

## SECTION 034900

### GLASS FIBER REINFORCED CONCRETE (GFRC)

#### PART 1 - GENERAL

##### 1.1 RELATED DOCUMENTS

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

##### 1.2 SUMMARY

- A. Section includes Glass Fiber Reinforced Concrete (GFRC) panels, including:

1. Structural Design and Detailing of GFRC panels.
2. Plant fabrication of GFRC panels.
3. Transportation of GFRC panels to job site.
4. Preweld and CIP hardware for GFRC to be attached to the structure.
5. Installation of GFRC panels.
6. Joint sealants, GFRC to GFRC joints and GFRC to CIP joints

- B. Related Sections:

1. Section 018316 "Exterior Enclosure Performance Requirements"
2. Section 033000 "Cast-in-Place Concrete"
3. Section 034500 "Precast Architectural Concrete"
4. Section 034501 "Precast Architectural Thinshell Concrete"
5. Section 051200 "Structural Steel Framing"
6. Section 055000 "Metal Fabrications"
7. Section 071900 "Water Repellents"
8. Section 072100 "Thermal Insulation"
9. Section 078453 "Building Perimeter Firestopping"
10. Section 079200 "Joint Sealants"
11. Section 085113 "Aluminum Windows"

- C. References:

1. California Building Code, Current Edition.
2. PCI MNL-128 - GFRC Recommended Practice for Glass Fiber Reinforced Concrete Panels, Current Edition.
3. PCI MNL-130 - Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products, Current Edition.
4. AWS D1.1: Structural Welding Code – Steel, Current Edition.
5. AWS D1.4: Structural Welding Code – Steel Reinforcing Bars, Current Edition.

##### 1.3 SUBMITTALS

- A. Product Data: for each type of product indicated. Retain quality control records and certificates of compliance for 5 years or period of warranty, whichever is greater.
- B. Shop Drawings: GFRC Shape Package, Erection Package, and Structural Calculations.
  - 1. Details the fabrication and installation of GFRC units. Indicate member locations, plans, elevations, dimensions, shapes and cross sections. Indicate aesthetic intent including joints, reveals, and extent and location of each surface finish. Indicate details at corners.
  - 2. Comprehensive engineering design signed and sealed by the qualified professional engineer responsible for its preparation registered in the state of California. Show governing panel types, connections, GFRC support frame, and skin (flex) anchors. Coordinate the location, type, magnitude, and direction of all imposed loadings from the GFRC system to the building structural frame with Engineer of Record
- C. Samples: Submit lab samples, approximately 12 inch by 12 inch, representative of finished exposed face. Prior to commencement of manufacturing panels, submit production samples, approximately 4 feet by 4 feet, for conformance with the approved 12 inch by 12 inch lab sample.
- D. Test reports and mill certifications: Submit test reports and Mill Certifications to Architect and/or Structural Engineer if requested.

#### 1.4 QUALITY ASSURANCE

- A. Qualifications
  - 1. Manufacturers: Willis Construction Company, Inc., or equal.
  - 2. The GFRC Manufacturer shall have an established PCI quality control program in effect prior to bidding.
    - a. When requested, Manufacturer will provide proof of PCI Certification and/or Quality Control Procedures.
  - 3. Erector: Regularly engaged for at least 5 years in erection of GFRC panels similar to those required on this project.
  - 4. Welders: in accordance with AWS D1.1 and AWS D1.3
- B. Testing and inspection program
  - 1. Testing and Inspection in general conformance with testing provisions of PCI MNL-130 and MNL-128 - Chapter 8 - Quality Control.
- C. In-Plant Quality Control
  - 1. GFRC Manufacturer's Quality Control Department shall test materials and inspect production techniques.
  - 2. Quality control program shall monitor glass content, spray rate, product physical properties, anchor pull-off and shear strengths.
  - 3. Preparation of the test specimens and test procedures shall be in accordance with PCI MNL-130 and MNL-128, Chapter 8 - Quality Control.

4. Produce test boards at a rate of not less than 1 per work shift.
  - a. Glass content by "Wash-out test".
  - b. Flexural yield and ultimate strength.
5. Keep quality control records available for 2 years after final acceptance.
6. Keep certificates of compliance available for 5 years after final acceptance.
7. All other testing and inspection, including 3rd party, to be provided by Owner.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

#### A. Glass fiber reinforced concrete:

1. Portland cement
  - a. Architectural Mixes: ASTM C150 Type I, II or III cement. For surfaces exposed to view in the finished structure use same brand, type and source of supply throughout the GFRC production.
  - b. Back up Mixes: Back-up mix shall be compatible with the architectural face mix.
  - c. Metakaolin may be used: ASTM C-618, Class N
2. Aggregates
  - a. Architectural Mixes: Fine and coarse aggregate for face mix shall conform to ASTM C33 except for gradation. The nominal maximum size of aggregate in the face mix shall not be larger than 1/4 inch.
  - b. Back-up Mixes: Sand for GFRC backup shall be washed and dried Lapis, or approved equal, with a history of successful use in GFRC. All sand shall pass through a No. 20 (850µm) sieve.
3. Water: Free from deleterious matter that may interfere with the color, setting, or strength of the concrete
4. Admixtures: Water reducers ASTM C494, accelerators to ASTM C494, retarders, air-entraining agents may be used to achieve certain characteristics ASTM C260. Use in accordance with manufacturer's recommendations.
5. Coloring agent: Conforming to ASTM C979.
  - a. Shall be stable under exposure to sunlight and UV radiation.
  - b. Shall be alkali-resistant.
6. Glass fiber: Alkali-resistant glass compositions for use as reinforcement in Portland cement concrete according to ASTM C1666/C1666M.
  - a. Conforming to PCI MNL-130, Appendix F
7. Polymer Curing Admixture: Acrylic thermoplastic copolymer dispersion complying with PCI MNL-130, Appendix G.

8. Plant applied one-coat water repellent sealer: Protectosil Chem-Trete BSM 350, or equal. Apply in accordance with manufacturer's recommendations.

B. Steel products

1. Structural Shapes, Bars & Plates (1/8 inch and thicker): ASTM A36
2. Tube Steel: ASTM A500 Grades A or B
3. Sheets and Strips (less than 3/16 inch): ASTM A570 Grade 36
4. Reinforcing Steel: Grade 60 or ASTM A706
5. Deformed Bar Anchors: ASTM A496
6. Welded Headed Studs: AWS D1.1 Type B
7. Coil Rods and Bolts: ASTM A108 - SAE 1016 to 1026,  $F_u/F_y = 70/55$  ksi minimum
8. Coil Nuts for Coil Rods and Bolts: Nuts passing a proof load stress of 80 ksi, based on the tensile stress area of the matching coil rods and bolts.
9. GFRC Pins: ASTM A36
10. Track and Studs
  - a. Rust Inhibitive Coated: ASTM A570 Grade 50
  - b. Galvanized ASTM A446 Grade A, coating designation 60

C. Steel protective coatings: All thin gauge material less than 3/16 inch thick shall have either a rust inhibitive primer or zinc coating. All steel materials in contact with the GFRC skin or exposed to weather shall have a zinc coating. Loose attachment hardware equal to or greater than 3/16 inch thick shall not be coated if not exposed to weather.

1. Rust inhibitive primers: Meets salt spray resistance ASTM B-117, VOC <100g/L
2. Zinc coatings:
  - a. Hot-Dip Galvanizing: ASTM A123, or ASTM A153
  - b. Hot-Dip Galvanized for Steel Sheet: ASTM A525
  - c. Electroplated Zinc for Steel Products and Steel Hardware: ASTM B633, minimum SC3.
  - d. Zinc Rich Paints: Meets salt spray resistance ASTM B-117, zinc dust level by weight in dried film equal to or greater than 85 percent, VOC <100g/L, DOD-P-21035A.

## 2.2 MIXES

A. GFRC shall consist of Portland cement, water, glass fibers, sand, and may contain admixtures. The component materials shall be in accordance with Article 2.01.

1. GFRC mix proportioning:
  - a. Fiber content minimum 4 percent by weight of total mix
  - b. Fiber length, maximum 2 inch
  - c. Cement-sand ratio approximately 1:1
  - d. Water-Cement ratio maximum 0.35
  - e. Polymer content min. 5 percent polymer solids by weight of cement
2. GFRC bonding pads for flex anchors shall be of the same proportions as the GFRC back-up mix.

3. Face mix: Thickness generally to be minimum thickness to achieve desired finish.

## 2.3 FABRICATION

- A. Manufacturing procedures shall be in general compliance with PCI MNL-130.
- B. Forms:
  1. Forms for GFRC panels shall be rigid and constructed of materials that will result in finished products conforming to profiles, dimensions, and tolerances indicated by this Section, the Contract Documents, and the reviewed Shop Drawings.
  2. Release agents shall be applied and used according to the manufacturer's instructions.
- C. Batching of face and backup mixes:
  1. All measurements of mix constituents shall be carried out in a careful manner to achieve the desired mix proportions.
  2. The glass fiber and cement slurry shall be metered at rates to achieve the desired mix proportions and glass content. These shall be checked in accordance with standard procedures described in PCI MNL-130.
  3. Cleanliness of equipment and working procedure shall be maintained at all times.
- D. Hand spray application:
  1. Spray operators shall be trained personnel.
  2. Face mix shall be sprayed or placed in thickness required by mix design. Localized increases in thickness are allowable at changes in planes, at returns, reveals, ribs, etc.
  3. Spray-up of the GFRC backing shall proceed before any facing mix has set.
  4. Application of GFRC backing shall be by spraying such that uniform thickness and distribution of glass fiber and cement matrix is achieved during the application process. Localized increases in thickness are allowable at changes in planes, at returns, reveals, ribs, etc.
  5. Consolidation shall be by rolling or such other techniques as necessary to achieve complete encapsulation of fibers and compaction.
  6. Control of thickness shall be achieved by using a pin-gauge or other appropriate methods.
- E. GFRC support frame
  1. The frame shall be a prefabricated welded frame produced in accordance with the Shop Drawings.
  2. All accessible welds shall be touched-up after welding.
- F. Pins and bonding pads
  1. Pins shall be properly embedded in built-up homogeneous GFRC bonding pads to develop their strength. Waste material such as overspray is not acceptable to encapsulate pins.
- G. Allowable tolerances: Manufacture panels so that finished units comply with the dimensional tolerances listed below. Dimensional tolerances not listed below shall be in accordance with PCI MNL 130.

1. Overall height and width of panels measured at the face exposed to view:
    - a. 10 feet or less: Plus or minus 1/8 inch.
    - b. 10 feet and over: Plus or minus 1/8 inch per 10 feet.
    - c. 20 feet to 40 feet: Plus or minus 1/4 inch.
    - d. Each additional 10 feet: Plus or minus 1/16 inch.
  2. Thickness
    - a. Architectural facing: Plus 1/8 inch, minus 0 inch.
    - b. GFRC backing: Plus 1/4 inch, minus 0 inch.
    - c. Panel depth from face of skin to back of panel frame or integral rib: Plus 3/8 inch, minus 1/4 inch.
  3. Variation from square or designed skew (difference in length of two diagonal measurements): Plus or minus 1/8 inch per 6 feet or plus or minus 1/4 inch total, whichever is greater.
  4. Local smoothness: 1/4 inch per 10 feet.
  5. Bowing: Not to exceed L/240 unless unit meets erection tolerances using connection adjustments.
  6. Length and width of block outs and openings within one panel: Plus or minus 1/4 inch.
  7. Location of block outs other than window openings: Plus or minus 3/8 inch.
  8. Location of window opening within panel: Plus or minus 1/4 inch.
  9. Window or door rough opening size: plus or minus 1/2 inch.
  10. Maximum permissible warpage of one corner out of the plane of the other three: 1/16 inch per 1 feet of distance from the nearest adjacent corner.
  11. Location of bearing connections: Plus or minus 1/4 inch.
  12. Location of Inserts and non-bearing connections: Plus or minus 1/2 inch.
  13. Support frame:
    - a. Vertical and horizontal alignment: 1/4 inch per 10 feet.
    - b. Spacing of framing member: Plus or minus 3/8 inch.
    - c. Squareness of frame (difference of diagonal length): 3/8 inch.
    - d. Overall size of frame: Plus or minus 3/8 inch.
- H. Panel identification:
1. Mark each GFRC panel to correspond with identification mark on Shop Drawings.
  2. Mark each GFRC panel with casting date.
- I. Panel Finish and Approval: GFRC panels and approved Samples shall be viewed side by side from a distance of 20 feet when comparing texture and color. GFRC panels that do not reasonably match the color and texture of the approved sample(s), the dimensional tolerances, or industry standards shall be satisfactorily corrected.

## PART 3 - EXECUTION

### 3.1 PRE-INSTALLATION RESPONSIBILITY

A. General Contractor's Responsibility:

1. The General Contractor shall provide perimeter control layout lines and an elevation benchmark on each floor receiving GFRC panels.
2. The General Contractor shall provide true, level, and clean support at attachment surfaces.
3. The General Contractor shall provide for the accurate (1/2 inch in all directions) placement and alignment of connection hardware on the structure.
4. The General Contractor shall allocate time withing the master schedule for pre-welding GFRC attachment hardware to the structure prior to fireproofing operations and shall be responsible for patching of fireproofing after panel installation.

- B. Erector's Responsibility: Prior to installation of the GFRC panels, the erector shall perform a preliminary panel layout and notify the General Contractor of any discrepancies discovered which affect the work under this contract. If discrepancies are discovered, installation shall not proceed further until directed by the General Contractor. Commencement of installation does not constitute acceptance of the structure.

### 3.2 PRODUCT TRANSPORTATION AND HANDLING

- A. Handle and transport panels in a position consistent with their shape and design to avoid excessive stresses or damage.
- B. Support panels during shipment on non-staining shock-absorbing material as needed to prevent damage.

### 3.3 ERECTION

- A. Unloading Areas and Access: Clear all-weather unloading areas and access roadways around the building and in the building, where appropriate, shall be provided and maintained by the General Contractor so that the hauling and erection equipment for the GFRC panels may operate under their own power.
- B. Safety Aspects: The General Contractor shall provide all required traffic controls, barricades, warning lights and/or signs to ensure safe installation.
- C. Setting
1. GFRC panels shall be lifted with suitable lifting devices at points provided by the GFRC Manufacturer to prevent excessive stresses or damage to the panels.
  2. GFRC panels shall be set level, plumb, square, and true within allowable tolerances.
- D. Temporary Supports: The erector shall provide temporary panel support as required to maintain position, stability and alignment until panels are permanently connected.
- E. Final Connection of Panels to Structure:
1. GFRC panels shall be attached to the structure as shown in the reviewed Shop Drawings.
  2. All modifications made to details shown on Shop Drawings shall be submitted for approval.

3. Field welding shall be performed by certified welders using equipment and materials compatible with the base material.
- F. Tolerances of Erected Panels: Erect GFRC panels to comply with the following non-cumulative tolerances. Tolerances not listed below shall be in accordance with PCI MNL 130.
1. Plan location from building grid datum: Plus or minus 1/2 inch.
  2. Top elevation from nominal top elevation:
    - a. Exposed individual panel: Plus or minus 1/4 inch.
    - b. Nonexposed individual panel: Plus or minus 1/2 inch.
    - c. Exposed relative to adjacent panel: 1/4 inch.
    - d. Nonexposed relative to adjacent panel: 1/2 inch.
  3. Maximum plumb variation over height of structure or 100 feet, whichever is less: 1 inch.
  4. Plumb in any 10 feet of element height: 1/4 inch.
  5. Maximum jog in alignment of matching edges: 1/4 inch.
  6. Joint width (governs over joint taper)
    - a. Panel dimension less than 20 feet: Plus or minus 1/4 inch.
    - b. Panel dimension over 20 feet: Plus or minus 3/8 inch.
  7. Joint taper maximum: 3/8 inch.
  8. Joint taper in 10 feet: 1/4 inch.
  9. Maximum jog in alignment of matching faces: 1/4 inch.
  10. Differential bowing or camber as erected between members of the same design: 1/4 inch.

#### 3.4 JOB SITE HANDLING AND PROTECTION

- A. The Erector shall be responsible for the repair of damage to GFRC panels caused by its own crew.
- B. After GFRC panels are installed in their final positions, the General Contractor shall be responsible for their protection.
- C. The General Contractor shall be responsible for the repair of any damage to the GFRC panels caused by someone other than the GFRC Manufacturer.

#### 3.5 PATCHING

- A. Repairs will be permitted provided structural adequacy of GFRC panel and appearance of the finished face surface shall have no obvious imperfections or evidence of repair other than minimal color and texture variations in accordance with PCI MNL 130 – “2.10 Acceptability of Appearance,”.
- B. Mix patching materials and patch GFRC so that cured patches blend with color, texture, and uniformity of adjacent exposed surface.



- C. The repair shall be viewed with the unaided eye at an appropriate distance of 20 feet or greater. The appearance of the surface shall not be evaluated when light is illuminating the surface from an extreme angle.

### 3.6 CLEANING

- A. Cleaning methods shall be per GFRC manufacturer's recommendations.
- B. The panel manufacturer is responsible for providing a clean panel to the Erector.
- C. The Erector shall be responsible for cleaning erection marks exposed to view, dirt, and debris on the GFRC panels caused by its own crew.
- D. The General Contractor shall be responsible for any cleaning that is required due to the actions of someone other than the GFRC Manufacturer and Erector.
- E. The General Contractor shall be responsible for "final cleaning" or "wash down" of the building.

### 3.7 ACCEPTANCE

- A. Immediately after the erection is completed, inspection and acceptance of the erected GFRC panels shall be made by the General Contractor to verify conformance with plans and specifications.
- B. Final acceptance of the GFRC panels shall be in accordance with PCI MNL 130 – "2.10 Acceptability of Appearance," and be obtained from the Architect and/or Owner.
- C. GFRC panels shall be viewed with the unaided eye at an appropriate distance of 20 feet or greater. The appearance of the surface shall not be evaluated when light is illuminating the surface from an extreme angle.

### 3.8 WARRANTY

- A. All labor and materials under the Precast Manufacturer's contract shall be warranted by the Precast Manufacturer for a period of 1 year following final approval of the GFRC panel by the Architect. Any additional labor or material warranties, i.e. caulking, shall be passed through to the General Contractor with no responsibility by the Precast Manufacturer.

END OF SECTION