

REQUIREMENTS FOR GLASS FIBER REINFORCED CONCRETE (GFRC) PANELS

References: 2013 California Building Code Section 1903A.2, PCI MNL-128-01, PCI MNL-130-09, and ASCE 7-10.

Disciplines: Structural

History:

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PURPOSE: To provide guidelines for the acceptance of glass fiber reinforced concrete (GFRC) panels by the Division of the State Architect (DSA) that will be used on projects under its jurisdiction.

1. DEFINITION: Glass fiber reinforced concrete is the term applied to products manufactured using cement/aggregate slurry thoroughly mixed with alkali-resistant (AR) glass fiber reinforcement. GFRC is typically used in thin-walled architectural cladding panels with a minimum thickness of ½-inch. Some of the terms used in this document are defined below:

- **Connection:** The welding and bolts used to attach the skin to the panel frame or the panel frame to the building structure.
- **Panel:** The whole panel, including the GFRC skin, support frame, anchors, and connection hardware.
- **Panel Anchor:** Anchor that connects the panel frame to the building structure.
- **Panel Frame:** Cold form or hot-rolled steel framing system supporting the skin.
- **Skin:** The GFRC only.
- **Skin Anchor:** Anchor that is bonded to the skin by the bonding pad and connects the skin to the panel frame. There are three types of skin anchors: flex anchors, flat plate gravity anchors, and truss rod gravity anchors. See Figures 24, 26 and 27 of *PCI Recommended Practice for Glass Fiber Reinforced Concrete Panels* (PCI MNL-128-01).

The strength of skin anchors shall be determined in accordance with PCI MNL-128-01, Section 5.7.2.3, and tested per Section 6.3.1 of this IR.

2. PRODUCT DESCRIPTION: GFRC is fabricated by spray-up or by premix processes. Provisions of spray-up GFRC are discussed in PCI MNL-128-01. The provisions specific to Premix GFRC are discussed in Appendix J of PCI MNL-128-01.

2.1 Spray-Up GFRC: PCI MNL-128-01 defines spray-up GFRC as a “sprayed composite... with a minimum thickness of ½ inches as produced by a PCI Certified Plant – Group G.” Mix composition, degree of compaction, type of cement, and the proportion, length, and orientation of glass fibers may all be varied to produce a specific product.

Lower fiber content leads to lower early ultimate strength, and higher fiber content leads to compaction and consolidation problems. Typically a spray-up GFRC panel consists of five percent (with an absolute minimum of four percent) by total mix weight of AR glass fibers randomly distributed throughout cement/sand slurry with a cement/sand ratio neither less than 1:1 nor greater than 3:1.

REQUIREMENTS FOR GLASS FIBER REINFORCED CONCRETE (GFRC) PANELS

2.2 Premix GFRC: Appendix J of PCI MNL-128-01 defines premix GFRC as a cement/sand slurry and chopped strands of AR glass fiber mixed together before transport to the mold. The slurry is cast usually with vibration into a mold similar to precast concrete, or it may be sprayed. Premix GFRC shall contain no less than three percent AR glass fiber by weight of the total mix. ←

Premix generally yields lower strength than spray-up due to shorter fibers and fiber orientation. Equipment for premix GFRC is also less expensive than spray-up GFRC. Premix should be used in products where strength is not the prime requirement.

2.3 Curing: Curing may be achieved either by moisture curing or by the use of a thermoplastic copolymer admixture, which retains moisture in the mix until adequately cured. Admixtures such as water-reducers, accelerators, retarders, and air-entraining agents may be used.

2.4 Performance: GFRC panels manufactured in accordance with the recommendations of PCI MNL-128-01 have shown a history of good performance in resistance to weather and water penetration. A weather-resistive coating, however, is recommended over the GFRC panel, along with approved joint caulking compounds, to create a complete weather-resistive barrier.

3. DESIGN OF GFRC PANELS: GFRC panels shall be designed in accordance with the California Building Code (CBC), ASCE 7-10, and PCI MNL-128-01 for in-plane and out-of-plane loads and effects.

3.1 Design Loads: Engineers must consider the following three types of loads in the design of GFRC panels.

3.1.1 Manufacturing and Installation Loads: Include loads and effects from stripping, handling, and installation. These loads will not be reviewed by DSA.

3.1.2 Service Loads: Panel design must consider dead, live, and environmental loads such as wind, earthquake, temperature, and moisture effects. Load factors and combinations for strength design shall be in accordance with CBC, Section 1605A.2.

3.1.3 Connection Loads: Anchors and connections shall *also* be designed to meet the drifts and forces from the effects of earthquake as required by ASCE 7-10, Section 13.5.3. The interior finish systems or windows that are attached to the panel frame should be compatible with the resulting deflection.

3.2 Manufacturer's Engineer: The manufacturer's engineer shall be responsible for the design of the panel, panel frame, anchors, and connections of anchors to the panel for the design loads in Section 3.1, above. The manufacturer's engineer must provide calculations for the following:

- Buckling of the skin anchors
- Structural members in the panel frame and the skin anchors
- Sub-frame to support the panels

3.3 Structural Engineer in General Responsible Charge shall check the building structural members, their connections, and the connections of the panel anchors to the structural member for torsional, vertical, and lateral loads imposed by the GFRC panels for the loads in Section 3, above.

REQUIREMENTS FOR GLASS FIBER REINFORCED CONCRETE (GFRC) PANELS

Project design engineer shall also check the joint spacing between panels, and between structural members and panels. The spacing shall be sufficient to accommodate the in-plane and out-of-plane movements of panels from the loads specified in this section.

4. DRAWINGS FOR GFRC PANELS: Drawings for the GFRC panels must include the following information:

- Details for skin and panel anchors; dimensions and thickness of bonding material; embedment dimension of skin anchors in bonding material; and dimension for weld length of connections to panel frame or building structure.
- Details showing the joints between the GFRC cladding elements. Joint width shall be based on panel size, structural tolerance, anticipated movement, story drift, joint materials, and adjacent surfaces.
- Details of panel anchors and connections (as defined in Section 1) shall indicate the size of oversized or slotted hole and the required clearance between connectors and the sides of holes, as determined by the structural engineer in general responsible charge to allow for erection tolerances, and inter-story drift to meet the requirements of ASCE 7-10, Section 13.5.3.
- For rectangular support tubes, indicate orientation.
- Clearly identify the boundary and interface between GFRC panel and supporting structural members on the design drawings.

4.1 Stamps and Signatures: The manufacturer's California registered structural or civil engineer shall stamp and sign all GFRC panel drawings in accordance with DSA [IR A-19](#). The project architect and/or structural engineer in general responsible charge shall provide a Statement of General Conformance in accordance with [IR A-18](#).

5. SPECIFICATIONS FOR GFRC PANELS. PCI MNL-128-01 provides useful guidelines for writing GFRC panel specifications. For DSA projects, the following provisions must be included in the specifications:

5.1 Fabrication and manufacturing: Specify GFRC panels to be fabricated in accordance with PCI MNL-128-01, as modified below.

5.2 Quality Control: Require the manufacturer to have an established quality control program that meets the requirements of PCI MNL-130-09.

5.3 Corrosion Protection: Require corrosion protection for the panel frames, anchors, and hardware such as connectors and inserts. Light gauge steel materials should be either painted or galvanized. Hot dip galvanizing is not recommended after fabrication, as it can cause distortion.

5.4 Mix Design: Specify mix design requirements for the GFRC backing material. The cement/sand ratio shall not be less than 1:1 or greater than 3:1.

5.5 Glass Fiber: Specify only alkali-resistant fiber specifically designed for alkali resistance and for use in concrete, required amount of AR fiber (see Section 2, above), form of fiber (i.e., roving or chopped strands), and fiber length, in accordance with PCI MNL-128-01, Appendix K or ASTM C1666 "Standard Specification for Alkali Resistant (AR) Glass Fiber for GFRC and Fiber-Reinforced Concrete and Cement."

5.6 Bonding material: Specify bonding material for panel connectors.

REQUIREMENTS FOR GLASS FIBER REINFORCED CONCRETE (GFRC) PANELS

- 5.7 Mechanical Properties:** Specify strength, strain, and shrinkage requirements.
- 5.8 Properties for Design:** Specify that the designs for in-service conditions be based on fully aged strength and strain properties.
- 5.9 Admixtures:** Specify the admixtures to be used. Admixtures containing calcium chloride shall not be used.
- 5.10 Testing:** Specify the required testing procedures and apparatus, and require the test results to be reported to the architect, structural engineer, project inspector, and DSA.
- 5.11 Continuous Fabrication Inspection:** Specify that continuous in-plant inspection by an approved independent inspector is required; unless the plant is currently certified under the PCI Certification Program (see Section 6.3, below).

6. PLANT FABRICATION AND QUALITY CONTROL REQUIREMENTS OF PRECAST GFRC PANELS: The requirements of this section shall apply to all GFRC panels regardless of the fabrication process (spray-up or premix).

- 6.1 Project Design Professional:** The design professional in general responsible charge of the project shall submit a testing and inspection program to DSA for review and acceptance. The design professional shall also complete the Statement of Structural Tests and Special Inspections (form [DSA-103](#)) for the work, clearly indicate testing and inspection requirements.
- 6.2 Manufacturer:** GFRC panels shall be fabricated in accordance with the provisions of PCI MNL-128-01. The manufacturer shall have an established quality control program which meets the requirements of the *PCI Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products* (PCI MNL-130-09), including the testing and inspection requirements of Division 5 and the test procedures of Appendix H.

Manufacturer shall submit its quality control manual to the project design professional and DSA for review and acceptance. A manufacturing plant that currently holds a Group G certification issued by PCI may submit the PCI certification in lieu of the quality control manual.

- 6.3 Testing Requirements:** If any structural material tests are required, such as for unidentifiable steel, testing must be performed by a test laboratory employed by the school district and acceptable to DSA. A list of acceptable test laboratories can be found on DSA's website.

All test reports shall be submitted by the laboratory within 14 days of the testing, and a final Laboratory of Record Verified Report ([DSA-291](#)) shall be submitted at the conclusion of the required tests.

- 6.3.1 Skin Anchor Pull-off and Shear Tests Acceptance:** Tests shall be conducted in accordance with the requirements of Appendix H of PCI MNL-130-09 and ASTM C1230. Acceptance shall be based on compliance with criteria in PCI MNL-130-09, Division 5, Section 5.2.5.
- 6.3.2 Premix GFRC:** The testing program for premix products may be modified as it applies to specific panels.
- 6.4 Special Inspection (Shop):** The manufacturing of GFRC panels shall be continuously inspected by a DSA approved special inspector. The special inspector shall provide

REQUIREMENTS FOR GLASS FIBER REINFORCED CONCRETE (GFRC) PANELS

detailed special inspection reports ([DSA-250](#)), and at the completion of the work, he/she shall submit a Special Inspection Verified Report ([DSA-292](#)) as required by the 2013 California Administrative Code. The manufacturer shall also file a Contractor Verified Report ([DSA 6-C](#)) per Title-24 Part 1, Section 4-343(c).

Exception: Continuous inspection is not required for plants holding a current Group G certification issued by PCI. However, the manufacturer is still required to submit a Contractor Verified Report per Title 24 Part 1 Section 4-343 (c). Any field work identified in Section 6.5, such as welding and bolting, etc., that is performed in the shop requires special inspection.

6.4.1 Panel Marking: All panels shall be marked with the approved inspector's identification mark, and a list of approved panels shall be provided to the project inspector and DSA.

Exception: Panel identification is not required for plants holding a current Group G certification issued by PCI. However, the manufacturer is required to include a list of panels with the verified report.

6.5 Special Inspection (Field): Any required special inspection of field work, such as welding, bolt installations, etc., shall be continuously inspected by a DSA approved special inspector. The special inspector shall provide detailed daily special inspection reports, and at the completion of the work, he/she shall submit a Laboratory of Record Verified Report, as required by the 2013 California Administrative Code.

Interpretations of Regulations (IRs) are used by the Division of the State Architect (DSA) staff, and as a resource for design professionals to promote more uniform statewide criteria for plan review and construction inspection of projects within the jurisdiction of DSA. Projects requiring plan review and construction inspection include California universities, state-owned or state-leased essential services buildings, and state-funded elementary schools (K-12) and secondary schools (community colleges) in the state of California. Interpretations of Regulations provide acceptable method for achieving compliance with applicable codes and regulations, although other methods proposed by design professionals may be considered by DSA.

This IR is reviewed on a regular basis and is subject to revision at any time. Please check the DSA website for currently effective IRs. Only IRs listed on the DSA website at www.dgs.ca.gov/dsa/Resources/IRManual.aspx at the time of plan submittal to DSA are considered applicable.