

Guide Specification

This Guide Specification is intended to be used as a basis for the development of an office master specification or in the preparation of specifications for a particular project. In either case this Guide Specification must be edited to fit the conditions of use. Particular attention should be given to the deletion of inapplicable provisions or inclusion of appropriate requirements.

Boxed portions are Notes to the Specification Writer.

SECTION 03491 GLASS FIBER REINFORCED CONCRETE

This Section uses the term "Architect." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions. Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

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. This Section includes glass fiber reinforced concrete (GFRC) panels, consisting of GFRC, panel frames, anchors, and connection hardware.

Retain subparagraph below if listing GFRC panel applications.

1. GFRC panels include [**wall units**] [**window wall units**] [**mullions**] [**column covers**] [**fascia units**] [**cornices**] [**soffits**] <Insert applications>.

- B. Related Sections include the following:

List below only products and construction that reader might expect to find in this Section but are specified in other Sections.

1. Section 033000 "Cast-in-Place Concrete" for placing connection anchors in concrete.
2. Section 034500 "Architectural Precast Concrete."
3. Section 051200 "Structural Steel Framing" for connection attachment to structural-steel framing.

4. Section 07920 "Joint Sealants" for elastomeric joint sealants and sealant backings.
5. Section 085113 "Aluminum Windows" for windows set into GFRC panels.

1.3 DEFINITIONS

Retain paragraph below if a design reference sample has been preapproved.

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

1.4 PERFORMANCE REQUIREMENTS

- A. Structural Performance: GFRC panels, including panel frames, anchors, and connections, shall withstand 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."

Retain subparagraph below if design loads are indicated on Drawings and delete four subparagraphs that follow.

1. Design Loads: **<As indicated.>**

Retain four subparagraphs below if indicating loads here and delete subparagraph above.

2. Dead Loads: **<Insert dead loads.>**
3. Live Loads: **<Insert live loads.>**
4. Wind Loads: **<Insert wind loads or wind-loading criteria, positive and negative for various parts of the building as required by applicable building code or ASCE/SEI 7, including basic wind speed, importance factor, exposure category, and pressure coefficient.>**
5. Earthquake Loads: **<Insert earthquake design data including seismic performance category, importance factor, use group, seismic design category, seismic zone, site classification, site coefficient, and drift criteria.>**

Revise deflection limit in subparagraph below to suit Project.

6. Deflection Limits: Design panel frames to withstand design loads without lateral deflections greater than 1/240 of wall span.

Differential values in first subparagraph below are suitable for most of the U.S. Revise to suit local conditions.

7. Thermal Movements: Provide for thermal movements resulting from annual ambient temperature changes of [80 degF (26 degC)] <Insert temperature>.
8. Design panel frames and connections to accommodate deflections and other building movements.

Retain below if window loads will be transmitted to structure through panel frames. Insert other performance and design criteria here to suit Project or add to Drawings.

9. Design panel frames to transfer window loads to building structure.

Retain "Fire-Resistance Rating" Subparagraph below if required. Fire ratings depend on occupancy and building construction type, and are generally a building code requirement.

10. Fire-Resistance Rating: Select material and minimum thicknesses to provide [1] [2] <Insert number> hour fire rating.

1.5 ACTION 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 sizes, spacings, thicknesses, and yield strengths of various members.
 8. Locations and details of connection hardware attached to structure.
 9. Size, location, and details of flex, gravity, and seismic anchors for typical panels.
 10. Other items sprayed into panels.
 11. Erection sequence for special conditions.
 12. Relationship to adjacent materials.
 13. Descriptions of loose, cast-in, and field hardware.
- C. Samples: Design reference samples for initial verification of design intent, approximately 12 by 12 inches (300 by 300 mm) and of actual thickness, representative of finishes, color, and textures of exposed surfaces.

1.6 INFORMATIONAL SUBMITTALS

Coordinate first paragraph below with qualification requirements in Section 01400 "Quality Requirements" and as supplemented in "Quality Assurance" Article.

- A. Qualification Data: For GFRC manufacturer, including proof of current PCI Plant Certification.

Retain paragraph below if procedures for welder certification are retained in "Quality Assurance" Article.

- B. Welding certificates.

Retain paragraph below if steel sheet certification is retained in "Quality Assurance" Article.

- C. Steel Sheet Certification. For steel sheet used in cold-formed steel panel framing.

Retain paragraph below if mill certificates are retained in "Quality Assurance" Article.

- D. Mill Certificates: For structural-steel shapes and hollow structural sections used in panel framing.
- E. Source Quality-Control Program: For GFRC manufacturer.
- F. Source Quality-Control Test Reports: For GFRC, inserts, and anchors.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer that participates in PCI's Plant Certification Program and is designated a PCI-Certified Plant for Group G, Glass Fiber Reinforced Concrete.

Retain option in first subparagraph below if requiring manufacturer to install GFRC.

- 1. Manufacturer's responsibility includes fabricating [and installing] GFRC panels and providing professional engineering services needed to assume engineering responsibility for GFRC panels.
- 2. Engineering responsibility includes preparation of Shop Drawings and comprehensive engineering analysis, based on GFRC production test values, by a qualified professional engineer experienced in GFRC design.
- B. Certification shall be maintained throughout the production of the glass fiber reinforced concrete units. Production shall immediately stop if at any time the fabricator's certification is revoked, regardless of the status of completion of contracted work. Production will not be allowed to re-start until the necessary corrections are made and certification has been re-

established. In the event certification(s) can not be re-established in a timely manner, causing project delays, the fabricator, at no additional cost, will contract out the remainder of the units to be manufactured at a PCI certified plant.

Retain paragraph below if requiring mill certificates or test reports for cold formed steel framing used in panel frames.

- C. Steel Sheet Certifications: Obtain mill certificates, signed by manufacturers of steel sheet or test reports from a qualified testing agency indicating steel sheet used in cold-formed metal panel framing complies with requirements, including uncoated steel thickness, yield strength, tensile strength, total elongation, chemical requirements, and galvanized-coating thickness.

Retain first paragraph below if requiring mill certificates for structural steel shapes and hollow structural sections used in panel frames.

- D. Mill Certificates: Obtain certified mill test report from manufacturer of structural-steel shapes and hollow structural sections used in panel framing indicating compliance of these products with requirements.
- E. Source Limitations: Obtain GFRC panels through one source from a single manufacturer.

Retain "Welding certificates" Paragraph in "Submittals" Article with paragraph below.

- F. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," and AWS D1.3, "Structural Welding Code--Sheet Steel."
- G. PCI Manuals: Comply with requirements and recommendations in the following PCI manuals, unless more stringent requirements are indicated:
 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."

Retain paragraph below if using cold formed metal framing for panel frames.

- H. AISI Specifications: Comply with AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members."

Retain subparagraph below if using structural-steel shapes or hollow structural sections for panel frames.

- I. AISC Specifications: Comply with ANSI/AISC 360, "Specification for Structural Steel Buildings."

Retain paragraph and subparagraphs below if required for GFRC. If retaining, indicate location, size,

and other details of mockups on Drawings or by inserts. Revise wording if only one mockup is required.

- J. Mockups: Build mockups to demonstrate aesthetic effects and set quality standards for fabrication and installation.
1. Build mockup of typical wall area as shown on Drawings [**as part of**] [**separately from**] building.
 2. In addition to GFRC panels, mockups include [**architectural precast concrete**] [**unit masonry**] [**aluminum windows**] [**joint sealants**] [**metal flashings**] [**and**] [**copings**] **<Insert construction>**.

Retain subparagraph below if mockups are erected as part of building rather than separately and the intention is to make an exception to the default requirement in Section 01400 "Quality Requirements" for demolishing and removing mockups.

3. Approved mockups may become part of the completed Work if undamaged at time of Substantial Completion.

Retain below if Work of this Section is extensive or complex enough to justify a preinstallation conference. If retaining, coordinate with Division 1.

- K. Preinstallation Conference: Conduct conference at [**Project site**] **<Insert location>** to comply with requirements in Division 01 Section "Project Management and Coordination."

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Handle and transport GFRC panels to avoid damage.
1. Place nonstaining resilient spacers between panels.
 2. Support panels on nonstaining material during shipment.
 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 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

Retain this Article if naming GFRC manufacturers. See PCI's Web site www.pci.org for current PCI-certified plant listings.

- A. Manufacturers: Subject to compliance with requirements, **[provide products by one of the following] [manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. **<Insert manufacturer's name>**.

2.2 MOLD MATERIALS

- A. Molds: Rigid, dimensionally stable, nonabsorptive material, warp and buckle free, that will provide 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 will not bond with, stain, or adversely affect GFRC surfaces and will not impair subsequent surface or joint treatments of GFRC.

Retain paragraph below if using form liners against molds. Insert description if particular form liner selected.

- 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 will not bond with, stain, or adversely affect GFRC surfaces and will not impair subsequent surface or joint treatments of GFRC.

Retain below if using retarder to help obtain exposed-aggregate finish on face mix.

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

2.3 GFRC MATERIALS

- A. Portland Cement: ASTM C150, Type I, II, or III.

Select portland cement color from options in subparagraph below.

1. For surfaces exposed to view in finished structure, use [gray] [white] of same type, brand, and source throughout GFRC production.

Retain metakaolin as supplementary cementing material if its use by GFRC manufacturer has been proven in service to maintain GFRC ductility.

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 ASTM C1666/C 1666M.
- C. Sand for GFRC Backing: 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.

Retain paragraph and subparagraph below if face mix is required.

- D. Facing Aggregate.

Revise subparagraph below and add descriptions of selected face aggregate colors, sources, sizes, shapes, and gradations if known.

1. Coarse Aggregate: ASTM C33, except for gradation, and PCI MNL 130, 1/4-inch (6-mm) maximum size. Selected, hard, and durable; free of material that reacts with cement or causes staining; to match sample.
2. Fine Aggregate: Natural sand or sand manufactured from coarse aggregate, ASTM C33, except for gradation with a maximum of 5 percent passing No. 100 (0.15 mm) sieve and a maximum of 3 percent passing No. 200 (0.075 mm) sieve.

Delete first paragraph below if coloring admixture is not required. Add color selection if known.

- 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.

Usually retain paragraph below as manufacturer's option with moist curing in "GFRC Fabrication" Article. PCI MNL 130 sets product requirements and mandates published independent laboratory test data verifying curing agent eliminates need for moist curing. Polymer curing admixture is used by most GFRC manufacturers.

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

Retain paragraph below if in-service exposure involves freeze-thaw conditions and face mix does not include polymer curing admixture. Air-entraining and polymer curing admixtures are incompatible.

- H. Air-Entraining Admixture: ASTM C260, containing not more than 0.1 percent chloride ions.

Insert types of chemical admixtures, if known, or limit types if required. Water-reducing admixtures, Types A, E, and D, or a high-range water reducer, Type F, predominate.

- I. Chemical Admixtures: ASTM C494/C494M, containing not more than 0.1 percent chloride ions.

2.4 ANCHORS, CONNECTORS, AND MISCELLANEOUS MATERIALS

Edit this Article to suit Project. Add other materials as required.

- 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:

Retain one of two subparagraphs below. Hot-dip galvanized finish provides maximum corrosion resistance. Electrodeposited zinc coatings provide some corrosion protection. MPI 79 in second paragraph provides some corrosion protection while SSPC-Paint 25, without topcoating, provides minimal corrosion protection.

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** paint on surfaces prepared to comply with SSPC-SP2, "Hand Tool Cleaning," or better.

Carbon-steel rods are used as flex, gravity and seismic anchors.

- B. Anchors and Inserts: Steel for anchors shall conform to the appropriate requirements of ASTM A29 or A108 with a minimum diameter of 1/4-inch (6 mm). Yield strength shall conform to design minimum and maximum steel yield strength. Inserts shall be compatible with or isolated from the other materials with which they will come in contact to avoid unwanted chemical or electrochemical reactions. Ductile materials shall be used.
 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] [electrodeposited cadmium according to ASTM B 766, Type II, Class 25.]**

Carbon-steel bars in paragraph below are used as flex, gravity, and seismic anchors.

- C. Carbon-Steel Bars: ASTM A108, AISI Grade 1018. Finish steel bars less than 3/16 inch (4.76 mm) thick as follows:

Retain one of two subparagraphs below. Hot-dip galvanized finish provides maximum corrosion resistance. Electrodeposited zinc coatings provide some corrosion protection. MPI 79 in second paragraph provides some corrosion protection while SSPC-Paint 25, without topcoating, provides minimal corrosion protection.

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** paint on surfaces prepared to comply with SSPC-SP2, "Hand Tool Cleaning," or better.
- D. Malleable-Iron Castings: ASTM A47/A47M, Grade 32510 (Grade 22010).
- E. Carbon-Steel Castings: ASTM A27/A27M, Grade 60-30 (Grade 415-205).
- F. Bolts: ASTM A307 or ASTM A325 (ASTM F568M or ASTM A325M).

Retain subparagraph below if service conditions warrant this added protection. Hot-dip galvanized finish provides maximum corrosion resistance. Electrodeposited zinc coatings provide some corrosion protection.

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**].

Retain PVC reglet or insert another material to suit Project. Coordinate with counterflashing materials and details.

- G. Reglets: PVC extrusions.

2.5 PANEL FRAME MATERIALS

- A. Cold-Formed Steel Framing: Manufacturer's standard C-shaped steel studs, complying with AISI's "North American 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:

Select required steel sheet and finish from two subparagraphs below. Select weight of zinc coating from options in first subparagraph for galvanized steel framing.

1. Metallic-Coated Steel Sheet: ASTM A 653/A653M, structural-steel sheet, [**G60 (Z180)**] [**G90 (Z275)**] zinc coating, of grade required by structural performance of framing.

Retain subparagraph below if using painted steel 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:

Select finish options in two subparagraphs below. Zinc-rich primer offers some corrosion resistance; primer, minimal corrosion resistance.

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** paint on surfaces prepared to comply with SSPC-SP 2, Hand Tool Cleaning," or better.
- C. Steel Channels and Angles: ASTM A36/A36M, finished as follows:

Select finish options from two subparagraphs below. Finishes are listed in descending order of corrosion resistance.

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** paint on surfaces prepared to comply with SSPC-SP 2, "Hand Tool Cleaning," or better.

2.6 GFRC MIXES

GFRC fabricator generally determines backing and face or mist-coat mix proportions.

- A. 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.
- B. Face Mix: Proportion face mix of portland cement, fine and coarse aggregates, and admixtures to comply with design requirements.

Usually retain mist-coat mix in first paragraph below with backing mix above where there is no face mix. Delete below if retaining face mix or where GFRC is faced with dimension stone or another veneer.

- 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.

Retain first paragraph below if GFRC panels are exposed to freeze-thaw conditions and GFRC manufacturer does not use polymer curing admixture. Air content range below is based on PCI MNL 130 recommendations for freeze-thaw conditions.

- E. Air Content: 8 to 10 percent; ASTM C185.
- F. 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/D1.1 M 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.

Retain paragraph above for galvanized surfaces or below for prime-painted surfaces.

- 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.

Usually retain subparagraph above. Delete subparagraph below unless exposed-aggregate surfaces require surface retarder to achieve desired finish.

- 2. Coat contact surfaces of molds with surface retarder.

Retain paragraph below if using form liners.

- 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.

Retain below if using flashing reglets.

- 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 (3 mm) on planar surfaces.

Retain subparagraph above or first subparagraph below, unless neither is required.

- 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 1/2 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 1/2 inch (13 mm) over top of anchor foot, before initial set of GFRC backing. Measure 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 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. Comply with PCI MNL 130 procedures.
 - 1. Keep moisture off of the surface of mixes with polymer curing admixtures during first 3 hours of curing. Maintain temperature between 60 and 120 deg F (16 and 49 deg C) during the first 12 to 16 hours.

2. Prevent drying of moist cured mixes during first 24 hours. Maintain units in surface-damp condition at a temperature above 60 deg F (16 deg C) in a minimum of 95 percent relative humidity for a period of 7 days.

Coordinate below with Shop Drawings.

- 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.

Retain paragraph above if incorporating tolerances by reference; retain first paragraph and subparagraphs below if detailed listing is required in this Section.

- 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.

Tolerances below are PCI recommendations. Manufacturers may be able to comply with closer tolerances if required. Closer tolerances normally increase costs.

1. Overall Height and Width of Units, Measured at the Face Adjacent to Mold: As follows:
 - a. 10 feet (3 m) or under, 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 1/2 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 1/4 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 1/4 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 1/4 inch (6 mm) total, whichever is greater.
8. Local Smoothness: 1/4 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 Blockouts and Openings within One Unit: Plus or minus 1/4 inch (6 mm).

11. Location of Window Opening within Panel: Plus or minus 1/4 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 1/4 inch (6 mm).
 2. Flashing Reglets at Edge of Panel: Plus or minus 1/4 inch (6 mm).
 3. Inserts: Plus or minus 1/2 inch (13 mm).
 4. Special Handling Devices: Plus or minus 3 inches (75 mm).
 5. Location of Bearing Devices: Plus or minus 1/4 inch (6 mm).
 6. Blockouts: Plus or minus 3/8 inch (10 mm).
- D. Panel Frame Tolerances: As follows:
1. Vertical and Horizontal Alignment: 1/4 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 mm).

2.11 FINISHES

This Article presumes Architect has preapproved one or more design reference samples. Include complete description of design reference sample here. If preapproving manufacturers, coordinate with "Manufacturers" Article. Revise paragraph below to add requirements if GFRC finish is to match another product such as architectural precast concrete.

- 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.

Retain subparagraph below if Architect's design reference sample is used. Revise if multiple samples are approved.

1. Design Reference Sample: <**Insert description and identify manufacturer and code number of sample.**>

Retain type of finish from subparagraphs below. If more than one finish is required, add locations to finish descriptions or indicate on Drawings. Add more detailed descriptions of finishes outlined below when greater definition is required.

2. As-Cast-Surface Finish: Provide surfaces to match accepted sample or mockup units for acceptable surface air voids, sand streaks and honeycombs.
3. Textured-Surface Finish: Impart texture by form liners to match accepted sample or mockup units for acceptable surface air voids, sand streaks, and honeycombs with uniform color and texture.

4. Retarded Finish: Use chemical-retarding agents applied to GFRC forms and washing and brushing procedures to expose aggregate and surrounding matrix surfaces after form removal to match accepted sample or mockup units.
5. Sand- or Abrasive-Blast Finish: Use abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces to match accepted sample or mockup units.
6. Acid-Etched Finish: Use acid and hot-water solution equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces to match accepted sample or mockup units.

2.12 SOURCE QUALITY CONTROL

PCI MNL 130 mandates source testing requirements. PCI certification also ensures periodic auditing of plants for compliance with requirements in PCI MNL 130.

- 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.

Revise frequency of testing in first subparagraph below to suit Project.

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 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.
- 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/D1.1M 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

Tolerances below are PCI MNL 130 recommendations.

- A. Erect GFRC panels to comply with the following noncumulative tolerances:
 - 1. Plan Location from Building Grid Datum: Plus or minus 1/2 inch (13 mm).
 - 2. Top Elevation from Nominal Top Elevation: As follows:
 - a. Exposed Individual Panel: Plus or minus 1/4 inch (6 mm).
 - b. Nonexposed Individual Panel: Plus or minus 1/2 inch (13 mm).
 - c. Exposed Panel relative to Adjacent Panel: 1/4 inch (6 mm).
 - d. Nonexposed Panel relative to Adjacent Panel: 1/2 inch (13 mm).
 - 3. Support Elevation from Nominal Elevation: As follows:
 - a. Maximum Low: 1/2 inch (13 mm).
 - b. Maximum High: 1/4 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: 1/4 inch (6 mm).
 - 6. Maximum Jog in Alignment of Matching Edges: 1/4 inch (6 mm).
 - 7. Maximum Jog in Alignment of Matching Faces: 1/4 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 1/4 inch (6 mm).
 - b. Panel Dimension More Than 20 Feet (6 m): Plus or minus 3/8 inch (10 mm).
 - 9. Maximum Joint Taper: 3/8 inch (10 mm).
 - 10. Joint Taper in 10 Feet (3 m): 1/4 inch (6 mm).
 - 11. Differential Bowing, as Erected, between Adjacent Members of Same Design: 1/4 inch (6 mm).

3.4 REPAIRS

Production blemishes are generally corrected at manufacturer's plant. Blemishes occurring after delivery are normally repaired before final joint cleaning and sealing.

- A. Repairs will be 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 A780.

Retain paragraph above if using galvanized framing, anchors, connections, and other items; retain first paragraph below if items are prime painted.

- D. Wire brush, clean, and paint accessible weld areas on prime-painted components 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 03491