SECTION 02205

REMOVAL AND RESTORATION OF EXISTING FACILITIES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies removing, restoring and reinstalling miscellaneous facilities on public and private property which are removed during construction.

B. Related Work Specified Elsewhere:
1. Demolition: Section 02220.
2. Grading, excavating and backfilling: Section 02320.
3. Base for pavements: Section 02725.
4. Bituminous pavement: Section 02740.
5. Concrete pavement: Section 02750.
6. Curbs, gutters and walks: Section 02772.
7. Fencing: Section 02820.
8. Topsoil, seeding and sodding: Section 02920.
9. Landscaping: Section 02930.
10. Concrete formwork: Section 03100.
11. Concrete reinforcement: Section 03200.
12. Cast-in-place structural concrete: Section 03300.

C. Definitions:
1. Miscellaneous facilities include, but are not limited to, the following: Store fronts, alarm and sprinkler systems, bay windows, cornices, signs, fire escapes, canopies, awnings, security grilles, heating, cooling and electrical facilities, vaults, entrance walkways, steps, sidewalks, curbs, walls, railings, fences, planter boxes, shrubs, lawns and trees.
2. Definitions pertaining to trees, shrubs and other plants: ANSI Z60.1.
3. .Salvage: To remove and store material and equipment for reuse in this or other Authority contracts.

D. Salvage:
1. Clean salvaged items of foreign material and store in accordance with the General Requirements at accessible points within right-of-way unless otherwise shown, approved or directed.
2. Repair or replace salvaged items which are damaged or destroyed.
3. Unless otherwise specified items removed but not to be salvaged will become the property of the Contractor.

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:
   a. Complete details of proposed reconstruction of store fronts and shop windows.
   b. Complete details of temporary signs including method of reinstalling existing permanent signs. Submit prior to removing signs.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. ANSI: Z60.1.
   3. ASTM: C4.
   4. ICNCP (International Commission for the Nomenclature of Cultivated Plants): International Code of Nomenclature for Cultivated Plants.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Materials for Restoration: New materials, unless otherwise approved, conforming to existing undisturbed materials in quality, color and finish.

B. Topsoil: Section 02920.

C. Seeding and Sodding: Section 02920.

D. Trees, Shrubs and Other Plants: Same species as that removed, unless otherwise specified, and identified in accordance with the International Code of Nomenclature for Cultivated Plants.

E. Clay Drain Tile: ASTM C4.

PART 3 - EXECUTION

3.01 REMOVALS:

A. Remove work to extent shown minimizing damage to work which is to remain in place.

3.02 STORE FRONTS, BAY WINDOWS AND CORNICES:

A. Store Fronts:
   1. Rebuild store fronts at or behind building line to match existing fronts insofar as practicable.
   2. Complete restoration in accordance with approved working drawings.

B. Bay Windows:
   1.Rebuild bay windows at or behind building line as window walls.

C. Cornices:
   1. Do not replace cornices which have been removed.
   2. Parge areas disturbed by removal with cement plaster.

3.03 ALARM AND SPRINKLER SYSTEMS AND FIRE ESCAPES:

A. Alarm Systems:
   1. Maintain existing alarm systems in operating condition. On completion of construction, reinstall components to provide same degree of protection as original system.

B. Sprinkler Systems:
   1. Maintain existing sprinkler systems fully operative in areas temporarily occupied for construction purposes.
   2. Protect system from freezing where exposed to open-air conditions.
   3. Restore sprinkler system to provide same degree of protection as original system.

C. Fire Escapes:
   1. Relocate fire escapes temporarily and maintain safe egress.
   2. Replace fire escapes in original location as soon as practicable.

3.04 CANOPIES, AWNINGS AND GRILLES:

A. Canopies and Awnings:
   1. Store canopies and awnings during construction.
   2. Reinstall as soon as construction permits.

B. Grilles:
   1. Remove and reinstall security grilles concurrently with building modifications.

3.05 VAULTS:

A. Perform work on vaults as specified in Section 02320.

3.06 HEATING, COOLING AND ELECTRICAL FACILITIES:

A. Heating and Cooling Facilities:
   1. Remove and rebuild heating and air-conditioning facilities as necessary to provide service.

B. Electrical Facilities:
   1. Remove and reconstruct electrical facilities to extent necessary to provide electrical service inside building line.

3.07 SIGNS, FLAGPOLES, RAILINGS AND FENCES:

A. Salvage signs, flagpoles, railings and fences where shown.

B. Provide temporary sign for each permanent sign removed in accordance with approved working drawings. Remove on completion of construction.

C. Reinstall items in their original locations or in other locations shown. Reinstall or replace chain-link fences in accordance with Section 02820.

D. Repair existing surfaces, damaged during the work, by cleaning and restoration to match existing.

3.08 STEPS, WALLS AND COPINGS:

A. Salvage steps and copings of wall components where shown and rebuild them to match existing.

B. Where new reinforcing steel and concrete construction is necessary, provide such items in accordance with Sections 03100, 03200 and 03300 so as to maintain continuity of quality and appearance between existing and new construction.

3.09 SIDEWALKS AND CURBS:

A. Salvage components of sidewalks and curbs where shown. Dispose of six-inch granite curb. It will not be reused.

B. Restore sidewalks and curbs to line and grades which existed originally or new lines and grades shown.

C. Restore asphalt and concrete sidewalks and curbs using new asphalt and concrete of equal quality to existing and to match lines, grades, thickness and construction existing prior to removal. Perform work in accordance with Sections 02725, 02740, 02750 and 02772.

3.10 PARKING AREAS AND DRIVEWAY PAVEMENTS:

A. Restore parking area and driveway pavements to lines, grades, thickness and construction existing prior to removal. Perform work in accordance with Section 02725, 02740 and 02750.

3.11 LANDSCAPING:

A. Tree Preservation:
   1. Repair injuries, abrasions or other damage to planting by cleanly removing broken members, loose or torn bark and shape edges in order to permit drainage of rain water from wounds. Perform pruning in accordance with Section 02930.
      a. Where depth of soil over root system of existing plantings is to be modified by final grading, provide the following:
         1) Where increase of one foot or more in elevation is shown, spread continuous layer of rock aggregate, graded 1/4 inch to two inches, six inches deep from trunk to drip line of branches prior to installation of fill.
         2) Provide proper aeration by installing, within perimeter of spread, system of four-inch clay drain tile, vertically from soil surface into aggregate fill.
         3) Construct stone wells around trunks as shown, detailed or as approved. Extend stone work from rock fill layer to final grade, allowing sufficient space for trunk growth.
         4) Protect trees, shrubs, groundcovers and features such as landforms, walls, wells, coping and similar items that are to remain. Exercise special precautions and provide treatment for retention and protection of such landscape items in preference to removal.

B. Tree Removal and Replacement:
   1. Where existing trees are to be removed and replaced by others at present locations, use replacement trees of comparable species and size up to four inches maximum caliper, except that the jurisdictional authorities have the right to specify alternate tree species or varieties of comparable size and cost, if such are readily available. Do not replant or relocate trees over 12 inches in caliper, except in cases of historical significance, rarity of type, excellence of form or other special considerations.
   2. Replace trees of minimum three-inch caliper, removed by construction, on the basis of diameter inch for diameter inch, up to four-inch maximum caliper, and on total diameter inches removed, so that planting can be complete and uniform throughout.
   3. Use replacement trees of prime specimen quality, field selected and seal-tagged. Measure, grade, install and maintain plants in accordance with ANSI Z60.1, except for National Park Service lands where trees are to be measured for diameter by taking the average of two trunk caliper measurements at right angles, six inches

above the root crown.

4. Replace shrubs removed with same species and varieties and of same size in height or width or substitute at locations designated by the Engineer a number of plants of same species and variety whose total measurements equal measurement of plant or plants to be replaced

C. Plant maintenance and replacements:

1. For 18 months after completion of plant installation, maintain planting and incidental work by replacing plants, watering, weeding, cultivating, fertilizing, remulching, pruning, controlling insects and diseases, reguying, rewrapping and by performing other maintenance operations for promotion of root growth and plant life so that work is in satisfactory condition at completion of Contract and throughout maintenance period.
2. Water and weed root system of plants at regular intervals and keep surrounding soil in condition for promotion of root growth and plant life.
3. Provide planting and planting materials that will be in a condition acceptable to the Engineer at end of maintenance period.
4. During next planting season, replace trees, ground cover, vines and shrubs which are discovered during and at end of maintenance period to be dead or in unhealthy, unsightly or badly impaired condition. Replace with healthy plants of same kinds and sizes as originally specified.
5. The Contractor will not be held responsible or liable for damages to plants and planting materials by animals, malicious or careless damage by human agencies over which he has no control, or by fire and storm damage following completion and acceptance of original planting.

D. Topsoil:

1. Provide and place topsoil in tree spaces and areas to be seeded in accordance with Section 02920.

E. Grassed Areas:

1. Unless otherwise shown, provide seed in accordance with Section 02920. If sodding is required, provide in accordance with Section 02920.

F. Replace landscaping, trees and grassed areas, inside and outside limits of work, if removed or damaged.

3.12 JOINTS BETWEEN EXISTING AND RESTORED WORK:

A. Make joints between existing and restored work as inconspicuous as practicable.

B. Use saw to cut straight line at joint between existing and new concrete surfaces.

C. Make joints between existing and restored work at least equal structurally to original undisturbed items.

END OF SECTION

SECTION 02220

DEMOLITION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies demolition work.

1. Related Work Specified Elsewhere:
2. Clearing, grubbing, removal and protection of trees and shrubs: Section 02230.
3. Removal of concrete and masonry walls and foundations 12 inches below existing grade: Section 02320.
4. Removal and restoration of miscellaneous facilities: Section 02205.

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 02205.

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. Buildings:

1. Demolish buildings in place.

B. Street and Road Closures:

1. Make arrangements with appropriate jurisdictional agency for temporary closing of public streets or highways to traffic as necessary.
2. Arrange with the appropriate agency for the rerouting of traffic and comply with its regulations.
3. Furnish and maintain temporary signs, barricades, flashing lights and flag persons necessitated by the work and remove same upon completion of work.

C. Maintenance of Traffic:
   1. Construct, maintain and remove on completion of work, temporary canopies and other structures for protection of the public in accordance with applicable codes to ensure continuous safety of traffic.
   2. Bridge cuts in traffic areas with steel plates or by other approved means.
   3. Keep traffic areas free from debris and spillage of materials.
   4. 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.

D. 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.

PART 2 - PRODUCTS

Not Used.

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 BUILDING DEMOLITION:

A. Undertake rodent control and extermination program in demolition areas.

B. Take possession of building materials, fixtures and equipment in, attached to or belonging to, buildings and structures.

C. Proceed with demolition of building or structure and appurtenances.

D. Party Walls:
   1. Where building wall being demolished is a party wall with another building not to be demolished, prevent damage to other building and avoid interference with its occupants.
   2. Restore and waterproof exposed party walls in accordance with applicable building code for exterior walls of particular type of construction involved.
   3. Should party wall become unsafe or dangerous because of demolition, effect remedial measures for anchoring, bracing or buttressing. If such work does not correct unsafe or dangerous conditions, remove and replace wall and perform necessary work to properly enclose structure that is to remain standing, at no cost to the owner of such property.

E. Cellars and Foundation Walls:
   1. Break concrete and masonry cellar floors into pieces not exceeding four cubic feet in volume or, where approved, punch holes of not less than one-square-foot area through full thickness of floor approximately at 10-foot centers.
   2. Remove wooden cellar floors.
   3. Remove foundation and cellar walls 12 inches minimum below final grade.

4. After breaking or removing cellar floors, fill cellar spaces with durable free-draining fill material, consisting of particles no one of which exceeds eight inches in its greatest dimension. Use masonry rubble obtained from demolition work if it meets this requirement. Place fill material in layers each of 12-inch maximum thickness, compact each layer and fill voids in each lift with approved coarse sand.
5. Correct subsidence in filled areas by placing and compacting additional fill.
6. The Engineer may waive the requirement to fill cellar voids where cellar structures will be subsequently excavated for construction.

3.03 REMOVAL OF STREETCAR TRACKS, PAVEMENTS, SIDEWALK, CURBS AND GUTTERS:

A. Removal of Streetcar Tracks:
1. Regardless of depth, totally remove and dispose of rails, slot rails, yokes, switches, turnouts, ties, manholes, concrete and masonry encasements, cables, insulators and other related parts and accessories of track installation located within boundaries drawn two feet outside outer rails. Remove materials within such boundaries horizontally and from existing street grade to yoke encasement subgrade, vertically. In double track installations, remove materials in intervening space between inner rails of each track.
2. Known locations of streetcar tracks are shown.
3. Remove streetcar tracks as necessitated by the work and as directed, whether tracks are shown or encountered during excavation.
4. Transport from the site removed or excavated track accessories or parts thereof which will become the property of the Contractor.
5. Methods of removal and disposal will be at the Contractor's option, subject to approval and meeting the requirements of the Construction Sequence and Maintenance of Traffic Schedule.

B. 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. Dispose of six-inch granite curb.

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

D. Adequately drain resulting surfaces.

3.04 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.

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.
   4. Construction Facilities and Temporary Controls- Div 1

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 Division 2 Section "Earthwork."

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

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.

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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 02240

DEWATERING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies general dewatering systems for control of groundwater and removal of surface water during construction.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. ASTM:
      a. D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
      b. D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
      c. D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
      d.

B. Qualifications:
   1. For mined earth tunnels, have the design, implementation, evaluation, and maintenance of the dewatering system under the supervision of a specialist with a minimum of five years experience in responsible control of work similar to that proposed.

C. Design Criteria:
   1. Provide dewatering system which will reduce hydrostatic pressure and lower groundwater levels below excavation levels excluding mined tunnels, as necessary for safe and proper prosecution of the work and which will result in obtaining stable, substantially dry subgrade for prosecution of subsequent operations.
   2. For mined earth tunnels, provide dewatering system which will reduce hydrostatic pressure and control groundwater in soil surrounding each tunnel to prevent the following:
      a. Heaving of the invert, hazardous seepage, and flow of soil in tunnel face.
      b. Loss of ground and surface subsidence.
   3. For mined earth tunnels in pervious soils, lower groundwater to two feet below invert or reduce hydrostatic pressure to a point where tunneling proceeds without groundwater related delay and loss of ground.
   4. For mined earth tunnels where impervious soils extend above invert, lower groundwater level to two feet above top of lowest impervious soil layer or reduce hydrostatic pressure to a point where tunneling proceeds without groundwater related delay and loss of ground.

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:
      a. Type of dewatering system proposed, showing arrangement, location and depths of proposed system, complete description of equipment and materials to be used, installation procedure, well and piezometer

development procedures, maintenance plan for dewatering system and piezometers, standby equipment and standby power supply (if required), and proposed location of points of discharge of water and settlement measuring procedure.

b. Obtain approval of jurisdictional agencies prior to installation of system.

2. Documentation:

a. Observe and record average flow rate and time of operation of each pump used in dewatering system. Provide appropriate devices, such as totalizing flow meters for observing flow rates.Provide interior dewatering well drop tube and exterior filter piezometer to observe and record operating levels and filter levels. Submit data on approved form and in approved format during period dewatering system is in operation.

b. Observe and record elevation of groundwater in the piezometers, including those previously installed, on approved form and in approved format, during the period that dewatering system is in operation. Sound depth to bottom of each piezometer monthly to ensure that soil particles are not building up in standpipe. Submit observation records promptly, regularly and as directed.

c. During dewatering, make observations daily. After dewatering levels have stabilized, observations frequency may be reduced as approved.

d. Submit maintenance schedule for piezometers and dewatering system. Record and submit maintenance records for each piezometer and dewatering well or dewatering system component weekly or as approved

e. Provide drill logs and installation details of all dewatering system components, and piezometers, 24-hours after installation.

1.03 JOB CONDITIONS:

A. Subsurface Conditions:

1. Reports of subsurface investigations are available as listed in the General Requirements.

B. Permits:

1. Prior to discharging water, obtain permit from jurisdictional agency.
2. Control discharge of water in accordance with the General Requirements, if specified.

C. Responsibilities:

1. Design and install dewatering system to accomplish groundwater control as specified.
2. Monitor, and report as required, discharge from dewatering system to determine if water quality meets the requirements of jurisdictional agency. Modify dewatering system as necessary to meet the requirements of jurisdictional agency.
3. Measure to determine if movement occurs in adjacent areas by dewatering operations; take approved measures to minimize movement and prevent damage to affected properties, buildings, structures, utilities or facilities. Establish criteria for acceptable tolerances.
4. Take measures to prevent damage to properties, buildings, structures, utilities and facilities resulting from groundwater pumping.
5. Modify system if it causes, or threatens to cause, damage to properties, buildings, structures, utilities or facilities.
6. Repair as approved, damage, disruption or interference to properties, buildings, structures, utilities or facilities resulting from dewatering operations.
7. Contract Drawings may designate locations where lowering of groundwater will not be permitted.

8. Locations of dewatering system elements and piezometers may be adjusted in field to suit job conditions, as approved.
9. Operate dewatering system without interruption until directed otherwise.

D. Coordination with Other Contractors:
1. The Contract Specifications govern requirements for access to areas outside Contract limits.
2. Coordinate installation and operation of dewatering system and piezometers with others concerned and with other Authority contractors if applicable.
3. If an adjoining Authority contract requires installation of portions of the adjoining contract dewatering system or piezometers within Contract limits, allow access for installation.

PART 2- PRODUCTS

2.01 PIEZOMETERS:

A. See Soil & Geological Standard Drawing Piezometer Details as shown.

B. Piezometer construction shall use ASTM-specified materials and procedures (D2466, D1785, and D2564) .

PART 3 - EXECUTION

3.01 SURFACE DRAINAGE:

A. Intercept and divert surface drainage away from excavations, piezometers and dewatering wells by use of dikes, curb walls, ditches, pipes, sumps or other means.

B. Design surface drainage systems to prevent erosion.

C. Remove surface drainage system when no longer required.

D. Remove debris and restore site to original conditions.

3.02 DRAINAGE OF EXCAVATED AREAS:

A. Provide and maintain ditches of adequate size to collect surface and subsurface water and divert it into sump for draining or pumping into channels or storm sewers, as approved.

B. Install settling basins, tanks or other approved apparatus as necessary to bring the discharge into compliance with permit requirements.

C. When no longer necessary, backfill and seal drainage ditches, sumps and settling basins with approved material.

3.03 DEWATERING:

A. Coordinate dewatering installation to prevent conflict with other construction activities.

B. Install dewatering system in accordance with approved drawings and procedures. If site conditions require modification of the dewatering system, implement modifications to achieve specified design criteria prior to excavation.

C. Demonstrate by approved methods that discharged sand content from each well meets the design criteria specified above under Quality Assurance.

D. Discharge subsurface water clear of the work area.

E. Maintain continuous and complete effectiveness of the installation through regularly scheduled maintenance of well screens, pumps, piezometers, electrical and piping systems.

F. Maintain water level so that no damage to structure can occur.

G. During backfill operations, the extent of dewatering may be reduced when approved, provided water level does not result in uplift pressure in excess of 80 percent of downward pressure produced by weight of structure and backfill in place.

H. At locations of piezometers in mined earth tunnel sections, reduce water level to specified criteria at least 48 hours in advance of tunnel excavation.

I. Maintain dewatering operations until permanent tunnel lining has been installed.

3.04 PIEZOMETERS:

A. Prior to dewatering operations, install piezometers at locations shown or as approved and to the depths shown or approved.

B. Verify installed piezometer tip elevation. Reinstall piezometers which do not comply with requirements at no additional cost to the Authority.

C. 48 hours after completion of each piezometer installation, prove proper functioning of piezometer by performing Falling Head Tests. Submit test records within 24 hours of test completion.

D. While dewatering system is in operation, prove continued proper functioning of each piezometer by performing rising head tests. Submit test records within 24 hours of test completion.

E. Take static water level readings prior to energizing dewatering system. Submit water level readings within 24 hours of observation.

F. Operate dewatering system so that groundwater level in piezometers is maintained continuously within prescribed limits.

G. Protect and maintain piezometers in good operating condition until completion of Contract.

H. Replace promptly any piezometer or dewatering well that is damaged or destroyed.

I. Terminate piezometer readings when approved.

3.05 PORTIONS OF SYSTEM TO BE LEFT IN PLACE:

A. When specified, leave portions of dewatering system in place.

3.06 PORTIONS OF SYSTEM TO BE REMOVED:

A. Upon completion of Contract, remove piezometers and well casings, unless otherwise specified, to a depth of two feet minimum below ground surface.

B. Backfill voids, well and piezometer casings with bentonite-cement grout.

C. Backfill remaining space with compacted earth and restore ground surface to its original condition.

END OF SECTION

SECTION 02255

UNDERPINNING, SUPPORT AND RESTORATION OF STRUCTURES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies underpinning, supporting and restoring of structures.

B. Definitions:
   1. Underpinning: Permanent supporting structure designed to transmit foundation loads to lower bearing levels necessary to securely maintain structure being underpinned. Also includes temporary support necessary to safely perform underpinning work and restoration of structure upon completion of work.
      a. Temporary support: Construction required and designed to support structures during underpinning or other construction work.
      b. Restoration: Correction by repair or replacement of structure which is damaged, removed or altered by the Contractor in furtherance of his operation equivalent to condition existing prior to start of Contract work unless otherwise shown or specified.
   2. Structure categories:
      a. Category 1 structures: Structures for which underpinning is necessary and has been designed.
      b. Category 2 structures: Structures which, because they are likely to be affected by construction operations, the Contractor has the option of supporting temporarily, underpinning or both. The decision rests solely with the Contractor who is entirely responsible for results.

C. Related Work Specified Elsewhere:
   1. Grading, excavation and backfilling: Section 02320.
   2. Dewatering: Section 02240.
   3. Support of excavation: Section 02260.
   4. Decking: Section 01530.
   5. Piles: Section 02460.
   6. Concrete work: Sections 03100, 03200 and 03300.
   7. Structural steel: Section 05120.
   8. Geotechnical instrumentation: Section 02291.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. ASTM: D1056, D1149, D1692.

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:
      a. Verify by field investigation foundation loads, locations, sizes and conditions of existing structures and footings requiring underpinning and temporary protection.

b. Prepare working drawings showing method, staging and necessary details, including computations for construction of underpinning and temporary support of each structure on which work is to be accomplished as well as method of transferring structural load to piles.

c. Have drawings and computations certified by a registered professional engineer who is licensed to practice in the jurisdiction where the work is to be performed and who is qualified to substantiate extent and design of underpinning work.

2. Documentation:

a. Submit written understandings with each structure owner with owner's signature signifying his agreement.

1.04 JOB CONDITIONS:

A. Consents, Permits and Approvals:

1. The Authority will obtain necessary rights from owner for Contractor to occupy construction areas for Category 1 Structures as shown.

2. The Contractor is responsible for obtaining in his own name, other agreements, rights, permits and consents necessary to effect underpinning work, which are to provide for and constitute agreement as to interdependent unitized system of underpinning support, when such system is feasible in the Contractors' opinion. Obtain permits required by jurisdictional agencies. Permits to name property owner and the Authority as co-applicants, when applicable, and the Contractor as their agent. Transmit copies of these instruments to the Engineer before starting work on each affected structure.

3. Additional requirements for permits, consents and approvals are contained in the General Provisions. Where plans for existing structures are available, they may be reviewed as specified in the General Requirements.

B. Responsibilities:

1. Maintain safety, stability and integrity of structures of whatever nature regardless of location which may be affected by the work.

2. Repair damage to structures caused by work necessary to restore structures to condition existing prior to start of work.

3. Perform underpinning operations in accordance with applicable codes and regulations of the jurisdictional agencies.

4. Perform underpinning operations with qualified personnel under continuous supervision of a registered professional engineer experienced in such work.

C. Coordination with Structure Owners:

1. Prior to starting work on structure, confer with owner or his authorized representative and obtain concurrence with underpinning procedures and sequence of operations including:

a. Means of access to the construction area.

b. Permitted areas of operations.

c. Time restrictions for performance of work which may disturb occupants.

d. Scheduling of time and durations of outages of utilities and other services to premises as well as of operation of systems within premises.

2. Notify the Engineer three days prior to intended conferences with owner.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Piling: Section 02460.
B. Concrete: Section 03300, Class 3500 or better.
C. Reinforcement: Section 03200.
D. Structural Steel: Section 05120.
E. Vibration-Isolation Materials:
   1. Closed-cell neoprene isolation board conforming to ASTM D1056, Grade 2C5.
   2. Self-extinguishing when tested in accordance with ASTM D1692.
   3. No cracks after exposure to air containing 100 ppm of ozone for 100 hours at 104F with samples under 20 percent strain tested in accordance with ASTM D1149.
   4. Water absorption: Not exceeding one percent by weight.

F. Bonding Adhesive: As recommended by the vibration-isolation material manufacturer.

PART 3 - EXECUTION

3.01 DETECTION OF MOVEMENT:

A. In accordance with the General Requirements, provide, install and maintain monitoring equipment to detect horizontal or vertical movement of structures as specified in Section 02291.

B. Inscribe or firmly affix on each column, pile cap, or wall to be underpinned or supported and at additional locations directed by the Engineer, visual methods of determining movements. Method used is optional but to be capable of being read to within 0.005 foot.

C. Take readings daily or more often if necessary during progress of underpinning or support operations and for a period of four weeks after completion of such operations. Frequency of readings may be reduced at specific location(s) with prior approval.

3.02 TEMPORARY PARTITIONS AND CLOSURES:

A. Build where shown and as required by property owner, closed, dustproof, weatherproof and burglarproof temporary partitions and closures of suitable materials to isolate work site from remainder of the structure. Comply with local building code requirements.

B. Provide emergency exits, with appropriate hardware.

C. Provide temporary protection against dust and damage from underpinning operations.

D. Remove temporary protective installations upon completion of work and restore area to original condition.

3.03 INSTALLATION:

A. Excavation:
   1. Excavate underpinning pits in accordance with Section 02320.
   2. Support excavated surfaces in accordance with Section 02260.
   3. Provide and maintain protective fencing and decking in accordance with Section 01530.
   4. Dewatering: In accordance with Section 02240.

B. Underpinning:

1. Perform needling, shoring, cribbing and posting as necessary to ensure that movements damaging to the structure do not occur prior to and during underpinning operations.
2. Place dry pack mortar, concrete and reinforcing steel in accordance with Sections 03100, 03200 and 03300.
3. Install structural steel shapes in accordance with Section 05120.
4. Install piling where shown in accordance with Section 02460.
5. When jacking piles, establish adequate controls to detect movement of structure being underpinned. Maintain suitable equipment and methods continuously available to contain movement should it occur.
6. Remove obstructions encountered when installing steel shell piling by drilling or spudding. Blasting is prohibited.
7. Test installed piling where shown and take remedial action necessary to obtain loading.
8. Use underpinning piles for underpinning purposes only, unless approved.
9. Transfer structural load to piles in accordance with approved procedures.
10. When transfer of loading has been completed and approved, clean pits of foreign matter.

C. Vibration Isolation:
1. Place vibration-isolation material where shown using boards supplied in lengths sufficient for one-piece installation. Apply bonding adhesive at rate recommended by manufacturer of board.

D. Backfill:
1. Place concrete backfill to limits shown.
2. Place and compact earth backfill in accordance with Section 02320.

E. Restore ground and building surfaces to their original condition.

F. Remove debris and construction materials. Leave site in a neat presentable condition.

END OF SECTION

SECTION 02260

SUPPORT OF EXCAVATION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies support for cut-and-cover, open-cut excavation, trench excavation and shafts.

B. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
2. Maintenance, support and restoration of utility facilities: Section 02270.
3. Decking: Section 01530.
4. Rock reinforcement: Section 02420.
5. Drilling: Section 02431.
6. Concrete reinforcement: Section 03200.
7. Cast-in-place structural concrete: Section 03300.
8. Steel bars, steel strand, anchorages, couplings for ground anchors, grout: Section 03415.
9. Structural steel: Section 05120.
10. Grounding and bonding of soldier piles: Section 16060.
11. Geotechnical instrumentation: Section 02291.

C. Contractor's Options:
1. System of support to consist of soldier piles and lagging, sheet-piling or slurry-trench concrete walls, secured in place by means of bracing members such as wales, struts, shores and ground anchors. Other methods of support permitted only when approved.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standard and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. API: 13A, 13B-1.
3. ASTM: A36, A709, A722.
4. EPA.

B. Design Criteria:
1. Design support of excavation in accordance with design criteria shown and specified. Criteria are the minimum acceptable.
2. Design component members of system to support temporary decking system, earth and rock pressures, unrelieved hydrostatic pressures, utility loads, applicable traffic and construction loads and other surcharge loads. Use loading combinations shown. Prepare design for staged removal of bracing to suit sequence of concrete placement.
3. Design support system for nonpenetration of station and entrance surfaces visible to public. Temporary penetration permitted only where location of penetration is eventually to be hidden by elements such as acoustical panels or similar items

4. Design sheeting and bracing for sides of excavations for underground structures in a manner permitting safe and expeditious construction of permanent structures, minimizing movement or settlement of the ground and preventing damage to adjacent buildings, structures and utility facilities. Locate and design the bracing system such that it will not interfere with the reinforcement and construction of the permanent structure.
5. For support systems in which struts are installed between opposite sides of the excavation, design and construct support of both sides to obtain comparable rigidity.
6. Choose location of soldier piles to allow for expected deviations from true line during driving procedure without encroaching on future permanent structures.
7. Approval of Contractor's plans and methods of construction does not relieve the Contractor of the responsibility for adequacy of support.

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:
      a. Details, arrangement and method of assembly of proposed system, including construction sequence.
      b. Method of preloading and bracing.
      c. Elevations and sections showing full excavation depth from top grade to bottom of soldier piles or subgrade, whichever is deeper.
      d. Loads for various stages of bracing removal and concrete placement.
      e. Anticipated equipment load.
      f. Maximum design load to be carried by various members of support system and preloads.
      g. Depths below main excavation to which support system will be installed.
      h. Methods of resolving difficulties arising from misalignment of soldier piles exposed during excavation and criteria for implementation of those procedures.
      i. Methods of controlling and monitoring vibrations caused by driving of soldier piles to prevent damage to structures and utility facilities.
      j. If proposed support system includes tieback anchors, show geologic profile or section for which each anchor is intended, design load for full depth of the excavation, maximum design and proof load and criteria proposed for deformations under proof loads.
      k. Ground anchors and rock bolts:
         1) Prior to starting work, submit support system tieback and rock bolt details including design calculations, installation and load test procedures, grouting materials, grouting methods and detailed working drawings of the proposed rock bolt system.
         2) Show geologic profile or section for which each ground anchor or rock bolt is intended and design load of ground anchor and rock bolt for full excavation condition.
      l. Include design calculations and maximum theoretical deflections of support members.
         1) The maximum allowable deflections of support members are as follows:

Soldier beams	1/2-inch
Walers	1/4-inch

         This does not include the movement of support due to creep in tieback.
      m. Include existing utility facilities. After checking their locations by field investigations, revise drawings to show actual locations of facilities, location of excavation supports, interference with proposed work and measures proposed to overcome such interferences.

2. Documentation:
   a. Where proposed system of tieback anchors or rock bolts projects beyond vertical projection of property lines shown onto adjoining property, obtain permission of owner in writing.
   b. Submit copies of permits with drawings.
   c. Calculations:
      1) Design calculations as applicable.
      2) Do not proceed with work prior to approval.

1.04 JOB CONDITIONS:

A. Provision for Contingencies:
   1. Monitor performance of components of support system, both vertical and horizontal movement in accordance with Section 02291, at regular intervals not to exceed three days.
   2. Provide contingency plan or alternative procedures to be implemented if unfavorable performance is evidenced.
   3. Keep on hand materials and equipment necessary to implement contingency plan.

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

C. If existing utility facilities interfere with proposed method of support, modify or relocate such facilities with the approval of the appropriate utility owner. If relocation of the utility is not possible, obtain Engineer's approval for field changes to the approved support scheme of the excavation.

D. Do not splice elements of support system unless approved.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Steel Sheet Piles: Continuous interlocking type with cross section selected for intended use.

B. Cast-In-Place Structural Concrete: Section 03300, Class 3500 unless otherwise shown.

C. Timber Lagging: Structural grade, minimum allowable flexural stress of 1,100 psi.

D. Concrete Reinforcement: Section 03200.

E. Structural Steel: Section 05120; ASTM A36 or ASTM A709, Grade 36, minimum.

F. Rock Bolts: Section 02420.

G. Ground Anchors:
   1. Steel bars: ASTM A722 and Section 03415.
   2. Steel strand: Section 03415.

H. Anchorages and Couplings for Ground Anchors: Section 03415.

I. Grout: Section 03415.

J. Bentonite Powder: API 13A.

K. Other Materials: Those best suited for intended use, and as approved.

2.02 MIXES:

A. Lean Concrete: Portland cement and mineral or soil aggregate proportioned so that concrete retains its shape during excavation operations.

B. Concrete for Slurry Trench Walls:
1. Tremie concrete of 3500 psi strength or higher if necessitated by design, with the following additional requirements:
   a. Minimum cement factor: Seven bags per cubic yard.
   b. Water-cement ratio: As necessary for strength and durability.
   c. Sand proportion: As necessary to produce optimum results.
   d. Rounded gravel aggregate: 1-1/2 inch maximum.
   e. Slump: Six inches plus-or-minus one inch.
   f. With water-reducing or fluidizing agents as necessary.
2. Submit mix design for approval.

C. Bentonite Slurry:
1. Stable suspension of powdered bentonite, or equal, and natural silts and clays in water.
2. Density: 64 pcf minimum, 85 pcf maximum.
3. Marsh funnel flow rate: 40 seconds minimum, 80 seconds maximum viscosity.
4. Fluid loss: 25-cc maximum in 30 minutes.
5. pH: 7.0 to 11.0
6. Shear strength:
   a. By shearometer: 1.4 to 10 N/M.
   b. By fan viscometer: 4.0 to 400 N/M.

PART 3 - EXECUTION

3.01 SHEETING, SHORING AND PILING:

A. Install soldier piles by driving, preboring or other pre-excavation methods. Drive soldier piles only in those areas where shown or approved. Install piles vertically within tolerance of one foot per each 100 feet for full depth of each pile.

B. Where piles are installed by preboring or other pre-excavation methods, take appropriate measures to stabilize excavation to preclude loss of ground.

C. Provide prebored holes for soldier piles adequate to accommodate pile section shown on approved working drawings. Extend hole to necessary depth below top of subgrade.

D. Carry bottom of support system to depth below main excavation, adequate to prevent lateral movement. In areas where additional excavation is required below main excavation subgrade, make provisions to prevent movement of main excavation supports.

E. Multiple-Layered Horizontal Bracing:
1. At locations where top of weathered bedrock is above the subgrade of main excavation, install soldier piles so that tips are at least two feet below top of subgrade.
2. At locations where top of weathered bedrock is five feet or more below subgrade of main excavation, install soldier piles so that lower tip is at least five feet below bottom of excavation.

3. If weathered bedrock is encountered at elevation between subgrade elevation and five feet below subgrade, install soldier piles so that lower tip is five feet below subgrade or two feet into rock, whichever is higher.

F. After seating soldier piles in pre-excavated holes, encase piles with Class 3500 concrete up to lowest point of excavation adjacent to pile location. Fill remainder of hole with lean concrete, completely encasing pile.

G. Use timber lagging, steel sheeting or precast reinforced concrete members secured in place for sheeting of excavations.

H. Follow excavation closely with placement of sheeting and lagging. Do not allow maximum height of unsheeted or unlagged face of excavation to exceed five feet in rock or predominantly clayey soils and three feet in sandy soils.

I. Do not permit height of unlagged face to exceed 15 inches if water flows from face of excavation or if soil in face moves toward excavation area.

J. Carefully perform excavation for installation of sheeting to minimize formation of voids. Separate sheeting members only to extent necessary to permit packing behind them.

K. Pack behind sheeting as installation progresses to establish tight contact between excavation face and sheeting. Pack openings between sheeting members with straw or other suitable material to allow free drainage of water without loss of soil or sand packing.

L. If unstable material is encountered during excavation, take suitable measures to contain it in place and prevent ground displacement which may cause damage.

M. Maintain sufficient quantity of material on hand for sheeting, shoring, bracing and other operations for protection of work and for use in case of accident or emergency.

N. Support System For Vertical Shafts Which Penetrate Soil/Rock Interface:

1. Soldier piles:

a. If shaft excavation is supported by soldier piles, locate piling at least five feet in a horizontal direction from outer face of shaft wall. Install lower tip of piling at least ten feet below top of unweathered bedrock.

b. Procedure for establishing tip elevations:

1) Make three pilot core borings at equal spacing along soldier pile line. Borings may be washed through overburden, but must be cored through bedrock to a depth of 20 feet into unweathered rock as determined by the Engineer. Advance holes in rock by rotary drilling methods and recover 2-1/8 inch diameter (NX) size rock cores using Series M double-tube core barrel. Drill in conformance to applicable portions of Section 02431. Place cores in wooden boxes as specified in Section 02431 and deliver to storage site as directed.

2) Install soldier piles to obtain tip elevations established by the Engineer's examination of coring results.

3) For shafts where pilot core borings indicate top of unweathered bedrock varies by more than three feet in elevation, set tips of soldier piles at least ten feet below lowest point of top of unweathered bedrock.

4) In drilling soldier pile holes, use equipment capable of penetrating hard igneous and metamorphic rock that has an average unconfined compressive strength of six to eight kips per square inch and that may reach even greater values in some locations.

2. Ring beams and lagging or liner plate:
    a. If shaft excavation is supported by ring beams or liner plates, install rings or liner plate to at least ten feet below average elevation of top of unweathered bedrock, which will be determined by the Engineer from examination of the rock in the advancing excavation.

3.02 SLURRY WALLS:

A. Slurry Trench Equipment:
1. Use equipment capable of removing from trench foreign materials embedded in soil as well as natural materials, including boulders, where necessary. Arrange equipment to permit free vertical passage of slurry within trench and to prevent development of suction or pressure.
2. Furnish trench inspection tools adequate to ensure that trench has been excavated to dimensions shown on approved working drawings and that cuttings and foreign material have been removed.
3. Use slurry mixing equipment capable of producing, with mechanical agitation, a stable suspension of bentonite and water. Transport slurry to panels by temporary pipe line or other approved methods.
4. Furnish slurry circulation equipment to provide circulation and agitation of the slurry throughout full depth of excavated panels. Do not agitate slurry by air
5. Use slurry reclaiming equipment which will remove detrimental quantities of excavated material from slurry to ensure use of clean slurry in trenches. Recirculate reclaimed slurry to trenches in a continuous operation regardless of slurry density. Monitor slurry and control its capability of retaining solid particles in suspension.

B. Field Quality Control:
1. Make tests on samples of in-place slurry to determine density, viscosity, filtration and sand content in accordance with API 13B-1.
2. Maintain quality of bentonite slurry compatible with soil characteristics of trench walls.

C. Construction:
1. Perform preparatory work to discover, protect, maintain, relocate and restore utility facilities and other obstructions in vicinity of slurry walls.
2. Construct slurry trench walls by displacement of bentonite slurry with tremie concrete.
3. Construct walls of reinforced concrete or plain concrete embedded with structural steel. Where soldier piles are used in construction of walls, it is permissible to consider piles as reinforcement.
4. Provide sufficient embedment of walls below subgrade of excavation to prevent loss of ground due to piping under wall or lateral movement of wall.
5. Use construction methods ensuring that slurry materials employed during trench excavation and placing of tremie concrete are contained and controlled to prevent leakage and spillage of slurry and excavated materials into basements, vaults, utilities and other facilities.
6. Excavate slurry wall trenches in panels of width and depth shown on approved working drawings with maximum panel length of 18 feet. Reduce panel length when excavating adjacent to facilities sensitive to settlement.
7. Maintain level of slurry in panels no more than five feet below top of trench during excavation operations and until tremie placement is essentially completed.
8. Progress construction with no less than one unexcavated panel and one tremie-filled panel with concrete cured at least 72 hours, between two slurry panels under active excavation.
9. Keep slurry circulated or agitated during drilling and excavating and immediately prior to concreting. Continuously maintain slurry requirements even during

nonworking periods and stoppages. If stoppage occurs in the operation causing slurry in panel to remain uncirculated and unagitated for more than 24 hours, backfill panel until operation can be resumed.

10. Place concrete by tremie methods either by gravity flow or by pumping. As soon as possible after placement of concrete is commenced, position bottom of pipe not less than five feet below upper surface of concrete being placed and maintain it in this position throughout operation. Equip tremie pipe with bottom valve or other device to prevent mixing of slurry with concrete inside tremie pipe. Aluminum pipe is prohibited.
11. Inspect trenching in the presence of the Engineer prior to concreting. Ensure that settled cuttings and excavated material have been removed.
12. Start placement of concrete in panels within 12 hours after completion of panel excavation and proceed continuously until concreting is completed.
13. When wales are used, obtain tight bearing between wales and wall and ample bearing area with wedges and dry pack for load transfer.
14. Preload braces at each level to computed maximum compressive force to be encountered at that level. Base calculations of this computed force upon pressure diagrams shown. Take into consideration increased strut loads that may develop because of removal of bracing as structure is built.
15. Accomplish preloading by approved procedures. Transfer load by jacking applied symmetrically to braces without introducing eccentricity.
16. Introduce jacking load into braces immediately after each tier of braces has been installed and before excavation has progressed more than two feet below bottom of bracing tier. Make provision to fix preload into each brace by shim plates, wedges, blocking or other approved device.
17. After concrete invert slab has been placed and attains sufficient strength to receive loads from slurry walls, remove tiers of bracing above invert level, provided the following conditions exist:
    a. Remaining tiers are capable of resisting total load calculated from trapezoidal pressure diagrams shown.
    b. Calculated deflection of the walls between tiers of bracing, assuming forces indicated by the trapezoidal pressure diagrams, does not exceed 1/2 inch.
18. Construct tight joints between adjacent pours of concrete in slurry wall to minimize loss of fines from retained earth. Take necessary care to accomplish this in terms of properly excavating trench and cleaning abutting face of hardened concrete or surfaces of structural members if used. Provide approved method of water stopping.
19. Seal leaks encountered in walls as excavation progresses, if leaks are of sufficient size to permit penetration of fines and loss of ground. Procedures may include grouting outside or through wall.
20. Dispose of unsuitable excavated material and debris in accordance with Section 02320.
21. Dispose of slurry waste offsite by means of sealed tanks and in accordance with EPA regulations.

3.03 PRIMARY SUPPORT:

A. Use wales, struts, tieback anchors and rock anchors as necessary to provide primary support of excavation faces retained by soldier piles, sheeting, sheet piles or concrete slurry walls. For excavation depths greater than eight feet, primary support or supports are required.

B. Provide struts with intermediate bracing as needed to enable them to carry maximum design load without distortion or buckling.

C. Provide diagonal bracing as needed to maintain stability of system.

D. Include web stiffeners, plates or angles as needed to prevent rotation, crippling or buckling of connections and points of bearing between structural steel members. Allow for eccentricities caused by field fabrication and assembly.

E. Install and maintain primary support members in tight contact with each other and with surface being supported.

F. Design primary support members to support maximum loads occurring during excavation or removal stages.

G. Preloading:
   1. Except for ground anchors and slurry wall bracing, preload primary bracing members including struts, shores, wales carrying axial load, and similar members at installation to 50 percent of design load, which for this purpose is maximum load that bracing member will have to carry. Preload tiebacks and slurry walls as specified for those installations.
   2. Use procedures that produce uniform loading of bracing member without appreciable eccentricities or overstressing and distortion of members of wall system.
   3. Make provisions for permanently fixing load in each member using steel shims or wedges welded into place.
   4. Accomplish preloading by jacking support in place against soldier piles or wales.
   5. Do not use wooden wedges to preload bracing member.
   6. Include in preloading system means to determine within five percent amount of preload induced into bracing members.

H. If decking beams are not required or if decking beams are not designed for support of excavation loads, install uppermost tier of bracing at vertical distance of not more than six feet below top of excavation.

I. Install tiers of primary support with no greater vertical distance between them than 16 feet

J. Reduce maximum vertical distance to 12 feet at locations where ground movement and settlement must be minimized to prevent damage, where shown and as directed.

K. Excavate to no more than two feet below point of support about to be placed. Install support and preload immediately after installation and prior to continuing excavation.

3.04 SUPPORT SYSTEM WITH TIEBACKS:

A. Install tieback system in accordance with approved working drawings. Install anchorage in soil no closer than a plane extending upward at an angle of 45 degrees to the horizontal from outer limit of lowest depth of excavation.

B. Stress tiebacks to proof loads equal to 140 percent of maximum design load and maintain proof load for 30 minutes prior to reducing to design load. Reject tiebacks which lose more than five percent of proof load during 30-minute period.

C. Apply proof loads in increments of five tons at one-minute intervals and provide means to measure load application within accuracy of plus-or-minus five percent.

D. After reducing tieback load to design load, encase anchors in grout maintaining design load until anchors are fixed in place.

E. In transfer of loads from jacks to support system, use fixation method which will limit load loss to no more than five percent of design load.

F. Provide and maintain convenient access and appropriate means to accomplish these observations.

G. Preliminary And Creep Tests On Tiebacks:
1. Reapply proof loads equal to 140 percent of design load at each level of support in excavation on first installation on each side of excavation at horizontal intervals not exceeding 500 feet and wherever there is significant difference in soil in which tiebacks are installed.
2. As specified for proof loading, apply proof loads in increments of five tons at one-minute intervals. Provide means to measure load applications with an accuracy of plus-or-minus five percent of design load. Maintain proof load for 24 hours prior to reducing it to design load.
3. Make records of axial movement with incremental applications of load as well as amount and time of load fall-off with no pumping of jack or axial movement during 24-hour period that proof load on tieback is maintained. If during 24-hour period axial deformation of tieback system exceeds 0.02 inch or decrease in jack pressure without pumping is more than five percent after correcting for temperature changes during the test period, redesign tieback system to satisfy requirements.

H. Rock Bolts:
1. Tension rock bolts to their design load as approved to permit checking of each loading by the Engineer.
2. If grouted rock bolts are used, after loading has been approved, pressure-grout each permanent rock bolt in place using methods and equipment which will ensure elimination of air from bolt hole.
3. If fully resin-encapsulated bolts are used, use slow-setting resin to allow Engineer sufficient time to approve loading prior to gelation.

I. Vertical Support System With Tiebacks:
1. nstall piles or other vertical support system members incorporated in a system utilizing tiebacks so that they are capable of resisting vertical components of tieback loads without significant settlement during excavation and construction.
2. Install vertical support members so that settlements will not be caused by construction. In general, install members to be end bearing in stratum below maximum depth of excavation and capable of carrying total vertical loads without assistance of skin friction at depth of excavation.

3.05 LAGGING:

A. Unless otherwise shown or specified, provide timber lagging of three inches minimum thickness where it spans soldier piles placed at distances five to seven feet on centers and for excavation depths up to 25 feet. Increase minimum lagging thickness to four inches for excavation below 25 feet in depth.

B. For other conditions and types of lagging, submit design details for approval.

3.06 TRENCH EXCAVATION:

A. Perform sheeting, shoring and bracing for trench excavation for utility facilities and other purposes in accordance with specified safety requirements.

B. Provide sheeting, shoring and bracing for trench excavation in subgrade of subway excavation to prevent movement of main excavation support system.

3.07 SUPPORT OF EXCAVATION AT INTERFACES:

A. Design, construct, maintain and remove all or parts of support system at limits of the Contract at interface with the Authority's adjacent contracts, as may be necessitated by construction schedules and sequence of operations of respective contracts.

B. In the event excavation is commenced at an interface prior to the commencement of excavation on adjacent contract, design, construct and maintain end support system making provisions as follows:
   1. Install near face of cofferdam on line separating contracts. Allow no part of support system to project into the next contract except thickness of supporting wall, e.g. soldier piles and lagging, and tiebacks if approved.
   2. Provide support system adequate to support backfill and restoration loads with installation of a reasonable bracing system by adjacent contractor during excavation for his contract.
   3. Design and construct support system so that it will be supported against vertical settlement when adjacent contractor removes lower portion of the cofferdam to effect connection of structures at juncture of two contracts.

C. If excavation has commenced on adjacent contract at interface prior to excavation on this Contract, make provisions as follows:
   1. Coordinate removal of such portions of cofferdam which have been installed in adjacent contract and support and maintain remainder as necessary to effect juncture of contracts.

3.08 FIELD QUALITY CONTROL:

A. Tests:
   1. Where system of tiebacks or rock bolts is proposed in conjunction with or in lieu of struts, bracing and shores, undertake approved number of on-site tests to demonstrate adequacy of tiebacks or rock bolts for typical subsurface conditions.
   2. Conduct tests and obtain approval prior to use of tieback system for excavation support.
   3. The Engineer may furnish and install certain instruments to monitor performance of tieback or rock-bolt system.

B. Remove components of support system which inadvertently penetrate or encroach on permanent structure without endangering stability of support.

C. Welding: In accordance with Section 05120.

3.09 REMOVAL OF SUPPORTING SYSTEM:

A. When removing support of excavation system, wholly or in part, do not disturb or damage adjacent buildings, structures, construction or utility facilities. Fill voids immediately with lean concrete or with approved backfill compacted to density specified in Section 02320.

B. During strut removal stages, design soldier piles or slurry walls for increased vertical spacing of supports. For the removal of the first level support immediately above the invert slab, the slab can be considered a support for the soldier piles or slurry walls if it is poured directly against the sheeting and shoring and the invert slab is in place for at least 48 hours and is adequate to safely support the support of excavation, adjacent structures and the works. Leave support immediately above top of intermediate structure element, such as walls, slabs, or other horizontal members, until they are placed and are in place for at least seven days and are adequate to carry the loads from the support of excavation and other loads imposed on them. Leave support immediately above top of roof slabs of structure in place for at least seven days after placement of roof slab concrete.

C. Remove other supports above roof structure only after backfill has been placed and compacted to required density to within three feet of bottom of support.

D. Except as specified below, remove supporting system to a depth of six feet below surface. Remove supporting systems of intersections of streets and at temporary access ramps to a depth of eight feet.

E. Where top of Authority structure extends into six-foot or eight-foot limit, remove adjacent supporting systems to a depth flush with top of the Authority structure or one-foot below surface, whichever is greater. Increase removal depths where necessary to accomplish work in this Contract.

F. Remove material of supporting system from site immediately.

END OF SECTION

SECTION 02270

MAINTENANCE, SUPPORT AND RESTORATION OF UTILITY FACILITIES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies protecting, supporting, maintaining and reconstructing existing utility facilities affected by construction, including but not limited to the following:
   1. Storm, sanitary and combined sewer facilities.
   2. Water distribution and service
   3. Gas distribution and services.
   4. Electric light and power facilities and services.
   5. Telephone, telegraph and GSA communication facilities and services.
   6. Police and fire alarm systems.
   7. Traffic signals and street lighting, temporary and permanent.
   8. Steam distribution facilities.
   9. Parking meter installations.

B. Related Work Specified Elsewhere:

1.	Selective Demolition:	Section 02220.
2.	Grading, excavating and backfilling:	Section 02320.
3.	Dewatering:	Section 02240.
4.	Support of excavation:	Section 02260.
5.	Sanitary Sewer:	Section 02535.
6.	Storm Sewer:	Section 02635
7.	Water distribution system:	Section 02515.
8.	Ducts, manholes and handholes:	Section 02585.
9.	Removal and restoration of existing facilities:	Section 02205.
10.	Concrete reinforcement:	Section 03200.
11.	Concrete:	Sections 03100 and 03300.
12.	Decking:	Section 01530.

C. Work by Others:
   1. Gas distribution and services: Gas company will do its own work.

D. Definitions:
   1. 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.
   2. Utility: Company, agency, owner or operator of facility concerned.
   3. Abandoned: Use of facilities shown as existing has been discontinued by the owners and operators. Demolish or remove such facilities to extent they conflict with proposed work.
   4. To be abandoned: Particular facility will be removed from operation and/ or replaced by other facilities after written notice has been received that service is no longer required. Maintain service for as long as required, including temporary support, rerouting, substitution of temporary facility or other measures, as directed by the Engineer. Demolish or remove such facilities to extent they conflict with proposed work.
   5. Maintenance: Ensuring continuous and satisfactory service during construction.
   6. Proposed facility:
      a. New facility constructed and, if necessary, temporarily supported in place, by the Contractor.
      b. Temporary facility constructed, supported in place and ultimately removed and new facility constructed, by the Contractor.
      c. New facility constructed as part of rapid transit construction.

7. Temporary facility: Facility provided by the Contractor in lieu of existing or proposed facility, to ensure continuity of service.
8. Maintain complete-in-place: Support and maintenance in serviceable condition, of existing facilities during construction, which may include constructing permanent support, temporary support or other measures necessary to maintain continuous service of existing facility.
9. Expose and maintain existing cables and replace ducts and manholes: Remove existing duct and manhole structures, construct temporary manholes, place existing cables in split conduits and replace spare ducts with whole conduit. Maintain this system during construction. Reconstruct permanent concrete manholes and encase conduits in concrete as specified. Cables for electric power and telephone facilities shall be exposed, separated and supported under supervision of electric power and telephone companies.
10. Maintain service and replace:
    a. Construct new facility in same location and support it in place.
    b. Provide temporary facility and ultimately remove it, and construct permanent replacement facility in its original location.
    c. Temporarily support original facility and ultimately replace it with new facility.
11. Remove and replace: Remove existing facility without providing temporary replacement and reconstruct new facility in same location during execution of contract.
12. Local Jurisdictional Authority: Agency responsible for acceptance and approval of work on storm, sanitary and water distribution facilities.
13. Salvage: Remove and store material and equipment for reuse in this or other Authority contracts.

1.02 SUBMITTALS

A. Schedule of Work on Utility Facilities:
1. Submit to the Utilities and the Engineer a detailed sequence of work, with starting and ending dates for each interruption of utility services, and method of coordination for shutoff, capping and continuation of utility services.
2. Give notice at least two weeks prior to date of intended commencement of operations to parties having surface, subsurface or overhead structures in the construction area.Provide copies of notices to the Engineer.
3. Do not commence work until written approval has been received from the Utility and the Engineer.

B. Record Documents:
1. Show actual location of existing facilities, interference which these facilities present to new work, proposed method of proceeding with actual construction and details of proposed support systems.
2. Show actual location of settlement measurement points for facilities as indicated on the drawings. Submit copies of readings and measurements within 24 hours after such readings are taken.
3. Prior to construction, submit two copies of records of inspection of sewers, one copy to local jurisdictional authority and one copy to the Engineer. On completion of tunneling and cut-and-cover and prior to paving or other construction over sewers, submit to local jurisdictional authority and the Engineer one copy each of the inspection records of sewers, including video-tape records of television inspections and coordinated logs, photographs and other records as specified by local jurisdictional authority for visual walk-through inspections. Obtain and submit a written approval and acceptance from local jurisdictional authority of the inspection records of preconstruction and post-construction conditions of affected storm and sanitary sewers.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, and Standards: Comply with codes and regulations of the jurisdictional authorities, published standards of owning utility agency, and ASTM: C136.

B. Inspection Of Sewers:
   1. Employ a sewer inspection company which has been regularly engaged in television sewer inspections and which is acceptable to local jurisdictional authority to perform preconstruction and post-construction inspections of sewers 36 inches and smaller in diameter. Submit to Local jurisdictional authority for prior approval one sample of the cassettes to be used.
   2. Conduct preconstruction and post-construction inspections under conditions as nearly identical as practical and using the same company.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Coordinate with utilities who are furnishing materials for the work to determine availability, locations and required methods of storage and care of materials prior to incorporation into the work.

B. Transport store and handle materials in accordance with the requirements of the utilities.

1.05 PROJECT CONDITIONS:

A. Existing Facilities:
   1. Locations of existing facilities shown are plotted from available records; however, these locations are not guaranteed.
   2. Verify by field investigation and “Miss Utility” utility locating service, locations of facilities within and adjacent to limits of project which may be affected by construction operations. Avoid damage or disruption of facilities during operation.
   3. Upon encountering existing facility which is not shown or upon ascertaining that facility differs from that shown, determine ownership, use and disposition of such facility and proceed as follows:
      a. If facility is abandoned or is to be abandoned, perform necessary work for either condition as specified.
      b. If facility is to remain in service, perform support and restoration work in accordance with these Specifications and the CHANGES article of the General Provisions.

B. Temporary Service:
   1. Do not interrupt facility service to building connections unless permitted in writing by Engineer, and then only after arranging to provide temporary service as required..
   2. Notify the Engineer and the Utility of damage to facilities caused by construction operations. Repair such damage, except that damaged cables will be repaired or replaced only by the Utility.
   3. Provide access for inspection of facilities and for emergencies involving utility services as specified in Section 01530.
   4. Permit free and clear access to utility personnel for purposes of inspection, maintenance, providing additional service and construction of new facilities.
   5. When approved working or shop drawings show temporary facility provided for the Contractor's benefit, supply necessary materials and perform necessary work.
   6. Pay utility directly if, as an aid to the Contractor's construction, the utility performs work not shown.
   7. Items supplied by the utility companies are as listed and as shown.

1.06 Coordination:

A. Establish through the Engineer direct and continuous contact with respective utilities and cooperate with them in all phases of the work.

B. ontact utility early enough to allow them sufficient time to accomplish the work. Give special consideration to lead times required for cable work. Provide schedule of utility relocation to the utility to permit coordination with Authority's construction sequence.

C. To locate buried telephone cables, call the local telephone company's Buried Cable Location Service at least 48 hours prior to starting excavation.

D. Comply with printed standards and practices of utilities available from the Engineer.

E. Aerial facilities shown to be relocated by others will be relocated by facility owner. The Contractor is responsible for coordinating relocation work with utility owner as far as possible in advance of required time of relocation. A minimum three-month lead time is required by utility owner when facility serves only one utility. When facility to be relocated is shared by more than one utility agency or when a street light is included in the relocation, a minimum four-month lead time is required

PART - PRODUCTS
2.01 MATERIALS:

A. Refer to individual Division 2 Storm, Combined And Sanitary Sewer, Water Distribution and Services, Ducts and Manholes Sections for pipe, tubing, fittings and appurtenances, and for joining and installation methods.

B. Refer to individual Division 3 Concrete and Reinforcement Sections for materials and installation methods.

C. Sand Backfill Around High Voltage Conduits And Pipes:
1. Thermal Resistivity Value (RHO) of not more than 70 and the following sieve analysis when tested in accordance with ASTM C136:

Sieve Size	Percent Passing
4	94 - 100
8	80 - 90
16	60 - 80
30	35 - 60
50	31 - 35
100	3 - 13
200	1 - 5

2. The power company, through the Engineer, will inform the Contractor of approved sources for this material.

PART 3 - EXECUTION
3.01 Salvage:

A. Salvage and clean material shown to be salvaged.

B. Maintain adequate records and storage facilities for salvaged items as specified in the General Requirements. Make available for inspection a detailed record including signed vouchers and receipts.

C. Reuse salvaged items after inspection and approval for reuse has been given by the Utility

D. Return salvaged materials which are not reused to the Utility.

3.02 SETTLEMENT OR MOVEMENT:

A. Where settlement or movement monitoring system is shown, comply with the following:
   1. Provide series of settlement measurement points along each facility and make regular readings to detect movements.
   2. Use approved painted marks, metal marker plugs or pins as settlement measurement points.
   3. Prior to subsurface work, make initial survey to establish elevations of installed settlement measurement points utilizing permanent, established bench marks outside 100-foot line.
   4. Take readings weekly on settlement points until completion of this Contract. Take readings daily during work which may affect facilities.
   5. Make readings to an accuracy of 0.01 foot.
   6. Take immediate remedial measures to correct conditions causing settlement or other movement and to repair damages thus caused.

3.03 EXCAVATION AND BACKFILLING OF UTILITY TRENCHES:

A. Excavate and backfill utility facility trenches in accordance with Sections 02320, 02240 and 02260.

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

3.04 SURFACE RESTORATION:

A. Remove pavements, sidewalks, lawns, landscaping , curbs and gutters where necessitated by utility trenches in accordance with Section 02220.

B. Replace pavements, sidewalks, curbs and gutters in accordance with Section 02205.

C. Place temporary pavements where necessitated by sequence of operations.

D. Replace lawns and landscaping in accordance with Sections 02920 and 02930.

E. Provide erosion control measures to prevent erosion or displacement of soils and discharge of sediment bearing water or airborne dust from the site.

3.05 UNSAFE AND UNSUITABLE UTILITY STRUCTURES:

A. General Requirements:
   1. If upon exposure, condition or location of facility to be supported in place is found to be unsafe for maintenance or support, replace or reconstruct facility as required after receiving prior approval of the Engineer and Utility Owner.
   2. Maintain continuity of existing utility facilities. Protect, support, relocate and reconstruct such facilities, regardless of jurisdictional control.

B. Electric, Communication and Similar Type Facilities:
   1. If structures containing electrical, communication and similar types of cables shown to be maintained complete in place are found upon exposure to be incapable of being maintained in place because of condition, location or both, replace such structures with timber enclosures or split ducts after prior approval of the Engineer and the utility owner.
   2. When service box, manhole or conduit structure containing electrical or communication cables is broken away, replace it immediately with temporary structure having facilities for racking and supporting cables equivalent to existing facilities.

3. Exercise care when working in vicinity of telephone structures containing coaxial cable which cannot withstand movement.
4. Give timber enclosures one interior and one exterior coat of fire-retardant paint of type specified by owners and operators.
5. Replace temporary timber enclosures with permanent structures in accordance with details shown and restore facilities to the satisfaction of the Engineer and utilities prior to completion of work. Remove materials of temporary nature after completion of permanent installation.

C. Procedures for payment of costs of work on unsafe and unsuitable utility structures are governed by the CHANGES article of the General Provisions.

END OF SECTION

SECTION 02291

GEOTECHNICAL INSTRUMENTATION

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the design, installation, maintenance, and removal of geotechnical instrumentation to monitor soil, rock, and structure movements during construction. This section also includes specifications for reading, analyzing, and reporting instrumentation monitoring results.

B. Design Criteria:
   1. Provide a system of geotechnical instrumentation which will allow monitoring of soil, rock, and excavation support elements, as well as adjacent structures and utilities to ensure safety and stability, confirm design assumptions, and provide a basis for establishing compliance with Contract requirements.

C. Definitions:
   1. Geotechnical Instrumentation - Any device designed to determine change in the position or state of stress of soil, rock, and structures.
   2. Instrument Monitoring - The procurement of data obtained from the repeated optical, mechanical, or electronic observations of geotechnical instruments.
   3. Frequency of Monitoring - The number of readings obtained from a geotechnical instrument with respect to time.
   4. Initial reading- The first stable reading set obtained after instrument installation, but prior to excavation, to which all subsequent readings will be compared.
   5. Threshold Limit Values Level 1 and Level 2 - Designer-specified limits for geotechnical instrumentation which if exceeded require (1) notification of the Authority and increased monitoring frequency and (2) implementation of the contingency plan.

1.02 QUALITY ASSURANCE:

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

B. Permits - Prior to instrumentation installation obtain any permits from the responsible jurisdiction and pay permit costs and any associated fees at no additional cost to the Authority.

C. Qualifications of Personnel:
   1. Instrumentation Selection, Design, Layout, and Data Analysis shall be performed by a registered Professional Engineer specializing in geotechnical engineering with 5 years experience in soil stability and geotechnical design
   2. Instrumentation installation shall be performed under the supervision of qualified technicians with at least one year experience in the installation of instruments of the type specified.
   3. Instrumentation monitoring shall be performed by qualified technicians with at least one year experience in the reading of instruments of the type specified.

D. Continuously maintain all geotechnical instrumentation in proper working condition and within manufacturer's specifications. Immediately repair or replace malfunctioning equipment. All instrumentation readout devices to be periodically tested and recalibrated within schedule as recommended by the instrument manufacturer or as approved by the Authority..

1.03 SUBMITTALS:

A. Submit the following for approval prior to proceeding with work:
   1. Type of instrumentation system proposed, showing arrangement, location and depths of proposed system.
   2. Manufacturer's literature including descriptions and installation recommendations for all instruments, software, and read-out devices proposed for use.
   3. Instrumentation installation schedule and monitoring schedule.
   4. Resumes listing the qualifications of the Professional Engineer and Technicians specified in 1.02.C.

B. Instrument Installation Data:
   1. Record of installation details including date and time of installation, general soil condition at instrument site, adjacent construction activities, and remarks of unusual conditions observed during installation.
   2. As-built location and elevation of installed instruments including coordinates and distance referenced to Outbound track centerline. Supply location data within 48 hours of instrument installation.

C. Instrumentation Monitoring Data:
   1. Analyzed data to be submitted on forms approved by the Authority within 48 hours after instrument monitoring. Supply copies of field notes if requested.
   2. Immediately report to the Authority movements exceeding Level 1 limits.
   3. Shift Reports of Construction Activities:
      a. For each shift in which work is taking place, submit a report within 24 hours containing the following:
         1) Detailed excavation and tunneling status at time of instrument reading.
         2) Excavation subgrade elevation and tunnel face station at time of instrument reading.
         3) Incidents of ground loss, groundwater flow, excavation support instability, or any other unusual event.
         4) General construction activity in the vicinity of the instruments.
         5) Duration and cause of delays to construction activities.
         6) Weather conditions.

D. Contingency Plans:
   1. Submit contingency plans to stabilize soil, rock, and structures affected by adverse movements detected by instrumentation. Submit contingency plans at least one month prior to start of excavation or tunneling. At a minimum, include the following:
      a. Names, telephone numbers, and locations of persons responsible for implementation of contingency plans.
      b. Materials and equipment required to implement contingency plans.
      c. Location onsite of all required materials and equipment to implement contingency plans.
      d. Step-by-step procedure for performing work involved in implementation of the contingency plans.
      e. Threshold limit Level 1 and Level 2 values for all instruments.
      f. Clear identification of objectives of contingency plans and methods to measure plan success.

1.04 JOB CONDITIONS:

A. Do not disclose to third parties or publish monitoring data without the approval of the Authority.

B. The Authority may monitor any geotechnical instrument at any time. Provide and facilitate access to instruments for the Authority.

C. The instrumentation monitoring data shall be continuously reviewed and interpreted by the responsible instrumentation specialist.

D. During construction, additional instrumentation may be required beyond that proposed in the initial design. Modifications to the instrumentation plan, including proposed instrument locations, may be required due to site conditions and instrumentation results.

E. Ensure that all instrumentation installations are continuously protected and are not damaged by construction activities, including blasting. Replace or repair as necessary any instrument damaged by construction activities or adverse soil, rock, or structure movement.

PART 2- PRODUCTS

2.01 INSTRUMENT TYPES:

A. Specify instrument types and locations in accordance with design criteria indicated in Section 1.01 B.1. and as approved by the Authority.

PART 3 - EXECUTION

3.01 INSTRUMENT INSTALLATION SCHEDULE:

A. Install and obtain initial readings for all surface instrumentation prior to excavation, chemical grout operations, or dewatering activities, in accordance with approved schedule. In areas to receive chemical grout, delay installation of instruments which might be damaged by chemical grout until completion of this activity.

B. For all instrumentation located within excavated areas, install and obtain initial reading as soon as practical after excavation or passage of tunnel heading in accordance with approved schedule.

3.02 INSTRUMENT LOCATIONS:

A. Install instruments as close as practical to locations submitted and approved. Actual conditions in field may require location adjustment. Obtain Authority approval for location adjustments.

B. After instrument installation, submit reports showing location and installation details of each instrument as specified in Section 1.03.B.

C. Ensure that all proposed instrument locations will not result in damage to utilities or other structures. Coordinate proposed instrument locations with Miss Utility and any other affected owners prior to instrument installation.

3.03 INSTRUMENTATION MONITORING:

A. Initial Reading:
   1. At time of initial reading, verify that instrument is functioning and has been installed in accordance with contract specifications and manufacturer's recommendations.
   2. Replace at no additional cost to the Authority any instrument which does not meet specification requirements.

3. Obtain at least three separate and complete sets of initial readings on each instrument which yield consistent results.
4. Should inconsistent initial readings be obtained on any instrument, reread until correct and repeatable readings are obtained.

B. Monitoring Frequency:
1. Monitoring frequency to be in accordance with schedule submitted and approved as specified in Section 1.3 A.3.
2. Instrument readings which show significant change from previous readings shall be reread immediately.

C. Instrumentation Monitoring Threshold Values:
1. Instrumentation system design shall establish threshold limit values for each instrument.
a. Level 1 Limit values if exceeded require notification of the Authority within 24 hours and notification of individuals listed within the contingency plan. Monitoring frequency of affected instruments which exceed Level 1 limit will be increased to frequency as approved within the contingency plan.
b. Level 2 limit values if exceeded require immediate notification of the Authority and implementation of the contingency plan. Instruments which exceed Level II limits will be monitored continuously until stability is achieved.

3.04 INSTRUMENT PROTECTION, MAINTENANCE, AND REPLACEMENT:

A. Protect and maintain instruments. Divert surface water from instrument covers. Flush debris from instrument installations. Maintain access to all instruments.

B. Provide barriers as required to protect instrument.

C. Install and maintain instruments and instrument access covers in a manner which protects workers and ensures public safety.

D. Repair or replace damaged instruments within 5 days at no additional cost to the Authority.

3.05 REMOVAL OF INSTRUMENTS:

A. Prior to final acceptance of work and subject to Authority approval, remove and dispose of all instrumentation.
1. Remove surface instrument installations to 2 feet below ground surface. Backfill voids and casing with cement grout.
2. Restore ground surface to original condition.

B. Fill holes in masonry with portland cement mortar. Restore structure surfaces to original condition.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY THE DESIGNER.

ENDNOTES:

1. The Designer must specify the level 1 and 2 threshold values before finalizing the contract-specific specifications.

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. Removal of existing construction and facilities: Section 02220.
2. Clearing and grubbing: Section 02230.
3. Dewatering: Section 02240.
4. Support of excavation: Section 02260.
5. Underpinning, support and restoration of structures: Section 02255.
6. Maintenance, support and restoration of utility facilities: Section 02270.
7. Rock tunneling: Section 02410.
8. Earth tunneling: Section 02415.
9. Rock reinforcement: Section 02420.

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.

B. Salvage:
1. Materials shown to be salvaged in accordance with Section 02205 and the General Requirements.

1.02 SUBMITTALS:

A. 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.
   b. Blasting plan:
      1) Submit a blasting plan in accordance with Section 02410.
   c. Plan for tunneling or jacking of utility facilities:
      1) Prior to tunneling, submit a tunneling plan.
         (a) Include in the plan the location of the facility, the method of construction, the types of equipment and the procedures proposed.
         (b) Procedure for field determination of soil bearing capacity, including description of the equipment to be used, and any calibration curves for the various soil types to be encountered, details of field test procedures, forms for reporting of test data/results and details of minimum number of tests required for each footing/base area

3. Certification:
   a. With samples of materials proposed for fill, backfill and embankment, submitcertified test reports of tests performed by an approved Independent Testing Agency for all tests required to demonstrate compliance with specified requirements.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AASHTO: M147.
   3. ASTM: C33, D75 , D698, D2487, D2922, D3017, D4318.

1.04 JOB CONDITIONS:

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

C. Blasting:
   1. Control blasting in accordance with Section 02410.
   2. Exercise care in drilling and blasting operations so that the remaining rock remains stable and overbreak is minimized. Use controlled blasting in areas where concrete for walls and arches of structures is to be placed against rock.

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

E. 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.

F. 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.

G. Ramps:
   1. Construct temporary ramps as necessary to provide access to work area.
   2. Locate such access ramps in Contractor's storage, operations and access areas or within excavation for subway structure and maintain traffic as specified.
   3. Support ramp excavation in accordance with Section 02260.
   4. When ramps are in use, station flag persons equipped with red flags at ramp entrances to keep unauthorized vehicles or persons from entering work area.
   5. When work necessitating entrance or exit of vehicles via ramps is not being performed, protect entrances and exits of ramps by warning signs, barricades and fences in accordance with the General Requirements.
   6. Upon completion of the work needing ramps, remove the ramps in accordance with Section 02260; backfill excavated ramp areas, if necessary.

H. Excavation Near Buildings:
   1. Control excavation in areas near buildings or structures to maintain stability of buildings or structures. If underpinning is necessary, perform excavation work in accordance with Section 02255, so that condition of surrounding area remains unimpaired.

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:

THIS SPACE NOT USED.

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. Support sides of excavation as specified in Section 02260.

D. Protect, support and maintain utility facilities as specified in Section 02270.

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

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

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

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

I. 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.

3.03 ROCK EXCAVATION:

A. Perform rock excavation to neat lines shown and so as to produce surfaces free of loose rock.

B. Install rock reinforcement in accordance with Section 02420.

C. Remove loose, semi-detached and unsound fragments from blasted surfaces. Remove standing water, debris, oil and other objectionable coatings from surfaces of rock upon or against which concrete or porous fill material is to be placed.

D. Repair shattered or loosened rock surfaces outside neat lines shown, which in the opinion of the Engineer would be detrimental to subway structure or would adversely affect subway drainage system.

E. Where directed, grout rock surfaces which have not been shattered but are naturally permeable.

F. Remove excavated rock to approved fill locations or disposal locations.

G. Fill excess excavation with concrete or other approved material.

H. If flowing or seeping water is encountered during excavation, install approved drainage system in accordance with Section 02240.

3.04 REMOVAL OF SUBSURFACE OBSTRUCTIONS:

A. Permanent Closure walls:

B. Prior to removal of parts of vaults or areaways which extend into Contract limits, build permanent closure walls where shown in such vaults or areaways to separate areas to be left intact from areas to be removed.
   1. Obtain the Engineer’s approval of permanent closure wall design prior to its installation.

C. Remove vaults, areaways and foundation walls as shown.

3.05 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. Leave struts, braces, lagging and timber sheathing in place as long as needed to support excavation and adjacent facilities and structures.

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

G. Do not place backfill on subway structures until requirements for curing and waterproofing have been complied with and, if required, until test cylinders for particular structure indicate that concrete has attained specified compressive strength.

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

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

J. 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.

K. Prior to placing embankment against slope greater than one vertical to four horizontal, cut benches into existing slope. Height of bench not to exceed two feet unless otherwise approved.

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

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

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

3.06 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.

3.07 EXCAVATION OF UNSUITABLE MATERIALS:

A. Remove unsuitable materials from the site.

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

3.08 PREPARATION OF GROUND AS SUBGRADE:

A. 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.

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

3.09 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 ASTMD2922 and ASTM D3017 respectively, or other test methods acceptable to the Engineer.

3.10 TUNNELING FOR OR JACKING OF UTILITY FACILITIES:

A. Location of facility, method of construction, type of equipment and procedures: As approved.

3.11 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 02410

ROCK TUNNELING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the following:
   1. Rock tunneling for running sections, stations, pilot drifts through stations, side drifts, crossover and transition sections, vaults, adits, auxiliary tunnels, escalator ways and cross-passages.
   2. Tunnel linings.

B. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Dewatering: Section 02240.
   3. Subway drainage system: Section 02625.
   4. Earth tunneling: Section 02415.
   5. Rock reinforcement: Section 02420.
   6. Drilling and pressure grouting for rock tunnels: Section 02431.
   7. NATM excavation (rock): Section 02411.
   8. Concrete work: Sections 03100, 03200 and 03300.
   9. Shotcrete: Section 03370.
   10. Structural steel: Section 05120.
   11. Epoxy injection: Section 07125.
   12. Bentonite slurry: Section 07170.
   13. Piping systems: Section 15205. *1

C. Definitions:
   1. Rock tunneling: Excavation of natural rock, which requires use of rock excavation methods, such as drilling and blasting, channeling, wedging or barring, or rock tunneling machines.
   2. Controlled blasting: Excavation of rock in which the various elements of the blast, i.e., hole size, depth, spacing, burden, charge size, distribution, delay sequence, are carefully balanced and controlled to provide a distribution of charge which will excavate rock to required contours with smooth surface to minimize overbreak, stressing and fracturing of the rock beyond the contour line. Smooth-wall blasting, presplitting, cushion blasting and line drilling are examples of operations included in the term controlled blasting.
   3. Initial support:
      a. Elements designed, furnished and installed by the Contractor for stability and safety during construction and not shown.
      b. To the extent elements of permanent lining shown are effective in providing initial support, such elements may be utilized to provide initial support. If permanent lining must be augmented by initial support to ensure stability and safety during construction, provide elements of such initial support.
      c. Elements of initial support may be in the form of additional rock bolts, shotcrete, plain concrete, reinforced concrete, timber or steel members which may be temporary or permanent if compatible with permanent lining shown. Plain or reinforced concrete may consist of elements such as wall girders, carrier beams or supplementary foot blocks for temporary posting. Timber may consist of elements such as posts, struts and cross beams. Steel members may consist of such elements as steel sets, straps, spiling,

crown bars, carrier beams, girders, brackets, posts, struts, shores or needle beams. Design and provide these or other alternative elements, singly or in combination, to ensure stability and safety during construction. Install initial support to transfer loads to rock so as to ensure stability and safety during construction.

4. Permanent lining: Tunnel lining elements and support as shown.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. Appendix G of the General Requirements: Geotechnical Design Report.
   3. MS: MIL-P-26915 (USAF).
   4. ASTM: C171, D638, D1304. *2
   5. ASTM: C171, D638, D1304, D1785, D2464, D2564. *3

B. Blasting Consultant:
   1. Engage the services of approved, qualified independent, professional blasting consultant to design, review, evaluate and modify blasting operations.

C. Allowable Tolerances:
   1. Steel rib bending tolerance:
      a. Conformance to true template:
         1) Wide-flange sections up to 14 inches deep weighing 150 pounds per foot: Rib segments to conform to true template at butt plates; intermediate points may depart from true template up to 3/8 inch, providing no point departs more than 1/8 inch from three-foot template section.
         2) Wide flange sections heavier than 150 pounds per foot: Intermediate departure not exceeding 5/8 inch from true template; deviation from three-foot template section not exceeding 3/16 inch.
      b. Bending curvature uniform.
      c. After bending:
         1) Outer flange will be permitted to droop 1/8-inch maximum toward inner flange for radii of bend equal to or greater than 14 times rib depth; 1/4-inch maximum droop will be permitted for radii of bend which are less than 14 times rib depth.
         2) Rib depth at not less than theoretical depth minus 1/4 inch.
   2. Steel rib fabrication tolerances:
      a. Chord, out-to-out of butt, foot plates or both measured on centerline of rib: Theoretical length plus-or-minus 1/16 inch.
      b. Face of butt or foot plates: Within plus-or-minus 1/16 inch of theoretical plane.
      c. Gap between ends of ribs and butt or foot plates prior to welding not exceeding 1/16 inch for at least 75 percent of cross sectional area of rib. Where gaps are in excess of 1/16 inch, fill by additional steel-shim welding.
      d. Tie rod holes in rib webs: Within plus-or-minus 3/8 inch of locations shown on approved shop drawings.
      e. Width or length of sheared plates: Within theoretical dimension plus-or-minus 1/8 inch.
      f. Center-to-center of bolt hole dimensions on butt or splice plates: Theoretical dimension plus-or-minus 3/64 inch.

g. Bolt hole groups in butt or splice plates after fabrication: Within plus-or-minus 1/16 inch of theoretical location regardless of variations in rib resulting from other tolerances.

h. Holes in butt plates welded to ribs: Within plus-or-minus 1/16 inch of theoretical location.

3. Precast-concrete segment tolerances: As shown.

4. Watertightness criteria: Section 03300.

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. Prior to using tunneling machines, submit drawings showing design, specification, method of operation and other pertinent data.

1) Drawings and pertinent data for shielded tunnel-boring machine (TBM). Show dust-suppression system. If precast-concrete tunnel-lining segments are used, show the following:

(a) That machine can develop forward thrust independently of installed precast-concrete tunnel lining, if this lining is to be used.

(b) That machine is equipped to handle and erect precast-concrete segments behind cutter head within tail shield, including auxiliary equipment necessary for erection.

(c) Descriptions, data or calculations of proposed facilities, equipment to be utilized and method of construction. Items include, but are not limited to, the following: Hoisting plant, tunnel ventilation, lighting and drainage; groundwater-control methods; temporary shafts, cuts, ramps and tunnels; breakouts; cross passages; bulkheads; details of initial support; details of placing concrete and erection procedures for the installation of precast-concrete tunnel lining.

b. For excavation of tunnels and stations, submit drawings, calculations, descriptions and specifications for the following:

1) Number, size, location, orientation and direction of excavation of drifts and benches including those excavated previously and temporary drifts.

2) Sequence and timing of excavating drifts and benches including stagger of advance of heading in adjacent drifts or benches and anticipated rate of advance.

3) Blasting program including length of round and charge distribution for each drift.

4) Initial support elements, including when and where they will be installed in relation to excavation plan and sequence and design calculation and assumptions.

5) Permanent lining elements relationship to initial support elements and to the plan and sequence of excavation and support.

6) Construction equipment and capacities.

7) Assumptions used in arriving at above items, including:

(a) Thickness and condition of various zones of rock, decomposed rock and overburden.

(b) Incidence, orientation and extent of rock discontinuities including foliation, joints, shears, fractures, faulting, folding,

depth and degree of weathering, condition of discontinuities (open, tightly closed, gouge-filled).

(c) Relationship of excavation and initial support to rock discontinuities.

(d) Design load conditions and design mechanical properties of rock and discontinuities used for determining initial support requirements.

(e) Stability of sidewall and vertical rock faces with respect to excavation dimensions, sequence and rock discontinuities.

(f) Groundwater.

2. Certification:

a. Certified test report of properties of electrical insulative coating.

3. Documentation:

a. Blasting plan:

1) Not less than 30 days prior to starting a new phase of work, submit the following data concerning proposed blasting operations:

2) Location, depth, area, anticipated neat lines and relationship to adjacent excavations and structures.

3) Diameter, spacing, burden, depth, pattern and inclination of blast holes.

4) Type, strength, amount in terms of weight and cartridges of explosives to be used in each hole, on each delay and total for each blast.

5) Distribution of charge in each hole and priming of each hole.

6) Type, sequence and number of delays, delay pattern; wiring diagram for blast; size and type of hookup lines, and lead lines; type and capacity of firing source; type, size and location of safety switches, lightning gaps.

7) Scaled range or distance used to calculate scaled range if blast will exceed vibration limits.

8) Stemming of holes and matting or covering of blast area.

9) Qualifications of person directly responsible for supervising loading of shot and for firing it.

10) Complete, maintain and submit permanent blast reports including logs of each blast. Complete reports after each blast to include the following:

(a) Date, time and limits of blast by station.

(b) Amount of explosives used by weight and number of cartridges.

(c) Total number of delays used and number of holes used for each delay period.

(d) On a diagram of approved blast pattern indicate each hole not drilled, drilled but not loaded, changes in spacing or in pattern of delays or in loading of holes.

(e) Total number of holes, maximum charge per hole and corresponding delay number.

(f) Evaluation of blast indicating tights, areas of significant overbreak and recommended adjustments for next blast.

b. Permits for disposal of excavated material:

1) Arrange for disposal of excavated materials at locations outside the Authority's right-of-way, and obtain written permits from owners of property where excavated material will be deposited.

2) Submit each permit and release from each property owner absolving the Authority from responsibility in connection with disposal of such material.
3) Details of temporary ventilation:
4) In the event it is planned to use equipment not covered by the SAFETY REQUIREMENTS article of the General Requirements, submit details of such equipment.
5) Approval of the use of alternative equipment will depend on submitted research information concerning performance in accordance with applicable standards in common use.

a. Air-quality reports:
b. Daily reports of tests for dust, toxic and hazardous gases and other atmospheric impurities in the working environment during construction.
c. Leak repair work plan:
1) Include proposed application methods, equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.
2) Submit prior to beginning leak repair work.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Formwork: Section 03100.

B. Reinforcing Steel: Section 03200.

C. Concrete: Section 03300, Class 3500; Class 2500 concrete backfill where specified for rock trench for track drain.

D. Contact Grouting: Section 02431.

E. Structural Steel, Ribs, Beams, Channels and Plates: Section 05120.

F. Bolts: ASTM A325, unless otherwise shown or specified.

G. Timber for Blocking, Lagging, Foot Blocks and Cribbing: Sound, well-seasoned, hardwood timber of rectangular cross section.

H. Track Drainage: Section 02625.

I. Porous Subgrade Material: Section 02625.

J. Pea Gravel: Smooth, rounded pieces of gravel, clean and free from objectionable materials such as soft particles, coal and lignite particles or friable particles, graded from 1/4 to 3/8 inch in size.

K. Sand: Section 03300, fine aggregate, except 100-percent passing U.S. Standard Sieve Size 16.

L. Precast Concrete Tunnel Lining Segments: Section 02425.

M. Impervious Membrane: Polyethylene, ASTM C171, clear or opaque, 0.006-inch thickness.

N. Epoxy Injection Material: Section 07125.

O. Bentonite Slurry for Repair of Leaks: Section 07170.

P. Epoxy Mortar:
1. Two-component, solventless epoxy-resin system, with 100-percent solids, workable in temperature range of 50F to 60F when mixed with sand in specified proportions.
2. Epoxy-resin system: FX-775, Fox Industries, Incorporated; Sikadur 31, Hi-Mod Gel, Sika Chemical Corporation or approved equal.
3. Sand for use with epoxy resin: Three parts No. 16 sand to one part No. 90 sand. High-silica type, dry and bagged.
4. Add sand to epoxy paste as necessary to provide best workability characteristics up to one part sand per one part epoxy.

Q. Electrical Insulative Coating: Approved moisture-insensitive coating, 100-percent solids, containing no solvents for use on dry or damp concrete or steel surfaces, with the following additional requirements:
1. Properties:
a. Minimum tensile strength: ASTM D638, 5,000 psi in 14 days.
b. Dielectric strength: ASTM D1304, 440-465 volts per mil.
c. Dielectric constant: ASTM D1304 as follows:
1) 60 Hertz: 3.4-3.5.
2) 1,000 Hertz: 3.3-3.4.
d. Power factor: ASTM D1304 as follows:
1) 60 Hertz: 0.006-0.007.
2) 1,000 Hertz: 0.03-0.04.
e. Viscosity: 6,000 centipoises plus-or-minus 1,000 centipoises, as determined by Brookfield Viscometer using No. 6 spindle at 50 rpm.
2. Primer: Zinc-rich primer, MS MIL-P-26915 (USAF) Type 1, Class B.

R. Hydrostatic-Pressure Relief System: *4
1. Plastic pipe: PVC, Schedule 40, ASTM D1785.
2. Plastic fittings: PVC, Schedule 40, ASTM D2464.
3. Solvent cement: ASTM D2564.
4. Galvanized steel pipe and fittings: Section 15205.

2.02 FABRICATION:

A. Fabricate steel supports in accordance with Section 05120.

B. The following operations are not required:
1. Portions of bearing members such as butt and foot plates, straightened, planed and connected after fabrication.
2. Grinding to remove nicks resulting from flame-cutting.
3. Planing and facing of sheared edges or bearing surfaces.
4. Subpunching or subdrilling of bolt holes.
5. Inspection of groove and fillet welds by other than visual inspection.

PART 3 - EXECUTION

3.01 TEMPORARY VENTILATION:

A. Provide, operate and maintain for duration of project temporary ventilation system which conforms to specified safety requirements and those of jurisdictional authorities. Remove system from site when work is completed.

3.02 SAFETY REQUIREMENTS:

A. Perform work so as to minimize safety hazards and exposure of men and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.

B. In case of emergency or work stoppage likely to endanger excavation or adjacent structures, continuously maintain full work force 24 hours per day including weekends and holidays until emergency or hazardous conditions no longer jeopardize stability and safety of the work.

3.03 DISTANCE BETWEEN HEADINGS:

A. Maintain longitudinal distance of no less than 150 feet between two adjacent tunnel faces being simultaneously excavated unless otherwise shown or approved in writing.

B. Where tunnel heading is being advanced adjacent to previously excavated tunnel, ensure that initial support in first tunnel is completely installed and is adequate to withstand construction of second tunnel.

3.04 DETECTION OF MOVEMENT:

A. In accordance with the General Requirements and as shown, install, maintain and make observations of a system of detection of vertical and horizontal movement of ground, tunnel support, permanent lining and utilities adjacent to the work.

B. Special Instruments:
   1. Provide instrumentation as specified and where shown.
   2. Provide such facilities as directed for monitoring these instruments and take appropriate action to arrest movement revealed by resulting observations.

3.05 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
   1. Excavate to accommodate tunnel cross section and minimum thickness of lining selected to within one inch of alignment and grade shown.
   2. When steel ribs are used for initial support, do not permit any portion of lagging except clips or bolts used to attach lagging to ribs to extend into tunnel within concrete design line as shown nor any portion of steel rib including bracing to extend further than three inches into concrete design line.
   3. Place cast-in-place tunnel concrete to the following tolerances:
      a. Tunnel lining:
         1) Departure of tunnel from line or grade shown as measured from working point of tunnel: One inch.
         2) Variation in thickness of lining at any point: Minus zero inch.
         3) Variation in internal diameter at any point: One inch.
      b. Invert: As specified in Section 03300.
      c. Safety walk: As specified in Section 03300.
   4. Install precast concrete segment lining to tolerances shown.

3.06 EXCAVATION:

A. Excavate to lines, grades, dimensions and tolerances as shown and specified to accommodate initial support and permanent lining.

B. Tunneling Machine:

1. When excavating with tunneling machine, use equipment which includes dust-control system with spray system and dust shroud. Keep intake end of fan suction line as close to machine as possible without interfering with other operations.
2. Use equipment which permits installation of initial support no further than ten feet from tail. Use hood if necessary. Install initial support in accordance with approved working drawings.
3. In order to exercise option for using circular permanent lining comprised of precast segments, excavate tunnel and erect the segments by means of TBM. If, during machine boring, material is encountered in reaches of tunnel that cannot be excavated satisfactorily by TBM, excavate such reaches by other approved methods. Provide necessary initial support and cast-in-place concrete permanent lining as shown for such conditions.

C. Air Quality:

1. Perform drilling and tunneling operations by methods and with equipment which will positively control dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities in accordance with specified safety requirements.
2. Provide approved instruments for testing quality of tunnel atmosphere; take samples under working conditions at prescribed intervals. Submit results of the quality tests.

D. Drilling and Blasting:

1. Perform blasting in accordance with the General Requirements and approved blasting plan.
2. Have the blasting consultant design initial blasts as well as supervise and conduct test blasts, if required, until regular production controlled blast patterns are developed that produce desired rate of excavation while meeting requirements for vibration and air-blast control. Have consultant periodically, or when requested by the Engineer, review blasting operations and direct such changes in blasting operations as necessary to produce a controlled blasting operation meeting specified requirements.
    a. Before blasting within 50 feet of cured concrete, except shotcrete, submit and obtain approval of plan showing relative positions of concrete, area to be blasted and blasting technique to be employed.
    b. Protect concrete work and structures in vicinity of blasting by limiting size of blasts, by covering blasts and by other means until it is certain that there is no danger of damage by shock waves or flying rock.
    c. Use controlled blasting techniques. Modify blasting round as necessary to achieve best obtainable results and to keep vibrations and noise within limits specified.
    d. As excavation proceeds and immediately after each blast, test the roofs and walls; scale loose and shattered rock which is likely to fall. Carry out similar checks on previously excavated sections at least every 48 hours; recheck support system and tighten, lagging, blocking and rock bolts as necessary.
    e. When so directed, drill feeler or pilot holes no less than 1-1/2 inch diameter ahead of excavation to predetermine nature and condition of materials to be excavated. Number of holes, location, direction and length, minimum 15 feet and maximum 30 feet: As directed.
    f. Install initial support in accordance with approved working drawings.

E. Vibration and Air-Blast Control:

1. Control operations in accordance with the following:
    a. Peak particle velocity:

1) Not to exceed two inches per second (ips) measured in or at any adjacent existing structure outside limits of construction site.

2) Peak particle velocity at structural concrete not to exceed the following limits dependent on age of freshly-placed concrete and powder charge per delay:

Concrete Age	Maximum Peak Particle Velocity (ips)
Less than three days	0.2
Between three and seven days	2.0
Over seven days	4.0

3) Calculate values of maximum powder charge per delay permissible at specified intervals of distance between point of detonation and critical structure and submit for approval.

4) exceed 140-dB peak sound-pressure level measured at edges of shafts or portals of tunnels.

2. Peak particle velocity is defined as maximum of three velocity components of a vibration measured at any point in three mutually perpendicular directions by an appropriate instrument.

3. Peak sound-pressure level is the peak level measured on the A-scale of a standard sound-level meter at slow response.

4. The Engineer may make measurements to determine if the Contractor's operations are exceeding such requirements. This data will be available to the Contractor.

5. If data indicates that specified requirements are not being met, take necessary measures including reducing size of charge, covering or matting blasts to reduce noise and vibrations to acceptable levels.

F. Dispose of excavated materials as specified.

G. Drain excavated areas as necessary in accordance with requirements of Section 02240.

H. If initial support is necessary, keep its installation within three feet of excavated face; do not leave tunnel unsupported without full initial support for longer than three hours after excavation. Stabilize face if necessary.

3.07 STRUCTURAL STEEL SUPPORT FOR PERMANENT LINING:

A. Install structural steel supports true to lines and grades, blocked, braced and wedged against rock surface or against initial layers of shotcrete placed on rock surface.

B. Install supports as soon as possible after initial layers of shotcrete are placed or as soon as possible after exposing rock by excavation and as close to headings as work will permit.

C. For support at base of steel ribs, use steel foot plates resting on smooth bearing surface formed by precast concrete or low slump, dry-packed concrete.

D. Position joints to facilitate steel-rib installation as necessary and as approved.

E. Wedge and brace blocking and cribbing solidly between rock surface or initial shotcrete layer and steel supports. Check blocking and cribbing and retighten after every blast or more frequently as necessary to maintain it in a secure condition.

F. Use no greater amount of wedging, blocking, timber lagging and cribbing than necessary to support ground safely and to distribute load to structural-steel supports.

G. Do not cover more than 25 percent of rock surface abovespring line with wedging, blocking, timber lagging and cribbing nor more than 25 percent of projected rock surface of walls below spring line. 25-percent criterion applies along any 10 feet of horizontal underground excavation and between any two adjacent steel ribs placed less than 10 feet on center.

H. Limit spacing of blocking and wedging points on outside flange of steel set to 48 inches maximum, unless otherwise shown.

I. Steel lagging may be used in any amount in any underground excavation providing it permits ready placement of shotcrete and flow of concrete around it.

J. Place wedging, blocking, lagging and cribbing in an open arrangement to permit ready placement of shotcrete and flow of concrete through and around them.

K. Repair or replace structural steel supports placed improperly or damaged.

3.08 PERMANENT LINING:

A. Cast-In-Place Concrete:
   1. Invert:
      a. Prior to installing drainage system and constructing invert slab, clean off loose material.
      b. Install drainage pipes and place porous subgrade material as shown and in accordance with Section 02625.
      c. Place impervious membrane over subgrade layer and extend it continuously up sides of invert and above top of expansion-joint material, taking care to prevent puncturing and tearing it. Tape laps and repair tears or punctures in membrane with material recommended by membrane manufacturer.
   2. Permanent lining: In accordance with Sections 03100, 03200 and 03300 and as follows:
      a. Prior to placement of concrete, remove timber blocks or wedges extending into concrete design line by such means as to not endanger stability of surrounding ground.
      b. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure. Do not use pneumatic equipment with high-velocity delivery, unless it has velocity-discharge control and unless its discharge line is continuously embedded at least four feet in fresh concrete
      c. Fill spaces around posts, ribs and lagging beyond limits of concrete lining. Use concrete, grout or mortar as best suited to conditions at particular locations.
      d. Fill enlargements of tunnel excavation beyond dimensions shown with concrete or grouted prepacking.
      e. Force concrete into contact with lagging and ribs

f. After concrete has attained its design strength, perform contact grouting to fill voids in accordance with Section 02431.

g. For sections in which permanent lining includes steel ribs, comply with sequence of operations and details shown.

h. Starter walls:

1) Construction of starter walls, 18 inches minimum height, permitted as separate pour after supporting concrete has attained strength to support starter wall forms.

i. Tolerances for cast-in-place permanent tunnel lining are based on design alignment, not on actual alignment. Locate initial support with sufficient allowance for permanent lining without violating clearance requirements.

B. Precast-Concrete Tunnel Lining:

1. Install tunnel lining so as to prevent damage to lining and coating. Use taper rings on curves.
2. When installing segments ensure that edges are clean and free from materials that could interfere with proper bearing of segments.
3. Place invert segment over properly shaped bed of pea gravel providing full and even bearing.
4. Alternate erection of side segments to prevent shifting of invert segment.
5. Erect precast-concrete segments immediately behind tunneling-machine cutter head and inside tail shield of TBM.
6. Complete ring of precast-concrete segments, without dislodging or damaging gasket. Lubricate gasket of last segment of each ring prior to its installation.
7. Backpack solidly each completed ring of precast-concrete segments with pea gravel and grout. Place pea gravel so as to ensure complete filling of space between lining and excavated surface of tunnel. Do not install more than two completed rings without filling space between lining and excavated surface of tunnel. Proceed with backfill grouting from bottom holes to top holes of completed rings. Use bulkheads as necessary to complete filling of space behind segments. Grouting pressure: 20-psi minimum, 30-psi maximum.
8. Continuously hold last six completed rings from heading by sufficient force to prevent separation of rings. Gap between adjacent rings not to exceed 1/8 inch.
9. Perform necessary remedial work. Damaged precast-concrete segments may be removed, repaired and reinstalled if approved.
10. Fill grout holes with portland-cement grout after backfill grouting is completed for each ring.

C. Hydrostatic-Pressure Relief System. *5

1. Install hydrostatic-pressure relief system as shown.

3.09 INSTALLATION OF ELECTRICAL INSULATIVE COATING:

A. Apply coating prior to placement of invert and safety-walk concrete on precast segmented lining. Do not apply in tunnels where full circumference water proofing membrane is sown or specified.

B. Surface Preparation:

1. Remove dirt, grease and heavy laitance by wet sandblasting, water blasting or wire brushing.

C. Application:

1. Apply in two coats of equal thickness totaling 20 mils minimum dry-film thickness (DFT) in accordance with recommendations of coating manufacturer.

3.10 TUNNEL CONNECTIONS AND TERMINATIONS AND TEMPORARY BULKHEADS:

A. Connect new tunnels to existing structures by removing existing bulkheads and constructing junction as shown.

B. By means of temporary bulkheads, seal terminations of tunnels which are not connected to existing structures.

C. Design temporary waterproof bulkheads where and when necessary, capable of resisting lateral pressures and capable of removal without damaging permanent lining. Obtain approval of design prior to construction.

3.11 TEMPORARY WORKSHAFTS AND OTHER OPENINGS:

A. Excavate and support temporary workshafts and other openings in accordance with Sections 02320 and 02260.

B. Seal such openings when no longer necessary.

C. Form and place Class 2500 concrete, two feet thick, in shafts over tunnels to prevent damage to tunnel shape. When concrete has attained design strength, backfill remaining void in accordance with Section 02320.

3.12 DEFECTIVE LINING:

A. Precast concrete segmented tunnel lining will be considered defective unless it is watertight, properly finished and within specified tolerances and has undamaged edges and joints.

B. Watertightness Criteria: Section 03300.

3.13 CORRECTIVE WORK:

A. Repair of Concrete Segments: Repair segments which have minor chipping of edges and corners, using epoxy mortar having surface color and texture closely matching adjacent concrete surfaces. As directed, repair or replace with new segments those cracked segments which the Engineer determines will impair structural integrity of tunnel lining.
   1. Ensure that surfaces to be repaired are clean, dry, free from dirt, dust, oil, water and other contaminants.
   2. Mix and place epoxy mortar as recommended by manufacturer of epoxy resin. Grind rough or raised projections smooth and flush with adjacent surfaces.

3.14 LEAK REMEDIATION:

A. If water leakage into tunnel exceeds specified allowable limit, undertake remedial measures such as injection of epoxy, bentonite slurry, chemical grout, cement or a combination thereof in accordance with Sections 07125 and 07170.

B. Prior to beginning work, submit leak-remediation plan.

C. If possible, use existing grout holes for injecting material.

D. Establish injection pressure by means of on-site demonstration; do not exceed structural capacity of lining.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

***1**. Add Article 1.1 B.13. for contracts where hydrostatic-pressure relief system work is directed to be performed.

***2**. For contracts where hydrostatic-pressure relief systems work is not directed to be performed.

***3**. Modification for contracts where hydrostatic-pressure relief systems work is directed to be performed.

***4**. Add 2.1 R. including 1.-4. for contracts where hydrostatic-pressure relief system work is directed to be performed.

***5**. Add 3.8 C. including 1. for contracts where hydrostatic-pressure relief system work is directed to be performed.

END OF SECTION

SECTION 02415

EARTH TUNNELING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the following:
   1. Earth tunneling for running sections, side drifts, adits and auxiliary tunnels.
   2. Installing tunnel linings.
   3. Concrete filled voids.
   4. The references in this section to steel ribs and lagging are restricted to the following:
      a. Misalignment correction.
      b. Stabilizing excessive deformations occurring in the precast segments.

B. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Dewatering: Section 02240.
   3. Support of excavation: Section 02260.
   4. Underpinning, support and restoration of structures: Section 02255.
   5. Subway drainage system: Section 02625.
   6. Rock tunneling: Section 02410.
   7. Earth (EPBM) tunneling: Section 02416.
   8. Precast-concrete tunnel-lining: Section 02425.
   9. Concrete work: Sections 03100, 03200 and 03300.
   10. Membrane waterproofing: Section 07125.
   11. Bentonite waterproofing: Section 07170.
   12. Tunnel waterproofing (two-pass system): Section 07137.

C. Definitions:
   1. Earth tunneling: Mined excavation in earth. The following, among others, are classified as excavation in earth: Mixed-face, filled ground including rock fill, boulders, concrete or stone masonry, buried trees, timbers or plankings, conduits, pipes or drains, wood, concrete or steel piles and sheeting and soft decomposed or disintegrated rock.
   2. Mixed-face tunneling: Mined excavation of earth and rock materials both in the same heading at the same time.
   3. Initial support: Elements designed, furnished and installed by the Contractor for stability and safety during construction preparatory to the construction of permanent lining.
   4. Permanent lining:
      a. For single-pass system precast concrete tunnel lining elements as shown.
      b. For the two-pass system there are two layers of linings, the initial and the final. The initial lining consists of precast concrete segments which are either jacked in place and retained by dutchmen and filled with concrete or grout to form the ring, or gasketed and bolted segments to form the ring. Final liner is a cast-in-place concrete liner.
         1) Concrete filled voids: Voids or chimneys which develop as the result of run-in of soil into the tunnel and which extend entirely or partially to the surface. These voids are then filled with lean concrete.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications.
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. Geotechnical Design Summary Report (GDSR) included as Appendix G to the General Requirements.
   3. AASHTO: M33, SDMS.
   4. MS: MIL-P-26915.
   5. FS: TT-S-230, TT-W-261.
   6. ASTM: A36, A325, A709, C109, C144, C150, D638, D1056, D1304, D2240.
   7. FGCC: Standards and Specifications for Geodetic Control Networks.
   8. OSHA: Standard 1926.800(k)(2) AND (3), CFR 1910720, CFR 1926.800.

B. Watertightness Criteria: Section 03300.
   1. Survey Control:
      a. Provide qualified survey personnel in accordance with the General Requirements pertaining to Layout of Work.
   2. Establish a secondary survey control system consisting of horizontal and vertical reference points for driving the tunnels and placing concrete lining. Install horizontal control points either as a brass disc or lead and tack. Install vertical control points either as a brass disk or a 1/2-inch diameter by minimum three-inch long anchor bolt with nut and washer.
      a. Employ survey procedures and equipment in accordance with FGCC Standards and Specifications for Geodetic Control Networks, using Second Order, Class 1 specifications for horizontal control work and Second Order, Class 1 specifications for vertical control work.
      b. Make tunnel horizontal transverses closed loops and adjusted by the least squares method. Make tunnel vertical traverses closed loops and adjusted by distributing the error of closure equally through the turning points. Provide the Engineer with traverse adjustment results within 24 hours.
      c. Advance and verify underground tunnel control after each 500 feet of tunnel lining placement.
      d. Install vertical control points maximum 300 feet on center throughout tunnel.
      e. Install inter-visible theodolite instrument platform mounting brackets in the shotcrete lining, at or below the springline, at maximum intervals of 500 feet on center throughout the tunnel, for the purpose of maintaining the secondary horizontal control system. Install additional platform mounting brackets where tunnel alignment curvature does not allow for intervisibility between instrument locations.
      f. See Part 2 - Products for bracket and surveyor platform specifications.
      g. Survey Data Collection:
         1) Provide and maintain equipment and software necessary to record secondary survey control measurement observations. Assemble measurement observations in digital data collection files and provide data to the Engineer in a format that is compatible and in accordance with the AASHTO Survey Data Management System (SDMS) technical specification for survey data.
         2) Survey data collection files transmitted to the Engineer are to contain a time and date stamp for each observation, original field measurements, and the correctly computed coordinates/elevations in addition to the survey data tags necessary to recompute the file if required.
         3) Preserve original unedited data collection files and provide one copy of each file to the Engineer.

h. Survey Equipment Adjustment and Calibration:

1) Adjust instrument for collimation error every six months or whenever difference between direct and reverse readings of theodolite depart from 180 degrees by more than 15 seconds. Readjust cross hairs and level bubble whenever their misalignments affect instrument reading by amount of least count.

2) The National Geodetic Survey (NGS) has established specific calibration baselines for the purpose of comparing survey equipment to known monumentation to verify correct instrument operation and verification of compliance with manufacturer's specifications. Service every six months and check frequently the electronic distance measuring instruments (EDMI's) and retroreflectors over lines of known distance at an approved NGS baseline. Recalibrate an EDMI if physical damage is incurred.

3) Compute calibration results using procedures in NOS NGS-10 Use of Calibration Base Lines. Record actual measurements, apply atmospheric corrections and then adjust by least squares to compute a constant, as well as a relative correction factor (scale correction). Calibrate prisms at the same facility.

4) Forward results of this calibration to the Engineer. Post correction factors in Contractor's office for computing area and apply them as required to maintain specified accuracy.

5) Immediately remove and repair, or replace instruments found to be in disrepair or misalignment.

6) Provide a certification of adjustment to the Engineer for instruments to be utilized before commencement of survey work.

7) Provide and maintain the ability in-house to check and adjust tribrachs for eccentricity. Perform adjustment checks at least once a week. Keep a record of adjustments to tribrachs current and made available to the Engineer monthly or upon request. Number and tag each tribrach with date of last adjustment.

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. Design, specifications, method of operation and other data pertaining to tunnel shields and tunnel machine.

b. Manufacturers' printed literature for the products, equipment and instrumentation proposed for use in the work, annotated clearly to indicate exact items to be used

2. Working Drawings:

1) Detailed description, data or calculations of proposed facilities, equipment to be utilized and method of construction, including but not limited to, the following: Method of operation and other data pertaining to tunnel shields and tunnel machine, hoisting plant, tunnel ventilation, lighting and drainage; ground water control methods; pre-support (chemical) grouting methods; temporary shafts, cuts, ramps and tunnels; breakouts; cross passages; bulkheads; initial support; method of construction including details of installation of initial support and permanent lining; method of controlling line and grade of shield and lining; details of rib and segment ring movement measurement; details of method and procedure for the expansion of initial lining including jack pressures

and test for completion of expansion; details of method and procedure for preventing the expansion jacks and dutchmen from dropping out from construction induced loads or vibrations; details of method procedure for filling expansion gaps with concrete and grout behind the initial tunnel support system.

b. Have drawings and computations certified by a professional engineer experienced in earth tunneling and registered in the jurisdiction in which the work is to be performed.

c. Details of temporary ventilation:
   1) In the event it is planned to use equipment not covered by Section 101, Article VII.A., Safety Requirements, submit details of such equipment.
   2) Approval of the use of alternative equipment will depend on submitted research information concerning performance in accordance with applicable standards in common use.

d. Leak-remediation plan:
   1) Include proposed application method, equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.
   2) Submit prior to beginning leak-remediation work.

e. Tunnel shield guidance system: Equipment and software details and operation. Include specific information concerning the method of controlling line and grade of Tunnel Boring Machine.

f. Contingency expansion or installation plans for initial lining: Submit in anticipation of the possibility that initial lining expansion or installation procedure is not successful.

g. Survey Control:
   1) Type and location of horizontal and vertical control monuments to be set.
   2) Survey procedures and equipment.
   3) Design and location of theodolite instrument platform mounting bracket, bracing support hardware, method of attachment to initial liner, brass mounting screw and standing platform underneath instrument mounting bracket.
   4) Survey data collection equipment and software; and traverse reduction and adjustment software.
   5) Survey equipment certification of adjustment; and calibration results of electronic distance measuring instruments (EDMI's) and prisms.
   6) Tribrach adjustment method and equipment.

3. Certification: Certified test report from the independent testing agency verifying that properties of concrete or non-shrink cement grout are as specified.

4. Documentation:
   a. Permits for disposal of excavated material: Each permit and release from each property owner where excavated materials will be deposited absolving the Authority from responsibility in connection with the disposal of such materials.
   b. Air quality reports: Reports of tests for dust, toxic and hazardous gases and other atmospheric impurities in working environment.
   c. Qualifications of the following:
      1) Survey personnel.
      2) Specialists in responsible charge of groundwater control.

3) Operators in responsible charge of operating the shield or the tunnel machine.
4) Specialists in responsible charge of pre-support (chemical) grouting program.
5) Independent testing agency.

5. Samples:
   a. Premolded circumferential filler: Two, each two feet square.
   b. Asphalt-saturated felt filler: Two, each two feet square.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Maintain an adequate supply of straight and tapered precast concrete segments for tunnel lining on site.

B. Avoid damage to surfaces and undue strain on segments during handling.

C. Chemical Grout: Transport, store and handle chemical grout, catalysts, inhibitors, additives and buffers in accordance with manufacturer's instructions.

1.05 JOB CONDITIONS:

A. Groundwater Control:
   1. Control groundwater along the tunnel alignment and within the tunnel heading to prevent the following:
      a. Heaving of invert, boiling conditions, hazardous seepage and sudden inflow of soil at the tunnel face and at the tail of the tunnel shield.
      b. Loss of ground and surface subsidence.
   2. Accomplish groundwater control by, but not limited to, the following:
      a. Lower the water table in accordance with Section 02240.
      b. Underpin and support structures in accordance with Section 02255.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Precast-Concrete Tunnel Lining Segments: Section 02425.

B. Reinforcing Steel: Section 03200.

C. Concrete: Section 03300.

D. Track Drainage: Section 02625.

E. Grout: Ingredients that are compatible, noncorrosive to steel and free from calcium chloride.
   1. Cement: ASTM C150, Type I.
   2. Sand: ASTM C144.
   3. Water: Potable.
   4. Admixtures and additives: Fly ash or other pozzolanic materials; fluidifiers; accelerating, retarding, and water-reducing agents; and bentonite may be used if approved.

F. Non-Shrink Cement Grout:

G. Chemical Grout: Gel-type as follows:

1. Self-supporting gel grout using a soluble polyacrylamide, producing no toxic hazard and which can be mixed in such proportions that dilute aqueous solutions, when properly catalyzed, will form stiff gels and yield true solutions at concentrations sufficiently high to accomplish soil solidification.
2. Polymer solution mixed using formulations and procedures to provide variable gel times in accordance with the manufacturer's recommendations.
3. Source: Chem G-9 by Polymer Chemicals, Incorporated or equal.

H. Ribs, Beams, Channels, Plates and Retainers: ASTM A36.

I. Timber for Blocking, Lagging, Foot Blocks and Cribbing: Sound, well-seasoned hardwood timber of rectangular cross section.

J. Pea Gravel: Smooth, rounded pieces of gravel, clean and free from objectionable material, such as soft particles, coal and lignite particles or friable particles, graded from 1/4 to 3/8 inch in size.

K. Sand: Section 03300, fine aggregate, except with 100-percent passing U.S. Standard Size 16 sieve.

L. Sealant and Back-Up Rod:
1. Siloxane-polymer sealant: FS TT-S-230.
2. Back-up rod: 5/8-inch diameter polyethylene.

M. White Lead (for Coating Grout-Plug Threads): FS TT-W-261.

N. Bentonite Slurry: Stable suspension of powdered bentonite in water.

O. Epoxy Mortar: Two-component, epoxy-resin and sand system without solvents; containing 100-percent solids, workable from 50F to 60F.
1. Sand grading: Three parts No. 16 sand to one part No. 90 sieve sand, high-silica content, dry and bagged.
2. Mortar mix: One part epoxy to maximum of one part sand.

P. Premolded Circumferential Filler:
1. Closed-cell neoprene, ASTM D1056, Grade SCE-45.
2. Water absorption: No increase in weight in excess of two percent when tested in accordance with ASTM D1056 and completely immersed in water for 70 hours at 65F to 95F.
3. Hardness: 50 plus-or-minus five on the Shore A durometer as measured by procedures given in ASTM D2240.
4. Size: One-inch thick, width and length as shown.

Q. Asphalt-Saturated Felt Filler: AASHTO M33.

R. Electrical Insulative Coating:
1. Properties: Moisture-insensitive coating, 100-percent solids, containing no solvents, for use on dry or damp concrete or steel surfaces, with the following additional requirements:
   a. Minimum tensile strength: ASTM D638, 5,000 psi in 14 days.
   b. Dielectric strength: ASTM D1304, 440-465 volts per mil.
   c. Dielectric constant: ASTM D1304 as follows:
      1) 60 Hertz: 3.4-3.5.
      2) 1,000 Hertz: 3.3-3.4.

d. Power factor: ASTM D1304 as follows:
   1) 60 Hertz: 0.006-0.007.
   2) 1,000 Hertz: 0.03-0.04.
e. Viscosity: 6,000 centipoises plus-or-minus 1,000 centipoises, as determined by Brookfield Viscometer using No. 6 spindle at 50 rpm.

2. Primer: Zinc-rich, MS MIL-P-26915 (USAF) Type 1, Class B.

2.02 GROUT MIX DESIGN:

A. Stage I Mix: To develop compressive strength of 100 to 120 psi at 24 hours.
1. Mix sand and cement dry.
2. Add minimum water to achieve water-cement ratio compatible with pumping and placing requirements.
3. Mix in high-speed mixer for minimum of three minutes.
4. Prepare batches so that standing time does not exceed 45 minutes.
5. Prepare trial mixes for laboratory testing.
6. Perform tests of compressive strength in accordance with ASTM C109.

B. Stage II Mix: Neat cement and water.

2.03 INSTRUMENT PLATFORM MOUNTING BRACKETS:

A. Construction: Steel, minimum 1/8-inch thick, having a smooth finish where instrument attaches. Make bracket rigid enough to resist deflection or movement when a theodolite is mounted and operated on top of it. If deflection or movement is apparent, add bracing supports as directed by the Engineer.

B. Bracket Supports: Attach bracket supports to the underside of platform mounting bracket to provide a clear and unobstructed working area at and above platform.

C. Size: Sufficient length and width to allow efficient set-up and operation of various theodolite and electronic distance measuring instruments (EDMI).
1. Minimum width: Nine inches.
2. Minimum length: Sufficient to allow a mounted instrument a at least one foot clearance from tunnel lining.

D. Install platform mounting brackets to a level plane within the adjustment limits of a standard tribrach.

E. Forced Centering Hole: Provide each platform mounting bracket with a forced centering hole to accept a brass instrument mounting screw (standard 5/8-inch by 11-inch thread) for securing a standard tribrach.
1. Provide a brass mounting screw that is hollowed and of sufficient diameter to allow the instrument operator to site below platform mounting bracket with a nadir optical plummet.
2. Mill force centering hole and brass mounting screw to match each other within 0.001 inch tolerance.
3. Provide the Engineer with three mounting screws for duration of the Contract.

F. Surveyor Platform: Provide a platform underneath each instrument mounting bracket for the purpose of supporting a surveyor during measurement observation process from wither side of instrument.

PART 3 - EXECUTION

3.01 TEMPORARY VENTILATION:

A. Provide, operate and maintain for duration of project a temporary ventilation system which conforms to specified safety requirements and those of jurisdictional authorities, and is capable of providing twice the required volume and velocity of air flow as specified in OSHA Standard 1926.800(k)(2) AND (3). Assume that other conditions likely to produce harmful vapors or gases may be present at portions of the alignment. Remove system from site when work is completed.

B. Use equipment which is adequate to maintain sufficient supply of fresh air in underground work areas.

3.02 SAFETY REQUIREMENTS:

A. Perform work so as to maximize safety and reduce exposure of men and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.

B. Emergencies:
   1. In case of emergency or work stoppage likely to endanger excavation or adjacent structures, continuously maintain full work force 24 hours per day including weekends and holidays until emergency or hazardous conditions no longer jeopardize stability and safety of the work.
   2. For emergency purposes, have always on-site and ready for use a minimum of 12 steel rib rings and lagging sufficient to support 25 feet of tunnel.

C. Perform tunnel construction so as to minimize ground movement in front of and surrounding tunnel and prevent subsidence of surface, structures and utilities above and in vicinity of tunnel.

D. Support ground continuously so as to prevent loss of ground and keep perimeters and maintain stability of tunnel faces, passages and bottoms of shafts.

E. If the Environmental Property Assessment Reports required in Section 101, indicate the potential for encountering contaminated groundwater or contaminated soil along the alignment, have electrical equipment in the tunnel and shafts comply with OSHA regulations CFR 1910720 and CFR 1926.800. Provide toxic and explosive gas sensors in the shafts, running tunnels and on the shield at the tunnel face to monitor the presence of potentially toxic or combustible materials.

3.03 BLASTING:

A. Whenever material requiring blasting is encountered, perform the work in accordance with Section 02410 and Section 101.

3.04 DISTANCE BETWEEN HEADINGS:

A. Maintain longitudinal distance of no less than 150 feet between adjacent tunnel headings being simultaneously excavated.

B. Where tunnel heading is being advanced adjacent to previously excavated tunnel, ensure that initial support in first tunnel is completely installed and that voids behind lining are filled and tendency of lining to distort is minimized before commencing work on second tunnel.

C. Where two adjacent tunnels are to be installed at different levels, complete and support lower level tunnel first as specified for previously excavated adjacent tunnel.

3.05 SURVEILLANCE OF HEADINGS:

A. If tunnel invert is below groundwater level, maintain qualified personnel on duty to monitor conditions that might threaten stability of heading whenever tunnel excavation is suspended or shut down.

B. Use of monitoring devices, such as closed-circuit television, which permit continuous monitoring of conditions at face by qualified observers from outside tunnel is permitted subject to approval.

3.06 AIR QUALITY:

A. Conduct drilling and tunneling operations by methods and with equipment which ensure control of dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities in accordance with specified safety requirements.

B. Provide instrumentation for testing quality of tunnel atmosphere and obtain samples under working conditions at prescribed intervals. Submit results of quality tests.

3.07 DISPOSAL OF EXCAVATED MATERIAL:

A. Dispose of excavated materials at locations outside the Authority's right-of-way.

3.08 DETECTION OF MOVEMENT:

A. Rib and Segment Ring Movement:
   1. Monitor dimensions and elevations of ribs and segmental rings as follows:
      a. Measure width of each rib and segmented ring at spring line to within plus-or-minus 0.01 foot.
      b. Measure height of each rib and segmented ring from crown to invert or foot block to within plus-or-minus 0.01 foot.
      c. Measure crown elevation of each rib and segmented ring and elevation of each footblock to within plus-or-minus 0.01 foot.
   2. Take measurements of width and height of each rib and crown elevation of each rib and each segmented ring within one hour after each rib or segmented ring is expanded or emerges from tail of machine.
   3. Take measurement of width and crown elevation of each segmented ring within 12 hours after each segmented ring is expanded or emerges from tail of machine.
   4. Following such initial readings, the Engineer will select one segmented ring in each 12-foot section of tunnel for additional measurements. Take measurements of width, height and crown elevation of each segmented ring on selected sets of ribs or rings three days after selected ring erected, and at monthly intervals thereafter until they are concreted in.
   5. If impracticable to obtain these measurements because of design of tunneling equipment or method of construction, use alternative methods of measurement as approved.
   6. If measurements indicate excessive deformations are occurring, take corrective measures, such as installation of ribs, and additional measurements on selected elements and on additional elements as directed.

B. Ground Movement: Install, maintain and make observations of instrumentation shown..

3.09 CONCRETE FILLED VOID:

A. Should run-in of the soil produce a concrete filled void as defined above, stop tunneling operations immediately and notify the Engineer. Secure the tunnel and construct a temporary bulkhead to prevent further run-ins. Provide a bulkhead which is capable of resisting lateral earth and hydrostatic pressure, waterproof and capable of removal without damage to the tunnel liner.

B. Fill the void from the surface with lean concrete.

C. Resume tunneling operations after a minimum of 48 hours has passed after filling the voids with lean concrete and after approval of the Engineer.

3.10 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
   1. Cast-in-place tunnel concrete: Place cast-in-place tunnel concrete to the following tolerances:
      a. Tunnel lining:
         1) Departure of tunnel from line or grade shown as measured from working point of tunnel: One inch.
         2) Variation in thickness of lining at any point: Minus zero inch.
         3) Variation in internal diameter at any point: Plus-or-minus one inch.
         4) For two-pass system where final cast-in-place liner is less than 12 inches but equal to or greater than nine inches, provide additional reinforcing as shown on the Contingency Reinforcement Drawing, at no additional cost to the Authority.
         5) No final liner wall thickness less than nine inches will be accepted. Tunnel remining necessary to maintain the allowable final liner thickness is at no additional cost to the Authority.
      b. Invert: Section 03300.
      c. Safety walk: Section 03300.
   2. Precast concrete segmented tunnel lining: Install precast concrete segmented tunnel lining to tolerances shown.

3.11 EQUIPMENT:

A. General: Use shields and machines which can be controlled to desired line and grade and minimize over excavation and loss of ground and provide for erection of specified tunnel linings.

B. Tunnel Shields:
   1. Use tunnel shields suitable for work conforming to shape of tunnel and having uniform exterior surface from leading edge of head or poling plates to rear edge of tail and free of projections. Horseshoe-shaped shield may have closed or open bottom; circular shield to have closed bottom. Permanent poling plats incorporated in the hood of the shield are prohibited.
   2. On shield, provide substantially proportioned hood, which projects not less than two feet, nor more than two feet six inches, beyond shield bottom and rear overhang or tail long enough to provide at least 12 inches of overlap beyond last installed element of lining when shield has been pushed forward to fullest extent possible. Ensure that

annular space between tail and lining is in accordance with current practice but in no case greater than 1-1/2 inches.

3. Provide a shield with either a suitably designed hydraulically operated breasting system with tight breast boards, with breast-jacks or breast-tables or both, and such other means necessary to accomplish the same results. Hinged or "orange peel plates" as the sole means of face support will not be approved. In addition, provide such means as necessary to continuously support the face of the tunnel without loss of ground through a continuous grouting operation where necessary.
4. Make the pattern of breast-jacks and soldier beams to fully support the upper 50 percent of the tunnel face in order to provide direct face support. Provide the forward bulkhead with reaction points for trench jacks to support the upper half moon breast boards.
5. Mechanical excavators may be used provided that they can be retracted and do not interfere with the capability of breasting. Do not allow excavation to extend beyond the leading edge of the hood.
6. Design breasting system to do the following:
    a. Permit drilling and soil sampling from the exploratory holes for grouting from the face of the shield.
    b. Provide space and facilities for grouting for ground stabilization.
    c. Provide capability to install probes ahead of the excavation face.
7. Include propulsion system on shield capable of moving shield in forward direction, while maintaining construction tolerances with respect to line, grade and direction. Design propulsion system so that in event of failure of propulsion-system elements there is no over stressing and distortion of lining, and there is no movement backward.
8. Jack loads: For precast-concrete tunnel lining, use shields and machines in which each jack load is applied uniformly at centerline of longitudinal rib of segment and over area equivalent to cross section of longitudinal rib. Use a minimum of 18 jacks each of 150-ton capacity, or 24 jacks each of 125-ton capacity, located at centerline of each longitudinal rib of lining.
9. Incorporate seal in tail of each shield to prevent leakage of grout into tunnel space between shield and lining.
10. Erection system: Equip shield with erector arm or erection system capable of handling largest sizes of lining and of erecting sections of lining to tolerances shown without damage to lining.
    a. Use erection system that allows for prompt expansion of the segment against the soil when segment emerges from tail of the shield.
    b. Use erection system that is fully integrated with the tunnel machine and capable of erecting the pre-cast liners in a smooth operation.
    c. Have previously installed segments in a ring supported prior to installation of ring expansion jacks.
    d. Have the erector arm equipped with a hydraulic system which prevents sudden movement of the liner during erection and which provides a fail-safe system should hydraulic pressure be lost in order to prevent accidental segment droppage.
11. Provide an adequate expansion system to include the following:
    a. Capability to start expansion as soon as clearances permit.
    b. Reaction for expansion jacks independent of shield and shield movement.
    c. Expansion system expanding outward and upward.
    d. A minimum capacity expansion of two 100-ton hydraulic jacks.
    e. If required because of insufficient expansion, ability to modify the system by increasing the jack capacity, adding more jacks and points of expansion, or by other means in accordance with a plan subject to the Engineer's approval.

12. Tunnel guidance: Provide a tunnel shield guidance system for automatic computation of curved axis coordinates to maintain proper tunnel line and grade within specified tolerances.
    a. Use guidance system capable of calculating and displaying the position and attitude of the tunnel shield or boring machine (TBM) relative to the designed tunnel axis at each point, including predicted points at the face of the shield or some specified distance ahead of the shield.
    b. Include in the tunnel shield guidance the following features:
        1) The parts and equipment necessary to continually and automatically measure horizontal, vertical, and axial displacement as well as horizontal, vertical, and main axis rotation.
        2) A control unit capable of storing the design tunnel alignment using a three-dimensional coordinate system and displaying the present position and attitude of the shield or the TBM and its predicted deviation from the design axis of the tunnel.
        3) Motorized electronic theodolite with electronic distance measuring instrument (EDMI) and laser. Have the laser directed through the eyepiece of the theodolite, used to automatically update laser beam directional information. Use the EDMI to automatically update the shield or TBM drive distance.
        4) An above-ground computer which enables entry, modification and verification of the designed tunnel axis coordinates.
            a) Have the above-ground computer display, print and digitally store the information available at the control unit and to document the position and progress of the tunnel drive without leaving the office. Make this information available to the Engineer upon request or at the end of each shift.
            b) Have the above-ground computer electronically connected to the equipment underground via cable or modem.
    c. Source for guidance system: Subject to the requirements, use ZED-260 or equal.
13. Equip shield with permissible electrical systems equipped with toxic gas and combustible gas sensors. Have toxic gas and combustible gas sensors linked to the machine operation to automatically shut the machine down should measured gaseous concentrations exceed established safety threshold values.

C. Tunnel Machines: Use tunnel machines which minimize loss of ground ahead of and around machine and provide for erection of specified tunnel linings within machine. Use machines which have same features as shields except for face-support requirement. For tunneling with Earth Pressure Balance Machines (EPBM) see Section 02416.

D. Grouting Equipment:
1. For pumping grout, use pump capable of developing specified uniform pressure at grout hole connection and hoses with minimum inside diameter of 1-1/2 inches. Provide automatic recording of volumes and pressures during grouting operations.
2. Provide mixing equipment with capacity to fill voids outside last ring after each advancement of tunnel shield.
3. Provide automatic shutoff control to prevent grouting pressure from exceeding that specified
4. Keep equipment lines clean by constant circulation of grout and by periodic flushing with water.
5. Use equipment that allows flushing with grout-intake valve closed, water-supply valve open and grout pump running at full speed.

6. Provide two pressure gauges, one at the pump and other on manifold hookup at collar of hole being grouted. Use pressure-gauge ranges as necessary for each part of grouting program.
7. Provide suitable stop valves at collar of hole to maintain necessary pressure until grout has set.
8. Provide grouting equipment with means of accurately determining amount of grout injected.
9. Furnish accurately calibrated, high-precision pressure gauge to periodically check accuracy of pressure gauges.

3.12 OPERATIONS BY TUNNEL SHIELDS AND MACHINES:

A. On initial setup, properly support tunnel shields or tunneling machines on concrete cradle at lines and grades which permit correct installation of tunnel lining. Based on design or existing soil conditions or both, pre-support grouting or dewatering or both may be required.

B. During forward movement of shield, provide sufficient support at excavation face to prevent movement of materials, except such materials as are physically displaced by elements of shield itself.

C. Control face efficiently using appropriate support procedures and methods, such as breasting, poling, face jacks, slide tables, singly or in combination.
1. No tunnel advance will be permitted until the crown has been grouted, and it has been determined by the Engineer that additional pre-support grouting is not required, to provide a stable soil mass into which to tunnel.
2. Perform pre-support grouting from existing ground surface locations shown. Extend the grouted arch at least two tunnel diameters in front of the shield when grouting from the surface and one tunnel diameter in front of the shield when grouting from within the tunnel prior to an advance of the tunnel face. The minimum required thickness of the grouted arch is five feet.
3. Additional pre-support (chemical) grouting will be required if, in the judgement of the Engineer, the ground conditions in advance of the excavation require it.
4. During probing, identify substantially cohesive deposits (such as TI, P1/P3 soils – See Appendix G, Geotechnical Design Report, of the General Requirements) which are continuous and occupy essentially the upper 50 percent of the face. Additionally, the observed performance of the excavation with respect to surface settlement and lateral deformation determined from the geotechnical instrumentation monitoring program will be evaluated in conjunction with the probe data.
5. More extensive pre-support ground control other than grouting may be required depending on the effectiveness of the dewatering system, the pre-support grouting and the data obtained from the geotechnical instrumentation program.

D. Dispose of excavated materials as required.

E. During shutdown periods, support face of excavation by positive means such as breasting of face. Do not rely solely on support by hydraulic pressure. Provide surveillance as specified above.

3.13 INSTALLATION OF TUNNEL LININGS:

A. Lining of One-Pass System or Bolted Initial Liner of Two-Pass System:
1. Install tunnel lining so as not to damage lining or coating. Use taper rings on curves. Develop and submit the details of taper rings not shown.

2. When installing segments, ensure that edges are clean and free from material that could interfere with proper bearing.
3. Install bolted connections consisting of one bolt, one nut, two grommets and two washers arranged and conforming to sizes as shown. Tighten bolts in accordance with AISC requirements for structural joints. After each advance of shield or tunneling machine, check tension of bolts on last two rings and retighten or replace if necessary those bolts which do not meet requirements.
4. Replace grommets at bolts which show signs of leakage.
5. Staggering Longitudinal Joints:
    a. For metallic lining, stagger longitudinal joints in adjacent rings by one half of segment length, but in no case by less than 25 percent of segment length.
    b. For precast concrete segmented lining, stagger joints in adjacent rings by one third of segment length. One joint between adjacent rings may be continuous.
6. After approval of bolted connections, clean out caulking recesses.
7. Insert metallic lead caulking in metallic lining or sealant with backup rod in precast-concrete lining so that it completely fills recess and forms tight and continuous plug providing watertight joint.
8. Recaulk joints which are leaking.
9. After each advance of shield or tunneling machine, fill voids between lining and excavated surfaces with grout. Where approved, pea gravel followed by neat portland-cement grout or one-to-one sand-cement grout may be used to fill voids in lieu of two-stage grouting. For special purposes, finer sand may be used. Do not exceed 30 psi at grout hole.
10. Perform grouting in two stages as follows:
    a. First stage: Perform immediately after each forward thrust of equipment, at nozzle pressure which will not cause movement of soil or lining nor damage to lining, but not exceeding pressure specified. Keep topmost hole in liner open as air vent. Assist Engineer in checking adequacy of first stage grouting.
    b. Prior to performing Stage II grouting, completely drill out previously filled grout holes and prepare for regrouting. When grouting of ring is completed and grout has set, clean threads of holes and plugs, coat plug threads with white lead, and screw plugs completely and tightly into holes.
    c. Second stage: Fill soft spots or voids which may be detected, no later than 24 hours nor more than 50 feet behind first stage grouting. Use nozzle pressures specified.
11. Avoid spillage or leakage of grout into tunnel. Clean up spillage promptly and remove it from tunnel.
12. Complete electrical bonding of segments as shown.
13. Install corrosion test rods through grout holes where shown, ensuring full contact with surrounding earth. Use insulating bushing in grout holes.
14. Support trailing edge of last installed ring by means of horizontal tie rod or vertical strut inserted before shield or tunneling machine is advanced. Keep support in place until grouting around lining has been completed and the tendency of lining to distort or surrounding ground to move has been overcome.
15. Repair or replace as directed damaged segments in previously placed ring.
16. Completely seal area of tunnel roof described by arch of approximately 45 degrees each side of tunnel's vertical centerline to at least one-foot beyond outside face of contact rail and on opposite side of track to one-foot beyond outside face of running rail. Perform such work in accordance with manufacturer's recommendations.

B. Expanded (Jacked) Initial Liner of the Two-Pass System:
1. Install tunnel lining so as not to cause damage to lining or coating. Use taper rings on curves as necessary. Develop and submit the details of taper ring not shown.

2. When installing segments, ensure that edges are clean and free from material that could interfere with proper bearing.
3. Ensure that reach ring is positioned properly and that each segment is supported in a secure position during erection within the shield, shoving of the shield expansion of the ring. Expand the rings with the use of jacking rings (or other approved equivalent measures). However, to provide proper bearing at the joints of the segments, use two 100-ton capacity hydraulic jacks in the circumferential "gap" in the segmented precast concrete ring and maintain pressure in these jacks. Install a plywood board on the outside of the initial liner at the "gap" to prevent ground loss during further expansion and installation of the liner ring.
4. Immediately after leaving the shield, expand initial liner segments outwards and radially using hydraulic jacks with jacking rings (or other approved equivalent measures) and hydraulic jacks in the "gap" so that the segments are in good contact with the ground. After the initial liner segments are fully expanded, install the steel dutchmen in the "gap" of the segmented ring and ensure proper bearing with the use of shims if necessary, and secure these dutchmen to prevent movement or loss of support.
5. First Stage Contact Grout (cement-sand grout):
    a. Perform the First Stage Contact Grout on the outside of the initial tunnel liner to fill the annular space between the initial liner and the excavated surface within 16 hours after initial tunnel support ring installation, but not more than the installation of four rings, or when directed by the Engineer. Use nozzle pressure that will not cause movement of soil or lining nor damage to the lining, and not exceeding 30 psi at the grout hole.
    b. Subject to the Engineer's approval, perform the First Stage Contact Grout on the outside of the initial tunnel liner to fill the annular space between the initial liner and the excavated surface after each advance of the tunnel machine. Use nozzle pressure that will not cause movement of soil or lining nor damage to the lining, and not exceeding 30 psi at the grout hole.
6. After the installation of the dutchmen in the "gap" and the removal of the jacks from the "gap", dry pack the "gap" with non-shrink grout after the heading has advanced no further than 150 feet past the ring, or within 48 hours from the time of the initial ring expansion.
7. After expansion and initial deformation of initial liner ring has occurred, if measurements indicate excessive deformations or indicate additional "squat" of more than one inch at the crown, install internal bracing to arrest additional deformation. Place contact grout behind the initial precast liner.
8. Seal leaking joints.
9. Avoid spillage or leakage of grout into tunnel. Clean up spillage promptly and remove from tunnel.
10. Support last installed ring by means of an erection arm, expansion system, horizontal tie rod or vertical strut inserted before shield or tunneling machine is advanced. Keep support in place until the tendency of lining to distort, or surrounding ground to move, has been overcome.
11. Repair or replace as directed damaged segments in previously installed rings

3.14 INSTALLATION OF ELECTRICAL INSULATIVE COATING:

A. Apply coating prior to placement of invert and safety-walk concrete on precast segmented lining.

B. Surface Preparation: Remove dirt, grease and heavy laitance by wet sandblasting, water blasting or wire brushing.

C. Application: Apply in two coats of equal thickness totaling 20 mils minimum dry-film thickness in accordance with recommendations of coating manufacturer.

3.15 CONCRETE CONSTRUCTION:

A. Prior to construction of the permanent liner, install the tunnel waterproofing with water barriers as shown. See Section 07137.

B. Complete electrical bonding of lining and invert shown. Electrically bond the invert of the final lining at each end of each unit.

C. Install corrosion test rods where shown, ensuring full contact with surrounding earth. Use bushing in grout holes.

D. Perform cast-in-place concrete work in accordance with Sections 03100, 03200 and 03300.

E. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure.

F. Prior to placement of concrete, remove timber blocks or wedges extending within concrete design line so as to avoid compromising stability of initial support and surrounding ground.

G. Fill enlargements of tunnel excavation beyond dimensions shown with concrete or grouted prepacking as approved.

H. Schedule erection of concrete tunnel lining so that no concrete is placed closer than 500 feet from tunnel excavation heading, unless otherwise approved.

I. Perform contact grouting through grout nipples, in such quantity and at sufficient pressure to fill voids. Use grouting pressure shown.

3.16 TUNNEL CONNECTIONS AND TERMINATIONS AND TEMPORARY BULKHEADS:

A. Connect new tunnels to existing structures by removing existing bulkheads if necessary and sealing junction as shown.

B. Provide temporary bulkheads to seal terminations of tunnels which are not connected to permanent structures.

C. Design temporary bulkheads where and when necessary. Obtain approval of design prior to construction. Provide bulkhead which is capable of resisting lateral earth and hydrostatic pressures, waterproof and capable of removal without damage to permanent liner.

D. Provide portal transitions as shown.

3.17 TEMPORARY WORKSHAFTS AND OTHER OPENINGS:

A. Excavate and support temporary workshafts and other openings in accordance with Sections 02320, 02240 and 02260.

B. Seal such openings when no longer necessary.

C. Form and place Class 2500 concrete, two feet thick, in shafts over tunnels to prevent damage to tunnel shape. When concrete has achieved design strength, backfill remaining void in accordance with Section 02320.

3.18 DEFECTIVE LINING:

A. Precast concrete segmented bolted tunnel lining will be considered defective unless it is watertight, properly finished, within specified tolerances and has undamaged edges and joints.

B. Watertightness Criteria: Section 03300.

C. Precast concrete expanded or jacked tunnel initial liner is considered defective unless it is properly finished, within specified tolerances and has undamaged edges and joints.

D. Defective concrete criteria for cast-in-place final liner for the two-pass system: Section 03300.

3.19 CORRECTIVE WORK:

A. Repair of Precast Concrete Segments: Repair segments which have minor chipping of edges and corners, using epoxy mortar having surface color and texture closely matching adjacent concrete surfaces. As directed, repair or replace with new segments those cracked segments which impair structural integrity of tunnel lining as determined by the Engineer.
   1. Ensure that surfaces to be repaired are clean, dry, free from dirt, dust, oil, water and other contaminants.
   2. Mix and place epoxy mortar as recommended by manufacturer. Grind rough or raised projections smooth and flush with adjacent surfaces.

B. Contingency Reinforcement: When tunneling misalignment results in a final liner thickness of less than 12 inches but greater than or equal to nine inches, install contingency reinforcement as shown. Furnish and install contingency reinforcement when required at no additional cost to the Authority.

C. Correction of Misalignment: In the case of misalignment which will result in a final thickness of less than nine inches, enlarge the tunnel excavation by remining or as otherwise approved. Provide additional materials and redesign required due to misalignment at no additional cost to the Authority.

3.20 LEAK REMEDIATION:

A. If water leakage into tunnel exceeds specified allowable limit, undertake remedial measures such as injection of bentonite slurry, cement, chemical grout or combination thereof in accordance with Section 07125 and 07170.

B. Prior to beginning work, submit leak-remediation plan.

C. If possible, use existing grout holes for injecting material.

D. Establish injection pressure by means of on-site demonstration. Do not exceed structural capacity of lining.

END OF SECTION

SECTION 02416

EARTH (EPBM) TUNNELING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the following:
   1. Earth tunneling for running sections, side drifts, adits and auxiliary tunnels.
   2. Installing tunnel linings.

B. Related Work Specified Elsewhere:
   1. Excavation and backfilling: Section 02320.
   2. Dewatering: Section 02240.
   3. Support of excavation: Section 02260.
   4. Maintenance, support and restoration of utility facilities: Section 02270.
   5. Underpinning, support and restoration structures: Section 02255.
   6. Subway drainage system: Section 02625.
   7. Pre-cast concrete tunnel lining: Section 02425.
   8. Concrete formwork: Section 03100.
   9. Concrete reinforcement: Section 03200.
   10. Cast-in-place structural concrete: Section 03300.
   11. Structural steel: Section 05120.
   12. Tunnel waterproofing: Section 07137.
   13. Geotechnical instrumentation: Section 02291.

C. Definitions:
   1. Earth tunneling: Mined excavation in earth, including but not limited to filled ground, rock fill, boulders, concrete or stone masonry, buried trees, timbers or plankings, conduits, pipes or drains, wood, concrete or steel pipes and sheeting, soft decomposed or disintegrated rock, concretionary rock-like material in lenses or layers, cemented sands, unconsolidated lignitized wood deposits, and naturally occurring gravel, cobbles and boulders.
   2. Mixed-face tunneling: Mind excavation of soil strata with a face exposing more than one type of soil or material including rock and hard rock in the same heading at the same time.
   3. Initial lining: Precast concrete elements furnished and installed by the Contractor for stability and safety during construction preparatory to the construction of final lining.
   4. Final lining: Cast-in-place concrete lining and waterproofing membrane placed after installation of initial lining.
   5. Precast concrete lining: For single pass system precast elements, per Contract Drawings to carry both short term and long term loads and adequate provision to exclude water into tunnel by use of gaskets.
   6. EPBM: Earth pressure balance machine.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. Geotechnical Design Summary Report (GDSR), included as Appendix G to the General Requirements.
   3. ASTM: C109, C144, C150.
   4. FGCC: Standards and Specifications for Geodetic Control Networks.

B. Watertightness Criteria: Section 03300.

C. Personnel qualifications: Have the Earth Pressure Balance Machine (EPBM) operated only by personnel who have had successful experience in similar work.

D. Survey control: Provide qualified survey personnel in accordance with General Requirements Article titled Layout of Work.

1.03 SUBMITTALS:

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

1. Working Drawings:

a. General: Detailed descriptions, design, specifications, data and calculations of proposed facilities, equipment to be used and, method of construction, including, but not limited to, the following:

1) Method of operation and other data pertaining to the EPBM.

2) Hoisting plant tunnel ventilation, lighting and drainage, groundwater control methods, temporary shafts, cuts, ramps and tunnels, breakouts, cross passages, bulkheads; initial support, methods of construction including details of installation of initial support; final lining and waterproofing membrane, method of controlling line and grade of shield and lining and, details for segment ring movement measurement.

3) Have drawings and computations certified by a professional engineer experienced in earth tunneling and registered in the jurisdiction in which the work is to be performed.

b. Details of temporary ventilation: Details of equipment not covered by the Safety Requirements article of the General Requirements. Approval of the use of alternative equipment depends on submitted research information concerning performance in accordance with applicable standards in common use.

c. Water inflow control, initial lining:

1) Submit proposed method, equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.

2) Submit prior to beginning tunnel excavation.

d. Leak remediation plan, final lining: Include proposed application method, equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.

e. Contact grouting:

1) Grouting procedure: Detailed description of proposed grouting equipment and layout, and the proposed order of grouting.

2) Grout mix: Details for materials, grout mix proportions, and the results of trial mixes and test specimens for sand-cement grout.

3) Records:

a) Maintain and submit weekly a record of drill holes, the time of each change of grouting operations, pressures, rates of pumping, amount of cement for each change in water-cement ratio, admixtures, and other such data required by the Engineer.

b) Maintain and submit daily records of grout take for each liner ring and the time performed. Have records available the following day for on-site review by the Engineer.

f. Earth pressure balance machine (EPBM):

1) Provide a complete technical description of the EPBM and backup equipment, including the cutters and cutterhead, thrust and steering systems, drive system, muck system, machine and tail seals, segment erector, machine-liner interface, guidance system, grout hole drilling system, ventilation system, and muck transport system. Make the level of detail in the submittal sufficient to clearly demonstrate that aspects of the specification requirements are met, including design for the maximum hydrostatic pressure specified. Have the technical description include drawings from the EPBM manufacturer showing details of the EPBM and backup equipment, the cutterhead assembly, muck system, thrust and steering system, drive system, machine and tail seals. grout hole drilling system, segment erector and the interface of the EPBM with the precast segmental lining system elements. Have the drawings show the relation between the excavated tunnel size, the ground support system and the tolerances specified. Submit equipment, software and operation details for the EPBM guidance system and include specific information on the method of controlling and correcting line and grade of the EPBM.

2) Have the proposed EPBM manufacturer certify in writing that the EPBM and backup equipment meet the requirements of this section.

3) Written certification from the EPBM manufacturer of design coordination between the EPBM manufacturer and the liner manufacturer. Include in the certification a statement of compatibility between the EPBM and liner system.

4) Description of EPBM spare parts required in paragraph 2.3.B.4.d giving storage location and condition.

5) A method statement covering the intended machine parameters to achieve earth pressure balance mode at the tunnel face for each of the expected ground conditions described in the Geotechnical Design Summary Report (GDSR) as Appendix G to the General Requirements. Have this include, but not be limited to, cutterhead rotation speed and torque, EPBM thrust, screw conveyor rotation speed and torque, discharger rate, rate of EPBM advance, muck conditioning materials and methods, and mix quantities and volumetric control of the screw conveyor discharge.

6) A method statement covering the start-u of the EPBM and the launch of the EPBM into the ground through the portal and shaft structure.

7) A method statement covering the disassembly and removal of the EPBM and back-up equipment.

2. Documentation:

a. Permits for disposal of excavated material: Each permit and release form from each property owner where excavated materials will be deposited, absolving the Authority from responsibility in connection with the disposal of such materials.

b. Air quality reports: Reports of tests for dust, toxic and hazardous gases and other atmospheric impurities in working environment.

c. Qualifications of personnel operating the EPBM.

d. Description of Contractor's experience with an EPBM similar to that specified for this work, operated in similar tunneling conditions. The

experience record si to demonstrate a successful completion of at least one project using a similar EPBMi in similar conditions. Include descriptions of the following in the information:

1) Features of EPBM used.
2) Lengths and diameters of tunnels, geologic conditions, and ground support systems installed.
3) EPBM performance, including average daily advance, average EPBM penetration or excavation rate, utilization, and description of any major machine-related delays.

3. Schedule Information:
   a. Contractor's estimated average daily advance for tunnel excavation in feet per day, average EPBM penetration or excavation rate in feet per hour, linear erection rate in minutes per ring and utilization, and average muck system and cutter wear in either parts, cost per cubic yards excavated per change.
   b. Schedule for the design, manufacturing or rebuilding of EPBM, shop testing, dismantling and shipment to site.
4. EPBM Quality Assurance Submittals: Submit continuous monitoring data of EPBM performance on a weekly basis for the duration of the EPBM excavation. Accomplish data collection by either automatic recording systems or manually. Include the following in the data to be collected:
   a. For every shove or stroke of the EPBM, the date, time and tunnel station at start of shove; duration and length of shove; average drive motor current and thrust and propel cylinder pressure; number of operating motors; mode of operation and cutterhead chamber pressure.
   b. Description of delays longer than 15 minutes, water inflow, incidence of ground loss or other unusual events.
   c. Cutter and muck system components changes, including time and date of replacement, cutter position and number.
5. Survey Quality Assurance Submittals:
   a. Survey personnel qualifications.
   b. Type and location of horizontal and vertical control monuments to be set.
   c. Survey procedures and equipment.
   d. Design and location of theodolite instrument platform mounting bracket, bracing support hardware, method of attachment to initial liner, brass mounting screw and standing platform underneath instrument mounting bracket.
   e. Survey data collection equipment and software; and traverse reduction and adjustment software.
   f. Survey equipment certification of adjustment; and calibration results of electronic distance measuring instruments (EDMI's) and prisms.
   g. Tribrach adjustment method and equipment.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Maintain adequate supply of straight and tapered precast initial lining segments on site.

B. Avoid damage to surfaces and undue strain on segments during handling. The Engineer retains the right to reject damaged segments resulting from improper fabrication, handling, storing, transporting or erection.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Track drainage: Section 02625.

B. Precast concrete tunnel lining: Section 02425.

C. Reinforcing steel: Section 03200.

D. Final lining, working slab, invert slab and safety walk concrete: Section 03300, Class 4000.

E. Grout: Ingredients that are compatible, noncorrosive to steel, and free from calcium chloride.
   1. Cement: ASTM C150, Type II.
   2. Sand: ASTM C144.
   3. Water: Potable.
   4. Admixture and additives: Fly ash or other pozzolanic materials; fluidifiers; accelerating, retarding, and water-reducing agents; and bentonite may be used if approved.

F. Sand: Section 03300, fine aggregate, except that 100 percent passes US Standard Size 16 sieve.

G. Epoxy mortar: Two-component, solventless, epoxy-resin system, containing 100 percent solids, workable from 50 degrees F to 60 degrees F when one part epoxy is mixed with maximum of one part sand graded as follows:
   1. Three parts No. 16 sieve sand to one part No. 90 sieve sand, high-silica content, dry and bagged.

H. Shrinkage-compensating grout: Section 03300.

I. Gasket lubricant: As recommended by gasket manufacturer.

J. Gasket: Section 02425.

2.02 GROUT MIX DESIGN:

A. Contact Grouting Stage One Mix: To develop compressive strength of 100 to 120 psi at 24 hours.
   1. Mix sand and cement dry.
   2. Add minimum water to achieve water-cement ratio compatible with pumping and pacing requirements.
   3. Mix in high speed mixer for minimum of three minutes.
   4. Prepare batches so that standing time does not exceed 45 minutes.
   5. Prepare trial mixes for laboratory testing.
   6. Perform tests of compressive strength in accordance with ASTM C109.

B. Contact grouting stage Two mix: Neat cement and water.

2.03 EQUIPMENT:

A. General Requirements:
   1. Use an excavation machine that can be controlled to desired line and grade, minimize over excavation and loss of ground and provide for erection of specified tunnel linings.

B. Earth pressure balance machine (EPBM):
   1. General:

a. The EPBM is to be a full face earth pressure balance machine designed for the excavation of saturated soils under maximum hydrostatic pressure described in the GDSR.
b. Soil type, density, gradation, strength and abrasivity, and the maximum hydrostatic pressure for the various tunnel reaches, as well as the ground conditions expected, are presented in the GDSR. Design the EPBM to operate in all the ground conditions, including running or flowing sands and clay, and combination thereof indicated in the GDSR.
c. The EPBM shall be designed to operate in either open (unpressurized) or closed (pressurized) mode using a muck disposal system fitted with a pressure lock out system. Accomplish switching from open to close mode within one minute or less.
d. The average width of the annular space between outside surface of the tunnel liner segments and excavated soil surface is not to exceed 2.5 inches.
e. Equip the EPBM with overcutters not more than 3/4-inch thick.
f. Equip the EPBM with a grouting system to allow soil grouting ahead of face of excavation.
g. Design the EPBM to maintain heading (face) stability at all times under all conditions described in the GSDR during excavation and periods of EPBM shutdown.
h. The EPBM is to have provisions for removal of boulders 12 inches in diameter and larger, and other obstructions as described in the GDSR.

2. Cutters and Cutterhead:
   a. The EPBM shall be Design the EPBM to pass up to 12-inch size cobbles through the head without special procedures.
   b. Design the EPBM with the capacity to use other techniques such as grouting, slurry, or foam injection to control the tunnel face, maintain tunnel integrity and mucking operations.
   c. Make cutters serviceable and replaceable from behind the cutterhead of the EPBM.
3. Thrust System and Steering:
   a. Designed the EPBM to provide forward thrust by thrust cylinders reacting against the installed segmental liner for the full range and combination of ground conditions described in the GSDR.
   b. Thrust system capacity is to exceed the combined reaction from maximum hydrostatic pressure, shield friction and face stabilization load.
   c. Provide symmetrically arranged thrust cylinders which have individual actuation, synchronized actuation for cylinders or for groups of cylinders as necessary for EPBM steering, and individual maximum thrust control. Thrust cylinders are not to exert forces when idle, but are to resist displacements.
   d. The shield is to be articulated if the total length exceeds 90 percent of the tunnel outside diameter. Shield length is measured from the last gauge cutter to the back of the tail.
4. Drive System:
   a. The EPBM is to have sufficient drive motor power, such that the machine is not torque limited when operating in earth pressure balance mode for the full range and combination of ground conditions described in the GDSR.
   b. The EPBM is to have the ability to start the cutterhead with at least rated full load torque. Provide clutches or hydraulic assist with an electric drive, or a variable speed hydraulic drive system may be used.
   c. The EPBM design shall permit the replacement of the main bearings and cutterhead seals from within the tunnel.
   d. One spare main bearing assembly and seals, and one spare main drive gear are be available for replacement of the corresponding parts, and

provided with the EPBM in the event that those parts fail. Make the spare parts available for the duration of the EPBM excavation and make them deliverable to the site within 36 hours notice. The spare parts may be used, provided they are in like-new condition, as certified in writing by the EPBM manufacturer.

e. Make the EPBM drive system operate the cutterhead such that it is fully operational in either direction or rotation.

f. Make the EPBM configured to provide access to the head of the machine for maintenance, repair or obstacle removal.

5. Muck System:

a. Fit the EPBM with a screw conveyor for controlled muck removal from the cutterhead chamber. Design the screw conveyor for operation in the soils described in the GDSR and for efficient replacement from within the tunnel.

b. Design the screw conveyor to be closed and sealed against maximum hydrostatic pressure at both the front and rear.

c. Fit the EPBM with a pressure lock out system, such as a piston discharger, rotary discharger or equivalent, to separate the high pressure groundwater and muck within the screw conveyor from the atmospheric pressure at the muck discharge point of the tunnel.

d. Design the discharge for the controlled release of muck under maximum hydrostatic pressure and readily maintained or replaced. Make the discharger operate in ground conditions described in the GDSR.

e. Design the muck systems for operation in either an open mode (unpressurized cutterhead chamber) or a closed mode (pressurized chamber).

f. For operations in the open mode, design the muck system capacity for continuous operation. Design the muck system such that changing from closed to open mode, or open mode to closed mode, takes less than four 12-hour shifts.

g. Muck transport in the tunnel may be by conveyor, rail or slurry system. Design the system selected for abrasive fines and high water content muck.

h. Design the EPBM for water, polymer, or slurry foam injections to facilitate mucking operations through the control of muck consistency.

6. Seals:

a. Provide high pressure seals designed for maximum hydrostatic pressure, as indicated in the GDSR, at the cutterhead drive and main bearings, the articulation joint, the tail shield, and probe and injection grout drill hole points.

b. Design and equip the EPBM with a suitable tail seal capable of handling the anticipated ground conditions and hydrostatic pressures. Also consider the influence of liner grouting in seal design.

c. Make tail seals replaceable from within the tunnel.

d. Employ a grout deal located at the rear of the tail shield to limit grout migration along the shield toward the cutterhead.

7. Segment Erector and Erection Ring:

a. Make the segment erector and erection ring compatible with the machine and the liner system and gasket selected to ensure safe and efficient segment installation and closing the ring.

b. Actuate the erector in the axial, radial, and circumferential directions and in the three articulation angles corresponding to the six degrees of freedom of the liner segments to grip and erect the segments properly such that they are positioned accurately, gaskets are aligned within the required tolerances, and no damage or distortion of the segments or gaskets occur and that the gasket is fully compressed when the ring is closed.

c. Once gripped by the erector, make it not possible for the segment to relocate with the erector under external loads or under the dead load of the

segment, in the axial direction as well as in the direction of the articulation angles, when corresponding actuators are idle.

d. Have the erector include a suitable gripping device for gripping the segments. Make segment design consistent with the chosen method of gripping.

e. For smooth and continuous operation, proportional valves are required on hydraulic actuators, or variable speed motors are required on electric actuators.

f. Equip the EPBM with measurement devices to indicate correct radial and circumferential positioning of the segments.

8. Machine-liner interface:

a. Do not exceed 1800 psi maximum bearing pressure at any point and at any time on the liner segment unless otherwise submitted and reviewed by the Engineer.

b. Equip the thrust cylinder with a jacking ring or shoes and pads to equally distribute the jacking forces to the liner. Make the design of thrust cylinder jacking ring or shoes and pads consistent with segment and segment joint design.

c. Do not bear jacking ring, shoes and pads on gaskets at any time.

d. Start contact grouting as soon as the grout holes are clear of the last tail seal. Do not install the next ring of segments in the tail shield until grouting is complete.

e. Coordinate the tail seal and the liner system to ensure a competent seal.

f. For tail seals requiring grease or other liquid sealants, make the sealant compatible with the liner system gaskets. Use inert materials which will not contaminate the surrounding ground or cause the long term deterioration of the liner concrete, the joint connector, the gaskets or joint packers.

9. Guidance System and Alignment Control:

a. Provide the DYWIDAG-Leica, ZED-260 or approved equivalent tunneling machine guidance system for automatic computation of curved axis coordinates to maintain proper tunnel line and grade within specified tolerances.

b. Make the guidance system capable of calculating and displaying the position and attitude of the EPBM relative to the designed tunnel axis at all points, including predicted points at the face of the shield or some specified distance ahead of the shield.

c. Have the EPBM guidance system include the following salient features:

1) The parts and equipment necessary to continually and automatically measure horizontal, vertical, and axial displacement as well as horizontal, vertical and main axis rotation

2) A control unit that is capable of storing the design tunnel alignment using a three-dimensional coordinate system and displaying the present position and the attitude of the EPBM and its predicted deviation from the design of the tunnel.

3) Motorized electronic theodolite with electronic distance measuring instrument (EDMI) and laser. Direct the laser through the eyepiece of the theodolite that is used to automatically update laser beam directional information. Use the EDMI to automatically update the EPBM drive distance.

4) An above-ground computer which enables entry, modification and verification of the designed tunnel axis coordinates.

a) Have the above-ground computer display, print and digitally store the information available at the control unit to document the position and progress of the tunnel drive without leaving the office. Make the information available to the Engineer upon request, or at the end of each shift.

b) Electronically connect the above-ground computer to the equipment underground via cable or modem.

5) Design the EPBM and backup equipment to negotiate curves in the alignment with minimum radius as shown, and meet the specified alignment tolerances.

10. Other Features:
    a. Equip the EPBM with a fire suppression system and hand operated fire extinguishers.
    b. Design the EPBM to control the ground at the heading and flow of ground water through the tail seal by grouting during abnormal conditions, construction removal or EPBM maintenance. Store at the site equipment and materials necessary to control the excavation during conditions described above, tested and ready to use when needed.
    c. Provide and maintain a stock of spare parts and consumables on site.
    d. Use fire resistant hydraulic fluids throughout the EPBM.

C. Contact Grouting Equipment:
1. For pumping grout, use approved pump capable of developing specified uniform pressure at grout hole connection and hoses with minimum inside diameter of 1-1/2 inches.
2. Provide mixing equipment with capacity to fill voids and annual space, outside last ring after each advancement of the EPBM.
3. Provide automatic shutoff control to prevent grouting pressure from exceeding that specified.
4. Use equipment that allows flushing with grout intake valve closed, water-supply valve open and grout pump running at full speed.
5. Provide two pressure gauges, one at the pump and a second on the manifold hookup at the collar of hole being grouted. Use pressure-gauge ranges as necessary for each part of grouting program.
6. Provide suitable stop valves at collar of hole to maintain necessary pressure until grout has set.
7. Provide grouting equipment with means of accurately determining amount of grout injected.
8. Furnish accurately calibrated, high-precision pressure gauge to periodically check accuracy of pressure gauges.

PART 3 - EXECUTION

3.01 TEMPORARY VENTILATION AND AIR QUALITY:

A. For the duration of the project, provide, operate and maintain a temporary ventilation system which conforms to specified safety requirements and those of jurisdictional authorities. Remove system from site when work is completed.

B. Use equipment which is adequate to maintain sufficient supply of fresh air in underground work areas.

C. Conduct drilling and tunneling operations by methods, and with equipment, which ensure control of dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities, in accordance with specified safety requirements.

D. Provide approved instrumentation for testing quality of tunnel atmosphere and obtain samples under working conditions at prescribed intervals. Submit results of quality tests.

3.02 TEMPORARY WORKSHAFTS AND OTHER OPENINGS:

A. Excavate and support temporary workshafts and other openings in accordance with Sections 02320 and 02260.

B. Seal such openings when no longer necessary.

C. Form and place Class 2500 concrete, two-feet-thick, in shafts over tunnels to prevent damage to tunnel shape. When concrete has achieved design strength, backfill remaining void in accordance with Section 02320.

3.03 SAFETY REQUIREMENTS:

A. Perform work to maximize safety and reduce exposure of personnel and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.

B. In case of emergency or work stoppage likely to endanger excavation or adjacent structures, continuously maintain full work force 24 hours per day, including weekends and holidays, until emergency or hazardous conditions no longer jeopardize the stability and safety of the work. In addition to rib rings and lagging needed for planned work and shown on Contract Drawings, have on site and ready for use in emergencies a minimum of 12 steel rib rings (W8 x 40 or larger) and lagging sufficient to support 25 feet of tunnel.

C. Perform tunnel construction to minimize ground movement in front of, and surrounding, tunnel and minimize subsidence if surface, structures and utilities above and in vicinity of tunnel for the ground conditions encountered.

D. Support ground continuously at the excavation face and surrounding tunnel perimeter to prevent loss of ground and to maintain stability of tunnel faces, passages and bottoms of shafts.

3.04 DISTANCE BETWEEN HEADINGS:

A. Maintain longitudinal distance of no less than 150 feet between adjacent tunnel headings being simultaneously excavated.

B. Where a tunnel heading is being advanced adjacent to a previously excavated tunnel, ensure initial support in first tunnel is completely installed, that voids behind linings are completely filled, and that the tendency of the lining to distort is minimized before commencing work on the second tunnel.

3.05 SURVEILLANCE OF HEADINGS:

A. If tunnel invert is below groundwater level, maintain qualified personnel on duty to monitor conditions that might threaten stability of heading whenever tunnel excavation is suspended or shut down.

B. Use of approved monitoring devices, such as closed-circuit television, which permit continuous monitoring of conditions at the face by qualified observers from outside the tunnel is permitted.

C. At the first indication of misalignment exceeding the bull's eye limit in the tunnel heading, stop the work and notify the Engineer immediately.

3.06 DETECTION OF MOVEMENT:

A. Segment Ring Movement:
   1. Monitor dimensions and elevations of segmental rings as follows:
      a. Measure width of each segmented ring to within plus-or-minus 0.01 foot.
      b. Measure height of each segmented ring from crown to invert to within plus-or-minus 0.01 foot.
      c. Measure crown elevation of each segmented ring to within plus-or-minus 0.01 foot.
   2. Take measurements of width and height of each segmented ring within one hour after each segmented ring emerges from the tail of the machine.
   3. Take measurement of width and crown elevation of each segmented ring within 12 hours after each segmented ring emerges from the tail of the machine.
   4. Following such initial readings, Engineer will select one segmented ring in each 25-foot section of tunnel for additional measurements. Take measurements of width, height and crown elevation of each segmented ring on selected sets of rings daily after each selected ring erected and within 250 feet of the trailing gear; monitor tunneling weekly between 250 feet and 1,000 feet, and at monthly intervals thereafter until the cast-in-place liner is installed.
   5. If measurements indicate excessive deformations are occurring, take corrective measures and additional measurements on selected elements and on additional elements as directed by the Engineer.

B. Ground Movement:
   1. Install, maintain and make observations as specified of instrumentation shown on the Contract Drawings and/or as specified in Section 02291.

3.07 FIELD QUALITY CONTROL:

A. Place cast-in-place tunnel concrete to the following tolerances:
   1. Tunnel lining:
      a. Departure of tunnel from line or grade shown as measured from working point of tunnel: one inch.
      b. Variation in internal diameter at any point: plus-or-minus one inch.
      c. Where thickness of cast-in-place tunnel lining is less than 12 inches but greater or equal to nine inches, provide additional reinforcing as shown, at no additional cost to the Authority.
      d. No final lining thickness below nine inches will be accepted. Tunnel remining necessary to maintain the allowable final lining thickness is at no additional cost to the Authority.
   2. Invert: Section 03300.
   3. Safety walk: Section 03300.

B. Install initial precast concrete segmental tunnel lining to tolerances shown on the Contract Drawings.

C. Contact Grouting:
   1. Keep workers aware that tunnel grouting is one of a series of linked tunneling processes, each one depending for its proper performance on the proper performance of the others; adverse consequences are likely to result for inadequate performance of tunnel grouting.
   2. Provide facilities and assistance necessary for the Engineer to inspect the grouted initial lining to ensure complete filling of voids, including assistance in drilling, probing, or sounding through the grout hole.

3. An inspection will be made by the Engineer not later than 24 hours after, nor more than 60 feet behind, the initial injection. Have voids, as determined by the Engineer, completely grouted by an additional injection performed immediately after this inspection.
4. From time to time, the Engineer may require the drilling through grout holes in precast segments, and up to one foot into surrounding ground, not to exceed one every 100 feet of tunnel on the average. If regrouting is required, drill additional check holes. Fill check holes flush with surface using epoxy mortar.

3.08 FIELD SURVEY CONTROL:

A. Secondary Survey Control System:
1. Establish a secondary survey control system consisting of horizontal and vertical reference points for driving the EPBM and placing final liner concrete. Install horizontal control points either as a brass disc or lead and tack. Install vertical control points either as a brass disc or 1/2-inch diameter by a minimum three-inch-long anchor bolt with nut and washer.
2. Employ survey procedures and equipment in accordance with FGCC Standards and Specifications for Geodetic Control Networks using Second Order, Class 1 specifications for horizontal control work and Second Order, Class 1 specifications for vertical control work.
3. Construct tunnel horizontal traverses as closed loops adjusted by the least squares method. Tunnel vertical traverses are to be closed loops and adjusted by distributing the error of closure equally through the turning points. Furnish the Engineer with traverse adjustment results within 24 hours.
4. Advance and verify underground tunnel control after every 300 feet maximum of tunnel lining placement.
5. Install vertical control points maximum 300 feet on center throughout tunnel.
6. Platform mounting brackets:
   a. Install inter-visible theodolite instrument platform mounting brackets in the tunnel initial liner, at or below springline, at maximum intervals of 500 feet on center throughout the tunnel, for the purpose of maintaining the secondary horizontal control system. Install additional platform mounting brackets where tunnel alignment curvature does not allow for intervisibility between instrument locations. Fabricate platform mounting bracket from steel, having a smooth finish where the instrument attaches. Make brackets rigid enough to resist deflection or movement when a theodolite is mounted and operated on top of it. If deflection or movement is apparent then add bracing supports to sufficiently stabilize the platform mounting bracket and install additional bracing supports as directed by the Engineer. Use minimum 1/8-inch-thick steel for brackets. Attach bracket supports to the underside of platform, mounting bracket to provide a clear and unobstructed working area at and above platform. The platform mounting bracket shall be of sufficient length and width to allow efficient set-up and operation of theodolite and electronic distance measuring instrument (EDMI). Minimum width of platform mounting bracket is nine inches; minimum length of platform mounting bracket is equal to a distance sufficient to allow a mounted instrument a minimum one foot of clearance from tunnel lining. Install platform mounting brackets to a level plane within the adjustment limits of a standard tribrach.
   b. Provide each platform mounting bracket with a forced centering hole that can accept a brass instrument mounting screw (standard 5/8-inch by 11-inch thread) for securing a standard tribrach. Mill force centering hole and brass mounting screw to match each other within 0.001 inch. Make the brass mounting screw hollow and of sufficient diameter to allow the instrument operator to site below platform mounting bracket with a nadir

optical plummet. Provide the Engineer with three mounting screws for the duration of the Contract. Construct and install a platform underneath the instrument mounting bracket for the purpose of supporting a surveyor during measurement observation process from either side of instrument.

B. Survey Data Collection:

1. Provide and maintain equipment and software necessary to record secondary survey control measurement observations. Assemble measurement observations in digital data collection files and provide data to the Engineer in a format that is compatible and in accordance with the AASHTO Survey Data Management System (SDMS) technical specification for survey data.
2. Have the survey data collection files transmitted to the Engineer contain: a time and date stamp for each observation, original field measurements, and the correctly computed coordinates and elevations in addition to the survey data tags necessary to recompute the file if required.
3. Preserve original unedited data collection files and provide one copy of each file to the Engineer.

C. Survey Equipment Adjustment and Calibration:

1. Adjust instrument for collimation error every six months, or whenever difference between reverse and direct readings of theodolite depart from 180 degrees by more than 15 seconds. Readjust cross hairs and level bubble whenever their misalignments affect instrument readings by amount of least count.
2. The National Geodetic Survey (NGS) has established specific calibration baselines for the purpose of comparing survey equipment to known monumentation to verify correct instrument operation and verification of compliance with manufacturer's specifications. Service every six months and check frequently the electronic distance measuring instruments (EDMI's) and retroreflectors over lines of known distances at an approved NGS baseline. Recalibrate EDMI if physical damage is incurred.
3. Compute calibration results using procedures in NOS NGS-10, Use of Calibration Base Lines. Record actual measurements, apply atmospheric corrections and then adjust by least squares to compute a constant, as well as a relative correction factor (scale correction). Calibrate prisms at the same facility.
4. Forward results of this calibration to the Engineer. Post correction factors in Contractor's office for computing area and apply them as required to maintain specific accuracy.
5. Immediately remove and repair, or replace instruments found to be in disrepair or misalignment.
6. Provide a certification of adjustment to the Engineer for instruments to be utilized before commencement of survey work.
7. Provide and maintain the ability in-house to check and adjust tribrachs for eccentricity. Perform adjustment checks at least once a week. Keep a record of adjustments to tribrachs current and made available to the Engineer monthly, or upon request. Number and tag each tribrach with date of last adjustment.

3.09 OPERATION BY THE EPBM:

A. On initial setup, support the EPBM on concrete cradle properly at lines and grades which will permit correct installation of tunnel lining.

B. During forward movement of the EPBM, provide sufficient support at excavation face to prevent movement of materials, except such materials as are physically displaced by elements of shield itself.

C. Control face efficiently using appropriate support procedures and methods.

D. Dispose of excavated materials as specified.

E. During shutdown periods, due to abnormal conditions, obstruction removal, EPBM maintenance or other reasons, ensure stability of the tunnel with appropriate support measures. In areas where the tunnel face stability cannot be maintained directly by the EPBM, support face of excavation by other means, such as grouting.

F. In the event of EPBM stoppage for more than 12 hours, inject bentonite slurry into gap between tail of shield and foil to facilitate resuming of EPBM advancement.

3.10 INSTALLATION OF INITIAL LINING:

A. Support segments as necessary to prevent damage or undue strain. During handling of segments, wire ropes, keep chains or hooks from direct contact with concrete or gaskets. Ship tapered segments in units of complete rings, properly identified.

B. Inspect segments with gaskets before taking them underground and just prior to erection. Damaged segments shall not be installed in the tunnel. Damaged segments shall be repaired or replaced as directed, at no additional cost to the Authority.

C. Install the segmented tunnel lining system to the specified dimensions and tolerances for line and grade, within the design tolerances for joint and structural performance. Projection or lipping (abrupt surface irregularity) of a segment with respect to the adjoining segment will is not allowed in excess of that shown on the Contact Drawings under Tolerances.

D. Assemble and mechanically connect each ring of segments inside the tunneling shield. Keep the invert of the EPBM free of excavated material prior to erection of each ring. Hose clean the joint surfaces of each segment with clean water immediately prior to erection. At time of erection, make joint and gasket surfaces free of material that could interfere with proper bearing and watertightness. Lubricate gasket along cross joints of key segments prior to key segment installation.

E. Prior to jacking the EPBM have mechanical connectors across joints in place ahead of the segment ring and tightened sufficiently to provide joint closure pressure as specified in Section 02425. Maintain the design tolerances on joint closure during erection of subsequent rings. If necessary, retighten the mechanical connectors of the last circumferential joint prior to retracting jacking rings or shoes.

F. Do not apply loads or eccentricities to the segments that are detrimental to the lining system as a result of the erection sequence. Do not permit jacking rings or shoes and pads to bear on the circumferential joint gaskets.

G. Use tapered rings on curves and elsewhere as necessary to maintain line and grade tolerances. In no case is compression packing to be added to or removed from the circumferential joints to adjust line and grade.

H. Stagger longitudinal joints in adjacent rings.

I. Perform contact grouting behind each ring and shall begin as soon as segment grout holes are clear of the tail seal.

J. Hangars for utility lines necessary for construction of the tunnel may be connected to concrete segments, but may not interfere with proper erection of each ring. Cast or drilled holes or embedded anchorages may be used for this purpose, if approved by the Engineer.

K. Support trailing edge of last installed ring by means of horizontal tie rod or vertical strut inserted before EPBM is advanced. Keep support in place until grouting around lining has been completed and tendency of lining to distort, or surrounding ground to move, has been overcome.

L. Repair or replace, as directed, damaged segments in previously placed ring.

3.11 WATERTIGHTNESS:

A. Watertightness of Initial Lining (of Two-Pass System):
   1. Provide clean, dewatered conditions during waterproofing membrane placement and installation of final lining.
   2. Prior to beginning work, submit plan for control of water entering tunnel through the initial lining. Include capacity of proposed water pumps.
   3. If water leakage into tunnel exceeds capacity of the proposed water pumps, undertake remedial measures, such as injection of bentonite slurry, cement, chemical grout or combination thereof.
   4. Repair visible leaks.
   5. If possible, use existing grout holes for injecting materials.
   6. Establish injection pressure by means of on-site demonstration. Do not exceed structural capacity of the lining, or combined hydrostatic and soil overburden pressure as determined for construction conditions.

B. Watertightness of Precast Concrete Lining (of Single-Pass System):
   1. Comply with Leak Remediation, specified above.

3.12 CONCRETE CONSTRUCTION:

A. For Two-Pass System:
   1. Perform concrete work in accordance with Sections 03100, 03200 and 03300.
   2. Clean and roughen working slab surface to expose aggregates prior to placing invert slab concrete.
   3. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure.
   4. Do not perform concreting of final lining of the first tunnel excavated until excavation of the second tunnel has progressed at least 100 feet beyond the limits of active concreting, unless otherwise approved.
   5. Schedule erection of concrete lining of the second tunnel so that no concrete is placed closer than 500 feet from tunnel excavation heading, unless otherwise approved.
   6. Perform contact grouting through grout nipples, in such quantity and at sufficient pressure to completely fill voids. Use grouting pressure as specified.
   7. Drill and grout safety walk reinforcement into final lining using shrinkage-compensating grout. Exercise care during drilling operation not to impair waterproofing membrane.
   8. Install remaining reinforcing steel in the safety wells and pour concrete.

B. For Single-Pass System:
   1. Perform concrete work in accordance with Sections 03100, 03200 and 03300.
   2. Place invert slab concrete on the cleared liner or over the insulative coating, if used.

3. Do not place the invert in the first tunnel excavated until excavation of the second tunnel has progressed at least 100 feet beyond the limits of active concreting, unless otherwise approved.
4. Schedule placement of the invert of the second tunnel so that no concrete is placed closer than 400 feet from tunnel excavation heading unless otherwise approved.
5. Install safety walk dowels per Contract Drawings, provide remaining reinforcing steel and place concrete in the safety walks.

3.13 CONTACT GROUTING:

A. First Stage-Precast Concrete Initial Lining (for Two-Pass System) and Precast Concrete Lining (for One-Pass System):
1. Perform cement-sand grouting behind initial tunnel support to fill the annular space between the initial support system and the excavated surface. Use nozzle pressure that will not cause movement of soil or lining nor damage to lining, and not exceed 30 psi at the grout hole. Keep topmost hole in liner open as air vent. Assist Engineer in checking adequacy of first stage grouting.
2. Consider grouting of a hole complete when the hole refuses grout for 60 seconds at 90 percent of highest pressure stipulated for conditions at that hole location. After the grouting of a hole is completed, maintain pressure by means of a stop cock or other suitable device until the grout has set sufficiently to be retained in the hole.
3. After grout has set, remove valves and fittings. Fill grout holes with epoxy mortar at completion of the grouting operations to have a smooth finished surface acceptable to the Engineer.

B. Second Stage-Cast-in-Place Concrete Final Lining (for Two-Pass System Only):
1. Place grout pipes or connections in the concrete lining or concrete pipe shown on the Drawings and as specified herein. Place grout pipes in the lining at a nominal 25 foot spacing. Place pipes behind the concrete forms and held securely in position. Suitably plug grout pipe perforations to prevent the entrance of concrete. Drilled holes may not be used in lieu of cast-in-place grout pipes
2. Ensure that concrete lining has reached 28-day strength prior to commencement of grouting operations.
3. Use nozzle pressure which will not puncture or otherwise injure waterproofing membrane.
4. Make connections by threaded fittings of ample strength and tightness to prevent leakage or with approved packers, and provide each with a straightway cock or valve. Remove plugs on ends of adjacent ungrouted pipes to ensure escape of air and water and filling of spaces with grout. Replace plugs as required to prevent loss of grout. The general direction of advance is to be from lower elevations to higher elevations.
5. Prior to injection of grout, inspect each grout pipe to ensure that the pipe is clear and open. Hook-up and pump grout at each grout pipe.
6. Operate and control grout pumps so that the grout is delivered uniformly and steadily. Inject grout in a sequential side-to-side progression along the tunnel to fill voids with grout.
7. Grouting at each grout pipe connection will be considered complete when no more grout of the required mix and consistency can be injected at the specified pressure or when clean grout appears at the next hole.
8. Exercise care to prevent the setting of escaped grout on exposed surfaces. Remove such grout and restore surfaces to their original conditions.
9. Upon completion of the grouting at each connection, close the valve and leave it in place until the grout has set, after which remove the valves and fitting. Remove grout supply connections from the embedded grout pipe to a minimum depth of two inches, and fill the hole with epoxy mortar to give a smooth finished surface.

C. Keep equipment lines clean by constant circulation of grout and by periodic flushing with water.

3.14 DEFECTIVE LINING:

A. Precast concrete segmented tunnel lining will be considered defective unless it is properly finished, and within specified tolerances and has undamaged edges and joints.

3.15 CORRECTIVE WORK:

A. Repair of Concrete Segments: Repair segments which have chips, spaces, or formed depressions meeting the conditions set forth in Section 07137, Tunnel Waterproofing. As directed, repair or replace with new segments those cracked segments which impair structural integrity of tunnel lining as determined by the Engineer.
   1. Ensure that surfaces to be repaired are clean, dry, free from dirt, dust, oils, water and other contaminants.
   2. Mix and place epoxy mortar as recommended by manufacturer. Grind rough or raised projections smooth and flush with adjacent surfaces.

3.16 LEAK REMEDIATION:

A. For Two-Pass System:
   1. If water leakage into tunnel after placement of final cast-in-place concrete lining exceeds specified allowable limit, undertake remedial measures such as injection of bentonite slurry, cement, chemical grout or combination thereof.
   2. Prior to beginning work, submit leak-remediation plan.
   3. If possible, use existing grout holes for injecting material.
   4. Establish injection pressure by means of on-site demonstrations. Do not exceed structural capacity of lining.

B. For Single-Pass System:
   1. If water leakage into tunnel exceeds specified allowable limits, undertake remedial measures such as injection of bentonite slurry, cement, chemical grout, or combination thereof.
   2. Prior to beginning work, submit leak-remediation plan.
   3. If possible, use existing grout holes for injecting material.
   4. Establish injection pressure by means of on-site demonstration. Do not exceed structural capacity of lining.

3.17 DISPOSAL OF EXCAVATED MATERIAL:

A. Dispose of excavated materials at locations outside of the Authority's right-of-way.

END OF SECTION

SECTION 02417

NATM EXCAVATION
(SOFT GROUND)

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the excavation and support of the NATM tunnels (center drift, middle drifts, side drifts, shafts and station, as applicable) in accordance with the construction sequences and limits of excavation shown for the NATM.*1
   1. Stations indicating limits of typical excavation and support types, pre-support types, and of concrete lining are approximate only and may vary due to geological and hydrological conditions actually encountered in the field.
   2. Stations are outbound stations; apply inbound stations accordingly.

B. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Dewatering: Section 02240.
   3. Support of excavation: Section 02260.
   4. Subway drainage system: Section 02625.
   5. NATM shotcrete lining: Section 02426.
   6. Concrete work: Sections 03100, 03200, and 03300.
   7. NATM concrete lining: Section 02427.
   8. Shotcrete: Section 03370.
   9. Tunnel waterproofing (NATM system): Section 07138.
   10. Geotechnical instrumentation: Section 02291.

C. Definitions:
   1. Excavation Line: Theoretical line of excavation inside of which no earth or surrounding ground may protrude.
   2. NATM Excavation in Soft Ground: Mined excavation in earth by the New Austrian Tunneling Method (NATM). The following, among others, are classified as excavation in earth: Filled ground including rock fill, boulders, concrete or stone masonry, buried trees, timbers or plankings, conduits, pipes or drains, wood, concrete or steel piles and sheeting, and shotcrete applied for protecting heading or as support for previously excavated drift, and soil pretreated by grouting.
   3. Mixed-face Excavation: Mined excavation of soil strata with a face exposing more than one type of soil or material, including rock and hard rock, in the same heading at the same time.
   4. NATM Portal Wall: A temporary, rigid structure that supports a mass of soil and from which NATM excavation can begin.
   5. Support: Support for NATM construction includes those measures necessary to maintain the inherent strength of the ground surrounding the tunnel openings while preventing unnecessary loosening and enhancing the stress redistribution process. This function of support is enhanced by installation of pre-support and local support where required by ground conditions.
   6. Pre-support: Systematic measures including chemical grout arch installed by directional drilling, grouted pipe spiling and rebar spiling installed as shown prior to or during NATM tunnel excavation.

7. Local Support: Grouted pipe spiling and rebar spiling installed in a non-systematic manner, dowels, face shotcrete, and face stabilization wedge installed individually or otherwise in addition to specified pre-support, for local stabilization and safety during tunneling.
8. Rebar Spiling: Rebars without end hardware installed at the tunnel heading ahead of excavation as a means to pre-support the ground.
9. Grouted Pipe Spiling: Perforated steel pipes installed at the tunnel heading ahead of excavation and grouted as a means to pre-support the ground.
10. Shotcrete of Initial Lining: Shotcrete layer of a minimum seven inches thickness reinforced with welded wire fabric, lattice girders, splice bars and splice clip.
11. Concrete or Final Lining: Cast-in-place concrete placed after installation of shotcrete lining and waterproofing.
12. Excavation and Support Type: Prescribed excavation sequence, support and local support based on the type of host material in both top heading and bench/invert encountered as well as by the anticipated response and behavior of the host material during excavation.[*2]
13. Break-Out: Support installed at support of excavation walls prior to and during the start-up of NATM tunneling including reinforced shotcrete collar, dowels, and thickened shotcrete lining.
14. Chemical Grout Arch: Zone of soil improved by chemical grouting above the tunnel roof and reinforced longitudinally by minimum two-inch ID tube-a-manchette steel pipes through which grout has been injected. Steel pipes installed in drill holes drilled by means of directional drilling.
15. Directional Drilling: Soil stabilization, for sandy and other running soil, chemical grouting by installing continuous horizontal grouting pipes. Directional drilling is also used for horizontal dewatering pipes. If it is necessary to use horizontal directional drilling for additional geologic investigation, have adequate records and logs maintained during the entire drilling operation.[*3]
16. Dowels: Injection bore anchors with end hardware installed at break-outs as shown to tie the shotcrete collar to the ground and pre-support the loosened ground where required.
17. Length of Round: Length of the unsupported span of exposed ground opened up during one round of excavation. Excavation to be immediately followed by the installation of support as shown.
18. Flash-crete: Minimum one-inch thick layer of unreinforced shotcrete placed immediately after excavation on exposed surface to seal and protect the material from deterioration and initial loosening. It is not part of the structural shotcrete lining as shown and specified.
19. Face Stabilization Wedge: Unexcavated portion of the heading temporarily left in place to enhance face stability.
20. Vacuum Lances: Slotted PVC or other approved temporary pipes with filter fabric inserted into the ground from within the tunnel for the purpose of performing local dewatering and removing perched water using vacuum pressure during excavation.
21. Drain Pipes: Slotted PVC pipes, or other pipes approved by the Engineer, with filter fabric inserted into the ground from within the tunnel to drain water and perched water by gravity during excavation.
22. Water Sheet and Drain Hose: PVC-sheet and PVC-hose or similar materials as approved by the Engineer. Use watersheet and drain hose to collect and drain off ground water from areas at either the excavated ground surface before applying shotcrete lining to prevent hydrostatic pressure build-up behind the shotcrete lining and/or for dewatering of seepage through the shotcrete lining. Use drain hose individually applied to drain off water ingress at localized spots behind the shotcrete lining.

23. Geologic Overbreak: The amount of ground dislocated beyond the theoretical excavation line primarily due to running or flowing in materials, like P2 material, and falling out of blocks along fissures in materials, like P1 material..

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. Geotechnical Design Summary Report (GDSR) in the Appendix G of the General Requirements.
3. AASHTO: Survey Data Management System
4. ASTM: A36, A53, A325, A615, C109, C144, C150, D638, D1304, D2240.
5. MS: MIL-P-26915
6. FGCC: Standards and Specifications for Geodetic Control Networks.

B. NATM Engineer: Have field staff include a civil engineer (NATM engineer) meeting the following requirements:
1. Education: Graduate civil engineer from an accredited college or university, foreign or domestic.
2. Experience: Field and design experience in soft ground NATM tunnel engineering.
3. Proficient in spoken and written English.
4. Do not commence field work until NATM engineer has been approved in writing by the Authority.
5. Have approved engineer report for work at the site at least six weeks prior to commencement of NATM excavation-related work, including installation of chemical grout arch, and remain at the site for four weeks after completion of the excavation work.
6. Duties include the following:
   a. Supervising excavation to ensure safety of construction.
   b. Coordinating preventative and remedial measures when ground loss at tunnel heading or instability of tunnel occurs, or when they appear likely.
   c. Preparing daily written interpretation of instrumentation measurement readings during excavation.
   d. Holding daily discussion with the Engineer at the tunnel face regarding ground conditions and corresponding Excavation and Support Type and other supports and keeping written records thereof.
   e. Submitting a weekly report on geologic conditions as encountered during excavation for the Engineer's use including record of daily discussion. Have the geologic report include geologic mapping of the face for a frequency recommended for various Excavation and Support types.[*4]
   f. Participating in pertinent coordination meetings with the Engineer, and providing minutes of each meeting to the Authority within one week.Preparing final reports on geologic conditions encountered, ground control measures taken, problems encountered and geometrical measurements.
7. Be always available to report to the site.

C. Survey Control:

1. Provide qualified survey personnel in accordance with the General Requirements pertaining to Layout of Work.
2. Establish a secondary survey control system consisting of horizontal and vertical reference points for driving the tunnels and placing concrete lining. Install horizontal control points either as a brass disc or lead and tack. Install vertical control points

either as a brass disk or a 1/2-inch diameter by minimum three-inch long anchor bolt with nut and washer.

a. Employ survey procedures and equipment in accordance with FGCC Standards and Specifications for Geodetic Control Networks, using Second Order, Class 1 specifications for horizontal control work and Second Order, Class 1 specifications for vertical control work.

b. Make tunnel horizontal transverses closed loops and adjusted by the least squares method. Make tunnel vertical traverses closed loops and adjusted by distributing the error of closure equally through the turning points. Provide the Engineer with traverse adjustment results within 24 hours.

c. Advance and verify underground tunnel control after each 500 feet of tunnel lining placement.

d. Install vertical control points maximum 300 feet on center throughout tunnel.

e. Install inter-visible theodolite instrument platform mounting brackets in the shotcrete lining, at or below the springline, at maximum intervals of 500 feet on center throughout the tunnel, for the purpose of maintaining the secondary horizontal control system. Install additional platform mounting brackets where tunnel alignment curvature does not allow for intervisibility between instrument locations.

f. See Part 2 - Products for bracket and surveyor platform specifications.

g. Survey Data Collection:

   1) Provide and maintain equipment and software necessary to record secondary survey control measurement observations. Assemble measurement observations in digital data collection files and provide data to the Engineer in a format that is compatible and in accordance with the AASHTO Survey Data Management System (SDMS) technical specification for survey data.

   2) Survey data collection files transmitted to the Engineer are to contain a time and date stamp for each observation, original field measurements, and the correctly computed coordinates/elevations in addition to the survey data tags necessary to recompute the file if required.

   3) Preserve original unedited data collection files and provide one copy of each file to the Engineer.

h. Survey Equipment Adjustment and Calibration:

   1) Adjust instrument for collimation error every six months or whenever difference between direct and reverse readings of theodolite depart from 180 degrees by more than 15 seconds. Readjust cross hairs and level bubble whenever their misalignments affect instrument reading by amount of least count.

   2) The National Geodetic Survey (NGS) has established specific calibration baselines for the purpose of comparing survey equipment to known monumentation to verify correct instrument operation and verification of compliance with manufacturer's specifications. Service every six months and check frequently the electronic distance measuring instruments (EDMI's) and retroreflectors over lines of known distance at an approved NGS baseline. Recalibrate an EDMI if physical damage is incurred.

   3) Compute calibration results using procedures in NOS NGS-10 Use of Calibration Base Lines. Record actual measurements, apply atmospheric corrections and then adjust by least squares to compute a constant, as well as a relative correction factor (scale correction). Calibrate prisms at the same facility.

4) Forward results of this calibration to the Engineer. Post correction factors in Contractor's office for computing area and apply them as required to maintain specified accuracy.
5) Immediately remove and repair, or replace instruments found to be in disrepair or misalignment.
6) Provide a certification of adjustment to the Engineer for instruments to be utilized before commencement of survey work.
7) Provide and maintain the ability in-house to check and adjust tribrachs for eccentricity. Perform adjustment checks at least once a week. Keep a record of adjustments to tribrachs current and made available to the Engineer monthly or upon request. Number and tag each tribrach with date of last adjustment.

D. NATM Tunnel Heading Inspector: Contractor's field staff to include inspector for each shift of work.
1. Qualifications of such persons to include inspection experience in soft ground NATM tunnel construction, proficiency in the English language, and capability to assume duties of NATM engineer.
2. By the Engineer approved inspector to report for work at the site prior to commencement of NATM excavation.
3. In the event that ground loss at the tunnel heading or instability of tunnel heading occurs or appears likely, and NATM engineer is not physically present at the tunnel heading, duties of inspectors to include the following:
a. Directing modifications in tunneling techniques.
b. Notifying the Engineer of ground losses at tunnel heading.
c. Notifying personnel responsible for performing preventative and/or remedial measures to report immediately at tunnel heading.
d. Coordinating preventative and remedial measures.
e. Notifying personnel responsible for monitoring instruments to increase frequency of monitoring as specified.

E. Have qualified firm or specialist, and necessary equipment in working order and always present at the site, for performing directional drilling, chemical grouting, probe drilling, installation of pre-support and local support, and other approved measures.

F. Have qualified firm or specialist responsible for groundwater control measures and knowledgeable in dewatering methods for use in this type of soils, preferably with adequate experience within the project areas.

G. *5

H. NATM Portal Wall:*6

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: Design, specifications, method of operation and other data pertaining to the following:
a. Grouted pipe spiling pipes and rebars.
b. Casings, packers, rubber sleeve pipes and drill rods to be used for chemical grouting, grout pipe spiling, probe drilling and installation of drain pipes and vacuum lances.

2. Working Drawings:
   a. Detailed descriptions, data or calculations of proposed facilities, equipment to be utilized and method of construction including, but not limited to, the following:
      1) Groundwater control system including the installation of vacuum lances and drain pipes, temporary sumps, construction drains, pumps, procedures to be followed and standby power supply.
      2) Number, location, direction and timing of headings including temporary drifts.
      3) Temporary tunnels, widenings, shafts, cuts and ramps.
      4) Batching plants, hoisting plant, tunnel ventilation, lighting and drainage.
      5) Methods of construction including details of installation of shotcrete lining, support elements (including lattice girder, welded wire fabric, forepoling bars and sheets, as necessary) and concrete lining.
      6) Method of controlling line and grade of lining; directional drilling and chemical grout arch.
   b. Reinforcement design for cast-in-place lining wherever thickness of cast-in-place concrete is less than 12 inches but greater than nine.
   c. Have drawings and computations certified by a professional engineer experienced in NATM tunneling and registered in the jurisdiction in which the work is to be performed.
   d. For excavation of tunnels, submit drawings, calculations, descriptions and specifications for the following:
      1) Sequence and timing of excavation of top heading and bench/invert including excavation sequencing for individual excavation and support types, key excavation plan including sequence of installation of chemical grout arch, grouted pipe spiling and anticipated rate of advance.
      2) Concrete lining elements, support elements and their relationship to the plan and sequence of excavation and support, and waterproofing installation.
      3) Excavation equipment details including make and model numbers, specifications, and complete manufacturer's literature including copies of owner's's manual and maintenance records.
3. Documentation:
   a. Permits for disposal of excavated material:
      1) Arrange for disposal of excavated materials at locations outside the Authority's right-of-way, and obtain written permits from owners of property where excavated materials will be disposed.
      2) Submit permits and releases from each property owner absolving the Authority from responsibility in connection with disposal of such material.
   b. Details of temporary ventilation:
      1) In the event it is planned to use equipment not covered by the SAFETY REQUIREMENTS Article of the General Requirements, submit details of such equipment for approval by the Engineer.
      2) Approval of the use of alternative equipment will depend on submitted research information concerning performance in accordance with applicable standards in common use.
   c. Air quality reports: Daily reports of test for dust, toxic and hazardous gases and other atmospheric impurities in the working environment during construction.
   d. Leak remediation plan:

e. Include proposed application method equipment details and schedule, as well as complete manufacturer's literature, data, instructions and recommendations.
   1) Submit plans prior to beginning leak remediation work.
   2) Establish injection pressure by means of on-site demonstration; do not exceed structural capacity of lining.

4. Survey Control:
   a. Survey personnel qualifications.
   b. Type and location of horizontal and vertical control monuments to be set.
   c. Survey procedures and equipment.
   d. Design and location of theodolite instrument platform mounting bracket, bracing support hardware, method of attachment to shotcrete lining, brass mounting screw and standing platform underneath instrument mounting bracket.
   e. Survey data collection equipment and software; and traverse reduction and adjustment software.
   f. Survey equipment certification of adjustment; and calibration results of electronic distance measuring instruments (EDMI's) and prisms.
   g. Tribrach adjustment method and equipment.
5. Samples:
   a. One-foot long sections of vacuum lances, and drain pipes that show full cross section and type to be used. Submit three samples for each.
   b. Two-foot long section of pipe to be used for grouted pipe spiling and rebar spiling that show full cross section and configuration of tip to be used. Minimum three-foot long tube-a-machette pipe.
6. Contingency Measures: At least 30 days prior to starting NATM excavation, submit the following for the Engineer's approval:
   a. Name and qualification of personnel responsible for implementing contingency measures.
   b. Plans outlining measures to be undertaken in the event of ground loss or instability at tunnel heading.
   c. Plans outlining surveillance during longer stoppages such as weekends and holidays.
7. Submit to the Engineer for approval the qualifications and experience of the NATM engineer within 10 days of Notice to Proceed. Do not commence field work until approval in writing of the Engineer has been received by the Authority.
8. Submit to the Engineer for approval the qualifications and experience of NATM tunnel heading inspectors within 30 days of Notice to Proceed.
9. Submit to the Engineer for approval the qualifications of the firm or specialist responsible for groundwater control, and directional drilling within 10 days of Notice to Proceed.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Have adequate supply of required materials for performing chemical grouting, grouted pipe spiling, rebar spiling, vacuum lances, drain pipes, water sheets and drain hoses, and other approved materials for measures always present at the site.

PART 2 - PRODUCTS

2.01 NATM SHOTCRETE LINING:

A. See Section 02426.

2.02 SHOTCRETE:

A. See Section 03370.

2.03 CHEMICAL GROUTING AND DIRECTIONAL DRILLING:

A. As shown.[*7]

2.04 VACUUM LANCES AND DRAIN PIPES:

A. Two-inch diameter, rigid PVC pipe with filter fabric, slotted, length as required.

2.05 WATERSHEETS AND DRAIN HOSES:

A. PVC sheet for application at exposed ground surfaces: System AKWA DRAIN, or equal.

B. Flexible PVC hose with end couplings as required.

2.06 WATERPROOFING:

A. See Section 07137.

2.07 GROUTED PIPE SPILING:

A. General::
   1. 1- 1/2-inch diameter pipe, length 15 feet.
   2. Steel, black: ASTM A53.
   3. Perforated as shown and approved by the Engineer.

B. Grout Mix Design: Ingredients that are compatible, noncorrosive to steel and free from calcium chloride.
   1. Cement: ASTM C150, Type 1.
   2. Sand: ASTM C144, except maximum particle size limited to Size 8 sieve.Water: Potable.
   3. Admixtures and additives: Fly ash or other pozzolanic materials; fluidifiers; accelerating, retarding and water reducing agents; and bentonite may be used if approved.

2.08 REBAR SPILING:

A. No. 8 standard deformed reinforcing steel bars, length eight feet as shown on the Contract Drawings, conforming to ASTM A615, Grade 60.[*8]

2.09 DOWELS:

A. Injection Bore Anchors:
   1. Assembly: Length 10 feet, O.D. 30 mm, bearing plate washer and nut.
   2. Bearing plate 3/8-inch thick, with bearing area not less than 36 inches, conforming to ASTM A36.
   3. Washer and nut: ASTM A325.
   4. Source: Subject to meeting requirements of dowels, as manufactured by G. D. Chance Company, or equal.

B. Grout Mix Design: According to manufacturer's recommendations.

2.10 GROUT MIX FOR CONTACT GROUTING:

A. Grout for Contact Grouting: One part portland cement, one part fine aggregate and approved admixture, or as approved otherwise by the Engineer.

B. Minimum Compressive Strength: 100 psi within 24 hours. Perform and submit tests of comprehensive strength in accordance with C109.

C. Water: Minimum water as needed to achieve water-cement ratio compatible with pumping and placing requirements.

2.11 ELECTRICAL INSULATIVE COATING:

A. Electrical Insulative Coating: Approved moisture-insensitive coating, 100 percent solids, containing no solvents for use on dry or damp concrete of steel surfaces, with the following additional requirements:

1. Properties:
   - a. Minimum tensile strength: ASTM D638, 5,000 psi in 14 days
   - b. Dielectric strength: ASTM D1304, 440-465 volts per mil.
   - c. Dielectric constant: ASTM D1304 as follows:
     - 1) 60 Hertz: 3.4 - 3.5.
     - 2) 1,000 Hertz 3.3 - 3.4.
   - d. Power factor: ASTM D1304 as follows:
     - 1) 60 Hertz: 0.006 - 0.007.
     - 2) 1,000 Hertz 0.03 - 0.04.
   - e. Viscosity: 6,000 centipoises plus-orus 1,000 centipoises, as determined by Brookfield Viscometer using No. 6 spindle at 50 rpm.
2. Primer: Zinc-rich, MS MIL-P-26915 (USAF) Type 1, Class B.

2.12 INSTRUMENT PLATFORM MOUNTING BRACKETS:

A. Construction: Steel, minimum 1/8-inch thick, having a smooth finish where instrument attaches. Make bracket rigid enough to resist deflection or movement when a theodolite is mounted and operated on top of it. If deflection or movement is apparent, add bracing supports as directed by the Engineer.

B. Bracket Supports: Attach bracket supports to the underside of platform mounting bracket to provide a clear and unobstructed working area at and above platform.

C. Size: Sufficient length and width to allow efficient set-up and operation of various theodolite and electronic distance measuring instruments (EDMI).
1. Minimum width: Nine inches.
2. Minimum length: Sufficient to allow a mounted instrument a at least one foot clearance from tunnel lining.

D. Install platform mounting brackets to a level plane within the adjustment limits of a standard tribrach.

E. Forced Centering Hole: Provide each platform mounting bracket with a forced centering hole to accept a brass instrument mounting screw (standard 5/8-inch by 11-inch thread) for securing a standard tribrach.

1. Provide a brass mounting screw that is hollowed and of sufficient diameter to allow the instrument operator to site below platform mounting bracket with a nadir optical plummet
2. Mill force centering hole and brass mounting screw to match each other within 0.001 inch tolerance.
3. Provide the Engineer with three mounting screws for duration of the Contract.

F. Surveyor Platform: Provide a platform underneath each instrument mounting bracket for the purpose of supporting a surveyor during measurement observation process from wither side of instrument.

PART 3 - EXECUTION

3.01 TEMPORARY VENTILATION:

A. Provide, operate and maintain for the duration of the project a temporary ventilation system which will conform to specified safety requirements and those of jurisdictional authorities. Remove the system from the site when work is completed.

B. Use equipment which is adequate to maintain a sufficient supply of fresh air in underground work areas.

3.02 SAFETY REQUIREMENTS:

A. Perform work so as to minimize safety hazards and exposure of men and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.

B. In case of an emergency or work stoppage likely to endanger excavation or adjacent structures, continuously maintain full work force 24 hours per day including weekends and holidays until emergency or hazardous conditions no longer jeopardize stability and safety of the work.

C. Perform tunnel construction so as to minimize ground movement in front of and surrounding the tunnel and prevent subsidence of surface, structures and utilities above and in the vicinity of the tunnel. Perform specified pre-support measures.

D. Support ground continuously so as to prevent loss of ground and keep perimeters and maintain stability of tunnel faces, passages and bottom of shafts.

3.03 DISTANCE BETWEEN HEADINGS:

A. Maintain longitudinal distance of a minimum of 150 feet between adjacent active tunnel faces being simultaneously excavated.

B. Where tunnel heading is being advanced adjacent to previously excavated tunnel, ensure that shotcrete lining in the first tunnel is completely installed and stable.

C. Where two tunnel headings of the same tunnel tube are being excavated toward each other, stop excavation at one face and install at this face elements of shotcrete lining and pre-support as specified and a minimum seven-inch thick one layer welded wire fabric reinforced shotcrete face support. Place these support measures at a minimum distance of 100 feet between the headings.

D. Where tunnel heading is being advanced toward previously excavated tunnel, ensure that shotcrete lining and face support as specified in the stopped tunnel are completely installed and stable.

3.04 SURVEILLANCE OF HEADINGS:

A. Maintain qualified personnel on duty to monitor conditions that might threaten stability of heading whenever tunnel excavation is suspended or shut down.

B. Have one qualified inspector always on duty to monitor stability of face and roof during tunneling operations. Use of approved monitoring devices, such as closed circuit television, which permit continuous monitoring of conditions at the face by qualified observers from outside of the tunnel is permitted.

3.05 DETECTION OF MOVEMENT:

A. Install instruments shown and monitor the horizontal and vertical movements of the tunnels and the station as applicable as specified in Section 02291. If movements are observed, take appropriate action to arrest these movements.

B. Displacement Limits of Initial Lining:
   1. NATM tunnels:
      a. Horizontal: 0.30 inch.
      b. Vertical: 0.30 inch.
   2. NATM station:
      a. Center drift:
         1) Horizontal: 0.50 inch.
         2) Vertical: 0.40 inch.
      b. Side drifts:
         1) Horizontal: 0.20 inch.
         2) Vertical: 0.25 inch.
      c. Center drift during excavation of side drifts in addition to 2.a. above:
         1) Horizontal: 0.50 inch.
         2) Vertical: 0.05 inch.
      d. Middle drift:
         1) Horizontal: 0.30 inch.
         2) Vertical roof: 0.50 inch.
         3) Vertical invert: 0.60 inch.
   3. NATM shafts:
      a. Shallow shafts:
         1) Horizontal: 1.0 inch.
         2) Vertical: 0.5 inch.
      b. Deep shafts:
         1) Horizontal: 0.5 inch.
         2) Vertical: 0.5 inch.

3.06 FIELD QUALITY CONTROL:

A. Do not encroach on NATM lining clearance line with shotcrete lining. Consider inaccuracy of construction, material tolerances, and shotcrete lining deflection to determine dimensions of actual excavation and support and pre-support elements.
   1. Install lattice girders as close as possible to the line of excavation but not closer than one inch (unless otherwise shown on the Contract Drawings), from the defined inside face of the initial lining.

2. Submit survey protocols and plotted profiles with a maximum spacing of 20 feet not later than 90 days after excavation.

B. Document stability of the tunnel support system bu monitoring as specified. Demonstrate the absence of continuing and significant deflection or increase of stress before installing the waterproofing system and the concrete tunnel lining.
1. Submit monitoring protocols and plotted information.

C. Allowable Tolerances: Place cast-in-place concrete to the following tolerances:
1. Departure of tunnel, shaft and station from line or grade shown as measured from working point of tunnel, shaft and station: One inch.
2. Variation in thickness of lining: Minus zero inch.
3. Variation in internal diametrical distance between two points: Plus-or-minus one inch.

3.07 EQUIPMENT:

A. General:
1. Use equipment that can be controlled to desired line grade, minimize over excavation and loss of ground, capable of excavating the ground materials and grouted soils. Provide specified tunnels, shaft and station lining.
2. Use equipment and methods that satisfy the requirements of this section while preserving and protecting the inherent strength of the material surrounding the tunnel, shafts and station.

B. Grouting Equipment for Contact Grouting:
1. For pumping grout, use approved pump capable of developing specified uniform pressure at grout hole connection.
2. Provide automatic shutoff control to prevent grouting pressure from exceeding that specified.
3. Keep equipment lines clean by constant circulation of grout and by periodic flushing with water.
4. Use equipment that allows flushing with grout-intake valve closed, water-supply valve open and grout pump running at full speed.
5. Provide two pressure gauges, one at the pump and other on manifold hookup at collar of hole being grouted. Use pressure-gauge ranges as necessary for each part of the grouting program.
6. Provide suitable stop valves at collar of hole to maintain necessary pressure until grout has set.
7. Provide grouting equipment with means of accurately determining amount of grout injected.
8. Furnish accurately calibrated, high-precision gauge to periodically check accuracy of pressure gauges.

3.08 INSTALLATION OF NATM SHOTCRETE LINING:

A. NATM Shotcrete Lining: Section 02426.

3.09 TUNNEL WATERPROOFING:

A. Install in accordance with Section 07138.

3.10 EXCAVATION:

A. General:

1. Excavate to lines, grades, dimensions and tolerances, as shown and specified to accommodate shotcrete lining and concrete linings including waterproofing.
2. Install support, pre-support systems and shotcrete lining as shown. Allow neither the shotcrete lining nor other support or pre-support systems to intrude into clearances required for the placement of the final concrete lining.
3. Unless otherwise noted or approved by the Engineer, open up a new round of excavation only following the complete installation of the support elements of the previous round and for a length not exceeding the maximum length of unsupported excavation shown for the respective support and excavation type and specified herein. However, reduce the spacing of the lattice girders and the length of round if ground conditions and the actual stand-up time encountered or achieved by pre-support means so dictate.
4. For station, remove shotcrete installed to support previously excavated tunnel or drift within the station interior as shown.*9
5. Apply additional subdivision of excavation areas, and face stabilization by means of a face stabilization wedge and/or shotcrete wherever ground conditions require to do so. The selected method is subject to approval by the Engineer.
6. Apply a flash-crete layer immediately after excavation to seal and protect material from deterioration and initial loosening. Install shotcrete lining in a timely manner so as to maintain the inherent strength of the ground.
7. Full face support with a minimum of two inches of shotcrete is mandatory for stoppages longer than 24 hours but not exceeding 72 hours. For stoppages beyond 72 hours full face support by a minimum seven inches thick shotcrete layer reinforced with one layer welded wire fabric is mandatory.

B. General Excavation Sequences:

1. Top Heading: Apply pre-support in advance of excavation wherever required by ground conditions or specified hereafter.
2. Bench/Invert: Excavate bench/invert alternating with advance of the top heading, with a remaining separation as shown.*10

C. Excavation and Support Types:

1. Generally, make the determination of excavation and support type in the top heading, and under consideration of the anticipated subsurface conditions immediately ahead of the face and in the following bench and invert area.
2. Make evaluation of the ground conditions and of the appropriate excavation and support type in the top heading, and under consideration of the anticipated subsurface conditions immediately ahead of the face and in the following bench and invert areas.
3. The approval of the proposed excavation and support type by the Engineer or his failure to call attention upon improper or inadequate application of the related excavation sequence and/or tunnel support and/or pre-support, or to require respective chance will not relieve the Contractor of his responsibility for the integrity of the tunnel support or the proper excavation of the work.
4. Excavation and Support Type 1:
   a. Top heading and bench/invert excavation, top heading two rounds ahead of bench/invert excavation as shown.
   b. Tunnel support requirements include:
      1) Shotcrete lining: minimum seven-inch thick shotcrete, reinforced with one layer of welded wire fabric type 6 x 6 - w4.0 x w4.0, lattice

girders, splice bards, and splice clip as shown on the Contract Drawings.

2) Grouted pipe spiling: 1.5-inch I.D. perforated steel pipe. Where no systematic grouted pipe spiling pre-support measures have been installed as specified herein, install grouted pipe spiling at length and at locations as required. Where installed for more than one section overlap, make spilling minimum three feet.

c. Face stabilization:
   1) Shotcrete minimum two inch thickness as required.
   2) Face stabilization wedge in top heading or bench/invert as required.

d. Maximum length of unsupported excavation (excluding length for wwf reinforcement overlap as shown): Install support elements within a distance to the face of 3'-4" in the top heading, and 6'-8" in the bench/invert.

e. Maximum distance between top heading face and shotcrete closure in the invert: 16'-8" (excluding lengths for welded wire fabric overlap as shown).

f. In case of stoppages and in addition to other requirements, provide invert closure at a maximum distance of 11'-10" for stoppages exceeding 72 hours.

5. Excavation and Support Type 2:

a. Top heading and bench/invert excavation, top heading one round ahead of bench/invert excavation as shown.

b. Tunnel support requirements include:
   1) Shotcrete lining: minimum seven-inch thick shotcrete, reinforced with one layer of welded wire fabric type 6 x 6 - w4.0 x w4.0, lattice girders, splice bards, and splice clip as shown.

c. Rebar Spiling: No. 8 rebar, eight feet long, installed as required individually or up to around tunnel roof perimeter as shown.

d. Face stabilization:
   1) Shotcrete minimum two-inch thickness.
   2) Face stabilization wedge in top heading or bench-invert as required.

e. Maximum length of unsupported excavation (excluding length for wwf reinforcement overlap as shown on the Contract Drawings): Install support elements within a distance to the face of three feet four inches in the top heading, and six feet eight inches in the bench-invert.

f. Maximum distance between top heading face and shotcrete closure in the invert: 13'-4" (excluding lengths for welded wire fabric overlap as shown).

g. In case of stoppages and in addition to other requirements, provide invert closure at a maximum distance of 8'-6" for stoppages exceeding 24 hours.[*11]

D. Pre-Support:[*12]

1. Three types of tunnel roof pre-support are specified:
   a. Chemical grouting.
   b. Grouted pipe spiling.
   c. Rebar spiling.
2. Do not perform NATM tunnel excavation without the aid of specified pre-support measures
3. Install chemical grout arch above both inbound and outbound tunnels as shown. Install grouting pipes for the chemical grouting canopy by means of directional drilling and perform chemical grouting as specified.
4. Perform grouted pipe spiling in a systematic manner as shown and as specified for both the inbound and outbound tunnels
   a. Exact extent of grouted pipe spiling to be determined in the field in accordance with the following requirements:

1) Grouted pipe spiling to overlap with chemical grout arch for a length of a minimum of five feet.
2) Grouted pipe spiling to be installed as long as cover of P1 material above tunnel crown is five feet or less.

b. Install pipes for grouted pipe spiling in four-inch diameter pre-drilled holes. Use distancers to center pipes in boreholes.

c. Inject cement grout through perforated pipes with low pressure until entire predrilled hole is grouted.

5. Rebar spiling: Install rebars without end hardware by jacking.
6. As required by geologic conditions encountered, substitute specified roof pre-support with another specified measure after obtaining written approval from the Engineer.
7. Provide additional pre-support measures as required by geological conditions encountered or as directed by the Engineer.

E. Sequence and Direction of Tunneling:
1. Install chemical grout arch as shown.
2. For limitations and direction of tunneling conform to **Section _____**.

F. Probe Drilling:

1. During excavation in accordance with Excavation and Support Type 1 drill two-inch minimum diameter probe holes to determine soil and groundwater conditions ahead of tunneling.
2. Drill a minimum of three probe holes in the top heading; one located at approximately the tunnel center line and two feet below the tunnel roof, one each to both sides of the tunnel approximately two feet above the top heading invert and three feet distant from the tunnel wall. Alter location of probe holes as approved or as directed by the Engineer.
3. Add more probe holes as required and as directed by the Engineer.
4. Drill probe holes to minimum distance of 50 feet ahead of the excavation face.
5. Drill 50 feet probe holes after every 40 feet of tunneling so that soil and groundwater conditions are always known for a minimum 10 feet ahead of tunneling.
6. Drill probe holes only in the presence of the Engineer.[*13]

G. Groundwater Control:
1. Control groundwater in soil surrounding each tunnel to prevent the following:
   a. Heaving of invert, blow-ups, hazardous seepage, and sudden flow of soil in the tunnel face.
   b. Loss of ground and surface subsidence.
2. Perform free-air tunneling when groundwater levels, as observed in piezometers are:
   a. Lowered to the top of P1 material or lower four weeks prior to tunneling. Use at a minimum piezometers CP-1, CP-2 and CP-3 as shown on the Contract Drawings to verify groundwater levels.
   b. Dewatering requirements are provided in accordance with Section 02240.
3. Maintain groundwater levels as specified herein and in Section 02240 during tunneling and until minimum four weeks after cast-in-place concrete lining is installed and approved.
4. Collect infiltrating groundwater and pump or drain it out of the tunnel.
5. Where a probe hole indicates water inflow apply further investigation by drilling an additional probe hole approximately two feet below the water bearing probe hole. Repeat this procedure until invert level is reached.
   a. Use vacuum lances and/or drain pipes installed along the tunnel perimeter or otherwise as required to provide relief from water.

b. Commence tunneling after sufficient results of dewatering could be verified, or as directed by the Engineer.

6. Upon approaching saturated strata during tunneling, seal entire excavation face with a minimum four inches of shotcrete, reinforced with one layer welded wire fabric, and apply drain pipes and/or vacuum lances as dewatering measures. Excavation may continue after sufficient results of the additional dewatering measures could be verified, or as directed by the Engineer.
7. Prior to application of shotcrete lining, collect seeping groundwater or local groundwater inflow by means of drain hoses or water sheets or both to prevent build up of hydrostatic pressure behind the shotcrete lining and to prevent deterioration or reduction of the strength properties of the fresh shotcrete. Use water sheet to collect water seepage through shotcrete and drain away by means of drain hoses.
8. Install and always maintain temporary drainage sumps at minimum one foot below tunnel invert and locations as required, and construction drains at tunnel sidewalls of sufficient capacity to pump out water collected from within the tunnel.
9. Maintain drainage and pumping systems free of hardness build-up caused by calcification and/or corrosive characteristics of the groundwater, treat systems to prevent or kill bacterial clogging of screens, piping and sumps.
10. Use approaching previously drilled exploratory or other borings which intersect the tunneling cross section, ensure that procedures and materials are in place to immediately seal off and stabilize the borehole as required to prevent water inrush and/or associated groundloss.

H. Break-Out:
1. Install shotcrete reinforced collars around the proposed break-outs from the support of excavation as shown on Contract Drawings. Submit for approval by the Engineer collar arrangement and break-out construction procedures as adjusted to actual support of excavation.
2. Excavate and support tunnels in the start-up section as shown.
3. Prior to break-out construction, install horizontal drain pipes and/or vacuum lances as required two feet below the tunnel invert for the local dewatering.
   a. Utilize knowledge of geologic conditions based on shaft excavation.
   b. As required to promote invert stability, limit length of round in bench/invert to three feet and four inches.
4. Construct break-out prior to “hole through” at support of excavation.
5. Construct break-out following installation of chemical grout arch.

I. Air Quality:
1. Conduct drilling and tunneling operations by methods and with equipment that will positively control dust, fumes, vapors, gases, fibers, fogs, mists or other atmospheric impurities in accordance with specified safety requirements.
2. Provide approved instruments for testing quality of tunnel atmosphere, take samples under working conditions at prescribed intervals. Submit results of the quality tests on a daily basis.

J. Dispose of excavated material at locations outside the Authority’s right-of-way. If contaminated soil is unexpectedly encountered, inform the Engineer immediately for a resolution.

K. Dispose of groundwater and wastewater from the operation as quickly as possible without causing damage. Maintain ditches and sump pumps. Dispose of groundwater in an environmentally approved manner to meet or exceed the code requirements.

L. Temporary Backfill: Protect the invert area of tunnel tubes from construction equipment traffic until placing of the final invert concrete by means of a work slab, gravel bed, or other suitable material approved by the Engineer. Have the temporary backfill protect the shotcrete lining from being damaged. This invert protection road to have a height in the centerline of the tunnel of at least three feet unless otherwise approved.

M. NATM Portal Wall:
1. The Contractor may choose slurry wall or other equivalent methods to construct the NATM portal wall.
2. The Contractor is not allowed methods such as soldier piles and lagging method to construct the NATM portal wall.
3. Have methods of excavation and portal wall construction approved by the Engineer before starting excavation and construction of the portal wall.

3.11 TEMPORARY TUNNEL WIDENINGS, WORKSHAFTS AND OTHER OPENINGS:

A. Design, excavate, support and backfill temporary tunnel widenings, workshafts and other openings conforming to this section, and in accordance with Sections 02320 and 02260.

B. Seal such openings when no longer necessary.

C. Form and place Class 2500 concrete, two feet thick, in shafts over tunnels to prevent damage to tunnel shape. When concrete has achieved design strength, backfill remaining void in accordance with Section 02320.

3.12 TUNNEL CONNECTION AND TERMINATIONS AND TEMPORARY BULKHEADS:

A. Connect new tunnels to existing structures by removing existing bulkheads if necessary and sealing junctions.

B. Provide temporary bulkheads to seal terminations of tunnels which are not connected to permanent structures.

C. Design temporary bulkheads where and when necessary. Obtain approval of the design prior to construction. Provide bulkhead which is capable of resisting lateral earth and hydrostatic pressures, waterproof and capable of removal without damage to concrete lining.

3.13 CONCRETE CONSTRUCTION:

A. Fill enlargements of tunnel excavation beyond dimensions shown with concrete, to provide a proper surface for installing waterproofing.

B. Install waterproofing and perform concrete work in accordance with Sections 03100, 03200, and 03300.

C. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure.

D. Protect waterproofing during installation of reinforcement and forms for placing cast-in-place concrete lining.

E. Schedule erection of concrete tunnel lining so that the concrete is placed after decline of shotcrete lining deflection.

F. Perform contact grouting through grout pipes in the roof.

3.14 DEFECTIVE LINING:

A. Watertightness Criteria: Section 03300.

B. Cast-in-place concrete lining will be considered defective if thickness of cast-in-place concrete at any point is less than 12 inches.

3.15 CORRECTIVE WORK:

A. Provide reinforcement in cast-in-place lining wherever thickness of cast-in-place concrete at is less than 12 inches but greater than nine, at no additional cost to the Authority.

B. Cast-in-place lining less than nine inches thick:
   1. Wherever cast-in-place concrete lining is less than nine inches thick, enlarge the excavation cross section by remining, so that the specified minimum thickness is achieved.
   2. Support the tunnel shotcrete lining during remining.
   3. Submit method of support during remining, including design calculation signed by a professional engineer registered in the jurisdiction where the work is being performed, description of material, and sequence of operation for the Engineer's approval.
   4. Maintain qualified personnel, equipment and adequate supply of materials on-site to perform emergency support measures during remining. Submit emergency action plan for the Engineer's approval prior to starting remining operations.

3.16 INSTALLATION OF ELECTRICAL INSULATIVE COATING:

A. Electric insulative coating installation may be omitted if the geomembrane meets the dielectric strength of 440-465 volts per mil as specified for electric insulative coating. If electric insulative coating will be installed, install as follows:

B. Apply coating prior to placement of invert and safety walk concrete on shotcrete lining.

C. Surface Preparation: Remove dirt, grease and heavy laitance by wet sandblasting, water blasting or wire brushing.

D. Application: Apply in two coats of equal thicknesses totaling 20 mils minimum dry film thickness in accordance with recommendations of coating manufacturer

PART 4 - MEASUREMENT AND PAYMENT

4.01 MEASUREMENT:

A. Placement of perforated steel pipes in predrilled holes: Lineal feet.

B. Placement of steel bars: Lineal feet.

C. Placement of lances and drain pipes (slotted PVC pipes): Lineal feet.

D. Measurement for payment will not be made for the following items:
   1. Drilled holes, grouted pipe spiling, rebar spiling, vacuum lances or drain pipes lost or damaged due to Contractor's negligence.

2. Grout loss due to improper anchorage of grout pipes, injections, and failure of Contractor to seal leaks.
3. Loss of grout when work is not being performed in accordance with specifications and is interrupted by the Engineer, or when work is stopped to implement specified contingency measures.

E. Except as defined below, no separate measurement or payment will be made for work specified in this section, such work being considered incidental to and part of other pay items.

4.02 PAYMENT:

A. Compensation for the following will be made on unit price basis.
1. Furnishing and installing Grouted Pipe Spiling for NATM Tunnels: Payment will be made for total length of pipes incorporated in work. Cost of pipes, drilling holes, grouting, fittings, manifolds, pumps, hoses, connections, and other incidentals required to perform work will be included in cost for placing pipes.
2. Furnishing and installing rebar spiling for NATM Tunnels: Payment will be made for total length of steel bars incorporated in work. Cost of steel bards and other incidentals required to perform work will be included in cost of placing rebar spiling.
3. Furnishing and Installing Vacuum Lances and Drain Pipes for NATM Tunnels: Payment will be made for total length of slotted PVC pipes incorporated in work. Cost of lances and pipes, hoses, connections, fittings, filter fabric, collection pipes, pumps, operating costs and other incidentals required to perform work will be included in cost for placing lances and drain pipes.
4. Cost of work includes cost of materials, labor and equipment required to perform work.
5. Compensation for work specified in this section will be made in the following manner:
   a. Grouted Pipe Spiling in NATM Tunnels: Lineal feet.
   b. Rebar Spiling in NATM Tunnels: Lineal feet.
   c. Vacuum Lances and Drain Pipes: Lineal feet
   d. Work not included in above is included in Lump Sun Pay Item No. 1.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Include the limits of NATM excavation and construction sequence on structural Contract Drawing.

***2**. Include ”Excavation and Support Types” based on the material anticipated being encountered during the proposed excavation. These types should also be shown and clarified on the structural Contract Drawings.

***3**. On a case-by-case basis, if directional drilling is to be used, write a new specification section on directional drilling.

***4**. Establish the frequency of mapping.

***5**. List additional Quality Assurance (QA) requirements, including requiring other specialists as necessary on the Contractor’s field staff, depending on the soil encountered and the procedures proposed. As an example, a proposal for jet grouting should be included in the definitions and QA sections and a jet grouting specialist should be required on the Contractor’s staff.

***6**. If an NATM Portal Wall is proposed at the beginning of excavation, include requirements such as the maximum lateral movement of soil behind the wall, the vertical movement of the wall, provisions for grouting for pre-support and chemical grout arch etc.. Otherwise delete this paragraph.

***7**. If directional drilling is to be used, write a new specification section on directional drilling.

***8**. If rebar spiling is used, show it on the Structural Contract Drawings. The size and the length of spiling rebar may be changed by the Section Designer if warranted by subsoil conditions.

***9**. Show these on the Contract Drawings.

***10**. Show the scheme of excavation sequence indicating heading, bench/invert, center drift, side drifts, middle drift, etc.

***11**. Revise these support Types 1 and 2, if necessary, to suite the subsurface conditions anticipated, based on the subsoil exploration.

***12**. Show types and extent of such support on Contract Drawings.

***13**. Show the arrangement of probe holes on Contract Drawings

END OF SECTION

SECTION 02420

ROCK REINFORCEMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing and testing rock bolts, accessories, welded-wire fabric and miscellaneous steel for reinforcement of roc

B. Related Work Specified Elsewhere:
   1. Rock tunneling: Section 02410.
   2. Drilling and pressure grouting: Section 02431.

C. Definitions:
   1. Initial support: Section 02410.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. ASTM: A185, A615, C144, C150, C579, F432.

B. Demonstration:
   1. Prior to installation of rock bolts, arrange demonstration to show that specified test requirements have been met.

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. Prior to beginning work, submit the following:
         1) Locations, installation procedures and layouts of rock bolt installations.
         2) Pattern covering crown, sidewalls and face.
         3) Spacing, type, size and length of rock bolts, together with type of bolt accessories and surface covering.
         4) Relationship to rock discontinuities and execution sequence as well as time and distance from face for installation.
   2. Samples:
      a. Bolts:
         1) At least 30 days prior to purchase of rock bolts, obtain samples of various sizes and types to be used from normal stock of manufacturer. Submit three such sample bolts of each type for testing by an independent testing agency designated by the Engineer.
         2) In the event of failure, provide additional samples until it can be demonstrated that bolts scheduled for delivery meet specified requirements.
      b. Grout additive:
         1) One two-ounce sample of pure, unpolished metallic aluminum powder or similar additive proposed for use in grout mixture.

c. Resin cartridges:
1) Three samples of each type of resin cartridge.

3. Certification:
a. Prior to installation of rock bolts, arrange demonstration to show that specified test requirements have been met.
b. Certificates verifying that samples for testing are from normal stock.
c. Certified mill reports of the bolts.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Rock Bolts and Accessories:
1. General requirements:
a. In accordance with ASTM F432.
b. Rock-bolt assembly: Bolt, bearing plate, washer and nut as specified.
c. At least 5-1/2 inches of rolled thread on outer end.
d. Fabricated from deformed bars.
2. Type 1, with resin end anchors and fully resin-encapsulated:
a. ASTM A615, Grade 60.
b. Approved method of resin anchorage to take specified tension.
3. Type 2, with mechanical end anchors and fully grouted:
a. ASTM F432, Grade 55, hollow core.
b. Approved expansion-shell anchorage on inner end.
4. Protective grease: Type used for bilge protection, containing rust-inhibiting compounds, factory-applied to threads of rock bolts and entire surface of nuts and washers.
5. Steel bearing plates: Square, not less than 3/8-inch thick, having bearing area of at least 36 square inches unless otherwise shown, with holes for injection of grout, for effective air release and for bolt. Hole in steel bearing plate of sufficient size to eliminate binding of bolt.
6. Nuts: Hexagonal head
7. Steel washers: Quenched and tempered. Hard-steel washers to be two inches in diameter and 1/8-inch thick unless otherwise shown. Center hole to be 1/8-inch larger in diameter than bolt with which it is to be used.

B. Miscellaneous Steel: Products of recognized manufacturer, comprising rock-bolt mats, mine roof ties, mine roof channels or similar members which are attached to roof surface by means of rock bolts.

C. Wire Fabric: ASTM A185, hot-dip galvanized.

D. Expansion Shells: As approved, capable of developing guaranteed minimum yield strength of rock bolt.

E. Grout and Mortar:
1. Cement: ASTM C150, Type I.
2. Water: Section 03300.
3. Additive: Pure, unpolished metallic aluminum powder or other approved additive.
4. Sand: ASTM C144, except maximum particle size limited to Size 8 sieve.

F. Lubricant for Threads and Washers: Molybdenum-disulfide base, Molykote G, Alpha Molykote Corporation or equal.

G. Resin Cartridges:

1. Two components as follows:
   a. Resin: High-strength unsaturated polyester with predominance of nonreactive inorganic filler.
   b. Catalyst: Containing peroxide with nonreactive inorganic filler.
2. Strength of mixed and cured resin when tested in accordance with ASTM C579:
   a. Compressive strength: 17,000 psi.
   b. Tensile strength: 7,500 psi.
   c. Shear strength: 4,800 psi.
3. Gel time:
   a. Gel and cure time of fast-set resin: Sufficient to permit bolt tensioning within 10 minutes or as recommended by manufacturer for the particular application.
   b. Gel time of slow-set resin: 15 to 30 minutes.
4. Materials to have thixotropic and viscous properties to permit adequate mixing of materials by manipulating bolt and to prevent mixture from running out of hole after mixing.
5. Shelf life: Six months, minimum.
6. Casing constructed of saturated polyester providing optimum resistance to moisture but easily fractured to enable complete mixing during installation.

2.02 MIXES:

A. Grout:
   1. Mix cement and sand dry.
   2. Add water to obtain water-cement ratio of approximately 0.4 by weight.
   3. Mix in high-speed mixer for three minutes minimum.
   4. Prepare batches so that time before use does not exceed 45 minutes.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL:

A. For underground excavation in rock on which bolts are used, install rock bolts within three feet of heading and within eight hours after blasting and prior to next shot.

B. When excavating with tunneling machine which provides direct ground support over machine such as a shield, install rock bolts within three feet of trailing edge of such support.

C. After each exposure of final rock surface, examine surface and confirm that rock bolt pattern to be installed will be adequate. Provide rock reinforcement that is adequate at all times to ensure safety of personnel and construction operations.

D. Drill holes in rock of depth and diameter necessary to accommodate bolt and to give anchorage consistent with type and length shown on Contract Drawings and approved shop drawings. Clean holes of drill cuttings, sludge and debris.

E. Avoid damaging threads on projecting end of bolt during installation.

F. Remove protective grease from threads and nuts.

G. Apply lubricant to threads. Use lubricant between washers and nuts.

H. Between bearing plate and steel washer, set bearing surface of nut perpendicular to bolt by use of bevel washers as necessary.

3.02 INSTALLATION OF RESIN-ANCHORED (TYPE 1) ROCK BOLTS:

A. For installation of resin-anchored rock bolts, have qualified representative of manufacturer supervise installation of initial 50 rock bolts. Have representative periodically reinspect installation procedures.

B. After drilling of rock bolt holes has been completed, insert resin cartridges in accordance with manufacturer's recommendations for anchorage conditions. Avoid rupture of cartridge skin.

C. To rupture cartridge and mix resin, insert bolt in hole rotating it at penetration rate of two inches per second through cartridge. Rotate bolt by mechanical means for five to ten seconds after bolt reaches bottom of hole or for 20 seconds minimum, whichever is least.

D. Apply tension as specified after recommended cure time for fast-set resin has elapsed, but before gel time for slow-set resin has elapsed.

3.03 INSTALLATION OF MECHANICALLY ANCHORED (TYPE 2) ROCK BOLTS:

A. Insert bolt in hole and set anchorage at necessary depth.

B. Tension bolt as specified.

C. Grout bolt as specified.

3.04 GROUTING OF ROCK BOLTS:

A. Pack or seal holes in bearing plate and between bearing plate and rock or shotcrete surface so that grout will be retained in hole.

B. Inject grout into hole at pressure not greater than that necessary to fill hole adequately.

C. Continue injecting grout until there is full return of grout through air vent.

D. If, during grouting of bolt, grout is found to flow from points in adjacent rock surface, plug or caulk leaks until leakage is stopped.

E. Grout only rock bolts located further than 50 feet behind working face as heading advances.

3.05 TENSIONING OF ROCK BOLTS:

A. Type 1 - Resin Anchored: Nominal tension to ensure proper nut tightening, not to exceed 20 percent of bolt guaranteed minimum yield strength.

B. Type 2 - Mechanically Anchored: Tension rock bolts by direct pull using approved hydraulic jacks and accurate calibrating techniques to between 60 and 80 percent of bolt guaranteed minimum yield strength; tighten nut.

C. If specified tension is not achieved for tensioned rock bolts, submit modified procedure for approval.

3.06 PULL TESTS ON INSTALLED BOLTS:

A. Equipment:
   1. Provide equipment consisting of suitably sized hollow ram jack, adjustable bearing truss for aligning direction of pull with centerline of bolt, extension bar for attaching

jack to bolt, hydraulic pump with gauge calibrated to read directly in pounds for ram being used, dial gauge which reads in increments of 0.001-inch over a range of two inches, magnetic or independent dial gauge mounting and other necessary accessories.

2. Calibrate pump gauge while connected to jack by testing machine before performing pull tests and at subsequent times as directed during construction period.
3. Maintain ready access to spare parts for testing equipment, especially gauges and pump seals, so that work will not be delayed.
4. Maintain pull test equipment in good working condition.
5. Ensure that equipment is used exclusively for pull tests. Store as directed.

B. Testing:

1. Conduct pull tests on installed rock bolts as directed.
2. Perform testing to:
   a. Measure head movement.
   b. Verify that specified tension can be sustained by bolt and anchorage without yield of steel or rock or slip of anchor.
   c. Check grouting procedure and prove grout strength.
3. Test rock bolts as follows:
   a. As selected at random by the Engineer according to the following schedule:

For Each Rock Bolt Type Installed	Required Testing
First 100 bolts	10
Remaining bolts	1 per 100

   b. No earlier than 24 hours and no later than three days after installation.
   c. To at least 80 percent of minimum specified yield strength.
4. Correction of defective work:
   a. For test purposes, bolt will be considered to have failed if outward movement of bolt anchorage in excess of 0.001-inch occurs and continues to occur at sustained loading below tension specified.
   b. Replace bolts that fail or pull out with bolts that meet specified testing requirements.
   c. Perform further testing, up to a minimum of five rock bolts in vicinity of failed bolt as directed. Replace as directed bolts that fail or pull out.

3.07 ROCK SURFACE REINFORCEMENT:

A. Install where shown, where directed and where approved when conditions at the site dictate, rock surface reinforcement consisting of wire fabric, miscellaneous steel or a combination of both. Rock conditions which may require surface reinforcement include, but are not limited to, places where the rock is weathered, excessively jointed or fractured or where it has a tendency to spall.

B. For installation of surface reinforcement and rock bolts simultaneously, place reinforcing materials over rock bolts between rock surface and steel bearing plate; tension bolt to draw reinforcing materials up tightly to the rock surface. Where wire fabric is used, overlap 1-1/2 times mesh dimension.

C. Where surface covering or reinforcement is placed after installation of rock bolts, attach materials to previously installed bolts by use of additional steel plate and nut by welding or

by supporting with additional rock bolts. Check existing rock bolts to which extra steel plate and nut are added.

D. Replace installed bolts which become loose after attachment of surface reinforcement.

E. Firmly attach surface covering or reinforcement so that it closely follows approximate contour of rock.

END OF SECTION

SECTION 02425

PRECAST-CONCRETE TUNNEL LINING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing precast-concrete segments for use as lining rings in one-pass tunnels with waterproofing gaskets and bolts, and as the initial lining of the two-pass system tunnels. Precast concrete lining segments for the two-pass system may be either gasketed and bolted when the initial liner needs to exclude water from tunnels being driven; or the segments may be jacked in place and retained by steel dutchmen and then grouted

B. Related Work Specified Elsewhere:
   1. Installation of the linings: Section 02415.
   2. Concrete formwork: Section 03100.
   3. Concrete reinforcement: Section 03200.
   4. 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. MS: MIL-23241 (Ships), MIL-P-26915 (USAF).
   3. FS: QQ-L-201, TT-S-230.
   4. ACI: 318.
   5. ASTM: A36, A123, A126, A153, A185, A325, A615, A706, C143, C309, C509, D395, D412, D471, D2240, D2628, F436.
   6. AWS: D1.4.

B. Dimensional Tolerances:
   1. Fabricate segments to dimensions and tolerances shown. Contractor may use closer tolerances if necessary for erection, watertightness or both.
   2. Maintain tolerances at mean temperature of 68F. Measure tolerances prior to installation of gasket and elastomeric compression packing. Replace or correct segments which do not comply with tolerances shown.
   3. Determine the necessary taper of rings to cope with horizontal and vertical curves or to correct misalignment, and submit details for approval.
   4. Provide labor, tools, templates and facilities necessary for inspection of manufactured segments.
   5.

C. Demonstration Lining:
   1. Before starting production of precast-concrete segments, furnish five-ring long section of complete precast-concrete segment lining, including gasket, compression packing, exterior coating, nuts, bolts and accessories to demonstrate construction of completed precast-concrete segment lining within tolerances shown. Include in demonstration lining two rings using tapered segments. For segments to be installed in earth tunnels include water-repellant treatment.
   2. Assemble entire demonstration lining at job site, above ground, with longitudinal axis of rings horizontal. Provide temporary support structures such as base cradle and lateral bracing for such demonstration. Place rings in longitudinal compression using identical type of holding devices proposed for use in tunnel erection.
   3. Notify the Engineer 15 days prior to installation of demonstration lining.

4. Maintain demonstration lining until tolerances of completed lining are verified and removal is approved. Dismantled segments may be used for permanent tunnel lining, if approved.
5. If approval is withheld, dismantle demonstration lining as directed, adjust forms, cast new segments, if necessary, and erect new demonstration lining for approval.

D. Production Units:
1. Commence production of segments only after written approval of demonstration lining has been obtained.

E. Recorders: If casting is done at off-site plants, recorders described in Section 03300 are not required.

F. Tunnel Demonstration Lining:
1. Construct one additional demonstration lining in initial 20 feet of tunnel. Erect the lining within the tail of the shield utilizing the erection methods for this project. The purpose of this additional demonstration lining is to ensure that the tunneling and erection procedures are capable of erecting the complete tunnel lining to the specified tolerances.
2. Stop tunneling after installation of the 20 feet (five rings) of demonstration lining until tolerances are verified and approved.
3. If approval is withheld, submit proposed measures to rectify the 20-foot demonstration lining as well as proposed modification of procedures to ensure satisfactory installation of the tunnel lining.
4. Do not resume tunneling until corrective measures are approved and implemented.
5. After approval of corrective measures, construct an additional lining if required by the Engineer.

G. Quality-Assurance Program for Gaskets: Before starting production of gaskets, provide quality-assurance program to ensure that manufactured gaskets meet the same specifications and quality as originally approved.

H. Rebar-Coating Applicator: Company approved by the Engineer specializing in hot-dip galvanizing after fabrication.

I. Qualifications of Fabricator: Have precast-concrete segments fabricated by a firm with recent continuous successful experience in the fabrication of precast-concrete structural units with tolerances equivalent to those specified in this section.

J. Adjust, if necessary, the gasket and gasket-groove dimensions to satisfy gasket testing requirements specified in Article 3.3.B, with the approval of the Engineer.

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. Include complete details of formwork, reinforcement, inserts and accessories necessary for manufacturing, transportation and erection.
1) Have drawings and design certified by a professional engineer licensed to practice in the jurisdiction where the work is to be performed.
2) Detailed design for segment lifting devices, providing for complete removal of lifting device if device intrudes into tunnel space
b. Plant layout: Detailed flow diagram showing stages in manufacture of segments.

c. Procedures:
1) Detailed description of procedures for fabricating, handling, transporting, storing and erecting segments, including calculations of stresses during handling.
2) If the reinforcement shown on the Contract Drawings is inadequate for the handling, storage, stacking and erection forces, including jacking, provide additional reinforcement to compensate for the anticipated stresses at no additional cost to the Authority.

2. Samples
a. Exterior coal-tar epoxy coating: One quart.
b. Gasket: One complete ring for each type.
c. Compression packing: Two square feet.
d. Adhesive: One pint of each kind used.
e. Bolt, with washer, nut and grommet in sets: Two of each set.
f. Sealant: Two tubes.
g. Back-up rod: Three feet.
h. Grout plugs: Two.
i. Water-repellant treatment: One-quart container and one concrete panel, 12 inches square, treated on one side.
j. Bolt sleeves, if required: Two.

3. Certification:
a. Certified reports of successful testing by an independent testing agency verifying that elastomeric joint-seal materials conform to the requirements of ASTM D2628 for earth-tunnel segments and with ASTM C509 for rock-tunnel segments.
b. Certification that fabricator of segments has demonstrable experience in the fabrication of precast-concrete structural units similar to specified units as a predominant portion of its production.
c. Certification for concrete as specified in Section 03300.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Precast Concrete Segments:
1. Store and handle materials in accordance with Section 03300, with the following additional requirements:
a. Transport, store and handle segment units so as to prevent damage to surfaces, edges and corners and to prevent development of stresses within units.
2. Keep units under cover and protected prior to installation.
3. Protect mating surfaces of segments and gaskets from detrimental conditions during transportation.
4. The Authority retains the right to reject any segments structurally damaged as a result of improper fabrication, handling, storing, stacking or transporting of the segments.
5. Ship tapered units of complete rings, properly identified, when the segments are to be bolted for erection.
6. Provide a positive means of identifying each segment, acceptable to the Authority. Identification markings must be cast in or stenciled on the interior face of the segments.

B. Water-Repellant Treatment:
1. Deliver products to the job site in their original unopened containers clearly labeled with the manufacturer's name and brand designation, the referenced specification number, and the quantity or net weight of contents.
2. Store products in an approved dry area and protect from contact with soil and from exposure to the elements. Keep products from freezing.

3. Handle products in a manner that will prevent breakage of container and damage to contents.

C. Markings, including logos, trademarks and proprietary information, but excluding panel-identification markings, are prohibited on surfaces of tunnel-lining segments.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Do not apply water-repellant treatment to unprotected surfaces in wet weather or to surfaces on which ice, frost, or water is present.
2. Do not apply water-repellant treatment unless the ambient temperature is at least 50F and rising unless approved in writing.
3. Provide ventilation in accordance with specified safety requirements.

PART 2 - MATERIALS:

2.01 MATERIALS:

A. Concrete:
1. Section 03300, with not less than seven bags of cement per cubic yard of concrete, with the following additional requirements as determined by ASTM C143:
a. Rock-tunnel segments: Class 5000.
b. Earth-tunnel segments: Class 8000.
c. Initial liner segment for two-pass tunnel: Class 6000.
d. Use mix of portland cement and ground-iron blast-furnace slag. Blast-furnace slag amount not to exceed 50 percent of the cement weight.
2. Admixtures, if used, to contain no chlorides, fluorides or nitrates.
3. Maximum size of aggregate: 3/4 inch.

B. Reinforcement: Section 03200, with the following additional requirements:
1. Rock-tunnel segments: Welded-wire fabric, ASTM A185.
2. Earth tunnel segments: ASTM A706, Grade 60 and ASTM A615, Grade 60. When welding of the reinforcing bars is required, use ASTM A706, Grade 60 bars. Conform to the Structural Welding Code–Reinforcing Steel, AWS D1.4 for the welding of reinforcing bars.
a. Liner rebar cage: Hot-dip galvanized, Section 05120. Coat reinforcing cages after assembly and welding.

C. Inserts, Anchors, Dowels and Accessories: Steel, ASTM A36 or equal; zinc-coated in accordance with ASTM A123. *1

D. Gasket:
1. Elastomeric seal: ASTM D2628.
2. Manufactured as continuous ring sized to fit panels snugly, formed to shape and size shown, with gasket corners molded, mitered and vulcanized to provide uniform thickness along entire length of mating surfaces.
3. Hardness: ASTM D2240, Shore A Durometer, as follows:
a. Rock-tunnel segments: 40, plus-or-minus five
b. Earth-tunnel segments: 55, plus-or-minus five.
4. Tensile strength: ASTM D412, 2,250-psi minimum, minus 10 percent.
5. Elongation: ASTM D412, 300-percent minimum, minus 25 percent.
6. Water absorption: ASTM D471, 24 hours at 212F, 10-percent maximum by weight.
7. Compression set: ASTM D395, Method B, 70 hours at 212F, 25-percent maximum.
8. Fire rating: Self extinguishing.

9. Dimensional tolerances: Plus-or-minus three percent.
10. Stress relaxations: 25 percent.
11. Contact pressure: Between 200 psi and 400 psi, as determined by specified compression test. *2

E. Compression Packing:
1. Neoprene sheet: 30 mils thick.
2. Hardness: ASTM D2240, Type A Durometer, 65, plus-or-minus five.

F. Adhesive:
1. As recommended by manufacturer of compression packing and gasket and compatible for conditions of application, including areas of applied waterproofing.
2. Use solution recommended by manufacturer for cleaning elastomers at time of segment installation.

G. Exterior Coating:
1. Coal-tar epoxy, MS MIL-P-23241 (Ships), Type 1, Class 2.
2. Thinner: As recommended by coating manufacturer.

H. Bond Breaker: Section 03100, non-staining.

I. Grout Plugs:
1. ASTM A126, Class B, 1-1/2 inch NSPM external threads, galvanized in accordance with ASTM A153, threads coated with thread sealing compound SEAL UNYTE or T-UTYPE 555 manufactured by J.C. Whitman Manufacturing Company, Wadsworth, Ohio, or approved equal.
2. Lead washer: FS QQ-L-201.

J. Fasteners:
1. Bolts and nuts: ASTM A325, Type I, galvanized. Bolts to have rolled threads.
2. Washers: ASTM F436, galvanized.
3. Grommets: Low-density polyethylene, hardness Shore D Durometer 45 to 55, ASTM D2240, configuration to seal bolt holes under conditions of maximum misalignment.

K. Water-Repellant Treatment: Acrylic, water-emulsion, ASTM C309.

L. Grout: Section 02415.

M. Sealant: Siloxane polymer and fillers, FS TT-S-230.
1. Backup rod: Polyethylene rod, closed cell, 5/8-inch diameter.

N. Primer: Zinc-rich primer, MS MIL-P-26915 (USAF), Type 1, Class

O. Bolt Sleeves: Low-density polyethylene, ribbed, hardness Shore D Durometer 45 to 55, ASTM D2240, minimum 1/8-inch wall thickness plus ribs, configuration as shown.

PART 3 - EXECUTION

3.01 FABRICATION:

A. Formwork:
1. Fabricated of steel.
2. Special sizes and cross sections as shown, with metal thickness, reinforcement, stiffness and surface finish as necessary to form concrete surfaces that are smooth, free of irregularities, welding blemishes and concrete stain.

3. Machine form surfaces for contact faces of segments to tolerance of plus-or-minus 0.016 inch.
4. Clean and coat forms with bond breaker prior to each reuse.
5. Ensure smooth surfaces for application of adhesive.
6. Accurately place reinforcing steel with tolerances in accordance with ACI 318.
7. Securely anchor form inserts and embedded items to formwork.
8. Mix and place concrete in accordance with Section 03300.

3.02 CURING:

A. Cure by steam in accordance with the following requirements:
1. Immediately after segments have been cast, enclose forms in an enclosure capable of vapor tight sealing to prevent escape of moisture and heat, and which is large enough to allow complete circulation of steam.
2. Introduce saturated steam into enclosure and maintain atmosphere in a saturated condition until compressive strength of 4,000 psi is attained, as determined by test cylinders. Do not attempt removal of segments from forms until 4,000 psi compressive strength is attained. The Engineer reserves the right to require compressive strength up to 0.75f'c, if there is evidence of distortion, cracking, spalling or similar damage which could occur during handling and storage of segments.
3. Enclosure ambient temperature: Not to exceed 100F for first two hours of curing. Thereafter, maintain temperature within 95F to 150F until specified curing strength is achieved.
4. Do not allow rate of change of temperature to exceed 30F per hour.
5. When specified strength is attained, allow segments to cool slowly but not exceeding rate of change specified in subparagraph 4. above.

3.03 TESTING:

A. Test in accordance with Section 03300, with the following additional requirements:
1. Mix design and curing strength test:
a. Prior to manufacture establish concrete mix that will produce concrete of specified compressive strengths and submit data for approval.
b. After approval of initial mix design has been obtained, make six cylinders from each single batch of concrete.
c. Obtain prior approval of changes in mix design during segment manufacture.
d. Prepare, cure and test cylinders in accordance with procedures specified for segment manufacture.
e. For cylinders prepared prior to manufacture:
1) Remove in pairs at appropriate time intervals during curing and test immediately upon removal to establish correct curing duration and compressive strength.
f. For cylinders prepared as result of change in mix design and as directed:
1) Follow procedures specified for cylinders prepared prior to manufacture.
2) Obtain approval of test results prior to manufacture of segments using new mix design. Inclusion or exclusion of any additives or admixtures to be treated as a change in mix design.

B. Production test cylinders:
1. Prepare three cylinders and cure as specified for each work shift or each 100 cubic yards of concrete used, whichever is more frequent.
a. Test cylinders in accordance with Section 03300.

b. 28-day compressive strength: 85 percent of cylinders to meet specified compressive strength.

C. Gasket Testing:

1. Compression test:

a. Testing device:

1) Hydraulic equipment capable of applying 20,000-pound force with load-scale capable of reading up to 20,000 pounds in 20-pound increments.

2) Two steel plates 16 inches by five inches by 1-1/2 inches thick, each plate with machined groove having dimensions and geometry of gasket groove in precast-concrete segments on one side.

3) Minimum 3/4-inch diameter rod by which upper steel plate is attached to hydraulic equipment.

b. Test preparation:

1) Attach compression packing to high side of groove on each plate.

2) Cut two pieces of gasket 16 inches long and attach one to each plate with contact cement. Center gasket in groove.

3) Attach steel end plates on both sides of bottom plate to prevent longitudinal deformation of both top and bottom gaskets.

4) Prepare bed of grout underneath bottom plate. Bring upper plate in contact with lower plate. Apply pressure until grout squeezes out from below bottom plate. Ensure that gaskets are properly aligned by placing 1/8-inch spacer between low sides of grooves while grout is setting. Leave in position until grout sets.

c. Test:

1) Apply pressure at rate of 400 lb/min. until closure is completed.

2) Calculate closure pressure based on two-inch width of gasket.

3) Record, calculate and submit closure load (lb.), gasket thickness (inches), length of gasket (inches), load rate (lb/min) and closure pressure (psi).

d. Test supervision: Have all phases of mechanical test supervised by test engineer with experience in similar test procedures.

2. Leakage test:

a. Testing device:

1) Two steel plates 16 inches by 16 inches by two inches thick with machined groove running along perimeter of plates and having geometry and dimensions of gaskets grooves in precast-concrete segments. Centerline of groove 2-1/2 inches from plate edge. Low side of groove to center of plate. Plates shall have 5/8-inch diameter holes evenly spaced around perimeter of plate between groove and edge. Both plates identical and symmetrical about centerline.

2) Eight 1/2-inch bolts capable of resisting 5,000-pound force.

3) Steel water tank, filled with water.

4) Nitrogen tank under 2,200-psi pressure with regulator.

5) Gasket material having passed mechanical test.

b. Test preparation:

1) Place gasket in groove by cutting 45-degree angles in ends of four equal pieces and gluing them together in a square with Super Glue or equal. Lengths of four pieces of gasket selected so as to fit squarely in groove of each steel plate. Attach gasket to each plate by means of contact cement.

2) Attach compression packing to high side of groove on each plate with contact cement.

3) Provide vent hole for escaping air pressure, and inlet hole for water, in center of top plate.
4) Bolt both plates together, tightening bolts until plates just close.

c. Test:
1) Attach water tank to plates. Add water to vent out air. Plug vent hole.
2) Apply 200-psi pressure to water tank with nitrogen tank. Record pressure through gauge in nitrogen to water-tank line.
3) Record pressure and inspect for leakage daily during period of one month. Submit result to the Engineer.
4) Gasket will be accepted if no leakage is observed during entire duration of test.

d. Have all phases of mechanical test supervised by test engineer with experience in similar test procedures.

3. Frequency of tests: Perform both compression and leakage tests on gasket before production begins and at 25-percent, 50-percent and 75-percent production levels.

3.04 INSTALLATION OF GASKET:

A. Prior to installation of gasket, apply water-repellant treatment to surface as shown.

B. Use gasket adhesive as recommended by manufacturer of gasket at intervals of approximately 15 inches.

C. Fit gasket snugly into groove provided around segments.

3.05 INSTALLATION OF COMPRESSION PACKING:

A. Clean surface as necessary. Apply adhesive in accordance with manufacturer's recommendations.

B. Cut elastomeric compression packing to proper dimensions and affix as shown.

3.06 EXTERIOR-COATING APPLICATION:

A. Apply coating to exterior surfaces of segments. Do not coat mating surfaces or sealant grooves.

B. Apply coating in two coats of equal thickness totaling 20-mil minimum dry-film thickness and in strict accordance with recommendations of manufacturer of protective coating, including pretreatment of first coat prior to application of second coat.

C. Apply second coat before first coat has dried tack-free and not later than 24 hours after application of first coat, unless otherwise specified by coating manufacturer.

3.07 APPLICATION OF WATER-REPELLANT TREATMENT:

A. Preparation:
1. Apply water-repellant treatment only after concrete has cured as specified in Section 03300.
2. Remove from surface to be treated dust, dirt, debris, oil, grease and other foreign matter. Prepare surfaces to be treated in accordance with treatment manufacturer's recommendations.

B. Installation

1. Apply one base coat of water-repellant treatment to segment surfaces as shown and in accordance with manufacturer's recommendations.
2. Allow a minimum of 24 hours elapsed time between treatment-coating applications.

3.08 TUNNEL BREAKOUT

A. Provide special liner segments and special lining rings, complete with steel frame and temporary bracing, where shown.

B. Upon completion of the tunnel breakout, remove and dispose of the special liner segments and special lining rings.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1.** Other joint connection systems, eg. coil inserts, tylags, plastic washers, etc., to be included in specifications by the Section Designer.

***2.** To be specified by the Section Designer.

END OF SECTION

SECTION 02426

NATM SHOTCRETE LINING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the shotcrete lining applied following NATM excavation.

B. Related Work Specified Elsewhere:
1. NATM excavation: Section 02417.
2. Shotcrete: Section 03370.
3. NATM concrete lining: Section 02427.
4. Tunnel waterproofing (NATM system): Section 07138.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: A36, A185, A325, A615, A706, C144, C150, C579.

B. Installer with a minimum of two years experience.

C. Lattice girder tolerances as certified by engineer's calculations.

1.03 DEFINITIONS:

A. Shotcrete: Section 03370.

B. Lattice Girder: A lightweight, three-dimensional steel frame made to act as a unit by connecting components with lacing bars used in conjunction with shotcrete for shotcrete lining reinforcement.

C. Splice Bar: Rebar installed to provide inherent connection of shotcrete in circumferential direction between top heading and bench shotcrete and at break-outs from cut-and-cover structures.

D. Splice Clip: Rebar installed at arch lines as means of longitudinal reinforcement of the shotcrete lining.

E. Local Support: See Section 02417.

F. Pre-support: See Section 02417.

G. Girder Brace: Rebar installed between two adjacent lattice girders for lateral support of lattice girders.

H. Soil Anchor: Steel bar installed in borehole on the tunnel shotcrete lining and fully encapsulated in cement mortar grout with accelerator cartridge when and where shown on drawings.

I. Forepoling or Spiling Bar: Steel bar without end hardware installed at the tunnel heading by jacking or other mechanical equipment.

J. Forepoling Sheets: Steel plate installed at the tunnel heading by jacking using mechanical equipment to provide earth support during excavation.

K. Grouting: Methods used for pre-support of tunnel excavation and ground stabilization by pressure injecting chemical grout or cement grout.

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:
      a. Shotcrete lining indicating structural construction details.
      b. Show relationship of waterproofing and concrete lining elements to shotcrete lining elements and to the plan and sequence of excavation and lining installation.
      c. Show relationship of shotcrete lining to intermediate excavation and support stages at break-out of tunnel and at interfaces.
      d. Design, specifications, method of operation and other data pertaining to the following:
         1) Fabrication details for lattice girders.
         2) Welded wire fabric, splice bars, and splice clips.
         3) Rebar spiles and perforated steel pipes.
   2. Documentation:
      a. Calculations for lattice girder connection details. Have these calculations certified by a professional engineer registered in the jurisdiction where the work is being performed.
      b. Tolerances: Include engineer's statement of acceptable tolerances in the certified calculations.
   3. Samples:
      a. Lattice Girders: Submit a two foot long sample of lattice girder with its accessories which shows full cross section and type to be used. Submit three such samples of lattice girder.
      b. Soil Anchors: Anchor bolts and accessories: Three samples of each.
      c. Accelerator Cartridge: Three samples.
      d. Forepoling Sheets and Bars: Three sample sections one foot long showing full cross section and type to be used.
   4. Testing:
      a. Prior to installation of soil anchor, arrange demonstration to show that specified pull out strength requirements can be met.

1.05 JOB CONDITIONS:

A. Maintain a minimum of a five-day supply of lattice girders and shotcrete on site to prevent delays to the work. Maintain constant and adequate supply of shotcrete at tunnel heading during excavation, such that shotcrete may be applied at any time.

1.06 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. General:
   1. Load, transport, unload and store structural materials to keep them clean and free from damage.

2. Store material on platforms, skids or other supports above ground and ensure proper drainage and protection from corrosion.

B. Lattice Girders:
1. When handling and shipping lattice girders prevent bending, scraping or overstressing members.
2. Block projecting parts likely to be bent or damaged during handling with wood or other approved material.
3. Replace pieces bent or damaged unless repair is approved.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Shotcrete: Section 03370.

B. Welded Wire Fabric: ASTM A185, Size 6 x 6 - W4.0 x W4.0.

C. Splice Bar: Fabricated from No. 4 standard reinforcing steel conforming to ASTM A615 Grade 60 as shown.

D. Splice Clips: Fabricated from No. 5 standard reinforcing steel conforming to ASTM A615 Grade 60 as shown.

E. Lattice Girder:
1. General:
a. Fabricate lattice girders to consist of three primary retaining bars, dimensioned and arranged as shown and connected by stiffening elements of the manufacturer's design or as shown and from rebars conforming to ASTM A706 Grade 60.
1) Facilitate shotcrete penetration into and behind the girder, thereby minimizing the creation of injection shadows.
2) Provide optimum bonding between the steel and shotcrete in order to form a composite, continuous, reinforced shotcrete lining structure.
b. Provide lattice girders with moment properties about the neutral axes in a section perpendicular to the longitudinal axis of the border, as shown. Have the stiffening elements provide a minimum five percent of the total moments of inertia. This percentage is calculated as an average value along repeatable lengths of the lattice girder.
c. Ensure stability against buckling. Maintain the maximum spacing between stiffening elements at less than three times the cross sectional height of the girder.
2. Dimensions:
a. As shown.
b. Fabricate the lattice girders to meet minimum clearances shown under consideration of inaccuracy of placement during construction, material tolerances, and of lining deflection following installation.
3. Testing:
a. Test lattice girder segments of typical length randomly selected by the Engineer from the standard stock. The Engineer will observe the testing.
b. Test segments in single point flexure with loading and constrains representative of the in-situ conditions of the girder. Record measurements of the gradually applied load and deflection of the girder at the point of

application until failure occurs to verify that the girder satisfies the minimum structural requirements.

c. Replace faulty lattice girders at no additional cost to the Authority.

F. Soil Anchors: Anchor Bolts and Accessories:

1. General Requirements:

a. Soil anchor assembly: Anchor bolt, anchor plate, washer and nut.

b. Fabricated from No. 6 standard deformed reinforcing steel bar suitably threaded conforming to ASTM A615 Grade 60.

c. Approved method of anchorage to take specified tension.

d. Anchor plate: Plate 3/8-inch thick conforming to ASTM A36 having bearing area of at least 64 square inches.

e. Nuts: Hexagonal head, ASTM A325.

f. Steel washers: Center hole to be 1/8-inch larger in diameter than bolt with which it is to be used. Flat or conical shape conforming to ASTM A325.

g. Grout and mortar:

1) Cement: ASTM C150 Type 1.

2) Water: Section 03300.

3) Sand: ASTM C144.

4) Accelerator cartridge: Accelerator cartridge to be such that pull out strength of 5,000 pounds is achieved within 20 minutes.

G. Forepoling or Spiling Bars: Fabricated from No. 8 standard reinforcing steel conforming to ASTM A615 Grade 60 as shown.

H. Forepoling Sheets: Steel ASTM A36.

I. Girder Brace: Fabricated from No. 6 standard reinforcing steel conforming to ASTM A615 Grade 60 as shown.

2.02 FABRICATION:

A. Provide each of the primary retaining bars of lattice girder segment in one piece, that is without splice, of high strength steel having a yield strength of 60 ksi.

B. Construct the connection elements at the end of the lattice girder segments of structural steel angles having a yield strength of 36 ksi or stronger, or of welded flat steel ensuring similar strength characteristics.

C. Fabricate steel supports in accordance with Section 05120, except as follows

1. Inspection of groove and fillet welds by visual inspection only.
2. Grinding to remove nicks resulting from flame cutting is not required.
3. Planing and facing of sheared edges or bearing surfaces is not required.
4. Subpunching or subdrilling of bolt holes is not required.
5. Portions of nearing members such as butt and foot plates need not be straightened, planed and connected after fabrication.

PART 3 - EXECUTION

3.01 GENERAL:

A. Install shotcrete lining as shown and specified herein, and in accordance with applicable requirements of Section 02417.

B. Verify that the ground types encountered in the tunnels or station excavation are the same as were considered in the design. If not, make the necessary changes to the excavation sequence with the prior approval of the Engineer.

C. Excavation sequences of headings as shown for Excavation and Support Type 1 and Type 2.

3.02 FLASH-CRETE:

A. Install as shown and as specified in Section 02417.

3.03 LATTICE GIRDERS:

A. Install to conform to excavated shape as shown. Consider inaccuracy of construction, tolerances of materials, and initial lining deflection to determine actual dimensions. Provide minimum embedment as shown.

B. Secure lattice girder segments by use of girder braces, temporary wood blocking and other appropriate means to maintain position during shocreting.

C. Provide butt plates of lattice girder segments and expansion unit in invert as shown or otherwise approved by Engineer. Ensure tight connection of elements.

3.04 WELDED WIRE FABRIC:

A. Install as shown. Provide minimum overlap of 12 inches in each direction or use splice bars as shown.

3.05 SPLICE BARS AND SPLICE CLIPS:

A. Install splice bars and splice clips for additional reinforcement as shown.

3.06 SHOTCRETE:

A. Install shotcrete lining to provide required shotcrete lining thickness as shown.

3.07 SMOOTHNESS CRITERIA:

A. General Smoothness Criteria: Provide shotcrete with a surface meeting the following tolerance:
   1. Shotcrete lining: Depth-to-wavelength ratio as measured with a 10-foot straightedge in random direction to be 1/5 or less.

3.08 DETECTION OF MOVEMENT:

A. As specified in Section 02417.

3.09 FIELD QUALITY CONTROL:

A. As specified in Sections 02417 and 03370.

END OF SECTION

SECTION 02427

NATM CONCRETE LINING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies cast-in-place concrete lining installation in NATM tunnels.

B. Related Work Specified Elsewhere:
1. NATM shotcrete lining: Section 02426.
2. Concrete formwork: Section 03100.
3. Concrete reinforcement: Section 03200.
4. Cast-in-place structural concrete: Section 03300.
5. Shotcrete: Section 03370.
6. Tunnel waterproofing (NATM system): Section 07138.
7. Drilling and pressure grouting for rock tunnels: Section 02431.
8. NATM excavation (soft ground): Section 02417.

C. Definitions:
1. NATM: New Austrian Tunneling Method.

1.02 QUALITY ASSURANCE:

A. Comply with the requirements of Sections 03100, 03200 and 03300.

1.03 SUBMITTALS

A. Comply with the requirements of Sections 03100, 03200 and 03300.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Comply with the requirements of Sections 03100, 03200 and 03300.

PART 3 - EXECUTION

3.01 INSTALLATION OF CONCRETE LINING:

A. Perform concrete work in accordance with Sections 03100, 03200 and 03300.

B. Place concrete for lining upper portion of tunnel by mechanical or pneumatic methods through pipes which discharge as nearly as practicable to highest point of structure.

C. Prior to placement of concrete, remove materials within concrete design lines so as to avoid compromising stability of shotcrete lining and surrounding ground.

D. Fill enlargement of tunnel excavation beyond theoretical outer limit of concrete lining shown with concrete.

E. Force concrete into contact with waterproofing.

F. Schedule erection of concrete tunnel lining so that no concrete is placed closer than 500 feet from tunnel excavation heading, unless otherwise approved.

G. Contact Grouting: Perform contact grout as specified in Section 02431 and 02417 and as follows:
   1. Perform contact grouting through grout pipes in roof, in such quantity and at sufficient pressure to fill all voids. Maximum allowable grouting pressure for contract grouting is not to exceed 20 psi.
   2. Pump grout until grout comes through adjacent grout pipes in the roof.
   3. Perform contact grouting behind concrete lining when concrete is more than 28 days old.

3.02 DEFECTIVE LINING:

A. Concrete tunnel lining is considered defective unless it is watertight, properly finished, is within specified tolerances and has undamaged surfaces and joints.

B. Watertightness criteria: Section 03300.

C. Cast-in-place concrete lining is considered defective if misalignments cause tunnel wall to be less than 12 inches thick.

3.03 CORRECTIVE WORK:

A. Repair of concrete: Repair concrete having minor chipping of surfaces using epoxy mortar having surface color and texture closely matching adjacent concrete surfaces. As directed, repair or replace with new concrete those cracked portions which impair structural integrity of tunnel lining as determined by the Engineer.
   1. Ensure that surfaces to be repaired are clean, dry, free from dirt, dust, oil, water and other contaminants.
   2. Mix and place epoxy mortar as recommended by the manufacturer. Grind rough or raised projections smooth and flush with adjacent surfaces.

B. If cast-in-place concrete lining thickness falls below nine inches, to maintain line and grade, remine tunnel so that concrete lining thickness is at specified minimum thickness.
   1. Remine as specified in Section 02417.

3.04 LEAK REMEDIATION:

A. Leak remediation: Section 07138.

END OF SECTION

SECTION 02431

DRILLING AND PRESSURE GROUTING FOR ROCK TUNNELS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies drilling feeler, exploratory, drainage and other holes, furnishing and injecting grout and patching finished grout holes in rock tunnels

B. Definitions:
1. Contact grouting: Injection of grouting material at crown areas of tunnels to fill voids between tunnel lining and surrounding rock.
2. Consolidation grouting: Injection of grouting material through holes drilled up to 25 feet long at appropriate intervals around periphery of rock tunnel prior to installation of lining.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: A53, C109, D1785, D2466.

B. Qualifications:
1. When taking rock cores, employ only experienced rock core-drilling personnel.

C. Tests:
1. Determine strength of cementitious grout from test specimens made and tested in accordance with ASTM C109.

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. Details of grout mix composition. Submit prior to grouting.
2. Documentation:
   a. Rock core logs prepared as approved. Submit daily.
      1) Include descriptions as follows:
         a) Materials of whatever character encountered in drilling and their locations in the holes.
         b) Length of each run with percentage of core recovery.
         c) Location of special features such as mud seams, open cracks and soft or broken ground.
         d) Points where abnormal loss or gain of drill water has occurred.
         e) Groundwater levels or other items of interest in connection with grouting in exploratory drilling.
         f) Significant actions of bit and reasons for loss of core.
3. Rock Cores:
   a. Place entire rock cores in boxes in same order they are recovered from each hole. Use wooden blocks to show lengths of core not recovered.

b. Mark core boxes with number of boring and depths from which cores are recovered.
c. Include the following information:
1) Percentage of core recovered compared with actual depth of drilling necessary to obtain sample.
2) Rock quality designation (RQD) for each core run.
d. Deliver cores to Engineer as directed.

1.04 JOB CONDITIONS:

A. Grouting Records:
1. Cooperate with and assist the Engineer in keeping records of grouting operations including time of each change in grouting pressure, rate of pumping, amount of cement for each change in water-cement ratio and other necessary data.

B. Start Date:
1. Notify the Engineer at least one week prior to beginning grouting operations

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Cement: Section 03300, Type II.

B. Water: Potable.

C. Admixture: For plasticizing or retarding as approved.

D. Fine Aggregate:
1. As specified in Section 03300, with the following additional requirements:
a. 100-percent passing U.S. Standard sieve Number 16.
b. Graded as follows for contact grouting:

U.S. Standard Sieve Size	Percent Passing
16	100
30	65 - 90
50	20 - 60
100	5 - 15
200	0 - 15

E. Grout Pipe and Fittings: ASTM A53, standard weight, Schedule 40, black.

F. Plastic Drain Pipe: PVC, ASTM D1785 and ASTM D2466, Schedule 40.

G. Core Boxes:
1. Wood fabrication, sufficiently strong to withstand handling and transportation.
2. Size: Forty-eight inches by nine inches by three inches.
3. With solid-wood dividing strips, not plywood, to separate cores.

2.02 GROUT MIXES:

A. Grout for Contact Grouting:
   1. Consisting of one part portland cement, one part fine aggregate and approved admixture or as otherwise approved.
   2. Minimum compressive strength: 100 psi within 24 hours.
   3. Fluid enough to be injected to fill voids.
   4. Comprising ingredients not corrosive to steel.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. For exploratory core drilling, use approved drilling equipment with double-tube core barrel to obtain continuous NX, minimum size cores, 2-1/8 inches diameter.

B. For feeler, grout and drain holes, use rotary or percussion-drilling equipment.

C. For pumping grout, use approved pump capable of developing appropriate, approved, uniform pressure at grout hole connection and hoses with inside diameter of 1-1/2 inches minimum.

D. Use horizontal shaft paddle or colloidal pump mixer with minimum capacity of 20 cubic feet and with accurate meter which reads to nearest 1/10-cubic foot for measuring amount of mixing water added to grout.

E. Provide approved pressure gauges at grout pump and on manifold hookup at collar of hole being grouted.

3.02 FEELER HOLES:

A. Drill feeler holes as directed ahead of excavation to determine in advance nature and condition of materials to be excavated.

B. Drill each hole to diameter of 1-1/2 inches minimum and length of 15 feet minimum and 30 feet maximum.

C. While drilling feeler holes, suspend or modify other operations as necessary to permit such drilling. Drill holes only in the presence of the Engineer.

D. Obtain approval for location, direction, length and number of holes.

3.03 EXPLORATORY HOLES:

A. Drill exploratory holes in order to determine type and quality of rock.

B. Depending on nature of rock, select length of drill run to ensure maximum core recovery, but in no case to exceed five feet.

C. Package cores as specified and deliver to the Engineer as directed.

D. Unless otherwise directed, pressure grout exploratory holes after removal of core.

3.04 DRAIN HOLES:

A. Locate and drill holes where shown or as directed. Keep holes clear of obstructions.

B. Use plastic pipe for weep holes where shown. Fasten fittings with adhesive or threads.

3.05 GROUTING:

A. General Requirements:
   1. Grout holes:
      a. Drill grout holes in rock or lining to diameter of two inches minimum and as shown or as directed or use existing grout holes.
      b. Avoid cutting embedded steel. If steel is encountered, cease cutting and patch hole.
      c. Clean obstructed holes for entire depth prior to grouting.
      d. Thoroughly wash grout holes immediately before starting pressure grouting.
   2. Pipes and fittings:
      a. Place pipes to be embedded in tunnel lining for contact-grout connections and air vents as shown.
      b. Set inner end of pipes not less than two inches back from finished inside surface and provide recesses from there to surfaces of lining. Fill recesses with concrete or mortar after grouting operations have been completed.
      c. Set grout pipes so that grout flows freely to voids behind lining.
      d. Hold pipes to be embedded firmly in position and protect from damage while concrete is being placed. Provide and attach caps or other devices to ends of pipe to prevent entry of concrete or other foreign materials prior to grouting and to facilitate location of grout pipe after forms are removed.
      e. Avoid clogging or obstructing pipes before grout hookups are made. Clean clogged or obstructed pipes.
   3. Connections:
      a. Make connections so as to prevent leakage.
      b. Remove plugs on ends of grout holes or pipes to permit escape of air and water and filling of spaces with grout.
      c. Provide straightway cock or valve at each connection.
   4. Grouting operations:
      a. Perform grouting operations in the presence of the Engineer.
      b. Use grout of consistency to suit the characteristics of the hole being grouted or the type of grouting being performed.
      c. Use approved pressure at hole.
      d. Consider grouting hole to be complete when hole refuses grout at 90 percent of highest pressure approved.
      e. Upon completion of grouting at each connection, close valve and leave it in place until grout has set.
      f. After grout has set remove valves and fittings and metal connections to depth of 1-1/2 inches minimum from face of concrete.
      g. Fill grout holes with thick grout or dry pack at completion of grouting operations to leave smooth finished surface.
      h. Do not block drains or drain lines during grouting operations.
      i. Clean drains after each grouting operation.

B. Consolidation Grouting:
   1. Perform consolidation grouting as necessary.
   2. If consolidation grouting has to be performed after contact grouting, allow at least seven days to elapse between completion of contact grouting and beginning of consolidation grouting.
   3. Perform consolidation grouting within radius of 50 feet of cast-in-place concrete tunnel lining only when lining is more than 14 days old.

C. Contact Grouting:

1. Perform contact grouting through holes drilled or placed in tunnel lining where shown.
2. Obtain approval of grouting pattern and order of grouting prior to start of contact grouting.
3. Provide vent pipes to suit conditions encountered.
4. Perform contact grouting behind concrete liner when concrete is more than 14 days old.
5. Use maximum pressure for contact grouting as approved.
6. Continue grouting until clear grout stream emerges from vent pipe.
7. Allow at least seven days after completion of contact grouting, before beginning further grouting.

END OF SECTION

SECTION 02460

PILES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing and installing bearing piles, performance of Static Pile Load Tests and Dynamic Pile Testing.

1. Sequence of Work:
   a. Conduct initial wave equation analysis, prepare Indicator Pile Order List and submit information to Engineer for review.
   b. Piles shall not be driven until embankments or excavations shown have been completed to the specified grade.
   c. Obtain and drive the indicator piles where shown on the drawings. During initial driving perform Dynamic Pile Testing and the refined wave equation analysis on each indicator pile to confirm the length, and control blow count. Determine pile driving criteria on the basis of the pile driving analysis (PDA) during the initial driving and the static load test. Incorporate results into driving of subsequent indicator piles.
   d. Perform Static Pile Load Tests per Article 3.2.B.2 on indicator piles designated by the Engineer after all indicator piles have been installed. After Static Load Test is complete immediately restrike all indicator piles with Dynamic Testing Apparatus installed and functioning.
   e. Analyze Static Pile Load Tests and evaluate data collected from Dynamic Pile Testing and refined wave equation analyses to determine pile driving criteria as indicated in item c.. Develop and submit the proposed “Order List” for production piles to the Engineer for approval.
   f. Order and procure production piles based on the approved “Order List”.
   g. Drive each production pile to twice the pile design load and “production maximum tip elevation”, and report all data as specified to evaluate the adequacy of the foundation system.

B. Definitions:

1. Pile Group: All piles to support a foundation element or column within a specified area, or all piles to support a linear unit of retaining wall. Pile groups are shown on the Contract Drawings.
2. Production Piles: All piles that are driven after the installation of required test piles in accordance with the contract documents and which upon approval by the Engineer, become part of the permanent structure.
3. Indicator Pile: Indicator piles are shown on the Contract Drawings. These piles shall be tested with the Dynamic Testing Apparatus. Static load tests shall be conducted on the indicator piles shown on the Contract Drawings or as directed by the Engineer. The Engineer may direct that additional indicator piles be driven and that dynamic or static testing be conducted on them to verify the load capacity.
4. Reaction Piles: Piles driven by the Contractor to provide reaction for Static Pile Load Tests.
5. Predicted Maximum Tip Elevation: The elevation below which indicator pile tips must penetrate by at least one foot.

SECTION 02515

WATER DISTRIBUTION SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing water mains.

B. Related Work Specified Elsewhere
   1. Grading, excavating and backfilling: Section 02320.
   2. Maintenance, support and restoration of utility facilities: Section 02270.
   3. Grounding and bonding: Section 16060.

1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Certification:
   1. Proof that the water sampling and testing 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
   2. Proof that the independent laboratory is approved by the EPA or jurisdictional health authority.
   3. Certified results of the specified Post-Sterilization Water Test.

B. Documentation:
   1. Bill of materials for material which will be supplied by operating agency. *1

C. Working Drawings: *2
   1. Complete detailed working drawings of the proposed fire hydrants. Approval of drawings submitted does not constitute a waiver of the requirements of the Contract, nor is the Authority compelled to accept hydrants unless they pass specified tests and requirements.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AASHTO: M36, M153. *3
   3. AASHTO: M153. *4
   4. ANSI/AWWA: C104/A21.4, C110/A21.10, C111/A21.11, C151/A21.11, C151/A21.51.
   5. ASTM: A36, A48, A53, B88, C33.
   6. ASTM: A36, A48, C33, C76. *5
   7. ASTM: A36, A48, C33. *6
   8. ANSI/AWWA: C108, C151, C500, C502. *7

9. ANSI/AWWA: C151, C200. *8
10. EPA: National Primary Drinking Water Standards.
11. WSSC: General Conditions and Standard Specifications, Standard Fire Hydrant Drawings. *9

B. Allowable Tolerances:
1. Leakage not to exceed figures given in Table 02515-1.
2. Lead concentration in specified water samples less than 15 micrograms per liter of water, and water quality meets the requirements of EPA National Primary Drinking Water Standards.

C. Testing Laboratory:
1. Furnish services of an EPA-certified or jurisdictional health agency-certified independent laboratory for sampling and testing water quality. Employment of an independent laboratory does not relieve Contractor of the obligation to perform work in accordance with Contract requirements.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Upon approval of bill of materials, pick up material at designated storage facility and transport to job site. *9

B. To reduce handling to a minimum, coordinate pipe delivery with installation.

C. Distribute pipe along line of work and outside trench as near as practicable to point of placement. Do not deposit material on or against pipe.

D. Arrange and install skids and wedges to prevent damage to pipe. Do not roll or drag pipe.

E. Avoid damage to coating and lining; use handling equipment designed for the purpose. Where approved, pipe may be handled by hand.

F. When pipe installation is not actually in progress, place watertight caps or plugs on open pipe ends.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate No. 4 or where directed No. 4 and No. 67 in combination and proportions to suit field conditions.

B. Aggregate for Fire Hydrant Dry Wells: ASTM C33, coarse aggregate, No. 67.

C. Ductile Iron Pipe:
1. ANSI/AWWA C151/A21.51.With standard cement-mortar lining with bituminous seal coat conforming to ANSI/AWWA C104/A21.4.
2. Furnished in uniform standard lengths. Short pipe lengths and fittings are permitted where line, grade and closure requirements necessitate.

D. Joints:
   1. ANSI/AWWA C151/A21.11.
   2. Where shown as DILM, use mechanical joint ductile iron pipe. Where shown as DILS, use push-on joint. Unless otherwise shown, ductile iron pipe joints may be either mechanical joints or push-on joints.

E. Fittings:
   1. ANSI/AWWA C110/A21.10 as modified.
   2. Suitable for use with ductile-iron pipe; designed for 250 psi working pressure.
   3. Furnished with coating and lining as for ductile iron pipe, with mechanical joint, except that offsets will have one plain spigot end.

F. Gasket Lubricant: For mechanical joints: Approved vegetable oil soap. For push-on joints: Approved gasket lubricant supplied by the pipe manufacturer and conforming to ANSI/AWWA C111/A21.11.

G. Concrete: Section 03300, Class 3500.

H. Mortar: Section 02535.

I. Brick: Section 02535.

J. Reinforcing Steel and Welded Steel Wire Fabric: Section 03200.

K. Precast Concrete Elements: Section 03400, Class 4000, air-entrained concrete.

L. Steps: ASTM A48, Class 30.

M. Manhole Frame and Cover; And Other Castings For Service With Utility Systems:
   1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
   2. Utility company manhole: Manhole frame and cover furnished as part of the Contract or furnished by the utility as shown on the drawings.
   3. Rust-resistant cast iron or rust-resistant malleable cast iron.
   4. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
   5. Fillets at angles in casting with arises sharp and perfect.
   6. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
   7. Metro logo: For utility components which will remain METRO property and are not within boundaries of utility easements as shown: Cast METRO logo as shown.
   8. Covers that receive paver tile:
      a. Omit bituminous coating.
      b. Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position

N. Piling for Thrust Blocks and Steel for Structural Use: ASTM A36.

O. Resilient Material at Pipe Penetrations: AASHTO M153, Type II. See Section 02320.

P. Vitrified Clay Pipe: Section 02535.

Q. Backfill: Section 02320.

R. Valves: Built and tested in accordance with ANSI/AWWA C500.

1. Cast-iron body, bronze-mounted, parallel-seat, double-disc gate valves with nonrising stems, nut-operated to open counterclockwise to withstand and operate under a working pressure of 150 pounds per square inch.

2. Mechanical joint or flanged ends as shown and manufactured by American Darling Valve and Manufacturing Company, Ludlow-Rensselaer Valve Company or equal.

3. No gearing or bypass will be required on valves smaller than 16 inches.

4. Valves 16 inches and larger equipped with a bypass and bevel gearing for horizontal installations or spur gearing for vertical installations.

S. Valves: In accordance with requirements of the operating agency. *10 and *9

T. Materials Supplied by the Operating Agency: *11 *and* *9 1.

1. Except for those items which bear the METRO logo, the WSSC furnishes the following:
   a. Water meter, meter frame and cover, meter housing, copper and brass pipe and fittings for meter settings, and adjustable valve box.

U. Materials Supplied by Operating Agency: As specified. *12 and *9

V. Yard Hydrant: Cast-iron box with lid, freeze proof valve with removable handle and threaded hose connection, hose bib size 2-1/2 inches, service pipe size as shown, Josam Series 71600 or equal.
Coal-tar epoxy: Section 02535.

W. Bituminous Coating: ANSI/AWWA C151. *13

X. Steel Pipe Casing: ASTM A53, Grade B, ungalvanized. *14

Y. Casing pipe: *15

1. Reinforced concrete: ASTM C76, Class IV.
2. Corrugated metal: AASHTO M36, 8-gauge, galvanized, asphalt coated.
3. Seamless steel: Black, welded, mill type, ANSI/AWWA C200.

Z. Fire Hydrants: Conforming to ANSI/AWWA C502, and WSSC's Standard Fire Hydrant Drawings with the following additional requirements: *16

1. Interchangeable with existing WSSC fire hydrant. A sample fire hydrant similar to those now in use will be available at the Warehouse at 3500 Kenilworth Avenue, Bladensburg, Maryland, for inspection and comparison.
2. Manufactured by Kennedy Valve Mfg. Company, Elmira, N.Y. or equal, including name of manufacturer and year of manufacture cast in raised letters.

3. Barrel sections:
   a. Two cast-iron sections, with hollow or breakable flange at least two inches above finished grade line, cast iron conforming to ANSI/AWWA A21.8/C108).
   b. Lower section of barrel: Static casting with an integral tapered top flange seat. Nozzle section attached to lower barrel section by means of a tapered flange ring held in place by six hydrant-head bolts and nuts.
   c. Flange and flange rings: Top or nozzle section, including bonnet and operating nut, revolving 360 degrees for facing without disturbing bottom section of barrel. The use of split bronze insert ring is prohibited.
   d. Hydrant: Barrel, complete with the working parts, including main and drain valve seats, removable for inspection or repair and replaceable without disturbing the ground.
   e. Depth of bury of the hydrant indicated in raised figures on barrel, showingdepth in feet. Figure on barrel just below the swivel flange and above protective case, visible when installed. Figure raised at least 1/8-inch above barrel surface and height of the figure at least one inch, integrally cast with barrel.
4. Frost case:
   a. Cast-iron, two-piece lower section may be centrifugally cast and 12 inches shorter than depth of bury.
   b. The upper section of frost casing normally furnished in lengths of nine inches, but sections both 15 and 21 inches long furnished as required to be used for maintenance purposes where longer hydrant barrels have to be replaced on existing installations.
5. Main valve:
   a. Main valve seat: Compression type, opening against pressure.
   b. Valve: Faced with Balata.
6. Discharge nozzles:
   a. One 4-1/2 inch pumper and two 2-1/2 inch hose nozzles, both pumper and hose nozzle threads conforming to the requirements of ANSI specifications for National (American) Standard fire hose coupling screw thread.
   b. Nozzle caps: For outlets, attached to the fire hydrant by means of suitable chains.
   c. Hose nozzles of bronze and leaded into the barrel.

7. Elbow or inlet connections:
   a. Cast-iron hydrant barrel to screw into the elbow. Elbow fitted with removable or replaceable threaded bronze ring to receive hydrant barrel.
   b. Inlet connection: Six inches, Class 350, mechanical joint bell, meeting the general requirement for Standard Mechanical Joint Cast-Iron Pipe and Fittings with the necessary accessories for each such mechanical joint.
   c. Bolts: Low-alloy steel, Corten, Usaloy or equal.
   d. Gaskets: Rubber.
   e. Glands: High-strength cast iron consistent in design with elbows with which they are to be used.

AA Copper Tubing: ASTM B88, Class I, Type K, hard-drawn. *17

BB Metro Logo: For utility components which remain property of the Authority and are not within the boundaries of utilities' easements indicated in the Right-of-Way drawings, use cast METRO logo as shown. *18

CC Oak Chock: Undressed, clear, four inches wide by 18 inches long, height variable, with recessed groove, 1-1/16 inches by 1/4-inch deep, centered across four-inch dimension. *19

DD Metal Band: Steel, one inch by 0.035 inch. *20

PART 3 - EXECUTION

3.01 MAINTAINING WATER SERVICES:

A. Maintain water service in accordance with Section 02270. In furtherance of this requirement, conduct operations at times selected to minimize duration and inconvenience of service interruption.

B. At least 24 hours prior to cutting or abandoning an existing water main, notify the Engineer and operations division of operating agency and obtain approval of schedule for performance of work. *9

C. Keep existing water mains parallel to new water mains in service until new water mains are ready for service.

D. Where existing water main must be cut for connection to new water main, provide necessary facilities and prosecute work on 24-hour basis.

E. Water valves in service will only be operated by personnel of the agency owning main. *9

3.02 EXCAVATION:

A. Perform excavation to line and grade in accordance with Section 02320 with the following additional requirements:

1. Excavate test pits sufficiently in advance of construction so that reasonable changes in line and grade can be made where the location of existing structures varies from that shown.
2. Excavate below horizontal plane extending two feet above top of water main structure to such width that construction may be properly performed, but not less than six inches nor more than nine inches from outside of proposed structure.
3. Excavation above such plane may exceed specified dimensions where approved.
4. If excavation exceeds permissible dimensions, install pipe of higher strength as directed.
5. Unless otherwise shown, install pipe in excavated trenches. Trench to have such depth that there will be at least two feet of trench of required width above top of pipe.
6. Where necessary to place backfill or embankment so that trench can be excavated, extend and compact backfill or embankment to full depth and laterally at least 2-1/2 times diameter of pipe on each side measured from centerline of pipe.

3.03 SUBGRADE:

A. Prepare subgrade so that pipe will rest solidly throughout its length. Excavate recesses to accommodate joints and fittings.

3.04 BACKFILL:

A. Backfill excavation upon completion of construction in accordance with Section 02320.

B. Perform backfilling after inspection and approval of pipe laying.

3.05 LAYING PIPES:

A. Take proper measures to keep pipe clean. Immediately prior to placing, clean inside and ends of outside surfaces of pipe. Keep interior surfaces clean throughout construction.

B. Prior to placing pipe in trench, have interior and exterior inspected. Where there is damage that the Engineer determines repairable, make repairs as directed. Replace pipe damaged beyond acceptable repair.

C. Complete excavation and placing of subgrade before pipe is placed. Place pipe solidly true to line and grade shown. Do not subject pipe to blows or shocks to achieve solid bedding or proper line and grade.

D. Make change in line with fittings. Do not spring joints to effect change of direction.

E. Do not field cut pipe unless necessary. Make such necessary cuts by means of equipment designed for purpose, ensuring smooth square end.

F. For connection to existing pipe, provide pipe with suitable ends or adaptors, after verification of size and type of existing pipe.

G. For railroad and highway crossings, lay casing and water mains as shown. *21

H. Place oak chocks as shown, fasten metal band to chocks as approved. Space chock arrangements on water mains at six feet zero inches on center. *22

I. After water main is in place, fill void between main and casing with sand. *23

J. Close ends of casing pipe with brick masonry enclosure as approved. *24

3.06 ASSEMBLING MECHANICAL JOINTS:

A. Assemble mechanical joints to provide tight, flexible joints that safely permit expansion, contraction and ground movement.

B. Prior to assembling mechanical joints, wire brush surfaces of pipe sections in contact with gasket so that surfaces are clean, smooth and free of rust and other foreign substances. Clean and lubricate contact surfaces with vegetable oil.

C. Assemble mechanical joints in accordance with ANSI/AWWA C111/ A21.11.

D. Furnish to the Engineer calibrated torque wrenches in sufficient number to permit complete inspection of work. Provide satisfactory means of recalibration.

E. If satisfactory seating of joint is not obtained at maximum permissible torque, disassemble joint, reclean and reassemble with new gasket.

3.07 ASSEMBLING PUSH-ON JOINTS:

A. Assemble push-on joints to provide tight, flexible joints that safely permit expansion, contraction and ground movement.

B. Assemble joints using lubricant in accordance with recommendations by pipe manufacturer.

C. File or grind spigot of field-cut pipe lengths to resemble manufactured pipe so that spigot end will slip into socket without hindrance or gasket damage.

D. Place identifying mark on pipe not bearing depth mark on spigot to show depth of socket.

3.08 VALVES:

A. Install valves in accordance with recommendations of the valve manufacturer.

B. Where valves are provided by operating agency, provide suitable access for performance of work. *9

C. Where necessary, alter typical valve manhole to suit actual conditions.

3.09 SUCTION OUTLETS:

A. Construct suction outlets where shown.

B. Provide necessary materials not furnished by operating agency to complete installation. *9

3.10 DEAD-END BLOWOFFS:

A. Provide tapped and drilled caps for dead-end blowoffs where shown.

B. Complete construction of dead-end blowoffs. Provide materials not furnished by operating agency but necessary to complete installation. *9

3.11 FIRE HYDRANTS:

A. Construct fire hydrant installations as shown.

B. Provide necessary materials not furnished by operating agency to complete installation. *9

C. Shop Painting: *25

1. Clean outside of hydrant above finished ground line and give two coats of paint as manufactured by Grow Chemical Coating Corp., Tropical Paint Division, 1250 West 70th Street, Cleveland, Ohio 44102, or equal. The bonnet of the hydrant painted with Rhinamel Forest Green No. 202-97-I.F. or equal and the body and outside of the top section frost casing painted with Rhinamel Gray No. 202-21-00 or equal

2. Bituminous Coating: Paint the barrel below the ground line, the bottom section of the frost casing and the cast-iron elbow, inside and outside. Paint only the inside of the top section of frost casing.
   a. The bituminous coating to be smooth, tough and tenacious coating, neither so soft as to flow when exposed to sun nor so brittle as to crack and scale off when exposed to temperature below freezing, and not deleterious to potable water.
   b. Apply the bituminous coating hot or cold either by brushing, dipping or spraying. The coating material to be subjected to chemical and physical tests by the Engineer to confirm its uniformity and quality.
   c. Examine surfaces for peeling or scaling. Repair damage to the coating because of rough handling or rubbing in shipping and restore coating to its original condition.

3.12 THRUST BLOCKS AND HARNESSING:

A. Make provision for counteracting thrust caused by static and dynamic forces including water hammer at bends, tees, reducers, valves and dead-ends by installing ductile iron retainer glands with mechanical joints. For other methods submit details for approval prior to use.

B. Install concrete thrust blocks as shown where harnessing is not practicable.

C. Where shown provide piles and reinforcing steel in concrete thrust blocks. Install piles for thrust blocks to bearing of 15 tons.

3.13 CAST-IN-PLACE CONCRETE CONSTRUCTION:

A. Conform to applicable requirements of Sections 03100, 03200 and 03300.

3.14 PRECAST CONCRETE CONSTRUCTION:

A. When installing precast sections, prevent damage to seals and sealants.

3.15 BRICK CONSTRUCTION:

A. Conform to applicable requirements of Section 04215.

3.16 WATER SERVICE CONNECTIONS:

A. Construct water mains and water service connections in accordance with the codes and regulations of the jurisdictional agency. *26

B. Make water service connections, where necessary, in accordance with applicable plumbing code. *27

C. Pay the required by the jurisdictional agency, except the water availability charge, which will be paid by the Authority. *28

D. Pay the water consumption charges until the time of final substantial completion for this Contract. *29

E. Do not connect water service to WSSC system until application for the connection has been approved by the WSSC. *30

F. Pay the water consumption charges until the time of final substantial completion for this Contract. *31

3.17 TUNNELING AND JACKING:

A. Perform tunneling and jacking as approved.

B. Where open cut is specified and the Engineer permits work to be done by tunneling or jacking, perform such work as specified and as approved.

C. Make horizontal borings for laying pipe lines true to line and grade.

D. Where pipes are laid in borings, completely fill void between pipe and the boring with sand, using water pressure to ensure that voids are filled.

E. Methods of boring and filling of voids between pipe and boring and subject to approval.

3.18 BONDING AND CATHODIC PROTECTION:

A. Bond ferrous pipe in accordance with Section 16060.

B. Where cathodic protection of piping system is shown, apply coal-tar epoxy coating as specified in Section 02535 and test as specified in Section 13115.

3.19 FIELD QUALITY CONTROL:

A. Notice of Testing:
   1. Coordinate with and assist the WSSC in testing water mains. Provide equipment necessary for and adequate to maintain required pressures for the required period. Do the work, such as making connections, operating pump, providing piping, valves and other materials necessary for making tests. Pressure recorder, charts and water meter for testing will be furnished by the WSSC. *32
   2. Give two days notice of intention of testing to operating agency which will furnish, install and operate pumps, gauges, meters and individual pipe connections to test openings. *33 *and* *9
   3. Designate largest sections feasible for testing and sterilizing. One testing and sterilizing operation will be performed at no expense to the Contractor; the cost of subsequent testing and sterilizing, if necessary, will be borne by the Contractor. *9

B. Tests:
   1. General requirements:
      a. Prior to coating and backfilling, isolate system by use of approved valves, caps and plugs or other means.
      b. Maintain such isolation throughout performance of leakage and pressure testing.

c. Where valves are used for isolation, eliminate leakage through such valves if it occurs. Maintain new work isolated from existing water mains, except for test connections, until testing and sterilization have been completed.

2. Leakage test:

a. For leakage tests, provide approved caps and plugs in sections to be tested and remove them after testing.

b. Prevent leakage in pipes and fittings at openings.

c. Block temporarily plugged and capped ends to prevent displacement.

d. Install water source connection for testing isolated section; the Engineer may permit the use of tap which will be furnished and installed by operating agency. *9

e. Perform work and furnish materials incidental to leakage testing, including excavation for installation and removal of pumps, gauges, meters and water source connections. Operating agency will apply 125-psig test-pressure section under test for 24 hours minimum. *9

f. Where leakage exceeds the amount specified in Table 02515-1, perform necessary corrective measures.

g. Pressure test:

1) After completion of leakage test, remove temporary caps and plugs and connect new water main into system. With new work valved off or otherwise isolated from system by approved means, assist with pressure test.

2) Operating agency will apply 175-psig test-pressure to section under test for one-hour minimum. *9

3) Take corrective measures necessary to provide system free of leaks.Remove and replace defective pipes, jointings, fittings, valves and other appurtenances. Reset such items, if displaced.

3.20 STERILIZING:

A. Operating agency will sterilize work during leakage test. *9

B. Provide access to opening used for sterilizing.

C. Provide Post-Sterilization Water Sampling and Testing Services: Have EPA-approved or jurisdictional health authority-certified laboratory sample and test water, and submit certified test results that water quality and lead concentration in samples meet EPA standards.

3.21 COMPLETION:

A. Upon completion of leakage testing and sterilizing remove temporary construction and complete connection of new work to system.

B. Bond ferrous pipe in accordance with Section 16060.

C. Have EPA-approved or jurisdictional health authority-certified laboratory sample and final proof-test water, and submit certified test results that water quality and lead concentration in samples meet EPA standards.

THIS SPACE NOT USED.

TABLE 02515-1

MAXIMUM ALLOWABLE LEAKAGE IN CUBIC FEET PER 24 HOURS PER JOINT

Test Pressure	Nominal Pipe Size											
psi	6"	8"	12"	16"	20"	24"	30"	36"	48"	60"	66"	72"

100	.052	.069	.104	.139	.173	.208	.260	.312	.416	.520	.572	.624
110	.054	.073	.109	.145	.181	.217	.272	.326	.435	.544	.598	.652
120	.057	.076	.114	.152	.190	.228	.285	.342	.456	.570	.627	.684
130	.059	.079	.119	.158	.197	.237	.296	.356	.474	.593	.652	.711
140	.062	.082	.123	.164	.205	.246	.308	.369	.492	.615	.677	.738
150	.064	.085	.127	.170	.212	.255	.318	.382	.509	.637	.701	.764
160	.066	.088	.132	.175	.219	.263	.329	.395	.526	.658	.724	.789
170	.068	.090	.136	.181	.226	.271	.339	.407	.542	.678	.746	.814
180	.070	.093	.140	.186	.232	.279	.349	.419	.558	.698	.767	.837
190	.072	.096	.143	.191	.238	.287	.358	.430	.573	.717	.788	.860
200	.074	.098	.147	.196	.245	.294	.368	.441	.588	.735	.809	.882
psi	6"	8"	12"	16"	20"	24"	30"	36"	48"	60"	66"	72"
Above tabulation is based on leakage at maximum rate of 23.3 gallons per inch of pipe diameter per mile per 24 hours at 150 psi for pipe in 18-foot lengths.												

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Delete or modify this paragraph as appropriate when project does not involve an operating agency.

***2**. Add 1.2 C. including 1. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***3**. Use first version of 1.3 A.2. modification for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***4**. Use second version of 1.3 A.2. for contracts where water distribution work is performed in all other jurisdictions.

***5**.. Use second version of 1.3 A.4. modification for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***6**. Use third version of 1.3 A.4. modification for contracts where water distribution work is performed in all other jurisdictions.

***7**. Add first version of 1.3 A.5. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***8**. Add second version of 1.3 A.5. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***9**. Add 1.3 A.7. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***10**. Use second version of 2.1 R. for contracts where water distribution work is performed outside the jurisdiction of WSSC.

***11**. Use first version of 2.1 S. including 1.a. modification for contracts where water distribution work is performed within the jurisdiction of WSSC.

***12**. Use second version of 2.1 S. for contracts where water distribution work is performed outside the jurisdiction of WSSC.

***13**. Add 2.1 V. for contracts where water distribution work is performed within the jurisdiction of WSSC and where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***14**. Add first version of 2.1 W. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***15**. Add second version of 2.1 W. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***16**. Add first version of 2.1 X. including 1.-7.e. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***17**. Add second version of 2.1 X. including 1.-3. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***18**. Add first version of 2.1 Y. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***19**. Add second version of 2.1 Y. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***20**. Add 2.1 Z. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***21**. Add 3.5 G. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***22**. Add 3.5 H. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***23**. Add 3.5 I. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***24**. Add 3.5 J. for contracts where water distribution work is performed within the jurisdiction of Fairfax County, Virginia.

***25**. Add 3.11 C. including 1.-2.c. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***26**. Use first version of 3.16 A. modification for contracts where water distribution work is performed within the jurisdiction of WSSC and where water distribution work is performed within the jurisdiction of Fairfax County, Virginia and Falls Church, Virginia.

***27**. Use second version of 3.16 A. modification for contracts where water distribution work is performed in all other jurisdictions.

***28**. Add 3.16 B. for contracts where water distribution work is performed within the jurisdiction of WSSC and where water distribution work is performed within the jurisdiction of Fairfax County, Virginia and Falls Church, Virginia.

***29**. Add first version of 3.16 C. where water distribution work is performed within the jurisdiction of Fairfax County, Virginia and Falls Church, Virginia.

***30**. Add second version of 3.16 C. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***31**. Add 3.16 D. for contracts where water distribution work is performed within the jurisdiction of WSSC.

***32**. Use first version of 3.19 A.1. modification for contracts where water distribution work is performed within the jurisdiction of WSSC.

***33**. Use second version of 3.19 A.1. modification for all other contracts where water distribution work is performed.

END OF SECTION

6. Production Maximum Tip Elevation: The elevation below which production pile tips must penetrate by at least one foot, based on the indicator pile test program.
7. Pile Design Load: The load each pile is designed to carry.
8. Ultimate Bearing Capacity: The maximum bearing capacity that the pile can sustain without rapid progressive settlement of the pile under constant load.

C. Pile Type:
1. Prestressed precast concrete piles, driven.

D. Related Information:
1. Grading, Excavating, and Backfilling: Section 02320.
2. Support of Excavation: Section 02260.
3. Concrete Formwork: Section 03100.
4. Concrete Reinforcement: Section 03200.
5. Cast-in-Place Structural Concrete: Section 03300.
6. Structural Precast Concrete: Section 03400.
7. Prestressed Concrete: Section 03415.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Codes and regulations of the jurisdictional authorities.
2. ASTM Standards:
a. D1143 - Test Method for Piles Under Static Axial Compressive Load.
b. D4945 - Test Method for High Strain Dynamic Testing of Piles.

1.03 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. Shop Drawings:
a. For Static Pile Load Tests, provide drawings that show load test apparatus setup including the method of applying the load. Drawings must show devices to be used to measure pile top movement.
b. For Dynamic Pile Testing, provide manufacturer's or vendor's data on transducers, computer, wiring, and schematic drawings for testing specified piles.
c. For Static Pile Load Test and Dynamic Pile Testing programs, provide detailed sequence of testing, evaluation of results and planned reports.
d. Pile splicing is not desired and shall be avoided. In the event that concrete piles are driven below the elevation of bottom of cap, build-ups, precast or cast-in-place splicing may be used when approved by the Engineer. The pile submittal shall include splice details, build-up details and any other details necessary to satisfy the requirements of these specifications.
e. The pile submittal shall show prestressing methods, tendon arrangement, working stresses, and methods for pick-up and handling of piles.
f. Submit certification of accuracy for all gauges and test equipment.
2. Documentation:
a. Driving Equipment/Accessories List:
1) Submit details of proposed driving equipment to include cranes, leads, hammer, compressors, powerpacks, driving caps, hammer cushions and pile cushions. Data on hammer shall include as a minimum the manufacturer's model number, estimate of efficiency,

energy ratings and ram details, including operation certification performed within the last 90 days.

2) Submit details of accessory equipment to be used including service cranes, hoses, throttles, and pile handling rigging.

b. Submit procedures and details for installation of reinforcement and prestressing.

c. Submit materials certifications and concrete mix designs for all concrete products to be used during the pile installation.

d. Indicator Pile Order List:

1) Submit a list of piles to be installed as part of the indicator pile test program. List shall show type, size, number, location, indicator pile order length, predicted maximum tip elevation, allowable driving stress related to hammer blows, and blow count needed to attain twice the pile design load. If locations for indicator piles differ from those shown on the drawings, provide reasons for change. The proposed revised location will be reviewed and, if appropriate, approved by the Engineer.

2) Submit list prior to ordering indicator piles.

e. Test Documentation and Reports:

1) The Contractor shall retain an experienced Engineer employed by a Dynamic Testing Consultant. The Dynamic Testing Consultant's Engineer shall be an integral part of the Contractor's Quality Control Program. Submit the qualifications of the Dynamic Testing Consultant's Registered Maryland Professional Engineer responsible for monitoring Static and Dynamic Pile Testing. The Dynamic Testing Consultant's Engineer shall have a minimum of five (5) years experience in similar work, of which two (2) years shall be field experience with the monitoring of pile driving operations. The Dynamic Testing Consultant shall provide the following:

a) Results of all Wave Equation Analyses using the GRLWEAP program, Dynamic tests, Static tests and the Case Pile Wave Analysis Program (CAPWAP). The GRLWEAP and CAPWAP program is a product of Globle Rausche Likins and Associates, Inc., 4535 Renaissance Parkway, Cleveland, OH 44128. Telephone (216)831-6131.

2) Sample pile driving record/report and sample sketch proposed to show any necessary deviations from planned locations.

3) An annotated sample of the dynamic testing apparatus output. Output shall include recorded input, reduced data and analysis.

4) After completion of each Static and/or Dynamic Pile Test, submit a test report for review and approval by the Engineer. The test report shall include reporting information specified in ASTM D1143 and D4945, results of the refined wave equation analyses, and recommendations for the Production Pile Order List.

5) Prepare a summary report of all the wave equation analyses, CAPWAP, and results of the dynamic and static pile tests. The report shall include test details, hammer and driving system details, soil conditions, instrumentation, test sequence and observations, discussions of test results (including hammer performance, driving stresses, pile integrity and pile capacity), and conclusions and recommendations for the Production Pile Order List.

f. Production Pile Order List:

1) After review and approval of the results of the Static Pile Load Test and Dynamic Pile Testing, submit an "Order List" of production piles proposed to be installed in each pile group. The list shall show type, size, number, location, sequence of installation, length, production maximum tip elevation , allowable driving stress related to hammer blows and blow count needed based on end of initial driving results to attain twice the pile design load for all piles in each pile group.

g. Pile Driving Record:

1) Maintain a record throughout the indicator pile test program and production pile driving operations and submit to the Engineer upon completion of each pile group. The record shall show the applicable established driving criteria developed by the Static Load Test, as modified by Dynamic Testing, for each pile. As a minimum include the following information:

a) Sequence in which piles were driven.

b) Equipment: type, model, serial number.

c) Required blow count per approved driving criteria, allowable driving stress related to hammer blows, production maximum tip elevation and final pile tip elevation.

d) Blow count for each foot of driven length.

e) For all piles, the number of blows per inch of penetration for last 12 inches.

f) Unusual conditions encountered during driving of each pile.

g) Immediately after final pile driving, record top elevation of pile to nearest 0.01 inch. Provide as built pile information after all piles in a pile group have been driven.

1.04 PRODUCT DELIVERY AND HANDLING:

A. Lifting loops shall be used as provided by the precaster. Lifting loops shall not be tied in any way to the pile reinforcement. Loops may remain in place during driving. When handling and delivering precast piles, avoid bending and breaking or chipping of piles.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Precast concrete piles:

1. Prestressed precast concrete piles in accordance with Sections 03100, 03200, 03300, 03400, and 03415 of these specifications as applicable, shaped as shown.

B. Miscellaneous Driving Accessories: Including driving heads, collars, bands, shoes, and other driving devices in accordance with pile manufacturer's recommendations.

C. Lean concrete: Section 02260.

PART 3 - EXECUTION

3.01 DRIVING EQUIPMENT:

A. The Engineer will review submitted data on driving equipment, accessories and methods for adequacy in conditions expected.

B. Adequacy of equipment and accessories remains the responsibility of the Contractor.

C. Should the equipment used by the Contractor prove inadequate to drive scheduled types of piles at the locations shown, or should progress schedule not be maintained, the Engineer may require replacement of equipment or different expendable accessories or additional equipment.

D. If the hammer, driving block, cushion or any other part of the driving system is changed for any reason, the system must be calibrated by conducting Dynamic Pile Testing to prove the new system is equal to the original system. This work shall be made at no additional time to the Contract and at no cost to the Authority.

3.02 INDICATOR PILE TEST PROGRAM:

A. Installation:

1. No later than twenty-one (21) days prior to driving indicator piles, conduct initial wave equation analysis that represents the subsurface conditions on this project, the pile properties and driving equipment provided. This analysis shall be submitted along with the required pile and driving equipment data to the Engineer.
2. Provide and install indicator piles where shown, to determine lengths of production piles to be furnished to achieve twice the pile design load in the scheduled pile groups. If twice the design load is not attained when the top of the pile is one-foot above planned cut off, discontinue driving for a period of 24 hours or as directed by the Engineer. After the specified period, restrike pile in accordance with Article 3.2.B.1.b. If twice the design load is not attained after restrike, splice the pile, if necessary, and drive it until the specified bearing value is obtained.
3. Locate piles at contract pile locations so they can become part of the completed structure provided they are approved as conforming to requirements specified for production piles. Install indicator piles to achieve pile tips below the predicted maximum tip elevation, in the presence of the Engineer. Assist the Engineer in verifying measurements and driving characteristics as necessary to evaluate the adequacy of the foundation system.
4. The indicator piles scheduled for Static Pile Load Tests are shown on the Contract Drawings. The Engineer may designate alternate or additional indicator piles that exhibit the weakest bearing capacity for Static Pile Load Tests.
5. Piles which are subjected to Static Pile Load Tests which do not pass the acceptance requirements shall be restruck, per 3.2. B.1.b with Dynamic Testing Apparatus installed and functioning, within 48 hours after completion of the Static Pile Load Test to reestablish the minimum required pile length and blow counts.
6. Additional piles may be driven, at the Contractor's option, in the area of the Static Load Test Piles to be used as reaction piles. All piles driven as indicator piles or reaction piles for load tests in accordance with the plans and specifications and meeting specified requirements for production piles can, upon approval, be cut off and become a part of the permanent structure.
7. Install all indicator piles that are intended to become part of the permanent structure with the same type and model of equipment and methods to be used to install production piles. Perform work in the presence of the Engineer.

8. Remove piles which are not incorporated into the completed structure or which do not satisfy test requirements. Alternatively, if rejected piles are not removed then cut off at least three (3) feet below finished grade and backfill resulting hole with lean concrete.

B. Pile Testing:

1. Dynamic Pile Testing:

a. Perform Dynamic Pile Testing in accordance with ASTM D4945.

b. Install indicator piles where shown with the Dynamic Testing Apparatus installed and functioning to measure performance of the driving system and the bearing capacity. Begin dynamic testing during initial driving when the pile tip achieves the predicted maximum tip elevation. Drive indicator piles to a bearing capacity of at least twice the pile design load based on initial driving. Restrike all indicator piles, with Dynamic Testing Apparatus installed and functioning to verify results from initial driving of these piles. Restrike indicator piles with the hammer at normal operating temperature for a maximum penetration of twelve inches, a maximum of 60 hammer blows, or to less than the driving stress limits established by Article 3.3.B, whichever occurs first. Pile driving shall resume as if it was the initial strike conditions per Article 1.1.A.1.c to obtain the correct pile driving criteria

c. Perform CAPWAP analyses using the Dynamic Pile Testing data from the end of initial driving and the beginning of restrike of all indicator piles.

d. Perform refined wave equation analyses using the dynamic test results of each indicator pile. Incorporate the results of the refined wave equation analyses in driving of subsequent indicator piles. Refined wave equation analyses shall be based upon the variations in the subsurface conditions and/or drive system performance measured by the dynamic testing apparatus.

2. Static Pile Load Tests:

a. Static Pile Load Test equipment and testing procedures shall be in accordance with ASTM D1143, Quick Load Test Method, except as modified herein.

b. Provide test equipment with capacity greater than three times the pile design load and having means of determining applied load to within five (5) percent of test load. Provide test equipment capable of measuring total settlement at the top of the pile to nearest 0.001 inch.

c. Perform Static Pile Load Tests. Commence loading the pile no sooner than 72 hours after installation of the pile. The maximum test load shall be equal to three times the pile design load or the ultimate bearing capacity, whichever occurs first.

d. The ultimate bearing capacity under axial comprehensive load is that load which produces a settlement of the pile head equal to:

$S_u = S + (0.15 + 0.008D)$

Where:

S_u = Settlement at ultimate bearing capacity in inches

S = Elastic deformation of total unsupported pile length in inches

D = Pile diameter or width in inches

e. The safe bearing capacity is defined as 50 percent of the maximum test load. Static load test results will be acceptable when the safe bearing capacity equals or exceeds the design bearing capacity.

f. Restrike piles for monitoring with Dynamic Testing Apparatus in accordance with Articles 3.2.A.5 and 3.2.B.1.

3.03 PRODUCTION PILE DRIVING:

A. Bearing Value, Length and Penetration:

1. Provide production piles of length necessary to attain production maximum tip elevation, twice the pile design load, and to extend into cap or footing block as shown.
2. Determine lengths of production piles by analysis of data obtained from Static Pile Load Tests, Dynamic Pile Testing and refined wave equation analyses.
3. Any pile that does not reach twice the pile design load by approved blow count or attain the minimum penetration will be rejected. Rejected piles will be restruck after 48 hours in accordance with Article 3.2.B.1 and ,if necessary tested using Dynamic Pile Testing equipment as directed by the Engineer to prove attained capacity at no additional cost to the Authority.
4. The Contractor may install additional test piles, make borings or make such other investigations as he may desire at no additional time to the Contract and no cost to the Authority.

B. Pile Driving Stresses:

1. Indicator and production piles shall not be driven above the hammer energy and blow count shown by the wave equation analyses to produce stresses above the point of impending damage. For concrete piles limit the tensile (TS) and compressive (CS) driving stresses to:

$$TS \leq 3\sqrt{f_c'} + EPV$$

$$CS \leq 0.85 f_c' - EP$$

Where:

f_c' = The 28-day design compressive strength of the concrete

EPV = The effective prestress value

2. Cut off grade: At the Contractor's option, production piles reaching design bearing capacity and production maximum tip elevation with tops above the cut off grade may be driven to the cut off grade providing the required bearing capacity is maintained, allowable driving stresses within the pile have not been exceeded and no damage to the pile occurs. Piles damaged or suspected of damage due to driving to achieve a cut off grade shall be pulled and/or replaced at the Contractor's expense.

C. General Requirements:

1. Drive piles only after completion of required excavation or construction of indicated embankments.
2. Stage driving within supported excavation areas so as not to damage internal bracing.
3. For production piles in permanent embankments, pre-drill through fill or embankment to natural ground or bottom of embankment.
4. Drive each pile in a continuous operation until required penetration and twice the pile design load have been attained. If driving is stopped before required blow count and penetration have been reached, drive the pile one foot upon resumption of driving before resuming blow count for bearing value determination.
5. Redrive each pile which is lifted 1/4 inch or more by ground heave during driving of adjacent piles to at least the original tip elevation or as directed.

6. Remove loose and displaced material forced up around piles during driving.
7. In Terrace deposits and directly above the Monmouth Formation, cobbles, boulders and cemented sand/silt deposits were found. Penetrate into and through these deposits as necessary to attain twice the pile design load and required maximum tip elevation.
8. Achieve pile penetration through miscellaneous fill, rubble concrete, tires, hardpan, cemented sands/silts, and any other obstruction, natural or man-made, by means of pre-drilling or other approved excavation methods.
9. Hold pile tops in position with steel driving block or anvil.
10. Do not drive piles with free swinging hammer.
11. Pull and replace piles which are not within specified tolerances or, if approved, redesign pile cap as specified. Costs associated with the redesign and construction of modified pile caps will be borne by the Contractor and no additional time to the Contract will be allowed.

D. Pre-drilled Holes:
1. Where shown on the Contract Drawings, drill holes to diameter of greatest cross section dimension of the pile to be installed in accordance with the notes and schedules on the drawings and with Section 204.
2. Set pile in pre-drilled hole and drive to predicted or production maximum tip elevation and twice the pile design load, but in all cases to a minimum depth of five (5) feet below bottom of pre-drilled hole.
3. Fill voids between pre-drilled hole and pile with lean concrete immediately upon completion of the driving sequence, as approved.
4. Dispose of material resulting from drilling holes in accordance with the requirements of Section 204.
5. Fill rejected pre-drilled holes with lean concrete and redrill at approved location.

E. Concrete Piles:
1. Cut off piles at such elevation that they will extend into cap or footing as shown. Saw cut piles with equipment capable of providing a flat smooth surface without spalling or damaging pile below cutoff. Replace or repair piles that are damaged when cut off.
2. Where reinforcing steel dowels are shown, dowels may be anchored in cast or drilled holes in concrete pile. If holes are drilled, drill by methods that will not damage concrete, reinforcing steel or prestressing steel. Drill minimum diameter consistent with placing approved epoxy adhesive and dowel. Leave holes free of dust, moisture or other deleterious material. Place sufficient epoxy in holes before inserting dowels leaving no voids afterwards. Leave dowels undisturbed until epoxy has developed 100 percent of its strength capacity.

3.04 FIELD QUALITY CONTROL:

A. Concrete Pile Allowable Tolerances:
1. Ensure straightness and cross-sectional dimensions of precast piles so that a line stretched from butt to tip on any face is not more than one inch from face of pile at any point.
2. Install piles within the following tolerances:
   a. Axis of pile within six inches of design location at cutoff elevation.
   b. Axis of pile not out of plumb or batter by more than one percent of its driven length.
   c. No encroachment of piles upon neat lines of Authority structures.

PART 4 - MEASUREMENT AND PAYMENT

4.01 BASIS:

A. Compensation for work specified in this section will be made in the following manner:

1. Furnishing and installing piles: Linear foot in place in the completed work measured from the tip of the pile to the plane of the cut off (top of pile). This price shall include conducting and reporting the initial wave equation analysis, furnishing piles; driving piles; splices; concreting; achieving specified load and tip elevations.
2. Static Pile Load Test: This work will be measured and paid for at the Contract unit price per each static pile load test performed. The payment will be full compensation for furnishing and setup of test equipment, providing reaction piles, conducting test, reporting and incidentals necessary to complete the work. If load test is terminated by the Engineer because of insufficient bearing capacity, test will be measured for payment. If the test is terminated because of malfunction of Contractor's equipment or other reasons that are the fault of the Contractor, the test will not be measured for payment.
3. Dynamic Pile Testing: This work will be measured and paid for at the Contract unit price per dynamic test performed. The payment will be full compensation for furnishing and setup of dynamic testing equipment and conducting test during initial and restrike driving of each indicator pile, performing CAPWAP analyses, performing the refined Wave Equation Analysis, reporting and incidentals necessary to complete the work. Incomplete tests and terminations treated in accordance with Article 4.A.2.
4. Pile restrike: This work will be measured and paid for at the Contract unit price, per each restrike performed. The payment will be full compensation for furnishing and setup of pile driving equipment required for restriking piles with dynamic equipment installed and functioning in accordance with Article 3.2. If test is terminated by Engineer because of insufficient bearing capacity pile restrike will be measured for payment. If the test is terminated because of malfunction of Contractor's equipment or other reasons that are the fault of the Contractor, pile restrike will not be measured for payment.
5. Pre-drilled holes shown and specified in Article 3.3 will be paid for at the Contract unit price per linear foot measured from the plane of the cut off (top of pile) to the level of the pre-drilled elevation specified. This price shall include providing the equipment, material and labor necessary to drill holes to the scheduled elevation, disposal of materials, placing lean concrete and incidentals necessary to complete the work.

END OF SECTION

SECTION 02535

SANITARY SEWER

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies installing sanitary sewers.

B. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Maintenance, support and restoration of utility facilities: Section 02270.
   3. Stray current and cathodic protection: Section 13110 and 13115.

C. Material Furnished By Others: *1
   1. Except for those items which bear the METRO logo, WSSC furnishes the following:
      a. Manhole frames and covers: 22-inch diameter.
      b. Manhole steps, except where precast manholes are used.

D. Definitions: *2
   1. Granular bedding required by WSSC is equivalent to aggregate for pipe cradle as specified.
   2. WSSC: Washington Suburban Sanitary Commission.
   3. WASA: Water and Sewer Authority.

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:
      a. Drawings for each size and configuration of precast manhole with details of accessories and joints.
      b. Diagrams showing dimensioned locations for openings in precast concrete manhole walls.
   2. Documentation:
      a. Submit calculations for modified or special designs to demonstrate compliance with required load-bearing capacity, certified by a professional engineer registered in the jurisdiction where the work is to be installed.
   3. Samples:
      a. Sewer brick: Ten.
      b. Manhole brick: Ten.
   4. Certification.
   5. Documentation: *3
      a. Submit two copies of records of inspection of new and relocated sewers, one copy to WSSC and one copy to the Engineer. Include video-tape cassette of television inspections and logs, photographs and other records specified by WASA for visual walk-through inspections.
      b. Obtain and submit a written approval and acceptance from WASA.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. Building Stone Institute: Stone Catalog
   3. CISPI: HSN 85.
   4. AASHTO: M33, M153, T85, T96, T104. *4
   5. AASHTO: H20, M33, M36, M153, M175, M176, M190, M252, M288, T85, T96, T104. *5
   6. ANSI/ASME: B16.1. *6
   7. ACI: 318.
   8. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C700, D698, D1682, D3034. *7
   9. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C700, D698, D3034, D5034. D5035. *8
   10. MS: MIL-P-23236.
   11. SSPC: SP-6.
   12. WSSC: General Conditions and Standard Specifications. *9

B. Allowable Tolerances:
   1. Rate of infiltration into sanitary sewer lines not to exceed 100 gallons per inch diameter per 24 hours per mile of sewer.
   2. Subgrade: Plus-or-minus 1/2 inch of elevation shown.

C. Inspection: *10
   1. Prior to paving or other construction over new or relocated sewers, conduct visual walk-through inspection of sewers larger than 36 inches in diameter and of associated structures and internal television inspection of sewers 36 inches and smaller in diameter.
   2. Employ the services of a sewer inspection company which has been regularly engaged in television sewer inspections and which is acceptable to WASA to perform preconstruction and post-construction inspections of sewers 36 inches and smaller in diameter.
      a. Submit to WASA for prior approval one sample of the cassettes to be used.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Formwork: Section 03100.

B. Reinforcing Steel: Section 03200.

C. Portland Cement Concrete: Section 03300, Class 3500, unless otherwise shown.

D. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate, No. 4. Where shown use layers of No. 4 and No. 67 in combinations and proportions determined by field conditions and as approved.

E. Aggregate for Pipe Cradle: ASTM C33, coarse aggregate No. 67.

F. Concrete Pipe:
   1. 10-inch diameter and smaller:
      a. STM C14, Class 2, nonreinforced concrete pipe.
      b. Bell-and-spigot type.

c. Joints fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.

2. 12-inch diameter and larger:
   a. ASTM C76, bell-and-spigot or tongue-and-groove, Class IV, unless otherwise shown.
   b. Radius (bevel) pipe, with drop between two pipe sections not exceeding the common wall thickness.
   c. Rubber gasket joints, when required, fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
   d. Acceptance tests as specified in ASTM C76 form basis of acceptance for concrete pipe in accordance with the following:
      1) 72-inch diameter and smaller: Acceptance on the Basis of Plant Load Bearing Test, Material Tests and Inspection of Manufactured Pipe for Visual Defects and Imperfections.
      2) Larger than 72 inches in diameter: Acceptance on the Basis of Material Tests and Inspection of Manufactured Pipe for Defects and Imperfections.
      3) Minimum laying lengths:
         (a) Sanitary sewer and combined system construction:
         (b) 72-inch diameter and smaller: Eight feet.
         (c) Larger than 72-inch diameter: Six feet.
   e. Rubber gaskets: ASTM C361. *11
   f. Rubber gaskets: ASTM C443. *12
   g. Jointing mastic: Elastic, water-resistant, formulation of plastic bituminous materials, nonflammable solvent and inert fillers so combined that:
      1) When applied to a vertical metal surface and heated to 120F, jointing mastic will neither slump nor lose plasticity.
      2) When applied directly from container without further fixing, jointing mastic can be applied in even, adherent coat within temperature range of 20F to 100F.

G. Plastic Pipe:
   1. Polyvinyl chloride (PVC) pipe: ASTM D3034, SDR-35.

H. Vitrified Clay Pipe: ASTM C700; Joints, ASTM C425, using plastic materials.

I. Cast-Iron Soil Pipe and Fittings: ASTM A74, extra-heavy (XH), with hub and spigot ends so constructed that joints may be made with gaskets conforming to CISPI Designation HSN 85 and the requirements of the relevant plumbing codes.

J. Lubricant for Rubber Gasket Pipe Joints: Vegetable oil soap.

K. Mortar Materials:
   1. Portland cement: ASTM C150, Type I.
   2. Sand: ASTM C144, natural sand.
   3. Lime: Pressure-hydrated, ASTM C207, Type S.
   4. Water: Potable.
   5. Pigment: As approved.

L. Brick: ASTM C32; solid brick; Grade MS for manhole brick, Grade SS for sewer brick; 2-1/4 inches by 3-3/4 inches by eight inches.

M. Precast Concrete Manhole Sections: *13
   1. ASTM C478.
   2. Joint entry seal gasket: A-LOK as manufactured by Atlantic Precast Concrete, Inc.; A-LOCK gaskets, manufactured by A-LOK Products Corporation, Trenton,

N.J.; DURAC-SEAL gaskets, manufactured by DURA-CRETE, Inc., Dayton, Ohio; or equal.

N. Precast Concrete Manholes: *14
1. Cylindrical, eccentrical and conical: ASTM C478.
2. Other configurations: ACI 318, AASHTO H20.

O. Manhole Steps:
1. Cast iron: ASTM A48 Class 30 A.
2. Rebar: No. 4 reinforcing bar with molded polypropelene or rubber encasement.

P. Manhole Frame and Cover; And Other Castings For Service With Utility Systems:
1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
2. Utility company manhole: Manhole frame and cover furnished as part of the Contract or furnished by the utility as shown on the drawings.
3. Rust-resistant cast iron or rust-resistant malleable cast iron.
4. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
5. Fillets at angles in casting with arises sharp and perfect.
6. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
7. Metro logo: For utility components which will remain METRO property and are not within boundaries of utility easements as shown: Cast METRO logo as shown.
8. Covers that receive paver tile:
   a. Omit bituminous coating.
   b. Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position.

Q. Metal Water Seals for Basin Connections: Neenah Foundry Model No. R-3707 or equal.

R. Structural Steel Members: ASTM A36.

S. Steel Pipe: ASTM A53, black finish, extra strong wall class.

T. Stainless Steel Angle: ASTM A167, Type 304.

U. Jute for Caulking: Good quality jute, free from tar, oil, or grease and dry when installed.

V. Preformed Expansion Joint Fillers: AASHTO M153, Type I, Type II or Type III.

W. Bituminous Expansion Joint Filler: AASHTO M33.

X. Galvanizing: Section 05120.

Y. Miscellaneous Metal: Section 05500.

Z. Coal-Tar Epoxy Coating:
1. Two-component.
2. Chemically cured.
3. Conforming to MS MIL-P-23236 (Ships), Type I, Class 2.
4. Thinner: As recommended by manufacturer of coating and as approved.

AA. Pipe Supports: *15
1. Pipe: Three-inch diameter, ASTM A53, Weight B, Class 1.

2. Flanges: ANSI/ASME B16.1, 125-pound Class, galvanized after fabrication.

2.02 MORTAR AND GROUT MIXES:

A. General Requirements:
1. Mix dry in specified proportions by volume. Control and maintain accurate measurement throughout progress of work.
2. Add sufficient water as specified to produce approved consistency.
3. Do not mix in amount exceeding that which can be used within one hour after introduction of water.
4. Do not retemper mix that has begun to set nor use such mix in the work.
5. Where shown, specified or directed, mix pigment into dry mix to attain color selected by the Engineer. Pigment not to exceed 10 percent of dry batch weight of cement.

B. Proportions:
1. Mortar: One part portland cement, 2-1/2 parts sand and water sufficient to produce stiff workable mix.
2. Grout: One part portland cement, 2-1/2 parts sand and water sufficient to produce plastic flowable mix.
3. Mortar for setting and pointing granite: One part portland cement, four to five parts sand, one part lime and water sufficient to produce approved consistency.
4. Mortar for setting granite paving and grouted granite blocks: One part portland cement, four parts sand, with water sufficient to produce approved consistency.

PART 3 - EXECUTION

3.01 EXCAVATION FOR SEWER:

A. Perform excavation for sewers line and grade shown in accordance with Section 02320 and the following additional requirements:
1. Excavate test pits sufficiently in advance of construction of sewers so that reasonable changes in line and grade can be made where location of existing structures varies from that shown.
2. Excavate below horizontal plane extending two feet above top of sewer to maximum width of trench pay width shown. Where dimensions are not shown, make maximum horizontal width of excavation 18 inches from outside of sewer and minimum six inches. Where approved, excavation above such plane may exceed specified dimensions.
3. If excavation exceeds permissible dimensions, encase pipe or install pipe of higher strength.
4. Where necessary to place backfill or embankment so that trench can be excavated, extend backfill or embankment full depth laterally at least 2-1/2 times diameter of pipe on each side measured from centerline of pipe.

3.02 PIPE CRADLE:

A. Place pipes on cradle of aggregate or concrete where shown.

B. Place aggregate so as to avoid segregation; compact to maximum practicable density so that pipe can be laid to required tolerances.

3.03 LAYING PIPE:

A. General Requirements:

1. Excavate to lines and grades shown in accordance with Sections 02320 and herein. Excavate depressions for bells.
2. Protect pipe and fittings during handling to prevent damage.
3. Place, shape and compact bedding material to receive barrel of pipe. Type and thickness of bedding material as shown.
4. Start laying pipe at lowest point; lay true to line and grade shown.
5. Install pipe to bear on bedding material along entire length. Shape bedding material to fit bells and flanges.
6. Install pipe so that bells and grooves are on upstream end.
7. Align each section of pipe with adjoining section with uniform annular space between bell and spigot and so as to prevent sudden offsets in flow line.
8. As each section of pipe is laid, place sufficient backfill to hold it firmly in place.
9. Keep interior of sewer clean as work progresses. Where small pipe size makes cleaning difficult, keep suitable swab or drag in pipe and pull through each joint immediately after jointing is completed.
10. Keep trenches and excavations free of water during construction and until backfilled. Each day, excavate only as much trench as needed to lay pipe.
11. When work is not in progress, securely plug ends of pipe and fittings to prevent trench water or other substances from entering pipes and fittings.
12. Where length of stub is not shown, install four-foot length and seal free end with brick masonry bulkhead or approved stopper.
13. Have work approved prior to covering pipe.
14. Where shown, place additional aggregate filter around and over pipe in lifts not exceeding six inches loose. Compact each lift before placement of next lift.
15. Backfill in accordance with Section 02320.
16. Accomplish compaction by method that will avoid damage to pipe and will not disturb its alignment and grade. The use of vibratory rollers is prohibited until compacted cover over pipe has reached three feet or half the pipe diameter, whichever is greater.
17. Where cathodic protection is shown, apply coal-tar epoxy coating.

B. Vitrified Clay Pipe:
   1. Nonperforated pipe:
      a. Use pipe hoist, crane or other approved device when laying pipe greater than 18 inches diameter.
      b. Prevent damage to premolded joint rings or attached couplings.
      c. Clean joint contact surfaces immediately prior to jointing. To complete joint, use lubricants, primers or adhesives as recommended by pipe or joint manufacturer.

C. Concrete Pipe:
      a. Bell-and-spigot joints:
      b. Lay bell-and-spigot joint pipe as specified for vitrified clay pipe.
   1. Tongue-and-groove joints:
      a. Clean groove end of preceding pipe with wet brush and apply soft mortar to lower 1/4 of groove. Clean tongue end of succeeding pipe with wet brush and position it. Remove mortar from interior surface if squeezed out of joint.
      b. Complete mortaring interior and exterior portions of joint for entire circumference, extending from previously placed mortar. Perform final exterior mortaring of joints three lengths of pipe behind laying.

D. Plastic Pipe:
   1. Nonperforated pipe:
   2. Join sections of pipe with couplings recommended by pipe manufacturer.

E. Inspections Of Sewers: *16

1. Perform all work in accordance with current requirements of WASA.
2. Perform inspections on new or relocated storm, sanitary and combined sewers within or adjacent to the zone of influence, as defined by the limits of a theoretical slope of 1:1 from the bottom edges of tunneling and cut-and-cover excavations, as follows:
   a. Make inspections upon completion of tunneling and cut-and-cover operations, but prior to paving.
   b. Obtain video-tape television inspection records of sewers 36 inches and smaller in diameter.
   c. By means of visual walk-through inspection, obtain coordinated logs, photographs and other records specified by WASA sewers larger than 36 inches in diameter and of associated structures.
3. Coordinate all television and walk-through inspection field operations with WASA. All such work to be performed in the presence of a WASA representative.

3.02 BACKFILL:

A. Perform backfilling only after inspection and approval of pipe laying.

B. On completion of construction, backfill excavation in accordance with Section 02320.

3.03 JOINTS FOR COMBINED SEWER SYSTEM CONCRETE PIPE:

A. Use rubber gasket and bell-and-spigot pipe as specified.

B. Prior to jointing pipe, liberally coat pipe joints with lubricant.

C. Fit bell or spigot with gasket in accordance with manufacturer's instructions.

D. Joint pipes with equipment designed for purpose.

E. Before joint is completely home, check position of gasket using suitable gauge. If gasket is found to be dislocated, repeat entire joining process using new gasket.

3.04 JOINTS FOR VITRIFIED CLAY PIPE:

A. Immediately before joining vitrified pipe, liberally coat bell with lubricant and fit spigot with gasket.

B. Join pipes using equipment designed for purpose.

3.05 JOINTS FOR CAST-IRON SOIL PIPE AND FITTINGS:

A. Immediately before joining cast-iron soil pipe and fittings, liberally coat hub with lubricant and fit spigot with pipes using equipment designed for purpose.

3.06 CONNECTIONS WITH EXISTING SEWERS:

A. Make connections with existing public sewers in accordance with requirements of the jurisdictional authority.

B. Connect house sewers in accordance with local plumbing code.

C. Connect house sewers by means of Y-branches. Approved cast-iron thimble may be used, provided it is bonded into sewer pipe wall with approved epoxy at manufacturer's plant.

D. Do not connect existing sewer to sewer under construction unless approved.

E. Do not connect sanitary sewers to the WSSC system until application for such connections has been approved by WSSC. *17

3.07 TUNNELING AND JACKING:

A. Perform tunneling and jacking by approved methods.

B. Where open cut is specified and the Engineer permits the work to be done by tunneling or jacking, perform such work as specified and as approved.

C. Cost of material substitutions required by change of methods will be borne by the Contractor.

D. Make horizontal borings necessary to lay pipe lines true to line and grade.

E. When sewers are laid in borings, completely fill void between outside barrel of pipe and boring with cement grout pumped into place.

F. When drainage pipes are laid in borings, completely fill void between pipe and boring with sand, using water pressure to ensure that voids are filled.

G. Methods of boring and filling of voids between pipe and boring are subject to approval.

3.08 CAST-IN-PLACE CONCRETE CONSTRUCTION:

A. Conform to applicable requirements of Sections 03100, 03200 and 03300. Section designer to specify the type of cement to be used. The type of cement will vary depending upon the jurisdiction where the work is performed.
   1. Cement. *18

B. Construct concrete support systems where shown. Section designer to specify the type of mortar to be used. Mortar type will vary depending upon jurisdiction in which the work is performed.
   1. Mortar and cement. *19

3.09 BRICK CONSTRUCTION:

A. Perform brick construction as specified in Section 04215, with the following additional requirements:
   1. Use sewer brick wherever brick construction is exposed to flow; otherwise, use manhole brick.
   2. Lay sewer brick on edge so that 2-1/4 by 8-inch side is exposed to flow.
   3. Lay manhole brick so that every sixth course is a header course.
   4. Where practicable, lay each course with a line. For curved courses or those in nonparallel planes, use bonded-and-keyed construction.
   5. Do not exceed joint thickness of 3/8 inch in straight courses in parallel planes; for courses curved or in nonparallel planes, make thickest part of joint as thin as practicable.

6. Rack or tooth uncompleted brick construction and parge unexposed surfaces with 1/2 inch of mortar.

3.10 MANHOLES:

A. Construct manholes of precast sections, cast-in-place concrete or brick as shown.

B. Provide base of precast or cast-in-place construction. Make watertight connection between base and risers.

C. Unless otherwise shown, place axes of manholes directly over centerlines of pipes.

D. Construct appropriate flow channels in bottom of manholes.

E. Where necessary, build connections for public and residential sewers into manholes. Cut pipe flush with inside wall of structure. Do not build pipe into wall; provide mortar joint between pipe and structure.

F. Install manhole steps and cast iron frame and cover for each manhole; adjust frame and cover to proper grade by brick construction.

G. Install joint entry seal gaskets in openings in the walls of 48-inch precast manholes with O-ring joint. *20

H.

3.11 COATING APPLICATION AND REPAIR:

A. Preparation of surface: Perform the following in order given:
   1. Clean surfaces contaminated with oil or grease using naphtha or xylol.
   2. Remove rust and mill scale from surfaces by dry abrasive blasting to commercial finish in accordance with SSPC SP-6.
   3. Coat surfaces within 24 hours and before dew point is reached.
   4. Apply coating only to surfaces which are dry and free of contaminants. Whip blast surfaces not coated within specified time limit.

B. Application of coating:
   1. Mix coating in quantity which can be applied within its pot life if in accordance with manufacturer's recommendation. Thin only with approval.
   2. Apply coating to exterior surfaces of pipes and fittings in accordance with recommendations of coating manufacturer and as follows:
      a. Two coats of equal thickness.
      b. Total dry film thickness: 20 mils.
      c. Pretreat first coat as required prior to application of second coat.
      d. Apply second coat before first coat has dried tack-free but not later than 24 hours after application of first coat, unless otherwise recommended by coating manufacturer.
      e. Inspect coating prior to burial. Repair damages in accordance with recommendations for field corrections by coating manufacturer.
   3. Test cathodic protection as specified in Section 13115.

3.12 FIELD QUALITY CONTROL:

A. Maximum Surface Variation Tolerances:
   1. Grouted riprap: 1-1/4 inches in four feet from true plane.
   2. Bituminous concrete: Plus-or-minus 1/4 inch from specified grade in 25 feet.

3. Cast-in-place concrete: Plus-or-minus 1/4 inch from specified grade in 15 feet.
4. Precast concrete block: Plus-or-minus 1/2 inch from specified grade in 25 feet.
5. Paving brick: Plus-or-minus 1/2 inch from specified grade in 25 feet.

B. Leakage Tests:
1. Perform leakage tests on sanitary sewer lines to verify compliance with allowable tolerances specified.

C. Obstruction Tests:
1. Perform field tests to verify that installed storm and sanitary systems are free from obstructions.
2. Remove obstructions by excavating at the apparent obstruction and repairing or replacing the defective pipe as directed by the Engineer.

D. Low-Pressure Air Testing Of Sanitary Sewers. *21
1. Test sanitary sewers with air under low pressure in accordance with WSSC procedures. The tests will not be accepted by the WSSC until the sewers meet the criteria enumerated. Pressure gauges, stop watches and test supervision will be provided by the WSSC. Provide air compressor, hose, plugs, labor and such materials, equipment and assistance required to perform the tests. Conduct tests in the presence of representatives of the WSSC. Do not place air under pressure in any sewer under any condition except those specified by WSSC.
2. Inspect sanitary sewers, including manholes, prior to air testing. Prior to undertaking the low-pressure air tests, correct and eliminate any water leakage into the system sufficient to constitute a noticeable trickle or dribble.
3. Wherever underdrains have been constructed or gravel placed under pipelines to dewater the trench during construction of the sewers, do not make air test until pumps used in the dewatering process have been removed from the site.
4. Before air tests are scheduled, complete backfill operations and compaction tests. Have compaction test approved before air tests are scheduled.
5. Schedule air tests with the WSSC at least 48 hours in advance. Test each section of completed sewers. Test sewers from manhole to manhole, or from manhole to terminus of the sewer if there is not a manhole at the other extremity. Do not exclude any sewers or sewer connections from this testing procedure.

3.13 TRANSPORTATION AND INSTALLATION OF MATERIALS FURNISHED BY OTHERS: *22

A. Transport and install materials furnished at the WSSC's storeyard at Bladensburg or other delivery points designated by the WSSC.

B. Use only suitable equipment, tools, and appliances for the safe and convenient handling and hauling of materials.

C. Check that all materials furnished by the WSSC are in satisfactory condition.

D. Materials damaged, lost or wasted after acceptance will be replaced by the WSSC at the expense of the Contractor.

E. Material showing inherent defects will be replaced by the WSSC without charge.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

1. Add 1.1 C. including 1.a.-b. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

2. Add 1.1 D. including 1. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

3. Add 1.2 E. including 1.-2. for contracts where sanitary systems work is performed within the jurisdiction of WASA.

4. Use first version of 1.3 A.4. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

5. Use second version of 1.3 A.4. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.

6. Use first version of 1.3 A.5. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

7. Use first version of 1.3 A.6. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

8. Use second version of 1.3 A.6. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.

9. Add 1.3 A.9. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

10. Add 1.3 C. including 1.-2.a. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

11. Use first version of 2.1 F.2.f. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

12. Use second version of 2.1 F.2.f. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.

13. Use first version of 2.1 N. including 1.-2. modification for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

14. Use second version of 2.1 N. including 1.-2. for contracts where sanitary systems work is performed outside the jurisdiction of WSSC.

15. Add 2.1 DD. including 1.-2. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

16. Add 3.4 E. including 1.-3. for contracts where sanitary systems work is performed within the jurisdiction of WASA.

17. Add 3.11 E. for contracts where sanitary systems work is performed within the jurisdiction of WSSC.

18. Specify the type of cement to be used. The type of cement will vary depending on the jurisdiction and the use of the sanitary system.

19. Specify the type of mortar and cement to be used. They will vary depending on the jurisdiction and the use of the sanitary system.

20. Add 3.15 G. for contracts where work is performed within the jurisdiction of WSSC.

21. Add 3.21 D. including 1.-5. for contracts where work is performed within the jurisdiction of WSSC.

22. Add 3.22 including A.-E. for contracts where work is performed within the jurisdiction of WSSC.

END OF SECTION

SECTION 02585

UNDERGROUND ELECTRICAL AND COMMUNICATIONS DISTRIBUTION SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION:

This section specifies providing new ducts, manholes and handholes for electrical and communications facilities.

A. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Support of excavation: Section 02260.
   3. Maintenance, support and restoration of utility facilities: Section 02270.
   4. Grounding and bonding: Section 16060.
   5. Concrete formwork: Section 03100.
   6. Concrete reinforcement: Section 03200.
   7. Cast-in-place structural concrete: Section 03300.
   8. Structural precast concrete: Section 03400.

B. Definitions:
   1. Conduit: Individual raceway.
   2. Ductbank: Assembly of conduits in configurations shown, with concrete encasement, with or without reinforcement.

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:
      a. Drawings for each cast-in-place manhole and handhole.
      b. Drawings for each size and configuration of precast manhole and handhole with details of accessories and joints.
      c. Diagrams showing dimensioned locations for openings and knockout panels for ductbank penetrations of manhole and handhole walls.
   2. Documentation:
      a. Submit calculations to demonstrate compliance with required load-bearing capacity, certified by a professional engineer registered in the jurisdiction where the work is to be installed.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AASHTO: H15-44, H20-44.
   3. ANSI: C80.1.
   4. ASTM: A36, A48, A123, A185, A615, C33, C109, C173, C231, D570, D638, D790, F512.
   5. NEMA: TC-14.
   6. UL: 6.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Transport those materials supplied by utility companies from companies' storage facilities to construction site.

B. Protect materials stored on site from damage prior to incorporation into work and during handling.

1.05 JOB CONDITIONS:

A. Coordination with Utility Companies:
1. Arrange with the Engineer to contact utility companies early enough to allow sufficient time for them to accomplish work they are required to perform, giving special consideration to lead times required for cable work.
2. Establish liaison with utility companies furnishing materials for the work in order to determine availability, locations, methods of storage and care of materials prior to incorporation into work.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Concrete Formwork: Section 03100.

B. Reinforcing Steel: Section 03200.

C. Concrete:
1. Cast-in-place: Section 03300, Class 3500 or as required by the power company for its facilities.
2. Precast: Section 03400, Class 5000, unless otherwise shown on the drawings.

D. Materials Supplied by Utility Company: As listed.

E. Conduit and Fittings:
1. PVC conduit and fittings: ASTM F512; modulus of elasticity, 500,000 psi.
2. Concrete encased: Schedule 40.
   a. Direct burial: Schedule 80 heavy wall.
   b. Solvent cement: As recommended by conduit manufacturer.
3. Galvanized rigid steel conduit and fittings: UL 6 and ANSI C80.1.
4. Fiberglass conduit and fittings:
   a. Rigid fiberglass reinforced epoxy conduit, UL 1684, IPS (Iron Pipe Size) based conduit.
   b. Rigid fiberglass-reinforced epoxy, filament wound with minimum fiberglass content of 65 percent by weight and no fillers.
   c. Type SW (Standard Wall) of IPS based standard conduit with nominal wall thickness of .09 inch for five-inch nominal conduit size, and nominal wall thickness of 0.07 inch for two through four-inch nominal conduit size.
   d. Conduits, elbows and fittings manufactured from the same material and using the same manufacturing process.
   e. Conduit sections formed with integral bell-and-spigot type couplings. Rubber sealing gasket at bell end is prohibited.
   f. Conduits, elbows and fittings shall be specified for use throughout a temperature range of -40°F to 230°F and protected from exposure to sunlight by pigmentation uniformly dispersed through resin material.
   g. Adhesive as recommended by conduit manufacturer.
   h. Conduit, elbows and fittings shall be suitable for encasement in concrete below grade and conform to UL 1684, and listed and labeled by UL, meeting

the requirement of NEC Article 347 for Rigid Nonmetallic Conduit and its use.

i. Conduit for above ground surface mounted duct systems shall pass the UL1684 mandatory flame test (UL 1684, Section 5.12.1) and be certified by the manufacturer as such.

j. Each piece of the straight length conduit and each piece of the elbow and other bend made from and for use with such conduit is to be labeled with the following information, marked clearly legible and durably every 10 feet or as recommended by the manufacturer:

a. "Reinforced Thermosetting Resin Conduit", "RTRC", or equivalent wording such as "FRE" (Fiberglass Reinforced Epoxy) conduit.

b. Nominal size: (IPS)

c. Manufacturer's name and trademark.

d. Temperature range for conduit application.

e. "Above ground", "AG", "Below ground", "BG", or equivalent wording.

f. "FT4" when flame test is required for above ground conduit.

5. Conduit seal fittings:

a. To provide watertight seal between concrete and conduit where it penetrates wall, floor or ceiling.

b. Size as shown or necessary.

c. Materials: Body and pressure clamp of malleable or cast iron with a neoprene sealing grommet and PVC-coated or galvanized-steel pressure rings, oversized sleeve of PVC or galvanized steel.

d. Seal between conduit and concrete to withstand pressure from 50-foot head of water without leakage.

F. Channel Inserts: Stainless steel, size and shape as shown, 12-gauge minimum thickness, with 7/8-inch slot; surface-mounted; slotted-base channel with 9/16-inch by 3/16-inch nominal mounting slots on eight-inch centers.

G. Cable Pulling Eye: Fabricated of plain steel reinforcement bar, ASTM A615, Grade 60; welded; size as shown. Hot-dip galvanized after fabrication, ASTM A123. Pulling tension: 5,000 pounds.

H. Manhole Frame and Cover:

1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
2. Utility company manhole: Manhole frame and cover furnished as part of the Contract or furnished by the utility as shown on the drawings.
3. Rust-resistant cast iron or rust-resistant malleable cast iron.
4. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
5. Fillets at angles in casting with arises sharp and perfect.
6. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
7. Covers to receive paver tile:

a. Omit bituminous coating.

b. Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position.

I. Manhole Steps:

1. ASTM A48, cast-iron, Class 30A.
2. Molded rubber or plastic on cast-iron or reinforcing steel core.

J. Handhole and Manhole: Option of cast-in-place or precast.

1. Cast-in-place concrete handhole and manhole: As shown and specified.
2. Precast concrete:

a. Shape shown. If precast manholes are selected and size shown is not standard, use nearest larger standard precast unit; where added size will conflict with other utilities or structures, use cast-in-place unit.
b. Designed for AASHTO H20-44 truck loading.
c. Manhole: Include lifting rings, manhole steps, pulling eyes, sump, hole through floor for ground rod, and seal or sealant for sealing joints between sections, precast extensions included where required by utility.

3. Precast concrete handhole: Compressive strength 3,500 psi, air entrainment six-percent minimum, ASTM C173 or ASTM C231; Section 03300 and Section 03400 and in accordance with the following:
   a. Box: Concrete formed with closed bottom and sides and recess at top of box or at edge of cover to provide mating surfaces to prevent lateral movement of flush-mounted cover. Knockouts provided to accommodate conduits as shown on the drawings..
   b. Cover:
      a. Material same as for box. Use of metallic cover and cover frame prohibited.
      b. Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
      c. Non-protruding provisions provided for lifting.
   c. Reinforcement:
      a. Sidewalk and landscape locations: Welded-wire fabric, ASTM A185.
      b. Areas subject to vehicular traffic: Deformed steel bars, ASTM A615.
   d. Loading:
      a. Sidewalk and landscape locations: AASHTO H15-44.
      b. Areas subject to vehicular traffic: AASHTO H20-44.
   e. Hardware: Stainless steel.
   f. Size: As shown or next available larger size.

K. Precast composite material handhole: Sand and gravel bound together with a polymer and reinforced with continuous woven glass strands and in accordance with the following:

Physical Properties	Values	Methods
Compressive strength	11,000 psi	ASTM C109
Tensile strength	1,700 psi	ASTM D638
Flexural strength	7,500 psi	ASTM D790
Water absorption (24 hours)	0.5 percent	ASTM D570

1. Box: Gray-color material formed with closed bottom and sides and flange with recess at top of box to accommodate flush-mounted cover.
2. Cover:
   a. Material same as for box.
   b. Skid-resistant top surface with minimum 0.5 coefficient of friction.
   c. Metro Type "B" logo with 3-1/8 inch by 4-inch envelope and service designation recessed in center of cover.
   d. Secured to box with bolts.
   e. Non-protruding provisions provided for lifting.
   f. Loading:
   g. Sidewalk and landscape locations: AASHTO H15-44.
   h. Areas subject to vehicular traffic: AASHTO H20-44.

i. Hardware: Stainless steel.
j. Size: As shown or next available larger size.

L. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate No. 4 and No. 67.

M. Spacer: As shown or recommended by conduit manufacturer.

N. End Bells: Flared, smooth-surfaced fittings of same material as conduit; if of different material, include adaptor for connection to conduit.

O. Grounding: Section 16060.

P. Brick: Section 04215.

Q. Mortar: Section 04050.

PART 3 - EXECUTION

3.01 EXCAVATING AND BACKFILLING:

A. Excavating and backfilling: In accordance with Section 02320.

B. If ducts and manholes are to be installed on backfill over subway structure, place and compact backfill up to grade shown for ductbanks, conduits, manholes and handholes; compact as specified in Section 02320; ensure the manhole sets level. Schedule completion of backfilling to allow sufficient time for installation of ductbanks, conduits, manholes and handholes.

C. Where shown for subgrade foundation, use layers of coarse aggregate No. 4 and No. 67 in combinations and proportions determined by field conditions.

3.02 PAVEMENTS, SIDEWALKS, CURBS AND GUTTERS:

A. Remove pavements, sidewalks, curbs and gutters where necessitated by construction of ductbanks, manholes and handholes in accordance with Section 02220.

B. Place temporary bituminous pavement in accordance with Section 02740, when necessary because of sequence of operations.

C. On completion of construction, replace pavements, sidewalks, curbs and gutters in accordance with Section 02205.

3.03 INSTALLATION:

A. General:
1. Use size, type, general routing and locations of ductbanks, conduits, manholes and handholes as shown and specified.

B. Ductbanks:
1. Place conduits in ductbanks on spacers or construct concrete base prior to placing bottom row of conduits.
2. Use spacers to provide conduit spacing and support as recommended by conduit manufacturer.
3. Make conduit joints watertight by complying with recommendations of conduit manufacturers and as follows:

a. PVC conduit: Use solvent cement to join conduits, elbows and fittings.
b. Galvanized steel rigid conduit: Use lead-free conductive anti-seize compound on threaded conduit joints.
c. Fiberglass conduit: Use adhesive to join conduits, elbows and fittings for water tightness and pull out strength. Follow instructions of conduit manufacturer for using adhesive during periods below the recommended temperature range. Use of rubber sealing gaskets and interference type joints is prohibited.

4. Use Schedule 40 PVC conduit for underground ductbanks except as follows:
   a. Use galvanized steel rigid conduit only in specific locations as shown.
   b. Use fiberglass conduit only for providing utility company's 13.8 kv electric services.
5. Place and compact concrete around conduits in accordance with Section 03300.
6. Where shown, install reinforcing steel in concrete encasement in accordance with Section 03200.
7. Bends:
   a. Unless otherwise shown or specified, install conduit bends in accordance with reference codes.
   b. Install bends in buried conduit in accordance with the following:

Size of conduit in inches	Minimum radius of factory-bend in inches	Minimum radius of field-bend in inches
3	18	24
4	24	30
5	48	48
6	48	48

   c. Total bends in each conduit run for traction-power cable: 225 degrees maximum.
   d. Bend conduit so that field-made bend is free from cuts, dents and other surface damage.
   e. Field-made bends in fiberglass conduits are prohibited.
8. Support conduit during construction using compatible conduit supports and spacers to maintain positions of conduit during placement of concrete and to ensure independent support.
9. Install conduit so that it drains to adjacent manhole or handhole.
10. Prevent concrete and other foreign materials from entering, obstructing or deflecting conduit. Cap or plug conduit ends prior to pouring concrete.
11. Remove burrs from conduit ends, clean and dry before applying solvent cement to PVC conduit joints or adhesive to fiberglass conduit joints.
12. Pull approved test mandrel and swab through each conduit after installation. Cap or plug conduit ends. If mandrel cannot be pulled through conduit, replace conduit.
13. Leave approved nylon or polyester pull-line in each conduit.
14. At the ends of each conduit, use corrosion-resistant metallic tags with stamped markings to establish identification in accordance with designations shown. Install tags securely to permanent structure near each conduit as approved by the Engineer.
15. Install caps at empty conduit ends for future use.

C. Conduits Without Concrete Encasement:
1. Use Schedule 80 for direct-buried train control conduit.

2. Install caps on ends of empty train control conduits and identify locations of conduit ends with stakes.

3.04 CONSTRUCTION OF MANHOLES AND HANDHOLES:

A. Provide drainage facilities for manholes and handholes where shown. If connection is made to existing sewer line, install connection in accordance with applicable local regulations

B. Erect formwork in accordance with Section 03100.

C. Place reinforcing in accordance with approved shop drawings.

D. Provide for location of ductbank entrances and inserts in walls as shown.

E. Place concrete as specified in Section 03300.

F. Install conduits of material shown.

G. Install end bells on conduits where ductbanks terminate in manholes and handholes.

H. Build ductbank formation into walls of manholes and handholes and seal around opening.

I. If location of manholes and handholes openings will be obstructed, so inform the Engineer.

J. Install frame and cover, adjusting to finished grade, building brick chimney as specified in Section 02535.

K. Seal conduit openings with approved conduit plugs.

L. Install cable pulling eyes and steps as shown. Test pulling eye for compliance with specified pullout load rating.

M. Install ground rods, 2-inch by 1/4-inch by 12-inch long ground bus bar and insulated grounding conductors where shown. If soil conditions prevent driving rod to required depth, install alternative grounding system as approved. Provide grounding for personnel protection as specified in Section 16060.

N. When installing sections of precast manholes and handholes, prevent damage to joints seals.

O. Provide full-height stainless steel channel inserts approximately two feet on center along interior walls, spaced to clear ductbank entrances and steps. Use expansion bolt anchors to secure channel inserts to walls. Install and test channel inserts in accordance with Section 16130.

3.05 INSTALLATION OF HANDHOLES:

A. Bury precast concrete or composite material handholes with cover mounted flush with finish grade or pavement. Comply with installation procedures furnished by manufacturer.

3.06 CLEAN UP:

A. Remove debris from manholes and handholes and ensure complete installation is left in neat and finished condition.

3.07 FIELD QUALITY CONTROL:

A. Arrange with the Engineer for inspection and approval of conduits in ductbank and cast-in-place manholes and handholes prior to concrete placement.

B. Arrange with the Engineer for a representative of the utility company to inspect and approve service conduits for Authority facilities, relocated utility conduits, manholes and handholes prior to concrete placement.

C. Arrange with the Engineer for inspection and approval of direct-buried conduits for future train control circuits, prior to backfilling.

END OF SECTION

SECTION 02625

SUBWAY DRAINAGE SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing subway drainage system except drainage pumping system.

B. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Concrete work: Sections 03100, 03200 and 03300.
   3. Drainage pumping station: Section 15444.
   4. Piping systems: Section 15205.

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. Submit proposed materials not less than ten days prior to date of expected first shipment.
   2. Shop Drawings:
      a. Include complete catalog information and shop drawings for material and equipment.
   3. Certification.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AASHTO: M352.
   3. ASTM: A48, B271, B584, C33, C131, C654, C700, D1785, D2729.

PART 2 - PRODUCTS

2.01 PRODUCTS AND MATERIALS:

A. Porous Concrete Pipe:
   1. Extra strength: ASTM C654.
   2. Tongue-and-groove joints formed of solid concrete.

B. Vitrified Clay Pipe: ASTM C700, standard strength, extra strength, as shown.

C. Plastic Pipe and Fittings:
   1. PVC pipe: ASTM D2729 or ASTM D1785.
   2. Polyethylene corrugated pipe: AASHTO M352. Individual lengths not less than10feet. Coil pipe not permitted for pipe eight inches in diameter or larger.
   3. Fittings:
      a. Polyvinyl chloride: ASTM D2729 or ASTM D1785.
      b. Polyethylene, corrugated: AASHTO M352.

D. Manholes:

1. Formwork: Section 03100.
2. Concrete reinforcement: Section 03200.
3. Concrete: Section 03300, Class 3500.Manhole frames and covers, inlet frames and grates:
   a. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo. Size as shown.
   b. Rust-resistant cast iron or rust-resistant malleable cast iron, fabricated as shown.
   c. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
   d. Fillets at angles in casting with arises sharp and perfect.
   e. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
   f. Covers to receive paver tile.
      1) Omit bituminous coating.
      2) Provide positioning lug and receptor permanently part of cover and frame rim so that cover can only be installed (flush) in one position.

E. Drainage Castings:
   1. Drain inlets, cleanouts, floor and scupper drains fabricated from cast iron: ASTM A48, Class 25 with brass parts, Alloy Number 844.
   2. Copper alloy sand castings: ASTM B584.
   3. Copper base alloy centrifugal castings: ASTM B271.

F. Drainage Casting Covers:
   1. Cast iron: ASTM A48, Class 30.
   2. Copper alloy: ASTM 584.

G. Wire Mesh Screen:
   1. Bronze or stainless steel wire, minimum .047-inch diameter, 1/4-inch mesh.

H. Porous Subgrade Material:
   1. Coarse aggregate: ASTM C33, Size No. 67.
   2. Maximum percentage of wear: 45 percent when tested in accordance with ASTM C131.

I. Drainage Pumping Station: Section 15444.

PART 3 - EXECUTION

3.01 EXCAVATION:

A. Excavate to lines and grades shown in accordance with Section 02320.

3.02 POROUS MATERIAL PLACEMENT:

A. Place porous material for subgrade around main track drain and drain pipes and for trench backfill as shown.

B. In rock excavation, do not place porous subgrade material on excavated rock surface until surface has been flushed with water to remove fine dust and sludge.

C. Place material only on stable rock surfaces.

3.03 VITRIFIED CLAY PIPE:

A. Place vitrified clay pipe to lines and grades shown.

B. Make joints in accordance with manufacturer's instructions.

C. Place concrete encasement where shown in accordance with Section 03300. Secure pipe to avoid displacement during concrete placement.

3.04 POROUS CONCRETE PIPE:

A. Lay pipe on porous subgrade material so as to provide full bearing and grades shown.

B. Install joints in accordance with the manufacturer's instructions.

C. Place porous material over and around the pipe as shown.

D. Place perforated pipe as specified with the perforations downward.

E. Place concrete for encasement in accordance with Section 03300.

F. Place and brace pipe for encasing to prevent displacement during placing of concrete.

3.05 PLASTIC PIPE:

A. Lay plastic pipe as specified for porous concrete pipe.

B. Use nonpressure pipe for drainage.

C. Use cast iron, concrete or vitrified clay pipe for last two feet at exposed termination points. Provide standard adaptor fittings for connections between differing pipe materials.

D. Plastic pipe may be used only if buried or encased in concrete. Its use is prohibited in exposed locations.

3.06 MANHOLES:

A. Construct cast-in-place concrete manholes as shown.

B. Construct flow channel in manhole where shown.

C. Place axis of manholes directly over centerlines of pipes unless otherwise shown.

D. Set manhole frame and cover or grate to required elevation. Set ballast screen where shown.

3.07 INSTALLATION OF PIPE AND CASTINGS:

A. Install cast-iron, ductile-iron, nickel-copper alloy steel pipe and fittings meeting the requirements of Section 15205.

B. Install drainage piping to the lines and grades shown.

C. Locate drainage castings and set to the finished floor elevation, slabs or inverts.

D. Install cleanouts at the locations shown.

3.08 PROTECTION OF DRAINAGE SYSTEM:

A. During the course of construction, maintain drainage lines free of debris and in undamaged condition.

B. Plug or close ends of completed runs of piping until the Engineer approves their use.

C. Cover the inlet end of drainage piping used to convey water to wet wells at the existing drainage pumping stations with wire mesh screen.

3.09 FIELD QUALITY CONTROL:

A. Where drainage piping is located below invert slabs, conduct a ball, shuttlecock, or mandrel test to ensure that the line is free of obstructions subsequent to the placing of porous subgrade material over the line and prior to the placement of the concrete invert slab.

B. Upon completion of the test and determination that the line is free of obstructions, plug, cap or otherwise close the open end or ends of the installed piping to prevent the entrance of debris into the lines.

C. Immediately prior to final inspection of the work, remove debris from manholes, drain inlets, and floor scupper drains. In the presence of the Engineer, prove by one of the methods specified above that the piping is free of obstructions.

END OF SECTION

SECTION 02635

STORM SEWER

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies installing storm sewers, roadway drains, roadway underdrains, ditch lining and slope protection.

B. Related Work Specified Elsewhere:
   1. Grading, excavating and backfilling: Section 02320.
   2. Maintenance, support and restoration of utility facilities: Section 02270.
   3. Stray current and cathodic protection: Section 13110 and 13115.

C. Material Furnished By Others: *1
   1. Except for those items which bear the METRO logo, WSSC furnishes the following:
      a. Manhole frames and covers: 22-inch diameter.
      b. Manhole steps, except where precast manholes are used.

D. Definitions: *2
   1. Granular bedding required by WSSC is equivalent to aggregate for pipe cradle as specified.
   2. WSSC: Washington Suburban Sanitary Commission.
   3. WASA: Water and Sewer Authority.

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:
      a. Drawings for each size and configuration of precast manhole with details of accessories and joints.
      b. Diagrams showing dimensioned locations for openings in precast concrete manhole walls.
   2. Documentation:
      a. Submit calculations for modified or special designs to demonstrate compliance with required load-bearing capacity, certified by a professional engineer registered in the jurisdiction where the work is to be installed.
   3. Samples:
      a. Sewer brick: Ten.
      b. Manhole brick: Ten.
      c. Slope protection materials:
         1) Concrete blocks: Ten each.
         2) Paving bricks: Ten each.
         3) Riprap: 1.5 cubic yards.
         4) Gabions: Two each, complete.
      d. Geotextile filter fabric: Two, 12 inches long by 12 inches wide, minimum.
   4. Certification.
   5. Documentation: *3
      a. Submit two copies of records of inspection of new and relocated sewers, one copy to W\SSC and one copy to the Engineer. Include video-tape

cassette of television inspections and logs, photographs and other records specified by WASA for visual walk-through inspections.

b. Obtain and submit a written approval and acceptance from WASA.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. Building Stone Institute: Stone Catalog.
3. CISPI: HSN 85.
4. AASHTO: M33, M36, M153, M175, M176, M190, M252, M288, T85, T96, T104. *4
5. AASHTO: H20, M33, M36, M153, M175, M176, M190, M252, M288, T85, T96, T104. *5
6. ANSI/ASME: B16.1. *6
7. ACI: 318. *7
8. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C507, C700, D698, D1682, D3034, D5034, D5035. *8
9. ASTM: A36, A48, A53, A74, A167, C14, C32, C33, C76, C144, C150, C207, C361, C425, C443, C478, C700, D698, D1682, D3034, D5034. D5035. *9
10. MS: MIL-P-23236.
11. SSPC: SP-6.
12. WSSC: General Conditions and Standard Specifications. *10

B. Source Quality Control:
1. Ditch lining and slope protection materials:
   a. After approval, do not change source.
   b. Replace defective material.

C. Allowable Tolerances:
1. Subgrade: Plus-or-minus 1/2 inch of elevation shown.

D. Inspection: *11
1. Prior to paving or other construction over new or relocated sewers, conduct visual walk-through inspection of sewers larger than 36 inches in diameter and of associated structures and internal television inspection of sewers 36 inches and smaller in diameter.
2. Employ the services of a sewer inspection company which has been regularly engaged in television sewer inspections and which is acceptable to WASA to perform preconstruction and post-construction inspections of sewers 36 inches and smaller in diameter.
   a. Submit to WASA for prior approval one sample of the cassettes to be used.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Formwork: Section 03100.

B. Reinforcing Steel: Section 03200.

C. Portland Cement Concrete: Section 03300, Class 3500, unless otherwise shown.

D. Aggregate for Subgrade Foundation: ASTM C33, coarse aggregate, No. 4. Where shown use layers of No. 4 and No. 67 in combinations and proportions determined by field conditions and as approved.

E. Aggregate for Pipe Cradle: ASTM C33, coarse aggregate No. 67.

F. Concrete Pipe:
1. 10-inch diameter and smaller:
   a. ASTM C14, Class 2, nonreinforced concrete pipe.
   b. Bell-and-spigot type.
   c. Joints fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
2. 12-inch diameter and larger:
   a. ASTM C76, bell-and-spigot or tongue-and-groove, Class IV, unless otherwise shown.
   b. Radius (bevel) pipe, with drop between two pipe sections not exceeding the common wall thickness.
   c. Rubber gasket joints, when required, fabricated in accordance with ASTM C361. Physical characteristics for rubber gaskets in accordance with ASTM C443.
   d. Acceptance tests as specified in ASTM C76 form basis of acceptance for concrete pipe in accordance with the following:
      1) 72-inch diameter and smaller: Acceptance on the Basis of Plant Load Bearing Test, Material Tests and Inspection of Manufactured Pipe for Visual Defects and Imperfections.
      2) Larger than 72 inches in diameter: Acceptance on the Basis of Material Tests and Inspection of Manufactured Pipe for Defects and Imperfections.
   e. Minimum laying lengths: Four feet.
   f. Rubber gaskets: ASTM C361. *12
   g. Rubber gaskets: ASTM C443. *13
   h. Jointing mastic: Elastic, water-resistant, formulation of plastic bituminous materials, nonflammable solvent and inert fillers so combined that:
      1) When applied to a vertical metal surface and heated to 120F, jointing mastic will neither slump nor lose plasticity.
      2) When applied directly from container without further fixing, jointing mastic can be applied in even, adherent coat within temperature range of 20F to 100F.
   i. Reinforced concrete elliptical pipe: ASTM C507. *14
3. Perforated nonreinforced concrete pipe: AASHTO M175, Type 1 or 2, bell-and-spigot or tongue-and-groove type.
4. Porous concrete pipe: AASHTO M176, tongue-and-groove.

G. Plastic Pipe:
1. Polyvinyl chloride (PVC) pipe: ASTM D3034, SDR-35.
2. Polyethylene corrugated pipe: AASHTO M252.

H. Bituminous-Coated Corrugated Metal Pipe: AASHTO M190, Type A or C, with connecting bands, AASHTO M36.

I. Vitrified Clay Pipe: ASTM C700; Joints, ASTM C425, using plastic materials.

J. Cast-Iron Soil Pipe and Fittings: ASTM A74, extra-heavy (XH), with hub and spigot ends so constructed that joints may be made with gaskets conforming to CISPI Designation HSN 85 and the requirements of the relevant plumbing codes.

K. Lubricant for Rubber Gasket Pipe Joints: Vegetable oil soap.

L. Mortar Materials:

1. Portland cement: ASTM C150, Type I.
2. Sand: ASTM C144, natural sand.
3. Lime: Pressure-hydrated, ASTM C207, Type S.
4. Water: Potable.
5. Pigment: As approved.

M. Brick: ASTM C32; solid brick; Grade MS for manhole brick, Grade SS for sewer brick; 2-1/4 inches by 3-3/4 inches by eight inches.

N. Precast Concrete Manhole Sections: *15
1. ASTM C478.
2. Joint entry seal gasket: A-LOK as manufactured by Atlantic Precast Concrete, Inc.; A-LOCK gaskets, manufactured by A-LOK Products Corporation, Trenton, N.J.; DURAC-SEAL gaskets, manufactured by DURA-CRETE, Inc., Dayton, Ohio; or equal.

O. Precast Concrete Manholes: *16
1. Cylindrical, eccentrical and conical: ASTM C478.
2. Other configurations: ACI 318, AASHTO H20.

P. Manhole Steps:
1. Cast iron: ASTM A48 Class 30 A.
2. Rebar: No. 4 reinforcing bar with molded polypropelene or rubber encasement.

Q. Manhole Frame and Cover; Inlet Frame and Grate; and Ballast Screen;
1. Authority manhole: Cast-iron, ASTM A48, Class 30, with METRO logo.
2. Rust-resistant cast iron or rust-resistant malleable cast iron.
3. True to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and defects affecting strength.
4. Fillets at angles in casting with arises sharp and perfect.
5. Sandblasted to effectively remove scale and sand, presenting smooth, clean and uniform surfaces. Coated with bituminous coating.
6. Covers that receive paver tile:
a. Omit bituminous coating.
b. Provide positioning lug and lug receptor as a permanent part of the cover and frame rim so that the cover can only be installed (flush) in one position.

R. Metal Water Seals for Basin Connections: Neenah Foundry Model No. R-3707 or equal.

S. Structural Steel Members: ASTM A36.

T. Steel Pipe: ASTM A53, black finish, extra strong wall class.

U. Stainless Steel Angle: ASTM A167, Type 304.

V. Jute for Caulking: Good quality jute, free from tar, oil, or grease and dry when installed.

W. Preformed Expansion Joint Fillers: AASHTO M153, Type I, Type II or Type III.

X. Bituminous Expansion Joint Filler: AASHTO M33.

Y. Galvanizing: Section 05120.

Z. Ditch Lining and Slope Protection:
1. Riprap: Material meeting the following requirements:

a. Hard, durable and free of fractures; angular in shape; weather-resistant; and free from overburden, spoil, shale and organic material.
b. Size: Weight distribution of pieces provided in accordance with the following:
1) Class I: From 50 to 150 pounds with 60-percent minimum weighing 100 pounds or more; approximately 10 percent may weigh 50 pounds or less.
2) Class II: From 150 to 500 pounds with 50-percent minimum weighing more than 300 pounds; approximately 10 percent may weigh 150 pounds or less.
c. Quality:
1) Water absorption: 3.0-percent maximum when tested in accordance with AASHTO T85.
2) Specific gravity: 2.5 minimum when tested in accordance with AASHTO T85.
3) Resistance to abrasion: Grade B maximum when tested in accordance with AASHTO T96.
4) Soundness: Loss 20-percent maximum when tested in accordance with AASHTO T104.

2. Aggregate filter:
a. Coarse aggregate, ASTM C33, Size 357.
b. Use only tough, durable materials free of thin, flat, elongated or soft friable particles and free of organic matter.
3. Granite block facing: Type 4, quarry split finish on face and edges.
4. Sand cushion for concrete block: Section 03300, fine aggregate.

AA. Geotextile Filter Fabric: AASHTO M288 and the following additional requirements:
1. Woven or non-woven pervious filter fabric weighing approximately 0.03 to 0.05 pounds per square foot; free of defects.
2. Fabric: Long chain synthetic polymer composed of at least 85 percent by weight of propylene, ethylene, ester, amide or vinyl-chloride and with stabilizers or inhibitors to make fabric resistant to deterioration due to ultraviolet and heat exposure.
3. Fabric formed or treated so that filaments retain their positions relative to each other.
4. Edges selvaged.
5. Physical strength:
a. Tensile strength: 200-pound minimum in each direction, ASTM D1682.
b. Elongation at failure: 10 to 30 percent, ASTM D5034 amd D5035.
c. Puncture strength: 70-pound minimum, ASTM D5034 and D5035.
6. Percent of open area: Not less than five percent nor more than six percent.
7. Equivalent opening size (E.O.S.): 70-100 US Standard Sieve, CW-02215-77.
8. Securing Pins: As recommended by manufacturer of filter fabric.

BB. Gabions:
1. Wire mesh: Galvanized steel wire 0.105 minimum diameter, 60,000 pounds per square inch tensile strength, galvanized at rate of 0.80 ounces per square foot. Wires twisted to form nonraveling hexagonal openings of uniform size, not to exceed 4-1/2 inches in length nor eight square inches in area of mesh opening. Horizontal dimension uniform, not to exceed 36 inches. Gabion dimensions not to vary more than three percent from manufacturer's stated size.
2. Tie devices: Malleable iron or steel, producing frictional force of 160 pounds per foot of spacing. Sized to conform to requirements of jurisdictional agency.
3. Stone: Durable, free from cracks and seams, unweathered, weighing between four pounds (four-inch average diameter) and 30 pounds (eight-inch average diameter) except five percent may vary more or less and 50 percent to exceed 10 pounds.
a. Stone size:

Basket Thickness (Inches)	Size of Stones (Inches)
6	3 to 5
9, 12, 18	4 to 7
36	4 to 12

CC. Coal-Tar Epoxy Coating:
1. Two-component.
2. Chemically cured.
3. Conforming to MS MIL-P-23236 (Ships), Type I, Class 2.
4. Thinner: As recommended by manufacturer of coating and as approved.

DD. Pipe Supports: *17
1. Pipe: Three-inch diameter, ASTM A53, Weight B, Class 1.
2. Flanges: ANSI/ASME B16.1, 125-pound Class, galvanized after fabrication.

EE. Underdrain Filter Material: ASTM C33, Size 57. *18

2.02 MORTAR AND GROUT MIXES:

A. General Requirements:
1. Mix dry in specified proportions by volume. Control and maintain accurate measurement throughout progress of work.
2. Add sufficient water as specified to produce approved consistency.
3. Do not mix in amount exceeding that which can be used within one hour after introduction of water.
4. Do not retemper mix that has begun to set nor use such mix in the work.
5. Where shown, specified or directed, mix pigment into dry mix to attain color selected by the Engineer. Pigment not to exceed 10 percent of dry batch weight of cement.

B. Proportions:
1. Mortar: One part portland cement, 2-1/2 parts sand and water sufficient to produce stiff workable mix.
2. Grout: One part portland cement, 2-1/2 parts sand and water sufficient to produce plastic flowable mix.
3. Mortar for setting and pointing granite: One part portland cement, four to five parts sand, one part lime and water sufficient to produce approved consistency.
4. Mortar for setting granite paving and grouted granite blocks: One part portland cement, four parts sand, with water sufficient to produce approved consistency.

PART 3 - EXECUTION

3.01 EXCAVATION FOR SEWER AND DRAINAGE STRUCTURES:

A. Perform excavation for sewers and drainage structures to line and grade shown in accordance with Section 02320 and the following additional requirements:
1. Excavate test pits sufficiently in advance of construction of sewers and drainage structures so that reasonable changes in line and grade can be made where location of existing structures varies from that shown.
2. Excavate below horizontal plane extending two feet above top of sewer or drainage structures to maximum width of trench pay width shown. Where dimensions are not shown, make maximum horizontal width of excavation 18 inches from outside of

sewer or drainage structure and minimum six inches. Where approved, excavation above such plane may exceed specified dimensions.

3. If excavation exceeds permissible dimensions, encase pipe or install pipe of higher strength.
4. Where necessary to place backfill or embankment so that trench can be excavated, extend backfill or embankment full depth laterally at least 2-1/2 times diameter of pipe on each side measured from centerline of pipe.

3.02 GEOTEXTILE FILTER FABRIC:

A. Prepare surface to receive fabric to relatively smooth condition free of obstructions, depressions, debris and soft or low density pockets of material.
   1. Place fabric with long dimension parallel to centerline of trench and lay smooth and free of tension, stress, folds, wrinkles or creases with sufficient excess to allow for minimum overlap of 12 inches.
   2. Place strips in trench to provide minimum width of 12 inches of overlap for each joint.
   3. Insert securing pins with washers through both strips of overlapped fabric at not greater than 3-foot intervals along a line through the midpoint of overlap at joints.
   4. Where this method of placement conflicts with manufacturer's instructions, the manufacturer's instructions prevail.

B. At time of installation fabric to be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation, storage or handling.

C. Place fabric in manner and at location shown.

3.03 PIPE CRADLE:

A. Place pipes on cradle of aggregate or concrete where shown.

B. Place aggregate so as to avoid segregation; compact to maximum practicable density so that pipe can be laid to required tolerances.

3.04 LAYING PIPE:

A. General Requirements:
   1. Excavate to lines and grades shown in accordance with Sections 02320 and herein. Excavate depressions for bells.
   2. Protect pipe and fittings during handling to prevent damage.
   3. Place, shape and compact bedding material to receive barrel of pipe. Type and thickness of bedding material as shown.
   4. Start laying pipe at lowest point; lay true to line and grade shown.
   5. Install pipe to bear on bedding material along entire length. Shape bedding material to fit bells and flanges.
   6. Install perforated pipe with perforations downward.
   7. Install pipe so that bells and grooves are on upstream end.
   8. Align each section of pipe with adjoining section with uniform annular space between bell and spigot and so as to prevent sudden offsets in flow line.
   9. As each section of pipe is laid, place sufficient backfill to hold it firmly in place.
   10. Keep interior of sewer clean as work progresses. Where small pipe size makes cleaning difficult, keep suitable swab or drag in pipe and pull through each joint immediately after jointing is completed.
   11. Keep trenches and excavations free of water during construction and until backfilled. Each day, excavate only as much trench as needed to lay pipe.

12. When work is not in progress, securely plug ends of pipe and fittings to prevent trench water or other substances from entering pipes and fittings.
13. Where length of stub is not shown, install four-foot length and seal free end with brick masonry bulkhead or approved stopper.
14. Have work approved prior to covering pipe.
15. Where shown, place additional aggregate filter around and over pipe in lifts not exceeding six inches loose. Compact each lift before placement of next lift.
16. Backfill in accordance with Section 02320.
17. Accomplish compaction by method that will avoid damage to pipe and will not disturb its alignment and grade. The use of vibratory rollers is prohibited until compacted cover over pipe has reached three feet or half the pipe diameter, whichever is greater.
18. Where cathodic protection is shown, apply coal-tar epoxy coating.

B. Vitrified Clay Pipe:
1. Nonperforated pipe:
   a. Use pipe hoist, crane or other approved device when laying pipe greater than 18 inches diameter.
   b. Prevent damage to premolded joint rings or attached couplings.
   c. Clean joint contact surfaces immediately prior to jointing. To complete joint, use lubricants, primers or adhesives as recommended by pipe or joint manufacturer
2. Perforated pipe:
   a. Firmly position spigot in bell of preceding pipe. Saturate jute gasket in cement grout and caulk into annular space. Ensure that jute is long enough to reach entirely around pipe and is of such thickness to bring pipe sections to same grade.
   b. After pipe sections have been caulked and centered, fill annual space with cement mortar.
   c. After mortar joints have set, place additional aggregate filter material as specified.

C. Concrete Pipe:
1. Bell-and-spigot joints:
   a. Lay bell-and-spigot joint pipe as specified for vitrified clay pipe.
2. Tongue-and-groove joints:
   a. Clean groove end of preceding pipe with wet brush and apply soft mortar to lower 1/4 of groove. Clean tongue end of succeeding pipe with wet brush and position it. Remove mortar from interior surface if squeezed out of joint.
   b. Complete mortaring interior and exterior portions of joint for entire circumference, extending from previously placed mortar. Perform final exterior mortaring of joints three lengths of pipe behind laying.

D. Plastic Pipe:
1. Perforated pipe:
   a. Use sleeve couplings designed to hold pipe in alignment without use of sealing compound or gaskets.
   b. Place additional aggregate filter material as specified.
   c. Cap open ends of underdrains.
2. Nonperforated pipe:
   a. Join sections of pipe with couplings recommended by pipe manufacturer.

E. Corrugated Metal Pipe:
1. Perforated pipe:
   a. Place additional aggregate filter material as specified
2. Nonperforated pipe:

a. When pipe is shown to be bituminous paved, place paved area on bottom.

3. Connections for corrugated metal pipe:
   a. Join sections of pipe with coupling bands arranged to fit corrugations accurately.
   b. Do not damage protective coating when tightening bolts.
   c. After final tightening of connection bolts, apply brush coat of bituminous paint to bands and bolts.

F. Porous Concrete Pipe:
1. Fill joints with mortar as specified for tongue-and-groove joints of concrete pipe.
2. After pipe joints have been made, place additional filter material as specified.

G. Inspections Of Sewers: *19
1. Perform all work in accordance with current requirements of WASA.
2. Perform inspections on new or relocated storm sewers within or adjacent to the zone of influence, as defined by the limits of a theoretical slope of 1:1 from the bottom edges of tunneling and cut-and-cover excavations, as follows:
   a. Make inspections upon completion of tunneling and cut-and-cover operations, but prior to paving.
   b. Obtain video-tape television inspection records of sewers 36 inches and smaller in diameter.
   c. By means of visual walk-through inspection, obtain coordinated logs, photographs and other records specified by WASA of sewers larger than 36 inches in diameter and of associated structures.
3. Coordinate all television and walk-through inspection field operations with WASA. All such work to be performed in the presence of a WASA representative.

3.05 BACKFILL:

A. Perform backfilling only after inspection and approval of pipe laying.

B. On completion of construction, backfill excavation in accordance with Section 02320.

3.06 JOINTS FOR CONCRETE STORM SEWER: *20

A. Use cold-applied jointing mastic for joints of storm sewer.

B. Bell-and-Spigot Joints:
1. Clean interior surface of bell and fill lower portion with mastic of sufficient thickness to make inner surfaces of abutting sections flush.
2. Install spigot end of adjoining pipe into bell so that sections are closely fitted and aligned.
3. Apply sufficient jointing mastic to fill remaining void in joint.
4. Remove excess mastic from interior of pipe.

C. Tongue-and-Groove Joints:
1. Clean groove. Apply mastic to lower half of groove.
2. Clean tongue of next pipe and apply layer of mastic to upper half.
3. Fit tongue into groove until pipes are closely fitted and aligned and mastic covers inner and outer surfaces.
4. Remove excess mastic from interior of pipe.

3.06 JOINTS FOR CONCRETE STORM SEWER 12 INCHES TO 33 INCHES: *21

A. Use cold applied jointing mastic for joints of storm sewer 12 inches to 33 inches in diameter.

B. Bell-and-Spigot Joints:
   1. Clean interior surface of bell and fill lower portion with mastic of sufficient thickness to make inner surfaces of abutting sections flush.
   2. Install spigot end of adjoining pipe into bell so that sections are closely fitted and aligned.
   3. Apply sufficient jointing mastic to fill remaining void in joint.
   4. Remove excess mastic from interior of pipe.

C. Tongue-and-Groove Joints:
   1. Clean groove. Apply mastic to lower half of groove.
   2. Clean tongue of next pipe and apply layer of mastic to upper half.
   3. Fit tongue into groove until pipes are closely fitted and aligned and mastic covers inner and outer surfaces.
   4. Remove excess mastic from interior of pipe.

3.06 JOINTS FOR CONCRETE STORM SEWER 36 INCHES AND LARGER. [*22]

A. Where not prohibited by jurisdictional agencies, Use mortar for joints of storm sewers 36 inches diameter and larger.

B. Bell-and-Spigot Joints:
   1. Where pipe cradle is aggregate, place shallow bed of mortar under joint.
   2. Thoroughly wet bell and fill lower half with mortar.
   3. Thoroughly wet spigot and uniformly fit into bell so that sections are closely fitted and aligned.
   4. Fill remaining annular space in bell with mortar sufficient to form bead around outside of spigot end of pipe.
   5. Remove excess mortar from interior of pipe and finish exterior and interior to smooth surfaces.

C. Tongue-and-Groove Joints:
   1. Thoroughly wet groove; apply mortar to lower half of groove.
   2. Thoroughly wet tongue of next pipe and apply a layer of mortar to top half.
   3. Fit tongue into groove until pipes are closely fitted and aligned and mortar covers inner and outer surfaces of the joint.
   4. Clean inner surface of pipes at joint and point up outside with bead of mortar.

3.07 JOINTS FOR VITRIFIED CLAY PIPE:

A. Immediately before joining vitrified pipe, liberally coat bell with lubricant and fit spigot with gasket.

B. Join pipes using equipment designed for purpose.

3.08 JOINTS FOR CAST-IRON SOIL PIPE AND FITTINGS:

A. Immediately before joining cast-iron soil pipe and fittings, liberally coat hub with lubricant and fit spigot with pipes using equipment designed for purpose.

3.09 CONNECTIONS WITH EXISTING SEWERS:

A. Make connections with existing public sewers in accordance with requirements of the jurisdictional authority.

B. Do not connect existing sewer to sewer under construction unless approved.

3.10 TUNNELING AND JACKING:

A. Perform tunneling and jacking by approved methods.

B. Where open cut is specified and the Engineer permits the work to be done by tunneling or jacking, perform such work as specified and as approved.

C. Cost of material substitutions required by change of methods will be borne by the Contractor.

D. Make horizontal borings necessary to lay pipe lines true to line and grade.

E. When sewers are laid in borings, completely fill void between outside barrel of pipe and boring with cement grout pumped into place.

F. When drainage pipes are laid in borings, completely fill void between pipe and boring with sand, using water pressure to ensure that voids are filled.

G. Methods of boring and filling of voids between pipe and boring are subject to approval.

3.11 CAST-IN-PLACE CONCRETE CONSTRUCTION:

A. Conform to applicable requirements of Sections 03100, 03200 and 03300. Section designer to specify the type of cement to be used. The type of cement will vary depending upon the jurisdiction where the work is performed.
   1. Cement. *23

B. Construct concrete support systems where shown. Section designer to specify the type of mortar to be used. Mortar type will vary depending upon jurisdiction in which the work is performed.
   1. Mortar and cement. *24

3.12 BRICK CONSTRUCTION:

A. Perform brick construction as specified in Section 04215, with the following additional requirements:
   1. Use sewer brick wherever brick construction is exposed to flow; otherwise, use manhole brick.
   2. Lay sewer brick on edge so that 2-1/4 by 8-inch side is exposed to flow.
   3. Lay manhole brick so that every sixth course is a header course.
   4. Where practicable, lay each course with a line. For curved courses or those in nonparallel planes, use bonded-and-keyed construction.
   5. Do not exceed joint thickness of 3/8 inch in straight courses in parallel planes; for courses curved or in nonparallel planes, make thickest part of joint as thin as practicable.
   6. Rack or tooth uncompleted brick construction and parge unexposed surfaces with 1/2 inch of mortar.

3.13 MANHOLES:

A. Construct manholes of precast sections, cast-in-place concrete or brick as shown.

B. Provide base of precast or cast-in-place construction. Make watertight connection between base and risers.

C. Unless otherwise shown, place axes of manholes directly over centerlines of pipes.

D. Construct appropriate flow channels in bottom of manholes.

E. Where necessary, build connections for public and residential sewers into manholes. Cut pipe flush with inside wall of structure. Do not build pipe into wall; provide mortar joint between pipe and structure.

F. Install manhole steps and cast iron frame and cover for each manhole; adjust frame and cover to proper grade by brick construction.

G. Install joint entry seal gaskets in openings in the walls of 48-inch precast manholes with O-ring joint. *25

3.14 CATCH BASINS AND INLETS:

A. When grading has been substantially completed as approved, construct catch basins of cast-in-place concrete using Class 3500 concrete and steel reinforcement as shown, precast sections or brick as shown.

B. Cut pipe flush with inside wall of structure. Provide mortar joint between pipe and structure or install water seal as shown.

C. Install cast iron frame and grate or cover and adjust to proper grade.

D. Install pipe supports as shown. Fill with concrete after installation. *26

3.15 DITCH LINING AND SLOPE PROTECTION:

A. Slope Preparation:
1. Excavate or fill slopes to the required cross section, lines and grades.
2. Compact earth slopes to not less than 95 percent of the maximum dry density for a depth of not less than 12 inches, as specified in Section 02725.
3. Where lining or protection is to be applied to rock surfaces, clean off mud, debris and loose fragments.
4. Construct toe or cut off walls where shown.
5. Remove loose material and buried debris protruding from subgrade.
6. Placement of aggregate filter:
   a. Place filter aggregate where shown to depth shown.
   b. Compact each layer of aggregate filter in accordance with ASTM D698, Method D, to 100 percent at plus-or-minus one percent of optimum moisture content.

B. Ungrouted Riprap:
1. Place aggregate filter as specified.
2. Place riprap by machine to full course thickness in one operation upward from bottom of slope. Prevent displacement of underlying materials. Dumping of riprap is prohibited.
3. Fill spaces between larger stones to produce nearly even surface with minimum of voids. Manually supplement machine placement of stone to choke in voids.
4. Rearrange individual stones as necessary to ensure that finished configuration conforms to lines, grades and thickness shown.

C. Bituminous Concrete Paving:

1. Place bituminous concrete where shown to the lines, grades, thickness and shapes shown.
2. Give base course prime coat of medium-curing, cutback asphalt and allow to cure before hot bituminous concrete is placed.
3. Place hot-mix bituminous concrete by hand or by machine.
4. When hand methods are used, place mixture by means of hot shovels or forks and spread with hot rakes to thickness required to obtain specified compacted thickness. Thoroughly rake loose material throughout its depth, to eliminate honeycombing. Use screed boards of width equal to required thickness of lining.
5. After spreading, compact until specified compacted thickness is obtained.
6. Place mixture as continuously as practicable to eliminate joints. Where joints are required at end of a day's work or when the placing is discontinued for such period of time that material becomes chilled, form joints as specified.

D. Cast-in-Place Concrete:
1. Use Class 3500 concrete unless otherwise shown.
2. Use wood or steel forms.
3. Place reinforcing steel or wire mesh as shown.
4. Provide and install dowel bars where shown in accordance with Section 02750.
5. Locate expansion and contraction joints where shown in accordance with Section 02750.
6. Unless otherwise shown, give surface wood float finish.
7. Protect and cure concrete in accordance with Section 03300.

E. Concrete Masonry Units:
1. Place two-inch layer of sand cushion on previously prepared slope.
2. Set units firmly by hand in sand cushion with long dimension parallel to base of slope so as to produce even surface.
3. Lay blocks with open 3/8-inch joints and with joints staggered as shown.
4. Completely fill joints with mortar.
5. Protect and cure newly laid blocks for seven days using wet cotton mats or wet burlap.
6. Lay blocks when the temperature is 40F or above.

F. Paving Brick:
1. On the previously prepared slope, place concrete base of thickness shown.
2. Give concrete smooth screed finish.
3. Clean base, dampen and lay one-inch thick mortar bed.
4. Lay bricks with long dimension parallel to base of slope, with open 3/8-inch joints and with joints staggered.
5. Bed bricks firmly in mortar bed so as to produce even surface free from depressions or high spots.
6. Fill joints completely with mortar.
7. Protect and cure newly laid brick for a period of seven days using wet cotton mats or wet burlap.

G. Sodding: Section 02920.

H. Concrete Pavement:
1. Lay plastic pipe as shown.
2. Place aggregate filter as specified.
3. Place concrete base in accordance with specified requirements for cast-in-place concrete.

I. Concrete with Granite Block Facing:
1. Lay plastic pipe as shown.

2. Place aggregate filter as specified.
3. Place concrete base in accordance with specified requirements for cast-in-place portland cement concrete.
4. Installation of granite block facing:
    a. et granite blocks in bedding course, one-inch minimum depth with 3/4-inch joint width.
    b. Slope bedding to true surface parallel to finished surface of blocks; strike off bedding until true alignment is attained.
    c. After final sloping, do not disturb bedding prior to laying blocks.
    d. Lay blocks on bedding course in successive courses with quarry split finish up.
    e. Align each course, lay true and even and bring to true grade by use of wood mallets or similar tools.
    f. Lay blocks in continuous sequence.
    g. Lay no more mortar than can be covered with blocks before end of work day.
    h. Point voids in joints with preshrunk mortar. Do not point when ambient temperature is 50F and falling.After pointing, scrub surfaces with soap solution and remove stains. Rinse immediately with clean water. Leave work in first class condition, free from mortar stain and other defacement as approved.

J. Gabions:
1. Prepare ground surface smooth and even where gabions will be installed.
2. Assemble gabions and tie together in accordance with manufacturer's instructions.
3. Fill gabions in lifts of 12 inches maximum. Install tie devices in all units with exposed faces, spaced in accordance with requirements of jurisdictional agency.
4. Ensure stone fill is placed without voids larger than approximately smaller stones. Hand-place stones in exposed faces.

3.16 CONCRETE HEADWALLS AND WINGWALLS:

A. Excavation:
1. Excavate for foundations and walls to lines and grades shown in accordance with Section 02320.

B. Formwork and Reinforcement:
1. Erect formwork and install reinforcement as shown and in accordance with Sections 03100 and 03200.

C. Concrete Work:
1. Place concrete of class shown and protect and cure in accordance with Section 03300.

D. Backfilling:
1. Backfill and compact in accordance with Section 02320.

3.17 COATING APPLICATION AND REPAIR:

A. Preparation of surface: Perform the following in order given:
1. Clean surfaces contaminated with oil or grease using naphtha or xylol.
2. Remove rust and mill scale from surfaces by dry abrasive blasting to commercial finish in accordance with SSPC SP-6.
3. Coat surfaces within 24 hours and before dew point is reached.

4. Apply coating only to surfaces which are dry and free of contaminants. Whip blast surfaces not coated within specified time limit.
5. Application of coating:
   a. Mix coating in quantity which can be applied within its pot life if in accordance with manufacturer's recommendation. Thin only with approval.
   b. Apply coating to exterior surfaces of pipes and fittings in accordance with recommendations of coating manufacturer and as follows:
      1) Two coats of equal thickness.
      2) Total dry film thickness: 20 mils.
      3) Pretreat first coat as required prior to application of second coat.
      4) Apply second coat before first coat has dried tack-free but not later than 24 hours after application of first coat, unless otherwise recommended by coating manufacturer.
      5) Inspect coating prior to burial. Repair damages in accordance with recommendations for field corrections by coating manufacturer.
6. Test cathodic protection as specified in Section 13115.

3.18 SUBWAY DRAINAGE SYSTEM: Section 02625.

3.19 FIELD QUALITY CONTROL:

A. Maximum Surface Variation Tolerances:
   1. Grouted riprap: 1-1/4 inches in four feet from true plane.
   2. Bituminous concrete: Plus-or-minus 1/4 inch from specified grade in 25 feet.
   3. Cast-in-place concrete: Plus-or-minus 1/4 inch from specified grade in 15 feet.
   4. Precast concrete block: Plus-or-minus 1/2 inch from specified grade in 25 feet.
   5. Paving brick: Plus-or-minus 1/2 inch from specified grade in 25 feet.

B. Obstruction Tests:
   1. Perform field tests to verify that installed storm systems are free from obstructions.
   2. Remove obstructions by excavating at the apparent obstruction and repairing or replacing the defective pipe as directed by the Engineer.

3.20 TRANSPORTATION AND INSTALLATION OF MATERIALS FURNISHED BY OTHERS: *27

A. Transport and install materials furnished at the WSSC's storeyard at Bladensburg or other delivery points designated by the WSSC.

B. Use only suitable equipment, tools, and appliances for the safe and convenient handling and hauling of materials.

C. Check that all materials furnished by the WSSC are in satisfactory condition.

D. Materials damaged, lost or wasted after acceptance will be replaced by the WSSC at the expense of the Contractor.

E. Material showing inherent defects will be replaced by the WSSC without charge.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

***1**. Add 1.1 C. including 1.a.-b. for contracts where storm systems work is performed within the jurisdiction of WSSC.

***2**. Add 1.1 D. including 1. for contracts where storm systems work is performed within the jurisdiction of WSSC.

***3**. Add 1.2 E. including 1.-2. for contracts where storm systems work is performed within the jurisdiction of WASA.

***4**. Use first version of 1.3 A.4. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.

***5**. Use second version of 1.3 A.4. for contracts where storm systems work is performed outside the jurisdiction of WSSC.

***6**. Use first version of 1.3 A.5. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.

***7**. Use second version of 1.3 A.5. for contracts where storm systems work is performed outside the jurisdiction of WSSC.

***8**. Use first version of 1.3 A.6. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.

***9**. Use second version of 1.3 A.6. for contracts where storm systems work is performed outside the jurisdiction of WSSC.

***10**. Add 1.3 A.9. for contracts where storm systems work is performed within the jurisdiction of WSSC.

***11**. Add 1.3 D. including 1.-2.a. for contracts where storm systems work is performed within the jurisdiction of WASA.

***12**. Use first version of 2.1 F.2.f. modification for contracts where storm and sanitary systems work is performed within the jurisdiction of WSSC.

***13**. Use second version of 2.1 F.2.f. for contracts where storm systems work is performed outside the jurisdiction of WSSC.

***14**. Add 2.1 F.2.h. for contracts where storm systems work is performed within the jurisdiction of WSSC.

***15**. Use first version of 2.1 N. including 1.-2. modification for contracts where storm systems work is performed within the jurisdiction of WSSC.

***16**. Use second version of 2.1 N. including 1.-2. for contracts where storm systems work is performed outside the jurisdiction of WSSC.

***17**. Add 2.1 DD. including 1.-2. for contracts where storm systems work is performed within the jurisdiction of WSSC.

***18**. Add 2.1 EE. for contracts where storm systems work is performed within the jurisdiction of Prince Georges County.

***19**. Add 3.4 G. including 1.-3. for contracts where storm systems work is performed within the jurisdiction of WASA.

***20**. Use first version of 3.6 including A.-C.4. modification for contracts where storm systems work is performed within the jurisdiction of Fairfax County, Virginia.

***21**. Use second version of 3.6 including A.-C.4. for contracts where storm systems work is performed outside the jurisdiction of Fairfax County, Virginia.

***22**. Use second version of 3.7 including A.-C.4. for contracts where storm systems work is performed outside the jurisdiction of Fairfax County, Virginia.

***23**. Specify the type of cement to be used. The type of cement will vary depending on the jurisdiction and the use of the storm system.

***24**. Specify the type of mortar and cement to be used. They will vary depending on the jurisdiction and the use of the storm system.

***25**. Add 3.15 G. for contracts where work is performed within the jurisdiction of WSSC.

***26**. Add 3.16 D. for contracts where work is performed within the jurisdiction of WSSC.

***27**. Add 3.22 including A.-E. for contracts where work is performed within the jurisdiction of WSSC.

END OF SECTION

SECTION 02725
(Version 1)[*1]

BASE FOR PAVEMENTS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing, placing, shaping and compacting aggregate base 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. ASTM: D1241, D1557.

B. Source Quality Control:
1. Not less than 10 days prior to the beginning of work, inform the Engineer of source of material to be used.
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.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Aggregate Base Materials:
1. ASTM D1241.
2. Grading requirements [*2]:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
2 inches	100
1 inch	70 - 95
3/8 inch	35 - 75
Size 4	20 - 60
Size 10	15 - 45
Size 40	10 - 30
Size 200*	0 - 15

*Fraction passing the Size 200 sieve to be not greater than 2/3 of the fraction passing the Size 40 sieve.

3. Grading requirements [*3]:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
2-1/2 inches	100
1 inch	85 - 100
1/2 inch	50 - 92
Size 10	35 - 65
Size 40	15 - 45
Size 200*	3 - 15

*Fraction passing the Size 200 sieve to be not greater than 2/3 of the fraction passing the Size 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.

3.02 PLACING MATERIAL:

A. Subgrade Preparation: In accordance with Section 02320.

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

C. 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.

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

E. 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 98 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 1/2 inch from steel straightedge as specified in Section 02750.
   2. Maintain moisture content within two percent of optimum moisture content.

B. Tests: Determine optimum moisture content and maximum density in accordance with ASTM D1557.

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.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Use first version of SECTION 02725 BASE FOR PAVEMENTS for contracts where pavement base work is performed outside the jurisdiction of the District of Columbia except as noted. (Use second version for contracts where pavement base work is performed within the jurisdiction of the District of Columbia.)

***2**. Use first version of 2.1 A.2. for contracts where pavement base work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***3**. Use second version of 2.1 A.2. modification for contracts where pavement base work is performed within the jurisdiction of Prince Georges County, Maryland.

END OF SECTION

SECTION 02725
(Version 2)[*1]

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. AASHTO: M147, T180, T191.

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.

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.

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 as specified in Section 02750.
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 and Density Relations of Soils Using a 10-lb. Hammer and an 18-inch 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.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Use second version of SECTION 02725 BASE FOR PAVEMENTS for contracts where pavement base work is performed within the jurisdiction of the District of Columbia except as noted. (Use first version for contracts where pavement base work is performed outside the jurisdiction of the District of Columbia.)

END OF SECTION

SECTION 02726

SUB-BALLAST

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing, placing and compacting sub-ballast on previously constructed subgrade.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. ASTM: C88, C117, C127, C131, C136, C142, D698, ~~D2922~~ replaced by D6938, ~~D3017~~ replaced by D6938 (duplicate).

B. Source of Materials:
   1. Obtain approval of sub-ballast prior to commencing installation.
   2. Do not change material or source of supply without approval.

C. Inspection:
   1. The Engineer has the right to stop delivery of material to the job site based on visual inspection pending sampling and testing.
   2. If material loaded, being loaded or installed does not conform to specified requirements, the Engineer will reject the material and no further delivery will be accepted until the deficiency is corrected.
   3. Replace defective material.

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. Certification.
   2. Samples and Documentation:
      a. Qualification: Submit samples and source of supply sufficiently in advance to obtain approval not less than 30 days prior to anticipated date of commencing installation.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Sub-Ballast: Crushed stone, with the following additional requirements:
   1. Gradation: ASTM C136 and ASTM C117 with the following additional requirements:

Sieve Size	Percent Passing By Weight
1 inch	100
3/8 inch	50 to 85
4	35 to 65
10	25 to 50
40	15 to 25
200	5 to 15

a. Fraction passing the Size 200 sieve less than two thirds of fraction passing Size 40 sieve.

2. Clay lumps and friable particles: ASTM C142, 0.5 percent maximum.
3. Wear: ASTM C131, 40 percent maximum.
4. Absorption: ASTM C127, 0.5 percent maximum.
5. Soundness: ASTM C88, weighted average loss 15 percent maximum after five cycles of magnesium sulfate tests.

PART 3 - EXECUTION

3.01 PLACING MATERIAL:

A. The subgrade shall have been graded, shaped and compacted as required by the plans and specifications. The top of the subgrade required special attention to obtain uniform density. A uniformly smooth surface compacted to specifications is required, containing no ruts, pot holes, loose soil or any imperfection retaining water on the surface. The surface shall be inspected by the engineer and if surface fails to conform to specifications the engineer may require blading, rolling and compacting to provide a satisfactory surface.

B. Do not place material on subgrade that is muddy, rutted or frozen or has standing water.

C. The sub-ballast material shall be transported and delivered to the site in a manner that will prevent separation or loss of material. The material shall be placed in layers of 3 inches to 6 inches (or as directed by the engineer) and compacted to a depth and density as required by the plans and specifications.

D. Prior to placing materials, repair subgrade using sub-ballast.

E. Place material to provide uniformity of grading throughout work.

F. If subgrade is dusty, sprinkle it prior to placing sub-ballast.

G. Install sub-ballast to shape and compacted thickness shown.
1. Where compacted thickness is six inches or less, place sub-ballast in one layer.
2. Where compacted thickness is more than six inches, place material in two or more layers of equal thickness of not more than six inches each.

H. Vehicular traffic is to be kept to a minimum across the newly prepared sub-ballast surface. The contractor shall be responsible for maintaining a firm, true and smooth surface compacted to the required density until track ballast is placed on the sub-ballast.

3.02 COMPACTION:

A. During placing and compacting, maintain moisture content within specified tolerance.

B. Compact material for its full depth to 100 percent of maximum dry density.

3.03 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
1. Construct surface of sub-ballast to the following tolerances:
   a. Within 0.1 foot of elevation shown.
   b. Deviation not more than ½ inch from 10-foot straightedge.
2. During compaction maintain moisture content within two percent of optimum moisture content.

B. Tests:

1. Determine optimum moisture content and maximum dry density in accordance with ASTM D698.
2. Determine in-place density and moisture content in accordance with ASTM D6938.

PART 4 -MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement of work specified in this Section will be made in the following manner:
   1. No separate measurement.

4.02 PAYMENT

A. Compensation for work specified in this Section will be made in the following manner:
   1. Included in the price of the work of which it is a part.

END OF SECTION

SECTION 02727

BALLAST

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies furnishing mineral aggregate for use as ballast for ballasted track construction.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. CE: CRD-C 119.
   3. ASTM: C88, C117, C127, C131, C 136, C142, C535.
   4. AREMA: Chapter 1-2-1, (Volume 1), latest edition.

B. Source:
   1. Obtain approval prior to installation.
   2. Do not change ballast or source without approval.

C. Inspection:
   1. The Engineer has the right to stop delivery of material to job site by visual inspection, pending sampling and testing.
   2. If material loaded, being loaded or installed does not conform to specified requirements, the Engineer will reject the material and no further delivery will be accepted until the deficiency has been corrected.
   3. Replace defective material.

D. Testing and Sampling:
   1. Subject ballast to specified tests, except gradation test, at an approved independent testing facility.
   2. Conduct testing, except gradation test, to determine if ballast meets specified requirements.
   3. Visual inspection and gradation testing will be made by the Engineer:
      a. 30 days prior to initial delivery.
      b. Immediately prior to placement on the track bed.
      c. Each 4,000 tons of ballast delivered.

      WMATA, or its representatives, reserve the right to visit the producers facility during usual business hours unscheduled to a) observe sampling and testing procedures, b) obtain samples of the prepare material being produced and shipped, and c) review plant inspection methods, quality control procedures, equipment and examine test results of current and previous tests.
   4. Prior to installation, the supplier shall provide the Engineer with certified results of ballast quality and gradation as conducted by a testing laboratory accepted by the Engineer. The supplier shall receive approval of the Engineer for the Testing Laboratory prior to performing the aforementioned tests.

4. Recommended limiting values of testing for ballast material:

Property	Ballast Material							
	Granite	Traprock	Quartzite	Limestone	Dolomitic Limestone	Blast Furnace Slag	Steel Furnace Slag	ASTM Test
% Material Passing No. 200 Sieve	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	C 117
Bulk Specific Gravity (See Note 2)	2.60	2.60	2.60	2.60	2.65	2.30	2.90	C 127
Absorption %	1.0	1.0	1.0	2.0	2.0	5.0	2.0	C127
Clay Lumps & Friable Particles	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	C 142
Degradation	35%	25%	30%	30%	30%	40%	30%	See Note 1
Soundness (Sodium Sulfate) 5 cycles	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	C 88
Flat and/or Elongated Particles	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	D 4791

Note 1: Materials having gradation containing particles retained on the 1 inch sieve shall be tested by ASTM C 535. Materials having gradations with 100% passing the 1 inch sieve shall be tested by ASTM C 131. Use grading most representative of ballast material gradation.

Note 2: The limit for bulk specific gravity is a minimum value. Limits for the remainder of the tests are maximum values.

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:
   a. 200-pound samples for gradation test unless otherwise directed by the Engineer. Submit 30 days prior to shipping ballast to work site.
2. Certification:
   a. Certificates:

1) Submit source of supply sufficiently in advance to obtain approval not less than 30 days prior to anticipated date of commencing installation.

b. At time of delivery, submit certificates attesting that material furnished is typical of that tested and conforms to specified requirements.

3. Certified test results:

a. Submit not less than two weeks prior to shipping ballast to work site.

4. Handling Procedures: Submit the proposed method of handling.

1.04 PRODUCT DELIVERY, HANDLING, AND STORAGE:

A. Deliver, handle, and store the material by methods which prevent damage, fouling and segregation.

B. The aggregate production facility shall be of such design to permit production and or blending without excessive working of the materials and the facility must be approved by the purchaser.

C. Blending, stockpiling and other production and handling operations shall be managed by the producer to minimize segregation of the finished product. Stockpiling operations shall be minimize as practical the breakage or excessive fall in stockpiling operations and the movement of wheeled or tracked machines over stockpiled materials shall be limited.

D. Processed ballast shall be washed and/or rescreened as necessary to remove fine particle contamination as defined by the specification or as directed by WMATA prior to stockpiling in operations using stockpiles or immediately prior to loading operations.

E. The following are prohibited:

1. Storage of ballast in cone-shaped piles.
2. Subjecting ballast to repeated passes of equipment over same levels in stockpile area.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Ballast: Crushed stone from diabase rock, hard, strong, angular, durable, free from injurious amounts of deleterious substances, with the following additional requirements:

1. Gradation:

SIEVE SIZE	PERCENT PASSING BY WEIGHT	
	AREA SIZE 4 Mainline	AREA SIZE 5 Yard
2 inches	100	-
1-1/2 inches	90 to 100	100
1 inch	20 to 55	30 to 70
3/4 inch	0 to 15	0 to 20
½ inch	-	0 to 8
3/8 inch	0 to 5	-
Size 4	-	-

2. Fine particles: Material finer than Size 200 sieve, ASTM C117, one percent by weight maximum.
3. Flat and elongated particles: CE CRD-C 119, five-percent maximum.
4. Clay lumps and friable particles: ASTM C142, 0.5-percent maximum.
5. Wear: ASTM C535, 40-percent maximum.
6. Absorption: ASTM C127, 1.5-percent maximum.
7. Soundness: ASTM C88, 5-percent maximum loss after five cycles of the sodium-sulfate test.

PART 3 - EXECUTION

3.01 INSTALLATION:

A. Install ballast in accordance with the ballasted trackwork construction requirements of WMATA Specification Section 5652.

PART 4 -MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement of work specified in this Section will be made in the following manner:
   1. No separate measurement.

4.02 PAYMENT

A. Compensation for work specified in this Section will be made in the following manner:
   1. Included in the price of the work of which it is a part.

END OF SECTION

SECTION 02740
(Version 1)[*1]

BITUMINOUS PAVEMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing asphaltic surface, binder and base courses on prepared subgrade or previously constructed base course in conformance with sections, lines and grades shown.

B. Related Work Specified Elsewhere:
   1. Base for pavements: Section 02725.

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. For each delivery of asphaltic material, submit certificate stating type and amount of asphalt and results of specified tests.
   2. Documentation:
      a. Job-mix formula:
         1) For each mix to be supplied submit job-mix formula based on expected production averages.
         2) In formula establish:
            a) Weight percent of total aggregate and of aggregate finer than each required sieve size.
            b) Weight percent of total mix of asphalt cement.
            c) Temperature of mix when placed.
         3) Maintain job-mix formula once approved.
      b. Weight ticket: For each load of bituminous mixture delivered to the site, submit weight ticket showing the following:
         1) Mix type.
         2) Mix temperature.
         3) Identification of the truck.
         4) Tare weight of truck.
         5) Loaded weight of truck.
         6) Net weight of load.
         7) Time of leaving mix plant.
         8) Signature of the Engineer's plant representative.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. MSHA. [*2]
   3. VDOT. [*3]
   4. AASHTO: M6, M29, M43, M45, M76, M79, M140, M156, M208, T30, T164, T165, T168. [*4]
   5. AASHTO: M6, M29, M43, M45, M76, M79, M82, M140, M156, M208, T30, T164, T165, T168. [*5]
   6. ASTM: D2950, D3515. [*6]
   7. ASTM: D3515. [*7]

B. Sources of Supply:
   1. Not less than 20 days prior to beginning the work, inform the Engineer of the source of the materials to be used and obtain approval.
   2. Once approved, do not change source of supply.
   3. Do not construe approval as approval of entire location but as approval only insofar as material continues to meet specified requirements.
   4. Maintain quality of material. Material may be sampled and tested by the Engineer as often as the Engineer deems necessary.
   5. The Engineer has the right to reject material at the job site by visual inspection pending sampling and testing.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Delivery Trucks:
   1. For transporting bituminous, mixtures use trucks which show no leakage of oil or grease, have solid metal dump-type beds which are clean and smooth with tight fitting rear gate to prevent loss of materials in transit.
   2. Prior to loading, spray inside surface of truck beds with minimum amount of approved thin oil or mixture of lime and water proportioned 50 gallons of water to 100 pounds of lime necessary to prevent adhesion of the mixture. Do not use kerosene, gasoline or excessive amount of oil.
   3. Equip trucks with coverings to protect loads from weather and with suitable insulation to prevent undue heat loss during transit at temperatures below 40F.

B. Weighing of Bituminous Mixtures:
   1. Provide approved truck scales having both dial and automatic printer or use public scales.
   2. Use scales complying with applicable laws, ordinances and regulations governing use of scales.
   3. Have scales tested and sealed by authorized public official as often as directed to ensure their accuracy.
   4. At least once a week, check tare weight of each truck with full load of fuel and fitted with its equipment.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
   1. Do not place bituminous pavement on wet surfaces.
   2. Place bituminous pavement when temperature of air and base exceed 40F.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Asphalt Cement: AASHTO _____. *8

B. Asphalt Cement: AASHTO _____, Table 2, with no requirement for maximum loss on heating. *9

C. Cut-Back Asphalt for Prime Coat: Equivalent to AASHTO _____. *10

D. Cut-Back Asphalt, AASHTO M82, _____. Note 4 option applies. *11

E. Emulsified Asphalt for Tack Coat: SS-1, SS-1h, CSS-1, or CSS-1h, diluted one-part water to one-part emulsified asphalt. Prior to dilution, emulsified asphalt to comply with AASHTO M140 or AASHTO M208. Apply at rate of 0.05 to 0.15 gallons per square yard.

F. Aggregate: Coarse and fine aggregate to be free from substantial portions of serpentine or talc materials or carbonate aggregates containing less than 25 percent by weight insoluble residue retained between Size 10 and Size 200 sieves as determined by leaching samples with 6N hydrochloric acid.

1. Coarse aggregate: Crushed stone, AASHTO M79 and AASHTO M76 except for grading. Weight loss not to exceed 15 percent by weight when subjected to five alterations of magnesium sulfate soundness test.
2. Fine aggregate for hot asphaltic concrete: Consisting of one or a combination of the following materials:
   a. Material conforming to AASHTO M6 with the following additional requirements:
      1) When the material is subjected to five alternations of the magnesium sulfate soundness test, weighted loss not exceeding 12 percent by weight; amount of deleterious substances not exceeding following maximum permissible percent limits by weight:
         a) Clay lumps: 0.5.
         b) Coal and lignite: 0.25.
         c) Material passing size 200 sieve: 3.0.
         d) Other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles: 2.0.
   b. Material conforming to specified requirements for No. 10 coarse aggregate in accordance with AASHTO M43.
3. Fine aggregate for sheet asphalt binder: AASHTO M45, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
8	100
50	15 - 40
100	0 - 10
200	0 - 5

4. Fine aggregate for sheet asphalt surface: AASHTO M29, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
4	100
10	95 - 100
40	55 - 80
80	15 - 40

5. Mineral filler:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
30	100
50	95 - 100
200	70 - 100

2.02 MIXES:

A. Provide mixes in accordance with ASTM D3515 and as specified.

B. Proportion constituents of job mixes within limits specified in Table 02740-1.

C. Submit mixes as directed for evaluation of job-mix formula, with bulk specific gravity determined in accordance with AASHTO T165.

2.03 TEMPERATURE OF MIXES:

A. Maintain temperature of mixes within plus-or-minus 25F of that given in job-mix formula. Temperature ranges as specified in Table 02740-2.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. Equipment for Preparing Bituminous Material:
   1. Use bituminous paving material prepared in mixing plant conforming to AASHTO M156.

B. Equipment for Spreading and Finishing Bituminous Material:
   1. Use equipment capable of placing material at widths ranging from eight to twelve feet by increments of one foot and at varying thickness.
   2. Use machines which spread bituminous mixture without tearing surface. Achieve finish that is smooth, true to cross section, uniform in density and texture and free from hollows, corrugations and other irregularities.

C. Equipment for Compacting:
   1. Provide approved equipment capable of compacting materials to specified Marshall density.

3.02 BASE PREPARATION:

A. Prior to placing bituminous mixture, check line, grade and cross section of underlying course. Repair defective areas.

B. Have base approved, prior to placement of surface course.

C. Aggregate and Soil Aggregate Bases:
   1. Apply cut-back asphalt primer at rate of 0.2 to 0.5 gallons per square yard when base is damp but with no standing water.

2. Allow 24 hours for base to entirely absorb primer. Blot excess primer with just enough sand to prevent pickup under traffic. Sweep loose sand from base before placing base course.

D. Portland Cement Concrete, Bituminous and Brick Pavement Bases:
1. Apply tack coat using equipment designed for that purpose.
2. Apply tack coat uniformly to clean dry base at rate of 0.05 to 0.15 gallons per square yard.
3. Ensure that surface has cured and is satisfactorily tacky before placing mix.

E. Immediately prior to placing mix, apply thin coat of hot asphalt cement to contact surfaces of curbs, gutters, manholes and similar structures.

3.03 PLACING MIX:

A. Place base course mixture in one or more lifts with asphalt paver or spreader to provide nominal compacted thickness as shown. Place surface course mixture with asphalt paver to provide nominal compacted thickness as shown. Minimum lift thickness at least two times maximum particle size. Maximum lift thickness to be that which can be demonstrated to be laid in a single lift and compacted to required uniform density and smoothness. Place material in continuous operation. Correct irregularities before final compaction of mixture.

B. If equipment being used produces tracks, pulling, indented areas or other permanent blemishes in material being spread, remove such equipment from site and substitute other approved spreading and finishing equipment.

C. Do not permit direction of movement of paving equipment to be changed by turning on newly completed base, binder or surface courses.

D. Adjacent to headers, gutters, manholes and similar structures, place surface course so that finished surface is 1/4-inch above edge of structure.

E. When the Engineer considers it impractical to place mix with two machines, one machine will be permitted. Treat joints created by such operation as cold joints.

F. Rake joints to eliminate seams between lane passes.

3.04 COMPACTION:

A. Compact immediately after placing. Initial rolling with steel-wheel tandem roller, steel three-wheel roller, vibratory roller, or pneumatic-tire roller following paver as closely as possible, oriented with drive wheel closest to paver. If intermediate rolling is needed, use pneumatic-tire roller immediately behind initial rolling. Final rolling to eliminate marks from previous rolling. Use vibrating plate compactor or hand tamper to achieve thorough compaction in areas too small for roller. Keep steel wheel rollers wet while rolling.

3.05 COLD JOINTS:

A. Longitudinal: Apply tack coat to cold material before joining new work.

B. Transverse: Place bulkhead full depth of course or cut back minimum of three inches from sloping surface with masonry saw. Apply tack coat to cold material.

3.06 BULKHEADS:

A. Where placement of mix is to be discontinued for such period of time that material will fall below specified street temperature, place suitable bulkhead.

B. Construct cold joint as specified when work is resumed.

3.07 HANDWORK:

A. When approved, perform bituminous paving work by hand in areas inaccessible to machines.

B. Undertake handwork using equipment designed and approved for purpose.

C. Perform handwork so that resulting paving meets specified requirements.

3.08 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
   1. Thickness: Place bituminous pavement to within tolerance of plus-or-minus 1/8 inch of thickness shown.
   2. Surfaces: Construct surfaces to the following tolerances:
      a. Base courses to within plus-or-minus 3/8 inch of elevation shown.
      b. Surface courses to within plus-or-minus 3/16 inch of elevation shown.
      c. Surfaces to deviate no more than 1/4 inch in the length of 10-foot steel straightedge, not cumulative.
      d. During compacting, screed surface using straightedge as specified in Section 02750. Adjust rolling procedures so that tolerances are met.
   3. Densities required:
      a. Base courses: 94 percent of Marshall density. *12
      b. Base courses: 95 percent of Marshall density. *13
      c. Surface courses: 96 percent of Marshall density.

B. Testing:
   1. Mixes:
      a. During course of the work submit mixes as directed for testing of gradation and bitumen content in accordance with AASHTO T30 and AASHTO T164 on random samples selected in accordance with AASHTO T168.
   2. Determine density of base and surface courses by one of the following methods:
      a. Test base and surface courses for density and thickness with a nuclear density meter in accordance with ASTM D2950. *14
         1) Compute average thickness of base and surface courses from average density and weight per square yard of paving mixture actually used as follows:

$$t = \frac{W}{0.75\,d}$$

Where:

t = pavement thickness, in inches.

W = average weight of base or surface mixture actually used, pounds per square yard.

d = compacted density of base or surface course as measured by the nuclear device, pounds per cubic foot.

0.75 = constant.

b. Not used. *15

c. Test base and surface courses for density by taking test cores at designated locations for testing by the Engineer, number of cores not exceeding one core per 500 square yards of bituminous pavements or two cores per shift, whichever is greater. *16

1) Wherever deficient pavement is discovered take such additional cores as directed.

2) Repair core holes promptly using the same mix that was cored; where cores are taken through both base course and surface course simultaneously, use surface course mix for repair work.

d. Test base and surface courses for density by taking test cores at designated locations for testing by the Engineer, number of cores not exceeding one core per 500 square yards of bituminous pavements or three cores per shift, whichever is greater. *17

1) Wherever deficient pavement is discovered take such additional cores as directed.

2) Repair core holes promptly using the same mix that was cored; where cores are taken through both base course and surface course simultaneously, use surface course mix for repair work.

3.09 PROTECTION OF BITUMINOUS PAVEMENT:

A. Obtain approval for use of pavement by public and construction traffic.

B. Do not permit traffic to cross uncompleted longitudinal joints.

3.10 DEFICIENT PAVEMENT:

A. Where directed, replace with new material or repair bituminous pavement that does not meet specified requirements.

B. Pavement is considered deficient if the densities of three cores from one day's work are below 95 percent or if the density of one core is below 90 percent. *18

TABLE 02740-1 CONSTITUENT PROPORTIONS [*19]					
GRADING OF TOTAL AGGREGATE (COARSE, FINE, MINERAL FILLER: AS NECESSARY) AMOUNTS FINER THAN LABORATORY SIEVE (SQUARE OPENING) WEIGHT PERCENT					
SIEVE	SHEET ASPHALT		HOT ASPHALTIC CONCRETE		* JOB-MIX FORMULA TOLERANCE:
	BINDER	SURFACE	BINDER	SURFACE	ALL MIXES
1 inch	- -	- -	100	- -	±7
3/4 inch	- -	- -	90 - 100	- -	±7
1/2 inch	100	- -	- -	100	±7
3/8 inch	85 - 100	- -	60 - 85	85 - 100	±7
No. 4	35 - 55	100	45 - 65	55 - 80	±7
No. 10	20 - 35	95 - 100	30 - 50	40 - 65	±6
No. 40	- -	55 - 92	10 - 25	10 - 30	±6
No. 80	- -	20 - 60	3 - 15	3 - 15	±4
No. 200	0 - 5	9 - 20	2 - 8	2 - 8	±3
	ASPHALTIC CEMENT, WEIGHT PERCENT OF TOTAL MIXTURE				
	4.0 - 7.0	8.5 - 11.5	5.0 - 8.0	5.0 - 8.0	+0.5

* Notwithstanding tolerances, supply mixes within specified grading limits.

TABLE 02740-1 CONSTITUENT PROPORTIONS *20			
GRADING OF TOTAL AGGREGATE (COARSE, FINE, MINERAL FILLER: AS NECESSARY) AMOUNTS FINER THAN LABORATORY SIEVE (SQUARE OPENING) WEIGHT PERCENT			
SIEVE	HOT ASPHALTIC CONCRETE		* JOB-MIX FORMULA TOLERANCE:
	P.G. CO. P2 BASE	P.G. CO. SN SURFACE	ALL MIXES
1-1/2 inch	100	- -	±7
1 inch	93 - 100	- -	±7
3/4 inch	82 - 95	100	±7
3/8 inch	60 - 78	90 - 100	±7
# 4	40 - 58	65 - 85	±7
# 8	- -	48 - 68	±4
# 10	23 - 40	- -	±4
# 16	- -	34 - 54	±4
# 20	14 - 29	- -	±4
# 30	- -	22 - 42	±4
# 40	9 - 21	- -	±4
# 50	- -	10 - 32	±4
# 80	5 - 13	- -	±4
# 100	- -	5 - 24	±4
# 200	2 - 6	3 - 12	±2
	ASPHALT CEMENT, WEIGHT PERCENT OF TOTAL MIXTURE		
	4.5 - 6.5	5.0 - 11.0	+0.4
* Notwithstanding tolerances, supply mixes within specified grading limits.			

TABLE 02740-2 MIX TEMPERATURE RANGES				
MIX	TEMPERATURES, DEGREES F			
	PLANT			STREET
	AGGREGATE	ASPHALT CEMENT	TOTAL MIX	
Sheet Asphalt Binder	250 - 325	250 - 325	250 - 325	250 - 325
Sheet Asphalt Surface	300 - 375	250 - 350	300 - 375	275 - 350
Hot Asphaltic Concrete	250 - 325	250 - 325	250 - 325	250 - 325

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Use first version of SECTION 02740 BITUMINOUS PAVEMENT for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia except as noted. (Use second version for contracts where bituminous pavement work is performed within the jurisdiction of the District of Columbia.)

***2**. Use first version of 1.3 A.2. for contracts where bituminous pavement work is performed within the jurisdiction of the State of Maryland.

***3**. Use second version of 1.3 A.2. for contracts where bituminous pavement work is performed within the jurisdiction of the Commonwealth of Virginia.

***4**. Use first version of 1.3 A.3. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***5**. Use second version of 1.3 A.3. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***6**. Use first version of 1.3 A.4. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***7**. Use second version of 1.3 A.4. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***8**. Use first version of 2.1 A. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland

***9**. Use second version of 2.1 A. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***10**. Use first version of 2.1 B. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***11**. Use second version of 2.1 B. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***12**. Use first version of 3.8 A.3.a. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***13**. Use second version of 3.8 A.3.a. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***14**. Use first version of 3.8 B.2.a. including (1) for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***15**. Use second version of 3.8 B.2.a. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***16**. Use first version of 3.8 B.2.b. including (1)-(2) for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***17**. Use second version of 3.8 B.2.b. including (1)-(2) modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***18**. Add 3.10 B. for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***19**. Use first version of TABLE 02740-1 for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***20**. Use second version of TABLE 02740-1 modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

END OF SECTION

SECTION 02740
(Version 1)[*1]

BITUMINOUS PAVEMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing asphaltic surface, binder and base courses on prepared subgrade or previously constructed base course in conformance with sections, lines and grades shown.

B. Related Work Specified Elsewhere:
   1. Base for pavements: Section 02725.

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. For each delivery of asphaltic material, submit certificate stating type and amount of asphalt and results of specified tests.
   2. Documentation:
      a. Job-mix formula:
         1) For each mix to be supplied submit job-mix formula based on expected production averages.
         2) In formula establish:
            a) Weight percent of total aggregate and of aggregate finer than each required sieve size.
            b) Weight percent of total mix of asphalt cement.
            c) Temperature of mix when placed.
         3) Maintain job-mix formula once approved.
      b. Weight ticket: For each load of bituminous mixture delivered to the site, submit weight ticket showing the following:
         1) Mix type.
         2) Mix temperature.
         3) Identification of the truck.
         4) Tare weight of truck.
         5) Loaded weight of truck.
         6) Net weight of load.
         7) Time of leaving mix plant.
         8) Signature of the Engineer's plant representative.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. MSHA. [*2]
   3. VDOT. [*3]
   4. AASHTO: M6, M29, M43, M45, M76, M79, M140, M156, M208, T30, T164, T165, T168. [*4]
   5. AASHTO: M6, M29, M43, M45, M76, M79, M82, M140, M156, M208, T30, T164, T165, T168. [*5]
   6. ASTM: D2950, D3515. [*6]
   7. ASTM: D3515. [*7]

B. Sources of Supply:
   1. Not less than 20 days prior to beginning the work, inform the Engineer of the source of the materials to be used and obtain approval.
   2. Once approved, do not change source of supply.
   3. Do not construe approval as approval of entire location but as approval only insofar as material continues to meet specified requirements.
   4. Maintain quality of material. Material may be sampled and tested by the Engineer as often as the Engineer deems necessary.
   5. The Engineer has the right to reject material at the job site by visual inspection pending sampling and testing.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Delivery Trucks:
   1. For transporting bituminous, mixtures use trucks which show no leakage of oil or grease, have solid metal dump-type beds which are clean and smooth with tight fitting rear gate to prevent loss of materials in transit.
   2. Prior to loading, spray inside surface of truck beds with minimum amount of approved thin oil or mixture of lime and water proportioned 50 gallons of water to 100 pounds of lime necessary to prevent adhesion of the mixture. Do not use kerosene, gasoline or excessive amount of oil.
   3. Equip trucks with coverings to protect loads from weather and with suitable insulation to prevent undue heat loss during transit at temperatures below 40F.

B. Weighing of Bituminous Mixtures:
   1. Provide approved truck scales having both dial and automatic printer or use public scales.
   2. Use scales complying with applicable laws, ordinances and regulations governing use of scales.
   3. Have scales tested and sealed by authorized public official as often as directed to ensure their accuracy.
   4. At least once a week, check tare weight of each truck with full load of fuel and fitted with its equipment.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
   1. Do not place bituminous pavement on wet surfaces.
   2. Place bituminous pavement when temperature of air and base exceed 40F.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Asphalt Cement: AASHTO _____. *8

B. Asphalt Cement: AASHTO _____, Table 2, with no requirement for maximum loss on heating. *9

C. Cut-Back Asphalt for Prime Coat: Equivalent to AASHTO _____. *10

D. Cut-Back Asphalt, AASHTO M82, _____. Note 4 option applies. *11

E. Emulsified Asphalt for Tack Coat: SS-1, SS-1h, CSS-1, or CSS-1h, diluted one-part water to one-part emulsified asphalt. Prior to dilution, emulsified asphalt to comply with AASHTO M140 or AASHTO M208. Apply at rate of 0.05 to 0.15 gallons per square yard.

F. Aggregate: Coarse and fine aggregate to be free from substantial portions of serpentine or talc materials or carbonate aggregates containing less than 25 percent by weight insoluble residue retained between Size 10 and Size 200 sieves as determined by leaching samples with 6N hydrochloric acid.

1. Coarse aggregate: Crushed stone, AASHTO M79 and AASHTO M76 except for grading. Weight loss not to exceed 15 percent by weight when subjected to five alterations of magnesium sulfate soundness test.
2. Fine aggregate for hot asphaltic concrete: Consisting of one or a combination of the following materials:
   a. Material conforming to AASHTO M6 with the following additional requirements:
      1) When the material is subjected to five alternations of the magnesium sulfate soundness test, weighted loss not exceeding 12 percent by weight; amount of deleterious substances not exceeding following maximum permissible percent limits by weight:
         a) Clay lumps: 0.5.
         b) Coal and lignite: 0.25.
         c) Material passing size 200 sieve: 3.0.
         d) Other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles: 2.0.
   b. Material conforming to specified requirements for No. 10 coarse aggregate in accordance with AASHTO M43.
3. Fine aggregate for sheet asphalt binder: AASHTO M45, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
8	100
50	15 - 40
100	0 - 10
200	0 - 5

4. Fine aggregate for sheet asphalt surface: AASHTO M29, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
4	100
10	95 - 100
40	55 - 80
80	15 - 40

5. Mineral filler:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
30	100
50	95 - 100
200	70 - 100

2.02 MIXES:

A. Provide mixes in accordance with ASTM D3515 and as specified.

B. Proportion constituents of job mixes within limits specified in Table 02740-1.

C. Submit mixes as directed for evaluation of job-mix formula, with bulk specific gravity determined in accordance with AASHTO T165.

2.03 TEMPERATURE OF MIXES:

A. Maintain temperature of mixes within plus-or-minus 25F of that given in job-mix formula. Temperature ranges as specified in Table 02740-2.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. Equipment for Preparing Bituminous Material:
   1. Use bituminous paving material prepared in mixing plant conforming to AASHTO M156.

B. Equipment for Spreading and Finishing Bituminous Material:
   1. Use equipment capable of placing material at widths ranging from eight to twelve feet by increments of one foot and at varying thickness.
   2. Use machines which spread bituminous mixture without tearing surface. Achieve finish that is smooth, true to cross section, uniform in density and texture and free from hollows, corrugations and other irregularities.

C. Equipment for Compacting:
   1. Provide approved equipment capable of compacting materials to specified Marshall density.

3.02 BASE PREPARATION:

A. Prior to placing bituminous mixture, check line, grade and cross section of underlying course. Repair defective areas.

B. Have base approved, prior to placement of surface course.

C. Aggregate and Soil Aggregate Bases:
   1. Apply cut-back asphalt primer at rate of 0.2 to 0.5 gallons per square yard when base is damp but with no standing water.

2. Allow 24 hours for base to entirely absorb primer. Blot excess primer with just enough sand to prevent pickup under traffic. Sweep loose sand from base before placing base course.

D. Portland Cement Concrete, Bituminous and Brick Pavement Bases:
1. Apply tack coat using equipment designed for that purpose.
2. Apply tack coat uniformly to clean dry base at rate of 0.05 to 0.15 gallons per square yard.
3. Ensure that surface has cured and is satisfactorily tacky before placing mix.

E. Immediately prior to placing mix, apply thin coat of hot asphalt cement to contact surfaces of curbs, gutters, manholes and similar structures.

3.03 PLACING MIX:

A. Place base course mixture in one or more lifts with asphalt paver or spreader to provide nominal compacted thickness as shown. Place surface course mixture with asphalt paver to provide nominal compacted thickness as shown. Minimum lift thickness at least two times maximum particle size. Maximum lift thickness to be that which can be demonstrated to be laid in a single lift and compacted to required uniform density and smoothness. Place material in continuous operation. Correct irregularities before final compaction of mixture.

B. If equipment being used produces tracks, pulling, indented areas or other permanent blemishes in material being spread, remove such equipment from site and substitute other approved spreading and finishing equipment.

C. Do not permit direction of movement of paving equipment to be changed by turning on newly completed base, binder or surface courses.

D. Adjacent to headers, gutters, manholes and similar structures, place surface course so that finished surface is 1/4-inch above edge of structure.

E. When the Engineer considers it impractical to place mix with two machines, one machine will be permitted. Treat joints created by such operation as cold joints.

F. Rake joints to eliminate seams between lane passes.

3.04 COMPACTION:

A. Compact immediately after placing. Initial rolling with steel-wheel tandem roller, steel three-wheel roller, vibratory roller, or pneumatic-tire roller following paver as closely as possible, oriented with drive wheel closest to paver. If intermediate rolling is needed, use pneumatic-tire roller immediately behind initial rolling. Final rolling to eliminate marks from previous rolling. Use vibrating plate compactor or hand tamper to achieve thorough compaction in areas too small for roller. Keep steel wheel rollers wet while rolling.

3.05 COLD JOINTS:

A. Longitudinal: Apply tack coat to cold material before joining new work.

B. Transverse: Place bulkhead full depth of course or cut back minimum of three inches from sloping surface with masonry saw. Apply tack coat to cold material.

3.06 BULKHEADS:

A. Where placement of mix is to be discontinued for such period of time that material will fall below specified street temperature, place suitable bulkhead.

B. Construct cold joint as specified when work is resumed.

3.07 HANDWORK:

A. When approved, perform bituminous paving work by hand in areas inaccessible to machines.

B. Undertake handwork using equipment designed and approved for purpose.

C. Perform handwork so that resulting paving meets specified requirements.

3.08 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
   1. Thickness: Place bituminous pavement to within tolerance of plus-or-minus 1/8 inch of thickness shown.
   2. Surfaces: Construct surfaces to the following tolerances:
      a. Base courses to within plus-or-minus 3/8 inch of elevation shown.
      b. Surface courses to within plus-or-minus 3/16 inch of elevation shown.
      c. Surfaces to deviate no more than 1/4 inch in the length of 10-foot steel straightedge, not cumulative.
      d. During compacting, screed surface using straightedge as specified in Section 02750. Adjust rolling procedures so that tolerances are met.
   3. Densities required:
      a. Base courses: 94 percent of Marshall density. *12
      b. Base courses: 95 percent of Marshall density. *13
      c. Surface courses: 96 percent of Marshall density.

B. Testing:
   1. Mixes:
      a. During course of the work submit mixes as directed for testing of gradation and bitumen content in accordance with AASHTO T30 and AASHTO T164 on random samples selected in accordance with AASHTO T168.
   2. Determine density of base and surface courses by one of the following methods:
      a. Test base and surface courses for density and thickness with a nuclear density meter in accordance with ASTM D2950. *14
         1) Compute average thickness of base and surface courses from average density and weight per square yard of paving mixture actually used as follows:

$$t = \frac{W}{0.75\,d}$$

Where:

t = pavement thickness, in inches.

W = average weight of base or surface mixture actually used, pounds per square yard.

d = compacted density of base or surface course as measured by the nuclear device, pounds per cubic foot.

0.75 = constant.

b. Not used. *15

c. Test base and surface courses for density by taking test cores at designated locations for testing by the Engineer, number of cores not exceeding one core per 500 square yards of bituminous pavements or two cores per shift, whichever is greater. *16

1) Wherever deficient pavement is discovered take such additional cores as directed.

2) Repair core holes promptly using the same mix that was cored; where cores are taken through both base course and surface course simultaneously, use surface course mix for repair work.

d. Test base and surface courses for density by taking test cores at designated locations for testing by the Engineer, number of cores not exceeding one core per 500 square yards of bituminous pavements or three cores per shift, whichever is greater. *17

1) Wherever deficient pavement is discovered take such additional cores as directed.

2) Repair core holes promptly using the same mix that was cored; where cores are taken through both base course and surface course simultaneously, use surface course mix for repair work.

3.09 PROTECTION OF BITUMINOUS PAVEMENT:

A. Obtain approval for use of pavement by public and construction traffic.

B. Do not permit traffic to cross uncompleted longitudinal joints.

3.10 DEFICIENT PAVEMENT:

A. Where directed, replace with new material or repair bituminous pavement that does not meet specified requirements.

B. Pavement is considered deficient if the densities of three cores from one day's work are below 95 percent or if the density of one core is below 90 percent. *18

TABLE 02740-1 CONSTITUENT PROPORTIONS [*19]					
GRADING OF TOTAL AGGREGATE (COARSE, FINE, MINERAL FILLER: AS NECESSARY) AMOUNTS FINER THAN LABORATORY SIEVE (SQUARE OPENING) WEIGHT PERCENT					
SIEVE	SHEET ASPHALT		HOT ASPHALTIC CONCRETE		* JOB-MIX FORMULA TOLERANCE:
	BINDER	SURFACE	BINDER	SURFACE	ALL MIXES
1 inch	- -	- -	100	- -	±7
3/4 inch	- -	- -	90 - 100	- -	±7
1/2 inch	100	- -	- -	100	±7
3/8 inch	85 - 100	- -	60 - 85	85 - 100	±7
No. 4	35 - 55	100	45 - 65	55 - 80	±7
No. 10	20 - 35	95 - 100	30 - 50	40 - 65	±6
No. 40	- -	55 - 92	10 - 25	10 - 30	±6
No. 80	- -	20 - 60	3 - 15	3 - 15	±4
No. 200	0 - 5	9 - 20	2 - 8	2 - 8	±3
	ASPHALTIC CEMENT, WEIGHT PERCENT OF TOTAL MIXTURE				
	4.0 - 7.0	8.5 - 11.5	5.0 - 8.0	5.0 - 8.0	+0.5

* Notwithstanding tolerances, supply mixes within specified grading limits.

TABLE 02740-1 CONSTITUENT PROPORTIONS *20			
GRADING OF TOTAL AGGREGATE (COARSE, FINE, MINERAL FILLER: AS NECESSARY) AMOUNTS FINER THAN LABORATORY SIEVE (SQUARE OPENING) WEIGHT PERCENT			
SIEVE	HOT ASPHALTIC CONCRETE		* JOB-MIX FORMULA TOLERANCE:
	P.G. CO. P2 BASE	P.G. CO. SN SURFACE	ALL MIXES
1-1/2 inch	100	- -	±7
1 inch	93 - 100	- -	±7
3/4 inch	82 - 95	100	±7
3/8 inch	60 - 78	90 - 100	±7
# 4	40 - 58	65 - 85	±7
# 8	- -	48 - 68	±4
# 10	23 - 40	- -	±4
# 16	- -	34 - 54	±4
# 20	14 - 29	- -	±4
# 30	- -	22 - 42	±4
# 40	9 - 21	- -	±4
# 50	- -	10 - 32	±4
# 80	5 - 13	- -	±4
# 100	- -	5 - 24	±4
# 200	2 - 6	3 - 12	±2
	ASPHALT CEMENT, WEIGHT PERCENT OF TOTAL MIXTURE		
	4.5 - 6.5	5.0 - 11.0	+0.4
* Notwithstanding tolerances, supply mixes within specified grading limits.			

TABLE 02740-2 MIX TEMPERATURE RANGES				
MIX	TEMPERATURES, DEGREES F			
	PLANT			STREET
	AGGREGATE	ASPHALT CEMENT	TOTAL MIX	
Sheet Asphalt Binder	250 - 325	250 - 325	250 - 325	250 - 325
Sheet Asphalt Surface	300 - 375	250 - 350	300 - 375	275 - 350
Hot Asphaltic Concrete	250 - 325	250 - 325	250 - 325	250 - 325

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Use first version of SECTION 02740 BITUMINOUS PAVEMENT for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia except as noted. (Use second version for contracts where bituminous pavement work is performed within the jurisdiction of the District of Columbia.)

***2**. Use first version of 1.3 A.2. for contracts where bituminous pavement work is performed within the jurisdiction of the State of Maryland.

***3**. Use second version of 1.3 A.2. for contracts where bituminous pavement work is performed within the jurisdiction of the Commonwealth of Virginia.

***4**. Use first version of 1.3 A.3. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***5**. Use second version of 1.3 A.3. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***6**. Use first version of 1.3 A.4. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***7**. Use second version of 1.3 A.4. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***8**. Use first version of 2.1 A. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland

***9**. Use second version of 2.1 A. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***10**. Use first version of 2.1 B. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***11**. Use second version of 2.1 B. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***12**. Use first version of 3.8 A.3.a. for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***13**. Use second version of 3.8 A.3.a. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***14**. Use first version of 3.8 B.2.a. including (1) for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***15**. Use second version of 3.8 B.2.a. modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***16**. Use first version of 3.8 B.2.b. including (1)-(2) for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***17**. Use second version of 3.8 B.2.b. including (1)-(2) modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***18**. Add 3.10 B. for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

***19**. Use first version of TABLE 02740-1 for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia and Prince Georges County, Maryland.

***20**. Use second version of TABLE 02740-1 modification for contracts where bituminous pavement work is performed within the jurisdiction of Prince Georges County, Maryland.

END OF SECTION

SECTION 02740
(Version 2)[*1]

BITUMINOUS PAVEMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing bituminous pavements complete in place as shown; placed on bases prepared under Section 02725, Base for Pavements and under Section 02750, Concrete Pavement.

B. Related Work Specified Elsewhere:
   1. Base for pavements: Section 02725.
   2. Concrete pavement: Section 02750.

C. Definitions:
   1. Equipment: This includes such specialized devices and tools as are customarily used in the construction of bituminous pavements; e.g., lutes, rakes, irons.

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. For each delivery of asphaltic material, submit certificate stating type and amount of asphalt and results of specified tests.
   2. Documentation:
      a. Job-mix formula:
         1) For each mix to be supplied submit job-mix formula based on expected production averages.
         2) In formula establish:
            a) Weight percent of total aggregate and of aggregate finer than each required sieve size.
            b) Weight percent of total mix of asphalt cement.
            c) Temperature of mix when placed.
         3) Maintain job-mix formula once approved.
      b. Weight ticket: For each load of bituminous mixture delivered to the site, submit weight ticket showing the following:
         1) Mix type.
         2) Mix temperature.
         3) Identification of the truck.
         4) Tare weight of truck.
         5) Loaded weight of truck.
         6) Net weight of load.
         7) Time of leaving mix plant.
         8) Signature of the Engineer's plant representative.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AASHTO: M6, M17, M20, M29, M43, M45, M76, M79, M81, M82, M140, T30, T164, T165, T168.

3. ASTM: D3515.

B. Sources of Supply:
1. Not less than 20 days prior to beginning the work, inform the Engineer of the source of the materials to be used and obtain approval.
2. Once approved, do not change source of supply.
3. Do not construe approval as approval of entire location but as approval only insofar as material continues to meet specified requirements.
4. Maintain quality of material. Material may be sampled and tested by the Engineer as often as the Engineer deems necessary.
5. The Engineer has the right to reject material at the job site by visual inspection pending sampling and testing.
6. Provide mix for a given area as defined by the Engineer from one mixing plant.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Delivery Trucks:
1. For transporting bituminous, mixtures use trucks which show no leakage of oil or grease, have solid metal dump-type beds which are clean and smooth with tight fitting rear gate to prevent loss of materials in transit.
2. Prior to loading, spray inside surface of truck beds with minimum amount of approved thin oil or mixture of lime and water proportioned 50 gallons of water to 100 pounds of lime necessary to prevent adhesion of the mixture. Do not use kerosene, gasoline or excessive amount of oil.
3. Equip trucks with coverings to protect loads from weather and with suitable insulation to prevent undue heat loss during transit at temperatures below 40F.

B. Weighing of Bituminous Mixtures:
1. Provide approved truck scales having both dial and automatic printer or use public scales.
2. Use scales complying with applicable laws, ordinances and regulations governing use of scales.
3. Have scales tested and sealed by authorized public official as often as directed to ensure their accuracy, and within the six months prior for use for the work. The Engineer has the option to require retesting and resealing.
4. At least once a week and whenever directed by the Engineer, check tare weight of each truck with full load of fuel and fitted with its normal equipment.

1.05 JOB CONDITIONS:

A. Environmental Requirements:
1. Do not place bituminous pavement on wet surfaces.
2. Place bituminous pavement only when temperature of air and base exceed 40F and when by U.S. Weather Bureau forecast, the temperature is expected to remain above 40F during the course of the work.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Asphalt Cement: AASHTO M20, Penetration Grade 85-100.

B. Cut-Back Asphalt for Prime Coat: AASHTO M82, Grade MC-30 or MC-70 as conditions warrant.

C. Emulsified Asphalt for Tack Coat: As conditions warrant, use either of the following:
   1. AASHTO M81, Cut-Back Asphalt (Rapid-Curing Type), Grade RC-70.
   2. AASHTO M140, Emulsified Asphalt, Grade SS-1 or SS-1h, diluted with water in the volumetric ratio of three parts emulsion to one part water.

D. Aggregate: Coarse and fine aggregate free from substantial portions of serpentine or talc materials or carbonate aggregates containing less than 25 percent by weight insoluble residue retained between Size 10 and Size 200 sieves as determined by leaching samples with 6N hydrochloric acid.
   1. Coarse aggregate: Crushed stone, AASHTO M79 and AASHTO M76 except for grading. Weight loss not to exceed 15 percent by weight when subjected to five alterations of magnesium sulfate soundness test.
   2. Fine aggregate for hot asphaltic concrete: Consisting of one or a combination of the following materials:
      a. Material conforming to AASHTO M6 with the following additional requirements:
         1) When the material is subjected to five alternations of the magnesium sulfate soundness test, weighted loss not exceeding 12 percent by weight; amount of deleterious substances not exceeding following maximum permissible percent limits by weight:
            a) Clay lumps: 0.5.
            b) Coal and lignite: 0.25.
            c) Material passing size 200 sieve: 3.0.
            d) Other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles: 2.0.
      b. Material conforming to specified requirements for No. 10 coarse aggregate in accordance with AASHTO M43.
   3. Fine aggregate for sheet asphalt binder: AASHTO M45, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
8	100
50	15 - 40
100	0 - 10
200	0 - 5

THIS SPACE NOT USED.

4. Fine aggregate for sheet asphalt surface: AASHTO M29, with the following additional requirements:

Sieve Designation	Percentage By Weight Passing Square Mesh Sieves
4	100
10	95 - 100
40	55 - 80
80	15 - 40
200	0 - 5

5. Mineral filler: Limestone dust, hydrated lime, or portland cement, AASHTO M17; uniformly graded, non-plastic, free from lumps, balls or foreign materials, and having a maximum moisture content of 0.5 percent when incorporated into the bituminous mix.
6.

2.02 MIXES:

A. Provide mixes in accordance with ASTM D3515 and as specified.

B. Proportion constituents of job mixes within limits specified in Table 02740-1.

C. Submit mixes as directed for evaluation of job-mix formula, with bulk specific gravity determined in accordance with AASHTO T165.

2.03 TEMPERATURE OF MIXES:

A. Maintain temperature of mixes within plus-or-minus 25F of that given in job-mix formula. Temperature ranges as specified in Table 02740-2.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. General:
   1. The requirements specified for equipment are pursuant to the equipment provisions of the General Provisions.
   2. The requirements specified for equipment are not intended to be complete; rather, the intent is that the characteristic equipment be used to produce certain of the required results.
   3. Suitability of the equipment is a determination made by the Engineer that the equipment will produce the required results.

B. Batch-Type Bituminous Mixing Plants: Of sufficient capacity to adequately handle the proposed construction; maintained in good mechanical condition; equipped with the necessary scales and measures to ensure proper proportioning of ingredients; and designed, coordinated and operated so as to produce a mixture within the job-mix tolerances. Ensure that defects which would adversely affect the proper functioning of the plants or the quality of the mixture are replaced or repaired immediately upon instruction from the Engineer.
   1. Tanks for storage of bituminous material: Capable of heating the material, always under effective and positive control, to specified temperature requirements.

a. Heating: Accomplished by steam coils, electricity or other means so that no flame can come in contact with the heating tank, and so that uniform heating of the entire contents is provided.
b. Circulating system for the bituminous material: Of adequate size to ensure the proper and continuous circulation during the entire operating period.
c. Pipelines and fittings: Steam-jacketed or otherwise properly insulated to prevent heat loss.
d. Provide separate tanks and delivery lines for each grade of asphalt cement or liquid asphaltic material for mixtures to be produced in the same mixer unit.

2. Feeder for drier: Accurate mechanical means for uniformly feeding the aggregate into the drier so that a uniform production and a uniform temperature may be secured.
   a. Have each aggregate, except for mineral filler added cold, fed to a central elevator, conveyor or feeder by accurate mechanical means with adjustable gates that will deliver each aggregate in the desired proportion. When more than one cold elevator is used, feed each by a separate feeder unit with the individual controls integrated with a master total control.
   b. Set and lock the total and proportional controls when so directed by the Engineer.
3. Driers: Capable of drying and heating the aggregates as specified for any item, and of sufficient capacity to supply the mixing unit at its operating capacity. Drier is to continuously agitate the aggregates during the heating and drying process so that the temperature can be positively regulated.
4. Screening system for grading the aggregate: Shaker or vibrating type capable of screening the aggregates to specified sizes and proportions, producing a quantity of aggregate sufficient to keep the mixer operating at the rated plant capacity.
   a. Have screening system equipped with a chute or pipe for removal of oversized aggregate having the discharge end located so as not to create a hazard or nuisance.
   b. Revolving double-jacketed screens may be accepted if they give satisfactory performance of a maximum plant production.
5. Storage bins: Of sufficient capacity to supply the mixer when it is operating at full capacity; divided into at least three compartments arranged to ensure separate and adequate storage of appropriate proportions of aggregates; each compartment provided with an adequate overflow opening located so as to prevent backing up of material into other bins.
   a. Each compartment provided with its individual outlet gate, so designed and constructed that when closed there will be no leakage; gates cutting off quickly and completely.
   b. Have discharge points of overflow located so that they will not create a hazard or nuisance.
   c. Bins equipped with adequate tell-tale devices to indicate the position of the aggregate in the bins at the lower quarter points.
   d. Provide separate dry storage for the mineral filler.
6. Bituminous control unit: Satisfactory means, either by weighing, metering or volumetric measurements, to obtain the proper amount of bituminous material in the mix within the tolerance specified for the job-mix; with suitable means, either by steam-jacketing or other insulation, for maintaining the specified temperature of the bituminous material in the pipelines, meters, weigh buckets, spray bars, and other containers or flow lines.
7. Bitumen bucket (if a bucket is used for weighing the bituminous material): Capacity sufficient to hold not less than 20 percent of the weight of aggregate required for one batch; steam-jacketed or equipped with properly insulated electric heating units; and suspended on dial scales or beam scales so that the tare weight of bucket will be shown for each weighing.

a. Bucket equipped with tell-tale device to accurately control the net weight of bituminous material added to the mix to within two percent above or below the actual weight in pounds required.
b. Bucket arranged so that it will deliver molten bitumen in a thin uniform sheet or in multiple streams the full width of the mixer, except in the case of a rotary mixer where bitumen is sprayed.

8. Thermometric equipment: Have plant equipped with the following as approved:
   a. Armored thermometer reading from 200F to 400F, fixed at a suitable location so that the temperature of the bitumen at the bucket or spray bar can be determined.
   b. Dial-scale, mercury-activated thermometer, electric pyrometer or other approved thermometric instrument, so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate; of such accuracy that the temperature of the aggregate can be maintained within the limits specified; and so located so that its dial is in plain view of the drier fireman or feeder.
9. Mixing time: Positive means to govern the time of mixing and to maintain it constant unless changed by order of the Engineer.
10. Timing devices: Accurate timelock to control the operation of a complete mixing cycle by locking the weight box gate after the charging of the mixer, until the closing of the mixer gate at the completion of the cycle. Timeclock is to lock the bitumen bucket throughout the dry-mixing period and lock the mixer gate throughout the dry-mixing and wet-mixing periods.
    a. Control of the timing is to be flexible and capable of being set at intervals of not more than five seconds throughout cycles up to three minutes.
    b. A mechanical batch or box counter is to designed so as to register only upon the actuation of the bucket release and to preclude the register of dry batches or the register of material through the operation of pulling bins.
11. Plant scales: Either the beam or springless-dial type; of a standard make designed as an integral part of the plant; accurate to within one-half percent of the true weight of the load being weighed; having significant graduations that can be easily read to that degree of accuracy; and with dials and indicators in plain view of the operator when on the weighing platform.
    a. Beam-type scales: Balanced on knife edges and fulcrums that are kept clean and constructed so that they will not easily be thrown out of alignment and adjustment; each beam having a locking device which will permit the beam either to be suspended or thrown into action; a separate beam for each size aggregate and a tare beam for balancing the hopper; each aggregate beam equipped with an auxiliary dial or tell-tale that will indicate that the required load to the weighing hopper is being approached and will continue to indicate further movement of the beam after that.
        1) For weighing bituminous material, use beam-type scales that are provided with a tare beam and a full-capacity beam.
        2) Gradations: Two pounds or smaller.
    b. Dial scales: Springless and so constructed, installed, and maintained, to be free from vibration; of such size that the numerals on the dial can be easily read from a distance of 25 feet; dials of the compounding type having full complements of index pointers.
        1) For weighing asphalt cement, capacity equal to or less than two times the maximum weight of the material to be weighed.
        2) Graduations: Such that they can be easily read to the nearest two pounds.
    c. Weigh box or hopper: Provide means for accurately weighing each bin size of aggregate in a weigh box or hopper suspended on scales and of sufficient size to hold a full batch without hand raking or running over; with gates on both bins and hopper constructed so as to prevent leakage when they are

closed. Have container supported on knife edges or fulcrums constructed so that it will not easily be thrown out of alignment or adjustment; with edges, ends and sides free from contact with supporting parts that could possibly affect proper weighing; and with adequate clearance of the parts to prevent accumulation of foreign materials. In plants where the weigh box is enclosed for the purpose of minimizing dust nuisance, have some provision made to permit sampling the materials by the Engineer as discharge is made from the storage bins.

d. Provide ten 50-pound standard test weights at each plant for testing weighing equipment.

12. Mixer unit: Batch mixer of an approved twin-pugmill type or rotary-drum type, with a batch capacity of not less than 2,000 pounds, and capable of producing a uniform mixture within the job-mix tolerances specified; constructed as to prevent leakage of contents until the batch is to be discharged.
    a. If mixer is the pugmill type, have the clearance of the blades from fixed and moving parts not to exceed 3/4 inch, unless the maximum aggregate particle exceeds 1-1/2 inches.
    b. If not enclosed, equip the mixer box with a dust hood to prevent loss of dust. When so enclosed, make provision to permit visual inspection of mixing operation by the Engineer.
13. Dust collectors: When plant is located where dust may be objectionable or become a nuisance or where dust interferes with the efficiency of the operation of the plant, provide proper housing, mixing covers, or dust collecting systems. Make provision to dispose of the material so collected or to return it uniformly to the mixture, as the Engineer may direct.
14. Safety Requirements:
    a. Provide a mixer platform sufficiently rigid and of ample size to provide for safe and convenient access to the mixer and pertinent equipment.
    b. Place adequate and safe stairways to the mixer platform and guarded ladders to other plant units at points where accessibility is necessary during plant operations.
    c. Thoroughly guard gears, pulleys, chains, sprockets and other dangerous moving parts.
    d. Always maintain a clear, ample and unobstructed passage in and around the truck loading space. Keep this space free from drippings from the mixing platform.

C. Continuous-Type Bituminous Mixing Plants: Meet the requirements for batch-type bituminous mixing plants, except for the requirements as to scales and weighing equipment and the requirements for the mixer unit which do not apply. The following are required in continuous mixing plant:

1. Gradation control unit: Means for accurately proportioning aggregate from each bin either by weighing or by volumetric measurement. When gradation control is by volume, have the unit include a feeder mounted under the bin compartments. Equip each bin with an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each bin compartment. Make the orifice of adequate dimensions to provide a positive feed without bridging and with one dimension adjustable by positive mechanical means provided with a lock. Provide indicators graduated from sufficient subdivisions of inches to provide accuracy of measurements, on each gate to show the size of gate opening. If mineral filler is required, proportion it separately, and add it to the mix in such a manner as to ensure uniform distribution.
2. Weight Calibration of Aggregate Feed: Have plant include a means for calibration of gate openings with weight test samples. Allow materials fed out of the bins through individual orifices to be bypassed to a suitable test box or boxes, the material from each compartment being confined separately. Equip the plant to

handle conveniently test samples of size adequate to provide an accurate gate calibration commensurate with the aggregate size, the gate opening, and the plant capacity setup. Provide an accurate platform scale with a minimum capacity of 500 pounds.

3. Synchronization of Aggregate Feed and Bitumen Feed: Provide satisfactory means to afford positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning source. Accomplish this control by interlocking mechanical means or by another positive method under the control of the Engineer.
4. Mixer Unit for Continuous Method: Continuous mixer of an approved twin-pugmill type, steam-jacketed and capable of producing a uniform mixture within the job-mix tolerances. Use paddles that are adjustable for angular position on the shafts and reversible to retard the flow of the mix. Have the mixer carry a manufacturer's plate stating the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Provide charts showing the rate of feed of aggregate per minute required, controlled by weight method under the following formula. The weights will be determined by tests made by the Engineer.

$$\text{Mixing time in seconds} = \frac{\text{Pugmill dead capacity in lbs.}}{\text{Pugmill output in lbs./sec.}}$$

D. Trucks for Transporting Bituminous Mixtures: Solid metal, dump-type bed, clean and smooth; with a tight-fitting rear gate to prevent loss of materials while in transit.
   1. Spray the inside surface of the bed with a minimum amount of approved thin oil or a mixture of lime and water proportioned at a rate of 100 pounds of lime to 50 gallons of water, prior to loading, to prevent adhesion of the mixture to the bed. Kerosene and gasoline will not be approved nor will the use of excessive quantities of approved oil be permitted.
   2. Equip each truck with a canvas or other covering of sufficient size to cover the material and protect it from weather. To prevent excessive temperature loss while in transit, equip the trucks with insulating units composed of wood or other approved material between October 15 and March 15, when so directed by the Engineer.
   3. Do not use trucks with appreciable oil leakage that may cause damage to the new bituminous construction.

E. Bituminous Spreading and Finishing Machines: Use spreading and finishing machine that operates without side forms and of a self-propelled type approved by the Engineer and equipped with the following features:
   1. An efficient steering device of both forward and reverse traveling speeds.
   2. Adjustments, of the manufacturer's standard design, that permit the bituminous material to be placed to a maximum width of not less than 12 feet and to a minimum width of 8 feet; the adjustments made in increments of one foot or less.
   3. Devices to adjust the thickness of material being placed, with suitable hopper for receiving the material, and with distributing screws, rake bars, or similar for evenly placing the mixture in front of the screed.
   4. The screed is a strike-off device operated by cutting, crowding or other practicable action that is effective on the bituminous mixture being placed, that is equipped with a heater, that produces a finished surface of uniform texture, and that is adjustable to the shape of the cross section of the finished surface.
   5. Joint-leveling or joint-blending devices for smoothing and adjusting longitudinal joints between adjacent layers of the same thickness.
   6. Ability to spread the bituminous mixture without tearing the surface and to strike a finish that is smooth, true to cross section, uniform in density and texture, and free from hollows, corrugations and other irregularities.

F. Tools for Finishing Asphalt Surfaces:

1. Asphalt lute: Wood, with a blade six feet in length, six inches in width, and one-half inch in thickness; edged on the contact surface; with the handle 16 feet in length, to one end of which the blade is firmly affixed with adequate bracing.
2. Rakes: Metal, not be less than 14 inches wide; with tines of sufficient depth to penetrate and rake the material for its full depth.
3. Smoothing irons: Metal, weighing not less than 40 pounds; with bearing surface not be less than 80 square inches.
4. Hand tampers for compaction of bituminous material in locations inaccessible to rollers: Metal, weighing not less than 25 pounds, with tamping face of not less than 48 square inches.

G. Rollers: Use rollers that are in first-class mechanical condition, complying with the requirements for the individual items as to classifications, weights and service requirements. Use tandem and three-wheel rollers that are power-driven, always capable of being reversed smoothly, and free from backlash, loose-link motion, faulty steering mechanism, and worn king bolts and bearings. A roller of these types that has been improperly weighted or that has in any way been thrown out of its original balance by the application of attachments not approved or not the manufacturer's original standard design will not be permitted on the project; nor will any roller that does not have displayed thereon in permanent legible characters the manufacturer's guaranteed net operating weight as distributed on each axle be permitted on the project. The net operating weight is the actual net weight plus one-half of the total maximum weight of fuel and water. Ensure that rolls have closely fitting spring scrapers, adjustable for forward and reverse motion.
   1. Two-Axle Tandem Rollers: Of rigid construction with the following features:
      a. Having a low center of gravity and balanced on the longitudinal axis, smooth operating friction clutches of the reversing type, smooth operating brakes, both hand-operated and power-operated steering devices.
      b. The type of driving mechanism is to be such as to give the lowest side clearance possible.
      c. Equipped with a water sprinkling system having a tank capacity as indicated in the table below, with the water piped to the spray pipes on each roll, the spray pipe extending the full width of the roll and installed so as to be readily cleanable, the water distributed from the spray pipes through cocoa-fiber mats securely suspended against the rolling surface, and having separate valves to control the flow of water to each roll and if enough pressure is not secured by force of gravity, some satisfactory pressure device installed.
      d. Minimum compression per inch of width of drive roll may include only the net operating weight of the roller, with the distribution of weight such that not more than 68 percent of the total gross weight is placed upon the drive roll.

THIS SPACE NOT USED

Manufacturer's rating, tons	5 - 6	10 - 12	15
Minimum diameter, drive roll, inches	42	60	70
Minimum diameter, guide roll, inches	36	48	50
Minimum rolling width, inches	20	20	20
Minimum compression, per inch width of drive roll, pounds	130	220	300
Minimum water sprinkling tank capacity, gallons	70	100	125

2. Three-Axle Tandem Rollers: Of rigid construction with the following features:
   a. Having a low center of gravity and balanced on the longitudinal axis, smooth operating friction clutches of the reversing type, smooth operating brakes of ample capacity, and power-operated steering devices, with both guide rolls steerable and the ratio of steering synchronized.
   b. The type of driving mechanism is to be such as to give the lowest side clearance possible.
   c. Equipped with a water sprinkling system having a tank capacity as indicated in the table below, with the water piped to the spray pipes on each roll, the spray pipe extending the full width of the roll and installed so as to be readily cleanable, the water distributed from the spray pipes through cocoa-fiber mats securely suspended against the rolling surface, and having separate valves to control the flow of water to each roll and if enough pressure is not secured by force of gravity, some satisfactory pressure device installed.
   d. Minimum compression per inch of width of drive roll may include only the net operating weight of the roller, with the distribution of weight such that not more than 68 percent of the total gross weight is placed upon the drive roll.

THIS SPACE NOT USED

Manufacturer's rating, tons	12 - 20
Minimum diameter, drive roll, inches	60
Minimum diameter, guide roll, inches	48
Minimum rolling width, inches	54
Minimum compression, per inch width of drive roll, pounds, all three rollers in same plane	210
Minimum water sprinkling tank capacity, gallons	200

3. Pneumatic-Tire Rollers: Provide the following features:
   a. Multiple-axle, multiple-wheel type with smooth-tread pneumatic tires of equal size staggered on the axles at such spacing and overlaps as will provide uniform compactive pressure for the full compacting width of the roller when operating. In operating pneumatic-tire rollers, have the tires inflated to the same air pressure, within a tolerance of five pounds, and to the pressure required or designated for use.
   b. If provided, have oscillation of the wheels in a vertical plane only.
   c. Capable of being ballasted sufficiently to bring its loaded weight to at least 2-1/2 times its own weight and of exerting compactive ground contact pressures of at least 80 psi. Have the roller ballasted to the extent required or designated; and within limits prescribed above, so that the roller provides the compactive ground pressure per square inch that is most efficient under the conditions and for the purpose of its use, and as directed.
   d. Furnish to the Engineer charts or tabulations showing the contact areas and contact pressures for the full range of tire inflation pressures and for the full range of tire loadings for each type and size compactor tire furnished.
4. Trench Rollers: Provide the following features:
   a. Constructed so that the guide roll or wheel either operates in tandem with the compression roll on the area to be compacted or in tandem with the auxiliary wheel or roll.
   b. An auxiliary wheel or roll that operates outside the area to be compacted, mounted upon an axle having height adjustability so that the contact surface of the auxiliary wheel or roll is capable of being adjusted at least 10 inches above and two inches below the rolling plane of the compression roll or the amount necessary to compact the soils base to the plan elevation. If the guide roll or wheel operates in tandem with the auxiliary roll or wheel, it may or may not be adjustable as to height. Have the auxiliary wheel or roll operate upon the surface of the pavement adjacent to the area to be compacted, and at such a distance from the pavement edge as to cause no change thereto. Keep the auxiliary wheel or roll in such adjustment as to

height that the compression roll will develop a smooth compacted surface true to crown.

c. Smooth operating friction clutches of the reversing type, smooth operating brake of ample capacity, and either hand-operated or power-operated steering devices.

d. Compression roll may be of hollow-type construction and the minimum weight secured by liquid ballast; minimum 300 pounds compression per inch of width of compression roll; and minimum width of compaction at least 15 inches.

e. Maximum rolling speed 1-1/2 miles per hour.

f. Equipped with sprinkling system having a tank or tanks with total capacity of not less than 50 gallons, with the water piped to the spray pipes on each roll, the spray pipes extending the full width of rolls and installed so as to be readily cleanable, the water distributed from the spray pipes through cocoa-fiber mats securely suspended against the rims of the rolls, and having separate to control the flow of water to each roll and if enough pressure is not secured by force of gravity, some satisfactory pressure device installed.

3.02 BASE PREPARATION:

A. Prior to placing bituminous mixture, check line, grade and cross section of underlying course. Repair defective areas.

B. Have base approved, before beginning installation work.

C. Aggregate and Soil Aggregate Bases:

1. Apply primer using equipment designed for that purpose.
2. When base is dry, uniformly apply primer at rate of application directed, approximately 0.15 gallons per square yard.
3. Allow primer to cure satisfactorily before placing mix.

D. Portland Cement Concrete, Bituminous and Brick Pavement Bases:

1. Apply tack coat using equipment designed for that purpose.
2. Prior applying tack coat, satisfactorily clean the base and verify that base is dry at time of application.
3. Apply tack coat uniformly to clean dry base at rate as directed by the Engineer, 0.02 to 0.05 gallons per square yard.
4. The Engineer has the right to direct omission of tack coat over new bituminous courses, or to order the tack coat to be "run in" by the use of trucks or other rubber-tire equipment.
5. Ensure that surface has cured and is satisfactorily tacky before placing mix.

E. Immediately prior to placing mix, apply thin coat of hot asphalt cement to contact surfaces of curbs, gutters, manholes and similar structures.

3.03 PLACING MIX:

A. Place mix by two or more machines operating in echelon in such manner that joints between lanes are hot. Keep machines clean and free from accumulations of asphaltic materials by acceptable means.

B. If equipment being used produces tracks, pulling, indented areas or other permanent blemishes in material being spread, remove such equipment from site and substitute other approved spreading and finishing equipment.

C. Do not permit direction of movement of paving equipment to be changed by turning on newly completed base, binder or surface courses.

D. Adjacent to headers, gutters, manholes and similar structures, place surface course so that finished surface is 1/4-inch above edge of structure.

E. When the Engineer considers it impractical to place mix with two machines, one machine will be permitted. Treat joints created by such operation as cold joints.

3.04 COMPACTION:

A. Compact as soon as the condition of the mix permits. Have rollers start longitudinally at the extreme sides and proceed toward the center of pavement, overlapping on each successive trip by one-half the width of the rear roll. Diagonally roll surface courses in two directions, the second diagonal crossing the lines of the first. Have rolling proceed in one continuous operation until roller marks are eliminated and until courses required density, specified below under Tolerances.

B. Perform breakdown rolling with a three-wheel steel-wheel roller designed for the purpose; the weight as required for job conditions.

C. Perform initial finish rolling and final rolling with at least one 10-ton tandem steel-wheel roller and one three-axle tandem steel-wheel roller designed for the purpose.

D. When temperature is below 50F, the Engineer may direct the use of a 5-ton tandem roller to seal the surface.

E. Perform intermediate rolling of sheet asphalt with tandem steel-wheel rollers or with self-propelled pneumatic-tire rollers designed for the purpose, as conditions warrant.

F. Perform intermediate rolling of hot asphaltic concrete with self-propelled pneumatic-tire rollers designed for the purpose.

G. For binder courses adjacent to structures where use of rollers is impractical, use hand tampers designed for the purpose.

H. Use trench rollers designed for the purpose where necessary.

3.05 COLD JOINTS:

A. Avoid cold joints; permitted only when necessary in the opinion of the Engineer.

B. Where mix is to be placed against cold asphaltic material, cut back the cold asphaltic material with a power masonry saw a minimum of three inches so that a vertical face of compacted full-thickness material is exposed. Treat this cut face as a contact surface.

3.06 BULKHEADS:

A. Where placement of mix is to be discontinued for such period of time that material will fall below specified street temperature, place suitable bulkhead.

B. Construct cold joint as specified when work is resumed.

3.07 HANDWORK:

A. When approved, perform bituminous paving work by hand in areas inaccessible to machines.

B. Undertake handwork using equipment designed and approved for purpose.

C. Perform handwork so that resulting paving meets specified requirements.

3.08 FIELD QUALITY CONTROL:

A. Allowable Tolerances:
   1. Thickness: Place bituminous pavement to within tolerance of plus-or-minus 1/8 inch of thickness shown.
   2. Surfaces: Construct surfaces to the following tolerances:
      a. Binder courses to within plus-or-minus 3/8 inch of elevation shown.
      b. Surface courses to within plus-or-minus 3/16 inch of elevation shown.
      c. Surfaces to deviate no more than 1/8 inch in the length of 10-foot steel straightedge, not cumulative.
      d. During compacting, screed surface using straightedge as specified in Section 02750. Adjust rolling procedures so that tolerances are met.
   3. Densities required:
      a. Binder courses: 94 percent of Marshall density.
      b. Surface courses: 96 percent of Marshall density.

B. Testing:
   1. Mixes:
      a. During course of the work submit mixes as directed for testing of gradation and bitumen content in accordance with AASHTO T30 and AASHTO T164 on random samples selected in accordance with AASHTO T168.
   2. Cores: Test base and surface courses for density by taking test cores at designated locations for testing by the Engineer, number of cores not exceeding one core per 500 square yards of bituminous pavements or two cores per shift, whichever is greater.
      a. Wherever deficient pavement is discovered take such additional cores as directed.
      b. Repair core holes promptly using the same mix that was cored; where cores are taken through both binder course and surface course simultaneously, use surface course mix for repair work.

3.09 PROTECTION OF BITUMINOUS PAVEMENT:

A. Obtain approval for use of pavement by public and construction traffic.

B. Do not permit traffic to cross uncompleted longitudinal joints.

3.10 DEFICIENT PAVEMENT:

A. Where directed, replace with new material or repair bituminous pavement that does not meet specified requirements..

THIS SPACE NOT USED

TABLE 02740-1 CONSTITUENT PROPORTIONS					
GRADING OF TOTAL AGGREGATE (COARSE, FINE, MINERAL FILLER: AS NECESSARY) AMOUNTS FINER THAN LABORATORY SIEVE (SQUARE OPENING) WEIGHT PERCENT					
SIEVE	SHEET ASPHALT		HOT ASPHALTIC CONCRETE		* JOB-MIX FORMULA TOLERANCE:
	BINDER	SURFACE	BINDER	SURFACE	ALL MIXES
1 inch	- -	- -	100	- -	±7
3/4 inch	- -	- -	90 - 100	- -	±7
1/2 inch	100	- -	- -	100	±7
3/8 inch	85 - 100	- -	60 - 85	85 - 100	±7
No. 4	35 - 55	100	45 - 65	55 - 80	±7
No. 10	20 - 35	95 - 100	30 - 50	40 - 65	±6
No. 40	- -	55 - 92	10 - 25	10 - 30	±6
No. 80	- -	20 - 60	3 - 15	3 - 15	±4
No. 200	0 - 5	9 - 20	2 - 8	2 - 8	±3
	ASPHALTIC CEMENT, WEIGHT PERCENT OF TOTAL MIXTURE				
	4.0 - 7.0	8.5 - 11.5	5.0 - 8.0	5.0 - 8.0	+0.5

* Notwithstanding tolerances, supply mixes within specified grading limits.

TABLE 02740-2 MIX TEMPERATURE RANGES				
MIX	TEMPERATURES, DEGREES F			
	PLANT			STREET
	AGGREGATE	ASPHALT CEMENT	TOTAL MIX	
Sheet Asphalt Binder	250 - 325	250 - 325	250 - 325	250 - 325
Sheet Asphalt Surface	300 - 375	250 - 350	300 - 375	275 - 350
Hot Asphaltic Concrete	250 - 325	250 - 325	250 - 325	250 - 325

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Use second version of SECTION 02740 BITUMINOUS PAVEMENT for contracts where bituminous pavement work is performed within the jurisdiction of the District of Columbia except as noted. (Use first version for contracts where bituminous pavement work is performed outside the jurisdiction of the District of Columbia.)

END OF SECTION

SECTION 02750
(Version 1)[*1]

CONCRETE PAVEMENT

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing portland cement concrete pavement, plain or reinforced or both, in conformance with the sections, lines and grades shown.

B. Related Work Specified Elsewhere:
1. Base for pavements: Section 02725.
2. Concrete reinforcement: Section 03200.
3. Cast-in-place structural concrete: Section 03300.

1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:

A. Shop Drawings:
1. Joint devices.

B. Certification: As specified in Section 03300, including design mixes.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AASHTO: M33, M74, M81, M148, M153, M171, M182, M194, M220, M227, T51, T148.
3. FS: TT-P-86, TT-S-00227.
4. ASTM: A185, A370, A615, C33, C294, C920, D3405.

B. Concrete: Conform to quality assurance requirements as specified in Section 03300 and this section.

C. Testing: Subject concrete for pavements to test procedures specified in Section 03300.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Aggregates and Cement: As specified in Section 03300.

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 50F 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. Wire Fabric: Welded steel-wire fabric, ASTM A185.

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

E. Joint Devices:
   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. Hook bolt:
      a. Material: As specified for dowels.
      b. Fabrication: As shown.

F. Grease for Dowels: Approved water-resistant grease.

G. Expansion Joint Materials:
   1. Preformed expansion joint fillers:
      a. Bituminous: AASHTO M33.
      b. Cork: AASHTO M153, Type II.
      c. Preformed joint seals: AASHTO M220.
   2. Expansion joint sealing compounds:
      a. Hot-poured: ASTM D3405 and when tested in accordance with AASHTO T51 having ductility not less than 40 centimeter and flow at 140F not greater than one centimeter. Use of ground rubber scrap is prohibited.
      b. Cold-applied: Single-component type, ASTM C920.
      c. Elastomeric: FS TT-S-00227, Type 1, Class A.

H. Burlap: AASHTO M182, Class 3 or 4.

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, Class 3500, air-entrained, with the following additional requirements:

1. Portland cement: Type I.
2. Minimum cement content: Six bags per cubic yard of concrete.
3. Maximum water content: Water/Cement ratio of 0.45 by weight.
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:
8. Size: ASTM C33 and as follows: 57; 67; 57 and 67; 57 and 4; 67 and 4; or 57, 67 and 4.
9. 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.
   a. Maximum abrasion loss: 40 percent by weight.
10. 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.
11. For bridge decks and bridge sidewalks: Use only crushed trap rock aggregate, trap rock to be diabase rock, ASTM C294.

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.

PART 3 - EXECUTION

3.01 EQUIPMENT:

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

B. Maintain machinery and equipment on site in first class working condition. Provide necessary tools and supplies for maintenance.

C. Straightedges and Templates:
1. Use metal straightedges, 10 feet long, rigidly constructed so as to prevent vertical deflection exceeding 1/32 inch and fitted with handles for ease of use.
2. Use templates, constructed so as to extend from form to form and to ride on form, having adjustable tines spaced at six-inch intervals and rigidly constructed so as to prevent vertical deflection exceeding 1/32 inch.

3.02 BASE:

A. Check previously placed base for grade and crown with templates and straightedges for compliance with tolerances specified in Section 02725.

B. Correct deficiencies in grade, contour and compaction.

C. 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.

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 Joints:
1. Make transverse construction joints at locations shown; use joint device applicable to particular type of joint.
2. Install dowels at transverse construction joints, spaced as shown but clearing pavement edges and longitudinal joints by a minimum of six inches. Align dowels both vertically and horizontally to tolerance specified.

C. Contraction Joints:
1. Provide longitudinal contraction joints between previously placed slabs and new slabs and between slabs and abutting curbs and gutters.
2. 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.
3. Make groove for contraction joints by formwork or using an approved joint tooling device. When latter method is used saw joint to one third depth of slab within 24 hours of concrete placement.

D. Expansion Joints and Joint Filler: 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.
1. Prepare preformed expansion joint filler in greatest length possible and no less than ten feet.
2. Cut filler for joints transverse to the slab in a single piece of the required shape.
3. Cut pieces for curb and gutter as directed to exact size, from larger pieces.
4. When splicing joint filler, butt tightly to prevent penetration of concrete between adjacent strips of joint filler.
5. For longitudinal joints, except at curb and gutter sections, use preformed tongue and groove filler as shown.
6. 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.
7. Make groove for cement pavement for surface course by forming, sawing or leaving preformed joint in place.
8. 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.

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

Depth of Slab/Inches	Pounds Per 100 Square Feet
6	30
8	50
10	61

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, 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. Prior to placing concrete around poles, manholes or other structures projecting through pavement, coat such structures heavily with bituminous paint.
3. 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.
4. Compact concrete thoroughly during placement.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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 radius shown.

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 along side 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.

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 an approved accelerating admixture in the concrete mix as specified in Section 03300.

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

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

***1**. Use first version of SECTION 02750 CONCRETE PAVEMENT for contracts where concrete pavement work is performed outside the jurisdiction of the District of Columbia. (Use second version for contracts where concrete pavement work is performed within the jurisdiction of the District of Columbia.)

END OF SECTION

SECTION 02750
(Version 2)[*1]

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 02725.
2. Concrete reinforcement: Section 03200.
3. Cast-in-place structural concrete: Section 03300.

1.02 SUBMITTALS:

Submit the following for approval in accordance with the General Requirements with the additional requirements as specified for each:

A. Shop Drawings:
1. Joint devices.

B. Certification: As specified in Section 03300, including design mixes.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. 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: A185, A370, A615, C33, C294, C920.

B. Concrete: Conform to quality assurance requirements as specified in Section 03300 and this section.

C. Testing: Subject concrete for pavements to test procedures specified in Section 03300.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Aggregates and Cement: As specified in Section 03300.

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 50F 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, 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.
9. For bridge decks and bridge sidewalks: Use only crushed trap rock aggregate, trap rock to be diabase rock, ASTM C294.

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.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. General: See General Provision's 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.

A. 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.

B. 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.

C. 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.

D. 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.

E. 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 02725.

B. Check previously placed base for grade and crown with templates and straightedges for compliance with tolerances specified in Section 02725.

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.

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.

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, 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 radius shown.

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 along side 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. The accelerating admixture shall comply with AASHTO M 194, Type C, except that it shall contain not 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 140F 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.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

***1**. Use second version of SECTION 02750 CONCRETE PAVEMENT for contracts where concrete pavement work is performed within the jurisdiction of the District of Columbia. (Use first version for contracts where concrete pavement work is performed outside the jurisdiction of the District of Columbia.)

END OF SECTION

SECTION 02765

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.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AASHTO: M249-79.
   3. USDOT/FHWA: Manual on Uniform Traffic Control Devices for Streets and Highways.
   4. Federal Test Method Standard 141.
   5. FED STD: 595.
   6. FS: TT-P-85, TT-B-1325.
   7. ASTM: D638.

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 five to plus five
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. Nonreflectorized 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 21C.
8. Tensile strength: Nonreflectorized 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 21C 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 compound, 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 nonreflectorized 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 curbs, gutters, curb and gutters and walks. [*1]

B. This section specifies providing walks, curbs, gutters, curb and gutters, coping curbs and integral curbs. [*2]

C. Related Work Specified Elsewhere:
1. Grading, excavating and backfilling: Section 02320.
2. Base course for pavements: Section 02725.
3. Concrete pavement: Section 02750.
4. Concrete reinforcement: Section 03200.
5. Cast-in-place structural concrete: Section 03300.
6. Granite: Section 04415.

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. Where stone curb is provided by street or highway jurisdiction, submit bill of stone curb materials prior to picking up materials at designated storage facility and transporting to site.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. ASTM: C979.

1.04 PRODUCT DELIVERY AND HANDLING:

A. Handle stone so as to maintain curb intact with exposed faces unmarred.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Concrete: Section 02750 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 nor 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, 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, with the following additional requirements:
a. Preformed joint filler for stone curb, 1/4-inch thick; otherwise, 1/2-inch thick, subject to specified construction requirements.

E. Granite Curb: Section 04415 and as specified in this section.

F. Polyethylene Tape: Section 02750.

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.

2.03 FABRICATION AND MANUFACTURING:

A. Fabrication of Granite Curbing:
1. Drill holes are prohibited, unless otherwise specified.
2. Straight granite curbstone:
a. Width: Eight inches plus-or-minus 1/8 inch at top surface.
b. Front face: Between 12 inches and 14 inches deep.
c. Batter: One-inch per foot to depth equal to reveal plus two inches.
d. Length: Random, three feet minimum.
3. Radius curb up to and including 100 feet: Radius to have same cross section dimensions as straight curb and cut true to radius ordered. Radius curb to be not less than three feet in length measured on arc.
4. Radius curb greater than 100 feet through 200 feet: Radius to consist of straight sections not exceeding five feet in length with the ends cut to form radial joints.
5. The top surface of curbstone to be finished with four-cut or 550-shot finish, but not both, to approximately true plane, with no projection or depression greater than 1/8 inch.
6. Front face finished same as top surface for depth of reveal plus two inches, except that sawn finish will be acceptable alternate, with no projection or depression greater than 1/8 inch. Remaining depth of front face may be rough cut with depressions or projections not exceeding 1-1/2 inches.
7. Arris line between top and face to have 1/4-inch bullnose.
8. Bottom surfaces to have no projection or depression greater than 1-1/2 inches.

9. Back surfaces to be sawn or split approximately at right angles to plane of top surface. No projection or depression greater than 1/4 inch will be allowed for a distance of four inches from top. Remaining distance to have no projection or depression greater than 1-1/2 inches. Drill holes will be permitted in back surface if they do not show in top arris line.

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.

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.

3.04 JOINT DEVICES AND CONTRACTION JOINTS:

A. General Requirements:
   1. Place joint devices and contraction joints as specified in Section 02750.
   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 1/2-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. [*3]

c. Place transverse expansion joints at intervals of 45 feet, unless otherwise shown. [*4]

d. 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 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 STONE CURB:

A. Excavating and backfilling in accordance with Section 02320.

B. Place no-slump concrete as setting bed.

C. Ram stone curb into proper position in setting bed and set to line and grade.

D. Where stone curb ties into existing curb, align exposed abutting surfaces.

E. Place preformed expansion joint filler at each joint.

3.07 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.

3.08 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.

3.09 CURING:

A. In accordance with Section 02750, 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.

3.10 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. Do not seal expansion joints in sidewalk and stone curb.

3.11 HIGH EARLY STRENGTH CONCRETE:

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

3.12 CORES:

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

3.13 PROTECTION OF THE WORK:

A. Protect new work in accordance with Section 02750.

3.14 DEFICIENT WORK:

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

3.15 INTEGRAL CURBS: [*5]

A. Pour integral curbs with the pavement slab.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

***1**. Use first version of 1.01 A. for contracts where curb, gutter and walk work is performed outside the jurisdiction of Alexandria, Virginia.

***2**. Use second version of 1.01 B. modification for contracts where curb, gutter and walk work is performed within the jurisdiction of Alexandria, Virginia.

***3**. Use first version of 3.04 A.5.b. for contracts where curb, gutter and walk work is performed outside the jurisdiction of Alexandria, Virginia.

***4**. Use second version of 3.04 A.5.c. modification for contracts where curb, gutter and walk work is performed within the jurisdiction of Alexandria, Virginia.

***5**. Add Article 3.15 including A. for contracts where curb, gutter and walk work is performed within the jurisdiction of Alexandria, Virginia.

END OF SECTION

SECTION 02820

FENCING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing chain-link fencing, gates and fan guards.

B. Related Work Specified Elsewhere:
   1. Cast-in-place Structural Concrete: Section 03300.
   2. Grounding: Section 16060.

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:
      a. Manufacturer's product data and installation instructions for fence, posts, fabric, gates, hardware and accessories.
      b. Site plan with fence showing locations of bracing, fan guards, gates, ground rods, depression closures and other special fence construction.
      c. Details of gates, depression closures and other special construction showing fabrication and installation.
      d. Details for installation of accessories.
   2. Samples:
      a. Chain link fabric: One of each width and type, each 24 inches long.
      b. Posts, railing, braces, gate frames: One of each size and type, each 24 inches long.
      c. Truss rod and turnbuckle: One each.
      d. Tension wire: One, 24 inches long.
      e. Barbed wire: One, 24 inches long.
      f. Tension bar: One, 24 inches long.
      g. Gate corner assembly: One.
      h. Fabric ties: Four each.
      i. Rail and brace ends and post caps: Two each.
      j. Barbed wire extension arms: One each.
      k. Other materials and accessories: One each.
   3. Certification.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AWS: D1.1.
   3. MS: MIL-P-21035.
   4. FS: FF-T-791, RR-F-191/2D, RR-F-191/3D, RR-F-191/4D.
   5. ASTM: A121, A392, A413/A413M-01, C1107/C1107M-07a, F668.

1.04 JOB CONDITIONS:

A. Right of Access to Adjacent Private Property: As shown.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Fabric:
1. Steel, hot-dip galvanized after weaving, ASTM A392; Class 2 coating, two-inch mesh, No. 9 gauge wire, height shown, both top and bottom selvage twisted and barbed unless otherwise indicated on Contract Drawings. *1
2. PVC-coated steel: ASTM F668 Class 2b; two-inch mesh, 0.148-inch diameter zinc-coated steel core wire, height as shown, black color PVC; top and bottom selvages twisted and barbed, unless otherwise shown on Contract Drawings.

B. Posts, Top Rails and Braces:
1. FS RR-F-191/3D, with the following additional requirements:
   a. Posts: Class 1, Grade. Size in accordance with Table I unless otherwise shown.
   b. Top rails: Class 1, Grade A; Size SP1.
   c. Bracing: Class 1, Grade A; Size SP1.
   d. Color coating: Where PVC-coated fabric is specified, provide matching PVC color ASTM F668 Class 2b coating.

C. Accessories:
1. FS RR-F-191/4D, with the following additional requirements:
   a. Hot-dip galvanized, unless otherwise specified.
   b. Wire ties:
      1) Fabric: No. 9-gauge steel.
      2) Tension wire: No. 11-gauge steel.
   c. Tension wire: No 7-gauge Steel. *1
   d. Color coating: Where PVC-coated fabric is specified, provide matching PVC color ASTM F668 Class 2b coating.

D. Barbed Wire:
1. ASTM A121, Chain Link Fence Grade,12-1/2 gauge steel wire with 14-gauge, four-point round barbs, five inches on center.

E. Turnbuckle:
1. FS FF-T-791, Type 1, Form 1, Class 8, Size 3/8 by six, hexagonal heads, UNC threads, hot-dip galvanized. Where PVC-coated fabric is required, provide matching PVC color coating thermally fused to the galvanized steel substrate.

F. Latch:
1. Plunger bar full height of gate, to engage stop at double gates.

G. Security Chain:
1. ASTM A413, Grade 43 High Test Chain, case-hardened carbon-steel, 3/8-inch diameter; hot-dipped galvanized at exterior locations.

H. Padlock:

1. WMATA Station areas - Corbin Russwin, Catalog No. PL5090 IC high security or equal. All keys are to be turned over to the Engineer or WMATA Representative.
   a. Removable interchangeable core; with two keys, keyed and master-keyed as directed.
   b. Body: Solid extruded brass.
   c. Six-pin tumblers.
   d. Shackle: Hardened steel, zinc-plated, 2-5/8 inch shackle length, ball bearing locking heel and toe.
2. WMATA Track & Line chain-link fence gates areas - Master Lock #5KA, Key A389 with two keys. All keys are to be turned over to the Engineer or WMATA Representative.

I. Concrete: Section 03300, Class 3500, air-entrained

J. Grout: Non-shrink, in accordance with ASTM C1107.

K. High Zinc-Dust Content Paint: MS MIL-P-21035.

2.02 SWING-TYPE GATES:

A. Provide swing-type gates, size as indicated on the Contract Drawings, complete with latches, stops (if required by the manufacturer), keepers, hinges and three strands of above the fabric (if shown on the Contract Drawings).

B. Conform to Federal Specifications RR-F-191/2D, Single Swing Type I, Double Swing Type II, and as follows:

1. Hot-dipped galvanized.
2. Fabrication:
   a. Fabricate gate perimeter frame from Class 1, Size SP2 pipe per Federal Standard RR-F-191/3D.
   b. Fabric: Same fabric as used on the fence. Attach fabric securely to the gate frame at intervals not exceeding 15 inches.
   c. Barbed wire: As specified in 2.1. D above.
   d. Fan Guard: Materials and fabrication as specified for fencing.
3. Hardware:
   a. Hinges: Two or more galvanized steel or malleable iron, to suit the gate size: non-lift type, offset to permit 180 degrees opening.
   b. Latch: Galvanized steel or malleable iron, combination type with provision for padlock.
   c. Gate stops and center rest: Manufacturers' standard.

2.03 CANTILEVERED SLIDE GATE:

A. Conform to Federal Specification RR-F-192/2D, Type III.

B. Barbed Wire: As specified in 2.01 D. above.

PART 3 - EXECUTION

3.01 FENCE INSTALLATION:

A. Perform necessary clearing, grubbing, excavation and filling to provide clear line-of-fence runs.

B. Set posts in concrete footings, sized as shown. All end, corner, pull and intermediate posts are to be embedded a minimum of 3 foot below final grade. Footing depth shall be a minimum of 3 feet 6 inches.

C. Extend concrete to two inches above ground line at posts and slope to drain away from posts. Form top 12 inches of footing, with remainder poured against excavated hole.

D. Space posts at 10 feet maximum and eight feet minimum on centers. Place additional posts at each abrupt change in grade.

E. Where rock is encountered, drill holes two inches deeper than depth shown and two inches greater than outside diameter of post. After post is placed as shown and specified, and supported, fill remaining void with one-to-three grout mixture of cement and sand.

F. Where fence is located on concrete structure, weld post to base plate, thickness and size as shown on Contract Drawings. Erect fence post truly vertical, where necessary using shims of approved alloy. Secure to structure with anchor bolts; number, diameter and length as shown on Contract Drawings. Fill void under base plate with non-shrink grout. Bolts, base plate and weld to be hot-dipped galvanized.

G. Space pull posts at approximately 500-foot intervals for straight runs and at each vertical angle point. Install corner posts at each horizontal angle point. Provide corner, end and pull posts with horizontal braces and tie rods on each side of posts extending to and connecting to adjacent line posts.

H. After posts are installed and grout has set, install top rail or tension wire and securely anchor at ends and to line posts before hanging fabric.

I. Secure ends of fabric by tension bars threaded through loops in fabric and secured to posts by bands with bolts and nuts or other approved devices.

J. Attach fabric outside framing system, away from Authority property. Stretch fabric by securing one end and applying sufficient tension by mechanical fence stretchers. Fasten fabric to line posts, tension wire and top railing with tie wires at spacing shown.

K. Hold bottom of fabric as uniformly as possible to, but in no case to exceed, two inches above finished grade.

L. Provide barbed wire where shown. Install support arms at 45 degrees upward and outward from Authority property; extend corner, gate and end posts as shown. Stretch barbed wire to remove kinks and sags and secure to bracket arms, using tension bands for attachment to posts.

M. Install gates, gate stops and fan guards as shown.

N. Set gate stops in concrete accurately so that plunger can be fully engaged.

O. Furnish one chain with one padlock for each gate.

P. Grounding: Section 16060.

3.02 GATE INSTALLATION

A. Install gates plumb, level and secure for full opening without interference. Install ground-set items in concrete for anchorage, as detailed on the Contract Drawings. Adjust the hardware for smooth operation and lubricate where necessary.

B. Attach barbed wire as shown on the Contract Drawings.

3.03 DEFECTIVE WORK:

A. Remove and replace fencing which is improperly located and is not true to line and grade, and posts which are not plumb.

B. Repair damaged galvanizing by thoroughly wire brushing damaged area to remove loose and cracked zinc coating, and paint with two coats of high zinc-dust content paint. Allow first coat to dry thoroughly before applying second coat.

PART 4 -MEASUREMENT AND PAYMENT

4.01 MEASUREMENT

A. Measurement of work specified in this Section will be made in the following manner:
1. No separate measurement.

4.02 PAYMENT

A. Compensation for work specified in this Section will be made in the following manner:
1. Included in the price of the work of which it is a part.

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES

1. Please verify that Standard Drawings conform to the revised Specifications for Section 02820; particularly that Utility Standard Drawing ST-U-34 contains Note 8 stating that fabric on Type A & A-1 fences less than 72 inches high have both top & bottom selvages knuckled, and that Note 8 is referenced on applicable section of CHART; and contains notes to Details 2 & 3 indicating maximum height of bottom tension wire above grade is 6 inches.

END OF SECTION

SECTION 02845

TRAFFIC CONTROL DEVICES

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing vehicular traffic barriers and raised concrete traffic bars.

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. Certificates from guardrail element manufacturer and pressure preservative-treatment plant stating that materials furnished meet specified requirements.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. AWPA: C1, P8.
   3. AASHTO: T68.
   4. ASTM: A36, A123, A153, A307.
   5. FS: TT-P-641.

B. Allowable Dimensional Tolerances:
   1. Steel guardrail elements fabricated to width and depth tolerance of minus 1/8 inch.
   2. Dimensions of concrete posts and raised concrete traffic bars: Plus-or-minus 1/8 inch of dimensions shown.
   3. Dimensions of timber posts and bracket blocks: Plus-or-minus 1/2 inch of dimensions shown.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Guardrail:
   1. Steel posts and brackets:
      a. Structural steel: ASTM A36.
   2. Wood posts and bracket blocks:
      a. Number 1 Dense SR southern pine, minimum stress-grade 1400f.
      b. Well-seasoned, sound and free from splits, cracks and other defects.
      c. Pressure treated in accordance with AWPA Standard C1 using pentachlorophenol preservative in light petroleum solvent conforming to AWPA Standard P8.
   3. Concrete posts:
      a. Concrete reinforcement: Section 03200.
      b. Concrete: Section 03300 and 03400.
   4. Rail elements and terminal sections:
      a. Rail elements and terminal sections fabricated from open-hearth or electric-furnace steel of thickness shown. Sheet shaped into beam with longitudinal corrugations forming section 12 inches minimum width and three inches minimum depth.

b. Fabrication:
   1) Edges of rail element straight and smooth.
   2) Steel sheet subject to standard mill tolerances for gauge.
c. For steel-beam type guardrail installed on curves having radius of more than 20 feet and less than 150 feet: Rail elements convex or concave as shown.
d. Elongation of two-inch specimen of sheet steel used for rail elements: 12-percent minimum when tested in tension in accordance with AASHTO T68.
e. Comply with the following:
   1) Tensile strength of specimen of full size of rail element, including a splice at center of specimen: 70,000-psi minimum.
   2) Post connections to withstand 5,000-pound side pull in both directions.
   3) Section of rail with traffic face up, freely supported at both ends of 12-foot span, to support concentrated load of 2,000 pounds at center of span with maximum deflection of two inches.
f. Rail elements and terminal pieces hot-dip galvanized after fabrication.

5. Hardware:
   a. Bolts and nuts: Steel, ASTM A307, Grade A.
   b. Post and splice bolts machined, button-head, shoulder bolts with roll threads, Class 2A fit before galvanizing. Shoulder or neck to have an oval shape as shown. Hexagon nuts for rail connections to be machined American Standard heavy-type with recess to accommodate shoulder on bolts.
   c. Bolts and nuts for offset steel brackets: American Standard heavy-type.
   d. Plate washers fabricated from steel conforming to requirements specified for rail elements and terminal connections.
   e. Hot-dip galvanized after fabrication.
6. Galvanizing:
   a. Steel posts, post anchors, brackets, rail elements and terminal sections hot-dip galvanized after fabrication in accordance with ASTM A123.
   b. Hardware hot-dip galvanized after fabrication in accordance with ASTM A153. Zinc coating: Two ounces per square foot minimum.
   c. Replace components on which galvanizing is damaged with new material having properly galvanized surfaces.
7. Primer coating: FS TT-P-641.
8. Non-shrink grout: Section 03300, shrinkage compensating.
9. Welding: Section 05120.

B. Raised Traffic Bars:
1. Formwork: Section 03100 or 03400.
2. Reinforcing steel: Section 03200.
3. Concrete: Section 03300, Class 3000, air-entrained.
4. Portland-cement grout: Section 03300.
5. Adhesive for attaching traffic bars to pavement: Polyvinyl acetate or asphaltic emulsion. If asphaltic emulsion is used, do not use clay or similar substances as emulsifying agents. Consistency of adhesive suitable for heavy trowel application at prevailing ambient temperature.
6. Anchor pins: Section 03200, concrete reinforcing rods.

2.02 FABRICATION AND MANUFACTURE:

A. Steel Posts, Brackets and Post Anchors:
1. Cut ends square. Punch or drill posts and brackets as shown.
2. After being cut to length and punched or drilled, hot-dip galvanize posts and brackets separately before bolting.
3. On end steel posts and adjacent posts weld steel channel anchor, 15.3 pounds per linear foot and one-foot three-inches long minimum.

a. Weld anchors to posts and hot-dip galvanize.
b. Welding: Section 05120.

4. Replace components on which galvanizing is damaged with new material having properly galvanized surfaces.

B. Wood Posts and Bracket Blocks:
1. Cut ends square. Drill posts and bracket blocks as shown.
2. After cutting to length and drilling, saturate cut ends and holes with same preservative as that used for pressure treatment.

C. Concrete Posts:
1. Precast concrete, Class 5000, in accordance with Section 03300, eight inches square by five feet-nine inches.
2. Reinforcement as shown and in accordance with Section 03200.
3. Cure in accordance with Sections 03300 and 03400.

D. Traffic Bars:
1. Apply shop mark on each raised traffic bar with water-resistant paint showing the following:
a. Date of manufacture.
b. Identifying mark of manufacturer.

PART 3 - EXECUTION

3.01 EQUIPMENT:

A. Where posts are to be set in drilled holes, use mobile auger.

B. Where steel posts are to be driven in place, use mobile drop hammer equipped with leads and mounted on track or on crawler treads. Protect heads of posts with driving cap designed to fit section of post being driven.

3.02 POSTS IN DRILLED HOLES:

A. Drill holes plumb, accurately positioned and of diameter and depth shown.

B. Position posts in hole to alignment shown; brace in position until remainder of hole has been backfilled with excavated material or concrete as shown.

C. Place backfill in layers six inches maximum and compact in accordance with Section 02320.

D. Dispose of surplus excavated material in accordance with Section 02320.

E. In unpaved areas, carry backfill to height of two inches above surface of ground and slope to drain away from post.

F. When holes in paved areas are shown to be backfilled with excavated material, place and compact backfill to bottom of pavement. Where pavement is portland-cement concrete pavement, fill remainder of hole with concrete to surface of pavement. Where pavement surface is asphaltic concrete, stop concrete fill two inches below final grade and fill remainder of hole with asphaltic concrete of same type as existing surface. Tamp asphaltic concrete well and slope to drain away from post.

G. Where shown to be encased in concrete, compact concrete well and carry it to height of two inches above natural ground and slope to drain. Trowel finish surface.

3.03 POST DRIVEN IN PLACE:

A. Ensure that posts are plumb and located as shown. Remove and redrive posts which are not in compliance.

B. Drive steel posts before offset bracket is attached.

C. After driving, top of posts to have substantially same cross-sectional dimensions as body of posts and be free of bends and damage to galvanizing coat. Remove posts not in compliance and drive new replacement post.

D. Drive posts carefully to prevent damage to utility facilities; if such facilities are encountered, relocate posts. Repair facilities damaged by construction operations.

3.04 POST SET ON CONCRETE PAVEMENTS AND DECK SLABS:

A. Where steel-beam guardrail is installed on existing portland-cement concrete pavement or deck slabs, fabricate steel post assembly as shown. Anchor assembly to pavement or deck slab with through-bolts or four-unit expansion anchors as shown.

B. Clean pavement or deck surface area where base plate is to be installed. Set post with base plate over bolts; plumb and shim posts to proper grade and alignment with metal shims.

C. Work nonshrink grout under plate to ensure full contact of bearing area. Remove shims as soon as concrete has hardened sufficiently to support weight of post. Finish edges true and smooth.

3.05 INSTALLATION OF STEEL-BEAM GUARDRAIL:

A. Install brackets and blocks on roadway side of posts. Tighten bolts after rail elements have been attached and entire assembly adjusted to line and grade.

B. Erection of Rail Elements and Terminals Sections:
   1. Erect rail elements and terminal sections on posts and post brackets previously set to produce smooth continuous rail to line and grade shown. Install rail with double-corrugation face toward traffic.
   2. Bolt edges and center corrugation fully.
   3. Make vertical adjustment at posts by use of oversize bolt holes in posts and brackets as shown. If oversize holes do not permit sufficient adjustment, reset post until guardrail is properly aligned.
   4. After rail has been correctly aligned, tighten bolts. Check or burr threads projecting beyond nut to prevent removal.
   5. Where steel beam-type guardrail is shown anchored to bridge piers or terminating at concrete parapet walls, punch slotted bolt holes in rail elements terminating at such locations and make connections as shown. Flame-cutting is prohibited.

C. Where approved, repair damaged zinc coating by wire brushing damaged area to remove loose or cracked zinc coating and applying two coats of primer.

D. Punching, drilling, reaming, cutting or welding rail elements or terminal pieces in the field is prohibited except as approved.

3.06 INSTALLATION OF RAISED TRAFFIC BARS

A. Install raised traffic bars at locations shown.

B. Before adhesive is applied, remove dirt, dust, grease, oil and other foreign matter that would adversely affect bond of adhesive.

C. Apply adhesive to surfaces in such quantity that firm even bearing is obtained throughout entire contact area. Remove excess adhesive.

D. Where use of steel pins is shown, drill holes through pavement, before adhesive is applied.

E. After adhesive has been applied and bars properly positioned, drive steel pins in place with top of pin two inches below top of bar. Firmly press bar into adhesive, fill pin holes with portland-cement grout flush with top of bar.

F. Where traffic bars extend across pavement joints, cut bars and make open joint of same width as joint in pavement.

G. Painting: In accordance with Section 02765.

H. Installation of traffic bars which are chipped, cracked or otherwise defective is prohibited.

I. Protect completed installation until final acceptance.

3.07 FIELD QUALITY CONTROL:

A. Top of post: Plus-or-minus 1/4 inch of elevation shown.

B. Location of post: Plus-or-minus 1/4 inch of location shown.

END OF SECTION

SECTION 02872

STATION MEZZANINE ENCLOSURES AND PLATFORM SHELTERS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing mezzanine enclosures and station platform shelters.

B. Related Work Specified Elsewhere:
1. Premolded expansion joint filler: Section 03100.
2. Cement grout and nonshrink grout: Section 03300.
3. Sealant: Section 07900.
4. Chain and padlock: Section 08710.
5. Tempered glass and safety plastic: Section 08800.
6. Field painting: Section 09920.

1.02 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications:
1. Comply with codes and regulations of the jurisdictional authorities.
2. AWS: D1.1.
3. AWI: Architectural Woodwork Quality Standards.
4. SDI: 100.
5. FS: FF-S-325.
6. ASTM: A36, A53, A123, A153, A181, A193, A307, A366, A384, A500, A501, A570, A780, B455, C307, C413, C509, C579, C580, D2559.

B. Qualifications of Welding Personnel: Employ welders whose qualification is certified in accordance with AWS Standard D1.1. Such certification is to remain in force for the duration of the welding operations under this Contract.

C. Job Mock-Ups:
1. Complete full-size mock-up of typical bay of mezzanine-area enclosure.
2. Complete full-size mock-up of station platform shelter.

D. Lock Functions and Keying: Require hardware supplier to provide padlock and chain and meet with Engineer to finalize cremone bolt lock-functions and keying requirements.

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. Include details of construction, connections, anchors, interfacing with the work of other trades, schedules and setting diagrams.
   b. Minor variations in detail for the purpose of improving fabrication and installation procedures, but not affecting general design or structural stability, will be given consideration.
   c. Note extent of shop-applied finishes and field-painted finishes.
   d. Use field measurements for critical dimensions and indicate them as such.

2. Samples:
   a. Three of each type of the following products used in the work:
      1) Steel frame section: 12 inches long, with bolting flange.
      2) Steel face sheet: 12 inches square.
      3) Gasket material: 12 inches long.
      4) Wood: 2-1/2 inches by 5-1/2 inches by 12 inches.
      5) Fasteners, attachments devices to substrates and other accessories.
   b. One sample of each of the following:
      1) Cremone bolt, trim, and escutcheon.
      2) Three 12-inch long assemblies of enclosure frame and stops for panels, with means of attachment to enclosure framewok.
3. Certification.
   a. Certified test reports: Certified test reports verifying that epoxy grout conforms to specified requirements.
   b. Certification that welding personnel are currently qualified in accordance with AWS D1.1.

1.04 PRODUCT, DELIVERY, STORAGE AND HANDLING:

A. Deliver products to the jobsite in original unopened containers or wrappings clearly labeled with manufacturer's name and brand designation, referenced specification number, type and class as applicable.

B. Store products in an approved dry area, protect from contact with soil and from exposure to the elements. Keep products dry.

C. Handle products to prevent breakage of containers and damage to products.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Steel Tubing: ASTM A500, ASTM A501.

B. Steel Bars, Plates and Shapes: ASTM A36.

C. Hot-rolled carbon steel sheets and strips: ASTM A570.

D. Cold-rolled steel sheets and strip for forming processes: ASTM A366.

E. Sleeves: Steel pipe, Schedule 40, ASTM A53, with welded steel-plate bottom.

F. Bolts:
   1. Carbon steel: ASTM A307, with mated nuts, washers, and anchors, hot-dip galvanized.
   2. Stainless steel: ASTM A193, Class 1A.
   3. Expansion shields: FS FF-S-325; Group, Type and Class best suited to each purpose as approved.

G. Screws: Corrosion-resistant, either hot-dip galvanized or stainless steel, oval, tamper-resistant design as approved. Where exposed, finish to match material being fastened.

H. Glazing Materials:
   1. Glass: 1/4-inch tempered glass specified in Section 08800.

2. Plastic: Clear safety plastic, 1/4-inch thick minimum specified in Section 08800.
3. Gaskets: Neoprene, ASTM C509. Shore A Durometer, scale of hardness 50-60.
4. Butyl tape: Preshimmed, Tremco Polyshim II or equal.

I. Wood: Natural-finished white oak, select-grade or better, dried to moisture content of 12-percent maximum. Formed from one piece of solid edge-grain lumber or glue-laminated boards matched for color and grain and with nonstaining adhesive complying with ASTM D2559.

J. Core material: Continuous phenolic-resin-impregnated honeycombed paper.

K. Paint:Shop finish (primer):
1. Manufacturer standard primer, providing it complies with primer requirements of Section 09920 and is compatible with undercoat and finish coat.Finish paint: Section 09920.
2. Zinc-rich paint: MS MIL-P-21035.

L. Cremone Bolt:
1. Handle: Bronze, ASTM B455 Alloy C38500.
2. Pins, washers, nuts and bolts: Stainless steel, ASTM A193, Alloy C30400.
3. Padlock and chain: Section 08710.

M. Flanges: ASTM A181.

N. Cement Grout and Nonshrink Grout: Section 03300.

O. Epoxy Grout:
1. Nonshrink, nonstaining, 100-percent solids, two-component or three-component epoxy-resin system, that has been in successful use for an equivalent application for a minimum of five years.
2. On horizontal applications: Self-leveling type.
3. On vertical and overhead surface application: Non-sag type.
4. Physical properties:

Property	Requirement	ASTM Test Method
Tensile strength	1,800-psi minimum in seven days	C307
Compressive strength	13,500-psi minimum in 28 days	C579
Modulus of rupture	13,500 psi	C580
Water absorption	One-percent maximum, two hours at 212F	C413

P. Sealant: Section 07900.

Q. Premolded Expansion-joint Filler: Section 03100.

R. Filler Panels:
1. Structural steel, ASTM A36.

S. Galvanizing Repair Compound:
   1. Stick form, melting point 600F to 650F,
   2. GALVABAR or equal.

2.02 FABRICATION:

A. Fabricated as shown on approved shop drawings.

B. Hollow-metal panels. Fabricate in accordance with SDI 100, Grade III, model 2A, one of the following styles:
   1. Seamless hollow-steel construction.
   2. Seamless composite construction.

C. Cremone bolt: Fabricate and assemble as shown.

D. Fabricate and fasten metalwork to prevent distortion and overstressing from expansion and contraction of metal. Conceal fastenings wherever practicable.

E. Perform welding in accordance with AWS D1.1. Grind exposed welds smooth. Finish flush and grind smooth welds exposed after installation.

F. Align members to provide true planes and square openings for installation of glass panels. Fabricate horizontal and vertical members square, level, plumb with respect to other members and true within a tolerance of plus-or-minus 1/8 inch. Cap mullions.

G. Fabricate woodwork to AWI Architectural Woodwork Quality Standards, Premium-Grade.

H. Pre-Assembly and final Installation: Insofar as practicable, preassemble and fit work of this section in shop to ensure proper field assembly. To the extent that work cannot be shop-assembled with permanent connections; pre-assemble, mark and disassemble before shipment.

I. Galvanizing: For installations exposed to weather and elsewhere where indicated, hot-dip galvanize enclosures and gates after fabrication and prior to finishing. Galvanize in largest assembled units possible.
   1. Use hot-dip galvanizing process in accordance with ASTM A123, ASTM A153 and ASTM A384 as applicable.
   2. Clean and phosphatize surface as needed for priming.
   3. Prior to priming, treat welds and cut edges with a galvanizing repair compound at a rate of two ounces per square foot, and prepare for priming.

J. Swing Gates
   1. Fabricate to operate smoothly with minimum applied pressure.
   2. Detail and construct assembles to permit replacement of components that wear without disassembling entire gate.

K. Miscellaneous Components:
   1. Fabricate metal items indicated on the drawings from materials shown or, if not otherwise described, from galvanized steel wherever exposed to the weather or in contact with concrete or masonry.
   2. 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.

2.03 SHOP PAINTING:

A. Shop paint (prime) before shipment. Work primer well into joints. Do not prime surfaces to be field-welded.

B. Ensure that galvanized surfaces are phosphatized before priming.

C. Thoroughly clean bare steel as recommended by primer manufacturer and in accordance with SSPC SP11 and apply one shop primer coat; work well into joints. Do not prime surfaces to be field-welded.

D. On surfaces not accessible for field painting after erection, apply two coats of primer in shop.

E. Finish Paint: Silicone-alkyd, two coats over primer; color to be determined. See Section 09920.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Verify dimensions before proceeding. Measure structure to ensure accurate fit to other construction, including wall-to-wall dimensions, floor-to-ceiling dimensions and those controlled by other trades.

B. Remove foreign substances from surfaces to receive work described in this section.

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

3.02 INSTALLATION:

A. General:
1. Coordinate work of this section with work of other trades.
2. Fit work to adjoining construction as shown on Contract Drawings and approved shop drawings.
3. Install work plumb and true, properly align, and securely fasten as shown on Contract Drawings and approved shop drawings.
4. Firmly anchor mullion of each station-platform shelter to withstand inward or outward wind pressure of 25 psf.
5. Touch-up prime coat to cover field welds and damaged areas.
6. Install glass and glazing material per specifications in Section 08800.
7. Install cremone bolt and adjust operation as approved.

B. 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 and prepare for priming.

C. Epoxy Grouting:
1. Remove contaminants from surfaces receiving and coming into contact with the grout. Remove surface contaminants such as curing compounds from holes that receive grout. Ensure that surfaces to receive grout are dry at the time of grouting.
2. Prime surfaces in accordance with grout manufacturer's recommendations unless manufacturer recommends against priming.

3. Mix and place epoxy grout for locations shown or specified as recommended by grout manufacturer. Level exposed surfaces of grout joints with adjacent surfaces. Grind rough or raised projections smooth and flush with adjacent surfaces.

D. Painting and Repairing Coated Surfaces:
1. Before enclosing construction, paint items that will be concealed in finished work.
2. Where shop primer coat is abraded or burned by welding, clean, apply galvanizing repair compound and touch-up. Touch-up primed surfaces with same material as original coating.
3. See Section 09920 for field painting.

3.03 CLEAN-UP:

A. Remove from the site rubbish and debris caused by this work.

B. Leave areas surrounding the work in broom-clean condition.

END OF SECTION

SECTION 02890

MARKERS

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing markers.

B. Related Work Specified Elsewhere:
   1. Concrete reinforcement: Section 03200.
   2. Cast-in-place concrete: Section 03300.
   3. Precast Structural Concrete: Section 03400.

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. Product Data:
      a. Manufacturer's construction details showing materials, dimensions and profiles for each individual component.
   2. Shop Drawings:
      a. Plans, elevations and sections detailing fabrication and erection. Show anchors, reinforcements, accessories, layout, installation details, colors and finish treatments.
      b. Message list including wording and lettering layout. Include full-size details of special graphics.
      c. Setting drawings, templates and directions for installation of anchors to be installed as work in other sections.

1.03 QUALITY ASSURANCE:

A. Codes, Regulations, Reference Standards and Specifications.
   1. Comply with codes and regulations of the jurisdictional authorities.
   2. FS: QQ-B-654, WW-T-791.
   3. ASTM: B36, B135

B. Survey Certification:
   1. All Right-Of-Way markers shall be set by a surveyor registered in the area where the work is to be performed.
   2. The following certification statement or a similar statement is required and shall be placed on all approved Mylar sepia as-built Right-of-Way drawings:

      "I hereby certify to the best of my knowledge that the Right-Of-Way markers shown on this as-built drawing have been set in accordance with the coordinate information provided by WMATA as shown on the Contract Documents."

      _____ (seal)
      Registered Surveyor in the State of Maryland *1

      _____ (seal)
      Registered Surveyor in the Commonwealth of Virginia *1

      _____ (seal)
      Registered Surveyor in the District of Columbia *1

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Precast Concrete: Section 03400.

B. Concrete: Section 03300, Class 3500, air-entrained.

C. Concrete Reinforcement: Section 03200.

D. Bronze Discs:
1. 3 ½ inch diameter domed survey marker forged from sold unleaded bronze in accordance with ASTM B98-98 with a classic 3 inch long and 5/8 inch diameter split-style tapered stem designed for use in concrete or rock (the Corp of Engineers Type 1 disc). Like or equivalent to the Berstsen C-1 Bronze 3 ½ inch domed marker #C35DB.
2. Refer to Standard Drawings ST-C-3 and ST-C-19 for additional details on bronze discs and installation.

E. Epoxy Hilti

2.02 FABRICATION AND MANUFACTURE:

A. Markers and Monuments:
1. Legend:
   a. Apply legend shown for various markers and monuments using characters of size and type shown. Clearly indicate use.
2. Bronze disc markers:
   a. Bronze discs as specified with imprinted or stamped legend.
3. Precast-concrete markers and monuments:
   a. Four inches square by length shown, with 1/2-inch chamfered edges.
   b. Precast concrete.
   c. One 29-inch long, No. 4 steel-reinforcing bar centered in casting.
   d. With lettering, when shown, incised v-shaped, 1/4-inch wide and 3/16-inch in depth.

PART 3 - EXECUTION

3.01 BRONZE DISCS FOR MARKERS AND MONUMENTS:

A. Except as shown, form discs into convex shape 3/16 inch in depth with edges free from burrs and blemishes.

B. Press legend into the upper surface of disc so that surface is not raised. Ensure that legend conforms to that shown for markers and monuments.

C. Do not place letters closer than 1/8 inch to outer rim of marker. Letters in outer ring of legend, 1/2-inch high; medium-sized letters, 7/32-inch high. Place letters along radius of disc. Imprint legend symmetrically about center of disc.

D. When bronze-disc markers are set in concrete pavements and roadways, set stem in drilled hole and secure with approved epoxy cement, like or equivalent to Hilti HIT Hy 150.

E. At other locations, set bronze-disc markers into tops of markers and monuments as specified; set markers and monuments in ground at locations shown.

3.02 PRECAST-CONCRETE MARKERS AND MONUMENTS:

A. Install precast-concrete markers and monuments at locations and to elevations shown or as directed.

B. Set markers and monuments as shown. Compact bottom of excavation to prevent settlement.

END OF SECTION

SEE ENDNOTES BELOW. THEY ARE AN ESSENTIAL PART OF THIS SECTION UNTIL EDITED BY SECTION DESIGNER.

ENDNOTES:

***1**. Enter jurisdictions as applicable for the project locations.

SECTION 02920

TOPSOIL, SEEDING AND SODDING

PART 1 - GENERAL

1.01 DESCRIPTION:

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

B. Related Work Specified Elsewhere.
   1. Site grading: Section 02320.
   2. Removal and restoration of existing landscaping: Section 02205.
   3. Landscaping: Section 02930.

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: C51.

B. Personnel Qualifications:
   1. 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.
   2. 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 crownvetch and lespedeza 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 crownvetch and lespedeza 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.

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 02920-2, 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.
   2. Crownvetch Seed: Dated material from last available crop, with date of test not more than nine months before date of sowing. Germination portion consisting of minimum 35-percent normal sprouts, maximum 35-percent hard seed and as specified in Table 02920-4.
   3. Appalow Sericea Lespedeza Seed: Germination portion consisting of minimum 35-percent normal sprouts, maximum 35-percent hard seed and as specified in Table 02920-5.

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 USDA-SCS.

E. Fertilizer:
   1. For grass seeded and sodded areas: Commercial fertilizer of standard quality, recommended by approved soil test report; 10-22-22.
   2. For crownvetch seeded areas: Use both of the following:
      a. Commercial fertilizer of standard quality; 0-20-20 or 3-25-25.
      b. Blue Chip Nitroform, slow-release nitrogen, granular form, of standard quality; 38-0-0.
   3. For appalow-sericea-lespedeza seeded 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.

B. Crownvetch Seed: Table 02920-4.

C. Lespedeza Seed: Table 02920-5.

D. Hydroseeding Crownvetch and Lespedeza Seed: Tables 02920-6 and 02920-7.

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 except areas to receive crownvetch or lespedeza (unless Contract Drawings require 2:1 or greater slopes to be sodded or seeded), 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 SEEDING CROWNVETCH:

A. Seed Bed Preparation: After construction work in the area has been completed, proceed as follows:
1. Grading: Rough grade to remove large stones and roots. Remove or break up clods greater than one-foot diameter. Chisel surface to depth of four to six inches. When preparing slopes, chisel parallel to contour of slope.
2. pH adjustment: Adjust soil pH by applying limestone or approved acidifying agent or elemental sulfur at per-acre rate in Table 02920-6, except as recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations.
   a. Apply 2/3 of limestone when seed bed is prepared. Work this into the top six inches of soil.
   b. Apply remaining 1/3 of limestone with seed mixture.
3. Fertilizing: After acidity adjustment, apply fertilizer at per-acre rate in Table 02920-6, except as recommended by approved soil test report.
4. Hydraulic overseeding: For overseeding existing vegetation, cut existing vegetation to height of three inches and remove resultant refuse prior to overseeding.

B. Seed Preparation:
1. Inoculate crownvetch seed on day it is used.
2. Reinoculate seeds not sown within 24 hours following inoculation.

C. Hydroseeding: Clean hydroseeders as approved prior to coming on site.
1. From March 1 to October 15, sow specified crownvetch seed mixture (Table 02920-4) at a rate of 100 pounds per acre.
2. From June 1 to August 15 sow specified crownvetch seed mixture (Table 02920-4) at a rate of 100 pounds per acre, except add an additional three-percent by weight of Loehmans Weeping Lovegrass.
3. Extend or reduce specified periods as approved and as required by weather and soil conditions.
4. Bare areas: Perform application-sequence Stages I and II, specified below.
5. Existing vegetation areas (hydraulic overseeding): Perform only application-sequence Stage I, specified below. Obtain the Engineer's on-site approval on whether to use nozzle or hose for hydraulic overseeding.
6. 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. Use mixtures within eight hours after mixing.
   d. Use inoculated crownvetch in slurry with fertilizers within one hour after mixing. Use fresh crownvetch seed and reinoculate seed whenever this requirement cannot be met.
7. Application sequence:
   a. Stage I, Table 02920-5: Load materials into water-filled tanks in proportion to tank size; agitate until smooth slurry is formed. Spray on seed bed at rates specified. Follow within two hours with Stage II.
   b. Stage II, Table 02920-6: Mulch area within two hours after completing Stage I. Use straw mulch for slopes up to 2:1. Use mulch blanket for slopes greater than 2:1. Do not use wood-cellulose fiber.

3.04 SEEDING LESPEDEZA:

A. Seed Bed Preparation: After construction work in the area has been completed, proceed as follows:
   1. Grading: Rough grade to remove large stones and roots. Remove or break up clods greater than one-foot diameter. Chisel surface to depth of four to six inches. When preparing slopes, chisel parallel to contour of slope.
   2. ph adjustment: Adjust soil pH by applying limestone or approved acidifying agent, or elemental sulfur at per-acre rate in Table 02920-6, except as recommended by approved soil test report so as to obtain a 6.5 pH. Apply separately prior to fertilizing and seeding operations.
      a. Apply 2/3 of limestone when seed bed is prepared. Work this into the top six inches of soil.
      b. Apply remaining 1/3 of limestone with seed mixture.
   3. Fertilizing: After acidity adjustment, apply fertilizer at per-acre rate in Table 02920-6, except as recommended by approved soil test report.
   4. Hydraulic overseeding: For overseeding existing vegetation, cut existing vegetation to height of three inches and remove resultant refuse prior to overseeding.

B. Seed Preparation:
   1. Have lespedeza seed hulled, scarified and inoculated for spring sowing.
   2. Inoculate lespedeza seed on day it is used.
   3. Reinoculate seeds not sown within 24 hours following inoculation.

C. Hydroseeding: Clean hydroseeders as approved prior to coming on site.
   1. Sow specified lespedeza seed (Table 02920-5) from March 1 to April 30 and August 15 to October 31 at the rate of 90 pounds per acre.
   2. Extend or reduce specified period as approved and as required by weather and soil conditions.
   3. Bare areas: Perform application-sequence Stages I and II, specified below.
   4. Existing vegetation areas (hydraulic overseeding): Perform only application-sequence Stage I, specified below. Obtain the Engineer's on-site approval on whether to use nozzle or hose for hydraulic overseeding.
   5. 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. Use mixtures within eight hours after mixing.
      d. Use inoculated lespedeza in slurry with fertilizers within one hour after mixing. Use fresh crownvetch seed and reinoculate seed whenever this requirement cannot be met.
   6. Application sequence:
      a. Stage I, Table 02920-5: Load materials into water-filled tanks in proportion to tank size; agitate until smooth slurry is formed. Spray on seed bed at rates specified. Follow within two hours with Stage II.
      b. Stage II, Table 02920-6: Mulch area within two hours after completing Stage I. Use straw mulch for slopes up to 2:1. Use mulch blanket for slopes greater than 2:1. Do not use wood-cellulose fiber.

3.05 MULCHING:

A. General:

1. Mulch according to the following slope limitations, except as limited for crownvetch and lespedeza.
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.

3.06 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.

3.07 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.

3.08 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.

3.09 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.

C. Final acceptance of crownvetch or lespedeza areas requires a minimum of nine vigorous, healthy seedlings evenly distributed per each square yard after 12 weeks of growing weather following germination.

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 5 pounds or 3 kilograms	If seed is purchased as a mixture. Per component prior to blending if Contractor blends mixture.
INOCULANT	7 days	1 packet	Keep temperature of inoculant below 70F (21C).
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) 1 unbroken bale 1 square yard (1 square meter)	Wood-cellulose fiber mulch. Straw mulch. Mulch blanket including staples.
MULCH BINDER	14 days	1 quart (1 liter) 1 square yard (1 square meter)	Synthetic binder. 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

TABLE 02920-3: GRASS SEED MIXTURES
For areas with slopes up to 2:1, unless otherwise shown.
Seed Mixture: 90-percent Tall Fescue (Maryland Green-label certified cultivars from current Agronomy Mimeo #77) 10-percent Kentucky Bluegrass (Maryland Yellow-label certified cultivars from current Agronomy Mimeo #77)

TABLE 02920-4: CROWNVETCH SEED MIXTURE.				
For areas with slopes 2:1 or greater, unless otherwise shown.				
SPECIES	**PROPORTION BY WEIGHT**	**MINIMUM GUARANTEED PURITY**	**MAXIMUM WEED SEED & OTHER CROP**	**MINIMUM GUARANTEED GERMINATION**
Certified Penngift Crownvetch Coronilla varia	40 percent	99 percent	0.25 percent	70 percent
Certified Pennfine or Manhattan or Citation Perennial Ryegrass Lolium perenne	60 percent	98 percent	0.25 percent	90 percent
Loehmans Weeping				

TABLE 02920-5: LESPEDEZA SEED MIXTURE				
For areas with slopes 2:1 or greater, unless otherwise shown.				
SPECIES	**PROPORTION BY WEIGHT**	**MINIMUM GUARANTEED PURITY**	**MAXIMUM WEED SEED & OTHER CROP**	**MINIMUM GUARANTEED GERMINATION**
Certified Lespedeza Certified Appalow	44 percent	99 percent	0.25 percent	70 percent
Nurse Grass: *Certified Tall Fescue per Maryland Green-label certified cultivars from current Agronomy Mimeo #77	56 percent	98 percent	0.20 percent	85 percent

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TABLE 02920-6: MATERIALS FOR HYDROSEEDING CROWNVETCH AND LESPEDEZA STAGE I		
MATERIAL	**PER ACRE**	**PER 1,000 SQUARE FEET**
Limestone	**2 ton minimum	**100 pounds
3-25-25 fertilizer or 0-20-20 fertilizer or *10-22-22 fertilizer	600 pounds 800 pounds *1,075 pounds	15 pounds 20 pounds *25 pounds
Blue Chip Nitroform, granular, 38-0-0	200 pounds	4.5 pounds
Nurse Grass: Certified Pennfine, Citation, or Manhattan Perennial Ryegrass Seed or *Certified Tall Fescue per Table 02920-5	 60 pounds *50 pounds	 1.5 pounds *1.25 pounds
Target Crop: Blue Tag Certified Penngift Crownvetch Seed or *Certified Appalow Sericea Lespedeza	 40 pounds *40 pounds	 1 pound *1 pound
Bacterial crownvetch or lespedeza inoculant in 5-pound-size packets	Five times manufacturer's recommended rate	Five times manufacturer's recommended rate
Wood-Cellulose Fiber	435 pounds (dry weight)	10 pounds
Mulch Binder (synthetic type)	20 pounds	0.5 pounds

* Lespedeza requirements only.
**Superseded recommendation of approved soil test report

TABLE 02920-7: MATERIALS FOR HYDROSEEDING CROWNVETCH AND LESPEDEZA STAGE II		
MATERIAL	**PER ACRE**	**PER 1,000 SQUARE FEET**
Straw	4,000 pounds	100 pounds
Mulch Blanket and Staples	Use according to manufacturer's instructions	Use according to manufacturer's instructions

END OF SECTION

SECTION 02930

LANDSCAPING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies providing and maintaining landscape plantings, edge plantings and related accessories. It also specifies existing tree pruning and removal requirements.

B. Related Work Specified Elsewhere:
1. Site grading: Section 02320.
2. Seeding and sodding: Section 02920.
3. Removal and restoration of existing landscaping: Section 02205.
4. Reforestation: Section 02933.

C. Definitions:
1. Landscape Plantings (Outside Reforestation areas and in Median strips): Designed planting of trees and shrubs within lawn or established areas, as shown. Landscape plantings are indicated on the Drawings with a square symbol as shown on the key in the Drawings.
2. Edge Plantings: Planting of trees and shrubs along edge of reforestation areas, as shown. Edge plantings are indicated on the Drawings with a triangular symbol as shown on the key in the Drawings.
3. Reforestation: Planting of trees and shrubs within designated reforestation areas. These reforestation areas are outside the limits of existing woodlands and wetlands and of landscape and mow areas, as shown. Reforestation planting areas are indicated on the Drawings with small circles as shown on the key in the Drawings.
4. Plants or Plant Material: Vegetation, including trees, shrubs, ground cover, vines, and seasonal flowers.
5. Size: The factor controlled by dimensions representing caliper, height or spread. For standard quality a dimension is given for caliper, height or spread, whichever is a typical characteristic of the plant. For specimen quality, all dimensions may be specified.
6. Condition: The factor controlled by vitality and ability to survive and thrive and be comparable with normal plants of the same species and variety in the vicinity, at the same season of the year, free from physical damage or adverse condition that would prevent thriving, whether dormant or growing.
7. Foliage line: Maximum dimension measured from ground to lowest part of body of plant.
8. Quality: Structure and form as evidenced by density and number of canes and branches, compactness, symmetry and general development, without consideration of size or condition.
    a. Standard: The least acceptable quality, good average uniform growth, absence of irregularities, typical characteristics of the species and variety, nursery-grown, well-formed, and uniformly branched, sound, healthy, vigorous and free of disease and insects, and having healthy, well-developed root systems, and having the minimum number of canes specified or conforming to minimum quality index. Plant materials below specified standard will be considered unacceptable culls and are not acceptable.

b. Specimen: An exceptionally heavy, symmetrical, tightly knit plant, trained or favored in its development and appearance so as to be An unquestionably and outstandingly superior in form, of the designated species or cultivar number of branches, compactness and symmetry.

9. Spread: Single dimension that represents the minimum acceptable width. Where range is shown between two spread dimensions, the lesser is the minimum acceptable.
10. Root Protection Zone (Area): The root protection area is an area equal to a radius of 1.5 feet for each inch of diameter at breast height (dbh) (i.e.; a 10-inch dbh tree will require protection 15 feet from the main trunk in every direction.
11. Diameter at Breast Height (DBH): The DBH is the trunk diameter measured at a point 4.5 feet (Maryland State Standard) above the average ground level. If the trunk divides into several smaller trunks at a point lower than 4.5 feet (Maryland State Standard) from the ground, the tree size is the diameter measured at the highest point on the single trunk.
    a. If a tree falls between sizes as listed in the bid schedule, the tree is placed in the next larger size. For example, a 17-1/2 inch diameter tree is placed in the 18-inch to 23-inch size.
12. Tracing: Careful cutting of bark along the line of sap flow to encourage wound closure and to smoothly outline the wound area.
13. Girdling Roots: Surface roots whose circular growth around the base of a tree trunk or around other roots applies pressure to the bark thereby restricting the sap flow.
14. Stumps: Stumps include the base of the trunk and visible surface roots attached to the trunk no more than three feet high, measured from the average ground level. Stump size is the diameter of the cut wood surface as measured across the narrowest portion.
15. B&B: Balled and burlapped.
16. NIC: Not in Contract.
17. Other Terms: The following in accordance with ANSI Z60.1:
    a. Height.
    b. Cane.
    c. Caliper: Determine caliper measurement by taking the average of two trunk caliper measurements at right angles six inches above the root crown.
    d. Height of branching.

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 jurisdictional authorities, including but not limited to NPS, MNCPPC and MDNR.
    a. Wherever specific reference is made to NPS, MNCPPC and MDNR, it applies to work performed on or affecting the property governed by these agencies.
2. ANSI: Z60.1 (American Standard for Nursery Stock), Z133.1 (Safety Requirements for Pruning, Trimming, Repairing, Maintaining and Removing Trees and Cutting Brush).
3. Bailey's Standard Cyclopedia of Horticulture.
4. American Joint Committee on Horticultural Nomenclature (AJCHN): Standardized Plant Names.
5. Hortus III.
6. USDA-SCS.
7. FS: O-F-241.
8. ASTM: A36, A48, A53, A153, A307, A501, C51, D448, D2729, F593.

B. Source Quality Control:

1. Verification of availability: Before bidding, verify sources of supply of the plants on the plant schedule, including requirements for size, species, variety and quality shown and specified.
2. Furnish plant materials certified by state or federal Department of Agriculture to be free from disease or infestation.
3. Obtain plants climatized to the Project area. Acclimate plants for a minimum of 3 months. Supply plants only from nurseries within U.S.D.A. Plant Hardiness Zone 6 or 7, and not more than 500 miles from the Project site.
4. Pre-select and tag at the nursery the large plants of quality and number indicated, prior to inspection by the Engineer.
5. Inspection of plant material:
    a. Inspection: Have plant material inspected and trees seal-tagged by the Engineer at the nurseries prior to digging. Have representative samples of shrubs and miscellaneous plants sealed.
        1) To be approved, remaining plants are to be equal to sealed samples. Obtain approval of plants after delivery and before planting.
        2) Inspection and approval of plants at the nursery or at delivery is for quality, size and variety only and will not abolish or abrogate the right of rejection for failure to meet other requirements discovered during the progress of the work.
    b. Travel expenses: In the bid price, include related Authority-incurred expenses for the Engineer's travel. Allow sufficient time for travel advance to be processed, minimum 2-weeks.
        1) Appropriate expenses include the costs associated with meals, lodging and transportation; i.e., airfare, auto rental, parking, tolls, and privately owned vehicles at the rate per mile currently in effect under Federal Travel Regulations. Daily lodging and meal expenses may not exceed the per diem limits allowed under the provisions of the Federal Travel Regulations in effect at the time the expenses are incurred. Air travel is limited to regularly scheduled airline flights, coach class, whenever possible
        2) In these costs allow for maximum 8-hour work days, including suitable inspection time and round-trip travel time.
        3) No costs are borne by the Contractor for Authority-furnished labor.
    c. The NPS and MNCPPC, as applicable to the planting location, have the right to inspect, select and tag plants before delivery to the job site. If this inspection is made, it will be at the nursery at no additional cost to the Contractor.
6. Inspection of topsoil.
    a. Make arrangements with the Engineer for inspection at the source. Furnish travel expenses as specified for Inspection of Plant Material.
    b. Obtain representative topsoil samples for submittal as specified in Section 02920.
    C. Contractor is liable and responsible for any deleterious soil material brought on site, and subsequent pollution abatement clean-up.

C. Personnel Qualifications:
1. Superintendent: Use a Landscaping Superintendent with previous knowledge and verifiable experience in supervising landscaping work and grounds maintenance 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 landscaping work.

2. Arborist: Perform tree pruning and removal work under the direction and general supervision of an Arborist certified by the International Society of Arboriculture, PO Box 908, Urbana, IL 61801, telephone 217/328-2032; or by a Maryland-licensed Tree Expert; who has verifiable experience and technical competence in tree physiology, identification, diagnosis of disorders, and current tree care and safety practices in accordance with accepted industry standards. The Arborist is responsible for controlling the quality of pruning and removal work and for inspecting such completed work.
3. Tree Crew Supervisor: Have tree pruning and removal work performed under the full-time supervision of an experienced Tree Crew Supervisor to accompany each tree crew while work is being preformed. Ensure that the Tree Crew Supervisor has verifiable work experience as a full time direct supervisor of shade tree pruning and climbing work crews.
4. 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 landscape planting, grounds maintenance, with the hazards of tree pruning and removal work, and with equipment used for each of these operations as applicable. Have each worker abide by the code of ethics or professional conduct established by the Landscape Contractors Association MD-DC-VA, the National Arborist Association and the International Society of Arboriculture.

D. Pre-Planting Conference: Hold a pre-planting conference prior to planting landscaped areas.
1. Set a time, date, and location agreeable to the Engineer and personnel of the Contractor, and jurisdictional agency, including but not limited to, NPS and MNCPPC, who are responsible for the contractual obligations of these parties. Participation of these parties at this conference is mandatory prior to beginning planting.
2. Have discussion topics include, but not limited to, confirmation of exact plant substitutions previously accepted by the Engineer.
3. Make notations on plans to document direction received from the jurisdictional agency, including but not limited to, NPS and MNCPPC, and send record copies to attendees.
4. After conference, notify the Engineer 48 hours prior to beginning landscape planting work. Notify MDNR through the Engineer.

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. Location list: Within 10 calendar days after receipt of NTP, submit a complete list of locations of plant material subject to inspection. Should plant material be exhausted from these sources, the Contractor is responsible to locate elsewhere, at no additional cost to the Authority.
2. Request for Substitutions: Submit requests for plant material substitutions, if necessary, within 10 days of NTP.
   a. If a substitute is to be used on and jurisdictional agency, including but not limited to, NPS property, it requires approval by the Engineer and the NPS, or applicable agency.
   b. The Engineer will approve substitutions only after thorough evaluation has been made concerning the need for such a change based upon the unavailability of plant material specified.If size changes are made, the Engineer will require equal total caliper inches for trees as bid, or if limited by space, extra numbers of plants equitable to unit cost bid price; at no additional cost to the Authority.
3. Work routes and details: Submit plans of entire project site clearly marked to show proposed work routes of crews and equipment, turning radii, and locations of

temporary protective markers, barriers and storage areas, coordinated with details of methods to distribute concentrated loads so as not to compact soil unacceptably (above 75% maximum density). Do not route through zones designated for planting.

B. Samples: Samples of each required type of material specified in Table 02930-1. Samples failing to meet specified requirements are unacceptable. Resubmit new samples of satisfactory material until approved.

C. Certifications:
1. Complete, certified reports attesting that proposed materials comply with specified requirements. Furnish certificates of inspection of plant materials by state or federal agency prior to delivery.
   a. Topsoil: As specified in Section 02920.
   b. Antidesiccant: Submit certificate from the antidesiccant manufacturer as evidence that the antidesiccant material can be safely used on both deciduous and evergreen plants. Mandatory use, if any plants installed outside the specified planting period.
2. Copies of each license and certificate necessary for complying with Federal, State, and municipal laws, codes, and regulations prior to delivery.

D. Documentation:
1. Personnel qualifications: A list of the qualifications and experience of the workers, and qualifications and experience of the Landscaping Superintendent, Arborist and Tree Crew Supervisor, as attested by knowledge and experience in supervising contracts of similar size and scope in the past.
2. Soil Density Tests: Submit soil proctor tests made by a qualified independent soil-testing agency, acceptable to the Engineer, stating soil density. Perform tests where directed by the Engineer. Compaction by rolling or operating heavy equipment is not permitted within planting locations. Maximum density of subgrade in planting locations is 75 percent. Disc or rototill bottom of plant beds to remove hard pan that may exist and remove rocks and debris off site, at no extra cost to the Authority.
   a. Before beginning work: Furnish one pre-construction soil proctor test to 24-inch depth for each 100 square feet of approved work routes and storage areas.
   b. After completing work: Furnish one post-construction soil proctor test to 24-inch depth for each 100 square feet of approved work routes and storage areas.
   c. Perform additional soil proctor tests if correcting soil density is required.
3. Topsoil pH Tests: Submit soil pH tests made by a qualified independent soil-testing agency, acceptable to the Engineer, stating soil pH. Report suitability of pH for growth of target crop in each area. State recommended quantities of soil amendments to be added to produce a satisfactory Ph.
   a. Furnish one test for each 500 square feet of each planting area, and not less than one test for each area.
   b. After adjusting pH, furnish one test for each 300 square feet of each pH-adjusted areas, and not less than one test for each area.
   c. Confirming orders: Within 10 calendar days after receipt of NTP, submit confirming orders from the nursery for plant material.
4. Packing slips: Certified plant materials packing slips with each delivery.
5. Reports: Furnish copies of the following reports to the Engineer either on a daily or weekly basis as requested.
   a. Daily Work Log: Maintain a daily work log recording the quantities of trees and shrubs installed, and their locations.
   b. Maintenance Reports:
      1) Prepare monthly reports describing the work of the previous month and work scheduled for the following month.

2) At the end of maintenance period, submit maintenance schedules and instructions for future maintenance.

6. Equipment list: A list of the equipment anticipated for use, including the make and model, year manufactured, tag number if applicable, and date of last inspection. If requested by the Engineer, submit a list of the equipment to be used for each delivery order. Have the listed equipment on the job site when necessary during the execution of the delivery order.

1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

A. Delivery:

1. Notify the Engineer at least 48 hours before each delivery. Describe in writing the method of shipment and include an itemized list of quantity and sizes. Do not deliver plants until the areas for planting are prepared as required, and approved by the Engineer.
2. With each delivery, include certified packing slip for the shipment listing types and sizes of plants, types of materials, and quantities of each shipped. Inspect received materials against packing slip promptly upon arrival at the job site.
3. Deliver materials and products to the job site in their original unopened containers or wrappings, clearly labeled with the manufacturer's name and address, material components, trademark, chemical analysis, species, age and source. Materials and supplies are subject to inspection and sampling for testing.
4. Allow no agronomic materials or supplies on site other than those for the project.
5. Protect plants from weather and adequately pack them to provide protection against climate and breakage during transit. When shipment is made by open vehicle, tie and cover plant materials to prevent wind-shipping and dehydration. When shipment is made by closed vehicle, carefully pack and adequately ventilate plants to prevent condensation on or overheating of plants during transit.
6. Spray evergreen and deciduous plants in leaf with an anti-transpirant in accordance with manufacturer's instruction to protect from drying.
7. Protect roots of bare-root plants with approved nursery packing. Keep damp during delivery and storage. If planting is delayed, heel-in plants in topsoil or wet straw and keep moist.
8. Do not expose fertilizer to weather until used. Completely protect fertilizer before use and do not store in direct contact with the ground.

B. Plant Identification Labels: Mark plants with identification before delivery to the site. Make labels durable and legible stating the correct botanical name and size/caliper in weather-resistant ink or embossed letters. Securely attach labels to each plant in a manner that will not restrict growth. Maintain labels until they are removed by the Contractor at final acceptance or when directed otherwise by the Engineer.

C. Move plants marked B&B on plant list with root systems as intact solid units and with root balls of earth firmly wrapped.

D. Exercise care during every handling operation so as to prevent damage to bark, branches, roots and stem, and to preclude cracked root balls. Use platforms under balls whenever hoisting plants. Do not use plants with cracked, broken or loosely wrapped root balls. Handle plants only by root balls. Plants handled by tops will be rejected. Protect plant roots, root balls and tops from sun or drying winds until planted.

E. Do not stack root balls. This will mean that for a 40-foot flat bed trailer, the number of 1.75-inch to 2-inch B&B plants may not exceed 130.

F. Do not handle soil in a frozen or muddy condition.

1.05 JOB CONDITIONS:

A. Conduct planting operations only under favorable seasonal conditions throughout the period of the Contract as determined by the Engineer. Install no plants during adverse weather or during periods when soil conditions are unfavorable as determined by the Engineer. Do not plant when ground is frozen.

B. Daily Work Log: Coordinate daily work log with work performed, recording numbers of plants planted and their locations.
   1. To indicate progress, attach color-coded survey tape in the planting areas, with a different color tape per month and marked with the date of installation in weather-resistant ink, keyed to the Plant Schedule shown.
   2. Securely attach tape to each plant in a manner that will not restrict growth. Maintain tape on plants until removal is directed by the Engineer.

C. Protection: During progress of operations, protect walls, walks, curbs, benches, lawn areas, plant material, and other site improvements by adequate means acceptable to the Engineer.
   1. Existing Vegetation: Preserve and protect existing vegetation such as trees, shrubs, and grass on or adjacent to the site which do not reasonably interfere with the construction. Box and protect trees and shrubs that may be subject to construction activities within the root protection area with chain link or wood fencing as directed by the Engineer.
   2. Weight Restrictions: Do not overload entrance paving, sidewalks and curbs. These areas are limited to a maximum load of 1,250 pounds per square foot.
   3. Existing Utilities and Structures: The existence and location of underground utilities on the plans are not guaranteed. Investigate and verify locations in the field before starting work. The Contractor will be held responsible for damages to, and for maintenance and protection of existing utilities and structures.
      a. Obtain copies of available as-built utility drawings from the Engineer for reference.
      b. Contact the local utility companies concerned to inform them of excavation plans.
      c. To locate utilities in the field, contact Miss Utility at 800/257-7777, 48 hours in advance of work.
      d. Perform excavation in vicinity of existing structures and utilities with great care.
   4. Pollution: Take necessary and adequate measures to prevent soil erosion, air pollution and water pollution by the materials and equipment used during construction.
   5. 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.
      a. Replace damaged existing turf areas with approved sod per Section 02920.

D. Root Protection Zone (Area): Do not permit heavy equipment or vehicles or the stockpiling of materials in the root protection area without advance permission of the Engineer. Where such activity is allowed within the root protection area, provide an ample mitigation plan to prevent the possibility of damage to the tree trunk and roots, or to increase soil compaction.
   1. If the Engineer approves construction activities within the root protection area, protect tree trunks and shrubs with chain link fence or wooden fencing as directed, cover the entire root protection area with landscape fabric and weed barrier as approved, and mulch with four inches of mulch prior to construction. Placing metal

plates, tree pruning, fertilization, aeration and irrigation may also be required as directed by the Engineer.

2. 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 the applicable regional jurisdictions, including, but not limited to NPS, MNCPPC, and at no additional cost to the Authority.
3. For pruning or removal of existing trees, obtain approval by the NPS or the MNCPPC, as applicable, through the Engineer. Tree pruning and removal, except as shown, is NIC. and at no additional cost to the Authority.

E. 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.

1.06 SCHEDULING AND COORDINATION:

A. General:
1. Perform planting operations according to Contractor's detailed and updated plan of the work as approved by the Engineer.
2. Schedule and arrange work so as not to interfere with normal activities of the applicable regional jurisdictions including, but not limited to NPS and MNCPPC land and adjacent properties. Advance notice will be given to the Contractor if a conflict is expected. Remove plant debris, personnel and equipment that could interfere with an activity or event prior to the activity.

B. Planting Seasons: The times of year in which planting is permitted is limited by the planting seasons for plant types as stipulated by the appropriate regional jurisdictional agency. Authority planting seasons are as follows. These time periods also include the time required, after initial planting, for staking, pruning and mulching operations.
1. Evergreen material:
a. Fall planting: September 15 through November 30.
b. Spring planting: March 1 through May 15.
2. Deciduous material:
a. Planting period: October 15 through April 30.
b. White and Willow Oaks, Ironwood, dogwoods and other species as specifically directed, may be planted in spring only: March 1 through April 30.
3. Subject to the Engineer's approval, extend or reduce planting season as required by weather and soil conditions. Preparations for planting may begin earlier than the specified seasons if weather permits and if the staking of plant locations has been approved.

1.07 WARRANTY:

A. Six months in addition to the requirements of the General Provisions for a total of 18 months, commencing the day the landscaping is accepted.

B. Contractor has the responsibility for plant material locations that may be considered by the Contractor to be affected by adverse conditions, such as undesirable soil pH, water table factors, or poor drainage. Contractor also has responsibility during and following adverse weather conditions such as periods of excessive precipitation, extreme temperatures, wind and drought.

C. As specified in Part 3, Concurrent Maintenance and Warranty Period, seasonally replace dead plants and plants that have died back beyond normal pruning lines as determined by the Engineer and at no additional cost to the Authority.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Plants and Plant Materials:

1. Provide plants meeting the requirements of the plant schedule as shown, identified by botanical and common names and in accordance with applicable standards of quality, size, condition and type listed.
2. Supply only plants free from disease, well-branched, in full foliage when in leaf and with healthy normal root systems. Have plants freshly dug, nursery-grown, and meeting the other specified requirements. Cold storage plants are unacceptable.
3. Plants in marked cans, pots, or other containers on the plant schedule are to have been grown in the containers for a minimum of three months and a maximum of two years. Ensure that plant roots filling the containers show no evidence of being or having been root-bound.
4. B&B plants: Use B&B plants that meet the Recommended Balling and Burlapping Specifications of ANSI Z60.1. Specifically: freshly dug by hand or with a mechanical tree digger in good condition, free of hydraulic leaks, with blades aligned and free of damage; roots wrapped firmly with untreated burlap, and bound carefully with untreated sisal or jute twine, cord or ungalvanized wire mesh; in a manner so as not to damage the bark, break branches, or destroy the natural shape.
5. Root ball: Dig trees so that the root crown is at the top of the root ball. Make diameter and depth of root balls sufficient to encompass fibrous and feeding root systems.
6. Provide genus, species and cultivar names which agree with the nomenclature of the most current edition of Hortus III by L.H. Bailey, Hortorium, Cornell University.

B. Topsoil:

1. Weathered surface soils or natural friable loam obtained from approved sources, free of subsoil, hard fragments and stones larger than one-half 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 the Walkley-Black Method; capable of sustaining normal, healthy growth and development of seed and sod scheduled and specified.
2. Grading analysis:
   a. All material must pass through a two-inch screen. Remove all material larger than two inches from the site.

SIEVE	MINIMUM PERCENT PASSING
2 inches	100
½ inch	90
¼ inch	80
No. 10	70

3. Test and analysis of proposed topsoil material: Performed by local state agricultural experiment station or agricultural laboratory recommended by U.S. Department of Agriculture and meeting the following requirements:
   a. Soil pH range: Between pH 5.0 and pH 7.6 inclusive.
   b. Soil salinity by electrical-conductivity measurement: 500-ppm soluble salt maximum.

c. Soil fertility: Rated high in natural nutrients in pounds-per-acre based on the standard soil test in laboratory.
d. Soil texture: Classification consisting of 5 to 25-percent clay, 20 to 60-percent sand, and 15 to 45-percent silt as determined by hydrometer or pipette method. Sand, silt and clay as defined by USDA-SCS.

C. Fertilizer:
1. Commercial fertilizer: FS O-F-241, Type I, of grade noted, Level B, composite and bearing manufacturer's guaranteed statement of analysis. Unless otherwise shown or specified, use 10-10-10 , slow-release, meeting the following minimum requirements:
a. Nitrogen content: Ten percent; slow-release, 50-percent organic.
b. Available phosphoric acid: Ten percent.
c. Potash content: Ten percent.
2. Soluble fertilizer: Standard commercial grade, 15-30-15 or higher analysis, Rapid-Gro or equal.
3. Packet tree and shrub fertilizer, minimum two-year time release: Root-Contact Packet, Sando Products, Inc., Prairie du Chien, Wisconsin 53821; Eeesy Grow, Specialty Fertilizer, Inc., Suffern, New York, 10901; 21 Gram, Planting Tablets, 200-10-5 Agriform International Chemicals, Inc.; or equal.

D. Stable manure: Well-rotted cow manure. Free from fresh manure, sawdust, wood chips, tanbark, long straw, stones, chemicals used to hasten decomposition artificially, or other substances injurious to plants.

E. Perlite: Granules, sterile, uniform gradation, insoluble, high water-holding capacity; as available from Pennsylvania Perlite Corporation, Lehigh Valley, Pennsylvania 18001 or equal.

F. Mulch:
1. Mulch blanket: Knitted construction of bio-degradable yarn with uniform openings, Hold-Gro as manufactured by Gulf States Paper Corporation, Tuscaloosa, Alabama 35401 or equal.
a. 150-foot lengths or greater.
b. U-shaped staples: As supplied by mulch-blanket manufacturer.

2. Shredded hardwood or shredded pine bark: Sound, non-decomposed bark free from sticks, stones, clay and other foreign and toxic substances, with 50 percent over the minimum size indicated.
a. Regular size: 1/2-inch to two inches.
b. Extra-Coarse size: One inch to three inches.
c. Sources: Cove Dehydrated Products, Martinsburg, Pennsylvania 16662; Weyerhauser Garden Bark, Weyerhauser Company, Silva Products Department, Takoma, Washington 98401; or equal.

G. Crushed Stone: ASTM D448, Size 57.

H. Pea Gravel: Smooth, rounded pieces of gravel, clean and free from objectional materials, such as soft particles, coal and lignite particles, or friable particles, graded from 1/4 to 3/8 inch in size.

I. Sand: Sharp, common, coarse, wet sand as approved, for use under plants.

J. Peat Moss: Type 1 sphagnum peat moss (at least 75-percent), finely divided, with a pH of 3.1 to 5.0, moistened prior to and at time of use.

K. Perforated Plastic Pipe: ASTM D2729.

L. Landscape Fabric and Weed Barrier: Porous geotextile fabric for water and nutrient exchange; tear-resistant, minimum four ounces per square yard; Typar Landscape Fabric, DeWitt Earthmat, Pro 5, or equal.

M. Limestone: Agricultural or dolomitic, ASTM C51, capable of neutralizing soil acidity and containing not less than 85 percent of total carbonates. Containers or sacks labeled to show chemical and mechanical analysis.

N. Plant Hormone: Vitamin powder; Transplantone, American Chemical Paint Co., Ambler, Pennsylvania 19002; Super Thrive, Vitamins Institute, 5409 Satsuma Avenue, North Hollywood, California 91601; or equal.

O. Antidesiccant for Retarding Excessive Loss of Plant Moisture and Inhibiting Wilt: Sprayable, water-insoluble vinyl-vinyldine complex which will produce a moisture-retarding barrier not removable by rain or snow. Capable of forming a film at temperature commonly encountered out-of-doors during planting season and with the moisture-vapor transmission rate of the resultant film not more than 10 grams per 24 hours at 70-percent humidity; Wilt-Pruf, as manufactured by Wilt-Pruf Nursery Specialty Products, Inc., Greenwich, Connecticut 06830; Vapor Gard as manufactured by Miller Chemical Company, Hanover, Pennsylvania 17331; or equal.

P. Tree Stakes and Guys:
   1. Stakes: Sound No. 2 Douglas fir or rough sawn straight-grain oak of uniform size.
      a. Type 1: Two-inch square or 2-1/2 inches in diameter, eight feet long, with six-inch point at one end. Paint with two heavy brush coats of dark walnut oil stain before installation. After installation, cut off stakes square to a level two inches above the wires.
      b. Type 2: Two-inch square by 30 inches long and notched to bold wires.
   2. Metal stakes: Steel angle, zinc-coated, ASTM A153, 1/4-inch thickness, 1-3/4 inches by 1-3/4 inches by 30 inches long.
   3. Pipe: ASTM A53, hot-dip galvanized, 1-1/4 inch OD eight feet long.
   4. Wood flags: 1/2 inch by two inches by ten inches, painted white.
   5. Turnbuckles: Galvanized, ASTM A153, three-inch minimum adjustment and 5/16-inch minimum diameter threaded opening fitted with screw eyes.
   6. Wires: Zinc-coated steel, No. 12 wire.
   7. Wire guards: Sound, two-ply, 5/8-inch inside diameter, round hose of fabric and rubber, black or green color.
   8. Ring bolts: 1/4-inch by three-inch tie-wire anchor HILTI HKT 14, HILTI Fastening Systems, Langley Park, Maryland 20783; or equal.

Q. Wrapping Material:
   1. Tree wrap: Two thicknesses of crinkled paper cemented together with bitumen, waterproof, four inches wide; as manufactured by Bemis Bag Company, Chase Bag Company, Sisalkraft or equal. Use as directed by Engineer or required by jurisdiction, always applicable for. plants subject to sun scald.
   2. Twine: Lightly tarred medium or coarse sisal yarn.

R. Watering Pipe: As shown.

S. Marker Stakes: Sound No. 2 Douglas fir, or equivalent grades of rough sawn straight-grain oak, rough sawn cypress, hard pine, cedar, or locust; straight, of uniform size, 3/4-inch x 2-inch x 18 inches, pointed at one end.

T. Tree Grates, Tree Grate Frames and Tree Guards:

1. Round tree grates: As shown, or with five-foot diameter, radial pattern, and expandable, as approved.
2. Square tree grates: As shown.
3. Guards: As shown.
4. Cast iron: ASTM A48.
5. Steel angles, plates and collars: ASTM A36.
6. Steel tubing: ASTM A501.
7. Bolts and washers: ASTM A307, zinc-coated.
8. Screws: Stainless steel, ASTM F593, Alloy S30400.
9. Tubing and collars: Shop-painted in accordance with Section 05500; finished as shown.
10. Steel bars: ASTM A36.

U. Hedge Guards: PVC-coated chain link fencing and accessories as specified in Section 02820, and as shown; consisting posts, fabric, tension wire and ties.

V. Water: Potable.

W. Composted screened leaf mold:
1. Processed leaves aerobically composted, free from litter such as glass, paper, plastic and other foreigh substances, as approved.
2. Source: Leaf-Gro as available from Maryland Environmental Services, 2020 Industrial Drive, Annapolis , Maryland 21401 (301) 261-8596, or equal. Do not use composted sewage sludge.

2.02 PLANTING MIXTURES:

A. Planting Mixture A:
1. Use: For backfilling plant pits of deciduous and evergreen trees, shrubs, excluding azaleas:
2. Mixture: Four parts topsoil and one part leaf mold or decomposed cow manure plus five pounds of 10-10-10 fertilizer per cubic yard, mixed on site to an approved consistency.

B. Planting Mixture B:
1. For backfilling plant pits of deciduous and evergreen groundcover and vines and all azaleas:
2. Mixture: Four parts topsoil, one part leaf mold and one part perlite plus five pounds of 10-10-10 slow-release fertilizer per cubic yard, all mixed on site to an approved consistency.

2.03 EQUIPMENT:

A. Use only equipment that meets federal OSHA, state and local safety requirements and that is properly licensed. This includes but is not limited to equipment such as bucket trucks, aerial lifts, chipper trucks, wood trucks and stump grinders, which may be needed to correctly perform landscaping, maintenance, and tree pruning and removal in accordance with the requirements.
B. Have the name or logo of the Contractor or subcontractor clearly displayed on trucks used on the job.
C. Use equipment of sizes that clear access routes, protective markers and barriers by 2 feet or more on each side.
D. Do not use material storage devices or equipment that could increase compaction of existing, undisturbed soils.

PART 3 - EXECUTION

3.01 PREPARATION FOR PLANTING:

A. See Article above on Scheduling and Coordination.

B. Pre-Planting Conference: See Article above, under Quality Assurance.

C. Locate and mark location of each underground utility.

D. Mark outlines on the ground for locations of individual trenches and planting beds as approved. Have the Engineer approve marked locations before excavating.
   1. Drive marker stakes with at least eight inches projecting above surrounding ground cover.
   2. Paint top four inches of each stake according to the following color schedule and mark stakes with plant common name and sizes for each location:
      a. Evergreens: Blue.
      b. Deciduous trees: Red.
      c. Flowering trees: Yellow.

E. Do not permit personnel, vehicles, or equipment not directly associated with the work into the planting areas.

F. Inspect Plants: Do not plant if plants appear damaged, unhealthy, insect infested, or if the root ball is cracked or broken either before or during planting operation.

3.05 PRESERVATION OF EXISTING PLANTS:

A. Preserve and protect existing plants in accordance with the existing Plant Schedule as shown and with the requirements of Section 02205.

3.02 EXCAVATION FOR PLANTING:

A. Exercise care during entire time of excavation and planting work so as to prevent contact with, disturbance of or unearthing of utilities and devices. Hand excavate wherever necessary to ensure this level of care.

B. Exercise care in excavating tree pits at locations with existing drainage systems so as to prevent contact with, disturbance of or unearthing of drainage systems. Hand excavate wherever necessary to ensure this level of care. Place landscape fabric as shown. Staple per manufacturer's directions.

C. Plant Locations: Locate plants as shown on the Contract Drawings, from dimensions shown, and as approved by the Engineer after locations are marked per the Preparation for Planting requirements specified above.

D. Excavate pits, trenches, and beds with vertical sides and flat bottoms, to dimensions shown.

E. Excavate pits to a minimum depth of 24 inches, measured from finished grades, or as shown.

F. Make pits for bare-root plants to diameters at least 12 inches larger than the maximum spread of the roots and to minimum depth of at least 12 inches below the roots of the plant as placed.

G. Make pits for balled or potted plants, with ball or container less than 12 inches in diameter, to diameters at least 16 inches larger and depth to size of ball or container. Alleviate hardpan compaction by rototilling or discing sub-soil beneath plant.

H. Make pits for balled or potted plants, with ball or container 12 inches or greater in diameter, to diameters at least 24 inches larger and minimum depth to size of ball or container.

I. Install trench drain for trees on slopes greater than 3:1 in locations as shown. Excavate four to six inches wide. Start bottom of trench at elevation of bottom of plant ball and extend away on low side of plant location until daylighted. Fill bottom twelve inches of trench with pea gravel. Backfill to surface with excavated material from trench. Blend surplus over area next to trench. Cover surface with material to match the surrounding area.

J. Make beds for ground cover plants to the length and width shown with minimum depth of six inches. Install landscape fabric beneath mulch layer, stapling per manufacturer's directions.

K. Backfill plant pits that are abandoned due to unsuitable conditions with same excavated material, grade and seed.

L. Before the close of each working day, barricade open pits. When pits are excavated more than fourteen days in advance of planting, backfill the excavations with the planting mixture specified.

M. Remove and dispose of rocks, debris and excess excavated material off site. Set aside excavated soil needed for backfill mix and to form saucers.

3.03 PLANTING:

A. Set plants plumb and straight with allowance for settlement. Set watering pipe as shown.

B. Place balled plants so that the top of the root ball bears the same relation to finish grade as it bore to previous finish grade in nursery, or 1/8 higher than depth of root ball= approximately two inches higher. Place fertilizer packets or tablets in accordance with manufacturer's recommendations alongside the base of root ball. Backfill with specified planting mixture in 12-inch layers and tamp each layer to fill voids until planting mixture is at grade. Cut and remove burlap and lacing six inches away from trunk, or as approved. Leave remainder of burlap and lacing intact. Soak plant with water containing plant hormone.

C. Open and remove containers from potted plants. If the growing medium is comprised of 75 percent or more of peat, perlite, sand or like material other than soil, pull visible roots away from container medium leaving the roots partially exposed. Place plants in plant pit or trench and carefully place backfill planting mixture among exposed roots. Continue backfilling and tamping in six-inch layers until finish grade is reached. Soak with water containing plant hormone.

D. Remove and store existing tree grates and replace when planting is complete.

E. Placement of bare-root plants: Place in pit or trench, cut off broken or frayed roots, spread root system, backfill with planting mixture in six-inch layers, settle to finish grade with water containing plant hormone.

F. Create saucer around isolated plants with soil to retain water unless otherwise shown. Bring beds to smooth, even surfaces which will conform to established grade after full settlement has occurred.Plant shrubs as a bed, using weed barrier fabric beneath mulch when shrubs are spaced less than six foot on center (6' O.C.), unless otherwise detailed.

G. Place specified planting mixture in groundcover bed at six-inch depth or as otherwise shown in contract drawing detail , place landscape weed barrier and then top with a layer of mulch to depth of three inches after compaction.

H. Remove groundcover plants from pots with root system intact and set in mulched planting beds, cut through weed barrier, in the spacing and arrangement shown. Work soil firmly around each plant and restore the mulching material. Settle to finish grade with water containing plant hormone. On slopes greater than 2:1, after preparing planting beds and mulching, but prior to planting, apply mulch blanket as directed and staple according to manufacturer's instructions.

I. When pits are dug in wet areas or where subsoil will not permit drainage as shown, set plant higher than normal using extra depth of crushed of crushed stone or sand, up to 12 inches total depth, to keep ball from settling. Set top of plant root ball up to six inches higher than grade, as directed. Blend the immediate area outside the saucer with suitable soil to meet existing grade.

J. Topsoil or approved fine, dry subsoil excavated or augered from plant pits may be used to form saucers. If plant pits are augered, break down side of the hole to permit root penetration.

K. Create soil berm around downhill portion of planting pits on slopes.

L. Cultivating: Cultivate trenches and shrub beds to the line shown. Cultivate area around isolated plants at least six inches beyond diameter of pit.

M. Mulching: After planting and cultivating are completed, spread a layer of mulch on finished grade around plants to a depth of three inches after compaction. Lay landscape fabric beneath shrubbery beds, groundcover areas, and in tree pits, stapling as necessary per manufacturer’s directions. Spread mulch around isolated plants over an area at least six inches greater than diameter of the pit and extend mulch over berm saucers as shown. Completely cover trenches and shrubbery beds with mulch. In planters and beds, spread a layer of mulch to depth of three inches after compaction.

N. Pruning: Prune plant material after installation as approved to thin branches and foliage and yet retain species shape and trim hedges as shown. Do not cut leaders.
   1. Remove limbs, branches, canes and runners which require trimming with a clean cut flush with trunk or adjacent stem.
   2. When pruning lateral branches, cut at the same angle as that at which the buds are growing from the branches. Cut at a distance of 1/8-inch to 1/4-inch beyond the buds to avoid injuring them.
   3. Sterilize cutting tools with alcohol before proceeding to next plant after pruning out infected twigs and branches.

O. Planting in Planters: Install crushed stone, landscape fabric and weed barrier, planting mixture and mulch as shown. Mound planting mix as shown for positive drainage. Do not work soil when frozen.

P. Flower Beds: Plant flowers as shown, at planting seasons recommended by regional jurisdictions and/or growers.

Q. Wrapping: Check with Engineer for necessity. For plants prone to sun scald use immediately after planting, spirally wrap trunk and main branches of trees with an overlay of two inches starting at the bottom. Tie wrap securely in place with twine.

R. Guying: Within three days after planting, guy each tree four-inch caliper or larger as shown. Protect trees at points of contact by use of wire guards. After installation, cut stakes square to a level two inches above the wires.

S. Staking: Support trees smaller than four-inch caliper within three days after planting by staking at perimeter line of ball as specified and to sufficient depth to hold tree rigid. Drive stakes vertically to achieve uniform height of five feet-six inches above finish grade or as directed. Do not twist or pull. Wire tree with wire guards interlocked to each stake at four inches above finish grade, or as directed.
1. Planting areas: Three stakes, 120-degrees apart.
2. Trees with grates: Four stakes, 90-degrees apart.

T. Installation of Hedge Guard: Space hedge guard posts at a maximum of eight feet on centers. On curves with radii less than 100 feet, space hedge guard posts at a maximum of four feet on centers. Drive posts plumb to a height of three feet-six inches; protect end of pipe. Install one-cubic foot of concrete around base of end post in each run to serve as pull anchor. Secure fabric to posts with ties spaced 12 inches on centers. Install tension wire two inches below top of fabric. Install permanent caps on posts.

U. Removal of Seals and Tags: As approved.

3.04 EXISTING TREE PRUNING AND REMOVAL:

A. Safety:
1. Conduct operations in accordance with national and local fire and safety codes, laws, rules, regulations and ANSI Z133.1 Safety Requirements for Pruning, Trimming, Repairing, Maintaining and Removing Trees and Cutting Brush.
2. Have employees wear reflective, bright orange vests while conducting operations in or adjacent to roadways.
3. Do not permit any one except the operator within six feet of a power saw.
4. Block off the work area to pedestrians, other workers and vehicles.
5. Look for, note and report to the Engineer in writing the presence of the slightest structural weakness, disease conditions, decayed trunk or branches, split crotches or branches, or other hazardous condition that has potential for damage to property or personal injury.

B. Tree Pruning:
1. Prune and thin trees when in foliage according to the Pruning Standards for Shade Trees (revised 1988) by the National Arborist Association. The classes of pruning are as follows:
   a. Class I Fine Pruning: Fine pruning consists of removing dead, dying, diseased, interfering, objectionable, obstructing and weak branches, as well as selective thinning to lessen wind resistance. Removal of such branches includes those on the main trunks as well as those within the leaf area. An occasional branch as described above up to ½-inch in diameter may remain within the main leaf area where it is not practical to remove.
   b. Class II Medium Pruning: Medium pruning consists of removing dead, dying, diseased, interfering, objectionable and weak branches on the main trunk as well as those within the leaf area. An occasional branch up to one inch in diameter may remain within the main leaf area where it is not practical to remove.
   c. Class III Coarse Pruning: Coarse pruning consists of removing dead, diseased, or obviously weak branches, two inches in diameter or greater.
   d. Class IV Cutting Back or Drop Crotch Pruning: Cutting back or drop crotch pruning consists of reducing tops, sides, underbranches or individual limbs.

1) Undertake this practice only in cases of utility line interference, or where certain portions of the roots or root systems have been severely damaged, or when there is unusual and rapid tree growth, where it is necessary to reduce the top, sides or underbranches, or for specific topiary training or dwarfing.
2) When cutting back, do not reduce more than 1/3 of the total area as a single operation. When cutting back trees, only drop crotch as much as necessary. Make every effort to cut back to a lateral, one-third of the diameter of the cut being made.
3) In reducing overall size, give attention to the symmetrical appearance. Keep top higher and sides reduced in order to maintain a tree-like form.
4) Contact the Engineer prior to pruning a tree specified as Class I or Class II pruning if said pruning will reduce the surface area of the tree by more than 25 percent. Report tree structural problems.

2. Cut back dead, diseased and dying wood into healthy wood.
3. On trees known to be diseased, disinfect tools after use on each tree with methyl alcohol at 70 percent (denatured wood alcohol diluted appropriately with water) or Chlorox bleach solution.
4. Remove weak crotches, defined as split or rotted wood between two trunks of limbs that may break and fall during high wind.
5. Where branches cross and rub together or are forming a V-crotch, remove one branch without ruining the appearance of the tree.
6. Selectively prune trees which are developing more than one dominant leader in order to promote a single dominant leader by sub-dominating the other competitive branches. Make selection of the dominant leader with consideration of the tree's natural form, health, and structure.
7. Inspect old injuries. Where appropriate, trace those not closing properly and where callus growth is not already completely established.
8. Remove girdling roots.
9. Trimming for clearance:
   a. Trim trees to provide three feet of clearance from adjacent buildings and structures.
   b. For street trees and trees over walks, trails, and picnic areas over six inches diameter at breast height (dbh), remove lateral limbs and water sprouts from the main trunk of the tree to a height of 12 feet above the ground. For trees over 10 inches dbh, remove lateral limbs and water sprouts from the main trunk of the tree to a height of fourteen feet above the ground.
   c. Prune trees in the vicinity of electrical or phone lines so as to provide six to eight feet of clearance between lines and the nearest limb.
10. Remove branches with a slanting cut starting just above a vigorous bud or shoot and running back across the limb at a 45 degree angle. Make cuts sufficiently close to the trunk or parent limb, without cutting into the branch collar or leaving a protruding stub, so that closure can readily start under normal conditions. Make clean cuts.
11. Precut branches that are too heavy to handle to prevent splitting or peeling the bark. Where damage to other trees, foliage or property is possible, lower branches safely to the ground by ropes or equipment. Under no circumstances drop branches or main trunks freely onto a road, shoulder or paved surface.
12. Trim salvageable branches by removing smaller branches flush with the surface of the main branch.
13. Do not remove entire or large portions of healthy, sound limbs in order to facilitate the removal of dead or dying terminals.
14. Complete required pruning and removals at the site of each tree, including removal of logs and debris, before initiating work on the next tree.
15. Do not use chain saws or circular power blades to remove branches less than two inches in diameter.

16. Do not use wounding paint,
17. Do not use climbing hooks while pruning.

C. Tree and Stump Removal:
1. Take every reasonable precaution, including but not limited to topping, sectioning and lifting of trees, diagnosing soundness of existing wood, and planning escape routes for workers to prevent damage to other vegetation, property, utility lines and persons and to prevent gouging and erosion of soils as a result of removal operations.
2. Fell trees only when there is an adequate felling area at least equal in radius to the height of the tree. Top and remove in sections trees that cannot be felled due to proximity of buildings, conductors, adjacent trees, or lack of an adequate felling area.
3. Properly rope, guy, or anchor trees to be felled that may cause damage to property or existing vegetation.
4. Climbing hooks may be worn for tree removal work.
5. Remove stumps to a depth of 12 inches below grade. Backfill and level the stump hole with clean wood-waste material.
6. Completely remove each tree, including removal of logs and debris, before initiating work on the next tree.

D. Debris removal:
1. Cut branches over six inches into 18 to 24 inch lengths.
2. Chip material less than six inches in diameter.
3. Collect, deliver, and unload wood and chips to a location specified by the Engineer. If approved, chips may be blown into adjacent natural areas.
4. Remove wood, debris and chips on a daily basis. Sale of wood is not permitted on the project site.

3.05 INTERIM MAINTENANCE (UNTIL SCI):

A. While planting is in progress, perform interim maintenance and management practices on work completed. During the post-planting period and until the SCI, properly care for plants furnished; performing watering, cultivating, and other maintenance tasks necessary to keep the plants in a live, healthy condition.

B. Maintain plants and work incidental thereto by performing the following and other operations of care to promote root growth and plant health so that plants are in an approved condition throughout the interim maintenance period. Perform work in a manner which maintains the original intent of the reforestation and landscape design. Submit maintenance reports and schedules as specified.
1. Watering and draining: Water plants as required twice each month, or more frequently if weather conditions require such, as directed.
2. Weeding: Weed by hand the mulched area around each plant and within bedded areas, at least twice each month during the growing season. Remove weeds from the site immediately. As directed, approved chemical weed killers may be used with precautions to prevent undesired damage resulting from such use. Submit Herbicide spill plan and daily use log , when required by jurisdictional agency.
3. Pruning: Prune plants to ensure a desired growth habit and to remove dead wood, as directed and approved.
4. Mulching: Mulch to maintain the depth as indicated or as directed.
5. Securing stakes: Replace or adjust as necessary to maintain stability.

C. Periodically inspect plants during the interim maintenance period and notify the Engineer in writing of suspected problems. The Contractor is responsible for insect and disease control on Authority property. Take necessary measures to ensure effectiveness of the treatment and plant survival. Insect and disease control are the responsibility of the NPS and MNCPPC ,unless brought in by Contractor's plant source.

3.06 SOIL DENSITY ADJUSTMENT:

A. After completion of work and before Substantial Completion Inspection (SCI), have the soil-proctor testing along work routes and storage areas performed as required above under Submittals, Documentation.

B. Adjust unacceptably compacted soil to a maximum of 75 percent maximum dry density in accordance with the Engineer's directions and at no additional cost to the Authority. In root protection zone, use of decompaction machinery is unacceptable.

3.07 SUBSTANTIAL COMPLETION INSPECTION (SCI):

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

B. Do not remove tags, labels, etc. after SCI. These are needed during Concurrent Maintenance and Warranty period. Remove such identifications only at final acceptance.

C. SCI commences the Concurrent Maintenance and Warranty Period of the Contract for items accepted as of this inspection.

3.08 CONCURRENT MAINTENANCE AND WARRANTY PERIOD:

A. See warranty requirements in General Provisions, General Requirements, and specified in Part 1 of this section.

B. After the Engineer has accepted the completed work in accordance with SCI, perform post-planting maintenance and plant management concurrent with the warranty period. During this period, properly care for plants; performing the following and other beneficial operations of care for promotion of root growth and plant life so that each plant is in an approved condition at the Substantial Completion Inspection and throughout the maintenance period:

1. Watering and draining: Water plants as required twice each month. Every two weeks during the growing season, examine or sound the watering pipe at each plant to determine if too much water is collecting in the plant pit. Remove surplus water by pump or syphon without staining the pavement. Bi-weekly check relative moisture content of soil for typical tree and typical area of shrub or hedge planting; weekly during the months of July and August. Use Peerless Moisture Indicator, Tree-Type; or equal; following manufacturer's recommendations. Provide sufficient water to maintain relative moisture content of 25 to 30 percent. Provide water, fittings, hose, and water tanks as required to perform watering operation.
2. Weeding: As necessary, perform seasonal weeding in the mulched area around each plant and in bedded areas, at least twice each month. Pull roots by hand or use approved chemical weed killers . Submit Herbicide spill plan and daily use log, when required by jurisdictional agency. Correct any damage resulting from such use and no not spray when winds are over . Remove weeds from the site.

3. Controlling insects and diseases: Treat plants year-round with an approved chemical spray or systemic chemical as necessary to prevent insects, disease and fungus. Take necessary measures to ensure effectiveness of the treatment and plant survival. Submit Pesticide spill plan and daily use log, when required by jurisdictional agency. Protect vehicles and construction in the vicinity from damage or staining.
4. Pruning: Prune plants during each growing season to develop a desired growth habit and to remove dead wood.
5. Fertilizing: Fertilize trees, shrubs, hedge plants and groundcover once between May 15 and July 1 with 15-30-15 soluble fertilizer, or equal, at the manufacturer's recommended rate.
6. Edging: At least twice during the growing season, edge around the mulched area of each plant.
7. Mulching: Mulch to maintain the depth as shown.
8. Wrapping: Rewrap to maintain protection and a neat appearance. Remove wrapping at end of first winter period after planting as approved. Repair damaged areas previously covered by wrapping.
9. Securing guys and stakes: Replace or adjust to maintain stabilization. Before end of maintenance period, remove stakes and guys above grade.

C. Removing and Replacing Plants: After early Spring and early Fall seasonal inspections and written notification by the Engineer of the plant material to be removed and replaced, proceed as follows:
1. Remove or cut off at ground line said plant materials that are dead or in an unhealthy, unsightly or badly impaired condition, within three weeks after notification.
2. Replace the plant materials during the next specified planting season with healthy plants of the same kinds and sizes as originally specified. Make such replacements in the same manner as specified for the original planting. Notify the Engineer prior to performing the work.
3. Attach color-coded tag indicating replacement, and mark with the date of replacement in weather-resistant ink, keyed to the Plant Schedule shown. Securely attach tag to each plant in a manner that will not restrict growth. Maintain tag on plants until removal is directed by the Engineer.
4. Failure to notify Contractor of plant material to be removed or replaced does not relieve the Contractor from warranty obligations.

D. 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.

E. Clean-Up: Leave paved surfaces broom clean and stain free. Remove rubbish and debris caused by this work. Keep site clean during maintenance period.

3.09 FINAL ACCEPTANCE:

A. Prior to final acceptance, perform final cleanup, including removal of stakes above grade, guys, signs and other items as directed by the Engineer, and for remulching plants and beds to a loose measurement as specified. Place no mulch against a trunk or stem.

B. Cut off watering pipe projecting above the mulch level.

C. Replace rejected plants as specified.

D. Submit maintenance reports and schedules as specified.

E. Request inspection for final acceptance at least 10 days before the end of the Concurrent Maintenance and Warranty Period.

PART 4 - MEASUREMENT AND PAYMENT

4.01 BASIS:

A. Compensation for work specified in this section will be made in the following manner for work done satisfactorily based upon the lump sum price for the work of this section:
   1. Installation: 70-percent of lump sum price, pro-rated monthly during planting operations.
   2. Concurrent Maintenance and Warranty: 20-percent of lump sum price, pro-rated monthly or quarterly after planting operations.
   3. Final Acceptance: 10-percent of lump sum price, for satisfying Contract requirements pertaining to Final Acceptance.

TABLE 02930-1: MATERIALS SUBMITTAL CHART
This chart indicates the 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
Fertilizer	14 days	50 pounds (25 kilograms)	Sample of each type to be used in unopened container.
Mulch	7 days	10 pounds (5 kilograms)	- -
Crushed Stone	7 days	10 pounds (5 kilograms)	- -
Sand	7 days	10 pounds (5 kilograms)	- -
Plastic Pipe	7 days	3 feet (1 meter)	- -
Mulch Blanket	7 days	1 square yard (1 square meter)	Include staples.
Pea Gravel	7 days	10 pounds (5 kilograms)	- -

ITEM	TIME	QUANTITY	COMMENT
Plant Hormone	14 days	10 pounds (5 kilograms)	- -
Antidessicant	7 days	1 pint (0.5 liter)	- -
Tree Stakes and Guys	14 days	1 each	Sample of complete guying system to be used.
Wrapping Material	14 days	1 foot (30 centimeters)	Sample of complete wrapping system to be used.
Landscape Fabric and Weed Barrier	7 days	1 square yard (1 square meter)	- -
Marker Stakes	7 days	1 each	- -
Tree Grates and Guards	14 days	1 each	Sample of complete system to be used.
Perlite	14 days	10 pounds (5 kilograms)	- -
Peat Moss	14 days	10 pounds (5 kilograms)	- -
Limestone	14 days	50 pounds (25 kilograms)	Sample in unopened container.
Hedge Guard	14 days	6 feet (2 meters)	Sample of complete system to be used.

ITEM	TIME	QUANTITY	COMMENT
Topsoil	28 days	25 pounds (15 kilograms)	- -
Screened Leaf Mold	14 days	50 pounds (25 kilograms)	Sample in unopened container
Herbicide	14 days		Supply MSDS and use directions
Other Material	- -	- -	As directed.

END OF SECTION