# PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 and 01 Specification Sections, apply to this Section.

## 1.2 SUMMARY

A. Section includes integrally-colored glass-fiber-reinforced concrete (GFRC).

B. Related Requirements:
1. Section 018113 “Sustainable Design Requirements.”
2. Section 033000 "Cast-in-Place Concrete" for embedding weld plates and angles in concrete for attaching connection devices.
3. Section 051200 "Structural Steel Framing" for attaching connection devices to steel framing.
4. Section 079200 "Joint Sealants" for elastomeric joint sealants and sealant backings.

## 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

## 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include GFRC design mixes.

B. LEED Submittals: Credits MRc4, MRc5 and EQc4.2: Refer to Section 018113 “Sustainable Design Requirements” for additional submittal requirements.

C. Shop Drawings: Show fabrication and installation details for GFRC including the following:
1. Cover elevations, sections, and dimensions.
2. Thickness of facing mix, GFRC backing, and bonding pads for typical panels.
3. Finishes.
4. Joint and connection details.
5. Erection details.
6. Panel frame details for typical covers including sizes, spacings, thicknesses, and yield strengths of various members.
7. Locations and details of connection hardware attached to structure.
8. Sizes, locations, and details of flex, gravity, and seismic anchors for typical covers.
9. Other items sprayed into covers.
10. Relationship to adjacent materials.
11. Description of loose, cast-in, and field hardware.

D. Samples for Verification: For each type of finish indicated on exposed GFRC surfaces, representative of finish, color, and texture variations expected, approximately 12 by 12 inches by actual thickness.

E. Delegated-Design Submittal: For GFRC, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Designated a PCI-certified plant for Group G - Glass Fiber Reinforced Concrete or designated an APA-certified plant for GFRC production.

B. Installer Qualifications: Manufacturer of GFRC panels.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel," and AWS D1.3, "Structural Welding Code - Sheet Steel."

D. Mockups: Build mockups to demonstrate aesthetic effects and to set quality standards for fabrication and installation.
   1. Build mockup of typical GFRC as shown on Drawings.
      a. Include typical components, attachments to building structure, finish (integral) color, and methods of installation.
      b. Include sealant-filled joint complying with requirements in Section 079200 "Joint Sealants."
   2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handle and transport GFRC supported on nonstaining material and with nonstaining resilient spacers between covers.

B. Store GFRC off of ground on firm, level, and smooth surfaces supported on nonstaining material and with nonstaining resilient spacers between panels. Place stored panels so identification marks are clearly visible.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Moonlight Molds, Inc.
   2. Advanced Architectural Stone
   3. Formglas Products, Ltd.
   4. GC Products, Inc.

B. Source Limitations for GFRC: Obtain cast-stone and GFRC units from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design GFRC and connections.

2.3 MOLD MATERIALS

A. Molds: Rigid, dimensionally stable, non-absorptive material, warp and buckle free, that provides continuous GFRC surfaces within tolerances; nonreactive with GFRC and capable of producing required finish surfaces.
   1. Mold-Release Agent: Commercially produced liquid-release agent that does not bond with, stain, or adversely affect GFRC surfaces and does not impair subsequent surface or joint treatments of GFRC.

B. Form Liners: Units of face design, texture, arrangement, and configuration indicated to match GFRC design reference sample. Provide solid backing and form supports to ensure that form liners remain in place during GFRC application. Use with manufacturer's recommended liquid-release agent that does not bond with, stain, or adversely affect GFRC surfaces and does not impair subsequent surface or joint treatments of GFRC.

C. Surface Retarder: Chemical liquid-set retarder capable of temporarily delaying hardening of newly placed GFRC face mix to depth of reveal specified.

2.4 GFRC MATERIALS

A. Portland Cement: ASTM C 150; Type I, II, or III.
   1. For surfaces exposed to view in finished structure, use white of same type, brand, and source throughout GFRC production.

B. Metakaolin: ASTM C 618, Class N.

C. Glass Fibers: Alkali resistant, with a minimum zirconia content of 16 percent, 1 to 2 inches long, specifically produced for use in GFRC, and complying with ASTM C 1666.

D. Sand: Washed and dried silica, complying with composition requirements in ASTM C 144; passing a No. 20 sieve with a maximum of 2 percent passing a No. 100 sieve.

E. Facing Aggregate: ASTM C 33, except for gradation, and PCI MNL 130, 1/4-inch maximum size.
   1. Aggregates: Selected, hard, and durable; free of material that reacts with cement or causes staining; to match sample.
   2. Fine Aggregate: Natural or manufactured sand with a maximum of 5 percent passing a No. 100 sieve and a maximum of 3 percent passing a No. 200 sieve.

F. Coloring Admixture: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures, temperature stable, nonfading, and alkali resistant.

G. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of GFRC and complying with chemical limits in PCI MNL 130.

H. Polymer-Curing Admixture: Acrylic thermoplastic copolymer dispersion complying with PCI MNL 130.

I. Air-Entraining Admixture: ASTM C 260, containing not more than 0.1 percent chloride ions.

J. Chemical Admixtures: ASTM C 494, containing not more than 0.1 percent chloride ions.

K. LEED Material Credits MRc4, MRc5 and EQc4.2: Refer to Section 018113 “Sustainable Design Requirements” for additional product requirements.

2.5 ANCHORS, CONNECTORS, AND MISCELLANEOUS MATERIALS

A. Carbon-Steel Shapes and Plates: ASTM A 36, finished as follows:
1. Finish: Zinc coated by hot-dip process according to ASTM A 123, after fabrication, or ASTM A 153, as applicable, or electrodeposition according to ASTM B 633, SC 3.
2. Finish: Shop primed with paint complying with MPI#79 on surfaces prepared to comply with SSPC-SP 2, "Hand Tool Cleaning," or better.

B. Carbon-Steel Bars: ASTM A 108, Grade 1018, not less than 1/4 inch in diameter, finished as follows:
1. Finish: Zinc coated by hot-dip process according to ASTM A 123, after fabrication, or ASTM A 153, as applicable, or electrodeposition according to ASTM B 633, SC 3.
2. Finish: Shop primed with paint complying with MPI#79 on surfaces prepared to comply with SSPC-SP 2, "Hand Tool Cleaning," or better.

C. Malleable-Iron Castings: ASTM A 47, Grade 32510.

D. Carbon-Steel Castings: ASTM A 27, Grade 60-30.

E. Bolts: ASTM A 307 or ASTM A 325, finished as follows:
1. Finish: Zinc coated by [hot-dip process according to ASTM A 123, after fabrication, and ASTM A 153, as applicable, or electrodeposition according to ASTM B 633, SC 3.

F. LEED Material Credits MRc4, MRc5 and EQc4.2: Refer to Section 018113 “Sustainable Design Requirements” for additional product requirements.

2.6 GFRC MIXES

A. Mist Coat: Portland cement, sand slurry, and admixtures; of same proportions as backing mix without glass fibers.

B. Face Mix: Proportion face mix of portland cement, sand, facing aggregates, and admixtures to comply with design requirements.

C. Backing Mix: Proportion backing mix of portland cement, glass fibers, sand, and admixtures to comply with design requirements. Provide nominal glass-fiber content of not less than 5 percent by weight of total mix.

D. Polymer-Curing Admixture: 6 to 7 percent by weight of polymer-curing admixture solids to dry portland cement.

E. Air Content: 8 to 10 percent; ASTM C 185.

F. Coloring Admixture: Not to exceed 10 percent of cement weight.

G. LEED Material Credits MRc4, MRc5 and EQc4.2: Refer to Section 018113 “Sustainable Design Requirements” for additional product requirements.

2.7 MOLD FABRICATION

A. Construct molds that result in finished GFRC complying with profiles, dimensions, and tolerances indicated, without damaging GFRC during stripping. Construct molds to prevent water leakage and loss of cement paste.
   1. Coat contact surfaces of molds with form-release agent.
   2. Coat contact surfaces of molds with surface retarder.

B. Place form liners accurately to provide finished surface texture indicated. Provide solid backing and supports to maintain stability of liners during GFRC application. Coat form liner with form-release agent.

2.8 GFRC FABRICATION

A. Proportioning and Mixing: For backing mix, meter sand/cement slurry and glass fibers to spray head at rates to achieve design mix proportions and glass-fiber content according to PCI MNL 130 procedures.

B. Spray Application: Comply with general procedures as follows:
   1. Spray mist coat over molds to a nominal thickness of 1/8 inch on planar surfaces.
   2. Spray or place face mix in thickness indicated on Shop Drawings.
   3. Proceed with spraying backing mix before face mix has set, using procedures that produce a uniform thickness and even distribution of glass fibers and matrix.
   4. Consolidate backing mix by rolling or other technique to achieve complete encapsulation of glass fibers and compaction.
   5. Measure thickness with a pin gage or other acceptable method at least once for every 5 sq. ft. of panel surface. Take no fewer than six measurements per GFRC item.

C. Hand form and consolidate intricate details, incorporate formers or infill materials, and overspray before material reaches initial set to ensure complete bonding.

D. Attach frame to GFRC before initial set of GFRC backing, maintaining a minimum clearance of 1/2 inch from GFRC backing, and without anchors protruding into GFRC backing.

E. Build up homogeneous GFRC bonding pads over anchor feet, maintaining a minimum thickness of 1/2 inch over tops of anchor feet, before initial set of GFRC backing. Measure bonding pad thickness at 25 percent of anchor locations.

F. Inserts and Embedments: Build up homogeneous GFRC bosses or bonding pads over inserts and embedments to provide enough anchorage and embedment to comply with design requirements.

G. Curing: Employ initial curing method that ensures sufficient strength for removing units from mold. Comply with PCI MNL 130 procedures.
   1. Keep moisture off of the surfaces of mixes with polymer curing admixtures during the first three hours of curing. Maintain temperature between 60 and 120 deg F during the first 16 hours.

2. Prevent drying of moist curing mixes during the first 24 hours. Maintain units in surface-damp condition at a temperature above 60 deg F and 95 percent relative humidity for seven days.

H. Identification: Mark each GFRC item to correspond with identification mark on Shop Drawings. Mark each item with its casting date.

2.9 FABRICATION TOLERANCES

A. Manufacturing Tolerances: Manufacture GFRC so each finished unit complies with PCI MNL 130 for dimension, position, and tolerances.

B. Manufacturing Tolerances: Manufacture GFRC so each finished unit complies with the following dimensional tolerances. For dimensional tolerances not listed below, comply with PCI MNL 130.
1. Overall Height and Width of Units, Measured at the Face Adjacent to Mold: As follows:
a. 10 feet or less, plus or minus 1/8 inch.
b. More than 10 feet, plus or minus 1/8 inch per 10 feet; 1/4 inch maximum.
2. Edge Return Thickness: Plus 1/2 inch, minus zero inch.
3. Backing Thickness: Plus 1/4 inch, minus zero inch.
4. Local Smoothness: 1/4 inch per 10 feet.

C. Position Tolerances: Measured from datum line locations, as indicated on Shop Drawings.
1. Panel Frame and Track: Plus or minus 1/4 inch.
2. Inserts: Plus or minus 1/2 inch.
3. Special Handling Devices: Plus or minus 3 inches.
4. Location of Bearing Devices: Plus or minus 1/4 inch.
5. Blockouts: Plus or minus 3/8 inch.

D. Frame Tolerances: As follows:
1. Vertical and Horizontal Alignment: 1/8 inch per 10 feet.
2. Spacing of Framing Member: Plus or minus 1/4 inch.
3. Squareness of Frame: Difference in length of diagonals of 1/4 inch.
4. Overall Size of Frame: Plus or minus 1/4 inch.

2.10 FINISHES

A. Exposed faces shall be free of joint marks, grain, and other obvious defects. Finish exposed-face surfaces of GFRC to match approved mockups and as follows:
1. As-Cast-Surface Finish: Provide surfaces to match approved sample for acceptable surface, air voids, sand streaks, and honeycomb, with uniform color and texture.
2. Sand- or Abrasive-Blast Finish: Use abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces.

2.11 SOURCE QUALITY CONTROL

A. Quality-Control Testing: Establish and maintain a quality-control program for manufacturing GFRC according to PCI MNL 130.
1. Test materials and inspect production techniques.

2. Quality-control program shall monitor glass-fiber content, spray rate, unit weight, product physical properties, anchor pull-off and shear strength, and curing period and conditions.
3. Prepare test specimens and test according to ASTM C 1228, PCI MNL 130, and PCI MNL 128 procedures.
4. Test GFRC inserts and anchors according to ASTM C 1230 to validate design values.
5. Produce test boards at a rate of no fewer than one per work shift per operator for each spray machine and for each mix design.
   a. For each test board, determine glass-fiber content according to ASTM C 1229 and flexural yield and ultimate strength according to ASTM C 947.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine structure and conditions for compliance with requirements for installation tolerances, bearing surfaces, and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 ERECTION

A. Install clips, hangers, and other accessories required for connecting GFRC to supporting members and backup materials.

B. Install GFRC plumb, square, and in alignment. Provide temporary supports and bracing as required to maintain position, stability, and alignment of panels until permanent connections are completed.
   1. Maintain horizontal and vertical joint alignment and uniform joint width.
   2. Remove projecting hoisting devices.

C. Connect GFRC in position by bolting or welding, or both, as indicated on Shop Drawings. Remove temporary shims, wedges, and spacers as soon as possible after connecting is completed.

D. Welding: Comply with applicable AWS D1.1 and AWS D1.3 requirements for welding, appearance, quality of welds, and methods used in correcting welding work.
   1. Protect GFRC from damage by field welding or cutting operations, and provide noncombustible shields as required.

E. At bolted connections, use lock washers or other acceptable means to prevent loosening of nuts.

### 3.3 ERECTION TOLERANCES

A. Erect GFRC to comply with the following noncumulative tolerances:
   1. Plan Location from Building Grid Datum: Plus or minus 1/4 inch.
   2. Plumb in Any 10 Feet of Element Height: 1/4 inch.
   3. Maximum Offset in Alignment of Matching Edges: 1/4 inch.
   4. Face Width of Joint: As follows (governs over joint taper):
      a. GFRC Dimension 20 Feet or Less: Plus or minus 1/4 inch.

b. GFRC Dimension More Than 20 Feet: Plus or minus 3/8 inch.

5. Maximum Joint Taper: 1/4 inch.
6. Maximum Joint Taper in 10 Feet: 1/4 inch.

3.4 REPAIRS

A. Repairs are permitted provided structural adequacy of GFRC panel and appearance are not impaired, as approved by Architect.

B. Mix patching materials and repair GFRC so cured patches blend with color, texture, and uniformity of adjacent exposed surfaces.

C. Prepare and repair accessible damaged galvanized coatings with galvanizing repair paint according to ASTM A 780.

D. Wire brush and clean accessible weld areas on prime-painted components and paint with same type of shop primer.

E. Remove and replace damaged GFRC panels when repairs do not comply with requirements.

3.5 CLEANING AND PROTECTION

A. Perform cleaning procedures, if necessary, according to GFRC manufacturer's written instructions. Clean soiled GFRC surfaces with detergent and water, using soft fiber brushes and sponges, and rinse with clean water. Prevent damage to GFRC surfaces and staining of adjacent materials.

END OF SECTION