SPECIFICATION FOR GLASS-FIBER-REINFORCED CONCRETE PANELS

A PCI Standard

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FOREWORD

This specification provides minimum requirements for the design, manufacture, and installation of glass-fiber-reinforced concrete (GFRC) panels. The primary emphasis is on thin-walled alkali-resistant (AR) GFRC architectural cladding panels with a steel-frame support structure made by the spray-up process in controlled factory conditions.

This specification also includes minimum requirements for GFRC panels manufactured using the premix process in controlled factory conditions.

The potential of using GFRC systems was recognized during the developmental work on glass-fiber-reinforced plastics carried out in the 1940s. Early experience indicated that portland cement composites made with unprotected E-glass fiber (conventional glass-fiber reinforcement used in plastics) were subject to alkaline attack. Because of this fact, a special AR glass-fiber product was developed.

Following the successful development of AR glass fibers in the late 1960s, test programs were undertaken to determine the properties of portland cement and AR glass-fiber composites. AR glass fibers have been used in GFRC panels in the United States since the early 1970s.

The PCI GFRC Certification Committee developed this specification. The PCI GFRC Certification Committee Task Group working on this document were:

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PREFACE

This standard was developed following the protocols required by the PCI Group Operations Manual. The provisions were balloted in the PCI Glass Fiber Reinforced Concrete Panels Committee. Review and comments by the PCI Technical Activities Council (TAC) followed and resulted in substantive changes to the document. These changes were returned to TAC and accepted. The document was then submitted to the PCI Standards Committee, where additional review and balloting took place. The membership of that committee is balanced according to the accreditation rules of the American National Standards Institute (ANSI). In addition, a public review period was provided, and public comments were resolved through the PCI Standards Committee. The entire process is a consensus process involving PCI members, nonmembers of PCI, and the general public.

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1.0 General

1.1 Scope

This specification provides minimum requirements for the design, manufacture, and installation of glass-fiber-reinforced concrete (GFRC) panels, fabricated with or without panel frames, using the spray-up process or the premix process. Energy considerations for the design of enclosure systems are excluded from this scope.

1.2 Definitions

Admixture — A material other than water, aggregate, or hydraulic cement, used as an ingredient of concrete and added to concrete before or during its mixing to modify its properties.

Air permeability — The rate of air flow through a material; commonly expressed in perm-inches.

Alkali-resistant (AR) glass fiber — Fiber conforming to ASTM C1666.

Anchor, flex — Device connecting GFRC skin to panel frame to resist tensile or compressive forces and detailed to allow in-plane movement with minimal restraint force development.

Anchor, gravity — Device to transfer GFRC skin weight to panel frame.

Anchor, seismic — Device connecting GFRC skin to panel frame to resist in-plane seismic forces.

Backing — The GFRC deposited into the mold after the face mixture or veneer has been placed and consolidated.

Bond breaker — With specific reference to GFRC, a substance placed to prevent bonding between a face material such as natural stone and the GFRC backing.

Bonding agent — With specific reference to GFRC, a substance used to increase the bond between hardened GFRC and a subsequent application of GFRC, such as a patch.

Bonding pad — A thickened area of GFRC that covers the foot of a flex, gravity, or seismic anchor.

Boss — With specific reference to GFRC, a thickened area of backing into which an insert can be embedded.

Chopped glass — Noncontinuous multifilament glass-fiber strands.

Compaction — With specific reference to GFRC**,** the process of reducing the volume of voids in the face mixture and GFRC backing by vibrating, tamping, rolling, or some combination of these.

Connection — Assembly including anchors, inserts, kerfs, and/or hardware for the attachment of GFRC panels, with or without a frame, to each other or to the building structure.

Creep — The time-dependent increase in deformation caused by a sustained load.

Curing — Action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic cement hydration and (if applicable) pozzolanic reactions to occur so that the properties of the mixture may develop.

Dunnage — Materials used for temporary support during storage and transportation.

Facing – A layer of mortar or concrete greater than 1/8 in. (3 mm) nominal thickness at the exposed face of GFRC.

Fiber — An individual alkali-resistant glass filament with a length-to-diameter ratio of at least 20:1.

Fiber content — The ratio, usually expressed as a percentage, of glass fiber to total composite; can be by weight or by volume.

General building code – governing building code adopted by jurisdiction local to project.

Insert — A connecting device or handling device cast into a GFRC panel.

Kerf — A slot sawn or cast into GFRC to receive connection hardware.

Mist coat — A thin (1/8 in. [3 mm] nominal) coat of cement/sand slurry of a composition similar to the GFRC backing mixture, but without glass fiber. It may be the exposed face of a GFRC panel.

Mold — The container or surface against which fresh GFRC is deposited to give it a desired shape.

Overspray GFRC — GFRC material that is sprayed outside the confines of the mold.

Panel — The entire prefabricated GFRC unit.

Panel frame — Plant-attached steel frame used to support and stiffen the skin and provide a means for connecting to the building frame.

Polymer admixture — An emulsion of an alkali-resistant synthetic thermoplastic in water obtained by polymerization and used as a curing admixture.

Premix — A process of mixing cement, sand, prechopped AR glass fiber, admixtures, and water into a mortar for subsequent placement by spraying, casting with vibration, press-molding, extruding, or slipforming.

Rib — (1) A stiffening member backing the skin. (2) A projection from the panel face.

Sealant — Compressible material used to exclude water and solid foreign materials from joints.

Sealer — Clear chemical compound applied to the surface for the purpose of reducing water absorption or improving weathering qualities.

Sizing — Coating materials applied to the glass fibers during manufacture to facilitate and/or improve the processing and performance of the fiber.

Skin — The thin exterior section of a panel, including the face mixture/veneer finish and GFRC backing, but excluding ribs, bosses, panel frame, etc.

Slurry — A mixture of water, portland cement, sand, and other additions or admixtures in suspension.

Spray-up process — The simultaneous chopping and spraying of glass fibers and spraying of slurry onto a mold, followed by appropriate compaction.

Strand — A number of individual continuous fibers bound together by sizing. Typical alkali-resistant glass-fiber strands contain 102, 204, or 408 fibers.

Tolerance — Specified permissible variation from stated requirements, such as dimensions and strength.

Volume change — An increase or decrease in volume of the skin. It includes initial drying shrinkage, moisture-induced movement, thermal movement, and creep.

1.3 Notation

f'_n = nominal value of maximum stress, not adjusted by shape factors, allowed in design

f_{nm} = nominal value of maximum flexural stress, adjusted by shape factors, allowed in design

f_{nn} = nominal value of maximum direct tensile stress allowed in design

f_{nv} = nominal value of maximum shear stress allowed in design

f_{ur} = average 28-day test values of flexural ultimate stress

f_{yr} = average 28-day test values of flexural yield stress

S'_n = 28-day anchor or bonding pad test strength in tension or shear

S_n = nominal anchor design strength

s = shape factor, to account for stress redistribution in different cross sections:

Single skin: s = 1.0

Box section: s = 0.5

t = Student's t, a 99%, one sided distribution statistical value to account for data scatter

ϕ = strength reduction factor

σ_c = standard deviation of anchor, insert, or kerf test values

σ_u = standard deviation of 28-day test values of flexural ultimate stress

σ_y = standard deviation of 28-day test values of flexural yield stress

1.4 Reference standards and other referenced documents

Referenced documents identified by am asterisk (*) are not consensus standards; rather they are documents developed within the precast/prestressed concrete industry that represent acceptable procedures for design and construction to the extent referred to in the specified section.

ASTM International

A29/A29M-16	*Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought*
A36/A36M-14	*Standard Specification for Carbon Structural Steel*
A108-13	*Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished*
A153/A153M-16a	*Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*
A500/A500M-18	*Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes*
A513/A513M-15	*Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing*
A572/A572M-18	*Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel*
A653/A653M-17	*Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*
A924/A924M-17a	*Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process*
A1003/A1003M-15	*Standard Specification for Steel Sheet, Carbon, Metallic- and Nonmetallic-Coated for Cold-Formed Framing Members*

B633-15	*Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel*
B766-86(2015)	*Standard Specification for Electrodeposited Coatings of Cadmium*
C33/C33M-18	*Standard Specification for Concrete Aggregates*
C138/C138M-17a	*Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete*
C144-17	*Standard Specification for Aggregate for Masonry Mortar*
C150/C150M-18	*Standard Specification for Portland Cement*
C260/C260M-10a(2016)	*Standard Specification for Air-Entraining Admixtures for Concrete*
C494/C494-17	*Standard Specification for Chemical Admixtures for Concrete*
C618-17a	*Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete*
C947-03(2016)	*Standard Test Method for Flexural Properties of Thin-Section Glass-Fiber-Reinforced Concrete (Using Simple Beam with Third-Point Loading)*
C979/C979M-16	*Standard Specification for Pigments for Integrally Colored Concrete*
C1077-17	*Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation*
C1230-96(2015)	*Standard Test Method for Performing Tension Tests on Glass-Fiber Reinforced Concrete (GFRC) Bonding Pads*
C1602/C1602M-12	*Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete*
C1666/C1666M-08(2015)	*Standard Specification for Alkali Resistant (AR) Glass Fiber for GFRC and Fiber-Reinforced Concrete and Cement*
G155-13	*Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials*

American Welding Society

D1.1/D1.1M:2015	*Structural Welding Code – Steel*
D1.3/D1.3M:2018	*Structural Welding Code – Sheet Steel*
D1.4/D1.4M:2011	*Structural Welding Code – Reinforcing Steel*

American Iron and Steel Institute

S100-16	*North American Specification for the Design of Cold-Formed Steel Structural Members*
S240-15	*North American Standard for Cold-Formed Steel Structural Framing*

American Institute of Steel Construction

ANSI/AISC 360-16	*Specification for Structural Steel Buildings*

International Accreditation Service, Inc

*AC 157	*Accreditation Criteria for Fabricator Inpsection Programs for Reinforced and Precast/Prestressed Concrete*

Precast/Prestressed Concrete Institute

*MNL 130-09	*Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products* Cited in: Sections 3.5.3; 4.1.1; 5.1.1; 5.1.2 and 7.4.1
*MNL 135-00	*Tolerance Manual for Precast and Prestressed Concrete Construction* Cited in: Sections 4.1.3 and 6.1.4

2.0 Materials

2.1 General

2.1.1 Materials shall conform to the requirements of this chapter. Materials not included in this specification are permitted only with approval of the engineer and architect of record and when acceptable evidence of satisfactory short- and long-term performance is provided.

2.2 Facing and backing

2.2.1 Cement

2.2.1.1 Portland cements shall conform to ASTM C150.

2.2.2 Facing materials

2.2.2.1 Compatibility of facing and backing shall be considered when developing mixture proportions.

2.2.2.2 Where fine and coarse aggregates are used for exposed finishes, they shall be clean, hard, strong, durable, inert, and free of staining or deleterious material.

2.2.2.3 Aggregates shall conform to ASTM C33, except for gradation.

2.2.2.4 Aggregates shall be nonreactive with cement.

2.2.2.5 A bond breaker with flexible mechanical anchors shall be used with natural stone veneer.

2.2.3 Sand for backing

2.2.3.1 Sands shall be washed and dried silica sand, be free of contaminants and lumps, and shall conform to ASTM C144, except for gradation.

2.2.4 Mixing water

2.2.4.1 Mixing water shall be free from deleterious matter that may interfere with the color, setting, or strength of the facing and backing and shall conform to ASTM C1602.

2.2.5 Admixtures and curing agents

2.2.5.1 Admixtures shall conform to ASTM C494, Types A through G. Chloride ion content shall be limited to 0.10% by weight of admixture.

2.2.5.2 Fly ash or other pozzolans used as supplemental cementitious materials shall conform to ASTM C618.

2.2.5.3 Air-entraining admixtures shall conform to ASTM C260.

2.2.5.4 Pigments shall conform to ASTM C979.

2.2.5.5 Set accelerators containing calcium chloride shall not be used.

2.2.5.6 A GFRC mixture cured using a polymer admixture shall have a unit weight, determined in accordance with ASTM C138, not less than 120 lb/ft^3 (1900 kg/m^3) and shall demonstrate conformance to (a) and (b) through testing by a laboratory complying with ASTM C1077.

(a) Flexural properties not less than those of a seven-day moist-cured GFRC mixture tested at 7 and 28 days in accordance with ASTM C947

(b) Ultraviolet resistance not less than that of a seven-day moist-cured GFRC mixture tested in accordance with ASTM G155

2.3 Reinforcement

2.3.1 Alkali-resistant glass fiber

2.3.1.1 Glass fibers shall conform to ASTM C1666.

2.3.1.2 Fiber content in spray-up mixtures shall be 5% by weight with a tolerance of -½% and +1%.

2.4 Panel frame and hardware

2.4.1 Panel frame

2.4.1.1 Cold-formed steel shall conform to ASTM A1003 with a minimum thickness of 0.0598 in. (1.52 mm) (16 gauge).

2.4.1.2 Cold-formed steel shall be galvanized in accordance with ASTM A653 or A924, or painted.

2.4.1.3 Thickness (gauge), yield strength, and size of studs, tubes, and tracks shall be shown on the GFRC shop drawings or calculations as approved by the owner's representative.

2.4.1.4 Structural steel tubes shall conform to ASTM A500, Grade B, or ASTM A513. Other structural shapes shall conform to ASTM A36 or A572.

2.4.2 Anchors and inserts

2.4.2.1 Steel for anchors shall conform to the requirements of ASTM A29 or A108.

2.4.2.2 Anchors shall be corrosion-resistant using (a), (b), or (c).

(a) Hot-dip zinc coating in accordance with ASTM A153

(b) Electrodeposited cadmium coating in accordance with ASTM B766

(c) Electrodeposited zinc coating in accordance with ASTM B633

2.4.2.3 Inserts shall be isolated from dissimilar metals or metal coatings.

2.4.3 Connection hardware

2.4.3.1 Miscellaneous structural shapes shall be fabricated from steel conforming to ASTM A36. Structural steel tubes shall conform to ASTM A500, Grade B, or ASTM A513.

2.4.3.2 Cold-formed steel shall conform to ASTM A1003.

2.4.3.3 Cold-formed steel shall be galvanized in accordance with ASTM A653 or A924, or painted.

2.5 Welding

2.5.1 Welding electrodes shall conform to the requirements of AWS D1.1, D1.3, and D1.4, as applicable.

2.5.2 Welding electrodes shall match the base metal, except if electrodes with lower strength than matching electrodes are allowed by design.

2.6 Coatings

2.6.1 Coatings, if specified by the owner's representative, shall be water-vapor permeable, and bulk-water impermeable.

2.6.2 Coatings shall be applied in accordance with coating manufacturer's instructions.

3.0 Design

3.1 General

3.1.1 Design loads shall be resisted only by the GFRC backing.

3.1.2 Mist coats, facings, or veneers shall not be considered in strength determination and shall not be included in test specimens.

3.1.3 The skin and panel frame shall not be designed as a composite system.

3.1.4 Determination of properties used in design shall be based on tests for each mixture used.

3.1.4.1 Any departure from established materials and proportions shall require a new series of tests.

3.2 Design loads

3.2.1 Loads specified by the general building code shall be considered as minimum requirements.

3.2.2 Design loads shall include the following:

3.2.2.1 Gravity load including self-weight of panels.

3.2.2.2 Wind load.

3.2.2.3 Earthquake forces.

3.2.2.4 Restrained volume-change effects induced by thermal and moisture changes and initial drying shrinkage.

3.2.2.4.1 Skins with facing and backing shall be tested and evaluated for different volume-change properties of the facing and backing.

3.2.3 Load combinations shall be as prescribed by the general building code.

3.2.4 Skin, panel frame, and lifting device design shall include consideration of loads imposed during handling, shipping, and installation.

3.3 Skin design

3.3.1 The nominal GFRC backing thickness shall be a minimum of ½ in. (13 mm).

3.3.2 Panels subject to out-of-plane bending shall be analyzed as a continuous one-way beam or as a two-way system, as appropriate, based on the spacing and pattern of flex anchors.

3.3.3 Average flexural yield and flexural ultimate strength test values shall be based on a minimum of 20 sets of tests. Each set shall consist of six specimens, half of which shall be tested with the mold side in tension and half of which shall be tested with the mold side in compression. All tests shall be conducted in accordance with ASTM C947.

3.3.4 Flexural stress due to factored loads shall not exceed:

$$\phi f_{nm} = \phi\, s\, f'_n \qquad \text{(Eq. 3-1)}$$

where

$\phi = 0.75$

f'_n is the least of (a), (b), and (c):

(a) $f_{yr}\,(1 - t\sigma_y/f_{yr})$ (Eq. 3-2)

(b) $0.4 f_{ur}\,(1 - t\sigma_u/f_{ur})$ (Eq. 3-3)

(c) 1000 psi (6895 kPa)

where

t = 2.5 for the minimum number of 20 tests of six specimens each, as specified in **3.3.3**. If the number of tests is greater than specified in **3.3.3**, t shall be permitted to be determined using a 99% one-sided t-distribution of the test results.

3.3.5 Tensile stress and shear stress due to factored load or differential volume-change properties shall not exceed:

$$\phi f_{nn} = \phi f_{nv} = 0.4\phi\, f'_n \qquad \text{(Eq. 3-4)}$$

where

$\phi = 0.75$

3.3.6 Calculation of skin stresses due to anchor restraint shall be based on the expected yield strength of the anchor steel and shall not be less than 1.5 times the specified yield strength.

3.3.6.1 A load combination including wind, volume change due to differential properties of facing and backing, and volume-change restraint due to anchor stiffness shall be included with a load factor of 1.0 on wind and a load factor of 1.2 on volume-change effects.

3.4 Panel frame design

3.4.1 Cold-formed steel frames shall be designed in accordance with AISI S100 and S240.

3.4.1.1 Local effects at anchors and connections shall be accommodated in the design of cold-formed frame members.

3.4.1.2 Weak axis strength and stiffness shall be provided for the transfer of in-plane seismic forces.

3.4.2 Structural steel shapes in panel frames shall be designed in accordance with ANSI/AISC 360.

3.4.3 Panel frames shall be designed to transmit forces from skin anchors to building connections with sufficient stiffness to prevent distress in the skin.

3.5 Connection, anchor, and insert design

3.5.1 Anchors and inserts embedded in GFRC and kerfs cast or cut into GFRC shall be tested to determine tensile and/or shear strength.

3.5.2 A minimum of 20 specimens shall be tested for each type of anchor, insert, or kerf.

3.5.3 Anchor and bonding pad tests shall be performed in accordance with PCI MNL-130.

3.5.4 Factored load on anchors, inserts, and kerfs shall not exceed:

$$\phi S_n = \phi\, S'_n\,(1 - t\,\sigma_c / S'_n) \qquad \text{(Eq. 3-5)}$$

where
$\phi = 0.65$
t = 2.5 for the minimum number of 20 tests, as specified in **3.5.2**. If the number of tests is greater than specified in **3.5.2**, t shall be permitted to be determined using a 99% one-sided t-distribution of the test results.

3.5.5 Arrangement of anchors from the skin to the panel frame shall minimize restraint of the in-plane volume-change movements of the skin considering the direction of stiffness and the direction of flexing of all anchors.

3.5.6 Flex anchors shall be of sufficient stiffness and strength to resist design loads without lateral buckling.

3.5.7 Gravity anchors shall be of sufficient stiffness and strength to support the weight of the skin without lateral buckling.

3.5.8 Seismic anchors shall be of sufficient stiffness and strength to resist in-plane seismic forces without lateral buckling.

3.5.9 Inserts shall be embedded in GFRC bosses or bonding pads.

3.5.10 Arrangement of inserts shall minimize restraint of the in-plane volume-change movements.

3.5.11 Overspray GFRC shall not be used to encapsulate inserts.

3.5.12 Miscellaneous structural shapes used as hardware in connections shall be designed in accordance with ANSI/AISC 360.

3.5.13 Cold-formed steel used as hardware in connections shall be designed in accordance with AISI S240.

3.6 Joints

3.6.1 Joint width and depth shall be determined based on the joint sealant considering panel size, tolerances, anticipated in-plane movements, and story drift.

4.0 Manufacturing

4.1 GFRC panel manufacture

4.1.1 Manufacturing, facilities, and quality control procedures shall comply with PCI MNL 130.

4.1.2 The GFRC manufacturing plant shall be certified at the time of bidding, production, and installation in product group G by the PCI Plant Certification Program or in accordance with AC157 by the IAS Fabricator Inspection Accreditation Program.

4.1.3 Panels shall be fabricated within tolerances specified in PCI MNL 135.

4.2 Molds

4.2.1 Molds shall conform to the profiles and dimensions given in the approved shop drawings.

4.3 Proportioning

4.3.1 Backing and facing mixtures shall be proportioned to establish properties used for design in accordance with (a) or (b).

(a) Trial mixtures
(b) Field experience

4.3.2 The backing mixture shall be proportioned considering (a) through (f).

(a) Fiber content
(b) Fiber length
(c) Cementitious materials–sand ratio
(d) Water–cementitious materials ratio
(e) Polymer curing admixture content (if used)
(f) Other admixture content

4.3. 3 Facing mixture shall be proportioned to achieve (a) through (h).

(a) Volume-change compatibility with GFRC backing mixture
(b) Required compressive strength
(c) Maximum water absorption
(d) Required entrained air content
(e) Maximum aggregate size
(f) Required cementitious materials–sand ratio
(g) Required water–cementitious materials ratio
(h) Required color and appearance

4.4 Mist coat

4.4.1 A mist coat, if used, shall be thick enough to cover mold surfaces and details and provide cover for the glass fibers in the GFRC backing.

4.5 Placement of facing

4.5.1 Facing mixtures shall be placed and compacted to the required thickness.

4.6 Spray-up of backing

4.6.1 The backing shall be placed before drying or initial set of the mist coat or face mixture.

4.6.2 The placement shall be by simultaneous depositing of glass fibers and slurry by spraying onto a mold followed by compaction.

4.6.3 The thickness shall be equal to or greater than ½ in. (13 mm) or the design thickness, whichever is greater.

4.7 Panel frame

4.7.1 Welding of panel frame members shall be in accordance AWS D1.1 for structural steel and AWS D1.3 for sheet steel.

4.7.2 The panel frame shall be set into place before the backing reaches initial set.

4.7.3 Anchors shall be connected to the skin using bonding pads.

4.7.4 The panel frame and the flex anchors shall not protrude into the thickness of the backing.

4.7.5 A bonding pad shall be placed over each anchor foot and made integral with the fresh backing.

4.7.6 Bonding pad installation procedures shall be the same as those used in tests to determine bonding pad design values.

4.8 Curing

4.8.1 Polymer admixture curing

4.8.1.1 GFRC backing temperature shall be maintained between 60 (16℃) and 120℉ (50℃) for 12 to 16 hours.

4.8.2 Moist curing

4.8.2.1 As soon as practicable after panel frame installation or the completion of spray-up operations in the absence of a panel frame, the panel shall be covered and cured for 12 to 16 hours. During this time the temperature of the GFRC shall be maintained between 50°F (10°C) and 158°F (70°C).

4.8.2.2 After curing in accordance with **4.8.2.1**, the panel shall be removed from the mold and placed in a controlled curing environment at a temperature above 50°F (10°C) and a minimum of 95% relative humidity for a period of seven days.

5.0 Quality control

5.1 General

5.1.1 Each GFRC manufacturer shall implement a quality control program that conforms to PCI MNL 130.

5.1.2 The quality control program shall include inspections and tests in accordance with the requirements of PCI MNL 130.

5.1.3 Each GFRC panel shall be identified with a piece mark that can be traced to the production drawings, erection drawings, testing records, and date produced.

5.1.4 A system of records as evidence of proper manufacture and conformance with plant standards and project specifications shall be maintained.

6.0 Installation

6.1 General

6.1.1 Installation shall be in accordance with the erection drawings.

6.1.2 Field modifications to the panel frame system shall be made only with the approval of the panel manufacturer and the engineer responsible for the design.

6.1.3 Field checks shall be performed to verify that installation is in accordance with the erection drawings.

6.1.4 Panels shall be installed within tolerances specified in PCI MNL 135.

6.2 Connections

6.2.1 Temporary connections shall not transfer unintended loads to panels already installed.

6.2.2 Welding of connections shall be in accordance AWS D1.1 for structural steel and AWS D1.3 for sheet steel.

6.2.3 Welding shall be performed in accordance with the erection drawings and performed by welders certified in accordance with AWS D1.1 or AWS D1.3.

6.2.4 Galvanized components shall be touched up after cutting or welding with a rust-inhibitive or zinc-rich paint.

6.2.5 Field modifications shall be made only with the approval of the panel manufacturer and the engineer responsible for the design.

7.0 Premix GFRC

7.1 General

7.1.1 Chapters 1 through 6 shall apply to premix GFRC unless modified by this chapter.

7.1.2 Premix GFRC products shall contain 3% alkali-resistant glass fiber by weight of the total mixture with a tolerance of ±½%.

7.2 Design

7.2.1 Flexural stress due to factored loads shall not exceed:

$\phi f_{nm} = \phi\, s\, f'_n$ (Eq. 7-1)

where

$\phi = 0.75$

f'_n is the least of (a), (b), and (c):

(a) $f_{yr}\,(1 - t\sigma_y/f_{yr})$ (Eq. 7-2)

(b) $0.4 f_{ur}\,(1 - t\sigma_u/f_{ur})$ (Eq. 7-3)

(c) 600 psi (4140 kPa)

where

t = 2.5 for the minimum number of 20 tests of six specimens each, as specified in **3.3.3**. If the number of tests is greater than specified in **3.3.3**, *t* shall be permitted to be determined using a 99% one-sided *t*-distribution of the test results.

7.3 Manufacturing

7.3.1 Mixing equipment shall be appropriate for premix GFRC.

7.3.2 The mixture shall be designed to avoid separation of the mixture components during delivery and placement.

7.3.3 Placing and casting procedures shall maintain a random glass fiber orientation in the premix.

7.3.4 If premix is sprayed onto the mold, the material shall be placed and compacted in layers not exceeding ¼ in. (6 mm).

7.4 Quality control

7.4.1 Premix glass content shall be verified by washout tests in conformance with PCI MNL 130.