GFRC

Glass Fiber Reinforced Concrete

Specification & Details

Prepared By: Petra Design Inc.

PETRA™

ARCHITECTURAL MOLDED COMPOSITES

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1.0 About Us

Petra Design, where architectural excellence meets a legacy of over **25 years** in delivering premium GFRC, FRP and Precast architectural products. We take pride in supplying a diverse range of solutions to both commercial and residential projects across North America.

At Petra Design, our extensive product line includes but is not limited to exterior cladding solutions, columns, cornices, door surrounds, sills, porticos, domes, balustrades, and more. Whether you're an architect, interior designer, contractor, builder, or homeowner, we collaborate with you on new

constructions and renovations, ensuring your project receives the highest quality and aesthetic appeal.

1.1 Engineering Excellence

Following an extensive and thorough research effort spanning the past few years, Petra Designs has successfully developed highly refined **Ultra-High-Performance Concrete** (UHPC) and **Glass Fiber Reinforced Concrete** (GFRC) mix designs, each branded differently. These formulations are crafted to be easily customizable, catering to the specific requirements outlined by architects and engineers.

1.2 Quality Assurance

Petra Design engineers benefit from a substantial database of material properties and comprehensive full-scale tests, offering a robust reference point for the creation of new systems. Our Petra team maintains ongoing communication with leading universities and researchers globally, integrating cutting-edge design knowledge into our projects. Many of our engineers have firsthand experience as shop or site engineers, ensuring that the designs not only showcase innovation but are also practical for efficient manufacturing and installation. This collaborative approach, with knowledge shared across the five main domains in which Petra operates, translates into a significant productivity advantage, enhancing the overall effectiveness of design and implementation processes at Petra Design.

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1.0 Scope

A. This section applies to Glass-fibre Reinforced Concrete (GFRC) intended for use in precast components. The work performed under this section includes all labour, material, equipment, related services, and supervision required for the manufacture of the precast GFRC work shown on the contract drawings.
B. GFRC Manufacturer: Petra Design Inc.
C. Location: 47 St. Regis Crescent, Toronto, ON, M3J 1Y6

1.1 Service expectations

A. The manufacturer will be solely responsible for design, mould fabrication, manufacturing, and delivery of GFRC panels.

B. Where required, the manufacturer will provide stamped drawings and calculations from a PE in the Province or State of the Manufacturer. Should the project be located in a different jurisdiction, it is the responsibility of the buyer to bear the cost of PE approval in that jurisdiction.

C. Panels will be cast to custom sizes to reduce waste, based on shop drawings by Petra Design, approved by the buyer and their client & site measurements provided by the Installer.

D. The manufacturer must be able to provide smooth, sand blasted, acid washed, and exposed aggregate finishes of a variety of degrees.

E. The manufacturer must be able to provide a variety of colours to meet design requirements.

F. The manufacturer will coordinate the shipping of panels to site with the Installer. Material should be checked by the site supervisor on receipt at site and the manufacturer should be informed in writing within a reasonable time of any deficiencies.

G. Cost of Packaging and Freight should be included with the quotation.

2.0 Terms and Definitions

The below definitions apply to terms in this section.

1. **Aggregate/cement ratio**

   The ratio of the mass of total dry aggregate to the mass of dry cement in the GFRC.

2. **Alkali resistant glass fibre**

   Alkali resistant glass fibres, or AR glass fibres, are glass fibres suitable for use in concrete which have a high alkali resistance (AR) as they have a minimum zirconium dioxide (ZrO_2) content of 16%.

3. **Concentric GFRC Spray gun**

A GFRC spray gun whereby both the AR glass fibres and the cementitious slurry are emitted from one nozzle and sprayed on to the mould. The Concentric GFRC Spray gun will have the capability to cut the glass-fibre to a range of different lengths from approximately 6 mm to over 40 mm.

4. **Dry curing**

   A method of curing which prevents early loss of moisture and allows curing to take place without keeping the GFRC damp. Dry curing is carried out by adding an appropriate quantity of the polymer into the GFRC mix.

5. **Face coat**

   An initial layer without fibres but containing decorative sands or aggregates and / or pigments.

6. **Glass fibre content by weight (WF)**

   The ratio (expressed as a percentage) of the mass of AR glass fibre to the mass of GFRC in the

   Uncured [wet mix] state.

7. **High shear mixer**

   A mixer with a high shear action capable of the preparation of the fine sand/cement slurries required for the spray process.

8. **Mist coat**

   An initial cementitious sprayed coating without glass fibres.

9. **Polymer-modified GFRC**

   GFRC which has been modified by the addition of an aqueous acrylic thermoplastic co-polymer dispersion for “dry curing” and property enhancement.

10. **Premix GFRC**

    A method of manufacture in which the pre-cut AR glass fibres and the cementitious slurry are blended during mixing.

11. **Premix GFRC mixer**

    A two-stage mixer which has the capability to mix the base cement/sand slurry at a high speed with a high shear mixing action and then to blend in the cut AR glass fibres with a slower, low shear mixing action.

12. Simultaneous sprayed GFRC

A method of manufacture in which a GFRC product is produced by simultaneously spraying the cementitious slurry and the AR glass fibre, which is chopped from a roving via a cutter mechanism inside a Concentric GFRC Spray gun to the length required. Both cementitious slurry and the chopped AR glass fibres are emitted from the same nozzle.

13. Slump test

A test for checking the consistency of the cementitious slurry.

14. Sprayed GFRC

A method of manufacture in which a GFRC product is produced by spraying the cementitious slurry and the AR glass fibre mix with a GFRC Spray gun.

15. Structural Engineer

The person or authority responsible for the structural design of the GFRC component. A Structural Engineer must hold formal qualifications, e.g. degree, chartered, licensed, certified etc.

16. Supplier

In respect to this Specification refers to the person or authority entering a contract to supply goods and/or raw materials to the Producer.

17. Test board

A sheet of GFRC manufactured during production for the purpose of assessing the quality of the GFRC products being made. The test board shall be made in the same way and from the same mix as the GFRC products so that it is representative of the quality of the GFRC incorporated in the products.

18. 'Wash out' test

A method for the determination of glass fibre content of Uncured GFRC.

19. Water/cement ratio

The ratio of the mass of total water to the mass of dry cement in the GFRC in the Uncured state. When pozzolanic fillers are used they can be considered as cementitious and the water/cement ratio can be expressed as a water/total binder ratio; examples of such pozzolanic fillers are fly ash, silica fume and metakaolin.

3.0 Materials

A. **Hydraulic cement:** CSA A3001, ASTM C150 or ASTM C595
B. **Metakaolin:** ASTM C618, Class N.
C. **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.
D. **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.

E. **Facing Aggregate:**
   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 samples.
   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.

F. **Colouring Admixture:** ASTM C979, synthetic mineral-oxide pigments or coloured water-reducing admixtures, temperature stable, nonfading, and alkali resistant.
G. **Water:** Potable; free from deleterious material that may affect colour stability, setting, or strength of GFRC and complying with chemical limits of PCI MNL 130.

H. **Polymer Curing Admixture:** Acrylic thermoplastic copolymer dispersion complying with PCI MNL 130.

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

J. **Water-reducing admixture:** ASTM C494/C494M, Type A and F

4.0 ANCHORS,CONNECTORS, & MISCELLANEOUS MATERIALS

The Structure engineer should specify the type of Anchors and connectors, any modified anchoring should be reviewed before starting of the production.

A. **Carbon-Steel Shapes and Plates:** ASTM A36/A36M. Finish steel shapes and plates less than 3/16 inch (4.76 mm) thick as follows:

1. Finish: Zinc coated by [hot-dip process according to ASTM A123/A123M, after fabrication, or ASTM A153/A153M, as applicable] [electrodeposition according to ASTM B633, SC3]. Or
2. Finish: Shop primed with MPI 79 paint on surfaces prepared to comply with SSPC-SP2, "Hand Tool Cleaning," or better.

B. Anchors and Inserts: Steel for anchors shall conform to the appropriate requirements of ASTM A29 or A108 with a minimum diameter of ¼-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 ASTMB633, SC3] [electrodeposited cadmium according to ASTM B 766, Type II, Class 25.]

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

1. Finish: Zinc coated by [hot-dip process according to ASTM A123/A123M, after fabrication, or ASTM A153/A153M, as applicable] [electrodeposition according to ASTM B633, SC3]. or
2. Finish: Shop primed with MPI 79 paint on surfaces prepared to comply with SSPC-SP2, "Hand Tool Cleaning," or better.

D. Bolts: ASTM A307 or ASTM A325 (ASTM F568M or ASTMA325M).

4.1 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:

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.
2. Painted, Non-Metallic-Coated Steel Sheet: ASTM A1011/A1011M hot rolled or ASTM A1008/A1008M cold rolled; non-metallic coated according to ASTM A1003/A1003M; of grade required by structural performance of framing.

B. Hollow Structural Sections: Steel tubing, ASTM A500, Grade B, or ASTM A513. Finish hollow structural sections with wall thickness less than 3/16 inch (4.76 mm) as follows:

1. Organic Zinc-Rich Primer: SSPC-Paint 20 on surfaces prepared to comply with SSPC-SP6/NACE No. 3, "Commercial Blast Cleaning."
2. 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:

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.

5.0 GFRC MIXES

A. Backing Mix: Proportion backing mix of Portland cement, glass-fibres, sand, and admixtures to comply with design requirements. Provide nominal glass-fibre 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.

C. Mist Coat Mix: Portland cement, sand slurry, and admixtures, of same proportions as backing mix without glass fibres.

D. Polymer Curing Admixture: 6 to 7 percent by weight of polymer-curing admixture solids to dry Portland cement.

E. Air Content: 8 to 10 percent; ASTM C185. (Only mix without polymer curing admixture)

F. Colouring Admixture: Not to exceed 10 percent of cement weight.

6.0 MOLD FABRICATION

A. Construct moulds that will result in finished GFRC complying with profiles, dimensions, and tolerances indicated, without damaging GFRC during stripping. Construct moulds to prevent water leakage and loss of cement paste.

1. Coat contact surfaces of moulds with form-release agent.
2. Coat contact surfaces of moulds with surface retarder where required. (Only use for exposed aggregate finish.

B. Place form liners (According to specific project requirements) 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.

6.1 PRODUCTION OF GFRC

A. Proportioning and Mixing: For backing mix, meter sand/cement slurry and glass fibres to spray head at rates to achieve design mix proportions and glass-fibre 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.
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 fibres and matrix.
4. Consolidate backing mix by rolling or other technique to achieve complete encapsulation of glass fibres 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 the 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 Embedment: Build up homogeneous GFRC bosses or bonding pads over inserts and embedment 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 mould. Comply with PCI MNL 130 procedures.

1. Keep moisture off the surface of mixes with polymer curing admixtures during the first 3 hours of curing. Maintain a temperature between 16 and 49 C during the first 12 to 16 hours.

H. Panel Identification: Mark each GFRC panel to correspond with identification marks on Shop Drawings.

6.2 FABRICATION TOLERANCES

A. Manufacturing Tolerances: Manufacture GFRC panels so each finished unit complies with PCI MNL 130 for dimension, position, and tolerances.

1. Overall Height and Width of Units, Measured at the Face Adjacent to Mould: 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 Mould: 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 the unit meets erection tolerances using connection adjustments.

10. Length and Width of Block outs 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.

B. 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. Inserts: Plus, or minus 1/2 inch (13 mm).
3. Special Handling Devices: Plus, or minus 3 inches (75 mm).
4. Location of Bearing Devices: Plus, or minus 1/4 inch (6 mm).
5. Block outs: Plus, or minus 3/8 inch (10 mm).

C. 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).

7.0 FINISHES

Finish exposed-face surfaces of GFRC as follows to match approved **[design reference sample] - [and] - [mock-ups].** Panel faces shall be free of joint marks, grain, or other obvious defects.

1. Design Reference Sample: Insert description and identify manufacturer and code number of samples.
2. As-Cast-Surface Finish: Provide surfaces to match accepted sample or mock-up units for acceptable surface air voids, sand streaks and honeycombs.
3. 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 mock-up units.
4. Sand Blast Finish: Use abrasive grit, equipment, application techniques, and cleaning procedures to expose aggregate and surrounding matrix surfaces to match accepted sample or mock-up units.
5. 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 mock-up units.

8.0 QUALITY CONTROL

A. Quality-Control Testing: Establish and maintain a quality-control program for manufacturing GFRC panels according to PCI MNL 130.

1. Test materials and inspect production techniques.
2. Quality-control program shall monitor glass-fibre content, spray rate, unit weight, product physical properties, anchor pull-off and shear strength, and curing period and conditions.
3. Prepare test specimens and test according to ASTM C1228, PCI MNL 128, and PCI MNL 130 procedures.
4. Test GFRC inserts and anchors according to ASTM C1230 to validate design values.
5. Produce test boards at a rate not less than one per work shift per operator for each spray machine and for each mix design.

a) For each test board, determine glass-fibre content according to ASTM C1229, and flexural yield and ultimate strength according to ASTM C947.

9.0 EXECUTION

9.1 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.

9.2 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 the Shop Drawings. Remove temporary shims, wedges, and spacers as soon as possible after connecting is completed.

E. At bolted connections, use lock washers or other acceptable means to prevent loosening of nuts.

9.3 ERECTION TOLERANCES

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)

9.4 REPAIRS

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

9.5 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 fibre brushes and sponges, and rinse with clean water. Prevent damage to GFRC surfaces and staining of adjacent materials.