



***Washington Metropolitan  
Area Transit Authority***

**Volume 2**

**CONTRACT SPECIFICATIONS**

**CONTRACT NO. FQ16078**

**STRUCTURAL RETROFIT OF B9 BEAM AT FARRAGUT  
NORTH METRORAIL STATION**

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Submitted By:



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**ENGINEER OF RECORD'S SEAL APPLYING TO THE FOLLOWING SPECIFICATION SECTIONS:**

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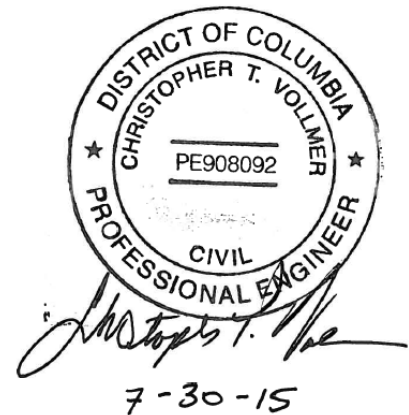
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**ENGINEER OF RECORD'S SEAL APPLYING TO THE FOLLOWING SPECIFICATION SECTIONS:**

<b>DIVISION 15</b>	<b>MECHANICAL</b>
15080	INSULATION
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## 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. Concrete formwork: Section 03100.
  - 3. Concrete reinforcement: Section 03200.
  - 4. Cast-in-place structural concrete: Section 03300.
- C. Definitions:
  - 1. Miscellaneous facilities include, but are not limited to, the following: heating, cooling and electrical facilities, vaults, entrance walkways, steps, platforms, curbs, walls, railings, benches, pylons, and ceilings.
  - 2. 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 benches, pylons and ceiling.
    - 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.

## **PART 3 - EXECUTION**

### **3.01 REMOVALS:**

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

### **3.02 CEILINGS:**

- A. Ceilings:
  - 1. Rebuild ceilings to match existing surface insofar as practicable.
  - 2. Complete restoration in accordance with approved working drawings.

### **3.03 BENCHES:**

- A. Benches:
  - 1. Remove, store and reinstall granite bench without damage in accordance with approved working drawings.

### **3.04 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:
    - a. 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 from other areas shown.
  - 2. Existing facilities include, but are not restricted to, station platform and other utility facilities located in the area to be cleared.
  - 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. Maintenance of Pedestrian access:
  - 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 pedestrians.
  - 2. Keep traffic areas free from debris and spillage of materials.
- B. Protection and Restoration:
  - 1. Prevent damage to pipes, conduits, wires, cables and structures above and below ground which are not designated for removal. Repair or replace damaged items.

#### 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 PLATFORM DEMOLITION:**

- A. Undertake rodent control and extermination program in demolition areas.
- B. Take possession of platform materials, fixtures and equipment in, attached to or belonging to, buildings and structures.
- C. Proceed with demolition of structure and appurtenances.

**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 03013

### EXTERNALLY BONDED CFRP CONCRETE STRENGTHENING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This specification is intended to define the minimum requirements of structural strengthening using externally bonded fiber reinforced polymer (FRP) composite systems.
- B. The work includes the furnishing of all materials, labor, equipment and services for the supply, installation and finish of all structural strengthening using externally bonded FRP systems.
- C. The general contractor or subcontractor shall furnish all materials, tools, equipment, transportation, necessary storage, access, labor and supervision required for the proper installation of the externally bonded FRP systems.

##### 1.02 QUALITY ASSURANCE

- A. Codes, Regulations, Reference Standards and Specifications:
  1. Comply with codes and regulations of the jurisdictional authorities.
  2. ACI: 440.2R-08, 440.R-07, 440.R-96, 503.R
  3. ICRI: Guideline No. 03742, Guideline No. 03739
  4. ASTM: D638, D648, D790, D2563, D3039.
- B. Quality Control procedures performed by the Manufacturer shall include, but not be limited to the following:
  1. The Manufacturer shall have a nationally recognized program of contractor training, certification and technical support.
  2. The Manufacturer shall have minimum ten years experience in FRP Reinforcement confirmed by actual field tests of minimum 100 successful installations.
  3. The Manufacturer shall be able to supply testing data to demonstrate system properties and durability of the actual FRP Reinforcement to be used.
- C. Quality Control procedures performed by the Contractor shall include, but not be limited to the following:
  1. The Contractor shall be trained by the Manufacturer and shall have completed a program of instruction in the use of FRP Reinforcement.
  2. The Contractor shall have a minimum of two years experience in FRP Reinforcement confirmed by actual field tests of at least 5 successful installations.
  3. The Contractor shall inspect all materials prior to application to assure that they meet specifications and have arrived to the job-site undamaged.
  4. The FRP Reinforcement shall be completely inspected by the contractor during and immediately following application of the composite materials. Conformance with the design drawings, proper alignment of fibers and quality workmanship shall be assured. Entrapped air

shall be released or rolled out before the epoxy sets. Defects shall be noted in the Daily Construction Log.

5. After FRP Reinforcement has cured, the contractor shall inspect the all work to check for voids and or debonding. Repairs shall be made as per Par. 3.07 Repair of Defects, and noted in the Daily Construction Log.

### **1.03 SUBMITTALS**

- A. Submit for record Material Safety Data Sheets (MSDS) of each product, used on site.
- B. Submit product data indicating product standards, physical and chemical characteristics, environmental durability, technical specifications, limitations, installation instructions, and general recommendations regarding each material for approval.
- C. Submit for record, a qualification statement by the Contractor listing their completed FRP Reinforcement projects, including size, location, owner, engineer/architect and contact numbers.
- D. Submit for record a complete description of the FRP Reinforcing system materials, surface preparation, application procedures, application rates, and cure times.
- E. Submit for record copies of purchase order and packaging slips showing quantities and dates of primer and resin purchased.
- F. Submit for review and approval shop drawings including, the following:
  1. Limits of FRP Reinforcing.
  2. Complete system details including, but not limited to, FRP Reinforcement, primer, resin, and protective coating.
- G. Submit for record test results of the Pull-off test to determine FRP adhesion to concrete substrate.
- H. Submit for record Daily Construction Logs kept by the Contractor. These logs shall include the following information: Weather and temperature at application times; Amount of product used and square footage/linear footage of substrate covered; Batch numbers of all products used; Names of all crew members; Any bond-strength tests, noting location, quantity and who performed these tests.
- I. Submit an approved ICC Evaluation Report in the name of the proposed FRP system to be used on this project.
- J. Submit independent test report verifying the environmental durability of the proposed system to be used on this project. Such reports shall include as a minimum:
  1. 10,000 hr. resistance to salt water
  2. 10,000 hr. resistance to high temperature (38C) and high humidity (100%)
  3. 10,000 hr. resistance to alkali solution (pH 9.5)
  4. 3,000 hr. resistance to dry heat (60C)
  5. resistance to 20 freeze/thaw cycles
  6. resistance to UV/condensation @ 100 cycles
  7. resistance to diesel fuel (4 hr. exposure)

### **1.04 JOB SITE CONDITIONS**

- A. Do not apply FRP Reinforcement materials if existing concrete surface is wet or if the ambient or surface temperature is below 40° F.

- B. The ambient temperature and temperature of the epoxy components shall be between 50° F (10°C) and 80° F (27°C) at the time of mixing. See appropriate technical data sheets for more specific instructions.
- C. Precautions should be taken to avoid damage to any surface near the work zone due to mixing and handling of the specified material.
- D. Relative humidity at the time of FRP application should be in the range of 65%-82%.
- E. The Contractor is solely responsible for fume control and shall take necessary precautions against injury to Installer personnel or adjacent building occupants during application of primer and resin, etc. Contractor personnel shall use protective equipment and area shall be well vented to the outside. As a minimum, Installer must take the following precautions:
- F. Contractor to locate and protect building air intake during application.
- G. Contractor to follow all state, federal, and local safety regulations.
- H. Contractor to follow all Manufacturers' safety requirements as indicated on appropriate MSDS sheets.

#### **1.05 PRODUCT DELIVERY, STORAGE AND HANDLING**

- A. All components of the FRP system, especially fiber sheets, must be handled with care according to the manufacturer recommendations to protect them from damage and to avoid mis-alignment or breakage of the fibers by pulling, separating or wrinkling them or by folding the sheets. After cutting, sheets shall be either stacked dry with separators, or rolled gently at a radius no tighter than 12 in. or as recommended by the Manufacturer.
- B. Deliver primer, saturant and protective coating in original, unopened containers with the Manufacturer's name, labels, product identification, and batch numbers.
- C. FRP Reinforcement shall be stored in a cool dry area away from direct sunlight, flame, moisture, or other hazards.
- D. Store primer, saturant and protective coating under conditions as recommended by the Manufacturer in a cool dry place out of direct sunlight. Products that have exceeded their shelf life shall not be used.
- E. Contractor is required to confirm that all materials used in accordance with this Section conform to local, state, and federal environmental and worker's safety laws and regulations.
- F. During operations Contractor shall maintain barricades.
- G. The Contractor shall properly dispose of empty containers in accordance with local regulations.

### **PART 2 – PRODUCTS**

#### **2.01 FRP REINFORCEMENT FABRIC AND/OR LAMINATE**

FRP Reinforcement fabric shall be high strength, high modulus, fiber fabric that may be unidirectional or woven (in various fiber architectures) to suit specific repair needs.

- A. FRP Reinforcement fabric shall be of the type, size, layer and location as indicated on the Drawings.
- B. FRP Precured Strip, shall meet the following minimum requirements:
  - 1. Laminate Tensile Strength (in primary fiber direction) – 250 ksi (ASTM D3039)
  - 2. Laminate Tensile Modulus (in primary fiber direction) –  $16.7 \times 10^3$  ksi (ASTM D3039)
  - 3. Laminate Elongation at break – 1.50 % (ASTM D3039)
  - 4. Laminate Thickness – 0.045 in.
  - 5. Fiber Volume – 50% (ASTM D2563)

## **2.02 CONCRETE SURFACE PRIMER**

- A. Surface Primer shall be a two component, 100% solids, moisture/tolerant, high modulus, high strength epoxy.
- B. Surface Primer shall meet the following minimum requirements:
  - 1. Tensile Strength – 5 ksi (ASTM D638)
  - 2. Tensile Modulus – 250 ksi (ASTM D638)
  - 3. Elongation at break – 3.0% (ASTM D638)
  - 4. Flexural Strength – 11.5 ksi (ASTM D790)
  - 5. Flexural Modulus – 500 ksi (ASTM D790)
  - 6. Heat Deflection Temperature (HDT) – 117 F (ASTM D648)

## **2.03 FABRIC SATURANT**

- A. Saturant resin shall be two component, 100% solids, moisture tolerant, high strength, high modulus epoxy.
- B. Saturants shall meet the following minimum requirements:
  - 1. Tensile Strength – 5 ksi (ASTM D638)
  - 2. Tensile Modulus – 250 ksi (ASTM D638)
  - 3. Elongation at break – 3.0% (ASTM D638)
  - 4. Flexural Strength – 11.5 ksi (ASTM D790)
  - 5. Flexural Modulus – 500 ksi (ASTM D790)
  - 6. Heat Deflection Temperature (HDT) – 120 F (ASTM D648)

## **2.04 EPOXY REPAIR MORTAR**

- A. Repair mortar shall be 100% solids, non-sag paste epoxy.

## **2.05 PROTECTIVE COATING**

- A. Protective coating shall be polymer or acrylic based and shall be UV resistant.

## **PART 3 – EXECUTION**

### **3.01 GENERAL**

- A. Inspect surfaces to receive the work and report immediately in writing to the Contracting Officer Representative as required in the General Conditions and deficiencies in the surface that render it unsuitable for proper execution of this work.

- B. Protect vehicles, concrete, and other items surrounding work area from dust or damage due to Work of this Section.
- C. Mixing and application of primer and saturant shall occur only when the station is closed and completely vacated of patrons.

### **3.02 SURFACE PREPARATION**

- A. All concrete surfaces shall be dry and free of surface moisture and frost, and tested by the Contractor to evaluate moisture transmission in accordance with ASTM D4263 "Indicating Moisture in Concrete by the Plastic Sheet Method."
- B. All concrete surfaces shall be sound. Remove deteriorated concrete, dust, laitance, grease, paint, curing compounds, waxes, impregnations, foreign particles, and other bond inhibiting materials from the surface by blast cleaning or equivalent mechanical means.
- C. All concrete surfaces shall be air blasted and vacuumed clean to a dust free condition.
- D. Concrete surface irregularities less than one inch shall be ground and smoothed and/or filled with an approved repair mortar with the addition of 1 part oven dried sand to make an epoxy mortar. Surface irregularities shall be limited to less than 0.04 inches (1 mm). Surface irregularities greater than one inch shall be repaired using an approved cementitious repair mortar.
- E. External concrete corners shall be rounded to at least a 1/2" radius when perpendicular to fiber orientation and internal corners shall be smoothed by trowelling epoxy mortar into the corners.
- F. The adhesive strength of the concrete shall be verified after preparation by random pull-off testing (ACI 503R) at the direction of the Contracting Officer Representative. Minimum tensile strength is 200 psi with concrete substrate failure, or as approved by the Contracting Officer Representative.

### **3.03 MIXING PRIMER AND SATURANT**

- A. Mix components in accordance with Manufacturer's recommendations.
- B. Diluting is not permitted. Pre-condition materials as indicated on technical data sheet.
- C. Mix only that quantity which can be used within its pot life.
- D. Do not batch delivered units into smaller quantities. Mix only full units.

### **3.04 PRIMER APPLICATION**

- A. Apply primer in accordance with Manufacturer's recommendations.
- B. Primer may be applied with a brush or roller. Apply second coat as necessary after first coat has penetrated into concrete.
- C. Surface depressions shall be filled with epoxy filler per manufacturers' instructions.
- D. Primer must be covered with fiber within 24 hours of application, depending on temperature conditions. If 24-hour window is exceeded, the primed surfaces must be solvent wiped with a fast flashing solvent or roughened with sandpaper to break the amine blush.

### **3.05 FRP REINFORCEMENT APPLICATION**

#### Precured Strip Application:

- A. Apply FRP Precured Strip in accordance with Manufacturer's recommendations.
- B. Care shall be taken not to damage the fibers in handling and unpacking the Strips.
- C. Strips may be either delivered to project site in factory pre-cut lengths, or cut on site. Care must be taken not to fray or otherwise damage the fibers when field cutting. Follow Manufacturer's recommendations for field cutting of strips.
- D. Strips shall be cleaned with a fast flashing solvent to remove any bond inhibiting materials. A clean white cotton rag shall be used for this purpose. Continue cleaning the Strip in this manner until no black residue shows on the rag. Cleaning shall be performed in a well ventilated area outside of the station the same day the strips are to be used.
- E. Any entrapped air between fiber sheet and concrete surface shall be released or rolled across the sheet in the direction parallel to the fibers, while allowing the resin to impregnate the fibers and achieve intimate contact with the substrate. Rolling perpendicular to the fiber direction is not allowed.

### **3.06 CURING**

- A. Protect finished installation of FRP Reinforcement from rain, sand, dust, etc. using protective sheeting or other barriers. Do not allow protective sheeting to come in contact with finished application.
- B. Curing of finished application shall be a minimum of 24 hours and in order to achieve full strength curing shall be extended for a period of two weeks at an average ambient temperature of 68°F.

### **3.07 REPAIR OF DEFECTS**

- A. Upon completion of the curing process, the installed system shall be checked for areas where saturant has not penetrated or where saturant has not completely cured. Such areas shall be epoxy injected to re-establish bond subject to the approval of the Contracting Officer Representative.
- B. Repair procedures shall be performed in accordance with guidelines established by ACI 440.2R-08 (paragraph 7.2.3) and approved by the Contracting Officer Representative. All repairs shall be subject to the same application, curing and quality control specifications as the original work.
  1. Small delaminations and voids less than 2 in<sup>2</sup> each are permissible as long as the delaminated area is less than 5% of the total laminate area and there are no more than 10 such delaminations per 10 ft<sup>2</sup>.
  2. Medium sized delaminations and voids greater than 2 in<sup>2</sup> but less than 25 in<sup>2</sup> may be repaired by epoxy resin injection or ply replacement, depending on the size and number of delaminations and their location. The repair procedure should be determined by the Contracting Officer Representative.
  3. Larger size delaminations and voids greater than 25 in<sup>2</sup> should be repaired by selectively cutting away the affected sheet and applying an overlapping sheet patch of equivalent plies. The overlap should extend a minimum of 6 in. in all directions.

### **3.08 PROTECTIVE COATING**

- A. Apply protective coating in accordance with Manufacturer's recommendations.



**3.09 CLEANING**

- A. Uncured saturants may be cleaned from tools with an approved solvent and properly disposed.
- B. Cured saturants shall be removed by mechanical means and properly disposed.

**END OF SECTION**

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## SECTION 03100

### CONCRETE FORMWORK

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies formwork for concrete structures and other facilities.
- B. Related Work Specified Elsewhere:
  - 1. Concrete reinforcement: Section 03200.
  - 2. Cast-in-place structural concrete: Section 03300.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ACI: 347, Publication # 4
  - 3. Western Woods Producers Association : Western Lumber Grading Rules.
  - 4. CE: CRD-C 572.
  - 5. AASHTO: M153.
  - 6. ASTM: D1056, D1149, D1692.
  - 7. APA: HDO Plywood Exterior Grade.
  - 8. U.S. Product Standard : PS 1
- B. Responsibilities:
  - 1. Design and construction of formwork is the responsibility of the Contractor, subject to review by the Engineer.
- C. Design Criteria:
  - 1. Design formwork for vertical loads and lateral pressures in accordance with ACI 347.
  - 2. Design formwork system which is adequately braced and has adequate strength and stability to ensure finished concrete within the specified tolerances.
  - 3. When necessary to maintain the specified tolerances, design camber into the formwork to compensate for anticipated deflection and creep due to the weight and pressure of the fresh concrete and construction loads.

##### 1.03 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Working Drawings:
    - a. Include details of form types, methods of form construction and erection, design computations and location of form joints and form ties, location and dimensions of blockouts and openings in structure, and embeds.
  - 2. Samples:
    - a. Each type of premolded expansion-joint filler proposed for use, each six inches by 12 inches: Two.
    - b. Snap-off form ties: Two.
  - 3. Certification:

- a. Manufacturer's certificates.
- b. Certified test reports of specified concrete tests.
- 4. Documentation:
  - a. Calculations: Early form removal calculations as specified certified by a professional engineer registered in the area where the work is to be performed. Submit in advance for obtaining approval prior to form removal.

## PART 2 - PRODUCTS

### 2.01 MATERIALS:

- A. General:
  - 1. Wood forms:
    - a. All framing lumber stress-graded.
    - b. Lumber in direct contact with concrete, dressed on at least the contact side, with dressed or tongue-and-groove edges; other lumber may be dressed or rough.
    - c. Where vertical board finish is shown or specified, use the following:
      - 1) Form board: Tongue-and-groove, Number 1 Common or better, Ponderosa or White pine, in accordance with the Western Lumber Grading Rules book published by WWPA (not the Southern Pine Inspection Bureau grading rules), one-inch nominal thickness, four-inch nominal width, groove S2S milled or beveled one side only and center matched with 45-degree beveled edges to produce sharp V-shaped 3/8-inch wide in concrete. Four-inch tongue-and-groove boards to be toenailed at edge or face-nailed to backer board.
      - 2) Smooth concrete: Tongue-and-groove, square cut unturned edges, Number 1 Common or better, Ponderosa or White pine, in accordance with the Western Lumber Grading Rules book published by WWPA (not the Southern Pine Inspection Bureau grading rules), one-inch nominal thickness, four inches nominal width, S2S and center-matched.
  - 2. Plywood forms:
    - a. APA grade-marked:
      - 1) B-B Plyform Exterior grade Group I or II for unexposed finished concrete.
    - b. APA High-Density Overlay (HDO) plywood;
      - 1) B or better face veneer Exterior grade Group I for exposed to public view finished concrete..
    - c. USPS : PS 1
  - 1. Fibrous-glass reinforced plastic forms:
    - a. One-piece dome system forms, fabricated of plastic reinforced with fibrous glass.
    - b. Molded under heat and pressure using matched metal dies.
    - c. Special sizes and cross sections with thickness, reinforcement and surface finish as necessary to form concrete surfaces that are smooth and free of irregularities.
  - 2. Steel forms:
    - a. One-piece dome system forms.

- b. Special sizes and cross sections as shown, with metal gauges, reinforcement, stiffeners and surface finish as necessary to form concrete surfaces that are smooth and free of irregularities and concrete stain.
3. Hardboard:
  - a. For concrete not exposed to public view: tempered, smooth-one-side (S1S) panels not less than 3/16-inch thick, in accordance with AHA IS 1.
4. Form ties:
  - a. Factory-fabricated, snap-off metal type, of adequate design to minimize form deflection and preclude concrete spalling upon removal.
  - b. Fabricated so that set-back in concrete is such that portion of tie remaining after snap-off and removal of exterior portions is at least 1-1/2 inches below concrete surface.
5. Form release agent: Chemically reactive liquid product that will not bond with, stain, or impair concrete surfaces. Follow form panel manufacturers approved product and recommendations for application. Agents containing castor oil are prohibited
6. Preformed expansion joint filler: AASHTO M153.
  - a. Type I: Sponge rubber.
  - b. Type II: Cork. Type III: Self-expanding cork.
7. Dovetail-anchor slots: 22-gauge electrogalvanized steel, with removable felt filler.
8. Chamfer strips: Except where other sizes are shown, 3/4-inch by 3/4-inch triangular fillets milled from clear, straight-grain pine, surfaced-each-side, or extruded-vinyl tape.
9. Miscellaneous preformed strips for reveals, rustications and similar joints: Fabricated of wood, metal, plastic or other approved material formed to cross sections shown.
1. Bonding adhesive: As recommended by manufacturer of premolded elastic filler.

### **PART 3 - EXECUTION**

#### **3.01 CONSTRUCTION AND WORKMANSHIP:**

- A. Concrete finishes and usage locations of various types of forms and form lining: As shown or specified.
- B. Unless otherwise shown for concrete surfaces exposed to public view, use HDO Plywood in largest practicable continuous panels to produce plane, smooth surface free from grain imprint, patchmarks, and discoloration.
- C. Construct adequately braced formwork so that resulting concrete surfaces conform to specified tolerances.
- D. Brace forms, falsework and centering adequately to retain forms in position as shown on approved working drawings.
- E. Provide mortar-tight forms of wood, plywood, fibrous-glass-reinforced plastic, steel or other approved materials which conform to shapes, lines and dimensions shown and produce smooth surface without fins and projections.
- F. Where shown or directed because of lagging or form irregularity, and where concrete surfaces will not be exposed to public view, line inner form surfaces with hardboard as follows:
  1. Use widest available width of hardboard.
  2. Line areas less than four feet wide with single-width piece of hardboard.
  3. Offset lining joints from those in backing.
  4. Fasten securely to backing with galvanized or aluminum nails driven flush.

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

**3.02 FIELD QUALITY CONTROL:**

- A. Allowable Tolerances:
  - 1. Construct elements except concrete linings of tunnels to meet allowable tolerances of dimensions, elevations and positions shown and specified in Section 03300.

**3.03 COATING FORMS:**

- A. Lightly coat form panels with chemically reactive release agent prior to initial concrete placement and before each subsequent placement.
- B. Do not allow excess coating material to stand in puddles in forms nor to come into contact with concrete against which fresh concrete is to be placed.
- C. Coat with release agent bolts and rods that are to be completely removed or to be free to move

**3.04 EMBEDDED ITEMS:**

- A. Ensure that items to be embedded in concrete are free from oil and foreign matter that would weaken bond of concrete to such items.
- B. Install in formwork inserts, anchors, sleeves and other items specified elsewhere. Close ends of conduits, piping and sleeves embedded in concrete with caps or plugs.
- C. Complete tests on piping and other items before starting concrete placement.
- D. Before depositing concrete, check location and support of piping, electrical conduits and other items which are to be wholly or partially embedded.

**3.05 OPENINGS AND RECESSES IN CONCRETE:**

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

**3.06 JOINTS:**

- A. Unless otherwise directed, make contraction, expansion and construction joints only where shown. Where concrete will be exposed to public view, use largest practicable size sheets to minimize joints.
- B. Form keyways as shown.
- C. Continue reinforcing steel and wire fabric across joints unless they are shown as being free to move.
- D. Make maximum distance between transverse contraction joints 50 feet or as shown, as measured along centerline of track on tangent alignment.

- E. Install premolded joint filler at locations shown. Extend filler from bottom of concrete up flush to finish concrete surface or hold down below finish surface as shown.
- F. Make splices in premolded filler in manner to preclude penetration of concrete between joint faces.
- G. Where premolded joint filler is held below finish concrete face, install in the form a water-soaked wood strip of dimensions shown, to form, after removal, proper size slot to receive sealant compound specified in Section 07900.

**3.07 REMOVAL OF FORMS, FALSEWORK AND CENTERING:**

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

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Structural Member	Minimum Percentage of Specified Design Strength	
	Schedule 1	Schedule 2
Footings; inverts; sides of beams; slabs and girders; slabs and beams on grade	25	20
Free-standing walls, columns and piers	40	30
Cut-and-cover box structure exterior walls; retaining walls	50	30
Cut-and-cover box structure roofs	80	40
Stairways	80	60
Soffits, beams, slabs and girders; clear span between supports,		
under 20 feet	80	60
over 20 feet	90	70
Tunnels, except intersecting sections	80	35

Station arches, except intersecting sections	80	40
Cantilevers	90	70

- B. Early removal of forms, falsework and centering will not be allowed for concrete strength values below Schedule 2, but will be allowed for concrete strength values between Schedule 1 and Schedule 2 only after:
1. The Engineer has approved calculations showing anticipated concrete strengths at time of proposed early removal based on:
    - a. Ratio of dead load over live load.
    - b. Span, height and shape.
    - c. Ratio of rise over span.
    - d. Reshoring.
    - e. Loads, resultant stresses and deformations to which concrete and reinforcing steel will be subjected at time of removal, subsequent to removal and until concrete has attained design strength.
    - f. Prevailing site conditions.
  2. Concrete strength attained prior to form removal has been determined by analysis of quality-assurance data in accordance with Section 03300.
- C. Do not remove wood board forms within 48 hours of pouring concrete.
- D. Do not alter loading conditions on concrete subsequent to removal of forms if it results in exceeding permissible stresses and deformations at attained concrete strengths.
- E. The Engineer may permit early removal of concrete support without submittal of calculations prior to attainment of specified design strength if he considers such submittals to be unnecessary.

**END OF SECTION**



## SECTION 03200

### CONCRETE REINFORCEMENT

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies reinforcement for concrete structures and other facilities.
- B. Related Work Specified Elsewhere:
  - 1. Concrete formwork: Section 03100.
  - 2. Cast-in-place structural concrete: Section 03300.
- C. Definitions:
  - 1. Cover: Thickness of concrete between outside surface of reinforcement and outside face of concrete.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ACI: SP-66, 318.
  - 3. CRSI: Manual of Standard Practice; Placing Reinforcing Bars.
  - 4. AASHTO: Standard Specifications for Highway Bridges.
  - 5. ASTM: A82, A185, A615, A775, A706.
- B. Allowable Tolerances:
  - 1. Cut and bend reinforcing steel to conform to dimensions shown within the following tolerances:
    - a. Sheared length: Plus-or-minus one inch.
    - b. Depth of truss bars: Plus zero or minus 1/2 inch.
    - c. Stirrups, ties and spirals: Plus-or-minus 1/2 inch.
    - d. All other bends: Plus-or-minus one inch.

##### 1.01 SUBMITTALS:

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Shop Drawings:
    - a. Detail reinforcing in accordance with ACI SP-66.
    - b. Bar lists showing the individual weight of each bar, total weight of each bar size and total weight of bars on list. Base calculated weights on theoretical unit weights shown in ASTM A615, Table 1.
    - c. Details showing bonding of reinforcement for stray current and cathodic protection.
  - 2. Certification:
    - a. Manufacturer's certificates.
    - b. Mill tests on each heat showing chemical and physical analyses performed in accordance with ASTM A615, as modified by ACI 318.
    - c. Record of mill tests traceable to individual reinforcement bars supplied to the project.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Ship reinforcing steel in bundles limited to one size and length.
- B. Tag each bundle at mill with waterproof tag showing name of mill, heat number, grade and size of bars and identifying number.
- C. Protect reinforcing steel and wire fabric from damage; foreign matter such as dirt, oil and grease; and rust-causing conditions.

#### **PART 2 - PRODUCTS**

##### **2.01 MATERIALS:**

- A. Reinforcing Steel Bars:
  - 1. ASTM A615, Grade 60, modified in accordance with ACI 318.
  - 2. Epoxy Coating: ASTM A775, as shown.
- B. Welded Steel-Wire Fabric: ASTM A185.
- C. Metal Accessories: As recommended by CRSI Manual of Standard Practice. Where concrete surfaces will be exposed to public view in finish structure, use supports with plastic-protected legs or stainless steel legs.

#### **PART 3 - EXECUTION**

##### **3.01 CUTTING AND BENDING:**

- A. Perform cutting and bending in the shop. Bend steel cold. Do not bend or straighten bars so as to damage material.
- B. Do not bend bars in the field except to correct minor errors and damage occurring during shipping and handling.

##### **3.02 BAR SUPPORTS AND SPACERS:**

- A. Support bars by means of bolsters or chairs with no less than minimum required by ACI SP-66.
- B. Reinforcing steel in bottom of slabs resting on earth may be supported by concrete brick or mortar blocks.
- C. In walls, columns, piers and abutments hold reinforcing steel in position by means of mortar blocks, bar supports or spacers wired to reinforcing steel.
- D. Do not use stones, clay bricks, wood blocks or pieces of broken concrete to support reinforcing steel.
- E. Do not place bars or fabricated mats on layers of fresh concrete as work progresses.

##### **3.03 PLACING AND FASTENING:**

- A. Arrange and place reinforcing steel as shown.
- B. Secure reinforcement positively against displacement during placing of concrete.
- C. Wire or clip bars together as recommended in CRSI Placing Reinforcing Bars.
- D. Maintain reinforcing steel accurately in locations shown in tops of inverts to permit arrangements of anchor bolts for rail-tie plates.
- E. Before placement, ensure that reinforcement is free from dirt, mill scale, rust scale, oil, grease and other foreign matter.

**3.04 SPLICING:**

- A. Furnish reinforcing bars in full lengths as shown on the Contract Drawings and approved shop drawings.
- B. Do not splice bars unless approved in writing.
- C. Make splices when authorized, in accordance with ACI 318.

**3.07 INSPECTION:**

- A. Placement of concrete prior to approval of reinforcement is prohibited.

**3.08 CONCRETE PROTECTION FOR REINFORCEMENT (COVER):**

- A. Other Underground Structures:
  - 1. Outer-face steel: Three inches.
  - 2. Inner-face steel: Two inches.
  - 3. Drainage slot: Two inches.
  - 4. Safety walk: 1-1/2 inches.
  - 5. Beams, girders and columns: 1-1/2 inches.
  - 6. Intermediate floors, platform and slabs and stairs: 3/4 inch.

**3.09 EPOXY COATING:**

- A. Preparation of surface: Perform the following in order given:
  - 1. Clean surface contaminated with oil and grease using naphtha or xylol.
  - 2. Remove weld slag, rust and mill scale from surfaces by wire brushing.
  - 3. Coat surfaces immediately with methyl-methacrylate primer.
  - 4. Apply coating only to surfaces which are dry and free of contaminants.

**END OF SECTION**

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## SECTION 03300

### CAST-IN-PLACE STRUCTURAL CONCRETE

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing portland-cement cast-in-place concrete.
- B. Related Work Specified Elsewhere:
  - 1. Concrete formwork: Section 03100.
  - 2. Concrete reinforcement: Section 03200.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. ACI: 201.2R, 211.1, 304, 309, 318, 318.1.
  - 3. AASHTO: M182, T26.
  - 4. NBS: Handbook 44.
  - 5. USBR: Concrete Manual.
  - 6. FS: A-A-341A, HH-I-521, K-P-146.
  - 7. ASTM: A43, A47, A48, C31, C33, C39, C40, C42, C87, C88, C94, C131, C150, C171, C172, C260, C295, C309, C311, C330, C494, C535, C586, C595, C618, C665, C685, C881, C989, C1107, C1260, D98, E328.
  - 8. CPMB (Concrete Plant Manufacturer's Bureau): Concrete Plant Standards.
- B. Testing Laboratory:
  - 1. Furnish the services of an independent testing laboratory. Employment of an independent laboratory does not relieve the Contractor of the obligation to perform the work in accordance with requirements of the Specifications and Drawings. Submit certified results of the tests performed.
  - 2. Furnish proof that the laboratory satisfies the requirements of the American Council of Independent Laboratories' Recommended Requirements for Independent Laboratory Qualification. Laboratory need not be a member of the American Council of Independent Laboratories.
  - 3. Certify that testing equipment has been calibrated by an accredited calibration agency at not more than 12-month intervals using devices of accuracy traceable to the National Institute of Standards and Technology (NIST) or accepted values of material physical constants
- C. Properties of Concrete:
  - 1. General:
    - a. Design mixes to produce concrete of proper workability, durability, strength, maximum density, minimum shrinkage and permeability.
    - b. Design mixes to have minimum water content per cubic yard of concrete, cement content corresponding to appropriate water-cement ratio, largest permissible maximum size specified of coarse aggregate available and optimum percentage of fine aggregate.
    - c. Use maximum size of coarse aggregate in accordance with ACI 211.1.
    - d. Use same brand from same source throughout the work.

- e. Use aggregates from same source throughout the work.
- f. Use ground-iron blast-furnace slag and fly ash from the same sources respectively throughout the work.
- 2. Durability:
  - a. Maximum water cementitious materials ratio as per ACI 318, Chapter 4 and ACI 201.2R.
  - b. Use a suitable combination of approved air-entraining admixture and water reducer to reduce water content and permeability of the concrete, provided such admixtures do not adversely affect other specified properties of concrete.
- 3. Workability:
  - a. Use approved chemical admixtures as needed for workability so that concrete can be placed, consolidated, and finished without segregation or excessive bleeding.
- 4. Strength:
  - a. Design mix for each class and type of concrete of each specified strength based on overdesign factor in accordance with ASTM C94. Unless otherwise shown, working-stress method applies to structures.
  - b. Design each class of concrete in accordance with the following:
    - 1) Not more than the following percentages of strength tests to have values less than specified strength:
    - 2) Working-stress method: 20 percent.
    - 3) Ultimate-strength method: 10 percent.
    - 4) Average of the following numbers of consecutive strength tests to be equal to or greater than specified strength:
      - a) Working-stress method: Six.
      - b) Ultimate-strength method: Three.
  - c. When number of tests totals six or less, average to be in accordance with Note 21 of ASTM C94.
- 5. Appearance:
  - a. Cured concrete exposed to public view shall be uniform in color, texture and finish with no discernible form or patch marks, grain imprint, joint irregularities or discoloration. Use only manufacturer approved chemically reactive release agents on HDO plywood forms.
  - b. Final selection and approval for color shall be made by the Engineer.
- D. Method of Proportioning:
  - 1. Proportion mixes as described in ACI 211.1.
  - 2. Approximate mixing-water and air-content requirements for mixes of different slumps and nominal maximum sizes of aggregates as specified in ACI 211.1, Table 5.3.3.
  - 3. Do not vary proportions of ingredients of approved mixes without written approval.

A. Ready-Mixed Concrete: ASTM C94.

### 1.03 SUBMITTALS:

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

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

- 4) Design concrete mix for protection against alkali-aggregate reactivity.
- 5) The Contractor may present for approval a concrete mix previously approved for Authority work provided such mix is made with proposed ingredients that meet requirements and provided that concrete has complied with compressive-strength requirements based on control record of at least 30 consecutive-strength tests recently obtained.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

##### **A. Aggregates :**

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

##### **B. Packaged Cement:**

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

##### **A. Ready-Mixed Concrete: ASTM C94.**

##### **B. Blast-Furnace Slag or Fly Ash for use with Portland Cement:**

1. Transport in covered carriers.
2. Store in watertight bins or silos to provide protection from dampness and contamination. When compartmented bins are used, conduct periodic, but not less than weekly checks between adjacent bins to avoid contamination of either of the stored materials.

##### **C. Concrete Additives, Sealers and Corrosion Inhibitor . As required by the manufacturer.**

#### **1.05 WARRANTY**

- ##### **A. Penetrating Concrete Sealer: Provide a minimum effective service life warranty of 10 years for the penetrating concrete sealer.**

### **PART 2 - PRODUCTS**



**2.01 MATERIALS:**

- A. Cementitious Materials:
1. Portland Cement: ASTM C150, Types I and II. Use Type II only for underground structures.
    - a. Alkali content not to exceed 0.6 percent.
- B. Ground-Iron Blast Furnace Slag: ASTM C989, Grade 100 or 120.
- C. Fly Ash: ASTM C311 and ASTM C618, Class F:
1. Loss on ignition not to exceed 4 percent.
  2. Maximum available alkalis (for combination of cement and fly ash) not to exceed 0.6 percent based on proportions to be used and alkalinity measurements for cement and fly ash individually or in combination.
    - a. Fly ash used to be qualified for each source.
  3. Uniform color when used in concrete exposed to public view.
- D. Aggregates:
1. Aggregates for normal concrete: ASTM C33 with the following additional requirements:
    - a. Coarse aggregate: Gravel, crushed gravel or crushed stone.
      - 1) Deleterious substances:

<u>Substance</u>	<u>Maximum Allowable Percentage by Weight</u>
(1) Soft particles:	5.0
(2) Coal and lignite particles:	0.5
(3) Friable particles:	0.25
(4) Material passing Size 200 sieve:	1.0
(5) Thin or elongated pieces:	15.0
(6) Other local deleterious substances:	1.0
      - b) Soft particles: Higher percentage may be approved where concrete is not subject to abrasion, provided concrete strength is achieved without the use of excess cement.
      - c) Crushed aggregates: If material finer than Number 200 sieve consists of dust of fracture essentially free from clay or shale, percentage may be increased to 1.5.
      - d) Thin or elongated pieces: Length of pieces to be greater than five times the smallest dimensions of a circumscribing rectangular prism.
    - 2) Percentage of wear: 45 maximum when tested in accordance with ASTM C131 and ASTM C535.

- 3) Weighted percentage of loss: 15-percent maximum by weight when subjected to five cycles of magnesium sulphate soundness test in accordance with ASTM C88.
  - 4) Gradation: In accordance with ASTM C33, Table 2, and represented by a smooth gradation curve within required limits.
- b. Fine aggregate:
- 1) Washed natural sand or washed stone sand. Stone sand may be subject to special gradation requirements as directed.
  - 2) Gradation in accordance with ASTM C33.
    - a) Minimum percentages of material passing Size 50 and Size 100 sieves may be reduced to five and zero, respectively, if aggregate is to be used in concrete with three percent minimum air entrainment, or in concrete containing more than 517 pounds of cement per cubic yard.
  - 3) Weighted percentage of loss not more than 12 percent by weight when subjected to five cycles of magnesium sulphate soundness test in accordance with ASTM C88.
  - 4) Deleterious Substances:

<u>Substance</u>		<u>Maximum Allowable Percentage by Weight</u>
a) Friable particles:		1.0
b) Coal and lignite:	0.5	
c) Material passing the Size 200 sieve:		5.0
d) Other deleterious substances, such as shale, alkali, mica, coated grains, soft and flaky particles:		2.0
  - 5) Free from injurious amounts of inorganic impurities as determined by ASTM C40. Should materials fail to pass test for organic impurities in sand for concrete, retest in accordance with ASTM C87. If fine aggregate shows by colorimetric test a darker color than that of sample originally approved for the work, stop using such aggregate until approved tests have been made to determine whether change in color is indicative of injurious amount of deleterious substances.
- c. Evaluate for potential alkali aggregate reactivity:
- 1) Perform a petrographic examination in accordance with ASTM C295. The petrographic analysis will identify the constituents of the fine and coarse aggregate and will also identify aggregate found to be potentially alkali-carbonate reactive. Fine and coarse aggregate containing more than the following quantities of constituents is unacceptable:
    - a) Optically strained, microfractured or microcrystalline quartz exceeding five percent (a common constituent or granite and granite gneiss).
    - b) Chert, Metaquartzite, Chalcedony or combination thereof exceeding three percent. However, fine aggregate may

- contain up to eight percent provided that mortar bar test results are acceptable.
- c) Tridymite or cristobalite exceeding one percent.
  - d) Opal exceeding five percent.
  - e) Natural volcanic glass in volcanic rocks exceeding three percent.
- 2) Test aggregate for alkali-silica reactivity in accordance with ASTM C1260. Aggregate sources that exhibit a C1260 mean mortar bar expansion at 16 days greater than 0.08 percent are unacceptable.
  - 3) Aggregate identified by the petrographic analysis to be potentially alkali-carbonate reactive is to be further evaluated in accordance with ASTM C586. Expansion of test specimen cylinders not to exceed 0.10 percent after 28 day immersion in NaOH solution.
- d. Aggregate which fails the evaluation criteria for potential alkali aggregate reactivity may be reclassified as acceptable if prior field performance demonstrates that the aggregate is nonreactive. Include service records (material records, batch quantities, exposure conditions, and petrographic evaluation) demonstrating the aggregate to be nonreactive in the mix design submittal.
- E. Water:
- 1. Natural potable water with no pronounced taste or odor.
  - 2. Containing no impurities, suspended particles, algae or dissolved natural salts in quantities that will cause:
    - a. Corrosion of reinforcing steel.
    - b. Volume change that will increase shrinkage cracking.
    - c. Efflorescence.
    - d. Excessive air entraining.
  - 3. pH: Not less than five.
  - 4. When tested in accordance with AASHTO T26, standard mortar-briquette tests to show no indication of unsoundness, no change in setting time in excess of plus-or-minus 30 minutes and no reduction in strength in excess of 10 percent.
- F. Ready-Mixed Concrete: ASTM C94, Option C.
- G. Admixtures:
- 1. In accordance with the following:
    - a. Air-entraining admixtures: ASTM C260.
    - b. Chemical admixtures: ASTM C494.
  - 2. Approved brands: Chlorides may be present in admixtures provided total chloride in mixing water of proposed concrete mixture, including chloride ions contributed by admixture or admixtures, aggregate and mixing water is not in excess of 150 ppm.
  - 3. Meeting requirements of reference standards or documented to have five-year minimum history of demonstrably satisfactory performance for similar structures under equivalent conditions.
- H. Aluminum Powder: FS A-A-341A, free of oil, grease, soluble alkalis and organic materials, gradation as approved.
- I. Ferrous Aggregate:

1. Cast-iron particles, ASTM A43, ASTM A47, or ASTM A48, free of oil, grease, soluble alkalis and organic materials.
2. Aggregate graded as follows:

<u>Sieve Designation</u> <u>US Standard Square Mesh</u>	—	<u>Percentage by Weight</u> <u>Passing Individual Sieves</u>
3/8 inch	—	
Size 4		100
Size 8		90 - 100
Size 16	75 - 90	
Size 30	45 - 60	
Size 50	15 - 25	
Size 100		10 - 20

3. If recommended by manufacturer and approved, in lieu of the above gradation use lower percentage of aggregate passing Size 100 sieve.

J. Abrasive Aggregate: 60 to 75 percent silicon-carbide abrasive, bonded by vitreous ceramic material, black, graded from 12 to 30.

K. Curing Materials:

1. Plastic sheeting: Polyethylene, ASTM C171.
  - a. Curing sheet: Type 1.1.1 and 1.1.2.
  - b. Vapor barrier: Clear 10-mils thickness.
2. Burlap sheet: AASHTO M182, Class 3 or 4.
3. Tarpaulin: FS K-P-146.
4. Blanket insulation: FS HH-I-521.
5. Membrane-forming curing compound: ASTM C309, Type 1-D, 100 resin with fugitive dye, and Type 2.

L. Epoxy Mortar:

1. Epoxy: ASTM C881, Type III-C, grey.
2. Sand: Clean, dry, well-graded particles, passing Size 16 sieve, with the following additional requirements:

<u>Individual Sieve Size</u>	<u>Percent by Weight Retained on Sieve</u>
30	26 to 36
50	18 to 28
100	11 to 21
Pan	25 to 35 (range shown is applicable when 60 to 100 percent of pan is retained on Size 200 sieve)

M. Chemical Grout: Section 02415.

N. Elastomeric Concrete:

1. Elastomeric Concrete to consist of an aggregate and binder mixture proportioned by the manufacturer.
2. Manufacturer qualifications: Manufacturer to have the following minimum qualifications:

- a. Ten years experience in the manufacturing of elastomeric concrete materials.
  - b. Qualified personnel, factory trained and certified in the proper installation procedures, are to be available during construction.
  3. Manufacturers: The naming of certain manufacturers is intended to establish a standard of quality. Elastomeric Concrete from the following manufacturers is acceptable:
    - a. Delcrete Elastomeric Concrete by the DS Brown Company, PO Box 158, North Baltimore, OH 45872, telephone (419)257-3561.
    - b. Wabocrete by Watson Bowman Acme Corporation, 95 Pineview Drive, Amherst, NY 14228, telephone (716)691-7566.
  4. Equal Products: Other manufacturers or material suppliers who wish to propose their product as equal to this specification submit product information and a working sample along with independent physical test property verification, and product literature for review and approval.
- O. Waterstop: Section 03100.
- P. Chairs for Reinforcement: Plastic or stainless steel.
- Q. Corrosion-inhibitor in concrete. The corrosion-inhibitor shall be calcium nitrite-based admixture DCI or approved equal. Use four (4) gallons per cubic yard of the corrosion inhibitor when the water-cement ratio is 0.40 or less and use three and a half gallons (3-1/2) per cubic yard when water-cement ratio is 0.38 or less

## **2.02 SAMPLING:**

- A. Sample concrete ingredients prior to use and have them tested by an approved laboratory in accordance with methods specified. Subsequently test materials as often as necessary to verify that materials conform to specified requirements and that quality of product is maintained.
- B. Make arrangements for the Engineer to witness sampling and testing. Submit record of test results.
- C. Ready-Mixed Concrete: ASTM C94.

## **2.03 GROUT MIXES:**

- A. Portland-cement grout:
  1. Prepare grout composed of portland cement, sand and water.
  2. Use portland-cement grout under bearing plates, in recesses, holes and surfaces under structural members and at other locations shown.
  3. Do not use staining ingredients in grout exposed to view.
  4. Formulation: Two parts sand and one-part cement measured by volume.
  5. Mix grout with sufficient water to permit placing and packing, approximately 45 minutes prior to use.
- B. Nonshrink grout: ASTM C1107.
- A. Mixing water:

1. Proportion mixing water in accordance with grout manufacturer's recommendation or to produce flowable mixture without segregation or bleeding.
- B. Curing:
1. After grout has attained initial set, keep damp for 24 hours minimum.

### PART 3 - EXECUTION

#### 3.01 FIELD QUALITY CONTROL:

- A. Classes of Concrete:
1. Classes of concrete are designated by numerals corresponding to their specified 28-day compressive strength in pounds per square inch as determined by ASTM C94.
  2. Concrete classes used in this project are specified. Unless otherwise indicated, use Class 3500.
  3. Each class of concrete may comprise one or more mixes determined by maximum size of aggregate, cement factor and types of admixtures used.
    - a. Portland cement may be used alone or mixed with either ground-iron blast-furnace slag or fly ash. Do not use fly ash in architectural concrete exposed to public view.
    - b. Maximum allowable ground-iron blast-furnace slag: 50 percent of the total weight of the portland cement and ground-iron blast-furnace slag mixture.
    - c. Maximum allowable fly ash: 20-percent of the total weight of the portland cement and fly-ash mixture.
  4. Concrete with fly ash or ground-iron blast-furnace slag may be used at locations shown on the drawings.
- B. Types of Concrete:
1. Types of concrete are designated as Concrete Other than Lightweight and Lightweight Structural Concrete.
- C. Minimum Cement Factor:
1. Observe minimum cement factor for various classes of concrete other than lightweight, as follows:

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

\* one bag of cement = 94lbs. of cement

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

1. Determine air content of concrete in accordance with ASTM C94.
- E. Testing of Concrete:
1. General:
    - a. Provide the Engineer with molds and concrete, and cast specimens for testing. In addition, furnish necessary testing equipment and tools to perform sampling, slump tests and yield tests. Furnish boxes for shipping samples.
  2. Perform strength tests by making not less than one set of standard cylindrical test specimens for each 100 cubic yards of concrete or any portion thereof for each structure.
    - a. For each work shift, when concrete is delivered, make at least one set of specimens. A set of test specimens consists of at least three standard cylinders from a batch.
    - b. Perform slump tests, unit weight and air content tests with no less frequency than that of strength-specimen sets.
  3. Concrete strengths:
    - a. Determine strengths from standard test specimens according to ASTM C31 and ASTM C172 and cured and tested in accordance with ASTM C39 by the testing laboratory. Core drilling and testing in accordance with ASTM C42. Consider the effects of corrosion-inhibiting admixture and other admixtures on the strength of the concrete, in the concrete mix design. The corrosion-inhibiting admixture and other admixtures must be present in the concrete used for the test of the proposed mix strength.
    - b. Compute and evaluate in accordance with ASTM C94.
- F. Variability of Constituents in Concrete:
1. Take representative samples of concrete mortar.
  2. Maximum allowable unit-weight variation of air-free mortar taken from consecutive batches as discharged from mixer:
    - a. Average of two mortar weights: 0.8-percent maximum.
    - b. Average of six mortar weights: 0.5-percent maximum.
  3. Maximum allowable weight variation of coarse aggregate per cubic foot of concrete taken from consecutive batches as discharged from mixer.
    - a. Average of two weights: Five-percent maximum.
- G. Batching Plant:
1. Arrangement:
    - a. Provide separate bins or compartments for each size or classification of aggregate and for bulk portland cement, ground-iron blast-furnace slag or fly ash.
  2. Compartments:
    - a. Provide compartments of ample size, so constructed that materials will be kept separated under working conditions. Equip batching plant so that flow of each material into its batcher is stopped automatically when designated weight has been reached.
    - b. Weigh aggregates in separate weight batches with individual scales or cumulatively in one batcher on one scale. Weigh bulk cement on separate scale in separate weight batcher. Weigh ground-iron blast-furnace slag or fly ash on the same scale in the same weight batcher containing the bulk cement. Weigh and record bulk cement first; then add to the bulk cement, weigh and record the ground-iron blast-furnace slag or

- fly ash. Weigh and record the cumulative bulk cement and ground-iron blast-furnace slag or the bulk cement and fly ash.
- c. Water amount may be measured by weight or volume. If measured by weight, do not weigh cumulatively with other ingredients.
  - d. Interlock batching controls so that charging mechanism cannot be opened until scales have returned to zero. Satisfy these requirements by semi-automatic batching system as defined in the Concrete Plant Standards of the CPMB, with specified interlocking, or by automatic-batching system as defined in the Concrete Plant Standard.
  - e. Arrange plant so as to continuously facilitate inspection of operations. Provide facilities for obtaining representative samples of aggregate from each bin or compartment for test purposes.
  - f. Deliver materials from batching equipment within limits specified in ASTM C94.
  - g. Subject to approval, accomplish batching in accordance with ASTM C685, in lieu of weight batching, provided batching plant complies with requirements of CPMB Concrete Plant Standards.
3. Water batcher and admixture dispensers:
- a. Provide equipment for batching water and air-entraining or other admixtures at batching plant except in cases where mixing is to be performed at jobsite in paving mixers or in truck mixers.
  - b. Provide water-measuring device capable of measuring mixing water within specified requirements for each batch. Provide mechanism for delivering water to mixers so that leakage does not occur when valves are closed.
  - c. Interlock filling and discharge valves for water batcher so that discharge valve cannot be opened before filling valve is fully closed.
  - d. Introduce admixtures in solution form.
  - e. Provide measuring devices for admixtures capable of ready adjustment to permit varying quantity of admixture to be batched. Interlock dispenser for admixtures with batching and discharging operations so that batching and discharging of mixture will be automatic.
  - f. If noninterlocked dispensers are permitted, check calibration of dispensers at directed intervals. Record results of such calibration for inspection by the Engineer.
4. Moisture control:
- a. Provide plant capable of ready adjustment to compensate for varying moisture contents of aggregate and to change weights of materials being batched. Provide approved electric moisture meter for measurement of moisture in fine aggregate. Calibrate as often as directed.
  - b. Moisture content of fine aggregate not to exceed eight percent. Arrange sensing element so that measurement is made near batcher.
5. Scales:
- a. Provide accurate measurement facilities for and control of each of the materials entering each batch of concrete. Provide accurate weighing equipment in accordance with NBS Handbook 44.
  - b. Include in each weighing unit a visual springless dial to indicate scale load at each stage of weighing operation or include beam scale with beam balance indicator to show scale in balance at zero load and at each beam setting, indicator to have undertravel and overtravel equal to at least five percent of capacity of beam.
  - c. Provide standard test weights and other auxiliary equipment necessary to verify operating performance of each scale or other measuring device.



- d. Make periodic tests in the presence of the Engineer at directed intervals. Upon completion of each check test and before further use of indicating, recording and control devices, make adjustments, repairs or replacements as necessary to ensure satisfactory performance.
- 6. Recorders:
  - a. Provide accurate recorder for producing digital printout of scale readings corresponding to each concrete ingredient of each concrete batch, including zero initial readings; indicate presence of each individual admixture by corresponding code in lieu of weight or volume record.
  - b. Record water in gallons where batched by volume. In addition, on each printout show date and time of batching, identification number identical to that of concrete delivery ticket and codes for mix design and for project section.
  - c. Prepare printout in duplicate and submit one copy with its corresponding concrete ticket at the time and site of concrete placement.
  - d. House each recorder in locked cabinet.
  - e. Place recorders in position convenient for observation by plant operator and the Engineer.
- 7. Protection:
  - a. Protect weighing, indicating and control equipment against exposure to dust and weather; isolate against vibration or movement caused by other operating equipment.
- 8. Dry batching:
  - a. When bulk cement and aggregates are hauled from central batching plant to mixers, place cement, ground-iron blast-furnace slag or fly ash for each batch in an individual compartment which, during transit, will prevent cement from intermingling with aggregates and will prevent loss of cement.
  - b. Provide bins of batch trucks with suitable covers to protect materials.
  - c. Provide batch compartments of sufficient capacity to prevent loss in transit and to prevent spilling and intermingling of batches as compartments are being emptied.
- H. Allowable Concrete Finish Tolerances:
  - 1. Finish concrete elements to dimensions, elevations and positions shown within the tolerances specified for each:
    - a. Formed surfaces such as walls, roof soffits, columns, beams and girders: Plus-or-minus 1/4 inch.
    - b. Station platforms:
      - 1) Vertical: Plus-or-minus 1/4 inch.
      - 2) Horizontal, measured from centerline of track to edge of platform: Plus 1/4 inch or minus zero.

### **3.02 MATERIAL PREPARATION:**

- A. Mixing Concrete:
  - 1. Operations:
    - a. Provide concrete mixers that discharge concrete of uniform composition and consistency.
    - b. Combine coarse aggregates of different gradation and identical sources, provided corresponding concrete mix has been approved. The use of alternate batches of gravel, crushed gravel or crushed stone of a single size is prohibited.

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

Cubic-Yard Capacity of Mixer	Mixing Time
2 or less	1-1/2 minutes
3	2 minutes
4	2-1/2 minutes
More than 4	To be determined per ASTM C94 tests by the Engineer

- d. Equip each mixer with mechanically operated batch counter and timing and signaling device to indicate completion of mixing period.
3. Truck-mixed concrete: Use equipment and procedures that conform to the requirements of ASTM C94 and ACI 304, Chapter 5, with the following additional requirements:
- a. Introduce materials, including water and mixtures, into the mixing drum only at the central batching plant, or
  - b. Transport aggregates from the central plant to the jobsite in the mixing drum and add measured and recorded cement, admixtures and water into the drum prior to mixing at discharge point.

- c. When ice is used, add it with the water and counted as part of the water-cement ratio.
  - d. Place concrete within 90 minutes after cement is introduced into the mixing drum.
  - e. Accomplish initial mixing by 70 to 100 revolutions with drum rotating at the manufacturer's recommended speed. 30 revolutions at mixing speed will be required, if the addition of water is permitted. Do not exceed total of 300 mixing and agitating revolutions.
4. Temperature control:
- a. Use preparation methods capable of producing concrete with temperature 85F maximum and 55F minimum at time of placement.
  - b. Do not heat concrete ingredients to temperature higher than that necessary to keep temperature of mixed concrete as placed within specified temperatures.
  - c. Do not heat water in excess of 140F.
- B. Admixtures:
1. Introduce admixtures in solution form.
  2. Air-entraining admixture: Use for concrete exposed to weathering or in contact with rock or moist soil.
  3. Chemical admixtures:
    - a. Use water-reducing admixtures in concrete areas below grade in contact with rock, earth or fill.
    - b. Employ admixtures without interfering with specified air-content dosage of air-entrained concrete.
    - c. Except as otherwise specified or approved, use of water-reducing, set-retarding or set-accelerating admixtures is prohibited.
    - d. If introduction of certain admixtures to improve concrete strength is approved, do not reduce cement content below minimum amounts specified.
- C. Consistency:
1. For concrete to be compacted by approved mechanical vibrators, maintain slump range at point of delivery within the following limits:
    - a. Reinforced concrete: Two to four inches.
    - b. Concrete placed by pumping and concrete for filling steel-shell piles: Four to five inches.
    - c. Do not use concrete if slump exceeds maximum by 1/2 inch or more.

### **3.03 CONVEYING:**

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

1. Use only ferrous-metal-lined chutes and open troughs. Where steep slopes are unavoidable, equip chutes or troughs with baffles to minimize segregation of aggregates. Keep chutes or open troughs clean of hardened concrete by flushing with water after each use.
  2. Discharge water used for cleaning outside lines of structure. Lay out chutes or open troughs with slope one-foot vertical to two feet horizontal maximum and one-foot vertical to three feet horizontal minimum.
  3. Discharge chutes 20 feet or more in length into hopper before final distribution.
- C. Adjustable Length Pipes (Elephant Trunks):
1. Use flexible pipes of ferrous metal, rubber or plastic, six inches minimum diameter so as to prevent segregation of concrete.
  2. Position chutes or flexible pipes so that concrete is delivered in continuous flow to points not more than five feet horizontally and five feet vertically from final location. In vicinity of expansion and contraction joints, reduce horizontal distance to three feet maximum.
  3. Clean flexible pipes and elephant trunks after each use.
- D. Buggies:
1. Construct runways for buggies so they will not come into contact with or be supported by reinforcing steel of structure.
- E. Pumping and Pneumatic Conveying Equipment:
1. Use pumping and pneumatic conveying equipment, designed to handle without segregation types, classes and volumes of concrete to be conveyed.
  2. Operate pump or pneumatic equipment so that continuous stream of concrete without air pockets is produced. Position discharge end of line as near final position of concrete as possible but in no case more than five feet away.
  3. At conclusion of placement, clean equipment. Discharge debris and flushing water outside of forms.

### 3.04 PLACEMENT:

- A. General:
1. Prior to placing concrete, remove debris and extraneous material from interior of forms.
  2. Place first lift of concrete on wet surface. Consolidate by dragging vibrator along edges of joints. Make sure there is no free or standing water over the surface.
  3. Place concrete continuously and as rapidly as possible after mixing. Do not use vibrators for shifting mass of fresh concrete.
  4. Place concrete in layers of such thickness that no concrete will be deposited on concrete which has hardened sufficiently to cause formation of seams or planes of weakness. Cover each layer of concrete with fresh concrete within 45 minutes.
  5. Do not place concrete which has attained initial set or concrete which has contained mix water for more than 90 minutes.
  6. Remove temporary spreaders in forms when concrete has reached elevation which makes them unnecessary.
  7. Place column concrete using adjustable-length flexible pipes or elephant trunks to avoid dropping concrete over five feet. In monolithic placements, do not deposit concrete in supported elements such as beams, girders and slabs until concrete previously deposited in columns or walls has completed its settlement shrinkage, but not to the point at which concrete in supporting members will not permit vibrator to sink into its mass of its own weight.

8. Placing will not be permitted when sun, heat, wind or limitations of facilities will prevent finishing and curing.
  9. Concrete temperature at time of placement:
    - a. 55F, minimum.
    - b. 85F, maximum.
  10. Unless approved, do not continue concreting when descending ambient air temperature falls lower than 40F.
  11. Prior to placing fresh concrete against rock or previously placed concrete, take necessary steps, such as flushing with water, to ensure removal of foreign matter which would adversely affect bond.
  12. Maintain wire fabric and other reinforcing in proper position on chairs during concrete placement.
- A. Consolidation:
1. Consolidate concrete thoroughly as it is placed in order to secure a dense mass. Work concrete well around reinforcement, embedded items and into the corners of forms. Consolidate concrete in accordance with ACI 309.
  2. Use internal vibrators unless external vibrators are approved.
  3. Use vibrators capable of generating frequencies of not less than 7,000 impulses per minute. Verify that vibrators have power and amplitude factor so as to visibly affect mass of concrete of one-inch slump over radius of at least 18 inches. Prevent formation of laitance and accumulation of excessive water on surface of concrete as it is deposited. Remove excessive water by pumping or other approved means.
  4. When consolidating concrete in haunches, girders, beams or slabs, ensure that vibrator penetrates and revibrates previously placed concrete in top of supporting members.
  5. Do not use vibrators where internal vibration might cause damage to embedded items; in such cases spading is required.

### 3.05 CURING AND PROTECTING:

- A. General:
1. Protect freshly placed concrete from excessively hot or cold temperatures. Maintain without drying for period of time necessary for hydration of cement and proper hardening of concrete.
  2. Provide sufficient tarpaulins to cover completely or enclose forms and working areas prior to and during placing and finishing operations.
  3. Cure newly placed concrete continuously for seven days at ambient temperature in excess of 55F.
  4. Cure concrete in subway structures by normal curing method specified.
  5. During curing period keep steel and wood forms wet. If forms are removed during curing, use one of the following methods of curing immediately and continue for remainder of the curing period.
- B. Normal Curing and Protection:
1. Use one of the following methods for flat surfaces, weather permitting:

- a. Use ponding on horizontal surfaces providing surface is continuously submerged for required curing period.
  - b. Apply continuous sprinkling with nozzle or nozzles which, during first 24 hours, atomize flow of water providing a mist and not a spray. Do not apply moisture under pressure directly upon concrete; avoid flowing or washing on surfaces while susceptible to erosion.
  - c. Cover entire surface of concrete with double thickness burlap sheet, laid directly on concrete and kept continuously wet. Maintain in good condition.
  - d. Sprinkle concrete surface as specified for at least 18 hours and immediately cover with waterproof curing sheet, free from holes or tears. Hold in position so that entire surface of concrete is fully and continuously covered.
  - e. Do not damage burlap, waterproof sheet or concrete surfaces.
- C. Membrane-Forming Curing Compound:
1. Use curing compound when approved for circumstances where application of moisture is impracticable and where such compounds will not jeopardize appearance of concrete. Except as otherwise specified, use Type-1 compound, uniformly applied over surface at thickness recommended by manufacturer. Thoroughly mix compound and apply within one hour after mixing.
  2. Do not apply wax-resin curing compounds to surfaces requiring bond for additional concrete or where bonded surface coating such as paint, tile, dampproofing, waterproofing or roofing is to be applied.
    - a. Do not apply curing compound to floors to be chemically sealed.
  3. Warm or stir curing compound if necessary for satisfactory application in accordance with manufacturer's recommendations. If film of compound is damaged before expiration of curing period, repair immediately with additional compound.
  4. Inside surfaces of tunnels, cut-and-cover boxes and other surfaces specifically approved may be cured with Type-1 membrane curing compound.
  5. Finish surfaces prior to application of curing compound. Do not use curing compound on construction joints.
  6. Apply curing compound in two coats. Apply first coat immediately after stripping of forms and acceptance of concrete finish.
  7. If surface is dry, thoroughly wet concrete with water and apply curing compound just as surface film of water disappears. Apply second coat after first coat has set.
  8. Protect coating against damage for at least 10 days after application. If damage occurs, apply additional coating.
  9. If use of curing compound results in streaked or blotchy appearance, cease operations and use other method of curing until cause of defective appearance is corrected.
- D. Protection of Rod Reinforcement:
1. After forms are removed, coat rod reinforcement and dowels extending beyond concrete surfaces with application of neat cement paste.
  2. Remove hardened cement paste and resultant debris immediately prior to extension of reinforcement or installation of formwork.

### **3.06 COLD WEATHER CONCRETING:**

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

- B. When ambient temperature is 40 ° F and falling, carry out one of the following procedures to protect placed concrete:
1. Heating:
    - a. Enclose forms or structures and heat to maintain concrete and air within enclosure at not less than 55 ° F for seven days after placement.
    - b. Maintain relative humidity at not less than 40 percent during curing period when heat is applied to enclosures. Arrange stoves, salamanders or heaters so as to provide uniform distribution of heat. Vent combustion gases to outside air. Do not let hot air blow across concrete surfaces.
    - c. After seven-day curing period, reduce temperature within enclosure gradually at maximum rate of 20 ° F per day until outside temperature has been reached.
    - d. Provide continuous and adequate fire protection and watchmen when heating units are in operation.
  2. Form insulation:
    - a. Insulate forms with blanket insulation of approved type and thickness to maintain concrete at 55 ° F minimum for seven days.
    - b. Protect top of placed concrete by tarpaulins or other approved waterproof material over insulation.
- C. Do not allow concrete to freeze in a saturated condition prior to achieving a strength of 4000 psi.

### 3.07 HOT WEATHER CONCRETING:

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

### 3.08 JOINTS:

- A. General:
1. Unless otherwise shown make construction joints bonded joints by roughening surface to expose aggregates. Clean and roughen surface by wet sandblasting, by cutting with high-pressure water jet with a minimum pressure of 2,000 psi or by other approved means. Perform cleaning after concrete has hardened to prevent raveling of surface.
  2. Exercise caution in cleaning concrete to prevent damage to waterstops.
  3. Treat overlays on slabs the same as for rock or other bonded joint.
  4. Place construction joints at locations shown, or at locations approved by the Engineer.
- B. Horizontal Construction Joints:
1. Joints within 18 inches of tops of faces are prohibited.
  2. Trowel top surface of concrete adjacent to forms smooth to minimize visible joints on exposed faces. Remove laitance and other objectionable materials from joint surface to expose sound concrete as soon as concrete is firm enough to retain its form.

3. Immediately after placement of concrete, remove accumulations splashed on exposed reinforcement and surfaces of adjacent forms before concrete attains initial set.

### 3.09 CONCRETE FINISHING:

- A. When forms are removed, do not remedy voids, stone pockets and other defects until the Engineer has inspected them and given directions.
- B. Finish concrete surfaces as shown and as follows:
  1. Number-1 Form Finish:
    - a. Immediately following form removal, remove fins and irregular projections from surfaces exposed to view or those that will receive waterproofing.
    - b. Prepare pointing mortar not more than 30 minutes prior to use.
    - c. Cure mortar patches as specified under curing and protection.
    - d. Leave contraction joints and articulated joints in completed work carefully tooled and free of mortar and concrete.
    - e. Leave joint filler exposed for its full length with clean and true edges.
    - f. Apply this finish to structures, unless otherwise shown.
  1. Number-3 Broomed Finish:
    - a. Where floors and other areas are shown to have rough finish, strike-off surface with screeds and wood floats at elevation shown.
    - b. Before concrete has achieved initial set, broom transversely to flow of traffic with stiff, medium-bristle broom especially made for intended purpose to develop corrugations not more than 1/8-inch deep.
  2. Number-4 Steel-Troweled Finish:
    - a. Where floors are shown to have a steel-troweled finish, screed concrete to established grades and compact with wood or power-driven disc float.
    - b. After surface has hardened sufficiently, finish with steel trowel to dense hard finish, free of trowel marks.
    - c. Do not use dry cement or mixture of dry cement and sand to absorb water.
  3. Number-5 Wood-Float Finish:
    - a. Screed inverts of subway structure, floors not specified or shown to be finished otherwise, areas below floating slabs and areas to receive dampproofing, waterproofing or roofing to a true and uniform surface conforming to shape and elevations shown.
    - b. Follow with wood-float finish to tolerances specified.
    - c. On slabs and floors, where drainage is shown, maintain accurate slopes for drainage.
    - d. Protect floors and slabs until final acceptance.
- A. Do not sprinkle water or cement on surfaces to be trowel finished.

### 3.10 DEFECTIVE CONCRETE:

- A. Concrete will be considered defective unless it is structurally sound, watertight, properly finished and within specified tolerances.
- B. Concrete in place that is deemed structurally defective will be checked by the Engineer by drilled core specimens. If testing of core specimens shows that strength is less than 85 percent of specified strength, costs incurred in taking and testing of core specimens will be borne by the Contractor.
- C. Replace, strengthen or correct defective concrete as directed.



**3.11 PROTECTION FROM AND REMOVAL OF STAINS:**

- A. Protect concrete structure from rust staining by structural-steel members or from other substances during the work.
- B. If staining should occur, remove stains and restore concrete to its original color.

**3.12 DAMAGED WORK:**

- A. Before final acceptance of the work, neatly repair damaged surfaces, corners of concrete and concrete finish.
- B. Where surface repairs are permitted, finish damaged areas to smooth, dense watertight condition.
- C. Replace concrete that is not satisfactorily repaired.

**3.13 CORRECTIVE WORK:**

- A. Submit corrective action patching procedure.
- B. If correction of defects is approved, remove defective concrete; key area to be repaired, soak surface with water and patch with approved materials. Patch architectural concrete so as to match existing. Use bonding agents applied to the substrate or mixed with patching material only as approved by the Engineer.
- C. Clean surface cavities produced by form ties, other holes, honeycomb spots, broken corners or edges and other defects. Saturate with water and point with mortar paste consisting of cement and fine aggregate mixed in proportions to give same appearance as original concrete.
- D. Prepare pointing mortar not more than 30 minutes prior to use. Cure mortar patches properly. Carefully tool contraction and articulated joints in completed work and keep them free of concrete. Where necessary, leave joint filler exposed for its full length with clean and true edges.
- E. Tolerance deviations and other surface defects may also be corrected, if approved, by grinding high areas and swales. Leaks in station electrical rooms, TPSS and TBS shall be epoxy injected.
- F. Where necessary or when directed, repair leakage in excess of specified maximum allowable, by means of contact grouting, chemical grouting or other approved means.
- G. Where corrective work is unsatisfactory, completely remove such work and replace with new work complying with specified requirements.

### 3.14 EPOXY MORTAR REPAIRS:

- A. Surface Preparation:
1. Remove defective concrete with chipping hammers or other approved equipment. To prevent removing extra material and causing cracks, saw-cut concrete area to be removed into maximum six-inch square checkerboard pattern 4-1/2 inches deep.
  2. Prepare exposed concrete surface by sandblasting clean and allowing to dry thoroughly. Surface drying may be accomplished by air jet. Ensure that compressed air used in cleaning and drying is free from oil or other contaminating materials.
  3. Maintain concrete surface in sufficient depth at temperature of 65F minimum during first four hours after placement of epoxy bond coat. Preheating may be done with radiant heaters or other approved means. Do not preheat concrete in excess of 200F with final surface temperature below 105F at time of placing epoxy materials.
- B. Application of Epoxy Bonding Agents:
1. Prepare epoxy bonding agent in accordance with manufacturer's recommendations.
  2. Apply epoxy bonding agent to prepared dry concrete surface at coverage of 80 square feet per gallon maximum or as recommended by manufacturer
  3. Epoxy bonding agent may be applied by any convenient and safe method which will yield effective coverage, such as squeegees, brushes or rollers.
  4. During application of epoxy bonding agent, ensure that material is confined to area being bonded; avoid contamination of adjacent surfaces. Extend epoxy bond coat slightly beyond edges of repair area.
- C. Application of Epoxy Mortar:
1. Mix epoxy components in accordance with manufacturer's recommendations.
  2. Proportion: 5-1/2 parts sand by weight to one-part epoxy.
  3. Mix components with slow-speed mechanical device.
  4. Prepare mortar in small batches so that each batch can be completely mixed and placed within approximately 30 minutes.
  5. Do not add thinners or dilutants to mortar mixture.
  6. Immediately after application of epoxy bonding agent, place, tamp, flatten and smooth epoxy mortar.
  7. Work mortar to grade.
  8. Steel-trowel finish. Trowels may be heated to facilitate finishing.
- D. Curing:
1. Cure epoxy mortar repairs immediately after completion at 60F minimum until mortar is hard.
  2. Initiate post-curing of four hours minimum at surface temperature of 90F minimum, 110F maximum.
  3. Heat may be applied by using portable propane heaters, infrared heaters or other approved sources positioned to attain necessary surface temperature.
  4. Do not subject epoxy-bonded epoxy mortar to moisture until after specified post-curing has been completed.

### 3.15 CONCRETE OVERLAYS AND TILE SETTING BEDS:

- A. General:

1. Water blast (3,000 - 5,000 psi) or sand blast the substrate.
2. Keep slabs continuously wet for 24 hours prior to concrete placement. Substrate to be air blown just prior to concrete placement.
3. Place concrete in two pours of equal thickness. Place welded-wire-fabric reinforcement on first pour and then place second pour.
4. Use a vibratory screed on overlays.
5. Float slab and apply light broom finish. Cure slabs with water.
6. Remove laitance by methods in number one above if the overlay requires a bonding surface for tile or other treatments.
7. Continuously moist cure of overlay( setting bed) for seven(7) days.

**END OF SECTION**

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## SECTION 03495

### PRECAST GLASS FIBER REINFORCED POLYMER CONCRETE PANELS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. Description of work:
  - 1. This Section specifies plant-cast, glass-fiber reinforcement, polymer concrete panels (GFRPC) including embedded hardware, loose connection hardware, integrated steel stud support framing, and related services for erection and installation.
  - 2. Work under this Section includes furnishing all labor, supervision, materials, tools and equipment for the complete installation of the precast polymer concrete wall panels system in accordance with contract documents.
- B. Related Documents: Drawings and general provisions of Contract, including General and Supplementary Conditions and Specifications Section, apply to this Section.

##### 1.02 QUALITY ASSURANCE:

- A. Design Responsibility: Design precast polymer concrete panels by a registered professional engineer employed or retained by panel manufacturer, licensed to practice in the District of Columbia.
- B. Manufacturer Qualifications: Firm with a demonstrated capability to produce precast polymer concrete products of quality and scope required for this Project and actively involved in precast polymer concrete production for at least 10 years. Manufacturer must have sufficient production capacity to produce, transport, and deliver required units without causing delay in the work.
  - 1. Metro Cast Corporation, 6140 N. Hix Road, Westland, Michigan 48185, phone (734) 728-0210 is used as the basis of design for work under this section.
  - 2. Alternate panel manufacturers shall be considered if provided samples and technical data are submitted to the Engineer not less than fourteen (14) days prior to bid date. Submitted alternates must conform fully with all sections of this specification.
- C. Erection Qualification: Regularly engaged for at least 5 years in erecting precast polymer concrete panels similar to those required in this project.
- D. Welder Qualifications: Qualified within past year according to American Welding Society codes and specifications.
- E. Field-Erected Mockup: prior to installation of precast polymer concrete units, erect mockups for each configuration and finish required. Fabricate additional mockups (if necessary) until color, texture, and pattern is acceptable to Architect.

##### 1.03 SUBMITTALS:

- A. General: Submit the following according to Conditions of Contract and Specifications Sections.

- B. Samples representative of finished exposed face showing typical range of color and texture and of appropriate thickness.
- C. Shop drawings detailing fabrication and installation of precast polymer concrete panels, including the following:
  - 1. Unit shapes (elevations and sections) and dimensions.
  - 2. Finishes.
  - 3. Joint and connection details.
  - 4. Lifting and erection details.
  - 5. Steel support-frame system.
  - 6. Locations of details for hardware attached to structure.
  - 7. Size, location, and detail of flex and gravity anchors.
  - 8. Sequence of erection for special conditions.
  - 9. Relationship to adjacent materials.
  - 10. Description of loose, cast-in, and field applied hardware.

#### **1.04 DELIVERY, STORAGE, AND HANDLING:**

- A. Delivery and Handling: Handle and transport units to avoid stress or damage.
  - 1. Lift or support units only at points indicated on shop drawings.
  - 2. Place non staining resilient spacers of even thickness between units.
  - 3. Support units during shipment on non staining shock-absorbing material.
  - 4. Protect units from dirt and damage during handling and transport.
- B. Job site Storage: Store units to protect from contact with soil, staining, and physical damage.
  - 1. Store units with non staining resilient supports at same position as when transported.
  - 2. Store units on firm, level, and smooth surfaces.
  - 3. Place stored units so that identification marks are readily accessible.

#### **1.05 WARRANTY**

- A. Panel systems shall be guaranteed against defects in materials and workmanship for a period of five (5) years from date of completion.
  - 1. Defective panels shall be repaired or replaced as required at no expense to the owner.

### **PART 2 - PRODUCTS**

#### **2.01 MATERIALS:**

- A. Anchors and subsystems:
  - 1. Steel Shapes, Plates, Bars: ASTM A36.
  - 2. Shop Primer: For exposed carbon steel anchors, SSPC- Paint 13.
  - 3. Galvanized Finish or Zinc Plated: For exposed carbon steel anchors, ASTM A 153, hot dipped after fabrication.
  - 4. Steel Stud Framing System: Fabricate of material, size, shape, weights, and details as indicated on shop drawings.
    - a. Galvanized stud and tracks, formed from steel conforming to ASTM A446, Grade D. Provide studs with minimum yield strength of 50 ksi (or 16ga).

- b. Finish, hot dip galvanized, ASTM A 525 with minimum G-60 coating.
  5. Touch up galvanized surfaces damaged by welding procedures according to ASTM A 780.
- B. Precast polymer concrete mixes:
  1. General: Combine thermosetting resin, graded silica sand and stable, non fading paste pigments premixed in proper proportions and reinforced with woven fiberglass cloth to produce panels that comply with the following:
    - a. Compressive Strength (ASTM D695) 12,000 psi.
    - b. Tensile Strength (ASTM D638) 1,500 – 3,000 psi.
    - c. Water Absorption – Less than 0.1 percent.
    - d. Coefficient of Expansion – 0.0000125 inch/deg.F.
    - e. Thickness – 3/4 inch minimum (1 1/2" is the basis of design).
    - f. Combustibility (ASTM E36) Noncombustible.
    - g. Flammability (ASTM E84) – Class A.

## 2.02 FABRICATION:

- A. Forms: Construct of rigid materials that will result in finished product conforming to profiles, dimensions, and tolerances indicated on contract documents.
- B. Steel Stud Framing System: Prefabricated welded steel stud frame assemblies according to shop drawings. Touch up accessible welds after fabrication.
- C. Proportioning and Mixing: Carefully measure amounts of mix constituents to achieve desired mix proportions.
- D. Form intricate details: Incorporate formers or infill materials before material reaches initial set to ensure complete bonding.
- E. Insert and Embedments: Properly embed inserts, or metal clips.
- F. Dimensional Tolerances: Manufacture units so that each panel complies with following dimensional tolerances.
  1. Overall height and width of finished units, measured to face adjacent to form.
    - a. 10 feet or under, plus or minus 1/8 inch.
    - b. Over 10 feet, plus or minus 1/8 inch per 10 feet
  2. Angular Deviation of Plane of Side Mold: 1/32 inch per 3 inches of depth or 1/16 inch total, whichever is greater.
  3. Variation from Square of Designated Skew (difference in length of two diagonal measurements): 1/8 inch per 6 feet or 1/4 inch total, whichever is greater.
  4. Steel Studs Frames: Plus or minus 1/4 inch.
- G. Finishes: Exposed panel faces to match existing building concrete column elements or approved samples. Joint marks, grain, or other obvious defects on panel faces are not acceptable.
- H. Panel Identification: Mark each precast polymer concrete panel to correspond with identification mark on shop drawings. Mark each panel with its casting date.

### **PART 3 - EXECUTION**

#### **3.01 INSPECTION:**

- A. Erector Responsibility: Prior to installing units, check job site dimensions affecting erection of precast polymer concrete units. Bring to precast polymer manufacturers' attention any discrepancy between design dimensions and field dimensions that could adversely affect installation. If discrepancies do exist, do not proceed until corrected or until installation requirements are modified as acceptable to Architect.

#### **3.02 ERECTION:**

- A. Lifting and Setting: Lift precast polymer concrete units at lifting points established by manufacturer. Set precast polymer concrete units level, plumb, and square within allowable tolerances.
- B. Support and Bracing: Provide temporary supports and bracing, as required to maintain positions, stability, and alignment while units are being permanently connected.
- C. Fastening: Fasten precast polymer concrete units in place by bolting or welding, as indicated on shop drawings.
  - 1. All welding shall be performed by a qualified welder.
- D. Panels shall be installed plumb and true, free of any warping or twisting, using procedures recommended by panel manufacturer.

#### **3.03 PATCHING:**

- A. General: Patching will be permitted provided structural adequacy of unit and appearance are not impaired, when accepted by Architect.
- B. Patching Mix: Match color and texture of precast polymer concrete unit. Blend and mix materials so that cured patching matches adjacent surfaces.

#### **3.04 PROTECTION FROM AND REMOVAL OF STAINS:**

- A. General: Perform cleaning procedures as recommended by precast polymer concrete unit manufacturer.
  - 1. Clean soiled precast polymer concrete surfaces with detergent water, using soft fiber brushes and sponges, and rinse with clean water.
  - 2. Prevent damage to precast polymer concrete surfaces and to adjacent materials.

**END OF SECTION**



## SECTION 05120

### STRUCTURAL STEEL

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies structural steel work.
- B. Options:
  - 1. Substitution of rolled shapes for welded sections and vice versa is permitted, provided that shapes and sections to be substituted are approved and comply with the following:
    - a. Keep depth, width, average or mean thickness, web shear area, moments of inertia, torsional constant and warping constant to be at least equal to those for shape or section shown. Maintain clearances and other dimensions shown as critical.
    - b. Have steel shapes, plates and bars conform to same ASTM designation as material for which substitution is made.

Related Work Specified Elsewhere:None

##### 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. AASHTO: Interim 1981 Fracture Control Plan; Standard Specifications for Highway Bridges, including supplements. Where conflict occurs between AWS and AASHTO, AASHTO governs.
  - 4. AISC:
    - a. Specification for Structural Steel Buildings-Allowable Stress Design and Plastic Design.
    - b. Manual of Steel Construction-Allowable Stress Design.
    - c. Code of Standard Practice for Steel Buildings and Bridges.
    - d. Allowable Stress Design Specification for Structural Joints using ASTM A325 or A490 Bolts.
    - e. Specifications for Architecturally Exposed Structural Steel.
  - 5. ASNT: Recommended Practice SNT-TC-1A.
  - 6. SSPC: SP-6, SP-10.
  - 7. ANSI: B27.2.
  - 8. MS: MIL-P-21035.
  - 9. FS: TT-P-645
  - 10. ASTM: A6, A27, A36, A108, A109, A123, A148, A153, A242, A307, A325, A370, A449, A490, A500, A501, A514, A517, A572/572M, A588, A668, A673, A709, A780, B663, B766.
- B. Source Quality Control:
  - 1. Testing and inspection:
    - a. Nondestructive-test requirements for welded members:
      - 1) Perform the following:
      - 2) Fillet welds connecting web plates to flange plates: 25 percent of welds inspected by magnetic particle inspection.

- 3) For all other fillet-weld connections: 10 percent of welds inspected by magnetic particle inspection.
      - 4) The Engineer may designate additional items to be inspected by radiography.
    - b. Mill testing:
      - 1) For identified stock materials provide three specimens from each heat number, one for tension test, one for bend test and one for Charpy V-notch impact test.
      - 2) Cut, machine and test specimens in accordance with ASTM A370.
      - 3) Perform Charpy V-notch impact test for tension flanges and other tension components of aerial structures in accordance with Table 05120-1.
    - c. Bolts:
      - 1) The Engineer will randomly select at least five bolts for test purposes from each bin of bolts furnished.
- C. Qualification of Welding Personnel and Procedures:
  1. Prior to qualifying welding personnel and welding procedures, confirm an agreement with the Engineer as to procedural details, sequence of welding, handling of materials to be inspected, and approval of electrodes, wire, flux and other welding materials and equipment.
  2. Employ welding personnel whose qualification is certified in accordance with AWS D1.1. Such certification is to remain in force for the duration of the welding operations under this Contract.
  3. Do not start fabrication until qualification has been successfully completed.
- D. Qualification of Nondestructive-Testing Personnel:
  1. Nondestructive testing of fracture-critical members to be conducted by personnel qualified as NDT Level II or Level III in accordance with ASNT SNT-TC-1A.
  2. Level-II technicians to be supervised by Level III-personnel.
- E. Stock Material:
  1. For qualification of welding personnel and procedures and for quality-assurance testing, use only stock materials which can be identified as having been rolled from a given heat and for which certified mill tests can be produced.
  2. When stock material is proposed, inform the Engineer of such intention at least 10 days in advance of commencing fabrication to permit sampling and testing. Select identified material from as few heats as possible.
- F. Welder's Identification Mark (for Fabrication Shops):
  1. Assign each welder and welding operator an identification mark to stamp on pieces he has welded.
  2. Have welder or welding operator place his identification mark by metal-die stamp in letters 3/8-inch high in position that identification of welder or operator will appear adjacent to each of his welds in finally assembled members for ready reference to radiographic films and for identification by the Engineer.

### 1.03 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. Structural details: Include the following:

- a. Bills of materials giving complete information for fabrication and erection of component parts of structures including material and finish information.
  - b. Details of location, type, sizes of bolts and welds and for welded structures details of welding as specified.
  - c. Structural computations for Contractor-designed work certified by a professional engineer registered in the jurisdiction where the work is to be performed.
2. Match marks:
    - a. Provide diagram showing match marks for connecting structural parts assembled in shop for purpose of drilling or reaming holes in field connections.
  3. Welding:
    - a. Complete shop details of qualification test specimens.
    - b. Include information on specimen identification, number of pieces and welding procedure specification, type of material, sizes of pieces and welds and other variables affecting detail or tests.
  4. Erection Plan:
    - a. Details of methods of erection proposed to be used, including calculated stresses for proposed erection certified by a professional engineer registered in the jurisdiction where the work will be performed. Do not proceed until approval has been received.
  5. Manufacturer's test procedures for bolts.
- B. Certification:
1. Certified mill test reports of structural steel at least 10 days prior to start of fabrication.
  2. Certified quality-assurance testing and inspection reports.
  3. Certification verifying that welding personnel have been qualified in accordance with AWS D1.1 and as specified above under Qualifications of Welding Personnel and Procedures.
  4. Manufacturer's certification that bolts meet approved testing.
  5. Certification of nondestructive-testing personnel.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. General:
1. Load, transport, unload and store structural materials so as to keep them clean and free from damage.
  2. Store material on platforms, skids or other supports above the ground and ensure proper drainage and protection from corrosion.
- B. Steelwork:
1. When handling and shipping steelwork, prevent bending, scraping or over stressing 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.
  4. Indicate weight on members weighing more than three tons by means of paint contrasting with shop coat.
- C. Bolts and Nuts:
1. Ship small parts such as bolts, nuts, washers, pins, fillers and small connecting plates or angles in boxes, crates or barrels.
  2. Pack separately bolts of each length and diameter and loose nuts or washers of each size.

## 1.05 JOB CONDITIONS:

- A. Environmental Requirements:
  - 1. Welding:
    - a. When welding during cold weather, avoid chilling weld metal within zone of welding influence and avoid restraining manual functions of welder or welding operator.
    - b. When temperature where steel is stored is more than 20F below that of welding shop, move steel to be welded into shop sufficiently in advance of welding to allow it to attain shop temperature prior to welding.
    - c. Steel to be free of moisture. Dry as necessary by application of heat not exceeding 100F.
    - d. Do not weld when shop temperature is below 40F.

## PART 2- PRODUCTS

### 2.01 MATERIALS:

- A. General Requirements for Rolled-Steel Plates, Shapes and Bars: ASTM A6.
- B. Carbon-Steel Plates, Shapes and Bars: ASTM A36, ASTM A709, Grade 36.
- C. High-Strength, Low-Alloy, Structural-Steel Plates, Shapes and Bars: ASTM A709, Grade 50.
- D. Low-Carbon Steel Bolts and Nuts: ASTM A307, Grade A or B.
- E. High-Strength Carbon-Steel Bolts, Nuts and Washers for Structural Joints: ASTM A325; for bolts over one-inch diameter, ASTM A449.
- F. High-Strength Alloy-Steel Bolts, Nuts and Washers for Structural Joints: ASTM A490.
- G. High-Strength Tension Control Alloy-Steel Bolt/Nut/Washer Assemblies for Structural Joints:  
ASTM F2280.
- H. Round Washers Other Than Those In Contact With High-Strength Bolt Heads And Nuts:  
ANSI B27.2, Type B.
- I. Beveled Washers:
  - 1. Square, smooth and sloped to make contact surfaces of bolt head and nut parallel.
  - 2. Diameter of hole in square beveled washers as follows:
    - a. For bolts less than one-inch diameter: 1/16-inch larger than bolt size.
    - b. For bolts larger than one-inch diameter: 1/8-inch larger than bolt size.
- J. Galvanizing:
  - 1. Steel products specified as galvanized to be hot-dip galvanized after fabrication in accordance with the following:
    - a. Zinc coatings on products fabricated from rolled, dressed and forged steel shapes, plates and strips: ASTM A123.
    - b. Zinc coating on iron and steel hardware: ASTM A153.
    - c. Zinc coating on assembled steel products: ASTM A123.
    - d. Zinc-coating weight: Two ounces per square foot minimum.

- e. Zinc-dust zinc-oxide primer conforming to MS MIL-P-21035 applied in accordance with ASTM A780 in two coats for repairs to damaged surfaces after removal of loose or cracked zinc coating.
- K. Electroplated Zinc Coating: ASTM B663 for type specified.
- L. Cleaning Solution: Muriatic acid solution, specific gravity 1.18, prepared in a solution of one-part muriatic acid and five parts water.
- M. Anchor Bolts: ASTM F1554, Grade 55.

### **PART 3 - EXECUTION**

#### **3.01 FABRICATION:**

- A. Workmanship and finish to best commercial practice accomplished in structural or bridge shops.
- B. Straightening Material:
  - 1. Use rolled material that, before being laid off or worked, is straight within tolerances specified in ASTM A6.
  - 2. Perform straightening where necessary by approved methods which will not overstress material.
  - 3. Do not heat-shrink low-alloy structural steel.
  - 4. Achieve fabrication tolerances which will result in full bearing.
  - 5. Perform straightening, planing and connecting of portions of members in bearing assemblies and in direct bearing after fabrication as necessary to provide full bearing assemblies and bearing areas.
- C. Cutting:
  - 1. Flame-cut edges of members subject to dynamic loading by mechanically guided torch or by hand. Remove nicks by grinding to depth not exceeding 1/4 inch.
  - 2. Shape re-entrant corners notch-free to radius of 1/2-inch minimum.
  - 3. Perform flame cutting so that metal does not carry stress during cutting operation.
  - 4. Direct flame so that remaining material is not damaged.
- D. Planing and Facing:
  - 1. Plane to depth of 1/4 inch sheared edges of plates more than 5/8-inch thick which will carry calculated stress.
  - 2. Face and bring abutting joints to even bearing where shown.
  - 3. Fabricate floor beams, stringers and girders having end connection angles to exact length back-to-back of connection angles.
  - 4. For compression joints depending on contact, prepare bearing surfaces to a common plane by milling, sawing or other approved means.
  - 5. Where end connections are faced, ensure that finished thickness of angle is not less than that shown.
- E. Bolt Holes:
  - 1. Punch or drill holes for bolts.
  - 2. Subpunch or subdrill and ream assemblies using steel template for alignment of connections as necessary. Flame cutting is prohibited.
  - 3. Subdrill or subpunch holes 3/16-inch less than nominal diameter of bolt; drill or ream holes 1/16-inch greater than nominal diameter of bolt.
- F. Connections:

1. Except where welded or ASTM A307 bolted connections are shown, use ASTM A325 or ASTM A490 bolts for shop connections.
2. Unless otherwise shown, bolt field connections using ASTM A490 tension control bolts in accordance with AISC Specifications for Structural Joints.
3. Use of ASTM A490 bolts for dynamic or fluctuating loadings is prohibited.

G. Plates:

1. Bent plates: For load carrying cold-bent plates, use identified stock and arrange direction of bending at right angles to direction of rolling. Ensure radius of bend, measured on concave face of metal, is not less and preferably more than the following:

Angle of Plate Bend in Degrees	Minimum Radius
61 - 90	1.0T*
91 - 120	1.5T*
121 - 150	2.0T*

\*T = Plate thickness.

2. Sheared plates: For gusset plates or connection plates, use sheared plates designed to resist applied loads in more than one direction in plane of plate.

**3.02 WELDING:**

- A. Perform welding in accordance with AWS D1.1.
- B. Perform procedure and sequence of welding so as to avoid needless distortion and to minimize stresses. Straighten transverse warpage of flanges, if necessary, by controlled heating along outside face.
- C. Make allowance in shop for expected weld shrinkage in laying out and assembling members. Trim members to size when most or all of welding has been completed.
- D. Complete butt welds in flange joints before flanges are assembled on web. Use extension blocks on such joints when making ends of butt welds, removing extension blocks only upon completion and cooling of weld. Ensure ends of welds are finished smooth and flush with edges of abutting parts. Use double-V-flange butt welds, unless otherwise shown. Back puddle all end craters.
- E. Make welds in web plates where shown.
- F. Prior to ultrasonic or radiographic testing of butt welds of flanges and webs, grind or machine weld reinforcement of joint to remove irregularities of weld surface so that it merges smoothly with base surface; one side for ultrasonic testing and both sides for radiographic testing.
- G. Ensure that welded joints which are to be radiographed are free of paint, scale and grease. Grind off welded ripples and surface irregularities on both sides of joint. Grind perpendicular to length of weld and to such a degree that resulting radiographic contrast due to remaining irregularities cannot mask or be confused with that of objectionable defect and so that weld surface will merge smoothly into adjoining surface.

- H. Repair defective welds by chipping or melting out such defects from one or both sides of joint removing no more weld metal than necessary to correct defect. Reweld and have weld retested radiographically.
- I. Welded Structures Subjected to Dynamic Loads:
  - 1. Do not use backup bars for fracture-critical nonredundant members or member components, as defined by AASHTO on Interim 1981 Fracture Control Plan.
  - 2. Avoid use of backup bars elsewhere, unless explicitly permitted by original design.
  - 3. When use of backup bars is unavoidable because of practicality but not explicitly permitted by original design, remove backup bar after welding is completed and affected surfaces of weld metal and base metal is ground flush. Roughness of ground surfaces to be similar to that of surrounding unaffected plate surface.

### **3.03 BOLTING:**

- A. Connections using high-strength steel bolts in accordance with AISC Specifications for Structural Joints using ASTM A325 or ASTM A490 bolts.
- B. Assemble high-strength bolted parts so that they fit solidly together when assembled. Do not use gaskets or other compressible materials.
- C. Remove scale, dirt, burrs and other defects likely to prevent proper seating when assembling joint surfaces, including those adjacent to washers.
- D. Remove oil, paint, lacquer and galvanizing from contact surfaces of friction joints.
- E. Use two nuts on unfinished bolts and turned bolts in tension.
- F. Tightening Bolts:
  - 1. Tighten ASTM A325 or A490 bolts to bolt tension not less than proof load given in AISC Specifications for Bolts.
  - 2. If approved, tighten by means of properly calibrated wrenches or turn-of-nut method.
  - 3. When tightening, place hardened washer under nut or bolt head, depending on which element is turned in tightening operation.
  - 4. Calibrate torque wrenches daily by tightening bolt assembly in device capable of indicating actual bolt tension.
  - 5. Install three bolts minimum from each lot.
  - 6. Nuts or bolts to be in tightening motion when torque is measured.
  - 7. Adjust power wrenches to cut-out or stall at required tension.
- G. Arrange bolts so that heads show in areas exposed to public view.

### **3.04 SHOP ASSEMBLY:**

- A. Undertake complete or progressive shop assembly of continuous plate and box girders, rigid frames, bents and towers when shown. Obtain approval of progressive shop-assembly procedure.
- B. Clean surfaces of metals in contact with each other with high speed wire brushes before assembling.
- C. Assemble parts to line and fit; drill or ream bolt holes while assembled. Hand reaming is prohibited unless approved.

### **3.05 ERECTION:**

- A. Install anchor bolts accurately in positions shown.
- B. If anchor bolts are cast in substructure masonry during its construction, ensure that each bolt is firmly held in its correct position and elevation by suitable templates.
- C. If approval is given for installing anchor bolts in preformed holes or in drilled holes in concrete or masonry, use approved nonshrink, nonstaining grout to secure them in place.
- D. Set bearing assemblies to lines and grades shown and adjust to horizontal position shown.
- E. Erect steel structures true and plumb following match marks.
- F. Use temporary bracing to support loads to which structures may be subjected including erection equipment and their operations. Leave bracing in place as long as safety requires.
- G. Report immediately to the Engineer errors in shop fabrication or deformation resulting from handling or transportation which prevent proper erection and fitting of parts.
- H. As erection progresses perform sufficient bolting of work to support dead load, wind load and erection load. Perform permanent bolting when enough alignment has been accomplished to ensure that as much of structure as possible will be supported by such fastening work.
- I. Ensure that holes are not enlarged and that metal in vicinity of holes is not disturbed by drifting during assembly.
- J. Enlargement of holes to accept bolts for connections is prohibited unless approved. Make enlargement by reaming not by burning. Avoid hand reaming.
- K. Do not field weld main stress members.
- L. Bond premolded elastic filler with adhesive to structural framing at elevator hoistways.

### **3.06 NONDESTRUCTIVE TESTING OF FIELD WELDS:**

- A. Perform pertinent testing specified for source quality control.



TABLE 05120-1				
BASE METAL CHARPY V-NOTCH REQUIREMENTS <sup>*a</sup> FOR FRACTURE-CRITICAL MEMBERS				
ASTM	Thickness, Inches (mm)	Zone 1 <sup>*b</sup>	Zone 2 <sup>*c</sup>	Zone 3 <sup>*d</sup>
A709	Up to 4 inches (101.6)	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
A572 <sup>*e</sup>	Up to 4 inches (101.6) mechanically fastened	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Up to 2 inches (50.8) welded	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
A588 <sup>*e</sup>	Up to 4 inches (101.6) mechanically fastened	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Up to 2 inches (50.8) welded	25 at 70F (33.9 Nm at 21.1C)	25 at 40F (33.9 Nm at 4.4C)	25 at 10F (33.9 Nm at minus 12.2C)
	Over 2 inches to 4 inches (50.8 to 101.6) welded	30 at 70F (40.7 Nm at 21.1C)	30 at 40F (40.7 Nm at 4.4C)	30 at 10F (40.7 Nm at minus 12.2C)
A514 <sup>*f</sup>	Up to 4 inches (101.6) mechanically fastened	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at minus 30F (47.5 Nm at minus 34.4C)
	Up to 2-1/2 inches (63.5) welded	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at zero degree F (47.5 Nm at minus 17.8C)	35 at minus 30F (47.5 Nm at minus 34.4C)
	Over 2-1/2 inches to 4 inches (63.5) welded	45 at zero degree F (61.0 Nm at minus 17.8C)	45 at zero degree F (61.0 Nm at minus 17.8C)	Not permitted

<sup>\*a</sup> CVN impact testing to be P-plate frequency testing in accordance with ASTM A673. Code Charpy test pieces with respect to heat/plate number and record such code on mill-test report of steel supplier with test result. If directed, package broken pieces from each test (three specimens, six halves) and forward to the quality-assurance organization of the jurisdictional authority. Use average of three tests. If energy value for more than one of three specimens is below minimum average requirements or if energy value for one of three specimens is less than 2/3 of specified minimum requirements, retest and obtain energy value from each of three retest specimens equal to or exceeding specified minimum average requirement.

<sup>\*b</sup> Zone 1: Minimum service temperature zero degree F (minus 17.8C) and above.

- \*c Zone 2: Minimum service temperature from minus 1F to minus 30F (minus 28.3C to minus 34.4C).
- \*d Zone 3: Minimum service temperature from minus 31F to minus 60F (minus 35C to minus 51.1C).
- \*e If the yield strength of the material exceeds 65 ksi (448.159MPa), reduce temperature for CVN value for acceptability by 15F (8.3C) for each increment of 10 ksi (68.947MPa) above 65 ksi (448.159MPa). Yield strength is value given in certified mill-test report.
- \*f ASTM A517 Charpy requirements are the same as for ASTM A514.

**END OF SECTION**

## SECTION 07815

### SPRAYED FIREPROOFING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section includes providing sprayed fireproofing for application to structural steel.

##### 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. Product data, installation instructions, and recommendations for each sprayed fireproofing product and auxiliary material, demonstrating compliance with requirements. Include written data verifying that applied thicknesses meet specified hourly fire-resistance ratings.
    - b. Structural framing plans indicating the following:
      - 1) Surface preparation requirements required prior to fireproofing application.
      - 2) Extent of sprayed fireproofing for each different construction and fire-resistance rating including the following:
        - a) Applicable fire-resistive design designations of inspecting and testing agency acceptable to authorities having jurisdiction.
        - b) Minimum thicknesses needed to achieve required fire-resistance ratings of structural components and assemblies.
      - 3) Treatment of fireproofing after application.
  2. Samples: Three of each type of the following:
    - a. Sprayed fireproofing sample 12 inches square by 3/8 inch thick.
    - b. Metal lath, anchorage devices, and accessories.
    - c. In-place samples of each type of fireproofing sprayed on structural-steel elements where directed and in thickness required for specified hourly fire-resistance ratings for testing by the Engineer.
  3. Quality Assurance Submittals:
    - a. Qualification Data: For firms and persons specified in the Quality Assurance article to demonstrate their capabilities and experience.
    - b. Code Approval: Submit research or evaluation reports of the model code organization acceptable to authorities having jurisdiction showing that sprayed fireproofing products comply with the building code.
    - c. Manufacturer's certification that the sprayed fireproofing system and each product used are compatible with adhesives, primers and other surface coatings on substrates indicated.

##### 1.03 QUALITY ASSURANCE:

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

2. UL: Fire Resistance Directory, Building Materials Directory.
  3. ASTM: E84, E119, E605, E736, E759, E760, E761, E859, E937, G21.
  4. AWCI: Technical Manual 12-A.
- B. Fire-Test-Response Characteristics: Provide sprayed fireproofing products identical to those used in assemblies tested for the following fire-test-response characteristics by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify packages containing fireproofing with appropriate classification markings of applicable testing and inspecting agency.
1. Fire-Resistance Ratings: As indicated by reference to fire-resistive designs listed in UL Fire Resistance Directory, or in the comparable publication of another testing and inspecting agency acceptable to authorities having jurisdiction, for fire-resistive assemblies where sprayed fireproofing serves as direct-applied protection, tested in accordance with ASTM E119.
  2. Surface-Burning Characteristics: As indicated for each sprayed fireproofing product required, tested in accordance with ASTM E84.
- C. Manufacturer Qualifications: Obtain sprayed-on fireproofing system materials from a single manufacturer who evaluates and licenses installers to ensure products are properly installed.
- D. Installer Qualifications: Employ an experienced installer licensed by the sprayed fireproofing manufacturer as having the necessary skill, training, experience and staff to install manufacturer's products as specified and in accordance with manufacturer's recommendations.
- E. Certify that each product in the sprayed fireproofing system is compatible with adhesives, primers, and other surface coatings on substrates.
- F. Provide fireproofing products containing no asbestos.

#### **1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:**

- A. Deliver products to jobsite in original unopened containers clearly labeled with manufacturer's name and brand designation, referenced specification number, type, class and ratings 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.
- D. Use materials with limited shelf life within period indicated. Discard materials whose shelf life has expired.

#### **1.05 JOB CONDITIONS:**

- A. Environmental Requirements:
  1. Application of sprayed fireproofing when temperature of substrate material or ambient temperature is lower than 40F is prohibited. Maintain temperature above 40F until fire proofing is cured and dried.
  2. Additional environmental requirements in accordance with manufacturer's recommendations.

3. Provide ventilation in area to receive sprayed fireproofing, introducing fresh air and exhausting air continuously for 24 hours after application to maintain nontoxic, unpolluted, safe working area.
- B. Coordination: Coordinate installation work to minimize need for other trades to cut into applied fireproofing.
  1. Perform application only when substrate construction and penetrating work is complete.
  2. Ensure that attachments to steel for work of other trades are complete before application of fireproofing.
  3. Immediately patch cut-away fireproofing to comply with requirements for original work.
  4. Install fireproofing prior to installation of ductwork, piping, conduits, suspended equipment and other obstructions.

## **PART 2 - PRODUCTS**

### **2.01 SPRAYED CEMENTITIOUS FIREPROOFING:**

- A. General: Factory-mixed, dry formulation listed in the UL Building Materials Directory or by another testing and inspecting agency acceptable to authorities having jurisdiction, consisting of portland cement, additives and mineral aggregates mixed with water at project site to form a slurry for pumping and dispersal by compressed air.
- B. Physical Properties: Minimum values, unless otherwise indicated or higher values required to attain designated fire-resistance ratings, measured per standard test methods referenced with each property listed below:
  1. Dry Density: 15 pcf for average and individual densities regardless of density indicated in referenced fire-resistive design, or greater if required to attain fire-resistance ratings indicated, as determined per ASTM E605 or Appendix A, Alternate Method for Density Determination, of AWCI Technical Manual 12-A.
  2. Bond Strength: 300 psf as determined in accordance with ASTM E736.
  3. Compressive Strength: 1400 psf as determined in accordance with ASTM E761.
  4. Surface-Burning Characteristics: Provide materials with the following maximum surface-burning characteristics as determined in accordance with ASTM E84.
    - a. Flame spread: 10.
    - b. Smoke developed: 0.
  5. Corrosion Resistance: No evidence of corrosion as determined in accordance with ASTM E937.
  6. Deflection: No cracking, spalling, delamination or the like as determined in accordance with ASTM E759.
  7. Effect of Impact on Bonding: No cracking, spalling, delamination or the like as determined in accordance with ASTM E760.
  8. Air Erosion: Maximum weight loss of 0.0025 gram per sq. ft. in 24 hours as determined per ASTM E859.
  9. Fungal Resistance: No observed growth on specimens in accordance with ASTM G21.
  10. Thickness: Provide minimum average thickness required for fire-resistive design indicated according to the following criteria, but not less than 1 inch, as determined per ASTM E605.

- a. Where the referenced fire-resistive design lists a thickness of one inch or greater, the minimum allowable individual sprayed-on fireproofing thickness is the design thickness minus 1/4 inch.
- b. Where the referenced fire-resistive design lists a thickness of less than one inch but more than 3/8 inch, the minimum allowable individual sprayed-on fireproofing thickness is the greater of 3/8 inch or 75 percent of the design thickness.

## **2.02 AUXILIARY FIREPROOFING MATERIALS**

- A. General: Provide auxiliary fireproofing materials that are acceptable to primary material manufacturer, are compatible with sprayed fireproofing products and substrates and are approved by UL or another testing and inspecting agency acceptable to authorities having jurisdiction for use in the fire-resistive designs indicated.
- B. Substrate Primers: Unless fireproofing manufacturer recommends against priming, provide primer that complies with one or more of the following requirements:
  1. Bond strength complies with requirements specified in UL Fire Resistance Directory for coating materials based on a series of bond tests in accordance with ASTM E736.
  2. Primer is identical to those used in assemblies tested for the fire-test-response characteristics of sprayed-on fireproofing, in accordance with ASTM E119, by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
- C. Adhesive for Bonding Fireproofing: Product approved by manufacturer of sprayed-on fireproofing.
- D. Metal Lath, Anchorage Devices and Accessories: Use only stainless steel, zinc alloy or hot-dip galvanized types as recommended by manufacturer for applications indicated.
- E. Topcoats: Type as recommended by manufacturer for applications indicated.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION:**

- A. Examine substrates with installer present to determine that they are in satisfactory condition to receive sprayed-on fireproofing. A substrate is in satisfactory condition if it complies with the following:
  1. Substrate is free of oil, grease, rolling compounds, incompatible primers, loose mill scale, dirt, or other foreign substances capable of impairing bond of fireproofing with substrate under conditions of normal use or fire exposure.
  2. Objects penetrating fireproofing, including clips, hangers, support sleeves, and similar items, are securely attached to substrate.
  3. Substrate is not obstructed by ducts, piping, equipment, and other suspended construction that will interfere with applying the fireproofing.
- B. Conduct tests according to sprayed fireproofing manufacturer's recommendations to verify that substrates are free of oil, rolling compounds, and other substances capable of interfering with bond where there is any doubt as to their presence.
- C. Do not proceed with installation of fireproofing until unsatisfactory conditions have been corrected.

### **3.02 PREPARATION:**

- A. Clean substrates of substances that could impair bond of fireproofing, including oil, grease, rolling compounds, incompatible primers, and loose mill scale.
- B. Prime substrates unless fireproofing manufacturer recommends against priming or unless compatible shop primer acceptable to fireproofing manufacturer has been applied and is in satisfactory condition to receive fireproofing.
- C. Cover other work subject to damage from fall-out or overspray of fireproofing materials during application. Provide temporary enclosure as required to confine spraying operations, protect the environment and ensure maintaining adequate ambient conditions for optimal temperature and ventilation.
- D. Install metal lath, anchorage devices and accessories where necessary to comply with tested fire resistance rating and with recommendations of fireproofing manufacturer for conditions of exposure and intended use. Securely attach lath to substrate in position required for support and reinforcement of fireproofing.

### **3.03 APPLICATION:**

- A. Comply with fireproofing manufacturer's instructions as applicable to the particular conditions of installation and as required to achieve fire-resistance ratings indicated.
- B. Match fireproofing design and assemblies per UL or other testing and inspecting agency acceptable to authorities having jurisdiction. Apply fireproofing in thicknesses indicated for each area in approved shop drawings.
- C. Coat substrate with adhesive prior to applying fireproofing where required to achieve fire-resistance rating or as recommended by fireproofing manufacturer for material and application indicated.
- D. Extend fireproofing in full thickness over entire area of each substrate to be protected. Unless otherwise recommended by fireproofing manufacturer, install body of fireproof covering in a single course.
- E. Apply fireproofing materials by sprayed-on method to maximum extent possible. Following the spraying operation in each area, complete the coverage by trowel application or other placement method recommended by manufacturer.
- F. Where sealers are used, apply products that are tinted to differentiate them from the sprayed-on fireproofing over which they are applied.

### **3.04 CLEANING, CURING, REPAIR, AND PROTECTION:**

- A. Cleaning: Immediately after completing spraying operations in each containable area, remove material over-spray and fall-out from surfaces of other construction and clean exposed surfaces to remove evidence of soiling.
- B. Cure cementitious fireproofing materials according to fireproofing manufacturer's recommendations to prevent premature drying.
- C. Protect fireproofing, according to advice of fireproofing manufacturer and installer, from damage resulting from construction operations or other causes so that fireproofing will be without damage or deterioration at time of final acceptance.

- D. As installation of other construction proceeds, inspect fireproofing and patch any areas where fireproofing was removed or damaged.
- E. Repair or replace work that has not been successfully protected.

**END OF SECTION**



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**SECTION 09320**

**TILE**

**PART 1 - GENERAL**

**1.01 DESCRIPTION:**

- A. This section specifies providing ceramic tile, ceramic mosaic tile, quarry tile and marble thresholds, typically in restricted areas as shown.
- B. Related Work Specified Elsewhere:
  - 1. Cast-in-Place Structural Concrete: Section 03300.

**1.02 PERFORMANCE REQUIREMENTS:**

- A. Static Coefficient of Friction: For tile installed on walkway surfaces, provide products with the following values as determined by testing identical products per ASTM C1028:
  - 1. Level Surfaces: Minimum 0.6.
  - 2. Ramp Surfaces (slope greater than 1:20): Minimum 0.8.

**1.03 SUBMITTALS:**

- A. Submit the following for approval in accordance with the General Requirements and with the additional requirements as specified for each:
  - 1. Product Data: For each type of tile, mortar, grout, and other products specified. Include recommendations for product application and use.
  - 2. Shop Drawings: For the following:
    - a. Tile patterns and locations.
    - b. Widths, details, and locations of expansion, contraction, control, and isolation joints in tile substrates and finished tile surfaces.
  - 3. Tile Samples for Initial Selection: Manufacturer's color charts consisting of actual tiles or sections of tiles showing the full range of colors, textures, and patterns available for each type and composition of tile indicated. Include Samples of accessories involving color selection.
  - 4. Grout Samples for Initial Selection: Manufacturer's color charts consisting of actual sections of grout showing the full range of colors available for each type of grout indicated.
  - 5. Samples for Verification: Of each item listed below, prepared on Samples of size and construction indicated. Where products involve normal color and texture variations, include Sample sets showing the full range of variations expected.
    - a. Full-size units of each type of trim and accessory for each color required.
    - b. Quarry Tile: Four standard size units mounted on 16 inches square by 1/4-inch thick hardboard with grouted joints using product complying with specified requirements and approved for completed work in color or colors selected by the Engineer.
  - 6. Master Grade Certificates: For each shipment, type, and composition of tile, per ANSI A137.1, bearing TCA-Certification Mark, signed by tile manufacturer and Installer stating type and quality of material. Submit at time of shipment..
  - 7. Product Certificates: Signed by manufacturers certifying that the products furnished comply with requirements.

8. Tile Test Reports: Certified test reports in accordance with ANSI A118.1 through A118.4.

#### **1.04 QUALITY ASSURANCE:**

- A. Codes Regulations, Reference Standards and Specifications:
  1. Comply with the codes and regulations of the jurisdictional authorities.
  2. ADA: Americans with Disabilities Act.
  3. ANSI: A108.1C, A108.5, A108.6, A108.10, A118.1, A118.2, A118.3, A118.4, A118.6, A137.1.
  4. ASTM: A82, A185, C144, C150, C206, C207, C241, C503, C920, C1028, D4397.
  5. FS: UU-B-790.
  6. TCA: Handbook for Ceramic Tile Installation.
- B. Installer Qualifications: Engage an experienced installer who has completed tile installations similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- C. Source Limitations for Tile: Obtain each color, grade, finish, type, composition, and variety of tile from one source with resources to provide products from the same production run for each contiguous area of consistent quality in appearance and physical properties without delaying the Work.
- D. Source Limitations for Setting and Grouting Materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from a single manufacturer and each aggregate from one source or producer. Mockups: Before installing floor and wall tile, construct mockups for each form of construction and finish required to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for completed Work.
  1. Mockups shall be minimum four feet square and in the location as directed by the Engineer.
  2. Notify the Engineer seven days in advance of the dates and times when mockups will be constructed.
  3. Demonstrate the proposed range of aesthetic effects and workmanship.
  4. Obtain the Engineer's approval of mockups before proceeding with final unit of Work.
  5. Approved mockups may become part of the completed Work.

#### **1.05 DELIVERY, STORAGE, AND HANDLING:**

- A. Deliver materials to the site in original unopened containers, clearly labeled with the manufacturer's name, brand designation, type, grade and color. Comply with requirement of ANSI A137.1 for labeling sealed tile packages.
- B. Store materials so as to prevent damage or contamination to materials by water, freezing, foreign matter, and other causes.
- C. Handle materials so as to prevent breakage of containers and damage to materials.

**1.06 PROJECT CONDITIONS:**

- A. Environmental Limitations: Do not start tile work unless ambient temperature of area in which work occurs is at least 50 deg. F and rising and is maintained at not less than 50 deg. F without interruption while work is being done and for at least 72 hours after completion.
- B. Substrate Conditions: Do not start tile work unless surfaces to receive tile are in satisfactory condition. Commencement of tile work constitutes Contractor's acceptance of the subfloor condition in accordance with ANSI A108-AN-2, General Requirements for Subsurfaces.

**1.07 EXTRA MATERIALS:**

- A. Deliver extra materials to Owner. Furnish and store extra materials in locations as directed on pallets and in original containers with protective covering for storage, and are clearly identified with labels describing contents and area of placement.
  - 1. Tile and Trim Units: Furnish quantity of full-size units equal to 5 percent of amount installed, for each type, composition, color, pattern, and size indicated.

**PART 2 - PRODUCTS**

**2.01 PRODUCTS, GENERAL:**

- A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1, "Specifications for Ceramic Tile," for types, compositions, and other characteristics indicated.
  - 1. Provide tile complying with Standard Grade requirements, unless otherwise indicated.
- B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI standards referenced in "Setting and Grouting Materials" article.
- C. Colors, Textures, and Patterns: Where manufacturer's standard products are indicated for tile, grout, and other products requiring selection of colors, surface textures, patterns, and other appearance characteristics, provide specific products or materials complying with the following requirements:
  - 1. Provide Engineer's selections from manufacturer's full range of colors, textures, and patterns for products of type indicated.
  - 2. Provide tile trim and accessories that match color and finish of adjoining flat tile.
- D. Factory Blending: For tile exhibiting color variations within the ranges selected during Sample submittals, blend tile in the factory and package so tile units taken from one package show the same range in colors as those taken from other packages and match approved Samples.

**2.02 TILE PRODUCTS:**

- A. Unglazed Quarry Tile: Provide square-edged flat tile complying with the following requirements:
  - 1. Wearing Surface: Nonabrasive or abrasive aggregate embedded in surface, as indicated.

2. Facial Dimensions: match existing.
3. Color: match existing.
4. Thickness: 1/2 inch.
5. Face: Plain.

### **2.03 SETTING AND GROUTING MATERIALS:**

- A. Portland Cement: ASTM C150, Type I.
- B. Sand: ASTM C144.
- C. Hydrated Lime: ASTM C206 or ASTM C207, Type S.
- D. Water: Potable.
- E. Portland Cement Mortar Installation Materials: Provide materials complying with ANSI A108.1A and as specified below:
  1. Cleavage Membrane: Polyethylene sheeting ASTM D4397, 4.0 mils thick.
  2. Reinforcing Wire Fabric: Galvanized, welded wire fabric, 4 x 4 - W4.0 x W4.0, Section 03200, furnish in sheets, not rolls.
- F. Dry-Set Portland Cement Mortar: ANSI A118.1.
- G. Chemical-Resistant, Water-Cleanable, Ceramic Tile-Setting and -Grouting Epoxy: ANSI A118.3.
  1. Provide product capable of resisting continuous and intermittent exposure to temperatures of up to 140 deg F and 212 deg F, respectively, as certified by mortar manufacturer for intended use.
- H. Sand-Portland Cement Grout: ANSI A108.10, composed of white or gray cement and white or colored aggregate as required to produce color indicated.
- I. Dry-Set Grout: ANSI A118.6, color as indicated.
- J. Chemical-Resistant Epoxy Grout: ANSI A118.3, color as indicated.
  1. Provide product capable of resisting continuous and intermittent exposure to temperatures of up to 140 deg F and 212 deg F, respectively, as certified by mortar manufacturer for intended use.

### **2.04 ELASTOMERIC SEALANTS AND BACKUP JOINT FILLER:**

- A. General: Provide manufacturer's standard chemically curing, elastomeric sealants of base polymer and characteristics indicated that comply with applicable requirements of Section 07900.
- B. Colors: Provide colors of exposed sealants to match colors of grout in tile adjoining sealed joints, unless otherwise indicated.

- C. One-Part, Mildew-Resistant Silicone Sealant: ASTM C920; Type S; Grade NS; Class 25; Uses NT, G, A, and, as applicable to nonporous joint substrates indicated, O; formulated with fungicide, intended for sealing interior ceramic tile joints and other nonporous substrates that are subject to in-service exposures of high humidity and temperature extremes.
- D. Multipart, Pourable Urethane Sealant for Use T: ASTM C920; Type M; Grade P; Class 25; Uses T, M, A, and, as applicable to joint substrates indicated, O.
- E. Backup Material: As recommended by sealant manufacturer and as required in Section 07900.
- F. Prime and Joint Cleaner: Use products as recommended by sealant manufacturer.

#### **2.05 MISCELLANEOUS MATERIALS:**

- A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland-cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.
- B. Concrete Leveling Bed: In accordance with Section 03300, Class 3500 concrete, pea gravel course aggregate 1/4-inch minimum to 3/8-inch maximum. Adjust slump with plasticizers to maintain proper water-cement ratio.
- C. Building Paper: FS UU-B-790, red-rosin-sized building, Type I, Style 1B.
- D. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.

#### **2.06 MIXING MORTARS AND GROUT:**

- A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.
- B. Add materials, water, and additives in accurate proportions.
- C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

### **PART 3 - EXECUTION**

#### **3.01 EXAMINATION:**

- A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of installed tile.

1. Verify that substrates for setting tile are firm; dry; clean; free from oil, waxy films, and curing compounds; and within flatness tolerances required by referenced ANSI A108 series of tile installation standards for installations indicated.
  2. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed before installing tile.
  3. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust latter in consultation with the Engineer.
- B. Do not proceed with installation until unsatisfactory conditions have been corrected.

### **3.02 PREPARATION:**

- A. Remove coatings, including curing compounds, and other substances that contain soap, wax, oil, or silicone and are incompatible with tile-setting materials by using a terrazzo or concrete grinder, a drum sander, or a polishing machine equipped with a heavy-duty wire brush.
- B. Provide concrete substrates for tile floors installed with dry-set or latex-portland cement mortars that comply with flatness tolerances specified in referenced ANSI A108 series of tile installation standards for installations indicated.
  1. Use trowelable leveling and patching compounds per tile-setting material manufacturer's written instructions to fill cracks, holes, and depressions.
  2. Remove protrusions, bumps, and ridges by sanding or grinding.
- C. Provide leveling course for masonry or concrete-wall when variation exceeds 1/4-inch in eight feet. Leveling course shall consist of dry-set mortar to which an equal volume of a mixture of one-part portland cement and 1-1/2 parts sand has been added. Apply leveling course to maximum thickness of 1/4-inch.
- D. Blending: For tile exhibiting color variations within the ranges selected during Sample submittals, verify that tile has been blended in the factory and packaged so tile units taken from one package show the same range in colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

### **3.03 INSTALLATION, GENERAL:**

- A. ANSI Tile Installation Standards: Comply with parts of ANSI A108 series of tile installation standards in "Specifications for Installation of Ceramic Tile" that apply to types of setting and grouting materials and to methods indicated in ceramic tile installation schedules.
- B. TCA Installation Guidelines: TCA's "Handbook for Ceramic Tile Installation." Comply with TCA installation methods indicated in ceramic tile installation schedules.
- C. Coordinate tile work with work of other trades.
- D. Extend tile work into recesses and under or behind equipment and fixtures to form a complete covering without interruptions, unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

- E. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.
- F. Jointing Pattern: Lay tile in grid pattern, unless otherwise indicated. Align joints when adjoining tiles on floor, base, walls, and trim are the same size. Lay out tile work and center tile fields in both directions in each space or on each wall area. Adjust to minimize tile cutting. Provide uniform joint widths, unless otherwise indicated.
  - 1. For tile mounted in sheets, use plastic spacers to make joints between tile sheets the same width as joints within tile sheets so joints between sheets are not apparent in finished work.

### **3.04 FLOOR TILE INSTALLATION:**

- A. General: Install floor tile by the portland cement mortar method in accordance with ANSI A108.1C.
- B. Tile Type: Unglazed ceramic mosaic tile and quarry tile.
- C. Setting Bed and Grout: ANSI A108.1C with the following mortar and grout:
  - 1. Dry-set portland cement mortar.
  - 2. Dry-set grout.
- D. Joint Widths: Install tile on floors joint widths as recommended by the tile manufacturer.
- E. Grout: Dry-set grout in accordance with ANSI A108.10.
- F. Where depression is not provided for mortar setting bed, install floor tile by the epoxy method in accordance with ANSI A108.6.

### **3.05 EXPANSION AND CONTROL JOINT INSTALLATION:**

- A. Provide expansion and control joints around floor perimeters, at interior corners of tiled walls, in tile surfaces directly above joints in concrete substrates and where recommended by the TCA Handbook for Ceramic Tile Installation.
- B. Do not saw-cut joints after installing tiles.
- C. Install removable divider strips of the same depth as the finished tile system, including setting bed, to keep sealant joints free of setting bed, mortar and grout. Remove strips after grouting and curing operations in order to install sealant.
- D. Install and cure sealant in accordance with manufacturer's instructions. Use primer unless sealant manufacturer recommends against priming.

### **3.06 CLEANING AND PROTECTING:**

- A.     Cleaning: On completion of placement and grouting, clean tile surfaces with warm water and washing compound in accordance with recommendations of tile manufacturer. Sponge and wash tile thoroughly and polish with clean dry cloths.
  - 1.       The use of acid or acid cleaners on tile is prohibited.
  
- B.     Finished Tile Work: Leave finished installation clean and free of cracked, chipped, broken, unbonded, and otherwise defective tile work.
  
- C.     Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure tile is without damage or deterioration at the time of Substantial Completion.
  - 1.       When recommended by tile manufacturer, apply a protective coat of neutral protective cleaner to completed tile walls and floors. Protect installed tile work with building paper taped to tile to prevent staining, damage, and wear. Lay board walkways on floors to be used as passageways.
  - 2.       Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.
  
- D.     Before final inspection, remove protective coverings and rinse neutral cleaner from tile surfaces.

**END OF SECTION**



## SECTION 09513

### SNAP IN METAL PAN CEILINGS

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

A. This section specifies providing exterior grade snap-in metal pan ceiling panels and concealed suspension systems.

B. Related Work Specified Elsewhere:  
1. Division 15 – Mechanical

##### 1.02 SUMMARY

A. Section includes:

1. Exterior grade un-perforated and perforated snap-in metal ceiling panels.
2. Accessories: including devices for attachment overhead construction, secondary members, splines, splices, connecting clips, wall connectors, wall angles, and other devices required for a complete installation.
3. Coordinate layout and installation of items penetrating or being installed in ceiling systems with responsible trades.

##### 1.03 DEFINITIONS

A. Not Required

##### 1.04 PERFORMANCE REQUIREMENTS

A. Structural Performance: Exterior grade snap-in metal pan ceilings shall withstand exterior exposure and the effects of gravity loads and the following loads and stresses without showing permanent deformation of ceiling system components including pans and suspension system; noise or metal fatigue caused by vibration, deflection, and displacement of ceiling units; or permanent damage to fasteners and anchors.

1. Wind Load: Uniform pressure 40 lbf/sq. ft. acting inward or outward.
2. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes. Base calculations on surface temperatures of materials.
  - a. Temperature Change (Range): 100 deg F (55 deg C).

##### 1.05 REFERENECES

A. Codes, Regulations, Reference Standards and Specifications:  
1. Codes and regulations of the jurisdictional authorities.  
2. CISCA: Ceiling Systems Handbook.

3. NAAMM: Metal Finishes Manual for Architectural and Metal Products.

B. American Society for Testing and Materials (ASTM):

1. A 653 – “Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip process.
2. B 209 – “Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate”
3. C 423 – “Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method”
4. C 635 – “Standard Specification for Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings”
5. C 636 – “Recommended Practice for Installation of Metal Ceiling Suspensions Systems for Acoustical and Lay-in Panels”
6. D 1044 – Practice for Abrasion Resistance
7. D 1002 – Practice for Adhesion Resistance
8. E 84 – “Standard Test Method for Surface Burning Characteristics of Building Materials”
9. E 580 – “Standard Practice for Application of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Requiring Moderate Seismic Restraint”
10. E 1264 – Classification for Acoustical Ceiling Products
11. E 1477 – “Standard Test for Luminous Reflectance Factor of Acoustical Materials by use of Integrating-Sphere Suspension System.

C. NEMA Standard 11-14-95 for Chemical Resistance

D. Aluminum Association Standards for Anodic Coatings

**1.06 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: For each type of product specified provide manufacturer’s printed product information including maintenance information.
2. Performance Data: For installed products indicated to comply with design loads and other criteria including governing codes, include structural analysis and other analytical data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Shop Drawings: Reflected ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
  - a. Ceiling suspension system members.
  - b. Method of attaching suspension system hangers to building structure.
  - c. Ceiling-mounted items including light fixtures; air outlets and inlets; speakers; sprinklers, sensors, CCTV’s, and special moldings at walls, penetrations, and other junctures of metal ceilings with adjoining construction.
  - d. Minimum Drawing Scale: 1/8 inch = 1 foot.
4. Samples for Initial Selection: Manufacturer's color charts consisting of actual metal panels or sections of metal panels, suspension systems, and moldings showing the full range of colors, textures, and patterns available for each type of ceiling assembly indicated.
5. Samples for Verification: Full-size units of each type of ceiling assembly indicated; in sets for each color, texture, and pattern specified, showing the full range of variations expected in these characteristics. Provide three of each type.

- a. Full-size samples of each metal panel type, pattern, and color.
  - b. Set of 12-inch-long samples of exposed suspension system members, including moldings, for each color and system type required.
  - c. Fasteners: Each type.
  - d. Accessories.
6. Manufacturer's certifications that products comply with specified requirements, including laboratory reports and product test reports: indicating compliance of metal panel ceilings and components with requirements based on comprehensive testing of current products.
  7. Manufacturer's installation instructions.
  8. Maintenance Data: For finishes, to include in maintenance manuals.

#### **1.07 QUALITY ASSURANCE:**

- A. Source Limitations for Metal Pan Ceilings: Obtain each combination of metal pans and exposed suspension systems from one source with resources to provide products of consistent quality in appearance, physical properties, and performance.
- B. Surface-Burning Characteristics: Complying with ASTM E 1264 for Class A Materials as determined by testing identical products according to ASTM E 84 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.
- C. Seismic Standard: Provide metal pan ceilings designed and installed to withstand the effects of earthquake motions according to the following: SEI/ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads" and 2012 International Building Code with Montgomery County, Maryland Amendments,
- D. Mockups: Build one mockup to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
- E. Installer Qualifications:
  1. Engage an experienced installer with a minimum of 5 years' experience who has completed metal panel ceilings similar in material, design, and extent to that indicated for this Project.
  2. Provide list of at least 5 successful installations with similar products and scope.
- F. Fire-Test-Response Characteristics: Provide metal panel ceilings that comply with the following requirements:
  1. Fire-response tests were performed by UL, ITS/Warnock Hersey, or another independent testing and inspecting agency that is acceptable to authorities having jurisdiction and that performs testing and follow-up services.
  2. Surface-burning characteristics of metal panels comply with ASTM E1264 for Class A materials as determined by testing identical products per ASTM E84.
    - a. Flame Spread: 25 or less
  3. Products are identified with appropriate markings of applicable testing and inspecting agency.

#### **1.08 DELIVERY, STORAGE, AND HANDLING:**

- A. Deliver metal panels and suspension system components to Project site in original, unopened packages, clearly labeled with the manufacturer's name, brand designation, specification number, type, class and ratings as applicable.
- B. Store metal panels and suspensions system components in a fully enclosed space where they will be protected against damage from moisture, direct sunlight, surface contamination, and other causes.
- C. Before installing metal panels, permit them to reach room temperature and a stabilized moisture content.
- D. Handle metal panels carefully to avoid chipping edges or damaging units in any way.

**1.09 PROJECT CONDITIONS:**

- A. Environmental Limitations: Do not install metal panel ceilings until spaces are weatherproof, wet-work in spaces is complete and dry, and work above ceilings is complete.
- B. Painted Panels: Building areas to receive ceilings shall be free of construction dust and debris. Products may be installed where temperatures are between 32°F (0°C) and 120°F (49°C). Such installations shall not be exposed to abnormal conditions, namely: chemical fumes, presence of standing water, or contact with moisture, as could result from condensations or building leaks.

**1.10 COORDINATION:**

- A. Coordinate layout and installation of metal panels and suspension system with other construction that penetrates ceilings or is supported by them, including but not limited to light fixtures, HVAC equipment, public address speakers, security cameras, etc.

**1.11 WARRANTY**

- A. Submit a written warranty executed by the manufacturer, agreeing to repair or replace panels that fail within the warranty period. Failures include, but are not limited to: Ceiling Panels and Suspension System: Rust and manufacturing defects.
- B. Warranty Period:
  - 1. One (1) year from date of substantial completion.
  - 2. Grid: Ten (10) years from date of substantial completion.
  - 3. The Warranty shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and will be in addition to and run concurrent with other warranties made by the Contractor under the requirements of the Contract Documents.

**1.12 EXTRA MATERIALS:**

- A. Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

1. Metal Pan Ceiling Panels: Full-size un-perforated and perforated snap-in units equal to 5.0 percent of amount installed of each type of panel.
2. Suspension System Components: Quantity of each exposed component equal to 2.0 percent of amount installed.

## **PART 2 - PRODUCTS:**

### **2.01 METAL PAN CEILINGS**

- A. Metal Pan Standard: Provide manufacturer's standard metal pans of configuration indicated that comply with ASTM E 1264 classifications as designated by types and light reflectance unless otherwise indicated.
  1. Aluminum Sheet: Roll-formed aluminum sheet, complying with ASTM B 209; alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated.

### **2.02 ALUMINUM PANS FOR METAL PAN CEILING**

- A. Aluminum Metal Pans:
  1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Armstrong World Industries, Inc. "MetalWorks" Torsion Spring
    - b. Ceilings Plus; "Illusions".
    - c. Hunter Douglas Architectural Products, Inc.; "Luxalon" Tile.
- B. Classification: Units complying with ASTM E 1264, other types described as unperforated aluminum facing (pan) units.
  1. Pattern: none.
- C. Pan Fabrication: Manufacturer's standard units of size, profile, and edge treatment indicated, formed from metal indicated and finished to comply with requirements indicated.
  1. Exterior Designer Torsion-Spring-Hinged Pans: Designed to be securely retained in pre-slotted exposed suspension grid by torsion springs, with concealed access. No access holes will be permitted.
  2. Cutouts for light fixtures, sprinklers, and other ceiling devices shall be factory fabricated to the extent possible.
- D. Surface Texture: Smooth
- E. Pan Thickness: Not less than 0.040 inch (1.0 mm).
- F. Pan Edge Detail: Square.
- G. Pan Joint Detail: Butt.
- H. Pan Size: 30 by 30 inches [760 by 760 mm].

### **SNAP IN METAL PAN CEILINGS**

- I. Pan Face Finish: Painted in color selected from manufacturer's full range.
- J. LR: Not less than 0.70.

### **2.03 ALUMINUM PANS FOR METAL PAN CEILING AT SPEAKER LOCATIONS**

#### **A. Aluminum Metal Pans**

- 1. Products: Subject to compliance with requirements, provide one of the following:

- a. Armstrong World Industries, Inc. "MetalWorks" Torsion Spring
- b. Ceilings Plus; "Illusions".
- c. Hunter Douglas Architectural Products, Inc.; "Luxalon" Tile

- B. Classification: Units complying with ASTM E 1264, other types described as perforated aluminum facing (pan) units with no backing.

- 1. Custom Perforation Pattern: Panel to be perforated around speaker area above ceiling with a 12" diameter perforated pattern. Speaker perforated pattern will have a diameter 0.118" holes @ 1/4" staggered centers with  $\pm 1/4$ " unperforated borders.

- C. Pan Fabrication: Manufacturer's standard units of size, profile, and edge treatment indicated, formed from metal indicated and finished to comply with requirements indicated.

- 1. Exterior Designer Torsion-Spring-Hinged Pans: Designed to be securely retained in pre-slotted exposed suspension grid by torsion springs, with concealed access. No access holes will be permitted.
- 2. Cutouts for light fixtures, sprinklers, and other ceiling devices shall be factory fabricated to the extent possible.

- B. Surface texture: Smooth

- C. Pan Thickness: Not less than 0.040 inch (1.0 mm).

- D. Pan Edge Detail: Square.

- E. Pan Joint Detail: Butt.

- F. Pan Size: 30 by 30 inches [760 by 760 mm].

- G. Pan Face Finish: Painted in color selected from manufacturer's full range.

- H. LR: Not less than 0.70.

- I. The plenum shall be 100% accessible. Every panel must be removable. Progressive panel access is not acceptable. Heavy duty torsion springs and steel clip assemblies to be mounted to every panel for downward access, without potential for damage to panel face or hinge assembly. Hinge assembly shall be mounted to every panel with minimum two flush to face, counter sunk chamfered fasteners. Attaching torsion spring directly to panel with fastener will not be acceptable.

## **2.04 METAL SUSPENSION SYSTEMS, GENERAL:**

- A. Recycled Content: Provide products made from steel sheet with average recycled content such that postconsumer recycled content plus one-half of pre-consumer recycled content is not less than 25 percent.
- B. Metal Suspension System Standard: Provide manufacturer's standard aluminum suspension systems of types, structural classifications, and finishes indicated that comply with applicable ASTM C 635 requirements.
- C. Suspension Systems: Provide systems complete with carriers, runners, splice sections, connector clips, alignment clips, leveling clips, hangers, molding, trim, retention clips, load-resisting struts, and other suspension components required to support ceiling units and other ceiling-supported construction.
- D. Hanger Rods or Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.
- E. Angle Hangers: Angles with legs not less than 7/8 inch (22 mm) wide; formed with 0.04-inch- (1.0-mm-) thick, galvanized-steel sheet complying with ASTM A 53/A 653M, G90 (Z275) coating designation; with bolted connections and 5/16-inch- (8-mm-) diameter bolts.
- H. Metal Sheet-Metal Edge Moldings and Trim: Provide exposed members as indicated or as required to comply with seismic requirements of authorities having jurisdiction, to conceal edges of and penetrations through ceiling, to conceal edges of pans and runners, for fixture trim and adapters, for fascias at changes in ceiling height, and for other conditions; of metal and finish matching metal pan ceiling units, unless otherwise indicated. Provide moldings with exposed flange of the same width as exposed runner.

## **2.05 GENERAL FINISH REQUIREMENTS**

- A. Finishes and Colors, General: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Provide manufacturer's standard factory-applied finish for type of system indicated.
  - 1. High-Humidity Finish: Comply with ASTM C 635 requirements for "Coating Classification for Severe Environment Performance."
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

## **2.06 ALUMINUM FINISHES**

- A. Metal Finish: Panel Finish shall be: Fluoropolymer "Painted" finish – 3105 alloy.
- B. Color and Gloss: as selected by the Owner from manufacturer's full range of colors and glosses.

## **SNAP IN METAL PAN CEILINGS**

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION:**

- A. Examine substrates, areas, and conditions, including structural framing to which metal pan ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of metal pan ceilings.
1. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.02 PREPARATION:**

- A. Coordination: Furnish layouts for cast-in-place anchors, clips, and other ceiling anchors whose installation is specified in other Sections.
1. If indicated, furnish cast-in-place anchors and similar devices to other trades for installation well in advance of time needed for coordinating other work.
- B. Measure each ceiling area and establish layout of Metal Pan Ceiling to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders, and comply with layout shown on reflected ceiling plans and Coordination Drawings.

### **3.03 INSTALLATION:**

- A. General: Install metal panel ceilings to comply with publications referenced below per manufacturer's written instructions and CISCA's "Ceiling Systems Handbook."
1. Standard for Ceiling Suspension System Installations: Comply with ASTM C636.
- B. Install edge moldings and trim of type indicated at perimeter of metal panel ceiling area and where necessary to conceal edges of metal panels.
1. Screw attach moldings to substrate at intervals not more than 16 inches on center and not more than 3 inches from ends, leveling with ceiling suspension system to a tolerance of 1/8 inch in 12 feet. Miter corners accurately and connect securely. Miter inside and outside corners accurately and connect securely.
  2. Do not use exposed fasteners, including pop rivets, on moldings and trim.
- C. Install suspension system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
- D. Cut metal pan units for accurate fit at borders and at interruptions and penetrations by other work through ceilings. Stiffen edges of cut units as required to eliminate evidence of buckling or variations in flatness exceeding referenced standards for stretcher-leveled metal sheet.
- E. Install metal pans in coordination with suspension system and exposed moldings



and trim.

1. For torsion-spring-hinged pans, position pans according to manufacturer's written instructions.
- F. Install metal panels with undamaged edges and fitted accurately into suspension system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide a neat, precise fit.
1. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension system runners and moldings.
  2. Install hold-down clips in areas indicated, in areas required by authorities having jurisdiction, and for fire-resistance ratings; space as recommended by panel manufacturer's written instructions, unless otherwise indicated or required.
  3. Align joints in adjacent courses to form uniform, straight joints.
  4. Fit adjoining units to form flush, tight joints.

**3.04 FIELD QUALITY CONTROL INCLUDING POWER-ACTUATED FASTENERS AND POST-INSTALLED ANCHORS:**

A. Inspections: Engage an inspector with prior experience of installation of approved manufacturer's ceiling system within the last 5 years, to perform the following inspections.

1. Suspended ceiling system.
2. Hangers, anchors, and fasteners.

B. Testing Agency: Contractor will engage a qualified independent testing agency to perform field quality-control testing.

C. Extent and Testing Frequency: Testing will take place in successive stages in areas described below. Proceed with installation of metal pan ceilings only after test results for previously installed hangers comply with requirements.

1. Existing hangers and support for existing framing: This applies if existing hangers and framing are to be reused. Test 1 in 20 hangers and support framing for 200 lbf tension. When testing discovers hangers and support framing that fails the test, testing agency will test other hangers and support framing not previously tested until 20 pass consecutively. Failed hangers and support framing will be considered defective and will be removed / replaced. Perform tests for each level of the station.
2. Extent of Each Test Area: When installation of ceiling suspension systems on each floor has reached 20 percent completion but no panels have been installed.
3. Within each test area, testing agency will select one of every 10 powder-actuated fasteners and post-installed anchors used to attach hangers to concrete and will test them for 200 lbf of tension; it will also select one of every two post-installed anchors used to attach bracing wires to concrete and will test them for 440 lbf of tension.
4. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 consecutively pass and then will resume initial testing frequency.

D. Ceiling hangers and anchors and fasteners will be considered defective if they do not pass tests and inspections.

- E. Testing agency will report test results promptly and in writing to Contractor and Engineer.
- F. Remove and replace those fasteners and anchors that test results indicate do not comply with specified requirements
- G. Additional Testing: Where fasteners and anchors are removed and replaced, additional testing will be performed to determine compliance with specified requirements.

**3.05 CLEANING:**

- A. Replace damaged and broken metal pan ceiling.
- B. Clean exposed surfaces of metal panel ceilings, including trim, edge moldings, and suspension system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.
- C. Clean up rubbish and debris and remove from site.
- D. Leave work areas in a broom clean condition.

**END OF SECTION**

## SECTION 15080

### INSULATION

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing insulation.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. NFPA: 90A.
  - 3. ASTM: C240, C534, C552, C1071.
  - 4. FS: HH-I-558.
  - 5. MS: MIL-B-19564.
  - 6. SMACNA: HVAC Duct Construction Standards – Metal and Flexible
- B. Each item listed in UL Building Materials Directory.
- C. Fire-Hazard Ratings:
  - 1. Determine fire-hazard ratings in accordance with ASTM E84.
    - a. Insulation, fastener, and jacketing materials, except flexible cellular plastic for expansion joints: Not exceeding 25 for flame spread, 50 for fuel contributed and 50 for smoke developed.
    - b. Use of flameproofing and fireproofing treatments for the purpose of achieving specified fire-hazard ratings for insulation not meeting specified requirements is prohibited.

##### 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.
  - 2. Certification.

##### 1.04 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Label each item with manufacturer's name and brand designation, referenced specification number, type, class and thermal and acoustical rating as applicable.
- B. Ship each type of insulation and accessory materials securely packaged and labeled for safe handling in shipment and to avoid damage.
- C. Store materials in secure and dry storage facility.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. External Ductwork Insulation with Vapor-Barrier Facing:

1. Insulation:
    - a. Rigid board for exposed ductwork:
      - 1) Thickness: One inch.
      - 2) Density: Three pounds per cubic foot.
      - 3) Vapor-barrier facing: As specified, factory-applied.
      - 4) FS HH-I-558, Form A, Class 2.
    - b. Flexible duct wrap for concealed ductwork:
      - 1) Thickness: Two inches.
      - 2) Density: 1.5 pounds per cubic foot.
      - 3) Vapor-barrier facing: As specified, factory-applied.
      - 4) FS HH-I-558, Form B, Type I, Class 6.
  2. Vapor-barrier facing: foil-reinforced kraft paper.
- 
- B. Expansion-Joint Insulation: Flexible unicellular, ASTM C534, one-inch thickness, two layers.
  - C. Wire Mesh: Galvanized wire, 22-gauge, one-inch mesh welded.
  - D. Corner Beads: Galvanized steel, 26-gauge, 2 1/2-inch wings.
  - E. Rigid-Insulation Adhesive and Sealer: Cold-applied, nonhardening asphaltic-type, in accordance with MS MIL-B-19564.
  - F. Vinyl-Emulsion Mastic: As recommended by manufacturer of rigid insulation.
  - G. Bore Coating: Anti-abrasive vinyl-base type as recommended by manufacturer of rigid insulation.
  - H. Sheet Metal Duct Lining: Galvanized sheet metal, 22 gauge, perforated with 3/32-inch holes on 3/16-inch centers, with 22-percent open area.

### **PART 3 - EXECUTION**

#### **3.01 APPLICATION OF INSULATION:**

- A. General:
  1. Do not apply insulation until all surfaces to be covered are clean, dry and free of foreign materials, such as oil, grease, rust, scale and dirt.
  2. Apply only clean and dry insulation.
  3. Install insulation in accordance with manufacturer's recommendations as a minimum requirement.
  4. Provide complete moisture and vapor seal wherever insulation terminates against metal hangers, anchors and other projections through insulation on cold surfaces.
  5. Provide continuous insulation through sleeves and openings except pipe sleeves piercing exterior walls, floors and ceilings below ground level.
  6. Stagger joints with respect to adjacent butt joints.
  7. Unless otherwise shown, insulate the following:
    - a. Platform and mezzanine air-conditioning supply ductwork.
    - b. Exhaust-air ductwork between automatic damper on discharge side of fan and louver, except underplatform and dome exhaust-air ductwork where insulation is not required.

8. The Contractor has the option of applying insulation internally or externally, except for the following required internal applications:
  - a. Where shown.
  - b. Insulated ductwork exposed to weather.
  - c. Air-conditioning pylons.
  - d. Air-conditioning ductwork under platform.
  
- B. External Ductwork Insulation:
  1. Install insulation continuously through openings provided for passage of ductwork and unbroken over seams, angles, hangers and other accessories.
  2. Do not use scrap pieces of insulation to make up full-length sections. Eliminate voids by refitting or replacing insulation.
  3. Rigid board for exposed ductwork:
    - a. Fasten to duct with mechanical fasteners spaced 12 inches to 18 inches on center, with minimum of two rows on each side of duct.
    - b. Secure with washers firmly embedded in insulation.
    - c. Seal joints, breaks and punctures with fire-resistant vapor-barrier coating reinforced with a three-inch wide vapor-barrier strip.
  4. Flexible duct wrap for concealed ductwork:
    - a. Adhere to duct with fire-resistant adhesive in sufficient quantities to prevent sagging.
    - b. Secure insulation tightly to the ducts with Type 316 stainless-steel insulation bands spaced 12 inches maximum center-to-center.
    - c. For duct widths over 30 inches, secure on underside of duct with mechanical fasteners on 18-inch centers.
    - d. Butt insulation, overlap joints with vapor-barrier facing two inches minimum; seal with fire-resistant vapor-barrier adhesive.
    - e. Seal breaks and punctures with vapor-barrier strip and coating.

**END OF SECTION**

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## **SECTION 15806**

### **AIR CONDITIONING PYLONS**

#### **PART 1 - GENERAL**

##### **1.01 DESCRIPTION:**

- A. This section specifies providing air-conditioning pylons.
- B. Related Work Specified Elsewhere:
  - 1. Ductwork: Section 15810.
  - 2. Insulation: Section 15080.
  - 3. System balancing and testing: Section 15950.
- C. Work by Others:
  - 1. Graphic panels.

##### **1.02 QUALITY ASSURANCE:**

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. ANSI: C80.3.
  - 2. FED STD: 595.

##### **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.

#### **PART 2 - PRODUCTS**

##### **2.01 PRODUCTS AND MATERIALS:**

- A. Air Control Damper:
  - 1. Each pylon body equipped with air control damper containing low leakage opposed blades of aluminum airfoil shape and 16-gauge galvanized steel frame.
  - 2. Single-shaft damper control provided with air control damper. Damper shaft end which projects to pylon exterior fitted with high-pressure damper regulator with neoprene gaskets and acorn nut.

- B. Supply Grille:
  - 1. Each pylon furnished with square supply grille. Frames, vanes and fins fabricated of steel (Tuttle and Bailey/Hart and Cooley G-series, GOS Core with Style A, or approved equal).
  - 2. Diffusion grille fabricated of 22-gauge galvanized steel, perforated with 3/32-inch diameter holes on 3/16-inch centers, 33-percent free area. Fixed horizontal vanes (square grille) fabricated of steel oriented to deflect supply air at 15-degree angle from horizontal plane. Vanes spaced maximum 1/4-inch apart. Grille finished in flat black, FED STD 595, Color No. 37038.
  - 3. Fixed vertical fins (masking plates), spaced as shown, welded to top and bottom finish plates, finished in baked enamel.
- C. Finish: Unless otherwise shown, factory-finish, FED STD 595, Color No. 20040, provided on items exposed to public view.

### **PART 3 - EXECUTION:**

#### **3.01 INSTALLATION:**

- A. Fit equipment and appurtenances into space provided. No portion of pylon to extend into space in which graphics panels will be installed by others.

#### **3.02 FIELD QUALITY CONTROL:**

- A. Pressure Test:
  - 1. Include pylon in ductwork pressure test as specified in Section 15810.
- B. Balancing and Testing:
  - 1. Include balancing of pylons in balancing and testing of system specified in Section 15950.

**END OF SECTION**



## SECTION 15810

### DUCTWORK

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing ductwork and accessories.
- B. Related Work Specified Elsewhere:
  - 1. Insulation: Section 15080.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
  - 1. Comply with codes and regulations of the jurisdictional authorities.
  - 2. SMACNA:
    - a. HVAC Duct Construction Standards - Metal and Flexible.
    - b. Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems.
    - c. HVAC Systems - Testing, Adjusting and Balancing.
    - d. HVAC Air Duct Leakage Test Manual.
  - 3. ASTM: A36, A53, A653.
  - 4. NFPA: 90A
  - 5. AASHTO: M81.
  - 6. UL: Building Materials Directory, 181, 555.

##### 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. Scale: 1/4-inch minimum

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS:

- A. Galvanized Sheet Steel: ASTM A653.
- B. Steel Plate: ASTM A36, Grade A.
- C. Steel Pipe: ASTM A53, Grade A.
- D. Flexible Material:
  - 1. Fibrous-glass cloth, 32 ounces per square yard, UL-listed.
  - 2. Tensile strength: 450-psi minimum.
  - 3. Coated on both sides with fire-resistant neoprene.
  - 4. Suitable for operating temperature of 200F and meeting requirements of NFPA 90A.
- E. Paint:
  - 1. Zinc-rich gray, No. 721, Detroit Graphite or equal.

2. Bituminous, AASHTO M81, Grade RC-250.

## 2.02 FABRICATION:

- A. Duct Construction:
  1. Fabrication in accordance with HVAC Duct Construction Standards-Metal and Flexible.
- B. Access Doors in Ducts:
  1. Doors: Of same metal thickness as ducts.
  2. Gasketed doors: Secured to duct.
- C. Plenums:
  1. Field-fabricated and reinforced consistent with class of ductwork in which used.
  2. Outward-opening access doors to plenums provided where necessary for equipment access and as shown.
- D. Dampers:
  1. Butterfly dampers:
    - a. Balanced-type with flat blades.
    - b. Rigid blades fabricated with close-fitting hemmed edges.
    - c. Damper rods minimum 3/8-inch square at one end passing directly through ducts.
    - d. Square end of each rod held in self-locking lever device.
    - e. Where installed in furred ceilings, damper-locking device may be provided with short lever and concealed in box with flush cover in lieu of access panel.
  2. Opposed-blade dampers:
    - a. Gang-operated multiple blades provided in ducts over 12 inches in dimension.
    - b. Multiple blades fabricated maximum six inches wide.
    - c. Fabricated with nonmetallic edges or coating in low-pressure, medium-pressure or high-pressure ducts.
    - d. Ends of damper rods sealed to prevent leakage of air.
  3. Splitter dampers:
    - a. Single blade with hemmed edges, provided at branch duct connections.
    - b. Each blade hinged at one end with sheet metal straps.
    - c. Free end of each blade connected to 1/4-inch adjusting rod secured to side of duct in flanged bushing with set screws.
    - d. Rods adjusted to operate freely between open and closed positions.
  4. Damper material:
    - a. Splitter and damper blades fabricated of same metal and two gauges heavier than ductwork and casings.
    - b. Fastening details and other items fabricated of metal specified for ductwork and casing bracing.
  5. Damper regulators:
    - a. Self-locking, damper and splitter regulators furnished, labeled SHUT and OPEN.
    - b. Factory-fabricated damper and splitter hardware furnished with zinc or cadmium protective coating.
  6. Fire dampers:

- a. Fabricated to meet requirements of codes and regulations of jurisdictional authorities.
  - b. Constructed so that, during normal operation, folded blade assembly does not interrupt air stream.
  - c. Access provided for replacement of links.
  - d. Sleeve provided for fire damper, 14-gauge hot-rolled steel.
  - e. Fire dampers remote from fire partitions; connecting ductwork provided between fire damper and fire partition, fabricated of 11-gauge, zinc-coated sheet steel and supported by ½-inch diameter rods.
  - f. Fire dampers constructed to meet requirements of NFPA 90A and UL 555.
- E. Flexible-Duct Connections:
1. Flexible-duct connections provided between air-handling unit fan and related ductwork and wherever necessary to prevent transmission of vibration to adjacent elements.
  2. Factory-assembled flexible material bordered each side with three-inch wide galvanized-steel edging mechanically attached.
  3. Width of flexible portion: Three to nine inches as necessary for installation conditions and to allow freedom of movement without unnecessary slack.
  4. Fabric parts of flexible connections: Unpainted.
- F. Instrument Test Holes:
1. Factory-fabricated, airtight, non-corrosive instrument test hole with screw cap and gasket.
  2. Instrument test holes provided where required by balancing and testing agency.
  3. Cap extended up through insulation.

## PART 3 - EXECUTION

### 3.01 INSTALLATION:

- A. Ductwork Installation:
1. Install dampers and splitters so as to permit adjustment after completion of the work.
  2. Install dampers without strain or distortion of any part of dampers.
  3. Adjust moving parts to move freely without binding.
  4. Caulk dampers airtight around frames.
  5. Adjust damper and splitter adjusting rods to operate freely between open and closed positions.
    - a. Cut off projecting ends of rods after adjustment and bend over two inches from bushings.
    - b. Leave cut ends smooth and free from burrs.
  6. Where diffuser is located at end of rectangular duct, extend duct minimum of one-neck diameter beyond center line of neck.
  7. Fire dampers:
    - a. Install fire dampers in ducts which penetrate walls or floors separating areas normally used by the public from ancillary areas. Patron-used areas include, but are not limited to, the following:
      - 1) Station train rooms.
      - 2) Train tunnels.
      - 3) Passageways ordinarily used by patrons.
    - b. Install fire dampers in ducts which penetrate walls and floors of elevator machinery rooms.
    - c. Install fire dampers to conform with fire, smoke and radiation damper installation guide for HVAC system

8. Embedded Ductwork:
    - a. Join sections by continuous weld to achieve watertightness.
  9. At in-line fans, provide flanged removable transition to permit access to and removal of fan motor
- B. Flexible Connections:
1. Install flexible connections in accordance with HVAC Duct Construction Standards – Metal and Flexible.
- C. Protection of Ductwork:
1. Protect ductwork, appurtenances and openings from dirt, foreign objects and damage during construction.
  2. Replace damaged ductwork and appurtenances.
  3. Provide sheet metal caps on duct ends that are to be connected to future ductwork.
- D. Painting of Embedded Ductwork:
1. After pressure test, clean joint areas.
  2. Coat outside of duct joints with zinc-rich paint measuring not less than five mils dry-film thickness or with two coats of bituminous paint over compatible primer.

### **3.02 FIELD QUALITY CONTROL:**

- A. Air-Leak Tests for Accessible Ductwork: Perform air-leak tests in accordance with SMACNA HVAC Air Duct Leakage Test Manual.
- B. Air-Leak Test for Embedded Ductwork: Test ductwork with internal air pressure of six inches wg. in accordance with SMACNA.

### **3.03 CLEANING OF AIR SYSTEM:**

- A. Before fans or filters are operated, clean inside of air system, including casing, plenums, ductwork and concrete tunnels used for air supply or return.
- B. Accomplish cleaning by means of industrial vacuum cleaners which will effectively remove dust and foreign material from surfaces swept by air stream.
- C. Clean exposed ductwork and leave in satisfactory condition, free from grease, oil and foreign material prior to application of insulation or finish painting.
- D. Clean ducts after the system has been used for adjusting, testing or temporary ventilation.

**END OF SECTION**

## SECTION 15850

### OUTLETS AND GRILLES

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies providing outlets and grilles.
- B. Related Work Specified Elsewhere:
  - 1. Air conditioning pylons: Section 15806.
  - 2. System balancing and testing: Section 15950.

##### 1.02 QUALITY ASSURANCE:

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

##### 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.
  - 2. Samples:
    - a. One full-size sample of each outlet and grille in each finish specified.
  - 3. Certification.

#### PART 2 - PRODUCTS

##### 2.01 PRODUCTS AND MATERIALS:

- A. Supply Grilles:
  - 1. Type: Removable core, adjustable, two-way directional.
  - 2. Horizontal adjustment: By means of individually adjustable vertical bars or vanes spaced one-inch apart maximum.
  - 3. Vertical adjustment: By means of individually adjustable horizontal bars or vanes placed in front of vertical bars or by means of fixed fins which can be removed as a unit from frame and inserted in four positions.
  - 4. Horizontal bars or vanes spaced one-inch apart maximum.
  - 5. Fixed fins spaced 1/4-inch apart maximum.
  - 6. Frames constructed of stamped-steel or rolled-steel sections.
    - a. Prior to priming and finishing, steel parts of grilles treated with zinc-phosphate or zinc-chromate, dipped after fabrication.
  - 7. Supply grilles provided with airtight felt, neoprene or plastic sealing strips at edges, designed to prevent leakage.
  - 8. Corner joints finished to provide neat, trim appearance.
  - 9. Each grille provided with factory-fabricated volume-control damper furnished by grille manufacturer.
    - a. Volume dampers: Group-operated, opposed-blade, key adjustable.
    - b. Volume adjustment: By inserting key through face of grille.
    - c. Operating mechanism not projecting through grille face.

- 10. Factory-fabricated multiple-blade extractors, furnished by grille manufacturer where shown.
  - a. Multiple-blade extractors: Air-deflecting and air-straightening type with blades spaced two inches apart maximum.
- B. Exhaust and Return Grilles:
  - 1. Exhaust and return grilles constructed as specified for supply grilles except with single set of nonadjustable face bars or vanes having same appearance as supply grilles.
  - 2. Volume-control dampers where shown.

**2.02 FINISHES:**

- A. Items exposed to public view in stations: Unless otherwise shown, factory-finished in baked enamel, colors as directed.
- B. Items not exposed to public view: Factory-finished in light-gray baked enamel.

**PART 3 - EXECUTION**

**3.01 INSTALLATION:**

- A. Install grilles and diffusers to permit key adjustment from face without other special tools.
- B. Install vanes and volume-control dampers to permit removal through diffuser for access to duct.

**END OF SECTION**

## SECTION 15950

### SYSTEM BALANCING AND TESTING

#### PART 1 - GENERAL

##### 1.01 DESCRIPTION:

- A. This section specifies balancing, adjusting and performance-testing of heating, exhaust, air-conditioning and ventilating systems with ductwork.

##### 1.02 QUALITY ASSURANCE:

- A. Codes, Regulations, Reference Standards and Specifications:
1. NEBB: Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems.
  2. ASHRAE III: Practices for Measurement, Testing, Adjusting and Balancing of Building HVACR Systems.
- B. Instrument Calibration:
1. Calibrate instruments required for air and water balance within six months prior to use on this project.

##### 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. Test and instrument location plans.
    - b. After initial balancing measurements, submit shop drawings for additional equipment such as balancing dampers, pressure taps and balancing cocks necessary to effect proper air and water balance.
  2. Certification:
    - a. Complete air balance report certified by professional engineer licensed in the jurisdiction where the work is to be performed.
    - b. Collect data in accordance with referenced standards.
    - c. Submit complete data on standard NEBB testing and balancing report forms without omissions or on approved report forms bearing identical data. Data to include types, serial numbers and calibration dates of instruments and to cover the following:
      - 1) Ductwork including transverse and pilot tube test: Section 15810.
      - 2) Air outlets: Sections 15850 and 15806.
    - d. In addition, provide the following data:
      - 1) Air-conditioning pylons: One temperature and velocity traverse at each air-conditioning pylon. Traverse consists of simultaneous readings at the following locations:
        - a) Twenty readings five feet above platform or mezzanine, one each at three feet, six feet, nine feet, twelve feet and fifteen feet from pylon, at each of four quadrant points around pylon.
        - b) Four readings at supply register one at each of four quadrant points.
        - c) One reading twelve feet above platform or mezzanine, three feet from pylon.

- d) Test and certify that net air flow per original design, which existed prior to construction, is achieved for any new or modified portion of the existing ventilation system.

## **PART 2 - PRODUCTS**

- 2.01** Provide, as specified in Section 15810, additional equipment, such as balancing dampers, pressure taps and balancing cocks necessary to effect proper air and water balance.
- 2.02** Design, construct and install necessary blanking baffles for air-conditioning pylons.

## **PART 3 - EXECUTION**

### **3.01 BALANCING AND PERFORMANCE TESTING:**

- A. After completion of installation of heating, exhaust and air-conditioning systems, and prior to acceptance by the Engineer, adjust and balance air-handling systems, and appurtenances applicable to those systems to deliver the air quantities as specified and as shown. Make final tests after modifications are completed. Seal instrument test holes upon completion of balancing operation.
- B. Air Balance:
  - 1. Perform testing in accordance with referenced NEBB Standard, ASHRAE 111 or other approved standard.
  - 2. Perform tests, adjust and balance when outside conditions approximate design conditions as shown for heating and cooling functions.

**END OF SECTION**