is permitted. Do not exceed total of 300 mixing and agitating revolutions.
4. Temperature control:
   a. Use preparation methods capable of producing concrete with temperature 85ºF maximum and 55ºF minimum at time of placement.
   b. Do not heat concrete ingredients to temperature higher than that necessary to keep temperature of mixed concrete as placed within specified temperatures.
   c. Do not heat water in excess of 140ºF.

B. Admixtures:
1. Introduce admixtures in solution form.
2. Air-entraining admixture: Use for concrete exposed to weathering or in contact with rock or moist soil.
3. Chemical admixtures:
   a. Use water-reducing admixtures in concrete areas below grade in contact with rock, earth or fill.
   b. Employ admixtures without interfering with specified air-content dosage of air-entrained concrete.
   c. Except as otherwise specified or approved, use of water-reducing, set-retarding, or set-accelerating admixtures is prohibited.
   d. If introduction of certain admixtures to improve concrete strength is approved, do not reduce cement content below minimum amounts specified.

C. Consistency:
1. For concrete to be compacted by approved mechanical vibrators, maintain slump range at point of delivery within the following limits:

a. Concrete pavement, pavement base, sidewalk, and incidental construction: Two to three inches.
b. Unreinforced concrete other than pavements: One to three inches.
c. Reinforced concrete: Two to four inches.
d. Concrete placed by pumping and concrete for filling steel-shell piles: Four to five inches.
e. Do not use concrete if slump exceeds maximum by 1/2 inch or more.

3.03 CONVEYING:

A. General:
1. Provide equipment for conveying concrete from mixer with continuous flow of concrete to point of placement without segregation.
2. Provide arrangement at discharge end of conveyor to prevent segregation.
3. Design long conveyor runs to discharge concrete into hopper, without segregation, before it is deposited in forms.
4. Ensure that pumps, pneumatic equipment, pipes, chutes and troughs are cleaned of dirt and concrete before use.

B. Chutes and Troughs:
1. Use only ferrous-metal-lined chutes and open troughs. Where steep slopes are unavoidable, equip chutes or troughs with baffles to minimize segregation of aggregates. Keep chutes or open troughs clean of hardened concrete by flushing with water after each use.
2. Discharge water used for cleaning outside lines of structure. Lay out chutes or open troughs with slope one-foot vertical to two feet horizontal maximum and one-foot vertical to three feet horizontal minimum.
3. Discharge chutes 20 feet or more in length into hopper before final distribution.

C. Adjustable Length Pipes (Elephant Trunks):
1. Use flexible pipes of ferrous metal, rubber, or plastic, six inches minimum diameter so as to prevent segregation of concrete.
2. Position chutes or flexible pipes so that concrete is delivered in continuous flow to points not more than five feet horizontally and five feet vertically from final location. In vicinity of expansion and contraction joints, reduce horizontal distance to three feet maximum.
3. Clean flexible pipes and elephant trunks after each use.

D. Buggies:
1. Construct runways for buggies so they will not come into contact with or be supported by reinforcing steel of structure.

E. Pumping and Pneumatic Conveying Equipment:
1. Use pumping and pneumatic conveying equipment, designed to handle without segregation types, classes, and volumes of concrete to be conveyed.
2. Operate pump or pneumatic equipment so that continuous stream of concrete without air pockets is produced. Position discharge end of line as near final position of concrete as possible but in no case more than five feet away.
3. At conclusion of placement, clean equipment. Discharge debris and flushing water outside of forms.

3.04 PLACEMENT:

A. General:
1. Prior to placing concrete, remove debris and extraneous material from interior of forms.

2. Place first lift of concrete on wet surface. Consolidate by dragging vibrator along edges of joints. Make sure there is no free or standing water over the surface.
3. Place concrete continuously and as rapidly as possible after mixing. Do not use vibrators for shifting mass of fresh concrete.
4. Place concrete in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause formation of seams or planes of weakness. Cover each layer of concrete with fresh concrete within 45 minutes.
5. Do not place concrete which has attained initial set or concrete which has contained mix water for more than 90 minutes.
6. Remove temporary spreaders in forms when concrete has reached elevation which makes them unnecessary.
7. Place column concrete using adjustable-length flexible pipes or elephant trunks to avoid dropping concrete over five feet. In monolithic placements, do not deposit concrete in supported elements such as beams, girders and slabs until concrete previously deposited in columns or walls has completed its settlement shrinkage, but not to the point at which concrete in supporting members will not permit vibrator to sink into its mass of its own weight.
8. Placing will not be permitted when sun, heat, wind or limitations of facilities will prevent finishing and curing.
9. Concrete temperature at time of placement:
   a. 55ºF, minimum.
   b. 85ºF, maximum.
10. Unless approved, do not continue concreting when descending ambient air temperature falls lower than 40ºF.
11. Prior to placing fresh concrete against rock or previously placed concrete, take necessary steps, such as flushing with water, to ensure removal of foreign matter which would adversely affect bond.
    a. Maintain wire fabric and other reinforcing in proper position on chairs during concrete placement.

B. Consolidation:
1. Consolidate concrete thoroughly as it is placed in order to secure a dense mass. Work concrete well around reinforcement, embedded items and into the corners of forms. Consolidate concrete in accordance with ACI 309.
2. Use internal vibrators unless external vibrators are approved.
3. Use vibrators capable of generating frequencies of not less than 7,000 impulses per minute. Verify that vibrators have power and amplitude factor so as to visibly affect mass of concrete of one-inch slump over radius of at least 18 inches. Prevent formation of laitance and accumulation of excessive water on surface of concrete as it is deposited. Remove excessive water by pumping or other approved means.
4. Do not use vibrators where internal vibration might cause damage to embedded items; in such cases spading is required.

3.05 CURING AND PROTECTING:

A. General:
1. Protect freshly placed concrete from excessively hot or cold temperatures. Maintain without drying for period of time necessary for hydration of cement and proper hardening of concrete.
2. Provide sufficient tarpaulins to cover completely or enclose forms and working areas prior to and during placing and finishing operations.
3. Cure newly placed concrete continuously for seven days at ambient temperature in excess of 55ºF.
4. Cure concrete in subway structures by normal curing method specified.

5. During curing period keep steel and wood forms wet. If forms are removed during curing, use one of the following methods of curing immediately and continue for remainder of the curing period.

B. Normal Curing and Protection:
1. Use one of the following methods for flat surfaces, weather permitting:
a. Use ponding on horizontal surfaces providing surface is continuously submerged for required curing period.
b. Apply continuous sprinkling with nozzle or nozzles which, during first 24 hours, atomize flow of water providing a mist and not a spray. Do not apply moisture under pressure directly upon concrete; avoid flowing or washing on surfaces while susceptible to erosion.
c. Cover entire surface of concrete with double thickness burlap sheet, laid directly on concrete and kept continuously wet. Maintain in good condition.
d. Sprinkle concrete surface as specified for at least 18 hours and immediately cover with waterproof curing sheet, free from holes or tears. Hold in position so that entire surface of concrete is fully and continuously covered.
e. Do not damage burlap, waterproof sheet or concrete surfaces.

C. Membrane-Forming Curing Compound:
1. Use curing compound when approved for circumstances where application of moisture is impracticable and where such compounds will not jeopardize appearance of concrete. Except as otherwise specified, use Type-1 compound, uniformly applied over surface at thickness recommended by manufacturer. Thoroughly mix compound and apply within one hour after mixing.
2. Where surfaces are subject to sunlight, apply Type-2 compound. Except for surfaces exposed to public view and architectural finished concrete.
a. .
3. Warm or stir curing compound if necessary for satisfactory application in accordance with manufacturer's recommendations. If film of compound is damaged before expiration of curing period, repair immediately with additional compound.
4. Finish surfaces prior to application of curing compound. Do not use curing compound on construction joints.
5. Apply curing compound in two coats. Apply first coat immediately after stripping of forms and acceptance of concrete finish.
6. If surface is dry, thoroughly wet concrete with water and apply curing compound just as surface film of water disappears. Apply second coat after first coat has set.
7. Protect coating against damage for at least 10 days after application. If damage occurs, apply additional coating.
8. If use of curing compound results in streaked or blotchy appearance, cease operations and use other method of curing until cause of defective appearance is corrected.

D. Protection of Rod Reinforcement:
1. After forms are removed, coat rod reinforcement and dowels extending beyond concrete surfaces with application of neat cement paste.
2. Remove hardened cement paste and resultant debris immediately prior to extension of reinforcement or installation of formwork.

3.06 COLD WEATHER CONCRETING:

A. Do not place concrete when ambient temperature is less than 55º F and falling. Do not place concrete unless the form temperature at the time of placement is at least 40º F.

B. When ambient temperature is 40º F and falling, carry out one of the following procedures to protect placed concrete:
   1. Heating:
      a. Enclose forms or structures and heat to maintain concrete and air within enclosure at not less than 55º F for seven days after placement.
      b. Maintain relative humidity at not less than 40 percent during curing period when heat is applied to enclosures. Arrange stoves, salamanders or heaters so as to provide uniform distribution of heat. Vent combustion gases to outside air. Do not let hot air blow across concrete surfaces.
      c. After seven-day curing period, reduce temperature within enclosure gradually at maximum rate of 20º F per day until outside temperature has been reached.
      d. Provide continuous and adequate fire protection and watchmen when heating units are in operation.
   2. Form insulation:
      a. Insulate forms with blanket insulation of approved type and thickness to maintain concrete at 55 º F minimum for seven days.
      b. Protect top of placed concrete by tarpaulins or other approved waterproof material over insulation.

C. Do not allow concrete to freeze in a saturated condition prior to achieving a strength of 4000 psi.

3.07 HOT WEATHER CONCRETING:

A. When temperature in forms is 75ºF or above, carry out the following procedures to protect placed concrete:
   1. Protect concrete from direct sunlight.
   2. Keep forms moist by means of cool-water sprinkling or application of wet burlap or cotton mats.
   3. At 90F or above cool aggregates with water spray hoses.
   4. Cool truck barrels with water spray system.

3.08 JOINTS:

A. General:
   1. Unless otherwise shown make construction joints bonded joints by roughening surface to expose aggregates. Clean and roughen surface by wet sandblasting, by cutting with high-pressure water jet with a minimum pressure of 2,000 psi or by other approved means. Perform cleaning after concrete has hardened to prevent raveling of surface.
   2. Place construction joints at locations shown, or at locations approved by the Engineer.

B. Horizontal Construction Joints:
   1. Joints within 18 inches of tops of faces are prohibited.
   2. Trowel top surface of concrete adjacent to forms smooth to minimize visible joints on exposed faces. Remove laitance and other objectionable materials from joint surface to expose sound concrete as soon as concrete is firm enough to retain its form.
   3. Immediately after placement of concrete, remove accumulations splashed on exposed reinforcement and surfaces of adjacent forms before concrete attains initial set.

3.09 CONCRETE FINISHING:

A. When forms are removed, do not remedy voids, stone pockets, and other defects until the Engineer has inspected them and given directions.

B. Finish concrete surfaces as shown and as follows:
   1. Number-1 Form Finish:
      a. Immediately following form removal, remove fins and irregular projections from surfaces exposed to view or those that will receive waterproofing.
      b. Prepare pointing mortar not more than 30 minutes prior to use.
      c. Cure mortar patches as specified under curing and protection.
      d. Leave contraction joints and articulated joints in completed work carefully tooled and free of mortar and concrete.
      e. Leave joint filler exposed for its full length with clean and true edges.
      f. Apply this finish to structures, unless otherwise shown.
   2. Number-3 Broomed Finish:
      a. Where floors and other areas are shown to have rough finish, strike-off surface with screeds and wood floats at elevation shown.
      b. Before concrete has achieved initial set, broom transversely to flow of traffic with stiff, medium-bristle broom especially made for intended purpose to develop corrugations not more than 1/8-inch deep.

C. Do not sprinkle water or cement on surfaces to be trowel finished.

3.10 DEFECTIVE CONCRETE:

A. Concrete will be considered defective unless it is structurally sound, watertight, properly finished, and within specified tolerances.

B. Concrete in place that is deemed structurally defective will be checked by the Engineer by drilled core specimens. If testing of core specimens shows that strength is less than 85 percent of specified strength, costs incurred in taking and testing of core specimens will be borne by the Contractor.

C. Replace, strengthen, or correct defective concrete as directed.

3.11 PROTECTION FROM AND REMOVAL OF STAINS:

A. Protect concrete structure from rust staining by structural-steel members or from other substances during the work.

B. If staining should occur, remove stains and restore concrete to its original color.

3.12 DAMAGED WORK:

A. Before final acceptance of the work, neatly repair damaged surfaces, corners of concrete, and concrete finish.

B. Where surface repairs are permitted, finish damaged areas to smooth, dense watertight condition.

C. Replace concrete that is not satisfactorily repaired.

3.13 CORRECTIVE WORK:

A. Submit corrective action patching procedure.

B. If correction of defects is approved, remove defective concrete; key area to be repaired, soak surface with water and patch with approved materials. Patch architectural concrete so as to match existing. Use bonding agents applied to the substrate or mixed with patching material only as approved by the Engineer.

C. Clean surface cavities produced by form ties, other holes, honeycomb spots, broken corners or edges and other defects. Saturate with water and point with mortar paste consisting of cement and fine aggregate mixed in proportions to give same appearance as original concrete.

D. Tolerance deviations and other surface defects may also be corrected, if approved, by grinding high areas and swales. .

E. Where corrective work is unsatisfactory, completely remove such work, and replace with new work complying with specified requirements.

END OF SECTION

# SECTION 05500

# MISCELLANEOUS METAL

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section specifies providing miscellaneous metal, with the exception of ornamental (architectural) metal and metalwork provided as a part of mechanical, electrical and construction systems.

B. Related Work Specified Elsewhere:
1. Concrete Formwork: Section 03100.
2. Concrete Reinforcement: Section 03200.
3. Cast in Place Structural Concrete: Section 03300.

### 1.02 SUBMITTALS:

A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
1. Shop Drawings: Detail fabrication and erection of each metal fabrication indicated.
   a. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items. Provide templates for anchors and bolts specified for installation under other Sections.
   b. Manufacturer's standard drawings may be submitted in lieu of Contractor-prepared shop drawings if manufacturer's standard drawings show required details.
2. Certification:
   a. Certification that welding personnel are currently qualified in accordance with AWS D1.1.
   b. Mill Certificates: Signed by manufacturers of stainless-steel sheet certifying that products furnished comply with requirements for corrosion resistance of Type 316 stainless steel.

### 1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards, and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. American Society of Mechanical Engineers (ASME):
   a. ASME A 17.1,
   b. ASME B18.6.3,
   c. ASME B18.21.1,
   d. ASME B18.22.1.
3. American Institute of Steel Construction (AISC):
   a. Specification for Structural Steel for Buildings-Allowable Stress Design and Plastic Design (Do not use plastic design).
4. American Welding Society (AWS):
   a. AWS D1.1.
5. FED STD: 595.
6. MS: MIL-P-21035.
7. FS: A-A-462, FF-B-588, FF-H-116, FF-P-395, FF-S-325, RR-T-650, TT-P-86.

8. The Society for Protective Coatings (SSPC):
   a. SP 11, Paint 12.
9. ASTM International (ASTM):
   a. ASTM A36, Standard Specification for Carbon Structural Steel.
   b. ASTM A53, Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless.
   c. ASTM A74, Standard Specification for Cast Iron Soil Pipe and Fittings.
   d. ASTM A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold Finished.
   e. ASTM A193, Standard Specification for Alloy Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   f. ASTM A242, Standard Specification for High Strength Low Alloy Structural Steel.
   g. ASTM A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength.
   h. ASTM A413, Standard Specification for Carbon Steel Chain.
   i. ASTM A500, Standard Specification for Cold Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   j. ASTM A501, Standard Specification for Hot Formed Welded and Seamless Carbon Steel Structural Tubing.
   k. ASTM A666, Standard Specification for Annealed or Cold Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   l. ASTM A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings.
   m. ASTM A1011, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
   n. ASTM B221, Standard Specification for Aluminum and Aluminum Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
   o. ASTM B632, Standard Specification for Aluminum Alloy Rolled Tread Plate , Aluminum.
   p. ASTM B633, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
   q. ASTM D1187, Standard Specification for Asphalt Base Emulsions for Use as Protective Coatings for Metal.
   r. ASTM E488, Standard Test Methods for Strength of Anchors in Concrete Elements.
   s. ASTM F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   t. ASTM F594, Standard Specification for Stainless Steel Nuts.
   u. ASTM F1554. Standard Specification for Anchor Bolts, Steel, 36, 55, and 105 ksi Yield Strength.
10. American Galvanizers Association (AGA):
   a. The Design and Fabrication of Galvanized Products.
11. American National Standards Institute (ANSI):
   a. ANSI 14.3, Ladders – Fixed – Safety Requirements.

B. Qualifications of Welding Personnel:
1. Welding: Qualify procedures and personnel according to the following:
   a. AWS D1.1, "Structural Welding Code--Steel."
   b. AWS D1.3, "Structural Welding Code--Sheet Steel."
   c. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone

recertification. Such certification is to remain in force for the duration of the welding operations under this Contract.

C. Fabricator Qualifications: A firm experienced in producing metal fabrications similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

D. Coordinate installation of anchorages for metal fabrications. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.04 PROJECT CONDITIONS:

A. Field Measurements: Where metal fabrications are indicated to fit walls and other construction, verify dimensions by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish dimensions and proceed with fabricating metal fabrications without field measurements. Coordinate construction to ensure that actual dimensions correspond to established dimensions. Allow for trimming and fitting.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Deliver products undamaged.

B. Store products so as to prevent rust.

C. Handle products so as to prevent damage.

D. After completion of factory testing, package and ship hatches as directed.

PART 2 PRODUCTS

2.01 MATERIALS:

A. General Requirements:
1. Insofar as practicable, furnish similar products of a single manufacturer.
2. Metal Surfaces, General: For metal fabrications exposed to view in the completed Work, provide materials with smooth, flat surfaces without blemishes. Do not use materials with exposed pitting, seam marks, roller marks, rolled trade names, or roughness.

2.02 FERROUS METALS:

A. Structural steel: Plates, shapes, bars and angles, ASTM A36.

B. High-strength low-alloy structural steel:
1. Resistance to atmospheric corrosion: Four times that of carbon steel, minimum.

C. Structural tubing: ASTM A501.

D. Hollow structural sections: ASTM A500 Grade B.

E. Steel Pipe: ASTM A 53, standard weight (Schedule 40), unless another weight is indicated or required by structural loads.

F. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666, Type 304. Type 316L for corrosive environments.

G. Hot-rolled carbon steel sheets and strips: ASTM A1011.

H. Pipe, Pipe Sleeves and Pipe Fittings:
1. Cast iron: ASTM A74, service weight.
2. Steel: ASTM A53, galvanized unless otherwise shown or specified.

I. Guard Chain: ASTM A413, Class Grade 28, galvanized steel, 9/32-inch thick, complete with stainless-steel eyes, spring-loaded catches and mounting components.

2.03 ALUMINUM:

A. Aluminum Extrusions: ASTM B221, Alloy 6063

B. Aluminum-Alloy Rolled Tread Plate: ASTM B632/B632M, Alloy 6061.

C. Cast Aluminum.

2.04 COATINGS:

A. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664; selected for good resistance to normal atmospheric corrosion, compatibility with finish paint systems indicated, and capability to provide a sound foundation for field-applied topcoats despite prolonged exposure.

B. Zinc-rich paint: MS MIL-P-21035.

C. Electrodeposited zinc coating: ASTM B633

D. Galvanizing repair compound: Stick form, melting point 600F to 650F, GALVABAR or equal.

E. Bituminous coating: Cold-applied asphalt mastic complying with SSPC Paint 12, except containing no asbestos fibers, or cold-applied asphalt emulsion complying with ASTM D1187.

2.05 FASTENERS:

A. General: Provide Type 304 or 316 stainless-steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B 633, Class Fe/Zn 5, where built into exterior walls. Select fasteners for type, grade, and class required.

B. Screws: Material, type and size to suit the purpose; steel, except stainless, cadmium-plated.
1. Stainless steel, ASTM A193, Alloy S30400.

C. Machine bolts: Material, type and size best suited to the purpose. Minimum tensile strength 60,000 psi.
   1. Carbon steel: ASTM A307, Grade B, galvanized.
   2. Stainless steel: ASTM A193, Class 1A.

D. Anchor Rods:
   1. Rods: ASTM F1554, Grade 36, 55, 105 as noted on drawings.
   2. Nuts: ASTM A563.
   3. Washers: ASTM F436.

E. Toggle bolt: FS FF-B-588.

F. Drive stud: FS FF-S-325, Group 6.

G. Expansion shield: FS FF-S-325 Group I, Type 2, Class 2, Style 1; Group II, Type 3, Class 1; Group IV, Type 1; best suited to the purpose.

H. Screw anchors: Lead or plastic for wood or metal screws.

I. Anchor-bolt sleeve: Corrugated high-density polyethylene plastic.

J. Powder actuated: FS FF-P-395.

K. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to six times the load imposed when installed in unit masonry and equal to four times the load imposed when installed in concrete, as determined by testing per ASTM E488, conducted by a qualified independent testing agency; ACI 318 Appendix D requirements for cracked concrete and have approved ICC-ES Evaluation Report.
   1. Material: Alloy Group 1 or 2 stainless-steel bolts complying with ASTM F593 and nuts complying with ASTM F594.

L. Internally Threaded Steel Anchor: ASTM A108.

2.06 CONCRETE AND GROUT:

A. Nonshrink Grout: Section 03300, Cast-in-Place Structural Concrete.

2.07 FABRICATION, GENERAL:

A. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.

B. Shear and punch metals cleanly and accurately. Remove burrs.

C. Ease exposed edges to a radius of approximately 1/32 inch, unless otherwise indicated. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.

D. Weld corners and seams continuously to comply with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

E. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

F. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.

G. Fabricate joints that will be exposed to weather in a manner to exclude water, or provide weep holes where water may accumulate.

H. Allow for thermal movement resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening up of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculation on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

I. Form exposed work true to line and level with accurate angles and surfaces and straight sharp edges

J. Remove sharp or rough areas on exposed traffic surfaces.

K. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed fasteners of type indicated or, if not indicated, Phillips flat-head (countersunk) screws or bolts. Locate joints where least conspicuous.

2.08 PEDESTRIAN BARRIER (GUARD RAIL):

A. Tubing: Hot-formed square steel. Fabricated as follows:
1. Heated and bent smoothly without distortion
2. Joints fully welded as shown.
3. Intersections coped, fully welded and ground smooth and flush.

B. Plate: Structural steel.

C. Floor-cover flange: Cast steel, as shown.

D. Finish: Shop-coated and finish painted in accordance with Section 09920.

2.09 MISCELLANEOUS ITEMS:

A. Fabricate metal items indicated on the drawings from materials shown or, if not otherwise described, from steel or from galvanized steel wherever exposed to the weather or in contact with concrete or masonry.

B. Make miscellaneous items to the size and configuration indicated, welded or bolted at joints to develop full strength equal to a continuous member, and in every way complete for the intended purpose and finished in appearance.

2.10 FINISHES:

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish metal fabrications after assembly.

B. Galvanizing:
1. Clean ferrous metal thoroughly before applying zinc coating.
2. Apply zinc coating to products after fabrication, by hot-dip method, using coating weighing not less than 2.0 ounces per square foot.

C. Shop Paint:
1. Ferrous metal thoroughly cleaned as recommended by primer manufacturer and in accordance with SSPC SP11 and, except for items to be encased in concrete, given prime coat of paint.
2. Zinc yellow iron-oxide primer or red-lead base primer applied so as to thoroughly cover surfaces without leaving runs or sags.

PART 3 EXECUTION

3.01 PREPARATION:

A. Remove foreign substances from surfaces to receive metal items.

B. Protect surrounding surfaces from damage while performing the work of this section.

3.02 INSTALLATION, GENERAL:

A. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing metal fabrications to in-place construction. Include threaded fasteners for concrete and masonry inserts, toggle bolts, through-bolts, lag bolts, wood screws, and other connectors.

B. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

C. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.

D. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

E. Field Welding: Comply with the following requirements:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.
4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.

F. Corrosion Protection: Coat concealed surfaces of aluminum that will come into contact with grout, concrete, masonry, wood, or dissimilar metals with a heavy coat of bituminous paint.

3.03 EXPANSION ANCHOR INSTALLATION:

A. General: Install expansion anchors in strict accordance with manufacturer's published instructions and those listed in the applicable ICC-ES Evaluation Report and in accordance with the following.

B. Install in dry, interior locations only; tension is not permitted in overhead applications.

C. Install anchors only after concrete has reached its minimum specified 28-day compressive strength.

D. Drilling Holes: Use rotary hammer type drill and drill holes to the required diameter and depth as consistent with anchor manufacturer's instructions for size of anchors being installed.

E. Minimum Installation Criteria: Unless otherwise indicated on Drawings, embed expansion anchors to 6.5 bolt diameters minimum. Anchors shall meet the manufacturer’s published centerline to centerline spacing and edge distance requirements.

3.04 PAINTING AND REPAIRING COATED SURFACES:

A. Before erection or enclosing construction, paint items that support masonry or will be concealed in finished work, except items encased in concrete.

B. Where shop coat is abraded or burned by welding, clean and touch-up.

C. Touch-up primed surfaces with same material as coating.

D. Where aluminum parts come in contact with concrete or steel, coat contact surfaces of aluminum with bituminous coating.

E. Coat field welds and repair damage to zinc-coated surfaces in accordance with ASTM A780 and as follows:
1. Wire-brush areas to be coated to bright metal.
2. Apply galvanizing repair compound at rate of two ounces per square foot.

END OF SECTION

# SECTION 07841

# FIRESTOPPING

## PART 1 GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Firestopping systems.

2. Firestopping of all joints and penetrations in fire-resistance rated and smoke-resistant assemblies, whether indicated on drawings or not, and other openings indicated.

B. Related Sections:

1. Section 16112: Conduits for Electrical Systems

### 1.01 REFERENCES

A. Reference Standards:

1. U. S. Government:
   a. Federal Transit Administration (FTA):
      1) 49 CFR 661 Buy America Requirements.
   b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities
   c. Codes, Regulations, Reference Standards and Specifications:
      1) Comply with codes and regulations of the jurisdictional authorities.

2. ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials; 2011.

3. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Fire Stops; 2011a.

4. FM P7825 - Approval Guide; Factory Mutual Research Corporation; current edition.

5. SCAQMD 1168 - South Coast Air Quality Management District Rule No.1168; current edition; www.aqmd.gov.

6. UL (FRD) - Fire Resistance Directory; Underwriters Laboratories Inc.; current edition.

### 1.2 SUBMITTALS

A. See Section 01330 - Submittal Procedures.

B. Schedule of Firestopping: List each type of penetration, fire rating of the penetrated assembly, and firestopping test or design number.

C. Product Data: Provide data on product characteristics, performance ratings, and limitations.

1.3 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Buy America Act :
      a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

B. Fire Testing: Provide firestopping assemblies of designs that provide the scheduled fire ratings when tested in accordance with methods indicated.

C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

D. Installer Qualifications: Company specializing in performing the work of this section and:

   1. With minimum 3 years documented experience installing work of this type.

1.4 FIELD CONDITIONS

A. Comply with firestopping manufacturer's recommendations for temperature and conditions during and after installation. Maintain minimum temperature before, during, and for 3 days after installation of materials.

PART 2 PRODUCTS

2.1 FIRESTOPPING SYSTEMS

A. Firestopping: Any material meeting requirements.

   1. Fire Ratings: Use any system listed by UL or tested in accordance with ASTM E814 that has F Rating equal to fire rating of penetrated assembly and T Rating Equal to F Rating and that meets all other specified requirements.

END OF SECTION

# SECTION 13120

# TENSIONED FABRIC STRUCTURES

## PART 1 GENERAL

### 1.01 DESCRIPTION:

A. This section includes an exterior architectural tensile membrane roof structure system. The membrane used in these structures shall be polytetrafluoroethylene ("PTFE"), such as Teflon® coated woven fiberglass.

B. The tensile membrane structure contractor (hereafter referred to as "Subcontractor") shall be responsible for the structural design, detailing, fabrication, supply, and installation of the Work specified herein, some or all of which may be contracted by Subcontractor to others meeting the qualification requirements of Section 1.04. The intent of this specification is to establish in the first instance an undivided, single-source responsibility of the Subcontractor for all of the foregoing functions.

C. Subcontractor's Work shall include, but not necessarily be limited to, the structural design, supply, fabrication, shipment, and erection of the following principal items:
1. The architectural membrane as indicated on the drawings and in these specifications.
2. Cables and end fittings.
3. Perimeter, catenary, and sectionalized aluminum clamping system.
4. Structural steel, including masts, trusses, struts, beams and/or weldments.
5. Fasteners and gasketing.

D. Related Work Specified Elsewhere:
1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 specification sections, apply to the Work of this Section.

E. Related Sections: The following Construction Specification Institute (CSI) MasterFormat™ divisions contain requirements relating to this section
1. Section 03100: Concrete Formwork.
2. Section 03200: Concrete Reinforcement.
3. Section 03300: Cast-in-Place Structural Concrete.
4. Section 16060: Grounding and Bonding for Electrical Systems.

### 1.02 REFERENCES:

A. General: Except as otherwise shown or noted, all Work shall comply with the requirements of the following codes and standards:
1. American Institute of Steel Construction (AISC):
   a. Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings.
   b. Code of Standard Practice for Steel Buildings and Bridges.
   c. Specification for Structural Steel Buildings - Allowable Stress Design and Plastic Design.
   d. Specification for Allowable Stress Design of Single-angle Members.
   e. Seismic Provisions for Structural Steel Buildings.
2. American Society of Civil Engineers (ASCE):
   a. ASCE 19: Structural Applications of Steel Cables for Buildings.
3. ASTM International (ASTM):

a. ASTM A36, Standard Specification for Carbon Structural Steel.
b. ASTM A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
c. ASTM A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
d. ASTM A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength.
e. ASTM A325, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
f. ASTM A500, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
g. ASTM A572, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
h. ASTM A586: Standard Specification for Zinc-Coated Steel Structural Strand.
i. ASTM A603: Standard Specification for Zinc-Coated Steel Structural Wire Rope.
j. ASTM A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
k. ASTM B633, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
l. ASTM C509, Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material.
m. ASTM D395, Standard Test Methods for Rubber Property—Compression Set.
n. ASTM D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension.
o. ASTM D573, Standard Test Method for Rubber—Deterioration in an Air Oven.
p. ASTM D1171, Standard Test Method for Rubber Deterioration—Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens).
q. ASTM D2000, Standard Classification System for Rubber Products in Automotive Applications.
r. ASTM D4851: Standard Test Methods for Coated and Laminated Fabrics for Architectural Use.
s. ASTM E84: Standard Test Method for Surface Burning Characteristics of Building Materials.
t. ASTM E108: Standard Test Methods for Fire Tests of Roof Coverings.
u. ASTM E136: Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C.
v. ASTM E424: Standard Test Method for Solar Energy Transmittance and Reflectance of Sheet Materials.
w. ASTM F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
x. ASTM F594, Standard Specification for Stainless Steel Nuts.

4. American Welding Society (AWS):
   a. AWS D1.1: Structural Welding Code.
   b. AWS 2.4: Symbols for Welding and Nondestructive Testing.
5. Aluminum Association.
   a. Specifications for Aluminum Structures.
6. National Fire Protection Association (NFPA).
   a. NFPA 701: Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.
7. Steel Structures Painting Council (SSPC).

a. Steel Structures Painting Manual, Volumes 1 and 2.

1.03 SYSTEM REQUIREMENTS:

A. General: Provide a structural tensile membrane system that complies with requirements specified herein by testing the Subcontractor's corresponding membrane system in accordance with the indicated test methods.

B. Building Code Criteria: The tensile membrane structure shall comply with the ICC IBC latest edition. ***PLEASE NOTE ALL BELOW ITEMS SHALL MEET ICC IBC 2012 STANDARDS***

| | | |
|---|---|---|
| 1. | Ground Snow Load: | 25 psf |
| 2. | Snow Load Importance Factor: | 1.0 |
| 3. | Thermal Factor: | 1.2 |
| 4. | Snow Exposure Factor | 1.0 |
| 5. | Roof Snow Load: | 21 psf+DRIFT |
| 6. | Basic Wind Speed: | Vult 115 mph ; Vasd= 90 mph |
| 7. | Wind Load Importance Factor (Iw): | 1.0 |
| 8. | Wind Exposure Category: | C |

C. Life Safety: All tensile membrane structures shall be detailed so that no life safety issue is created in the event of a loss of a part of the membrane. The tensile membrane structure shall not rely on the membrane for structural stability.

D. Fire Performance: Range of characteristics required of membranes:
1. Burning Characteristics (ASTM E84)
   a. Flame Spread: 5 max
   b. Smoke Generation (Tunnel Test): 20 max
2. Fire Resistance of Roof Coverings (ASTM E108)
   a. Burning Brand: Class A
3. Incombustibility of Substrates (ASTM E136)
   a. Substrate Noncombustible: Pass
4. Flame Resistance (NFPA 701 Small Scale, UL 94):
   a. Flame Out: 2 sec.
   b. Char Length: 0.25-inch max.

1.04 QUALITY ASSURANCE:

A. Subcontractor Qualifications: Fabrication and erection of the tensile membrane structure is limited to firms with proven experience in fabrication and construction of complex tensile membrane structures. Such firms, through their own experience and/or that of their qualified subcontractors, shall meet the following minimum requirements:
1. The Subcontractor shall have at least ten (10) years of experience in the successful fabrication and erection of permanent, custom tensile membrane structures.
2. The Subcontractor shall have fabricated and erected at least twenty (20) PTFE-coated woven fiberglass tensile membrane structures, with at least five (5) structures of similar size and complexity as this project.
3. Demonstrate it has maintained an in-house professional engineering design staff for at least ten (10) years, and will provide final engineering drawings that have been prepared by licensed Professional Engineers in its employ.
4. The Subcontractor shall demonstrate it has a fabrication facility of adequate capacity and a staff experienced in the fabrication of PTFE-coated woven

fiberglass tensile membrane structures that will undertake the fabrication of this project.

5. The Subcontractor shall submit a Corporate Quality Control Manual describing the company's complete quality assurance program.
6. All bidders will need to provide a payment and performance bond. The bidder needs to provide proof of a minimum bonding capacity of $5,000,000 with bid.

1.05 SUBMITTALS

A. General: Notwithstanding any provisions of these specifications that may appear to be to the contrary, any and all submittals by the Subcontractor shall be subject to review, approval, and adoption by the Architect/ Engineer as part of the overall project design and engineering, and shall not create a contractual or other professional design relationship between the Subcontractor and either the Architect/Engineer or the Owner.

B. Product Data: Include manufacturer's specifications for materials, fabrication, installation, and recommendations for maintenance. Include test reports showing compliance with project requirements where test method is indicated.
   1. Sample: Submit selection and verification samples.

C. Design Drawings: Subcontractor shall submit tensile membrane structure drawings defining the completed structure, anchorage, and connection details, interfaces with building construction, and general membrane seam arrangements. Design Drawings are to be signed and sealed by a Structural Engineer licensed in the Commonwealth of Virginia.

   Design Calculations: Subcontractor shall submit complete calculations for the Tensile Membrane Structure, as one package with the Design Drawings, signed and sealed by a Structural Engineer licensed in the Commonwealth of Virginia. Structural calculations shall include all required loading cases and load combinations used in the design and resulting member forces, reactions, deflections, and drift. The magnitude of maximum reactions on the supporting structures from all critical load combinations shall be separately tabulated. Critical load conditions used in the final sizing of the members shall be emphasized. The design analysis shall include the name and office phone number of the designer to answer questions during the design drawing review.

D. Quality Assurance Submittals.
   1. Test Reports: Provide test reports from a qualified testing laboratory that show compliance of the Subcontractor's PTFE-coated woven fiberglass tensile membrane system with specification requirements, as follows:
      a. Physical test data of the actual fabric roll goods to be used in the project confirming conformance with specifications for the membrane.
   2. Certificates: Product certificates signed by the Subcontractor certifying materials comply with specified characteristics, criteria, and physical requirements.

E. Closeout Procedures: submit the following items:
   1. Warranty: Project Warranty documents as described herein.
   2. Record Documents: Project record documents for all installed materials.
   3. Maintenance Manual: Submit two (2) copies of a maintenance manual for the tensile membrane structure to the Owner. The manual shall include a schedule for routine inspection, an inspection checklist, instructions for

emergency repair and use of emergency repair materials, and warranty. During the system erection period, the Owner shall provide maintenance personnel to be trained in the use of repair materials.

1.06 PRODUCT DELIVERY, STORAGE, AND HANDLING:

A. Materials shall be packed, loaded, shipped, unloaded, stored, and protected in a manner that will avoid abuse, damage, and defacement.

1.07 WARRANTY:

A. The Subcontractor shall furnish the Owner with a written Warranty, which warrants that the membrane, its perimeter attachment system, and the structural support system as supplied by the Subcontractor have been installed in accordance with the project specifications and will be free from defects in materials and workmanship that will impair their normal use or service. The Warranty shall start from the date of Substantial Completion of the tensile membrane structure; which shall be the first date on which the entire tensile membrane structure is subject to design pre-stress conditions, and continue for a period of five (5) years thereafter.

PART 2 PRODUCTS

2.01 QUALIFIED SUBCONTRACTOR:

A. Birdair, Inc.65 Lawrence Bell Drive, Amherst, New York 14221, Telephone (716) 633-9500, Fax (716) 633-9850, www.birdair.com

B. USA Shade & Fabric Structures, Inc. branded as FabriTec Structures, 8505 Chancellor Row, Dallas, TX 75247, Telephone (800) 966-9005, Fax (214) 905-9514

C. Or approved equal.

2.02 ARCHITECTURAL MEMBRANE:

A. General: The membrane used in these structures shall be polytetrafluoroethylene ("PTFE", such as Teflon®) coated woven fiberglass. All references to "membrane" in this Section 13120, Tensioned Fabric Structures, without exception, and whether singular, plural, or capitalized or not, are to such architectural membrane.

B. The membrane shall meet the following general requirements:
1. Source Quality Control: The primary materials shall be obtained from a single manufacturer. Secondary materials shall be those recommended by the primary manufacturer.
2. Physical Characteristics: The following indicates a range of physical properties type of PTFE Architectural membranes. The determination of specific characteristics and selection of a membrane shall be derived from project engineering by the Project Engineer.
   a. Coated Fabric Weight (oz./sq. yd.) (ASTM 4851): 24- 45.5 nom.
   b. Thickness (mils) (ASTM 4851): 18-36 nom.
   c. Strip Tensile (lbs./in., avg.):
      1) Dry, Warp (ASTM D4851): 520 min.- 975 min. avg.
      2) Dry, Fill (ASTM D4851): 380 min.- 900 min. avg.
   d. Tensile after Flexfold (lbs/in., avg.)
      1) Dry, Warp (ASTM D4851): 375 min.- 760 min. avg.
      2) Dry, Fill (ASTM D4851): 350 min.- 735 min. avg.

e. Trapezoidal Tear (lbs. avg.)
   1) Warp (ASTM D4851): 35 min.- 95 min. avg.
   2) Fill (ASTM D4851): 35 min. - 120 min. avg.
f. Solar Transmission (%) (ASTM E424): 7-22 nom.
g. Solar Reflectance (%) (ASTM E424): 70-75 nom.

C. Materials:
1. Base Fabric: The yarns used shall be of the highest commercial quality, essentially free of broken fibers and fully suitable for coating. The fabric shall be woven with uniform tension and crimp in the warp and fill yarns and free of defects deleterious to the coating process.
2. Fluorocarbon Coatings: The coating materials shall be fluorocarbon resins formulated specifically for architectural applications. These materials shall be applied to form a weatherized barrier between the fiberglass yarns and the environment. The bulk of the coating shall be formulated dispersions of PTFE fluoropolymer resin and additives to enhance abrasion and tear resistance, impart pigmentation or modify solar transmission. The additives shall not constitute more than 20 percent by weight of the total coating or 25 percent by weight of any individual layer. The surface shall be totally a fluoroethylenepropylene ("FEP") resin to facilitate heat welding.
3. After weaving, the base fabric shall be cleaned and primed to achieve optimum mechanical properties of the coated membrane. The coating, described above, shall be virtually free of mud cracks and pinholes. The coating shall be applied evenly to both sides of the fabric and the FEP fluorocarbon resin topcoat shall be of sufficient thickness to permit proper heat fusion of joints with the recommended die pressure and temperature.

2.03 CABLE AND END FITTINGS:

A. Materials:
1. All structural wire rope cables shall conform to the latest revision of ASTM A603.
2. All structural strand cables shall conform to the latest revision of ASTM A586.
3. All cables shall be coated to "Class A" zinc coating throughout.
4. All cables in contact with the membrane shall be white PVC coated. All other cables may be galvanized only.

B. Fabrication:

1. Cable fabricator shall provide effective quality control over all fabrication activities. Inspection of the place of fabrication may occur at any time to verify proper quality control. This inspection does not relieve the fabricator from meeting the requirements of this specification.
2. Cables that are designated to be pre-stretched shall be pre-stretched per ASTM A603 for wire rope and ASTM A586 for structural strand. Cables of the same type shall have the same modulus of elasticity.
3. All cables shall be manufactured to the following length tolerances at 70 degrees Fahrenheit (23 degrees Celsius):
   a. Length< 70 feet (213 meters): ¼ inch (6.4mm)
   b. Length 70 to 270 feet (32.3 to 82.3 meters): 0.03% of length
   c. Length> 270 feet (82.3 meters): 1 inch (25.4 mm)
4. Cables shall have a continuous longitudinal paint stripe (1/4 inch wide max.) along their top surface unless noted otherwise.
5. Index markings shown shall be a circumferential paint stripe (1/4 inch wide max.).
6. All cables and end fittings shall be delivered clean and dry.

7. All swaged and speltered fittings shall be designed and attached to develop the full breaking strength of the cable. Thimble end fittings shall develop a minimum of 90% of the cable breaking strength.
8. Swaged end fittings, pins, nuts, and washers shall be electro-galvanized. Any damage to the zinc coating shall be cleaned and painted with a gray zinc-rich paint per ASTM A780.
9. Speltered end fittings shall be hot dip galvanized per ASTM A153. Any damage to the zinc coating shall be cleaned and painted with a gray zinc-rich paint per ASTM A780.

2.04 ALUMINUM CLAMPING SYSTEM:

A. Materials:
1. All structural aluminum clamping systems shall be ASTM alloy 6061-T6.
2. Bent plates shall be formed from ASTM alloy 6061 and then heat-treated to T6.
3. All structural "U straps" shall be ASTM Aluminum Alloy 6063, heat-treated to T5.

B. All structural aluminum clamping shall have the following finish:
1. Polyester thermosetting powder coating with a tri-glycidyl di-isocyanurate (i.e. TGDI) curing agent/hardener per American Architectural Manufacturers Association (AAMA) 603 to a thickness of 3 mils, white in color.
2. Clear anodized per MIL-A 8625C, Type 2, Class 1.

C. Structural sheet aluminum shall be ASTM alloy 5052-H32.

D. Non-structural sheet aluminum shall be ASTM alloy 1100 series.

E. Fabrication.
1. Aluminum fabricator shall provide effective quality control over all fabrication activities.
Inspection of the place of fabrication may occur at any time to verify proper quality control. This inspection does not relieve the fabricator from meeting requirements of this specification.
2. Fabricated aluminum shall have no sharp edges.
3. Stamp all parts with the appropriate mark number.
4. All fabricated aluminum shall be free of oil, grease, and machining chips.
5. Tolerances shall be as follows:
a. Cross sectional dimensions: +/- 10%, 0.03 in. (0.8 mm) max.
b. Bolt hold locations: +/- 1/32 in. (0.8 mm)
c. Overall length: +/- 1/16 in. (1.6 mm)
6. All welded joints shall conform to AWS D1.2.

2.05 STRUCTURAL STEEL:

A. General: The structural steel fabrication shall comply with the latest revision of all applicable codes, standards, and regulations including the following:
1. ASTM International (ASTM) as referenced.
2. American Institute of Steel Construction (AISC):
a. Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings
b. Code of Standard Practice for Steel Buildings and Bridges.
3. The Society for Protective Coatings (SSPC):
a. Steel Structures Painting Manual, Volumes 1 and 2.

4. Research Council on Riveted and Bolted Structural Joints: Specification for Structural Joints Using ASTM A325 or A490 Bolts.
5. American Welding Society (AWS):
    a. AWS D1.1, Structural Welding Code, Steel.
    b. AWS A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.

B. In the event of conflict between pertinent codes and regulations and the requirements of the references standards or these specifications, the provisions of the more stringent shall govern.

C. Materials:
1. Structural steel for plates and bars shall conform to the requirements of ASTM A36 or ASTM A572, Grade 50, unless noted otherwise.
2. Structural pipe shall conform to ASTM A53, Types E or S, Grade B.
3. Structural tubing shall conform to ASTM A500, Grade B or C.
4. Structural bolts:
    a. High strength bolts: ASTM A325, unless noted otherwise
    b. Common bolts and nuts: ASTM A307
    c. Threaded rods: ASTM A36, unless noted otherwise
5. Other materials: All other materials, not specifically described but required for a complete and proper installation of structural steel, shall be provided and shall be new, free from rust, first quality of their respective kinds, and subject to the approval of the Subcontractor.

D. Accessories.
1. Base Plates and Anchor Bolts.
    a. Base plates supported on concrete, whether shop attached or shipped loose, shall be furnished and set on shims or leveling plates. Grouting shall be by the General Contractor.
    b. Anchor bolt locations shall be furnished by the Subcontractor and used by the General Contractor to set the bolts. The General Contractor is to check carefully the setting of the bolts to their proper position prior to pouring of concrete. Anchor bolts, provided by the General Contractor, shall have two (2) nuts and washers. Damaged threads shall be repaired or be cut to permit full tightening of nuts.

E. Fabrication:
1. Workmanship: All members, when finished, shall be true and free of twists, bends and open joints between the components parts. Members shall be thoroughly straightened in the shop by methods that will not injure them, before being worked on in any way.
    a. Properly mark materials, and match-mark when directed by the Subcontractor, for field assembly.
2. Connections:
    a. Connections shall be as indicated on the drawings. When details are not shown the connections shall conform to the requirements of the AISC.
    b. Provide high-strength threaded fasteners for all structural steel bolted connections, unless noted otherwise.
    c. Combination of bolts and welds in the same connection are not permitted, unless otherwise details.
    d. Welded Connections:
        1) Definitions: All terms herein relating to the welds, welding and oxygen cutting shall be construed in accordance with

the latest revision of *Standard Definitions of Welding Terms and Master Chart of Welding Processes* of the AWS.

2) Operators: Welds shall be made only by operators who have been previously qualified by tests, as prescribed in AWS D1.1 to perform the type of work required.

3) Welding equipment shall be of sufficient capacity and maintained in good working condition, capable of adjustment in full range of current settings. Welding cables shall be adequate size for the currents involved and ground methods shall be such as to insure proper machine operation.

4) No welding shall begin until joint elements are clamped in proper alignment and adjusted to dimensions shown on the drawings with allowance for any weld shrinkage that is expected. No members are to be spliced without prior approval.

5) All welding shall be done in accordance with the reference specifications, with the following modifications and additions:
   a) All field welding shall be done by manual shielded metal-arc welding.
   b) All groove welds shall have complete penetration, unless otherwise specified on the drawings.
   c) The minimum preheat and interpass temperature requirements shall be as required per AWS 01.1.

6) Welding Sequence: Heavy sections and those having a high degree of restraint must be welded in a sequence with the prop preheat and post-weld heat treatment such that no permanent distortion occurs.

7) Oxygen Cutting: Manual oxygen cutting shall be done only with a mechanically guided torch. Alternatively, an unguided torch may be used provided the cut is not within 1/2 inch of the finished dimension and the final removal is completed by chipping or grinding to produce a surface quality equal to that of the base metal edges. The use of oxygen-cut holes for bolted connections will under no circumstances be permitted, and violation of this clause will be sufficient cause for the rejection of any pieces in which oxygen-cut holes exist.

3. Tolerances: All tolerances shall be as per the AISC *Code of Standard Practice for Steel Buildings and Bridges*.

4. Paint System, Two-Part:
   a. Source Quality Control: Primary materials shall be obtained from a single manufacturer. Second materials shall be those recommended by the primary manufacturer.
   b. Surface Preparation and Base Coat:
      1) The surface shall be commercial blast cleaned in conformance with SSPC- SP-6, after all fabrication operations such as machining and welding are complete. There shall be no more than eight hours time lapse between the surface preparation and the application of the primate coat.
      2) The base coat shall be Sherman Williams Macropoxy 646 PW color mil white or light blue or approved equal, and shall conform to SSPC-Paint 22.
      3) The base coat shall be mixed and applied in accordance with the manufacturer's instructions and shall meet the

requirements of SSPC Paint Specification No. 22. The minimum thickness shall be 2.0 to 4.0 mils dft.

c. Finish Coat:
   1) The finish coat shall be Sherman Williams Hi-solid polyurethane (semi gloss) or approved equal, and shall conform to SSPC-paint number 36, level 3.
   2) The finish coat shall be mixed and applied in accordance with the manufacturer's instructions and the minimum thickness shall be 3.0 to 4.0 mils dft.

d. Two-Part System Thickness: The minimum system thickness shall be 8.0 mils dft.

e. Color: The paint color shall be as selected by the Architect.

f. Finish Quality: The dry paint shall be uniform and continuous with no voids or puddles and shall not be broken by scratches or nicks. Although the Subcontractor's Quality Assurance personnel may witness the painting operation, this does not relieve the painting Subcontractor of the responsibility for meeting the quality and workmanship requirements of these specifications.

g. Care and Handling: Subcontractor shall make every reasonable effort to ensure that the painted steel is thoroughly dry and that it is handled carefully to prevent damage to the paint and to reduce field repairs. Nylon slings should be used when handling the painted steel.

h. Certification: The Subcontractor shall be required to certify the paint manufacturer's name, paint identification, conformance with manufacturer's written instructions, and the paint dry mil thickness.

F. Source Quality Control:
   1. Testing:
      a. An independent testing laboratory paid for by the Owner shall perform testing and inspection of the structural steel and welding. All welds shall be tested by visual, dye penetrant, magnetic particle methods or ultrasonic methods in accordance with instructions from the Subcontractor.
      b. The Subcontractor and the testing laboratory inspector shall be permitted to inspect the work in the shop or field throughout fabrication and erection.
      c. The Inspector shall check for workmanship of steel, both in the shop and field, and check general compliance with the Contract Documents and steel shop drawings. The Inspector shall record types and locations of all defects found in the work and measures required and performed to correct such defects.
      d. The steel fabricator shall make all repairs to defective work to the satisfaction of the Inspector and at no additional cost to the Subcontractor.
      e. The Inspector shall submit reports of his inspection and test findings to the Subcontractor. He shall record all defects found with the subsequent repair operations and submit reports to the Subcontractor.
      f. The work of the independent inspector shall in no way relieve the steel fabricator of his responsibility to comply with all requirements of the Contract Documents.

G. Product Handling and Protection: Use all means necessary to protect structural steel before, during, and after installation and to protect the installed work and materials of all other trades.

H. Rejection and Replacement:
1. In the event of damage to the steel, immediately make all repairs and replacements necessary to the approval of and at no additional cost to the Owner.
2. Any materials or welding rejected through inspection either in the shop, mill or field must be promptly replaced to the satisfaction of, and at no additional cost to, the Owner.

I. Qualifications of Steel Fabricator: The steel fabricator shall have not less than five (5) years' continuous experience in the fabrication of structural steel.

2.06 FASTENERS:

A. General: Provide fasteners used to secure clamp systems to curbs and cables, assemblage of clamp systems, and other fasteners as required to complete the work specified herein.

B. Materials:
1. All work shall comply with the latest edition of ASTM standards and American Iron and Steel Institute (AISI), as referenced herein.
2. Fasteners used in membrane clamping systems shall be stainless steel. Bolts and studs shall conform to ASTM F593, Type 304. Nuts shall conform to ASTM F594, Type 316. Washers shall be plain, narrow, and conform to AISI Type 18-8. All clamping systems subjected to relative movement between clamping and curb shall receive a split-ring lock washer conforming to AISI Type 18-8.
3. Unless otherwise specified on the drawings, all other bolts and nuts shall conform to ASTM A307-76B, zinc plated to conform to ASTM B633 Class Fe/Zn 8 type Ill.

C. Source Quality Control: The manufacturer shall certify that all fasteners comply with the above referenced specifications.

2.07 GASKETING:

A. General: All work shall comply with the latest edition of ASTM standards, as referenced herein.

B. Sponge Neoprene Gasketing:
1. Material.
a. All sponge neoprene shall be of a cellular elastomeric compound of a firm grade, which has been manufactured in pre-formed shapes for use as gasket and sealing material, as specified in ASTM C509.
b. Cellular elastomeric materials furnished to this specification shall be manufactured from natural or synthetic rubber, or mixtures of these, with added compounds of such nature and quality that, with proper curing, the finished product will comply with this specification.
c. The cured compounds shall be suitable for use where resistance to sunlight, weathering oxidation, and permanent deformation under load are of prime importance.
d. The manufacturing process shall be such as will ensure a homogeneous cellular material free of defects that may affect serviceability.
e. The physical characteristics of the neoprene must meet or exceed ASTM C509, Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Materials.\

f. Certification of material shall be provided that conforms to ASTM C509.

C. Dense Neoprene Gasketing:

1. All neoprene material shall conform to ASTM D2000M hardness Grade 60. The material shall be homogenous, free from defects, and shall be compounded and cured to meet the requirements specified herein.
2. All neoprene shall be non-staining formulation and shall consist of at least 50 percent by weight of basic rubber hydrocarbon. Material shall not contain crude or reclaimed rubber.
3. The physical characteristics of the neoprene must meet or exceed the following physical test requirements when tested using the standard ASTM test slab can compression set plug (or approved equal):

| PROPERTY | ASTM METHOD | UNITS |
|---|---|---|
| Shore A Durometer | D2240 | 55-65 |
| Tensile Strength (Min.) | D412 | 1,100 psi |
| Percent Elongation (Min.) | D412 | 300% |
| Percent Compression Set (Max.) | D395, Method B, 22 hrs at 212ºF | 35% |
| Heat Aging, Change from Original Properties<br>• Hardness Change (Max.)<br>• Tensile Strength (Max.)<br>• Elongation Change (Max.) | D573, 70 hrs at 212ºF<br><br>+15 points Shore A<br><br>-40% | <br><br><br>-15% |
| Flame Resistance | | Must not propagate Flame |
| Temperature Range | | -30ºC to -100ºC |
| Ozone Resistance | D1171, Method A, 72 hrs at 38º | |
| Resistance to Oil Aging<br>• Tensile Strength (Max.)<br>• Elongation (Max.)<br>• Volume Change (Max.) | | <br>-70%<br>-55%<br>+120% |

2.08 MAINTENANCE KIT

A. Architectural Membrane Maintenance Kit: The Owner shall be supplied with the following materials for emergency repair or maintenance. The materials shall be neatly packaged into a maintenance kit for storage by the Owner.

| Quantity | Description |
|---|---|
| 6 | 12-inch diameter patch with FEP sheets |
| 12 | 5-inch diameter patch with FEP sheets |
| 12 | 4 inch x 8 inch rectangular patch with FEP sheets |
| 6 sq. yds. | Outer Membrane |
| 200 ft. | FEP tape, 3 inches wide |
| 1 | Soldering iron, 500W with wedge tip |
| 1 | Tacking sealer, 3 inch x 5 inch die |
| 2 | Insulating bearing blocks |
| 1 | 5/8 inch hole punch |

| | |
|---|---|
| 1 | Utility knife |
| 50 | Repair clips |
| 1 | Spool of No. 36 nylon twine |
| 36 yds. | Cormar 829/4 x 15 Kevlar® thread |
| 1 | Hand awl |
| 1 pkg. | C-29 needles |
| 1 | Repair manual |

END OF SECTION

# SECTION 13593- FABRICATED CONTROL BOOTHS (MANAGER'S KIOSK)

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section includes fabricated steel control booths.

### 1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control booths.

B. Shop Drawings: For control booths. Include plans, elevations, sections, details, accessories, and fastening and anchorage details, including mechanical fasteners.

1. Anchor-Bolt Plans: Submit anchor-bolt plans and templates. Include location, diameter, and projection of anchor bolts required to attach control booths to foundation. Indicate post reactions at each location.

C. Samples for Initial Selection: For each type of exposed finish.

D. Samples for Verification: For each type of exposed finish in manufacturer's standard sizes.

1. Include Samples of wall panels and accessories to verify finish selection.

### 1.4 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

### 1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For control booths to include in maintenance manuals.

## 1.6 COORDINATION

A. Cast-in Anchorage: Coordinate installation of anchorages for control booths. Furnish sleeves, concrete inserts, anchor bolts, and items with integral anchors that are to be embedded in concrete bases. Include setting drawings, templates, and directions for installing anchorages. Deliver such items to Project site in time for installation.

## 1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair finish or replace control booths that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Control booths shall withstand the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7:

1. Dead Loads: Weight of materials and construction plus weight of fixed service equipment.
    a. Assumed Roof Dead Load: 25 psf.
2. Live Load: Roof Live Load, 50 psf (non-reducible).
3. Snow Loads:
    a. Snow Load: Comply with local building code.
    b. Drifting Snow Load: ASCE/SEI 7.
    c. Snow Exposure Factor: Ce=1.0
    d. Snow Load Importance Factor: I=1.1
    e. Thermal Factor: Ct=1.2 (unheated structure)
4. Wind Loads (as listed below unless otherwise provided):
    a. Basic Wind Speed (3-second gust): 90 mph
    b. Wind Importance Factor: I=1.15
    c. Wind Exposure Category: C

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Safety Glazing Products: Category II materials complying with testing requirements in 16 CFR 1201.

1. Subject to compliance with requirements, obtain safety glazing products permanently marked with certification label of SGCC or another certification agency acceptable to authorities having jurisdiction.

## 2.2 FABRICATED STEEL CONTROL BOOTHS

A. General: Fabricate control booths from an integrated set of mutually dependent components to form a completed assembly, ready for installation on Project site.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. B.I.G. Enterprises, Inc.
b. MFI Mardan Fabricators.
c. Par-Kut International, Inc.
d. Porta-King Building Systems.

B. Building Style: Standard square corners.

C. Structural Framework: Fabricated from 2-by-2-by-0.075-inch (50-by-50-by-1.90-mm) steel structural or mechanical tubing. Connect framework by welding.

D. Doors: Sliding door on one side.

1. Sliding Door: Top suspended from aluminum track with ball-bearing rollers; 1-3/4 inches thick; tubular-frame design fabricated from galvanized steel; with top half of door glazed. Equip door with deadlock, lock support, guide hardware, and full weather stripping.

a. Glazing: Horizontal sliding unit with clear insulating glass.
b. Deadlock: Mortised, laminated-hook bolt type with removable cylinder capable of being master keyed.

E. Windows: Extruded-aluminum sash frames glazed with clear insulating glass.

1. Frame Finish: Manufacturer's standard mill or clear anodic.

2. Corner Shape: Square.

F. Wall Panel Assembly: Assembly consisting of exterior face panel fabricated from 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet; and interior face panel fabricated from 0.052-inch (1.32-mm) nominal-thickness, galvanized-steel sheet; with minimum R-12 rigid fiberglass insulation in cavity between exterior and interior face panels.

G. Base/Floor Assembly: 4-inch-high assembly consisting of perimeter frame welded to structural framework of booth. Fabricate frame from 2-by-4-inch galvanized-steel structural tubing; 0.108-inch nominal-thickness, C-shaped, galvanized-steel sheet channels; or galvanized structural-steel angles. Include anchor clips fabricated from 1/4-inch-thick galvanized-steel plate, predrilled and welded to exterior of integral floor frame.

1. Finished Floor: 0.108-inch nominal-thickness, galvanized, rolled steel tread plate.
2. Subfloor and Finished Floor: Assembly consisting of 0.079-inch nominal-thickness, galvanized-steel sheet underside with minimum R-12 rigid insulation core; covered by 0.125-inch-thick, aluminum rolled tread plate; with overall assembly thickness of 2 inches.

H. Flat Roof/Ceiling Assembly: Assembly consisting of exterior roof panels, interior ceiling panels, and insulation between exterior and interior panels; sloped to drain at booth perimeter.

1. Exterior Roof Panel: Fabricated from 0.064-inch (1.63-mm) nominal-thickness, galvanized-steel sheet; with painted finish, continuously welded seams.
2. Interior Ceiling Panel: Fabricated from 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet; with minimum R-19 fiberglass insulation in cavity between ceiling and roof.
3. Insulated Exterior/Interior Panel: Fabricated from 0.028-inch (0.71-mm) nominal-thickness, galvanized-steel sheet faces and expanded-foam insulation core.
4. Canopy Fascia: Fabricated from 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet, of manufacturer's standard design.

    a. Height: 8 inches (203 mm).
    b. Overhang: 3 inches (76 mm) beyond face of walls below.

5. Downspouts: Integral, extending 3 inches (76 mm) beyond booth walls.

I. Work Counters: Full width of control booth, reinforced; with an access opening for electrical cords at each rear corner of counter.

1. Material: 0.078-inch- (1.98-mm-) thick, stainless-steel sheet.
2. Depth: 18 inches (457 mm).

J. Electrical Power Service: 100-A, 120/240-V ac, single-phase, three-wire service with 12 circuit-breaker panel with 100-A, two pole main circuit breaker and all supplementary circuit breakers; located on side wall. Run existing panel feeder in 1-1/2-inch (13-mm) RMC conduit.

1. Provide two 120-V ground-fault circuit interrupter (GFCI) power receptacle(s).

K. Lighting Fixtures: One ceiling-mounted fluorescent lighting fixture(s), 48 inches (1219 mm) long, with acrylic lens and two 40-W lamps in each fixture or LED fixture equivalent. Provide single-pole switch mounted adjacent to door to control lighting fixture.

L. Heating Unit: Wall-mounted, thermostatically controlled, 110-V, 1500-W electric heater with fan-forced operation and with capacity of not less than 5000 Btu/h (1465 W). Enclose in enameled-steel cabinet and mount under work counter.

M. Cooling Unit: Roof-mounted, thermostatically controlled air conditioner with cooling capacity of not less than 13,500 Btu/h (3956 W). Enclose in enameled-steel cabinet.

N. Anchorage: Cast-in-place anchor bolts fabricated from non-ferrous or corrosion-resistant materials, with allowable load or strength design greater than or equal to the design load as determined by testing conducted by a qualified testing agency.

O. Materials:

1. Zinc-Coated (Galvanized) Steel Sheet: ASTM A 653/A 653M, commercial quality, G90 (Z275) coating designation; mill phosphatized.
2. Galvanized, Rolled Steel Tread Plate: ASTM A 786/A 786M, rolled from steel plate complying with ASTM A 572/A 572M, Grade 55 (380); hot-dip galvanized according to ASTM A 123/A 123M.
3. Steel Structural Tubing: ASTM A 500/A 500M, Grade B.
4. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
5. Steel Mechanical Tubing: ASTM A 513, welded-steel mechanical tubing.
6. Zinc-Coated (Galvanized) Steel: Hot-dip galvanized according to ASTM A 123/A 123M.
7. Aluminum: Alloy and temper recommended by aluminum producer and manufacturer for type of use and finish indicated, and as follows:

    a. Sheet: ASTM B 209 (ASTM B 209M).
    b. Extruded Shapes: ASTM B 221 (ASTM B 221M).
    c. Rolled Tread Plate: ASTM B 632/B 632M, Alloy 6061-T4 or Alloy 6061-T6.

8. Stainless-Steel Sheet: ASTM A 666, Type 304.
9. Plastic Laminate: NEMA LD 3, HGS or HGL grade.
10. Plywood: DOC PS 1, Exterior grade.
11. Particleboard: ANSI A208.1, Grade M-2.
12. Clear Insulating Glass: ASTM E 2190. Factory-assembled units consisting of two lites of 2.5-mm-thick clear float glass, ASTM C 1036, Type I, Class 1, Quality q3, and dehydrated air space, with a total overall unit thickness of 5/8 inch (16 mm) and with manufacturer's standard dual seal.

P. Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

1. Color and Gloss: As selected by Architect from manufacturer's full range.

2.3 FABRICATION

A. Factory fabricates control booths completely.

B. Factory pre glaze windows and doors.

C. Factory prewire control booths, ready for connection to service at Project site.

D. Fabricate control booths with [forklift pockets in base of booth] [removable lifting eye centered in roof].

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, including concrete bases; accurate placement, pattern, and orientation of anchor bolts; critical dimensions; and other conditions affecting performance of the Work.

B. Examine roughing-in for electrical and communication systems to verify actual locations of connections before control booth installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install control booths according to manufacturer's written instructions.

B. Accessible Control Booths: Install with interior floor surface at same elevation as adjacent paved surfaces.

C. Set control booths plumb and aligned. Level baseplates true to plane with full bearing on concrete bases.

D. Fasten control booths securely to concrete base with anchorage indicated.

E. Connect to electrical power service and data systems.

F. Perform startup checks of heating and cooling units according to manufacturer's written instructions.

## 3.3 ADJUSTING

A. Adjust doors, operable windows, and hardware to operate smoothly, easily, properly, and without binding. Confirm that locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

C. After completing installation, inspect exposed finishes and repair damaged finishes.

END OF SECTION 13593

# SECTION 16050

# COMMON WORK RESULTS FOR ELECTRICAL

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes:
   1. Requirements for basic electrical studies and reports, material handling, and other basic electrical materials and methods.

B. Related Sections:
   1. Refer to Procurement Documents
   2. Section 02585 Electrical Underground Ducts and Manholes
   3. Section 16060 Grounding and Bonding for Electrical Systems
   4. Section 16070 Hangars and Supports for Electrical Systems
   5. Section 16082 Acceptance of Electrical Systems
   6. Section 16112 Conduits for Electrical Systems
   7. Section 16119 Low Voltage Electrical Power Conductors and Cables
   8. Section 16130 Boxes for Electrical Systems
   9. Section 16271 Low-Voltage Transformers
   10. Section 16446 Panelboards
   11. Section 16525 Lighting

### 1.02 REFERENCES

A. Regulatory Agency Sustainability Approvals:
   1. Buy America Act :
      a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.
      b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities

B. National Fire Protection Association (NFPA):
   1. NFPA 70, National Electrical Code (NEC).
   2. NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces.

C. The Society for Protective Coatings (SSPC):
   1. SSPC-SP 2, Hand Tool Cleaning.

### 1.03 SUBMITTALS

A. Submit the following information for approval in accordance with the requirements of the Procurement Documents:
   1. Product Data:
      a. Submit Product Data, including catalog cuts, for all products provided for the electrical work of this Contract and as specified in other Sections.
         1) Clearly indicate the usage of each product on each submittal.
   2. Shop Drawings:
      a. Submit Shop Drawings for the electrical work of this Contract as specified in other Sections.

3. Quality Assurance/Control Submittals:
   a. Certificates:
      1) Testing agency quality verification that all products meet requirements or manufacturer disclaimer statements.

1.04 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Buy America Act :
      a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

B. Regulatory Requirements:
   1. Perform all electrical work in conformance with the requirements of NFPA 70, the National Electrical Code.

C. Certifications:
   1. Submit evidence with all Product Data that the products represented meet testing agency quality verification requirements, including agency listing and labeling requirements.
      a. Such evidence may consist of either a printed mark on the data or a separate listing card.
      b. Submit a written statement from those product manufacturers that do not provide evidence of the quality of their products that indicates why an item does not have quality assurance verification.
         1) Such statements provided in lieu of quality assurance verification are subject to the acceptance of the Authority and the Engineer.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials and equipment to the work site in accordance with the requirements of the Procurement Documents.
   1. Deliver materials and equipment in a clean condition.
      a. Provide packaging that plugs, caps, or otherwise seals openings both during shipping and temporary storage.
   2. Provide equipment needed for unloading operations, and have such equipment on the work site to perform unloading work when the material and equipment is delivered.
      a. If possible, clearly identify pick-points or lift-points on electrical equipment crating and packaging.
      b. In the absence pick-points or lift-points on equipment crating and packaging, identify pick-points or lift-points on the equipment itself.

B. Handle materials and equipment in accordance with the requirements of The Procurement Documents.
   1. Handle materials and equipment in accordance with manufacturer's written instructions.
   2. When unloading materials and equipment, provide special lifting harnesses or apparatus as required by manufacturers.

C. Store electrical materials and equipment, whether on-site or off-site, in accordance with The Procurement Documents and the following:
   1. Follow the manufacturer's written instructions for storing the items.
   2. Store electrical equipment and products under cover.

a. Except for electrical conduit, store electrical equipment and products in heated warehouses or enclosed buildings with auxiliary heat and that provide protection from the weather on all sides.

## PART 2 PRODUCTS

### 2.01 MATERIALS

A. Grounding and Bonding Materials:
1. Provide grounding and bonding materials in accordance with the requirements of Section 16060, Grounding and Bonding for Electrical Systems.

B. Hangers and Supports:
1. Provide hangers and supports for electrical equipment in accordance with the requirements of Section 16070, Hangers and Supports for Electrical Systems.

C. Wire and Cable:
1. Provide low-voltage electrical wire, cable, and accessories in accordance with the requirements of Section 16119, Low Voltage Electrical Power Conductors and Cables.

D. Conduit and Raceway:
1. Provide conduit and raceway as indicated, as appropriate for the application per NFPA 70, and in accordance with the following:
a. Conduit and Tubing: Provide electrical conduit and tubing in accordance with the requirements of Section 16112, Conduits for Electrical Systems and Section 02585, Electrical Underground Ducts and Manholes.

### 2.02 SHOP FINISHING

A. For electrical equipment, factory-apply paint and coating systems that at a minimum meet the requirements of the NEMA ICS 6 corrosion-resistance test and the additional requirements specified in individual Specification Sections.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Field-Applied Finishes:
1. Except for factory-finished items that have been completely finished with factory-applied primer and final finish coatings, finish installed electrical materials, equipment, apparatus, and items in the field in accordance with manufacturer requirements and existing finishes.
a. Apply paint material matching the composition of the factory-applied products.
1) Obtain factory-supplied paint for this work whenever available.
b. Comply with the paint manufacturer’s instructions for mixing, thinning, surface preparation, application, spreading rate, drying time, and environmental limitations concerning application of the paint.
c. Apply paint in such a manner so that the finished appearance will match as nearly as possible the factory finish.

1) Poorly applied paint may be required to be repaired and re-applied by the Contractor in accordance with Article 3.02 at no additional cost to the Authority.

2. Coordinate the painting of large areas with the Engineer to minimize the duration of exposure of other workers to toxic paint fumes.

3.02 REPAIR/RESTORATION

A. If the factory finish of factory-finished items is damaged for any reason, refinish the item.
1. If an item that has several surfaces has damage on one surface, refinish the entire damaged surface.
a. Surface Preparation:
1) Outside the damaged area, lightly sand the entire surface and perform additional sanding to profile the damaged paint edge.
2) Prepare the surfaces of damaged areas in accordance with SSPC-SP 2.

3.03 FIELD QUALITY CONTROL

A. Perform electrical testing as detailed in Section 16082, Acceptance of Electrical Systems and in each Specification Section.

B. Have electrical work inspected as required by the local Authority Having Jurisdiction (AHJ).
1. Submit a copy of the certification of inspection with the final project closeout documents, and post the original in the electrical room on-site protected by a metal frame with a protective plate glass cover.

C. The quality of finishing and refinishing work is subject to approval by the Engineer.

END OF SECTION

# SECTION 16060

# GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes:
   1. Requirements for connecting, energizing, testing, cleaning, and protecting grounding and bonding systems.

B. Related Sections:
   1. Refer to Procurement Documents
   2. Section 02585 Electrical Underground Ducts and Manholes
   3. Section 16050 Common Work Results for Electrical
   4. Section 16082 Acceptance of Electrical Systems
   5. Section 16112 Conduits for Electrical Systems
   6. Section 16271 Low-Voltage Transformers
   7. Section 16446 Panelboards

### 1.02 REFERENCES

A. Reference Standards:
   1. U. S. Government:
      a. Federal Transit Administration (FTA):
         1) 49 CFR 661 Buy America Requirements.
      b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities

B. American Public Works Association (APWA):
   1. APWA Public Works Management Practices Manual.

C. American Society for Testing Materials (ASTM):
   1. ASTM B 1; Standard Specification for Hard-Drawn Copper Wire.
   2. ASTM B 8; Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

D. National Fire Protection Association (NFPA):
   1. NFPA 70, National Electrical Code (NEC).

E. Underwriter's Laboratories, Inc. (UL):
   1. UL 467, Standard for Grounding and Bonding Equipment.
   2. UL 486A-486B, Wire Connectors.
   3. UL 486C, Standard for Splicing Wire Connections.
   4. UL 486E, Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

### 1.03 DESIGN REQUIREMENTS

A. Design the electrical system installation to conform to Article 300 of NFPA 70, Wiring Methods, and to other applicable articles of NFPA 70 governing methods of wiring.

B. Ground the conduit systems, metal enclosures, equipment frames, motors, and receptacles in accordance with Article 250 of NFPA 70, Grounding.
   1. Ground all metallic conduits, wiring channels, and armored cables continuously from device to device and from devices to cabinets, junction boxes, or pull boxes.
      a. Bond each run of raceways to form a continuous path for ground faults from end to end.
   2. Provide insulated, Type XHHW-2 internal equipment ground wire in all conduits.
      a. Bond the internal wire to all pullboxes, junction boxes, equipment enclosures, and other enclosures as required by NFPA 70.

C. Equipment Grounds:
   1. Design all feeders and branch circuits to include an equipment grounding conductor consisting of a copper wire within a raceway or cable and sized as specified herein.

D. Ground Wire Sizes:
   1. The minimum size for bonding jumpers, equipment ground conductors, grounding electrode conductors, and ground grid conductors is as follows:
      a. Under 600 volts:
         1) Provide #12 AWG, minimum.
         2) When the ground wire size is not specified or indicated on the Contract Drawings, provide wire sized in accordance with the requirements of NFPA 70.

1.04 SUBMITTALS

A. Submit the following information for approval in accordance with the requirements of the Procurement Document:
   1. Product Data:
      a. Manufacturer’s product data

1.05 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Buy America Act :
      a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

B. Qualifications:
   1. Installer Qualifications:
      a. Employ installers who specialize in the work of this Section, and who can demonstrate a minimum of three years documented experience.
      b. Submit the system installers’ qualifications.
   2. All products are to be certified by Underwriters Laboratories, Inc. (UL),

C. Regulatory Requirements:
   1. All grounding and bonding Work must comply with the requirements of NFPA 70, the National Electrical Code.

D. Certifications:
   1. Testing Agency Product Certification:

a. Verify product quality by certifying products as meeting the requirements of one of the following:
   1) Underwriters Laboratories, Inc. (UL).
      a) Provide products listed and labeled by UL.
b. Testing agency product certification must include agency listing and labeling, either by a printed mark on the data or by a separate listing card.
   1) If an item does not have this quality assurance verification, provide a written statement from the product manufacturer indicating why not; such manufacturer's statements are subject to the approval of the Authority and the Engineer.

1.06 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Transport materials, both on site and from Contractor's storage to site, in accordance with the recommendations of the respective manufacturers.

B. Storage and Protection:
   1. Store materials, both on and off site, in accordance with manufacturer's written instructions.
   2. Store products indoors on blocking or pallets.

PART 2 PRODUCTS

2.01 MATERIALS

A. Wire:
   1. Bare Ground Wire:
      a. Soft drawn copper, Class A or Class B stranded, meeting the requirements of ASTM B8 for sizes #6 or larger.
      b. Soft drawn stranded copper, meeting the requirements of ASTM B1 for sizes #8 or smaller.
   2. Insulated Ground Wire:
      a. Provide type XHHW-2 insulated Class B copper stranded wire rated for 600 volts that conforms to the requirements of NEMA WC-7, and is green in color.
   3. Acceptable Manufacturers:
      a. Cablec Continental Co.
      b. SouthWire
      c. Okonite
      d. Rome Cable
      e. Or Approved Equal

PART 3 EXECUTION

3.01 EXAMINATION

A. Site Verification of Conditions:
   1. The Contract Drawings are generally indicative of the Work, but due to their small scale, it is not possible to indicate some offsets and fittings required nor the minor structural obstructions that may be encountered.

a. Perform field measurements to discover offsets and fitting requirements not shown.
b. Locate all on-site utilities and other obstructions in the area of construction, and verify that interferences will not occur.

3.02 PREPARATION

A. Layout electrical work to suit actual field conditions and in accordance with accepted standard practice.

3.03 INSTALLATION

A. Construct each ground system and connection so it is mechanically secure and electrically continuous.
1. Secure grounds to boxes in such a manner that each system is electrically continuous from the point of service to each outlet.
2. Clean paint, grease and such other insulating materials from the contact points of grounds.

B. Equipment Grounds:
1. Install equipment grounds in spaces accessible to authorized personnel only.
2. Equipment Grounding Conductors:
a. Only use approved grounding connectors.
b. Do not use a system neutral or a current carrying conductor as the equipment grounding conductor.
1) Do not ground the electrical and electronic equipment neutral to chassis, racks, equipment ground conductor, or any non-current carrying conductor on the equipment.
3. Grounding Lighting Fixtures:
a. Provide the housing of each lighting fixture with a separate, factory-installed grounding device and ground conductor.
b. Use the factory-installed grounding device for connecting a separate grounding conductor meeting applicable grounding requirements of the NEC to the fixture.
1) Provide a green covered grounding conductor of the same wire gauge as the two power feed wires.
2) Provide a continuous ground for the fixture construction.

3.04 FIELD QUALITY CONTROL

A. Site Testing:
1. Prior to energizing any system, test the resistance to ground for the system in accordance with Section 16082, Acceptance of Electrical Systems.
a. Perform a continuity test from all utilization and distribution equipment to the end devices.

END OF SECTION

# SECTION 16070

# HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes:
   1. Requirements for furnishing, installing, cleaning, and protecting hanger and support systems for electrical wiring, conduit boxes, and equipment.

B. Related Section:
   1. Refer to Procurement Documents
   2. Section 16050: Common Work Results for Electrical

### 1.02 REFERENCES

A. Reference Standards:
   1. U. S. Government:
      a. Federal Transit Administration (FTA):
         1) 49 CFR 661 Buy America Requirements.
      b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities

B. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts maximum).

C. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC).

D. Underwriters Laboratory, Inc. (UL):
   1. UL 2239 - Hardware for the Support of Conduit, Tubing, and Cable.

E. U. S. General Services Administration (GSA)
   1. Federal Specifications:
      a. A-A-1922A - Shield, Expansion (Caulking Anchors, Single Lead).
      b. FF-S-107C(2) - Screws, Tapping and Drive.

### 1.03 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of the Procurement Documents, and Section 16050, Common Work Results for Electrical:
   1. Product Data:
      a. Provide product data and catalog cuts for the products provided under this Section.
   2. Quality Assurance/Control Submittals:
      a. Certificates:
         1) Testing Agency/Quality Verification:
      b. With the product data for electrical hangers and supports, provide evidence of quality verification, listing, and labeling by the Electrical

Testing Agency (ETA); either by a printed mark on the data, or by a separate listing card.

c. If an item does not have ETA quality assurance verification, provide a written quality assurance verification statement from the product manufacturer indicating why the item does not have the specified quality assurance verification.

1) Such quality assurance verification statements are subject to approval by the Authority and the Engineer.

1.04 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:

1. Buy America Act :

a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

1.05 DELIVERY, STORAGE AND HANDLING

A. Packaging, Shipping, Handling, and Unloading:

1. Deliver, store, and handle the hangers and supports in accordance with Section 16050, Common Work Results for Electrical, and as specified herein.
2. Deliver material to Site in the original factory packaging.

B. Storage and Protection:

1. Shelter and store the components under cover, and supported off the ground and floors on blocking.

PART 2 PRODUCTS

2.01 MATERIALS

A. Manufactured Units

1. Metal U-Channel Electrical Support Framing Systems and Fittings:
2. Stainless Steel U-Channel Support Framing Systems:

a. Provide U-channel supports, fittings, threaded rod, and hardware fabricated from Type 316 stainless steel.

b. Manufacturers:

1) Unistrut Corporation, Unistrut® Metal Framing System, www.unistrut.com.
2) Thomas & Betts, Kindorf®, http://elec-cat.tnb.com.
3) Cooper B-Line®, Inc., www.b-line.com.
4) Or Approved Equal

B. Conduit Supports:

1. Malleable Iron Conduit Supports:

a. Provide one-hole style galvanized malleable iron fasteners with pipe straps similar to those as manufactured by Thomas & Betts.

2. Manufacturers:

a. Thomas & Betts, http://www-public.tnb.com/contractor/docs/superstrut.pdf.

b. Or Approved Equal.

C. Bolts, Nuts, and Washers:
1. For bolts, nuts, and washers smaller than 1/4-inch trade size, provide 316 stainless steel fasteners complying with the requirements of ASTM A 325.

D. Anchors and Fasteners:
1. Drive (Deep-Pitch) Screws:
a. Provide Type 316 stainless steel self-tapping type drive (deep-pitch) screws that comply with the requirements of FF-S-107C(2).
2. Drilled-In Anchors and Fasteners:
a. Provide drilled-in anchors and fasteners that comply with the requirements of FF-S-107C(2).
b. Masonry Anchors:
1) Provide masonry anchors designed to accept both machine bolts and threaded rods as fasteners.
a) Provide SAE J 429 Grade 2 machine bolt fasteners fabricated from AISI Type 316 stainless steel.
b) Provide nuts and washers conforming to the requirements of ASTM A 563.
2) Provide masonry anchors consisting of an expansion shield and expander nut contained inside the shield.
a) Expander Nuts:
(1) Fabricate square expander nuts with their sides tapered inward from the bottom to the top.
(2) Design the expander nuts to simultaneously climb the bolt or rod thread and expand the shield as soon as the threaded expander nut reaches and bears against the shield bottom when being tightened.
b) Expansion Shields:
(1) Provide expansion shield bodies consisting of four legs, the inside of each tapered toward the shield bottom, or nut end.
(2) The end of one leg shall be elongated and turned across shield bottom. Outer surface of shield body shall be ribbed for grip-action.
3) Masonry Anchor Material:
a) Provide die cast Zamac No. 3 zinc alloy having a 43,000 psi minimum tensile strength.
4) Manufacturers:
a) U.S.E. Diamond, Inc., FORWAY System, , www.mktfastening.com.
b) Or Approved Equal
c. Concrete Anchors:
1) Carbon Steel Anchor/Fastener:
a) Provide UL listed one-piece studs (bolts) with integral expansion wedges, nuts, and washers.
b) Provide carbon steel anchor/fasteners complying with the physical requirements specified in FF-S-325 for Group II, Type 4, Class 1.
2) Stainless Steel Anchor/Fastener:
a) Provide one-piece AISI Type 303 or 304 stainless steel studs (bolts) with integral expansion wedges, AISI Type

316 stainless steel nuts, and AISI Type 316 stainless steel washers.

b) Provide stainless steel anchor/fasteners complying with the physical requirements of FF-S-325 for Group II, Type 4, Class 1.

3) Acceptable Manufacturers:
   a) U.S.E. Diamond, Inc.; SUP-R-STUD, www.mktfastening.com.
   b) Hilti Fastening Systems; KWIK-BOLT, hilti.com.
   c) Molly Fastener Group; PARABOLT.
   d) Phillips; RED HEAD Wedge-Anchor, www.phillipsfastener.com.
   e) Or Approved Equal

3. Hammer drive-type explosive charge drive-type anchors and fastener systems are unacceptable.
4. Lead shields, plastic-inserts, fiber-inserts, and drilled-in plastic sleeve/nail drive systems are unacceptable.

## PART 3 EXECUTION

### 3.01 EXAMINATION

A. Field Measurement:
   1. Although the Contract Drawings are generally indicative of the Work, take field measurements to verify actual conditions.
      a. Due to the small scale of the Contract Drawings it is not possible to indicate all offsets, fittings, and apparatus required or the minor structural obstructions that may be encountered during the Work.
   2. Carefully investigate the structural and finish conditions, and other construction work, at the Site which may affect the work of this Section.

### 3.02 PREPARATION

A. After carefully investigating structural and finish conditions and other in-place construction work, produce detailed Shop Drawings showing proposed departures from the original design due to field conditions or other causes.
   1. Layout the electrical work according to accepted standard electrical trade practice to suit actual field measurements.
   2. Arrange the electrical work to consider existing conditions and to preserve access to other equipment, rooms, areas, and similar features of the construction.
   3. Provide plan and profile views of duct banks, and show equipment backboards and support structures not directly fastened to the walls on the Shop Drawings.
   4. Indicate the location and details of conflicting utility construction and slopes on the Shop Drawings.

B. Obtain roughing-in dimensions of electrically operated equipment, including equipment being installed by both electrical and other construction trades.
   1. Set conduit and boxes only after receiving approved dimensions and checking such equipment locations.

2. Arrange electrical Work accordingly and furnish such fittings and apparatus as required to accommodate such conditions and to preserve access to other equipment, rooms, areas, and similar spaces.

3.03 INSTALLATION

A. Install electrical Work in conformance to the requirements of NFPA 70 for wiring methods general requirements (Refer to Procurement Documents), and to other applicable Articles of the NEC governing methods of wiring.

B. Installing Anchors and Fasteners:
1. For anchoring or fastening applications in masonry and hollow-core precast concrete structural elements, provide masonry anchors as specified herein.
2. For anchoring or fastening applications in cast-in-place concrete and solid precast concrete structural elements, provide concrete anchors as specified herein.
3. Threaded Bolts:
a. Draw threaded bolted connections up tight using 316 stainless steel lock washers to prevent the bolt or nut from loosening.
4. Drilled-In Expansion Anchors:
a. Install expansion anchors in strict accordance with manufacturer's instructions and the following.
1) Drill holes to the required diameter and depth in accordance with anchor manufacturer's instructions for the size of anchor being installed.
2) Minimum Embedment:
a) Embed expansion anchors to four and one-half bolt diameters minimum unless otherwise indicated on the Contract Drawings.

C. Installing Conduit Supports:
1. For all locations provide malleable iron conduit supports.

3.04 PROTECTION

A. Protect the items provided under this Section from damage during the work of other trades.

END OF SECTION

# SECTION 16082

# ACCEPTANCE OF ELECTRICAL SYSTEMS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of materials to performance test electrical systems and equipment.
   1. Items Supplied Under This Section:
      a. Electrical System Testing

B. Related Sections:
   1. Refer to Procurement Documents.
   2. Division 16 Sections, As Applicable

### 1.02 REFERENCES

A. Reference Standards:
   1. U. S. Government:
      a. Federal Transit Administration (FTA):
         1) 49 CFR 661 Buy America Requirements
      b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities

A. Applicable Documents and Testing Requirements of:
   1. America National Standards Institute (ANSI): as applicable, including:
      a. ANSI C2, National Electrical Safety Code.
      b. ANSI Z244.1 American National Standards for Personnel Protection.
   2. National Fire Protection Association (NFPA), as applicable, including:
      a. NFPA 70 - National Electrical Code (NEC).
      b. NFPA 70E - Electrical Safety Requirements for Employee Workplaces.
   3. Local Utility Codes and Ordinances.
   4. Occupational Safety and Health Administration (OSHA), as applicable, including:

### 1.03 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Buy America Act :
      a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

### 1.04 GENERAL REQUIREMENTS

A. Refer to Procurement Documents.

B. Field Inspection:
   1. This Contractor is responsible for a complete inspection of all equipment, prior to testing and energizing to ascertain that it is free from any damage, scratches, or missing components and that all power connections are correct, and that they

are tight in conformance with recommended standard practice. The inspection is to also include a check of control wiring, terminal connections and all bolts and nuts.

2. Perform field inspection by this Contractor during a time when the Field Engineer and the Design Engineer are present to witness each inspection and its performance.
3. Correct any deficiencies found during the inspection by this Contractor prior to the energizing and testing of the equipment.

1.05 SCHEDULING

A. Schedule all testing with work of other contractors to ensure an orderly sequence of startup and completion of work.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 ELECTRICAL INSPECTIONS AND TESTS

A. Perform, supervise, and furnish all test equipment needed to perform tests and provide safety measures, procedures and equipment required for each test.

B. Schedule all testing with the Engineer. Perform testing in the presence of the Engineer except when the Engineer approves in writing conducting a specific test without the Engineer's presence.

C. Notify all involved parties including the Engineer prior to tests, advising them of the test to be performed and the scheduled date and time.

D. Coordinate the tests with others involved.

E. Prepare written test procedures and forms used in the test reports and submit for approval prior to commencement of testing.

F. Refer to individual tests and inspections hereinafter specified for any additional or specified requirements.

G. Test Instrument Calibration:
1. The testing firm is to have a calibration program, which assures that all applicable test instrumentation are maintained within rated accuracy.
2. The accuracy is to be directly traceable to the National Bureau of Standards.
3. Instruments are to be calibrated in accordance with the following frequency schedule.
   a. Field Instruments: Analog - 6 months maximum
      Digital - 12 months maximum
4. Make dated calibration labels visible on all test equipment.
5. Keep records up-to-date, which show date and results of instruments calibrated or tested.

6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.
7. Calibrating standard is to be of higher accuracy than that of the instrument tested.
8. Perform all tests with apparatus de-energized except where otherwise specifically required.

3.02 TESTING TO BE PERFORMED BY THE CONTRACTOR

A. Continuity Test: Make test for continuity and correctness of wiring and identification on all conductors installed.

3.03 CORRECTION OF DEFICIENCIES

A. Report all unacceptable values immediately. Correct all deficiencies found in work of this contract and separately report deficiencies in work of items of other contracts.
   1. Retest items requiring correction. Correct or have corrected any remaining deficiencies and retest until work is acceptable.

END OF SECTION

# SECTION 16112

# CONDUITS FOR ELECTRICAL SYSTEMS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes:
   1. Requirements for furnishing, installing, energizing, and testing conduit, tubing, and fittings for communication lines and electrical transmission, distribution, and service lines.

B. Related Section:
   1. Refer to Procurement Documents
   2. Section 02585 Electrical Underground Ducts and Manholes
   3. Section 16050 Common Work Results for Electrical
   4. Section 16060 Grounding and Bonding for Electrical Systems
   5. Section 16070 Hangars and Supports for Electrical Systems
   6. Section 16082 Acceptance of Electrical Systems
   7. Section 16271 Low-Voltage Transformers
   8. Section 16446 Panelboards

### 1.02 REFERENCES

A. Reference Standards:
   1. U. S. Government:
      a. Federal Transit Administration (FTA):
         1) 49 CFR 661 Buy America Requirements.
      b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities

B. American National Standards Institute (ANSI):
   1. ANSI/ASME B1.20.1 - Pipe Threads, General Purpose (Inch).
   2. ANSI C80.1 - Rigid Steel Conduit - Zinc-Coated (GCR).

C. ASTM International (ASTM):
   1. ASTM A 568/A 568M - Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold Rolled, General Requirements (Refer to Procurement Documents).

D. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code® (NEC).

E. Underwriters Laboratory, Inc. (UL):
   1. ANSI/UL 6 - Standard for Rigid Metal Conduit.
   2. ANSI/UL 360 - Standard for Liquid-Tight Flexible Steel Conduit.
   3. ANSI/UL 514A - Metallic Outlet Boxes.

F. Institute of Electrical and Electronics Engineers (IEEE):
   1. IEEE C2 - National Electrical Safety Code.

1.03 DEFINITIONS

A. Definitions for all items are as stated in NFPA 70, IEEE C2, and in other reference documents unless otherwise stated, specified, or noted.

1.04 DESIGN REQUIREMENTS

A. Conduit Systems:
   1. Provide conduit of the type and material shown in Tables 16112 - 1 below for the application indicated, or as indicated on the Contract Drawings.
      a. In a given location, provide only the type of conduit indicated or scheduled for that location.
   1. Provide conduit fittings made of material identical to that of the conduit system with which they are used.

**Table 16112 - 1 Conduit System Selection**

| Location | Condition 1 | Condition 2 | Conduit Type | Size (Minimum) [1] |
|---|---|---|---|---|
| Under-Ground | Encased | Bends, over 10 degrees in length | Rigid Galvanized Steel | 1 Inch |
| | | Conduit Risers | Rigid Galvanized Steel | 1 Inch |
| | | Exposed conduit within 6-inches of exit from encasement | PVC Coated Rigid Galvanized Steel | 1 Inch |
| | | Straight Runs | PVC Schedule 40 | 1 Inch |
| 1 No conduit smaller than 1-inch trade size is permitted unless indicated otherwise on the Contract Drawings. | | | | |
| Under-ground | Direct Burial | Classified (Hazardous Areas) | Rigid Galvanized Steel | 1 Inch |
| | | Other | PVC Schedule 80 | 1 Inch |
| 1 No conduit smaller than 1-inch trade size is permitted unless indicated otherwise on the Contract Drawings. | | | | |

| Table 16112 - 1 Conduit System Selection | | | | |
|---|---|---|---|---|
| **Location** | **Condition 1** | **Condition 2** | **Conduit Type** | **Size (Minimum)** [1] |
| Above-Ground | Outside | Exposed to weather NEMA 3R/4 Locations | PVC Coated Rigid Galvanized Steel or Rigid Galvanized Steel | 3/4 Inch |
| | | NEMA 4X Locations | PVC Coated Rigid Galvanized Steel | 3/4 Inch |
| | | Covered or Protected from weather NEMA 3R/4 Locations | Rigid Galvanized Steel | 3/4 Inch |
| | Inside NEMA 1/12 | Within 6-inches of floor when exposed | PVC Coated Rigid Galvanized Steel | 3/4 Inch |
| | | Within 6-inches of floor when within footprint of floor mounted equipment | PVC Schedule 40 | 3/4 Inch |
| | | Above suspended ceilings | Electrical Metal Tubing or Rigid Galvanized Steel | 3/4 Inch |
| | | Concealed in Open-Cell Masonry Block Wall | Electrical Metal Tubing or PVC Schedule 40 | 3/4 Inch |
| | | Concealed in Cast-in-Place Concrete Wall or Floor | Rigid Galvanized Steel | 3/4 Inch |
| | | Concealed behind Gypsum Board Wall or Ceiling | Electrical Metal Tubing or Rigid Galvanized Steel | 3/4 Inch |
| | | Recess Mounted Lighting Fixtures and Rotating or Vibrating Equipment | Flexible Metal Conduit or Liquid-Tight Flexible Metal Conduit | 3/4 Inch |
| | | Exposed within 10’-0” AFF | Rigid Galvanized Steel | 3/4 Inch |
| | | Exposed above 10’-0” AFF | Electrical Metal Tubing or Rigid Galvanized Steel | 3/4 Inch |

| Table 16112 - 1 Conduit System Selection | | | | |
|---|---|---|---|---|
| **Location** | **Condition 1** | **Condition 2** | **Conduit Type** | **Size (Minimum)** [1] |
| Above-Ground | Inside NEMA 3R/4/4X | Within 6-inches of floor | PVC Coated Rigid Galvanized Steel | 3/4 Inch |
| | | Concealed in Masonry Block Wall | Rigid Galvanized Steel, or PVC Schedule 40 | |
| | | Concealed in Cast-in-Place Concrete Wall or Floor | Rigid Galvanized Steel | 3/4 Inch |
| | | Recess Mounted Lighting Fixtures and Rotating or Vibrating Equipment | Liquid-Tight Flexible Metal Conduit | 3/4 Inch |
| | | Exposed | PVC Coated Rigid Galvanized Steel | 3/4 Inch |
| | | Recess Mounted Lighting Fixtures and Rotating or Vibrating Equipment | Liquid-Tight Flexible Metal Conduit | 3/4 Inch |
| 1 No conduit smaller than 3/4-inch trade size is permitted unless indicated otherwise on the Contract Drawings. | | | | |

1.05 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of the Procurement Document:
   1. Product Data:
      a. Rigid Polyvinyl Chloride (PVC) Conduit.
      b. Non-metallic conduit solvent.
      e. Electrical Metallic Tubing (EMT).
      f. Plastic coated rigid galvanized steel conduit.
      g. Liquidtite flexible metal conduit.
      h. Rigid galvanized steel conduit (RGS).
      i. Hazardous location flexible coupling
      j. Fittings for non-metallic conduit systems.
      k. Fittings for metallic conduit systems.
      l. Conduit spacers.
      m. Heat shrink tubing.
      n. Wall and floor penetration seals.
      o. Cold galvanize coating.
   2. Shop Drawings:
      a. Proposed departures from the original design.
   3. Quality Assurance/Control Submittals:
      a. Certificates:
         1) Testing agency/quality verification, listing, and labeling.

1.06 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Buy America Act :

a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

B. Regulatory Requirements:
1. Perform the Work of this Section in accordance with the requirements specified in NFPA 70 (NEC), and to other applicable state, local, and national governing codes and regulatory requirements.

C. Certifications:
1. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) for the location the product is installed in, and the application intended, unless products meeting the requirements of these nationally recognized testing laboratories are not available or unless standards do not exist for the products.
a. Submit evidence with the Product Data that the products represented meet testing agency quality verification requirements, including agency listing and labeling requirements.
1) Such evidence may consist of either a printed mark on the data or a separate listing card.
b. Submit a written statement from those product manufacturers that do not provide evidence of the quality of their products that indicates why an item does not have a quality assurance verification.
1) Such statements provided in lieu of quality assurance verification are subject to the acceptance of the Authority and the Engineer.

1.07 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
1. Pack, ship, handle, and unload products in accordance with the requirements of Section 16050, Common Work Results for Electrical, and as detailed herein.

B. Acceptance at Site:
1. Acceptance products at the Site in accordance with the requirements of Section 16050, Common Work Results for Electrical, and as detailed herein.

C. Storage and Protection:
1. Store products in accordance with the requirements of Section 16050, Common Work Results for Electrical, and as detailed herein.
a. Store all products indoors on blocking or pallets.

PART 2 PRODUCTS

2.01 NON-METALLIC CONDUIT

A. Electrical Plastic Tubing and Conduit:
1. Rigid Polyvinyl Chloride (PVC) Conduit:
a. Provide high impact PVC conduit conforming to the requirements of NEMA TC 2 at 90 degrees Celsius, and made from compounds conforming to the requirements of ASTM D 1784.
1) Use material that at 78 degrees Fahrenheit has a tensile strength exceeding 5500 psi, a flexural strength exceeding 11,000 psi, and a compressive strength exceeding 800 psi,

b. Provide PVC conduits that are UL listed, labeled, or approved for both underground and above ground use.

2. Manufacturers:
   a. JM Eagle, www.jmeagle.com
   b. Queen City Plastics, Inc., www.queencityplastics.com.
   c. Approved equal.

B. Non-Metallic Conduit Solvent:
   1. Provide solvent for non-metallic conduit joints from the same manufacturer as the conduit and conforming to the requirements of ASTM D 2564.

2.02 METALLIC CONDUIT

A. Electrical Metallic Tubing (EMT):
   1. Provide electrical metallic tubing (EMT) conforming to the requirements of Article 358 in NFPA 70 (NEC) for materials and uses, ANSI C80.3 and UL 797.
   2. Provide galvanized steel tubing conduit lengths bearing the manufacturer's trademark.
   3. Manufacturers:
      a. Tyco/Allied Tube and Conduit, www.alliedtube.com
      b. Wheatland Tube Company, Division of John Maneely Company, www.wheatland.com.
      c. Or Approved equal.

B. PVC Coated Rigid Galvanized Steel Conduit:
   1. Provide PVC coated rigid galvanized steel conduit bearing the UL label.
   2. Provide base conduit of rigid hot-dip galvanized steel conduit as specified in Paragraph 2.02D, and of the type indicated, specified, or scheduled to be coated.
   3. Apply PVC coating in accordance with the following:
      a. Apply a 40-mil thick PVC coating on the outside and a 2-mil thick fusion-bonded urethane coating on the inside, exterior coatings conforming to the requirements of NEMA RN 1.
      b. Provide PVC coating of one uniform color on all PVC coated rigid galvanized steel conduit provided for the Contract.
   4. Provide 40-mil thick PVC sleeves to protect internally threaded conduit openings.
      a. Provide sleeves with an inside diameter equal to the outside diameter of the conduit/pipe protected by it; and extending either one pipe diameter or 2-inches, whichever is less, beyond the opening.
   5. Manufacturers:
      a. OCAL, http://www.tnb.com/contractor/docs/ocal.pdf.
      b. Plasti-Bond www.plastibond.com
      c. Perma-Cote www.permacote.com
      d. KorKap www.korkap.com

C. Liquidtite Flexible Metal Conduit:
   1. Provide PVC coated flexible metal conduit conforming to the requirements of Article 350 of NFPA 70 (NEC) for materials and uses and ANSI/UL 360.
   2. Provide conduit with interlocking spiral strip construction capable of bending to a minimum radius of five times its diameter without deforming the spiral strips both inside and outside of the conduit.
      a. Provide conduit with a flexible, galvanized, interlocking spiral strip steel core jacketed with smooth, liquid-tight polyvinyl chloride designed to withstand temperatures from minus 40 degrees Celsius to plus 60 degrees Celsius.

3. Finish the interior and exterior of flexible conduit smooth and free from burrs, sharp edges, and other defects that may injure wires; and place the manufacturer's trademark on each length.
4. Furnish an integral continuous copper ground in 1/2-inch through 1-1/4-inch PVC coated flexible metal conduit.
5. Acceptable Manufacturers
   a. Electri-Flex Company, Liquatite®, Type LA, www.electriflex.com.
   b. ANAMET Electrical, Inc., Anaconda Sealtite®, www.anacondasealtite.com.
   c. Approved equal.

D. Rigid Galvanized Steel Conduit (RGS):
1. Provide rigid galvanized steel conduit (RGS) conforming to the requirements of Article 344 of NFPA 70 (NEC) for materials and uses, ANSI C80.1, and UL 6.
2. Fabricate the RGS from mild steel piping, galvanized or sherardized inside and outside, and protected against corrosion by a dichromate rinse or a zinc chromate coating.
3. Provide defect free conduit bearing the UL label, and furnished in 10-foot minimum lengths with both ends threaded and one end fitted with a coupling.
   a. Provide tapered NTP 3/4 inch per foot threads complying with ANSI/ASME B1.20.1.
4. Acceptable Manufacturers:
   a. Tyco/Allied Tube and Conduit, www.alliedtube.com.
   b. Wheatland Tube Company, Division of John Maneely Company, www.wheatland.com.
   c. Approved equal.

## 2.03 CONDUIT FITTINGS

A. Fittings for Non-Metallic Conduit Systems:
1. Electrical Plastic Tubing and Conduit:
   a. Provide high impact non-metallic fittings conforming to same requirements as for the plastic tubing and conduit as specified in Article 2.01.
   b. Non-Metallic Conduit Expansion Fittings:
      1) Provide a two-piece nonmetallic, noncorrosive, nonconductive, UL listed expansion fitting.
   c. Acceptable Manufacturers:
      1) Lamson & Sessions, Carlon®, www.carlon.com.
      2) Queen City Plastics, Inc., www.queencityplastics.com.
      3) Approved equal.

B. Fittings for Threaded Metallic Conduit Systems:
1. Construct conduit bodies/fittings from cast malleable iron or cast steel.
2. For PVC coated raceway systems, provide PVC coated fittings of cast malleable iron or cast steel from the same manufacturer that provides the uncoated conduit bodies/fittings.
3. Conduit Outlet Bodies:
   a. Provide malleable iron threaded entry type conduit outlet bodies with neoprene gaskets and cast steel cover.
   b. Acceptable Manufacturers:
      1) EGS/Appleton Electric, www.appletonelec.com.
      2) EGS/O-Z/Gedney, www.o-zgedney.com.
      3) Approved equal.
4. Conduit Expansion Joints:

a. Provide telescoping sleeve type galvanized, weatherproof, and vapor tight conduit expansion joints designed for 4-inch maximum expansion with an insulated bushing and lead-wool packing.
b. Acceptable Manufacturers:
1) EGS/Appleton Electric, www.appletonelec.com.
2) EGS/O-Z/Gedney, www.o-zgedney.com.
3) Approved equal.

5. Conduit Unions:
a. Provide conduit unions capable of completing a conduit run when neither conduit end can be turned.
b. Acceptable Manufacturers:
1) EGS/Appleton Electric, UNF and UNY Unions, www.appletonelec.com..
2) Thomas and Betts Company, Erickson® Coupling., www.tnb.com/contractor/docs/tbhazardous.pdf
3) Approved equal.

6. Conduit Outlet Boxes:
a. Provide malleable or cast iron conduit outlet boxes conforming to the requirements of UL 886, and having a cover with O-rings to keep out moisture.
b. Acceptable Manufacturers:
1) EGS/Appleton Electric, GRF outlets and covers, www.appletonelec.com.
2) EGS/O-Z Gedney, www.o-zgedney.com.
3) Approved equal.

7. Conduit Device Boxes:
a. Provide malleable iron conduit device boxes with internal grounding screws and conforming to the requirements of UL 498 and UL 514A.
b. Acceptable Manufacturers:
1) EGS/Appleton Electric, FD device boxes, www.appletonelec.com.
2) EGS/O-Z Gedney, www.o-zgedney.com.
3) Approved equal.

8. Conduit Sealing Fittings:
a. Provide, triple coated, malleable iron conduit sealing fittings.
1) Coat the conduit sealing fittings with zinc electroplate, dichromate, and an epoxy powder coat.
b. Provide drain fittings in conduit sealing fittings where required.
c. Provide sealing covers for junction boxes where required.
d. Acceptable Manufacturers:
1) EGS/Appleton Electric, www.appletonelec.com.
a) Sealing hubs: ES.
b) Sealing fittings: EY, EYS, EYSF, EYSM, EUS, EYD, EYDM
2) EGS/O-Z Gedney, www.o-zgedney.com.
3) Approved equal.

C. Fittings for Electrical Metallic Tubing Conduit Systems:
1. Construct conduit bodies/fittings from cast steel.
2. Fittings may be either set-screw or compression type.
3. Fittings shall be galvanized or zinc electroplated.

## 2.04 CONDUIT SPACERS

A. Provide non-metallic, interlocking type conduit spacers which snap together to join any combination of intermediate and base units together, both vertically and horizontally.

B. Manufacturers:
   1. Underground Devices Inc., www.udevices.com.
   2. The George-Ingraham Corp.
   3. Approved equal.

2.05 HEAT SHRINK TUBING

A. Provide all-weather corrosion resistant vinyl plastic heat shrink tubing designed for application on the exterior of metallic conduit to protect against galvanic action, moisture or other deteriorating contaminants.

B. Manufacturers:
   1. Tyco Electronics, Raychem, www.raychem.com.
   2. Thomas & Betts
   3. Approved equal.

2.06 WALL AND FLOOR PENETRATION SEALS

A. Provide watertight mechanical seals capable of holding up to 20 psig, and sealing against water, soil, and backfill material.

B. Acceptable Manufacturers:
   1. Pipeline Seal & Insulator, Inc., Thunderline/Link-Seal, www.linkseal.com.
   2. Flexicraft Industries, PipeSeal, lhttp://flexicraft.com.
   3. Approved equal.

2.07 FINISHES

A. Cold Galvanize Coating:
   1. Provide a cold galvanize coating to provide protection against corrosion by forming an insoluble zinc salt barrier from a cathodic reaction when the coating is damaged by abrasion and exposed to weather.
      a. Provide a single component pre-mixed liquid organic zinc compound producing 95 percent zinc in the dry film.
      b. Provide a coating that bonds to clean iron, steel, or aluminum through electrochemical action.
   2. Acceptable Manufacturers:
      a. ZRC. Worldwide, www.zrcworldwide.com.
      b. Clearco
      c. Krylon
      d. Rustoleum
      e. Or approved equal

PART 3 EXECUTION

3.01 EXAMINATION

A. Although the Contract Drawings are generally indicative of the Work, take field measurements to verify actual conditions.
   1. Due to the small scale of the Contract Drawings it is not possible to indicate all offsets, fittings, and apparatus required or the minor structural obstructions that may be encountered during the Work.

B. Inspect the condition of existing conduit that is required for the Work of this Section.

3.02 PREPARATION

A. After carefully investigating structural and finish conditions and other in-place construction work, prepare and submit detailed Shop Drawings showing proposed departures from the original design due to field conditions or other causes.
   1. Layout the electrical work according to accepted standard electrical trade practice to suit actual field measurements.
   2. Arrange the electrical work to consider existing conditions and to preserve access to other equipment, rooms, areas, and similar features of the construction.

B. Submit Product Data and catalog cuts for all products provided under this Section.
   1. Clearly indicate the usage of each product on the submittal.

C. Obtain roughing-in dimensions of electrically operated equipment, including equipment being installed by both electrical and other construction trades.
   1. Set conduit and boxes only after receiving approved dimensions and checking such equipment locations.

D. Remove dirt, debris, and other obstructions from existing conduit required for the Work of this Section by blowing out and mandreling the conduits as applicable.

3.03 INSTALLATION

A. Perform the Work of this Section as specified in Section 16050, Common Work Results for Electrical.

B. Fabricate and install conduit and wireway systems in accordance with accepted electrical trade standard practice.
   1. Layout the electrical work of this Section to suit actual field measurements.
      a. Record the actual installed elevations and locations of duct banks and the as-found locations of conflicting utility lines on the record drawings specified in Section 01775, Closeout, and submit the record drawings.
   2. Install the electrical Work of this Section in conformance to the wiring methods general requirements of Article 300 in NFPA 70 (NEC), and to all other applicable Articles of NFPA 70 governing wiring methods.
   3. Cut conduit and wireway square, and ream the cut ends according to the requirements of NFPA 70 (NEC) to deburr the openings so that they are not restricted more than cuts made by the material manufacturer.
   4. Avoid bending conduits as much as possible and practical; but if bends are made, use an approved conduit bending tool or machine to make the bends.
   5. Do not install crushed or deformed conduit, and remove crushed or deformed conduit from the Site.
   6. On conduit that is installed outside, provide a second equipment ground conductor and use fittings with a built-in ground lug for bonding.
   7. Provide flexible conduit only to the extent permitted by NFPA 70 (NEC).
      a. In flexible conduits that do not have an integral ground wire, install a green insulated wire in addition to the neutral wire for grounding purposes.
         1) Form a ‘J’ or ‘S’ hook with a drip loop to allow flexibility.
         2) Provide a second equipment grounding conductor on outside conduit and provide fittings with built-in ground lug for bonding.
      b. In exposed areas, use PVC coated flexible metal conduit and fittings.
      c. Use flexible metal conduit or liquid tight flexible metal conduit for final connection to recessed lighting fixtures and rotating and vibrating equipment.

1) Flexible Metal Conduit is only permitted for final connections to lighting fixtures in dry, environmentally conditioned spaces.
2) Liquid tight flexible metal conduit, as herein specified, for final connection to recess mounted lighting fixtures in unconditioned spaces and to all rotating and vibrating equipment including transformers, motors, solenoid valves, pressure switches, limit switches, generators, engine-mounted devices and pipe-mounted devices.
3) Flexible conduit not to exceed 18 inches in length for motor connections, 36 inches in length for equipment connections or 72-inches for lighting fixture connections.

8. Provide fittings and apparatus as required to construct the approved electrical design.
   a. Running threads on conduit are not permitted.
      1) Where couplings and connectors are required for metal conduits, use approved threaded couplings and connectors.
   b. Provide conduit unions where necessary to complete a conduit run when neither conduit end can be turned.
   c. Where conduit and raceway runs cross building expansion joints, make provision for expansion in the conduit and raceway runs.
   d. Provide sealing fittings with drain fittings in all lower runs and vertical runs.
   e. Provide sealing covers for junction boxes where required.
   f. Provide weatherproof conduit hubs on all conduit connections exterior to the building, and on instruments, process equipment, and pump motors.
9. Installing RGS and PVC Coated Conduit:
   a. Installation of the RGS and PVC Coated Conduit System shall be performed in accordance with the Manufacturer’s recommendations.
   b. To assure correct installation of PVC Coated Conduit System, the installer shall have a current and unexpired certification provided by the Manufacturer to install coated conduit.
   c. Threading Conduit:
      1) Field thread the conduits per the manufacturers instructions.
         a) For PVC coated conduit, first use a cylindrical guide, oversized to fit over the plastic coating, to neatly cut the coating off at the proposed end of the threads.
         b) Do not damage or remove the coating beyond the proposed end of the threads.
      2) Once the threading operation is complete, protect the newly cut threads against corrosion by applying a "sealing" compound as recommended by the manufacturer.
   d. Assembling RGS and PVC Coated Conduit Fittings:
      1) Use PVC coated conduit bodies, clamps, supports, accessories, and fittings with coated conduit systems.
      2) Just prior to assembling each conduit joint, apply the conduit manufacturer's touch-up compound to the end of the conduit in the area normally covered by the fitting sleeve.
      3) Use cloth or other material over strap type wrenches to protect the coating while tightening conduits.
10. Breathers and drains shall be provided at the low point(s) of all conduit runs in NEMA 3R, 4, 4X and 7 areas, and where otherwise subject to the accumulation of condensation. Conduits shall be arranged to drain away from dry areas toward damp or wet areas, and away from equipment and enclosures.

C. Exposed Work:

1. In exposed work, run conduit and raceway parallel to centerlines and structure surfaces; or perpendicular to centerlines where required, with right angle turns consisting of symmetrical bends or fittings.
2. Maintain at least 6 inches clearance between conduit and raceway runs and pipes, ducts, and flues of mechanical systems.
3. If a portion of a metallic conduit run, whether plastic-coated or not, extends above grade or is otherwise exposed to personnel, ensure that the conduit is properly bonded to an equipment grounding conductor at both ends.
   a. Install the equipment grounding conductor either inside or outside the box.

D. Concealed Work:
1. When performing electrical work in concealed spaces, provide the same quality workmanship as in exposed work.
2. Conceal conduits and raceways in the structure's construction where practicable unless otherwise indicated on the Contract Drawings or required by the Engineer.
   a. Group conduit and raceway runs in concealed work as much as practical to avoid congesting the concealed spaces.
   b. Do not weaken the structure by excessive or unnecessary cutting.
      1) Only make cuts into the structure's construction in conformance to the applicable building codes.
3. Conduits and Raceways Embedded in Concrete Slabs:
   a. Separate multiple conduits encased together by not less than two inches of concrete.
   b. Locate conduit installed in floor slabs within the reinforced area of the slab.
   c. Where conduit crosses expansion joints, provide weather tight expansion and defection fittings and bonding jumpers.
4. Install below grade conduit in conformance with the requirements of Section 02585, Electrical Underground Ducts and Manholes.
   a. For conduits that pass under building support walls, provide a minimum of 3 inches of concrete encasement all around.
   b. For underground and concrete encased duct banks, provide non-metallic conduit spacers.
      1) Provide sufficient space to allow pouring the concrete envelope without displacing or shifting the individual conduits.
      2) Install conduit spacers at intervals not exceeding five feet.

E. Hangers and Supports:
1. Install auxiliary support structures, anchors, and fasteners as specified in Section 16070, Hangers and Supports for Electrical Systems.
   a. Mount or suspend conduit and wireway systems directly on structural members of the structures and walls.
   b. Do not attach conduit or raceway systems to suspended ceiling members or to the suspending mediums.
   c. Securely attach anchors into walls.
2. At all conduit attachments, allow space between the mounting surfaces and the conduit by providing U-channel supports, clamp-backs, or spacers.
   a. Attach wall-mounted conduit runs close to the walls following the contour of the walls, parallel to the walls and other building lines except at bends.

F. Structure Penetrations:
1. Make penetrations in existing concrete structures by core-drilling.
   a. Drill the penetrations true, clean, and free from spalling.
2. At penetrations through fire rated floors, walls, and similar assemblies, provide firestopping as specified in Section 07841, Firestopping.

3. Install a wall penetration seal at all wall penetrations.
   a. Size wall penetrations to accommodate the conduit outside diameter plus either 1/4 inch or a hole allowance to allow the installation of the wall penetration seal.
4. For conduits that enter rooms from concrete floors or masonry, provide corrosion protection by using an RGS- or PVC-coated conduit that extends from 12 inches inside the concrete or masonry to at least 6 inches into the room.

G. Wiring:
1. Install wiring in conduit as indicated.
2. Prior to the installation of any wire, verify that the conduit is clean and free of debris.
3. Install a separate ground conductor within every conduit.

## 3.04 FIELD QUALITY CONTROL

A. Inspection:
1. Inspect installed conduit runs for obstructions, proper support, proper grounding, and completeness.

END OF SECTION

# SECTION 16119

# LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes:
1. Requirements for furnishing, installing, connecting, energizing, testing, cleaning, and protecting low voltage cable with low smoke generating characteristics and accessories.

B. Related Sections:
1. Procurement Documents
2. Section 02585 Electrical Underground Ducts and Manholes
3. Section 16050 Common Work Results for Electrical
4. Section 16060 Grounding and Bonding for Electrical Systems
5. Section 16082 Acceptance of Electrical Systems
6. Section 16112 Conduit for Electrical Systems
7. Section 16130 Boxes for Electrical Systems
8. Section 16271 Low-Voltage Transformers
9. Section 16446 Panelboards

### 1.02 REFERENCES

A. Reference Standards:
1. U. S. Government:
   a. Federal Transit Administration (FTA):
      1) 49 CFR 661 Buy America Requirements.
   b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities
   c. Codes, Regulations, Reference Standards and Specifications:
      1) Comply with codes and regulations of the jurisdictional authorities.
2. National Electrical Code (NEC).
3. Insulated Cable Engineers Association (ICEA): S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
4. IEEE: 1202-1991 IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies, 383-1974 IEEE Standard for Type Test of Class 1E Electrical Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
5. National Electrical Manufacturers Association (NEMA): BU1, WC70, WC71, WC74.
6. American National Standards Institute (ANSI): C37.20.1, Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear; C37.20.2, Metal-Clad and Station-Type Cubicle Switchgear; C37.20.3, Metal-Enclosed Interrupter Switchgear; Z55.1, Gray Finishes for Industrial Apparatus and Equipment.
7. UL: 44, Rubber-Insulated Wires and Cables Thermoset-Insulated Wires and Cables; 62, Flexible Cord and Fixture Wire; 857, Electric Busways and Associated Fittings; and 1581, Standard for Electrical Wires, Cables, and Flexible Cords.
8. ASTM International (ASTM):
   a. ASTM B3, Standard Specification for Soft or Annealed Copper Wire
   b. ASTM B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

c. ASTM D471, Standard Test Method for Rubber Property-Effect of Liquids
d. ASTM E662, Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials.

9. ITS: Directory of ITS Listed Products

1.03 DESIGN REQUIREMENTS

A. Conductors in Raceway and Conduit Systems:
1. Provide conduit systems for installing the wiring that is outside of all equipment, except wiring that is placed within the canopy structure which shall run loose.
2. Except for conduit indicated on the Contract Drawings, design raceway and conduit systems so that the maximum number of low-voltage conductors in each raceway or conduit does not exceed 4, including three phase conductors and one neutral, plus a ground.

B. Product Data and Catalog Cuts:
1. Submit low-voltage ground, power, and control wiring product data as listed below for the products provided as the Work of this Section; and clearly indicate the usage of each product on the data submitted.
a. Wires and cables.
b. Connectors.
c. Tapes.

C. Use of Trade Names:
1. The use of trade names within the Contract Documents is intended to establish the basis of design and to illustrate the constructability and level of quality required.
a. The use of trade names is not intended to exclude other manufacturers whose products are equivalent to those named, subject to compliance with Contract requirements.

1.04 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of the :
1. Product Data:
a. Wires and cables.
b. Connectors.
c. Tape.
2. Samples:
a. Smoke-density test sample for jacket material: Specified sample will become property of the Authority.
3. Certification:
a. Certified flame-retardancy test reports (VW-1, IEEE 383, and IEEE 1202, Article 18) and data for tests performed not more than 12 months prior to submittal, for materials which are identical to those of cable furnished. Include test reports with submittal of shop drawings.
b. Submit smoke-density test reports and data for tests performed on the jacket material not more than 12 months prior to the submittal, for materials which are identical to those of the furnished cable. Include test reports with submittal of shop drawings.
c. Certified test reports demonstrating that cable complies with specified requirements and those of referenced ICEA Standards. Submit test reports prior to cable shipments.

d. Certificates from manufacturers verifying that products conform to specified requirements. Include certificate with submittal of shop drawings and with each cable shipment.

1.05 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
1. Buy America Act :
a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

B. Regulatory Requirements:
1. Perform the Work of this Section in accordance with the requirements specified in NFPA 70, and to all other applicable state, local, and national governing codes and regulatory requirements.

C. Certifications:
1. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) for the location installed in, and the application intended, unless products meeting the requirements of these testing laboratories are not available or unless standards do not exist for the products.
a. Provide copper conductors listed and labeled by UL for all wiring.
2. Submit evidence of testing agency/quality verification, listing, and labeling for each product with the submitted product data either by providing a printed mark on the data or by attaching a separate listing card.
a. For items without such evidence, submit a written statement from the product manufacturer that indicates why it does not have quality assurance verification.

1.06 DELIVERY, STORAGE AND HANDLING

A. Mark each single-conductor cable, each multiple-conductor cable and each busway to show label per referenced UL or ITS directory, size, voltage, manufacturer and number of conductors or phases in accordance with NEC requirements.

B. Packing, Shipping, Handling, and Unloading:
1. Imprint insulated conductors with the date of manufacture, the wire type, and the manufacturer.
2. Package wire and cable in conformance with the requirements of NEMA WC 26/ EEMAC 201.
3. Protect items from damage during delivery, handling, and installation.
a. Comply with the cable manufacturer’s recommendations for inspection, handling, storage, temperature conditioning, bending and training limits, pulling limits, and calculation parameters for installing cable.

C. Acceptance at Site:
1. Wire and cable manufactured more than 12 months before delivery to the Site is unacceptable for use under this Contract, and will be rejected.

D. Storage and Protection:
1. Store products indoors on blocking or pallets.
2. Protect items from damage during storage.

PART 2 PRODUCTS

2.01 LOW VOLTAGE CONDUCTORS

A. General Requirements for Single-Conductor and Multiple-Conductor Cable (In RGS Conduit):
   1. Type and size: As shown.
   2. Rated voltage: 600 volts.
   3. Conductors:
      a. ASTM B3 or B8 annealed copper.
      b. Size 10 AWG and smaller: Solid or Class B or Class C stranded.
      c. Size 8 AWG and larger: Class B stranded.
   4. Standards: Except as modified, wires and cable complying with the following standards:
      a. Cross-linked polyethylene (XLPE) insulated cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
      b. Other cable: ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, S-81-570.
   5. Non-metallic jacket for single-conductor cable and an overall covering on multiple-conductor cable:
      a. Chlorosulfonated polyethylene or cross-linked polyolefin
      b. Cross-linked polyolefin complying with the following physical requirements. Properties tested in accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570 if ethylene-propylene-rubber (EPR) insulation is used, or with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692 if cross-linked polyethylene insulation is used. Jacket material free of PVC and PVC-based compounds.
         1) Tensile strength, minimum pounds per square inch: 1,800.
         2) Elongation at rupture, minimum percent: 150.
         3) Aging requirement: After 168 hours in air oven test at 100C, plus-or-minus one degree C:
         4) Tensile strength, minimum percentage of unaged value: 100
         5) Elongation at rupture, minimum percentage of unaged value: 80.
         6) Oil immersion: 18 hours at 121C, plus-or-minus one degree C, ASTM D471, Table 1, No. 2 oil:
         7) Tensile strength, minimum percentage of unaged value: 80
            a) Elongation at rupture, minimum percentage of unaged value: 80.
            b) Jacket materials other than cross-linked polyolefin complying with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Jacket material free of PVC and PVC-based compounds.
   6. Flame retardancy: Single-conductor and multiple-conductor cable tested by independent agency demonstrating flame retardancy in accordance with the following:
      a. Single-conductor cable and individual conductors of multiple-conductor cable passing vertical wire (VW-1) flame test in accordance with UL1581 or ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692. Cable size for testing: 14AWG.
      b. Single-conductor cable , size 1/0 AWG and larger, passing vertical tray flame test, using ribbon gas burner in accordance with IEEE 1202 or IEEE 383. Cable size for testing: 1/0 AWG.
      c. Multiple conductor cable passing vertical tray flame test using ribbon gas burner in accordance with IEEE 383 or IEEE 1202. Cable size for testing:7/C or 9/C with No. 12 AWG or No. 14 AWG conductors.

7. Smoke generation: Single and multiple-conductor cable jacket materials demonstrating low-smoke generation when tested in accordance with ASTM E662 by independent, nationally recognized testing agency.
   a. Conduct tests on specimens of overall jacket material for multiple-conductor cable and of jacket material for single-conductor cable.
   b. Prepare slab specimens for each material .100 inch, plus-or-minus .005-inch thick, identical to those of finished cables and meeting minimum physical requirements specified.
      1) Prior to testing, submit six-inch square portion of each specimen. Tag sample with manufacturer's jacket or insulation identification code or number.
   c. Test values for chlorosulfonated polyethylene not to exceed the following:
      1) Flaming mode:
         a) Uncorrected maximum specific optical density during first four minutes of test: 325.
         b) Uncorrected maximum specific optical density for entire 20-minute test: 400.
      2) Nonflaming mode:
         a) Uncorrected maximum specific optical density during first four minutes of test: 325.
         b) Uncorrected maximum specific optical density for entire 20-minute test: 480.
   d. Test values for cross-linked polyolefin not to exceed the following:
      1) Flaming mode:
         a) Uncorrected maximum specific optical density during first four minutes of test: 150.
         b) Uncorrected maximum specific optical density for entire 20-minute test: 300.
      2) Nonflaming mode:
         a) Uncorrected maximum specific optical density during first four minutes of test: 150.
         b) Uncorrected maximum specific optical density for entire 20-minute test: 300.
8. Applied voltage testing:
   a. Single-conductor cable and individual conductors of multiple-conductor cable to be given applied ac voltage dielectric-strength test, i.e., six-hour water-immersion test.
   b. For single conductors of multiple-conductor cable, conduct tests prior to assembly as multiple-conductor cable.
   c. Test procedures:
      1) Polyethylene-insulated conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.
      2) Other conductors: In accordance with ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, S-105-692, and S-81-570.

B. Single-Conductor Cable:
   1. Insulated with ethylene-propylene-rubber with non-metallic jacket as specified. UL-Labeled as Type RHW-2.
   2. Color coding: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

C. Multiple-Conductor Cable:
   1. Individual conductors:
      a. Number of conductors: As shown.
      b. Construction: Complying with one of the following:
         1) Insulated with ethylene-propylene-rubber, with or without non-metallic jacket.

2) Insulated with composite compound of ethylene-propylene-rubber and polyethylene, without outer jacket.
3) Insulated with filled cross-linked polyethylene without jacket.

c. Phase and neutral conductors: Individually insulated.
d. Neutral conductors: Same size as phase conductors.
e. Bare ground conductors: Sized in accordance with the NEC, unless otherwise shown.
f. UL Listed as Type XHHW-2.

2. Conductors assembled with nonwicking, flame-retardant filler to form cable of circular cross section.
3. Metallic sheath (In Liquid-Tite and Concealed in Structural Steel of Canopy):
   a. Provide one of the following:
      1) Size 1 AWG and larger:
         a) Interlocked aluminum-tape armor.
         b) Continuous corrugated aluminum sheath conforming to ICEA S-19-81, Table 4-26A.
      2) Size 2 AWG and smaller: As specified for 1 AWG and larger or continuous smooth aluminum sheath conforming to ICEA S-95-658, S-96-659, S-93-639, S-94-649, S-97-682, and S-105-692.
   b. Metallic covering not required for multiple-conductor TC cable with overall non-metallic jacket when installed in cable tray.
4. Multiple-conductor cable provided with overall non-metallic jacket as specified.
5. Cable UL-listed as follows:
   a. Non-metallic-sheathed cable: Type TC, suitable for wet and dry locations.
   b. Metallic-sheathed cable: Type MC, suitable for wet and dry locations.
6. Color coding:
   a. Power cables: In accordance with paragraphs 200-6, 200-7 and 210-5 of the NEC.

D. Bare Conductors: ASTM B3 or B8, annealed copper conductor; 8AWG and larger, Class B stranded, unless otherwise shown or specified.

2.02 TAPES:

A. Vinyl Insulating Tape:
1. Provide UL-listed flexible polyvinyl chloride (PVC) backed insulating tape with a pressure sensitive adhesive, such as black Scotch® 33+ Vinyl Electrical Tape, that is resistant to abrasion, acids, alkalis, and copper corrosion; resistant to, hot, cold and wet weather; and resistant to damage from UV sunlight exposure.

B. Manufacturers:
1. 3M, Scotch, http://solutions.3m.com/portal/3M/en_US.
2. Plymouth, www.plymouthrubber.com.
3. Permacel, www.permacel.com.
4. Or approved equal.

2.03 WIRE AND CABLE CONNECTIONS:

A. Grounding Connectors:
1. Provide grounding connectors conforming to the requirements of Section 16060, Grounding and Bonding for Electrical Systems.

B. Connectors for Other Conductors:
1. Wire Nuts:

a. For making splices of copper wire, provide pre-insulated, UL-listed, solderless connectors of the spring-lock or compression type that can be installed by hand or using tools.
   1) Manufacturers:
      a) Thomas & Betts Corp., www-public.tnb.com/ps/pubint.
      b) Tyco Electronics, AMP Inc., www.amp.com.
      c) Ilsco Corp., http://ilsco.com.
      d) FCI-Burndy® Products, https://portal.fciconnect.com.
      e) Or Approved Equal.

PART 3 EXECUTION

3.01 INSTALLERS

A. Install the work of this Section only under the supervision of licensed electricians.

3.02 EXAMINATION

A. Inspect all conduits, junction boxes, electrical vaults, and handholes to verify that they are clean, that they do not have burrs, that conduits are properly aligned, and that they are complete.
   1. Verify that proper sized boxes are installed.

B. Verify that boxes and conduit fittings conform to the bending requirements specified in Article 314 of NFPA 70 (NEC).

3.03 PREPARATION

A. Do not begin installing wiring until other work which might cause damage to the wires, cables, or conduits has been completed.
   1. Correct deficiencies in conduits, junction boxes, electrical vaults, and handholes that have been discovered by the inspection required in Paragraph 3.02.A.

B. Prepare conduits to receive wire and cable.
   1. Swab the conduits with a nylon brush and steel mandrel.

C. Take the necessary precautions to prevent water, dirt, or other foreign material from accumulating in the conduits during the execution of wiring work.

3.04 INSTALLATION

A. Wiring Identification:
   1. Color code all feeder wires and cables as indicated in Table 16119 – 1 & 2.

Table 16119 - 1 Feeder Wire and Cable Color Coding

| Phase | 208Y/120 Volts |
|---|---|
| A | Black |
| B | Red |
| C | Blue |
| Neutral | White |
| Electrical Ground Conductor | Green |

| Table 16119 - 2 Feeder Wire and Cable Color Coding | |
|---|---|
| Phase | 480Y/277 Volts |
| A | Brown |
| B | Orange |
| C | Yellow |
| Neutral | Gray or White with Yellow Tracer |
| Electrical Ground Conductor | Green |

Identify all power wiring by circuit and panelboard numbers.

3.05 FIELD QUALITY CONTROL

A. Site Tests:
1. Prior to energizing wire and cable, field test the wire and cable as specified in Section 16082, Acceptance of Electrical Systems.

END OF SECTION

# SECTION 16130

# BOXES FOR ELECTRICAL SYSTEMS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes:
1. Requirements for furnishing, installing, connecting, cleaning, and protecting electrical pull and junction boxes.

B. Related Section:
1. Refer to Procurement Documents
2. Section 16050 Common Work Results for Electrical
3. Section 16060 Grounding and Bonding for Electrical Systems
4. Section 16070 Hangers and Supports for Electrical Systems
5. Section 16082 Acceptance of Electrical Systems
6. Section 16112 Conduits for Electrical Systems
7. Section 16119 Low-Voltage Electrical Power Conductors and Cables
8. Section 16271 Low-Voltage Transformers
9. Section 16446 Panelboards

### 1.02 REFERENCES

A. Reference Standards:
1. U. S. Government:
a. Federal Transit Administration (FTA):
1) 49 CFR 661 Buy America Requirements.
b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities

B. National Electric Manufacturer's Association (NEMA):
1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
2. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable.

C. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code® (NEC).

D. American National Standards Institute (ANSI):
1. ANSI Z55.1 - Gray Finishes for Industrial Apparatus & Equipment (*withdrawn 1990, no replacement*).

### 1.03 DESIGN REQUIREMENTS

A. Product Data:
1. Submit a list of the materials proposed to satisfy the requirements of this Section.
2. Submit Product Data and catalog cuts of the materials and equipment proposed to be used to satisfy the requirements of this Section.
3. Include Product Data for the equipment and material provided under this Section with the Operation and Maintenance Manuals submitted in accordance with the requirements of The Procurement Documents at project closeout.

1.04 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of The Procurement Documents:
   1. Product Data:
      a. List of the proposed materials.
      b. Catalog cuts of cast outlet and small boxes for general purpose applications used with steel conduit systems.
      c. Catalog cuts of equipment and pull boxes
      d. Catalog cuts of plastic outlet boxes for LED Lighting fixtures only
   2. Quality Assurance/Control Submittals:
      a. Design Data.
         1) Manufacturer's comprehensive calculations.
      b. Certificates.
         1) Testing agency/quality verification, listing, and labeling.

1.05 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Buy America Act :
      a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

B. Regulatory Requirements:
   1. Perform the Work of this Section in accordance with the requirements specified in Articles 250, 300, and 370 of NFPA 70 (NEC), and to all other applicable state, local, and national governing codes and regulatory requirements.

C. Certifications:
   1. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) for the location installed in, and listed and labeled or approved for the application intended as indicated or specified, unless products meeting the requirements of these testing laboratories are not readily available or unless standards do not exist for the products.
      a. Provide products that are approved, listed, and labeled for the short circuit currents, voltages, and currents indicated or specified to be applied.
      b. Provide service entrance labeled products for all service entrance equipment.
   2. Submit evidence of testing agency/quality verification, listing, and labeling for each product with the submitted product data, either by providing a printed mark on the data or by attaching a separate listing card.
      a. For items without such evidence, submit a written statement from the product manufacturer that indicates why it does not have quality assurance verification.

1.06 MATERIAL DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Pack, ship, handle, and unload products in accordance with the requirements of Section 16050 Common Work Results for Electrical.

B. Acceptance at Site:

1. Accept products at the Site in accordance with the requirements of Section 16050 Common Work Results for Electrical.

C. Storage and Protection:
1. Store products in accordance with the requirements of Section 16050 Common Work Results for Electrical.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

A. Use of Trade Names:
1. The use of trade names within the Contract Documents is intended to establish the basis of design and to illustrate the constructability and level of quality required.
2. The use of trade names is not intended to exclude other manufacturers whose products are equivalent to those named, subject to compliance with Contract requirements.

### 2.02 MANUFACTURED UNITS

A. Cast Outlet Boxes for General Purpose Applications:
1. For Use with Steel Conduit Systems:
   a. For use with steel conduit systems, provide small cast steel or cast malleable iron outlet boxes with threaded hubs that meet the NEMA 250 requirements for Type 12 enclosures.
   b. If covers are indicated or specified, provide cast steel or cast malleable iron covers with neoprene gaskets.
      1) Provide captive Type 316 stainless steel mounting screws for the covers.
   c. Finish:
      1) Provide outlet boxes, covers, and hangers with an electroplated zinc coating, followed first by a dichromatic prime, and then by an aluminum polymer finish coating conforming to NEMA FB 1.
   d. Manufacturers:
      1) EGS/Appleton Electric, www.appletonelec.com.
      2) EGS/O-Z/Gedney, www.o-zgedney.com.
      3) Crouse Hinds
      4) Killark
      5) Or Approved equal.

B. Plastic Boxes for LED Lighting:
1. For recessed mounting in stainless steel canopy structure:
   a. Provide rugged polycarbonate construction that withstands extreme temperatures.
   b. Round non-metallic old work box with 3 zip-mount retainers and ground lug
   c. The hole diameter in the structural steel is 4”, provide box suitable for that hole size.
   d. Finish:
      1) Colored: Blue
      2) Volume: 18 cubic inches
      3) Mounting Method: Swing Clamps.
      4) Depth: 2-5/8” inches

C. Equipment and Pull Boxes:
1. Provide enclosures that meet the NEMA 250 requirements for Type 4X enclosures, and as follows:
a. Enclosure Box:
1) For wall mounted enclosures, fabricate enclosure bodies from 14 gauge Type 304 or Type 316L stainless steel sheets; and having continuously welded seams, ground smooth.
2) Provide a grounding stud on the enclosure body.
3) Provide enclosures having no holes or knockouts.
4) Provide the minimum sizes listed below or as required to support cable/equipment installation
a) 12”H x 12”W x 6”D for ComNet Box
b) 6”H x 6”W x 6”D for Future Camera Box
c) 6”H x 16” x 6” for Transformer/Pull Box
b. Enclosure Doors:
1) For wall mounted enclosures, provide a removable hinged door fabricated from 14 gauge Type 304 or Type 316L stainless steel sheets; and having a rolled lip on three sides and a continuous stainless steel hinge with a removable hinge pin on the fourth side.
a) Provide a stainless steel door clamp assembly that assures a watertight seal.
2) Provide a means of bonding on the door.
c. Door Gasket:
1) Provide a seamless, foam-in-place, oil-resistant door gasket for each enclosure.
d. Finish:
1) Provide enclosures with unpainted, Number 4 brushed finish surfaces.
e. Manufacturers:
1) Hoffman Enclosures
2) Rittal Corp
3) Milbank Manufacturing
4) Or Approved Equal

2.03 SOURCE QUALITY CONTROL

A. Tests:
1. Submit factory test reports to the Engineer as specified for the products in this Section.

PART 3 EXECUTION

3.01 INSTALLERS

A. Install the work of this Section only under the supervision of licensed electricians.

3.02 EXAMINATION

A. Verify that conduit stub-ups to be mated with electrical boxes and enclosures are the correct type and size, and are at the proper location.

3.03 INSTALLATION

A. Installing Boxes for Electrical Outlets and Devices:

1. Install boxes level and plumb within 1/16-inch of vertical or horizontal over the length of the box.
2. Install device boxes at a uniform height as indicated on the Contract Drawings.
   a. Mount all adjacent boxes in alignment at the same mounting height.
3. When installing boxes outside or to exposed conduit in unfinished areas, provide cast boxes.
   a. Mount these boxes on spacers to be 1/8-inch from wall unless box has built-in raised pads to perform the same function.
4. Support cast boxes for outlet and device using one of the following methods:
   a. Mount the boxes directly to the structure using 4 or more anchors.
      1) Attach mounting screws to feet located outside of the box interior.
      2) Provide 1/4-inch spacers behind the boxes unless the box has raised pads.
   b. Attach the box to two 1-inch or larger conduits which are supported within 12-inches of the box.

B. Installing Boxes for Other than Electrical Outlets and Devices:
1. Accurately punch holes for conduit openings using a hydraulic punch and punches sized for the conduit to be installed.
2. Support boxes for other than electrical outlets and devices using one of the following methods:
   a. Mount the boxes directly to the structure using 4 or more anchors.
      1) Attach mounting screws to feet located outside of the box interior. or seal the screw holes to prevent water penetration.
      2) Provide 1/4-inch spacers behind the boxes unless the box has raised pads.
   b. Attach the box to two 1-inch or larger conduits which are supported within 12-inches of the box.
   c. Attach the box to two 1-inch or larger conduits which exit from a poured concrete floor no further than 18-inches from the box.
   d. Mount the box on U-channel and structural supports conforming to Section 16070 Hangars and Supports for Electrical Systems.

B. Make up all conduit connections to boxes in accordance with the requirements of Section 16112 Conduits for Electrical Systems.

C. Install wiring in boxes in accordance with the requirements of Section 16119 Low Voltage Electrical Power Conductors and Cables.

D. Ground boxes in conformance with Section 16060 Grounding and Bonding For Electrical Systems.

3.04 REPAIR/RESTORATION

A. Touch up damaged coatings on electrical boxes and enclosures.

3.05 FIELD QUALITY CONTROL

A. Site Tests:
1. Test all boxes to verify that they are properly connected to the grounding system.

B. Inspection:
1. Inspect flush boxes to verify that the opening between the box and the wall finish is less than 1/16-inch.

2. Inspect flush boxes to verify that each box is flush with the wall, or protrudes less than 1/16-inch, and is not set behind the wall surface.
3. Inspect surface mounted boxes to verify that they are level and plumb within 1/16-inch as specified.
4. Record the actual installed elevations and locations of pull and junction boxes on record drawings specified in The Procurement Documents.

3.06 CLEANING

A. Waste Management and Disposal:
1. Clear and dispose of waste materials in accordance with the requirements of Section 16050 Common Work Results for Electrical.

3.07 PROTECTION

A. Except for surfaces to be painted, mask electrical boxes to protect them from paint overspray or over-brushing during painting operations.

B. Protect boxes against damage from other work.

END OF SECTION

# SECTION 16271

# LOW-VOLTAGE TRANSFORMERS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of material for furnishing, installing, connecting, energizing, testing, cleaning and protecting transformers.

B. Related Section:
1. Section 16050 Common Work Results for Electrical.
2. Section 16060 Grounding and Bonding for Electrical Systems
3. Section 16082 Acceptance of Electrical Systems
4. Section 16112 Conduits for Electrical Systems.

### 1.02 REFERENCES

A. Reference Standards:
1. U. S. Government:
a. Federal Transit Administration (FTA):
1) 49 CFR 661 Buy America Requirements
b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities

B. Institute of Electrical And Electronic Engineers/American National Standards Institute (IEEE/ANSI):
1. IEEE/ANSI C57.12.01: General Requirements for Dry-type Distribution and Power Transformers.
2. IEEE/ANSI C57.12.59: Guide for Dry-type Transformer Through-Fault Current Duration.
3. IEEE/ANSI C57.12.70: Terminal Markings and Connections for Power and Distribution Transformers.
4. IEEE/ANSI C57.12.80: Standard Terminology for Power and Distribution Transformers.
5. IEEE/ANSI C57.12.91: Test Code for Power and Distribution Transformers.
6. IEEE/ANSI C57.94: Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers.
7. IEEE/ANSI C57.96: Guide for Loading Dry-Type Distribution and Power Transformers.

C. National Electric Manufacturer's Association (NEMA):
1. NEMA ST 20: Dry Type Transformers for General Applications.
2. NEMA TR 1: Transformers, Regulators, and Reactors.

D. Underwriters Laboratory, Inc. (UL):
1. UL 1561: Transformers, Dry-Type General Purpose and Power.

E. National Fire Protection Association (NFPA):
1. NFPA 70: National Electrical Code® (NEC).

### 1.03 DEFINITIONS

A. Definitions of terms are as indicated in NFPA 70, IEEE/ANSI C57.12.80 and NEMA ST 20 unless otherwise indicated, noted or specified.

1.04 SYSTEM DESCRIPTION

A. Design Criteria:
   1. Provide transformers with ratings as indicated.
   2. Provide transformers designed for the following conditions:
      a. 40 degrees C. maximum ambient temperature.
      b. -20 degrees C. minimum ambient.
      c. 1,000 feet (300m) above sea-level.
      d. Indoors unless otherwise indicated or specified.

B. Provide transformers for connecting to the following systems with nominal voltages and operating ranges as specified in IEEE/ANSI C84.1:
   1. 480Volt, 3-phase, 3-wire, grounded or ungrounded.

C. Provide transformers for supplying the following systems with nominal voltages and operating ranges as specified in IEEE/ANSI C84.1
   1. 208/120 Volt, 3-phase, 4-wire, grounded wye.

D. Provide transformers for connecting to systems with a let-through fault capability up to the limits of IEEE/ANSI C57.12.59.

1.05 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Buy America Act :
      a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

B. Regulatory Requirements:
      a. The execution of work of this Section must satisfy the applicable requirements of the latest edition of NFPA 70 (NEC), the National Occupational Safety and Health Act as embodied in 29 CFR 1910 and 29 CFR 1926, and regulations of local jurisdictional authorities.

C. Certifications:
   1. All products must be Underwriters' Laboratories (UL) listed; and must bear the UL label.
      a. The UL standards appropriate for the products specified are listed in Paragraph 1.02.D.
      b. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory unless products meeting the requirements of these testing laboratories are not readily available or unless standards do not exist for the products. Provide products that are listed and labeled or approved as stated above for the location installed in and listed and labeled or approved as indicated and specified for the applications the items are intended for.

D. Conform all work to NFPA 70, National Electrical Code®.

E. Install work under supervision of skilled licensed electricians.

1.06 SUBMITTALS

A. Testing Agency/Quality Verification: Provide with all product data evidence of testing agency/quality verification, listing, and labeling either by printed mark on the data or by a

separate listing card. Provide from product manufacturers a written statement indicating why an item does not have a quality assurance verification. Such statements are subject to the approval of the Engineer.

B. Product Data:
   1. List of transformers and accessories to be furnished and installed.
   2. Catalog cuts of all transformers and accessories.

C. Shop Drawings: Provide shop drawings for the following:
   1. Complete outline drawing, showing overall length, width, and height and including ratings of equipment, impedance, and installation restrictions.

D. Submit Operation and Maintenance Manual.

PART 2 PRODUCTS

2.01 SECONDARY TRANSFORMERS

A. Provide transformers of the general purpose, indoor, double-wound, ventilated, dry-type designed and tested in accordance with NEMA Standard ST 20 and ANSI Standard C57.12.01, Underwriter's Laboratories Standard UL-1561, and ANSI C57.12.91 of capacities and mounting arrangements, (floor or wall) as indicated on the Drawings. Provide wall-mounted transformers with the wall bracket that is adequate for the supporting weight.

B. Design transformers for continuous operation at rated KVA, 24 hours a day, 365 days a year, with normal life expectancy as defined in ANSI/IEEE C57.96. Provide a transformer which will make this performance obtainable without exceeding 150 degree C. average temperature rise by resistance or 180 degree C. hot spot temperature rise in a 40 degree C. maximum ambient and 30 degree C. average ambient. Do not exceed 220 degree C as the maximum coil hot spot temperature.

C. Provide proven 220 degree C. insulation systems.

D. Wind the coils with copper which has insulated, proven, high temperature resistant, 220 degree C. materials.

E. Use all materials in the transformer that are flame retardant and do not support combustion as defined in ASTM Standard Test Method D635.

F. Totally immerse the transformer in an insulating varnish, which will maintain superior bond strength, high dielectric strength, and outstanding power factors at temperatures associated with the 220 degree C. system as a final insulation treatment. After immersion, cure the varnish at normal operating temperatures for such a period of time as to assure complete curing of the varnish and scourging of volatiles in the varnish solvent.

G. Construct transformers with core materials of a high quality, low loss nature as to minimize exciting current, no-load losses, and interlaminar vibrations.

H. The core and coil assembly shall be installed on vibration-absorbing pads.

I. Transformer average sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:
   1. Up to 9 kVA 40 db
   2. 10 to 50 kVA 45 db

J. Design the core-coil assembly and mechanically brace to withstand short circuit tests as defined in ANSI C57.12.91 by the use of full scale testing. The coil construction and mechanical bracing members shall be such as to prevent mechanical degradation of the insulation structures during short circuit.

K. Provide single phase transformers 2 KVA and below without taps. Provide 3 KVA and 5 KVA with 2-2 ½ percent above nominal full capacity (ANFC) and 2-2 ½ percent below nominal full capacity (BNFC) taps. Provide 7-1/2 KVA and above with 2-2 ½ percent ANFC and 4-2 ½ percent BNFC taps.

L. Provide three phase transformers with 2-2 ½ percent ANFC and 4-2 ½ percent BNFC taps.

M. Provide transformer with enclosures removable front and back panels, and must have screened or grilled ventilation openings designed to prevent accidental access to electrified parts.

N. The following factory tests shall be made on all transformers:
1. Ratio tests at the rated voltage connection and at all tap connections.
2. Polarity and phase relation tests on the rated voltage connection.
3. Applied potential tests.
4. Induced potential tests.
5. No-load and excitation current at rated voltage on the rated voltage connection.

O. Transformers shall be low loss type with minimum efficiencies per NEMA TP-1 when operated at 35% of full load capacity.

P. Acceptable Manufacturers:
1. Square D Company
2. Eaton Electric
3. General Electric
4. Siemens Industry for LV Power Distribution
5. Or Approved Equal

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Install, connect, and interconnect products where indicated, and in accordance with NEMA Standards, manufacturer's printed installation instructions, and this Section. Make connections in a manner, which will insure electrical continuity and operability of the products.

B. Protect the equipment against foreign matter and moisture during installation.

C. Install a 3-foot (1m) length of liquid-tight flexible metal conduit between transformer and fixed conduit system in accordance with Section 16112, Conduits for Electrical Systems. Make power conductor connections in accordance with manufacturer's drawings, and as indicated on the Drawings.

D. Ground in accordance with Section 16060, Grounding and Bonding for Electrical Systems. Provide ground bond for enclosure and neutral, minimum size #6 AWG to nearest structural steel and nearest water pipes to conform with Section 16060, Grounding and Bonding for Electrical Systems and the NEC.

### 3.02 FIELD QUALITY CONTROL

A. Dry out dry type transformers before they are energized.

B. Check transformer for tightness of external structural members and mechanical joints in order to minimize audible sound levels. Check the ground connections.

C. Test as specified in Section 16082, Acceptance for Electrical Systems.

END OF SECTION

# SECTION 16446

# PANELBOARDS

## PART 1 GENERAL

### 1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of all materials for furnishing, installing connecting, energizing, testing, cleaning and protecting wall-mounted panelboards.

B. Related Section:
1. Section 16050 Common Work Results for Electrical
2. Section 16070 Hangers and Supports for Electrical Systems
3. Section 26 05 53 – Identification for Electrical Systems
4. Section 16082 Acceptance of Electrical Systems
5. Section 16119 Low Voltage Electrical Power Conductors and Cables
6. Section 26 43 13 – Surge Protective Devices for Low-Voltage Electrical Power Circuits

### 1.02 REFERENCES

A. Reference Standards:
1. U. S. Government:
   a. Federal Transit Administration (FTA):
      1) 49 CFR 661 Buy America Requirements
   b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities

B. ASTM International (ASTM):
1. ASTM B164 Nickel-Copper Alloy, Bar and Wire.
2. ASTM B187 Standard Specifications for Copper Bus, Bus Bar, Rod and Shapes

C. National Electrical Manufacturers Association (NEMA):
1. NEMA 250 Electrical Enclosures.
2. NEMA AB 1 Molded Case Circuit Breakers and Molded Case Switches.
3. NEMA AB 2 Molded Case Circuit Breakers and their Application.
4. NEMA PB 1 Panelboards.
5. NEMA PB 1.1 General Instructions for Proper installation, Operation, and Maintenance of Panelboards.

D. National Fire Protection Association (NFPA):
1. NFPA 70 National Electrical Code® (NEC).

E. Underwriters Laboratories (UL):
1. UL 489 Molded Case Circuit Breakers and Circuit Breaker Enclosures
2. UL 50 Cabinets and Boxes
3. UL 67 Panelboards

### 1.03 SYSTEM DESCRIPTION

A. Panelboards are connected to system voltages as follows:
1. 480Y/277 Volt, 3-phase, 4-wire.
2. 208Y/120 Volt, 3-phase, 4-wire.

1.04 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Buy America Act :
      a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

B. Regulatory Requirements:
   a. The execution of work of this Section must satisfy the applicable requirements of the latest edition of NFPA 70 (NEC), the National Occupational Safety and Health Act as embodied in 29 CFR 1910 and 29 CFR 1926, and regulations of local jurisdictional authorities.

C. Certifications:
   1. All products must be Underwriters' Laboratories (UL) listed; and must bear the UL label.
      a. The UL standards appropriate for the products specified are listed in Paragraph 1.02.E.
      b. Alternatively, Listing by an OSHA Nationally Recognized Testing Laboratory (NRTL) to the relevant UL standards is permitted.

D. Provide panelboards, which have been design tested in accordance with NEMA PB 1.

E. Provide panelboards which have been production tested in accordance with NEMA PB 1.

F. Install work under supervision of licensed electricians

1.05 SUBMITTALS

A. Testing Agency/Quality Verification: Provide with all product data evidence of testing agency/quality verification, listing, and labeling either by printed mark on the data or by a separate listing card. Provide from product manufacturers a written statement indicating why an item does not have a quality assurance verification. Such statements are subject to the approval of the Engineer.

B. Product Data and Catalog Cuts: Provide product data for all products provided. Indicate clearly the usage and designation of each product.

C. Shop Drawings: Submit shop drawings for all panelboards.

D. Provide manufacturer’s instructions for all panelboards.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Basic Electrical Materials: Those products such as conduit, wireways, wire and connectors, cable, support devices, fasteners, and similar devices as required for work of this Section are as specified in other Sections of these Specifications.

2.02 PANELBOARDS

A. Provide dead-front panelboards as follows:
   1. Accommodate bolt-on molded case circuit breakers as specified below.
   2. Conform to NEMA PB 1 and NFPA 70, Article 384.

3. Consist of interiors, matching enclosures and covers of a single manufacturer as specified below.
4. Have circuit breakers of frame sizes, trip ratings, number of poles, and types as scheduled, indicated and noted.
5. Provide branch circuits phased in sequence vertically and numbered uniformly left to right, top to bottom.

B. Provide panelboards that are fully rated for a short circuit capacity as scheduled, indicated and noted on the Drawings.

C. Interiors: Provide interiors, as follows:
1. Provide tin plated main, ground and neutral copper buses conforming to ASTM B187 having not less than 98 percent conductivity.
2. Mount interiors on galvanized steel backplate.
3. Make provisions for future breakers and for circuit breakers in all future spaces as indicated, scheduled or noted and so that additional breakers can be mounted without additional connectors or extension of busses.

D. Provide solderless type main, sub-feed, and through feed lugs rated for copper and aluminum conductors of size, number and type, as indicated, scheduled and noted on the Drawings.

E. Enclosures:
1. Provide enclosures conforming to NEMA 250 for the types as indicated, scheduled, noted, and specified. Provide NEMA 1 enclosures unless otherwise indicated on the Drawings.
2. Fabricate from galvanized steel without knockouts.
3. Provide side, bottom, and top gutters of minimum 4-inch (10cm) width, of minimum 5-1/2 inch (14cm) depth, and sized as indicated, scheduled, and noted and as required by NFPA 70 Article 312 for the actual entry point.
4. Provide circuit directory of sufficient size to allow 40-characters per circuit; indicate the source of service (i.e. upstream panelboard, switchboard, motor control center, etc.) to the panelboard. Mount the directory in a transparent protective covering.

F. Doors: Provide doors as follows:
1. Provide concealed hinges and trim clamps.
2. Provide combination catch and master keyed, flat key lock with two keys for each lock and common keying throughout each building of the facility.

G. Finishes:
1. Factory finish enclosure cover completely using an electro-deposition process that deposits a complete finish coat of paint on all interior and exterior surfaces as well as bolted joints.
2. Include in the paint process cleaning, rinsing, phosphatizing, prepaint and post paint rinses, bake-cure and cool down steps.
3. Finish switchboards with rust inhibiting primers and electro-disposition acrylic baked enamel top coating of No. 49 medium light grey conforming to ANSI Z55.1.
4. Provide overall finish capable of passing a 300-hour salt spray per ASTM B117 with less than 1/8 loss of paint from a scribed line.

H. Molded case circuit breakers:
1. Provide inverse time and instantaneous tripping characteristics.
2. Provide trip ratings, frame sizes, and number of poles as indicated, scheduled, and noted on the Drawings.
3. Provide full rated circuit breakers with short circuit ratings equal to the panelboard installed as scheduled on the Drawings.

4. Provide molded case circuit breakers conforming to NEMA AB 1, and UL 489.
5. Provide circuit breakers of the same manufacture and type as the panelboard installed.
6. New circuit breakers for existing panelboards or loadcenters shall match the existing circuit breaker type, manufacturer, and AIC rating. Circuit breakers that are added into existing equipment shall be new, unless noted on the drawings as existing to be relocated and/or reused; and shall be purchased from an authorized manufacturer's distributor. Purchase of used, reconditioned, or brokered circuit breakers is prohibited unless approved by the Engineer.

I. Panelboard Types (Basis of Design):
1. Distribution (Square D I-Line).
2. Branch Power and Lighting 208Y/120V (Square D NQ).
3. Branch Power and Lighting 480Y/277V (Square D NF).
4. Branch Power 480Y/277V (Square D I-Line).

J. Acceptable Manufacturers:
1. Square D Company
2. Eaton Electric
3. General Electric
4. Siemens Industry for LV Power Distribution
5. Or Approved Equal

PART 3 EXECUTION

3.01 PREPARATION

A. Painted surfaces, which will be covered by items of this Section have a prime and finish coat of paint.

B. Ensure that all indoor areas are enclosed from the weather.

3.02 INSTALLATION

A. Space enclosures out from surfaces mounted on 1/4-inch (6mm) spacers or U-channel supports. Provide supports as specified in Section 16070, Hangers and Supports for Electrical Systems.

B. Install all panelboards and circuit-breakers in accordance with the manufacturer's instructions and NEMA PB 1.1.

C. Set enclosure top 6-feet 6-inches above finished floor or grade unless otherwise indicated or specified.

D. Punch holes for conduit entries in the enclosures.

E. In all areas except dry areas, install conduit drain fitting in punched hole in bottom of enclosure, conduit breather fitting in top of enclosure.

F. Interface with other work:
1. Connect conduits to enclosure with watertight hubs, except in damp locations on the bottom of enclosures a sealing locknut may be used in place of watertight hubs, and in dry locations two locknuts and bushings may be used.
2. Connect wiring to line and load terminals with lugs provided or approved by manufacturer in conformance with Section 16119, Low Voltage Electrical Power

Conductors and Cables. Remove interior or protect interior components during wire pulling.

3. Identify in accordance with Section 26 05 53.

G. At the end of the project update the circuit directories to reflect as-built conditions. Circuit directions shall be typed.

3.03 CLEANING

A. After wiring, vacuum out interior and wipe clean of all foreign material.

B. After painting in areas, remove all over paint, drips and splashes.

3.04 FIELD QUALITY CONTROL

A. Site Testing:
   1. Prior to Energizing:
      a. Have insulation testing and setting of overcurrent protective device adjustments made in conformance of Section 16082, Acceptance of Electrical Systems.
      b. Ensure that all load side wiring is clear of shorts and has received and passed the insulation tests of Section 16082, Acceptance of Electrical Systems.
      c. Open all downstream disconnects and open circuit breaker.
   2. Final testing after energizing:
      a. Perform thermographic test and record circuit parameters in conformity with Section 16082, Acceptance of Electrical Systems.

3.05 PROTECTION

A. During painting, mask all nameplates, all plastic parts, and all items not to be painted.

B. Protect all items during work of other trades including welding and cutting.

C. Protect panelboards against overloads, short circuits, and improper operation, padlock off when work is being done on downstream circuits.

END OF SECTION

# SECTION 16525

# LIGHTING

## PART 1 GENERAL

### 1.1 SUMMARY

A. Section Includes:
   1. Requirements for general and emergency egress lighting equipment, components, and related installation.

B. Related Sections:
   1. Section 16060 Grounding and Bonding for Electrical Systems
   2. Section 16070 Hangers and Supports for Electrical Systems
   3. Section 16082 Acceptance of Electrical Systems
   4. Section 16112 Conduits for Electrical Systems
   5. Section 16119 Low Voltage Electrical Power Conductors and Cables
   6. Section 16130 Boxes for Electrical Systems
   7. Section 26 27 26 Wiring Devices

### 1.2 REFERENCES

A. Reference Standards:
   1. U. S. Government:
      a. Federal Transit Administration (FTA):
         1) 49 CFR 661 Buy America Requirements
      b. WMATA Manual of Design Criteria for Maintaining and Continued Operation of Facilities

B. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   1. ANSI/IEEE C62.41; Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.

C. Illuminating Society of North America (IESNA)
   1. IESNA LM-79, Electrical and Photometric Measurements of Solid-State Lighting Products
   2. IESNA LM-80, Approved Method for Measuring Lumen Maintenance of LED Lighting Sources
   3. IESNA TM-15, Luminaire Classification System for Outdoor Luminaires.

D. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250, Enclosures for Electrical Equipment.
   2. NEMA SSL 3, High Power White LED Binning for General Illumination
   3. NEMA ST 1 - Standard for Specialty Transformers (Except General Purpose Type)

E. National Fire Protection Association (NFPA):
   1. NFPA 70, National Electrical Code (NEC).

F. Underwriter’s Laboratories, Inc. (UL):
   1. UL 1029, Standard for High-Intensity-Discharge Lamp Ballasts.
   2. UL 1598, Luminaires.

G. U. S. Government:
1. Occupational Safety and Health Administration (OSHA):
a. 29 CFR 1910 Occupational Health and Safety Standards.
b. 29 CFR 1926 Safety and Health Regulations for Construction.
2. Federal Communications Commission (FCC):
c. 47 CFR 18 Industrial, Scientific, and Medical Equipment.

1.3 DESIGN REQUIREMENTS

A. Design Criteria:
1. The Lighting Fixtures described below and indicated on the Contract Drawings constitutes the basis of the lighting design for this Contract, but may not indicate the special design details required.
a. The lighting fixtures as described meet the requirements of the lighting design for this Contract with respect to the visible style, light source, and lenses desired.
2. Provide lighting fixtures meeting the requirements of the basis of the lighting design for this Contract, and which have the special details specified in this Section.
a. Submit Shop Drawings and manufacturer's installation instructions to show details of assemblies and sub-assemblies, and specially-fabricated supporting and fastening devices.
b. Submit bills of material for the fixtures and their appurtenances.
1) Reference the bills of material to the Shop Drawings.
2) Provide bills of material consisting of itemized lists of the parts required (i.e. ballast capacitor igniter, and other similar item descriptions).
3) Identify each part with a part number and/or manufacturer number.
c. Provide fixtures for exterior installation that are designed to be completely waterproof.
d. Provide luminaire brackets designed to be compatible with configuration of the luminaire.

1.4 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
1. Buy America Act :
a. Except for those products which are exempt under the specific statutory waivers stipulated in 49 CFR 661, all other products supplied under this Section must comply with the requirements of the Buy America Act.

B. Regulatory Requirements:
a. The execution of work of this Section must satisfy the applicable requirements of the latest edition of NFPA 70 (NEC), the National Occupational Safety and Health Act as embodied in 29 CFR 1910 and 29 CFR 1926, and regulations of local jurisdictional authorities.

C. Certifications:
1. All products must be Underwriters' Laboratories (UL) listed; and each fixture, Emergency Battery Unit, and exit sign must bear the UL label.
a. The UL standards appropriate for the products specified are listed in Paragraph 1.02.E.
b. Alternatively, Listing by an OSHA Nationally Recognized Testing Laboratory (NRTL) to the relevant UL standards is permitted.

1.5 SUBMITTALS

A. Submit the following information for approval in accordance with the requirements of the Procurement Document:
   1. Submit the following information to obtain the Engineer's approval:
      a. The manufacturer's catalog cuts indicating the type, design, dimensions, mounting arrangement, and other industry standard lighting fixture information.
         1) Describe the lighting fixtures and appurtenances.
      b. Manufacturer's photometric data and electronic ies files.
      c. Complete photometric data for the fixture, including optical performance, completed by an independent testing laboratory developed according to the standards of the Illuminating Engineering Society of North America as follows:
         1) For direct, direct/indirect and indirect lights used for general illumination:
            a) Coefficients of utilization.
            b) Candlepower data, presented graphically and numerically, in 5 degree increments (5 degree, 10 degree, 15 degree, etc.). Data developed for up and down quadrants of normal, parallel, and at 22-1/2 degree, 45 degree, 67-1/2 degree planes to lamp(s). If light output is asymmetric, provide additional planes as required to complete report.
            c) Zonal lumens stated numerically in 10 degree increments (5 degree, 15 degree, etc.) as above.
            d) Average luminaire luminance calculated in the lengthwise, crosswise, and 45 degree vertical planes.
      d. Point-by-point lighting calculations showing the uniformity of light and compliance with WMATA design requirements.
   2. Submit a complete light source inventory for approval, including specific lamp type, manufacturer, and all appropriate lamp criteria including but not limited to: life, initial and mean lumens, beam spread, candlepower, lamp envelope, base type, color temperature, and color rendering index.
   3. Quality Assurance/Quality Control Submittals:
      a. Certificates:
         1) Proof that equipment furnished has the required Underwriters' Laboratories (UL) listing.
         2) Ballast certifications.
         3) Compliance with the requirements of the Buy America Act
      b. Manufacturer's Instructions:
         1) Manufacturer's installation instructions.

1.6 EXTRA MATERIALS

A. Maintenance Tools:
   1. Provide two each of the special maintenance tools as may be necessary for re-lamping fixtures and for fixture maintenance.

PART 2 PRODUCTS

2.1 MATERIALS

A. Conduit and Raceway:

1. Provide electrical conduit and raceway in accordance with the requirements of Sections 16112, Conduits for Electrical Systems as indicated and as appropriate for the application per NFPA 70.

B. Fixture Support Devices and Fasteners:
1. In addition to the supporting devices and fasteners specified in Section 16070, Hangers and Supports for Electrical Systems, provide suspension accessories, canopies, casing, sockets, holders, reflectors, plaster frames, recessing boxes, and similar items required to support the lighting equipment and luminaries as specified or indicated.

C. Wire and Cable:
1. Provide electrical wire and cable in accordance with the requirements of Section 16119, Low Voltage Electrical Power Conductors and Cables.

2.2 MANUFACTURED UNITS

A. Light Fixtures:
1. Fixture Grounding Device and Conductor:
a. Provide the housing of each fixture with a separate, factory-installed grounding device and ground conductor.

B. Lamps:
1. Provide the proper type of lamps for the lighting fixtures scheduled on the Contract Drawings or indicated on the approved Shop Drawings.
a. Match the voltages of lamps to installed fixtures.
b. Provide lamps having the proper type of sockets to suit the fixtures provided.
2. If fluorescent lamps are required, provide the energy saving type unless otherwise indicated on the Contract Drawings.
a. Fluorescent T5HO Lamps: low mercury content, T5HO lamps having a minimum CRI of 85, color temperature of 3500K, and suitable for operation with electronic ballasts or as otherwise specified. Minimum expected life (w/ 12 hour start) shall be 24,000 hours.

C. LED Lighting Fixtures
1. Color temperature of any submitted fixture shall be within 10% of the specified value, 3100 degrees K.
2. Provide fixture housing with internal driver, LED board and Spot (18-degree) optical focus lens. Clear tempered, shock resistant glass lens shall be adhered to fixture cap to provide a hermetically sealed optical compartment. Provide an additional eight narrow spot optical focus lens (14 degree) for site focusing.
3. Lens cap of fixture shall be 90 degree cut off type and provided with lens holder for use of directional linear lens accessory. The lens holder shall be ‘fixed’ to the correct position (relative to axis of fixture) to ensure that the fixture is aimed properly as directed by the Architect. See Architectural Drawing for specified lens orientation. Directional lens will not be used in every fixture and shall not be ‘permanently’ attached to holder.
4. Lighting fixtures shall be constructed of copper-free aluminum, finish and color as specified by the Architect. Fixture housing, lens cap, LED board, optic module and lens accessory to be provided with natural physical ‘stop’/locking devises to obtain and ensure optimum light output/focus.
5. Fixture shall have integral dimming ballast.

6. Provide 360 degree rotating knuckle, with locking device and canopy mounting faceplate option of color and finish matching fixture.
7. Mounting hardware and fixture screws shall be stainless steel.
8. Power consumption of any submitted fixture shall not exceed the specified value of 8.2 Watts by more than 10%. If a fixture is submitted and approved at an increased wattage within 10% of the specified wattage), any power system modifications necessary to accommodate the fixtures will be the responsibility of the contractor (i.e. increased wire sizes, increased circuit breaker size, additional circuits/breakers, etc.)
9. LED Lumen Efficacy (Lumens/Watt) of a submitted fixture shall not be less than the specified fixture (30 lumens/watt) by more than 10%. Fixture lumen output shall provide at sidewalk surface an average illumination level of 3FC maintained, 4.3 FC initial as required by WMATA Manual of Design Criteria for Station Entrance Within 30-ft. of the Entrance or Parapet Wall.
10. Characteristics of submitted fixtures shall have the same features as the specified LED fixtures (i.e. redundant drivers, driver protection, etc.) whether specifically noted on the lighting fixture schedule or not.
11. LED Light fixtures shall have a minimum expected life of 50,000 hours. The aforementioned life rating must be conducted with a 40 degrees calcium ambient temperature.
12. Operational Performance: the LED circuitry shall prevent visible flicker.
13. Thermal Management: The thermal management (of the heat generated by the LED's) shall be of sufficient capacity to assure the proper operation of the luminaire over the expected useful life. Thermal management shall be by passive design – the use of fans or other mechanical devised is not allowed.

D. Control Power Transformers
1. Transformer: NEMA ST 1; machine tool transformer with isolated secondary winding.
2. Enclosure: Open Type (mounted in junction box)
3. Power Rating: 100 VA.
4. Voltage Rating: 120VAC primary; 12VAC secondary.

E. Boxes, Gaskets, Hardware, and Support Devices:
1. Provide plastic outlet boxes, neoprene gaskets, and stainless steel hardware to render the installation of the lighting waterproof.
2. Supply special mounting supports and hardware, and miscellaneous materials and incidentals required to install the lighting products in place.

F. Mounting poles:
1. Steel or aluminum, straight or tapered as shown. Complete assembly of anchor bolts, pole, arms and luminaire designed to withstand wind pressure (P) developed by wind speed (V) of 80 MPH in accordance with AASHTO LTS-3. Pole assembly to fully comply with AASHTO requirements for permissible stresses, deflection, vibration and fatigue. Ratio of deflection to pole height under action of applicable static loading not to exceed 1/60.

2. Steel, straight or tapered. Complete assembly of anchor bolts, pole, arms and luminaire designed to withstand wind pressure (P) developed by wind speed (V) of 80 MPH in accordance with AASHTO LTS-3. Pole assembly to fully comply with AASHTO requirements for permissible stresses, deflection, vibration and fatigue. Ratio of deflection to pole height under action of applicable static loading not to exceed 1/60.
3. Size and shape: As shown.
4. Base assembly: Steel base plate, designed to withstand full-bending movement of shaft and welded to shaft; anchor bolts; and base cover.

5. Handhole size: As shown, with 12-gauge steel sheet coverplate.
6. Polygonal-shaped poles fabricated with sharp bends.
7. Longitudinally welded with welds continuous and ground smooth.

G. Lighting controls:
1. All light fixtures shall be controlled by WMATA through existing Remote Telemetry Unit (RTU).

## PART 3 EXECUTION

### 3.1 EXAMINATION

A. Prior to beginning installation of the lighting fixtures and accessories, verify that all other work affecting the installation of the lighting fixtures and accessories is complete to the extent that the light fixtures may be installed over substrates or incorporated into integrated systems without adversely affecting the lighting or other construction.

### 3.2 INSTALLATION

A. Assemble lighting fixtures if required; and install and wire the lighting fixtures, supports, brackets, and accessories at the locations and mounting heights indicated on the Contract Drawings.
1. Wire the lighting fixtures and accessories as specified in Section 16119, Low Voltage Electrical Power Conductors and Cables.
2. Ground the lighting fixtures in accordance with the requirements of Article 410 of NFPA 70 (NEC) and Section 16060, Grounding and Bonding of Electrical Systems.
a. Use the fixture grounding device to connect a separate grounding conductor in compliance with requirements specified in Section 16060, Grounding and Bonding of Electrical Systems.

B. Exposed Fixture Installation:
1. Install surface mounted and exposed fixtures as indicated on the Contract Drawings.
a. Install surface mounted fixtures tight up against the substrate to eliminate gaps except where NFPA 70 (NEC) or local code restrictions require a separation between the fixtures and substrate.

### 3.3 INTERFACE WITH OTHER WORK

A. Verify the locations and clearances of other installed or proposed work, and coordinate lighting fixture installations accordingly.

B. Coordinate the installation of lighting fixtures with all building systems and components to avoid any installation conflicts.

### 3.4 FIELD QUALITY CONTROL

A. Inspect, test, and certify lighting and the associated electrical distribution system and equipment in accordance with the requirements of Section 16082, Acceptance of Electrical Systems.

3.5 CLEANING

A. Clean new lighting fixtures by following the cleaning procedures as recommended by the fixture manufacturer:
   1. Use only those products for cleaning as recommended in the fixture manufacturer's literature.

3.6 AIMING AND FOCUSING

A. Contractor shall notify the Architect and Authority one week in advance and establish schedule for a night when final aiming will be done. Final aiming shall be as directed by the Architect. Aiming shall include adjustment of fixture angle, use of and orientation of linear lens accessory and lens SP selection.

B. Lock the aiming adjustments, set during final aiming, in position. Position must hold during relamping and normal maintenance.

END OF SECTION