DSA IR 19-2

GLASS FIBER REINFORCED CONCRETE (GFRC) PANELS: 2019 CBC

Disciplines: Structural

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Division of the State Architect (DSA) documents referenced within this publication are available on the DSA Forms or DSA Publications webpages.

PURPOSE

This Interpretation of Regulations (IR) clarifies requirements relating to glass fiber reinforced concrete (GFRC) panels used on construction projects under DSA jurisdiction.

SCOPE

This IR is applicable to GFRC panels fabricated by the spray-up or premix processes and covers design, fabrication, quality control, and inspection requirements. This IR is not applicable to polymer modified E-glass fiber reinforced concrete.

BACKGROUND

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. The Precast/Prestressed Concrete Institute (PCI) provides guidance for GFRC design and construction through various publications. California Building Code (CBC), Section 1903A.3 requires GFRC to comply with the PCI publication Recommended Practice for Glass Fiber Reinforced Concrete Panels (MNL-128).

1. GENERAL

GFRC is traditionally fabricated by the spray-up or premix process. MNL-128 generally focuses on the spray-up process, which is the most common method of GFRC fabrication. The provisions specific to the premix process are presented in Appendix J of MNL-128. GFRC panels are fabricated with a minimum thickness of ½ inches, and are typically supported by a steel panel frame. 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, while higher fiber content can create compaction and consolidation challenges.

1.1 Spray-Up Process

The spray-up process of GFRC fabrication can be a manual or automated process. The slurry consisting of cement, sand, and water is applied through a compressed-air-powered gun. A continuous strand of glass fiber is fed separately, chopped into specified fiber lengths and combined with the slurry at the nozzle. In this manner, the glass fibers are mixed with the concrete slurry in the spray process. The material is applied in layers (1/8- to 1/4-inch thick) and compacted, often by a rolling process.

Typically a GFRC panel fabricated by the spray-up process consists of five percent (with an absolute minimum of four percent) by total mix weight of alkali-resistant glass fibers randomly distributed.

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1.2 Premix Process

The premix process of GFRC fabrication involves mixing chopped strands of alkali-resistant glass fibers with the slurry consisting of cement, sand, and water before casting, spraying, press molding, or extruding. The premix slurry is usually cast with vibration into a mold similar to precast concrete. Premix GFRC shall contain no less than three percent alkali-resistant glass fiber by weight of the total mix.

The premix process generally yields lower strength than the spray-up process due to shorter fibers and fiber orientation. Equipment for the premix process is generally less expensive than that required for the spray-up process.

1.3 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. Refer to MNL-128 Section 7.10 for additional information.

1.4 Performance

GFRC panels manufactured in accordance with the recommendations of MNL-128 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.

2. DESIGN

GFRC panels shall be designed in accordance with the California Building Code (CBC), American Society of Civil Engineers Standard 7: Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7), and MNL-128 for in-plane and out-of-plane loads and effects.

2.1 Design Criteria

The responsible engineer shall consider each of the following in the design of GFRC panels. Structural calculations shall demonstrate adequacy for strength, stiffness, and deformation compatibilty.

2.1.1 Panels shall be adequate for all loads and effects resultings from fabrication, stripping, handling, and erection. These loads will not be reviewed by DSA.

2.1.2 Panels shall be adequate to resist all dead, live, and environmental loads such as wind, earthquake, temperature, and moisture effects prescribed by the CBC and standards identified above. Load factors and combinations shall be in accordance with CBC Section 1605A.

2.1.3 Anchors and connections of exterior panels shall ***also*** comply with the earthquake induced drift and force requirements of ASCE 7 Section 13.5.3.

2.1.4 Exterior wall systems shall be designed with adequate deformation compatibility as required by ASCE 7 Sections 13.5.3 and 13.3.2. Deformation compatibility is required with the building structure, adjacent wall systems of different construction, and windows or other components occurring within the GFRC wall system. The drift demand of the building shall be defined by the project design professional on the DSA-approved construction drawings.

2.2 Manufacturer's Engineer

The manufacturer's engineer shall be responsible for the design of the panel, panel frame, anchors, and connections of the anchors to the panel for the design criteria in Section 2.1 above. The manufacturer's engineer shall provide calculations for the following:

2.2.1 Buckling of the skin anchors.

2.2.2 Structural members in the panel frame and the skin anchors.

2.2.3 Sub-frame to support the panels.

2.3 Project Structural Engineer of Record

The structural engineer of record for the project as listed on the form *DSA 1: Application for Approval of Plans and Specifications* shall verify the adequacy of the building structural members, their connections, and the connections of the panel anchors to the structural member when subject to the torsional, vertical, and lateral loads imposed by GFRC panels as prescribed in Section 2.1 above.

The structural engineer shall also check the spacing and size of joints between panels and between structural members and panels. The joints shall be sufficient to accommodate the in-plane and out-of-plane movements of panels and provide the deformation compatibility described in Section 2.1 above.

3. APPROVAL PROCESS

The approval of GFRC for use on a specific project can be achieved by the deferred submittal process in compliance with the California Administrative Code (CAC), Section 4-317(g) when permitted by the DSA Regional Office performing plan review and construction oversight for the project. Alternately, the GFRC panels may be included with the construction documents. In this case, the review and approval of construction documents and GFRC panels will be combined.

3.1 Deferred Submittal Review and Approval

When the deferred submittal process is used, the detailed design, plan review, and approval for the GFRC system is performed after the construction contract has been awarded and a qualified GFRC manufacturer selected. The following summarizes notable aspects of the deferred submittal process for GFRC systems. If the deferred submittal process is not used, the following requirements shall be incorporated into the submission, review, and approval of the construction documents.

3.1.1 The DSA-approved construction documents shall define the complete design criteria of the GFRC system, including material properties, dimemsions, applied loads, deformation compatibility demands, support conditions, and all non-structural performance requirements.

3.1.2 The manufacturer, working in a coordinated effort with the project design professional, shall prepare the GFRC submittal package in accordance with the requirements of the DSA-approved construction documents.

3.1.3 If changes to the DSA-approved construction documents are required during the preparation of the GFRC submittal package, the project design professional shall prepare and submit a construction change document (CCD) to DSA for review in accordance with *IR A-6: Construction Change Document Submittal and Approval Process*. Depending on the nature and extent of changes, DSA may require the revised documents to be submitted and processed as a Revision. When a CCD or Revision is required, it must be approved prior to or concurrent with approval of the GFRC submittal package.

3.1.4 In accordance with *PR 18-04: Electronic Plan Review for Design Professionals of Record*, Section 5, the GFRC submittal package shall be organized into two separate electronic

files. The primary electronic file contains the approval documents including the GFRC design drawings. The second electronic file contains all supporting documents including the structural calculations and any other supporting documentation not included in the primary file.

3.1.5 The manufacturer submits the GFRC submittal package to the project design professional for review and approval. This step may take multiple exchanges between the project design professional and the manufacturer to finalize the package for submission to DSA. The design professional will submit the GFRC submittal package to DSA bearing the stamps and signatures required by Section 3.4 below.

3.1.6 DSA review of the GFRC submittal may result in plan review comments that require action by the manufacturer, the design professional, or both. The GFRC submittal shall be revised and/or additional information provided as required to resolve all plan review comments. The project design professional shall coordinate with the manufacturer and DSA as necessary to resolve plan review comments.

3.2 Project Specificaitons

MNL-128 provides useful guidelines for writing GFRC panel specifications. The following provisions shall be included in the project specifications prepared by the design professional:

3.2.1 Specify GFRC panels shall be fabricated in accordance with MNL-128, as modified below.

3.2.2 Require the manufacturer to have an established quality control program that meets the requirements of the PCI publication Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products (MNL-130).

3.2.3 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.

3.2.4 Specify mix design requirements for GFRC backing material. The cement/sand ratio shall not be less than 1:1 nor greater than 3:1.

3.2.5 Specify only alkali-resistant glass fiber specifically designed for alkali resistance and for use in concrete. Specify the minimum required amount of fiber (see Section 1 above), form of fiber (i.e., roving or chopped strands), and fiber length in accordance with MNL-128, Appendix K or American Society for Testing and Materials (ASTM) C1666:

3.2.6 Specify bonding material for panel connectors.

3.2.7 Specify strength, strain and shrinkage requirements.

3.2.8 Specify that the designs for in-service conditions be based on fully-aged strength and strain properties.

3.2.9 Specify admixtures that are permitted to be used. Admixtures containing calcium chloride shall not be used.

3.2.10 Specify the required testing procedures and apparatus, and require the test results to be reported to the architect, structural engineer, project inspector, and DSA.

3.2.11 Specify that continuous in-plant special inspection by an approved independent inspector is required; unless the plant is currently certified under the PCI Certification Program (see Section 4.4 below).

3.3 GFRC Panel Drawings

Whether processed as a deferred submittal or incorporated into the project construction drawings, drawings for GFRC panels shall include the following information:

3.3.1 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.

3.3.2 Details showing the joints between GFRC cladding elements. Joint width shall be based on panel size, structural tolerance, anticipated movement, story drift, joint materials and adjacent surfaces.

3.3.3 Details of panel anchors and connections (as defined in Glossary below) shall indicate the size of oversized or slotted holes and the required clearance between connectors and the sides of holes for erection tolerance and to accommodate the drift compatibility requirements of ASCE 7 Section 13.5.3.

3.3.4 For rectangular support tubes, indicate orientation.

3.3.5 Clearly identify the boundary and interface between GFRC panel and supporting structural members on the design drawings.

3.4 Stamps and Signatures

The manufacturer's California registered structural or civil engineer shall stamp and sign all GFRC panel drawings in accordance with *IR A-19: Design Professional's Signature and Seal (Stamp) on Construction Documents*. The project architect and/or structural engineer in general responsible charge shall provide a Statement of General Conformance in accordance with *IR A-18: Use of Construction Documents Prepared by Other Professionals*.

4. PLANT FABRICATION AND QUALITY CONTROL

The requirements of this section shall apply to all GFRC panels regardless of the fabrication process (spray-up or premix).

4.1 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 form *DSA-103: List of Required Structural Tests and Special Inspections* for the work, clearly indicating testing and inspection requirements.

4.2 Manufacturer

GFRC panels shall be fabricated in accordance with the provisions of MNL-128. The manufacturer shall have an established quality control program which meets the requirements of MNL-130, 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.

The manufacturer shall also complete and submit a form *DSA 6-C: Contractor Verified Report* per CAC Section 4-343(c).

4.3 Testing Requirements

4.3.1 If any structural material tests are required, such as for unidentifiable steel, testing must be performed by a testing laboratory employed by the school district and qualified by the DSA Lab Evaluation and Acceptance (LEA) program. LEA accepted test laboratories are listed on the

DSA website. All test reports and verified reports shall be submitted by the laboratory in accordance with *PR 13-01: Construction Oversight Process.*

4.3.2 Skin Anchor Pull-off and Shear Tests shall be conducted in accordance with the requirements of Appendix H of MNL-130 and ASTM C1230. Acceptance shall be based on compliance with the criteria in MNL-130, Division 5, Section 5.2.5. Test reports shall be submitted to the project inspector and the project's LEA testing laboratory.

4.3.3 The testing program for GFRC fabricated by the premix process may be modified as it applies to specific panels.

4.4 Special Inspection (Shop)

The manufacturing of GFRC panels shall be continuously inspected by a DSA-approved special inspector. The special inspector shall provide detailed daily special inspection reports in accordance with *IR 17-12: Special Inspection Reporting Requirements* and verified reports in accordance with PR 13-01. All panels shall be marked with the approved special inspector's identification mark, and a list of approved panels shall be provided to the project inspector and DSA.

Exception: Continuous special inspection 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 their verified report. In addition, any work identified in Section 4.5 below that is performed in the shop, rather than the field, is **not** exempt from special inspection requirements.

4.5 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 in accordance with IR 17-12 and verified reports in accordance with PR 13-01.

REFERENCES:

2019 California Code of Regulations (CCR) Title 24
Part 1: California Administrative Code (CAC), Section 4-335
Part 2: California Building Code (CBC), Section 1903A.2 and 1903A.3

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GLOSSARY

Connection

The welding and bolts used to attach the skin to the panel frame or the panel frame to the building structure.

Panel

The entire cladding component, including 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

GFRC portion of the panel.

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 MNL-128. The strength of skin anchors shall be determined in accordance with MNL-128, Section 5.7.2.3, and tested per Section 4.3.2 above.