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Section 03491 Glass Fiber Reinforced Concrete

PART 1 – GENERAL

1.1 Related Documents

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

1.2 Summary

- A. This Section includes glass fiber reinforced concrete (GFRC) panels, consisting of GFRC, panel frames, anchors and connection hardware.
 - 1. GFRC panels include [wall units] [window wall units] [mullions] [column covers] [fascia units] [cornices] [soffits].
- B. Related sections include the following:
 - 1. Division 3 Section "Cast-in-Place Concrete." for placing connection anchors in concrete.
 - 2. Division 3 Section "Plant-Precast Architectural Concrete."
 - 3. Division 5 Section "Structural Steel" for connection attachment to structural steel framing.
 - 4. Division 7 Section "Joint Sealants" for elastomeric joint sealants and sealant backings.
 - 5. Division 8 Section "Aluminum Windows" for window set into GFRC panels.

1.3 Definitions

- A. Design Reference Sample: Sample of approved GFRC color, finish and texture, preapproved by the Architect.

1.4 Performance Requirements

- A. Structural Performance: Provide GFRC panels, panel frames, anchors and connections, capable of withstanding the following 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."

1.5 Submittals

- A. Product Data: For each type of product indicated. Include GFRC design mixes.
- B. Shop Drawings: Show fabrication and installation details for GFRC panels, including the following:
 - 1. Structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Panel elevations, sections and dimensions.
 - 3. Thickness of facing mix, GFRC backing, and bonding pads for typical panels.
 - 4. Finishes.
 - 5. Joint and connection details.
 - 6. Erection details.
 - 7. Panel frame details for typical panels, including size, spacings, thickness, and yield strengths of various members.
 - 8. Locations and details of connection hardware attached to structure.
 - 9. Sizes, locations and details of flex, gravity, and seismic anchors for typical panels.
 - 10. Other items sprayed onto panels.
 - 11. Erection sequence for special conditions.
 - 12. Relationship to adjacent materials.
 - 13. Descriptions of loose, cast-in, and field hardware.
- C. Samples: Representative of finished exposed face of GFRC showing the full range of colors and textures expected, 6 X 6 inches (152.4 by 152.4 mm) or 12 x 12 inches (304.8 X 304.8 MM) and of actual thickness.
- D. Welding certificates.
- E. Qualification Data: For GFRC manufacturer, including proof of current PCI Plant Certification.
- F. Source Quality-Control Program: For GFRC manufacturer.
- G. Source Quality-Control Test Reports: For GFRC, inserts, and anchors.

1.6 Quality Assurance

- A. Manufacturer Qualifications: A qualified manufacturer who participates in PCI's Plant Certification Program and is designated a PCI-Certified Plant for Group G, Glass Fiber Reinforced Concrete.
- B. PCI Manuals: Comply with requirements and recommendations in the following PCI manuals:
 - 1. PCI MNL 128, "Recommended Practice for Glass Fiber Reinforced Concrete Panels."
 - 2. PCI MNL 130, "Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products."

1.7 Delivery, Storage, and Handling

- A. Handle and transport GFRC panel to avoid damage.
 - 1. Place nonstaining resilient spacers between panels.
 - 2. Support panels during shipment on nonstaining material.
 - 3. Protect panels from dirt and damage during handling and transport.
- B. Store GFRC panels to protect from contact with soil, staining, and physical damage.
 - 1. Store GFRC panels with nonstaining resilient supports in same positions as when transported.
 - 2. Store panels on firm, level, and smooth surfaces.
 - 3. Place stored panels so identification marks are clearly visible.

PART 2 – PRODUCTS

2.1 Manufacturers

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. <Insert, in separate subparagraphs, manufacture's name.>

2.2 Mold Materials

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

2.3 GFRC Materials

- A. Portland Cement: ASTM C150, Type I, II, or III.
 - 1. For surfaces exposed to view in finished structure, use [gray] [white] [buff] of same type, brand, and source throughout GFRC production.
 - 2. Metakaolin: ASTM C618, Class N.
- B. Glass Fibers: Alkali resistant, with a minimum zirconia content of 16 percent, 1 to 2 inches (25 to 50 mm) long, specifically produced for use in GFRC, and complying with PCI MNL 130.
- C. Sand: Washed and dried silica, complying with composition requirements of ASTM C144; passing No. 20 (0.85 mm) sieve with a maximum of 2 percent passing No. 100 (0.15 mm) sieve.
- D. Facing Aggregate: ASTM C33, except for gradation and PCI MNL 130, ¼ inch (6 mm) maximum size.
 - 1. Aggregates: Selected, hard, and durable; free of material that reacts with cement or causes staining; to match sample.
- E. Coloring Admixture: ASTM C979, synthetic mineral-oxide pigments or colored water-reducing admixtures, temperature stable, nonfading and alkali resistant.
- F. Water: Potable; free from deleterious material that may affect color stability, setting, or strength of GFRC and complying with chemical limits of PCI MNL 130.
- G. Polymer Curing Admixture: Acrylic thermoplastic copolymer dispersion complying with PCI MNL 130.
- H. Chemical Admixtures: ASTM C494/C494M, containing not more than 0.1 percent chloride ions.

2.4 Anchors, Connectors, and Miscellaneous Materials

- A. Carbon-steel Shapes and Plates: ASTM A36/A36M. Finish steel shapes and plates less than 3/16 inch (4.76 mm) thick as follows:
 - 1. Finish: Zinc coated by [hot-dip process according to ASTM A123/A123M, after fabrication, or ASTM A153/A153M, as applicable] [electrodeposition according to ASTM B633, SC3].
 - 2. Finish: Shop primed with [MPI 79] [SSPC-Paint 25] on surfaces prepared to comply with SSPC-SP2, "Hand Tool Cleaning," or better.
- B. Carbon-Steel Bars: ASTM A108, AISI Grade 1018. Finish steel bars less than 3/16 inch (4.76 mm) thick as follows:
 - 1. Finish: Zinc coated by [hot-dip process according to ASTM A123/A123M, after fabrication, or ASTM A153/A153M, as applicable] electrodeposition according to ASTM B633, SC3].
 - 2. Finish: Shop primed with [MPI 79] [SSPC-Paint 25] on surfaces prepared to comply with SSPC-SP2, "Hand Tool Cleaning," or better.
- C. Malleable-Iron Castings: ASTM A47/A47M, Grade 32510 (Grade 22010).
- D. Carbon-Steel Castings: ASTM A27/A27M, Grade 60-30 (Grade 415-205).
- E. Bolts: ASTM A307 or ASTM A325 (ASTM F568M or ASTM A325M).

1. Finish: Zinc coated by [hot-dip process according to ASTM A123/A123M, after fabrication, or ASTM A153/A153M, as applicable] [electrodeposition according to ASTM B633, SC3].
- F. Reglets: PVC extrusions.

2.5 Panel Frame Materials

- A. Cold-Formed Steel Framing: Manufacturer's standard C-shaped steel studs, complying with AISI's "Specification for the Design of Cold-Formed Steel Structural Members," minimum uncoated steel thickness of 0.0538 inch (1.37 mm) [of web depth indicated], with stiffened flanges, U-shaped steel track, and of the following steel sheet:
 1. Metallic-Coated Steel Sheet: ASTM A653/A653M, structural-steel sheet, [G60 (Z180)][G90 (Z275)] zinc coating, of grade required by structural performance of framing.
 2. Painted, Nonmetallic-Coated Steel Sheet ASTM A1011/A1011M hot rolled or ASTM A1008/A1008M cold rolled; nonmetallic coated according to ASTM A1003/A1003M; of grade required by structural performance of framing.
- B. Hollow Structural Sections: Steel tubing, ASTM A500, Grade B, or ASTM A513. Finish hollow structural sections with wall thickness less than 3/16 inch (4.76 mm) as follows:
 1. Organic Zinc-Rich Primer: SSPC-Paint 20 on all surfaces prepared to comply with SSPC-SP6/NACE No. 3, "Commercial Blast Cleaning."
 2. Primer: [MPI 79][SSPC-Paint 25] on all surfaces prepared to comply with SSPC-SP2, "Hand Tool Cleaning," or better.
- C. Steel Channels and Angles: ASTM A36/A36M, finished as follows:
 1. Organic Zinc-Rich Primer: SSPC-Paint 20 on surfaces prepared to comply with SSPC-SP6/NACE No. 3, "Commercial Blast Cleaning."
 2. Primer: [MPI 79][SSPC-Paint 25] on all surfaces prepared to comply with SSPC-SP2, "Hand Tool Cleaning," or better.

2.6 GFRC Mixtures

- A. Backing Mix: Proportion backing of mixed portland cement, glass fibers, sand and the admixtures to comply with design requirements. Provide nominal glass-fiber content of not less than 5 percent by weight of total mix.
- B. Face Mix: Proportion face mix of portland cement, sand, facing aggregates, and admixtures to comply with design requirements.
- C. Mist Coat Mix: Portland cement, sand slurry, and admixtures, of same proportions as backing mix without glass fibers.
- D. Polymer Curing Admixture: 6 to 7 percent by weight of polymer curing admixture solids to dry portland cement.
- E. Coloring Admixture: Not to exceed 10 percent of cement weight.

2.7 Panel Frame Fabrication

- A. Fabricate panel frames and accessories plumb, square, true to line, and with components securely fastened, according to Shop Drawings and requirements in this Section.
 1. Fabricate panel frames using jigs or templates.
 2. Cut cold-formed metal framing members by sawing or shearing; do not torch cut.
 3. Fasten cold-formed metal framing members by welding. Comply with AWS D1.3 requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
 4. Fasten framing members of hollow structural sections, steel channels, or steel angles by welding. Comply with AWS D1.1 requirements and procedures for welding, appearance and quality of welds, and methods used in correcting welding work.
 5. Weld flex, gravity, and seismic anchors to panel frames.
- B. Reinforce, stiffen, and brace framing assemblies, if necessary, to withstand handling, delivery, and erection stresses. Lift fabricated assemblies in a manner that prevents damage or significant distortion.
- C. Galvanizing Repair: Touch up accessible damaged galvanized surfaces according to ASTM A780.
- D. Painting Repair: Touch up accessible damaged painted surfaces using same primer.

2.8 Mold Fabrication

- A. Construct molds that will 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.
- 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.
- C. Locate, place and secure flashing reglets accurately.

2.9 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 (3mm) on planar surfaces.
 2. Spray or place face mix in thickness indicated on Shop Drawings.
 3. Proceed with spraying backing mix before [mist coat] [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 each 5 sq.ft. (0.5 sq. m) of panel surface. Take not less than six measurements per panel.
- C. Hand form and consolidate intricate details, incorporate formers or infill materials, and over spray before material reaches initial set to ensure complete bonding.
- D. Attach panel frame to GFRC before initial set of GFRC backing, maintaining a minimum clearance of ½ inch (13 mm) 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 ½ inch (13 mm) over top of anchor feet, before initial set of GFRC backing.
- F. Inserts and Embedments: Build up homogeneous GFRC bosses or bonding pads over inserts and embedments to provide sufficient anchorage and embedment to comply with design requirements.
- G. Curing: Employ initial curing method that will ensure sufficient strength for removing units from mold.
 1. After initial curing, remove panel from mold and place in a controlled curing environment.
- H. Panel Identification: Mark each GFRC panel to correspond with identification mark on Shop Drawings. Mark each panel with its casting date.

2.10 Fabrication Tolerances

- A. Manufacturing Tolerances: Manufacture GFRC panels so each finished unit complies with PCI MNL 130 for dimension, position, and tolerances.
- B. Manufacturing Tolerances: Manufacture GFRC panels 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 (3 m) or less, plus or minus 1/8 inch (3 mm).
 - b. More than 10 feet (3 m), plus or minus 1/8 inch per 10 feet (3 mm per 3 m); 1/4 inch (6 mm) maximum.
 2. Edge Return Thickness: Plus ½ inch (13 mm), minus 0 inch (0 mm).
 3. Architectural Facing Thickness: Plus 1/8 inch (3 mm), minus 0 inch (0 mm).
 4. Backing Thickness: Plus ¼ inch (6 mm), minus 0 inch (0 mm).
 5. Panel Depth from Face of Skin to Back of Panel Frame or Integral Rib: Plus 3/8 inch (10 mm), minus ¼ inch (6 mm).
 6. Angular Variation of Plane of Side Mold: Plus or minus 1/32 inch per 3 inches (0.8 mm per 75 mm) of depth or plus or minus 1/16 inch (1/5 mm) total, whichever is greater.
 7. Variation from Square or Designated Skew (Difference in Length of Two Diagonal Measurements): Plus or minus 1/8 inch per 72 inches (3 mm per 1800 mm) or plus or minus ¼ inch (6 mm) total, whichever is greater.
 8. Local Smoothness: ¼ inch per 10 feet (6 mm per 3 m).
 9. Bowing: Not to exceed L/240 unless unit meets erection tolerances using connection adjustments.
 10. Length and Width of Block Outs and Openings within One Unit: Plus or minus ¼ inch (6 mm).
 11. Location of Window Opening within Panel: Plus or minus ¼ inch (6 mm).
 12. Maximum Permissible Warpage of One Corner out of the Plane of the Other Three: 1/16 inch per 12 inches (1.5 mm per 300 mm) of distance from nearest adjacent corner.
- C. Position Tolerances: Measured from datum line locations, as indicated on Shop Drawings.
 1. Panel Frame and Track: Plus or minus ¼ inch (6 mm).
 2. Flashing Reglets at Edge of Panel: Plus or minus ¼ inch (6 mm).
 3. Inserts: Plus or minus ½ inch (13 mm).
 4. Special Handling Devices: Plus or minus 3 inches (75 mm).
 5. Location of Bearing Devices: Plus or minus ¼ inch (6 mm).
 6. Blockouts: Plus or minus 3/8 inch (10 mm).
- D. Panel Frame Tolerances: As follows:
 1. Vertical and Horizontal Alignment: ¼ inch per 10 feet (6 mm per 3 m).
 2. Spacing of Framing Member: Plus or minus 3/8 inch (10 mm).
 3. Squareness of Frame: Difference in length of diagonals of 3/8 inch (10 mm).
 4. Overall Size of Frame: Plus or minus 3/8 inch (10).

2.11 Finishes

- A. Finish exposed-face surfaces of GFRC as follows to match approved [design reference sample] [and] [mockups]. Panel faces shall be free of joint marks, grain, or other obvious defects.
 1. Smooth-Surface Finish: Provide free of sand streaks, honeycombs, and excessive air voids, 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.
 3. Acid-Etched Finish: Use acid and hot-water solution equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces.

2.12 Source Quality Control

- A. Quality-Control Testing: Establish and maintain a quality-control program for manufacturing GFRC panels 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 C1228, PCI MNL 128, and PCI MNL 130 procedures.
4. Test GFRC inserts and anchors according to ASTM C1230 to validate design values.
5. Produce test boards at a rate not less 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 C1229, and flexural yield and ultimate strength according to ASTM C947.

PART 3 – EXECUTION

3.1 Examination

- A. Examine structure and conditions for compliance with requirements for installation tolerances, true and level bearing surfaces, and other conditions affecting performance.
 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 Erection

- A. Install clips, hangers, and other accessories required for connecting GFRC panels to supporting members and Backup materials.
- B. Lift GFRC panels and install without damage.
- C. Install GFRC panels level, plumb, square, and in alignment. Provide temporary support 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.
- D. Connect GFRC panels 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.
- E. 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 panels from damage by field welding or cutting operations, and provide noncombustible shields as required.
- F. At bolted connections, use lock washers or other acceptable means to prevent loosening of nuts.

3.3 Erection Tolerances

- A. Erect GFRC panels to comply with the following noncumulative tolerances:
 1. Plan Location from Building Grid Datum: Plus or minus ½ inch (13 mm).
 2. Top Elevation from Nominal Top Elevation: As follows:
 - a. Exposed Individual Panel: Plus or minus ¼ inch (6 mm).
 - b. Nonexposed Individual Panel: Plus or minus ½ inch (13 mm).
 - c. Exposed Panel relative to Adjacent Panel: ¼ inch (6 mm).
 - d. Nonexposed Panel relative to Adjacent Panel: ½ inch (13 mm).
 3. Support Elevation from Nominal Elevation: As follows:
 - a. Maximum Low: ½ inch (13 mm).
 - b. Maximum High: ¼ inch (6 mm).
 4. Maximum Plumb Variation over the Lesser of Height of Structure or 100 Feet (30 m): 1 inch (25 mm).
 5. Plumb in Any 10 Feet (3 m) of Element Height: ¼ inch (6 mm).
 6. Maximum Jog in Alignment of Matching Edges: ¼ inch (6 mm).
 7. Maximum Jog in Alignment of Matching Faces: ¼ inch (6 mm).
 8. Face Width of Joint: As follows (governs over joint taper):
 - a. Panel Dimension 20 Feet (6 m) or Less: Plus or minus ¼ inch (6 mm).
 - b. Panel Dimension More Than 20 Feet (6 m): Plus or minus 5/16 inch (8 mm).
 9. Maximum Joint Taper: 3/8 inch (10 mm).
 10. Joint Taper in 10 Feet (3 m): ¼ inch (6 mm).
 11. Differential Bowing, as Erected, between Adjacent Members of Same Design: ¼ inch (6 mm).

3.4 Repairs

- A. Repairs will be permitted provided structural adequacy of GFRC panel and appearance are not impaired, as approved by Architect.
- C. Mix patching materials and repair GFRC so cured patches blend with color, texture, and uniformity of adjacent exposed surfaces.
- D. Prepare and repair accessible damaged galvanized coatings with galvanizing repair paint according to ASTM A780.
- E. Wire brush, clean, and paint accessible weld areas on prime-painted components with same type of shop primer.
- F. 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 GRC surfaces and staining of adjacent materials.

END OF SECTION 03491