

# GFRC Specification \_

## *PART 1 - General*

### 1.1 **SUMMARY:**

1.1.1 Section Includes: Plant-cast glass-fiber-reinforced precast concrete (GFRC) panels including embedded hardware, loose connection hardware, integrated steel support framing, metal lath, and related services for erection and installation.

1.1.2 Related Documents: The conditions of the Contract and Division 1 apply to this section as fully as if repeated herein.

### 1.2 **REFERENCES:**

The edition of the specifications and standards referenced herein, published by the following organizations, apply to the precast glass fiber reinforced concrete only to the extent specified by the reference. Refer to Section 01422 for information concerning availability and use of references.

American Concrete Institute (ACI)

American Society for Testing and Materials (ASTM)

Precast Concrete Institute (PCI)

American Welding Society (AWS)

### 1.3 **SYSTEM:**

1.3.1 System Description: Plant fabricated GFRC panels consisting of face mix, back-up mix, steel support frame attached via pins, gravity anchors and flex anchors, steel connections for panel attachment to structure, and other inclusions for attachments to panels.

1.3.2 Design Requirements: Design GFRC panels and shapes under the supervision of a professional engineer employed or retained by the Contractor; and in accordance with procedures of PCI "Recommended Practices for Glass Fiber Reinforced Concrete Panels" using property data generated from the manufacturer's actual production.

1.3.3 Structural Performance: Provide GFRC panels and panel frames capable of withstanding gravity, wind, seismic, and erection design loads as well as the effects of thermal and moisture-induced volume changes, according to load factors and combinations established in PCI MNL 128, "Recommended Practice for Glass Fiber Reinforced Concrete Panel."

1. Design Loads: As indicated.

2. Design framing systems to withstand design loads with lateral deflections no greater than 1/240 of the wall height.

1.3.4 Design panel framing to provide for movement of framing members without damage or overstressing, connection failure, undue strain on fasteners and anchors, or other detrimental effects when subject to a maximum ambient temperature change of 100 deg F.

### 1.4 **SUBMITTALS:**

1.4.1 Shop Drawings and Product Data: Submit shop drawings and product data including the following:

1. GFRC dimensions, cross-sections, and edge details; location, size, and type of reinforcement, including reinforcement necessary for safe handling and erection of

GFRC panels and shapes.

2. Design calculations demonstrating compliance with indicated loading conditions and showing flexural ultimate strengths assumed for design, stamped by a structural professional engineer.

3. Layout, dimensions, and identification of each panel segment corresponding to installation sequence.

4. Location and details of anchorage devices embedded in GFRC panels and shapes, and connection details to building.

5. Manufacturer's printed instructions covering installation.

1.4.2 Samples: Submit samples of the following:

1. Built-in anchorage devices, full-size, one of each type to be used in the construction.

2. Surface Finish: Submit 2 sample sections 24" by 24" showing joint conditions.

1.4.3 Certificates of Conformance or Compliance: Submit proofs of conformance or compliance for the following:

1. Admixtures.

2. Reinforcing Steel.

3. Portland Cement: Identify the cement brand name, type, mill location, quantity to be used, size of lot represented by quality control sample, lot number, and destination of shipment.

4. Glass Fibers: Submit evidence that glass composition, portland cement matrix, or both have been designed for GFRC applications.

1.4.4 Submittal procedures and quantities are specified in Section 01330.

1.5 **QUALITY ASSURANCE:**

1.5.1 Manufacturer Qualifications: Provide GFRC panels and shapes only from a manufacturer who has demonstrated capability to produce products of the quality and scope required for this project, and with not less than 5 years of successful experience in manufacturing GFRC panels and shapes.

1.5.2 Erector Qualifications: A firm which has specialized in erection of GFRC or architectural precast concrete items similar to those required on this project for not less than 5 years and who is acceptable to manufacturer of GFRC.

1.5.3 Welder Qualifications: Use welders who have been qualified in accordance with AWS D1.1-96 and AWS D1.4-92 within the last year.

1.5.4 Mock-Ups:

1.6 **DELIVERY, STORAGE, AND HANDLING:**

1.6.1 Delivery and Handling:

1. Handle and transport units in a position consistent with their shape and design in order to avoid excessive stresses or damage.

2. Protect units from dirt and damage during handling and transport.

1.6.2 Storage at Project Site:

1. Store units to protect them from contact with soil, staining, and from physical damage.

2. Store units on firm, level, and smooth surface.

3. Place stored units so that identification marks are easily readable.

## **PART 2 - PRODUCTS**

### **2.1 MATERIALS:**

#### 2.1.1 Aggregates:

1. Back-up Mix: Washed and dried silica sand or other sand having a history of successful use in GFRC construction; passing through a No. 20 sieve.
2. Facing Mix: Fine and course aggregate for face mix shall conform to ASTM C33 except for gradation. Aggregates shall be clean, hard, strong, durable, inert, and free of staining and deleterious materials. Provide aggregate in colors and sizes as required to achieve the panel finish texture and colors indicated on the Drawings.

2.1.2 Portland Cement: ASTM C 150-96, Type II. Use the same type, brand and color of portland cement for all panels and shapes. Color shall be as required to obtain the panel facing color indicated.

2.1.3 Admixtures: Air-entraining admixtures, ASTM C 260-95. Pozzolan and fly ash, ASTM C 618-97. Other admixtures, ASTM C 494-92.

2.1.4 Coloring Agent: ASTM C979; shall have no adverse effects to GFRC set and strength; shall be stable at high temperature; and shall be alkali-resistant. Color shall be as required to obtain panel facing color indicated.

2.1.5. Water for Mixing Concrete: Use potable water.

2.1.6 Glass Fiber: Fibers specifically designed to be compatible with the aggressive alkaline environment of portland cement based composites or fibers with a history of successful use in portland cement based composites that has been modified to be compatible with the fiber.

#### 2.1.7 Anchors and Loose Attachment Hardware:

1. Structural Steel: ASTM A 39-96.
  2. Cold Drawn Wire:
  3. Anchor Bolts: ASTM A 307-94 or ASTM A 325-96.
  4. Pipe: ASTM A500 Grades A or B.
  5. Tube Steel: ASTM A500 Grade A or B.
  6. Carbon-Steel Rods: ASTM A 108, AISI 1018, cold drawn.
  7. Carbon-Steel Plate: ASTM A 283/A 283M.
  8. Malleable-Steel Castings: ASTM A 47.
  9. Carbon-Steel Castings: ASTM A 27/A27M, Grade 60-30.
  10. Finish: Galvanized in accordance with ASTM A 153-96.
- 2.1.8 Steel Subframing System: Fabricate in accordance with Section 05400 for cold formed metal framing or Section 05120 for hot rolled structural steel framing. Hot dip galvanize framing in accordance with ASTM A 123-89a, or ASTM A 653-96 coating designation G60 as applicable.
- 2.1.9 Form Materials: Provide form materials that will produce panels having the profile, dimensions and tolerances indicated. Use release agents which are compatible with finish specified and joint sealants proposed for use.

### **2.2 MIXES:**

Portland cement, water, glass fibers and sand mixed in proportions determined in accordance with PCI "Recommended Practice for Glass Fiber Reinforced Concrete".

### **2.3 FABRICATION:**

### 2.3.1 Proportioning and Mixing:

1. Carefully measure mix constituents in a manner to achieve the desired mix proportions.
2. Meter the glass fiber and cement slurry to the spray head at rates to achieve the desired mix proportion and glass content. Check rates in accordance with standard procedures described in PCI "Recommended Practice for Glass Fiber Reinforced Concrete".
3. Maintain cleanliness of equipment and working procedures at all times.

### 2.3.2 Hand Spray Application:

1. Spray apply a mist coat consisting of the matrix without fiber. Apply this coating not to exceed 1/32 inch thick in order to avoid an unreinforced surface.
2. Spray-up main body of material before the mist coat has set.
3. Apply by spraying such that uniform thickness and distribution of glass fiber and cement matrix is achieved during the application process.
4. Consolidate by rolling or such other techniques as necessary to achieve complete encapsulation of fibers and compaction.
5. Control thickness by using a pin gauge or other approved method. Perform a minimum of 2 measurements per 5 square feet of panel surface with at least 3 measurements per panel.
6. Perform hand forming of intricate details, incorporate formers or infill material, and overspray before the material has achieved its initial set so as to insure complete bonding.

### 2.3.3 Inserts and Embedments:

1. Properly embed inserts in built up homogeneous GFRC bosses to develop their strength.
2. Test inserts to establish test data and reduce test values by the appropriate safety factors to determine connection strength to be used in design.
3. Rigid embedded items bonded to the GFRC shall not create undesirable restraint to volume changes.

2.3.4 Finish of Exposed Faces: As cast finish free of honeycombs, form marks, concrete droppings or other blemishes that would telegraph through the water repellent coating specified in Section 07190. Provide a finish surface free of laitance, grease, form release treatments, efflorescence, curing compounds or other foreign material that would adversely affect bonding of the coating.

2.3.5 Allowable Tolerances: Manufacture units so that each panel complies with the dimensional tolerances listed below. For dimensional tolerances not listed below, comply with those listed in PCI MNL 117, "Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products".

1. Dimensional Tolerances of Finished Units:
  - a. Overall Height and width of units measured at the face adjacent to the form:

10 feet or under	+1/8" _
10 to 20 feet	+1/8", -3/16"
20 to 30 feet	+1/8", - 1/4"

- Each additional 10 feet 1/16" per 10 ft. or +1/4" whichever is greater\_\_\_\_
- b. Thickness:
 

Skin thickness	+1/4", -0"
Side return thickness	+3/8", -0"
Panel depth	+3/8", -1/8"
  - c. Angular deviation of plane of side mold: 1/32 inch per 3 inch depth or 1/16 inch total whichever is greater.
  - d. Variation from square or designated curvature: 1/8 inch per 6 feet or 1/4 inch total whichever is greater.
2. Position Tolerances: For sprayed-in items measured from datum line locations as shown on the approved erection drawings.
    - a. Inserts, bolts and pipe sleeves: +3/8 inch
    - b. Blockouts: +1/4 inch
    - c. Flashing reglet at edge of panel: +1/4 inch
- 2.3.6 Cover: Provide embedded anchors, inserts, and other sprayed in items with sufficient anchorage and embedment for design requirements.
- 2.3.7 Curing:
1. Immediately after the completion of spraying of the panel, cure panels using a method to ensure sufficient strength for removing the units from the form.
  2. After initial curing, remove panel from form and place in a controlled curing environment. Keep panels continuously set for a minimum of 7 days in accordance with manufacturer's standard curing practice. Maintain temperature between 60 degrees F and 110 degrees F during this period.
- 2.3.8 Panel Identification:
1. Mark each GFRC panel to correspond to identification mark on shop drawings for panel location.
  2. Mark each GFRC panel with date on which it was cast.
  3. Apply markings on surface that will not be exposed in the finished construction.
- 2.4 **SOURCE QUALITY CONTROL:**
- 2.4.1 Plant Testing: Test GFRC units in accordance with PCI "Recommended Practices for Glass Fiber Reinforced Concrete Panels", Appendix A. Perform testing by a testing agency capable of performing the specified tests, retained and paid for by the Contractor.
- 2.4.2 Acceptability of Appearance: The finished construction in place shall present a uniform, pleasing appearance when viewed in good typical lighting with the naked eye at a distance of 10 feet and shall show no imperfections at a distance of 20 feet.

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

#### **3.1 INSPECTION:**

Check placement of structural support system to assure a true and level surface for attachment of panels. Do not begin construction until discrepancies that could adversely affect installation of panels have been corrected.

#### **3.2 ERECTION:**

- 3.2.1 Safety Aspects: Provide adequate barricades, warning lights or signs to safeguard traffic in the immediate are of hoisting and handling operations.

- 3.2.2 Setting:
  - 1. Lift GFRC units with suitable lifting devices at points provided by the manufacturer.
  - 2. Set GFRC units level, plumb, square and true within the allowable tolerances.
- 3.2.3 Supports and Bracing: Provide temporary supports and bracing required to maintain position, stability, and alignment as units are being permanently connected.
- 3.2.4 Fastening:
  - 1. Fasten GFRC units in place by bolting or welding or both as shown on erection drawings.
  - 2. Field welding shall be done by qualified welders using equipment and materials compatible with the base material.
- 3.2.5 Tolerances of Erected Units: Tolerances for location of GFRC units shall be noncumulative and as listed below. For erection tolerances not listed below, those listed in PCI MNL 117 shall apply.
  - 1. Face width of joint:
 

Panel dimension 10 feet or less	+3/16"
Panel dimension 10 to 20 feet	+3/16", -1/4"
Panel dimension greater than 20 feet	+1/4", -5/16"
  - 2. Warpage: Maximum permissible warpage of one corner out of plane of the other three shall be 1/16" per foot of distance from the nearest adjacent corner or 1/8"

total after installation.

- 3. Bowing: Not over L/360, where L is the panel length.

**3.3 PATCHING:**

Patching blemishes occurring during fabrication, transportation, handling or erection using a patching mixture matching the color and texture of surrounding surface.

Complete patching operations before sand blasting.

**3.4 FIELD TESTS AND INSPECTION:**

3.4.1 Quality Control Program: The GFRC manufacturer shall have an established quality control program in effect at the plant or shall employ an independent testing laboratory approved by the Architect to monitor glass content, spray rate, physical properties and curing period and conditions.

3.4.2 Sampling and Testing: Prepare test specimens and use test procedures in accordance with PCI "Recommended Practice for Glass Fiber Reinforced Concrete" Chapter 8 and Appendix A.

- 1. Prepare a minimum of 2 test boards per work shift until a production uniformity acceptable to the quality control personnel has been achieved. At such time frequency may be reduced to one board per work shift.
- 2. For each board determine glass content by the washout test, flexural ultimate strength and flexural yield strength.
- 3. Glass content shall be considered satisfactory if within -0.5 and +1.0 percent, by weight, of the glass content in the design mix.
- 4. Flexural yield strength shall be considered satisfactory if both of the following requirements are met.
  - a. The average of all sets of 3 consecutive strength tests equal or exceed assumed ultimate flexural strength for design purposes.

- b. No individual test (average of 6 coupons) fall below required assumed ultimate flexural strength for design purposes by more than 10 percent.
  5. Submit reports giving proportions, test results, inspection results, unit identification numbers and casting date for each work shift.
- 3.4.2 Rejection: Panels in place may be rejected for any one of the following product defects or installation deficiencies:
1. Nonrepairable damage incurred during construction operations.
  2. Ragged or irregular edges.
  3. Visible form joints or irregular surfaces.
  4. Panels not conforming to tolerance requirements.
  5. Foreign material embedded in the face.
  6. Visible repairs.
  7. Cracks visible at a distance of 10 feet.
  8. Panels do not meet design strength requirements.

**END OF SECTION**