Particular Specification of GRC Products

YEUNG'S fiberglass

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Particular Specification of Glass Reinforced Concrete (GRC) Rockscape

1.0 GENERAL

1.01 All Glass Reinforced Concrete (GRC) Rockscape shall be designed, supplied and installed by Yeung's Fiberglass Company, a Specialist Contractors in the "Supply and Installation of Glass (or Fibre) Reinforced Plastic Units" category of the list of approved Suppliers of Materials and Specialist Contractors for Public Works of HKSAR Government.

1.02 The Contractor should be in the approved list of registered sub-contractor under PROVISIONAL CONSTRUCTION INDUSTRY CO-ORDINATION BOARD of Hong Kong

1.03 The Contractor shall furnish, fabricate (where necessary), and install all Glass Reinforced Concrete (GRC) items, with all appurtenances, accessories and serviceable installation as shown on the Contract Drawings and as specified herein, and in accordance with the requirements of the Contract Documents. The Contractor should have ISO 9001:2015 and ISO 14001:2015 certificates for quality control and environmental assurance certificates. The Contractor should also have more than 30 years proven solid experiences on manufacturing GRC Rockscape.

1.02 DEFINITIONS

Design Reference Sample: Sample of approved GFRC color, finish and texture; preapproved by Project Manager.

1.03 REFERENCES

A. Reference British Standards and specifications:

1. BS 476-4: Fire tests on building materials and structures. Non-combustibility test for materials
2. BS 476-7: Fire tests on building materials and structures. Method of test to determine the classification of the surface spread of flame of products.
3. BS EN 1170: Precast concrete products. Test method for glass-fibre

reinforced cement.

4. BS 12: Specification for Portland cement
5. BS 5328: Concrete
6. BS 882: Specification for aggregates from natural sources for concrete.
7. BS 8110: Structural use of concrete. Code of practice for design and construction.
8. BS EN ISO 1461: Specification for Hot Dip Galvanized Coatings on Iron and Steel Articles.

B. Reference American standards and specifications:

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".
3. ASTM: C144 Standard Specification for Aggregate for Masonry Mortar.
4. ASTM: C150 Standard Specification for Portland Cement
5. ASTM: F593 Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
6. ASTM: F594 Standard Specification for Stainless Steel Nuts
7. AWS D1.1, "Structural Welding Code - Steel,"
8. AWS D1.3, "Structural Welding Code - Sheet Steel."

C. Local Rules and Regulations; Current Editions.

1.04 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide GFRC panels, including panel frames, anchors, and connections, capable of withstanding the following design loads as well as the effects of thermal- and moisture-induced expansion and contraction, according to load factors and combinations established in Architectural Services Department.

B. Loads:

1. Design Loads: All non-accessible balconies and projections shall be designed to withstand a person standing on it for maintenance or repair work. A concentrated loading of 0.75kN and a uniform live load of 3.0 kPa shall be used.
2. Dead/Live Loads: Shall be in accordance with the Building(Construction) Regulations.

3. Wind Loads: Shall be in accordance with the more onerous requirements of the Code of Practice "Wind Effects in Hong Kong 2004".
4. Maintenance Equipment Loads: As imposed by work of Division 11 Section Maintenance Equipment".

C. Deflection: Design panel frames to withstand design loads without lateral deflections greater than 1/100 of wall span.

D. Thermal Movements: Thermal component of joint movement shall be based upon a minimum material temperature increase of 55ºC and decrease of 55ºC relative to the time of installation.

E. Building Maintenance Unit Interface: Coordinate GFRC, supports, anchors, and attachments with requirements of Division 11 Section "Maintenance Equipment" to accommodate fully functional building maintenance unit system, including tracks, supports, and other elements as indicated on Drawings

F. GFRC Cladding and units shall comply with Fire Retardant Requirement BS 476 Part 4, 6 and 7 Standard.

1.05 SUBMITTALS

A. Submit the following documents / test reports when submitting tender

1. Compressive Strength of GRC
2. Dry Density and Water Absorption test to BS EN 1170-6:1998
3. Fibre "Wash Out" test to BS EN 1170-2:1998
4. Interlaminar Shear Strength Test
5. Complete Bending Test to BS EN 1170-5:1996
6. Shear Testing of Structural Fixings in Concrete and Masonry to BS 5080 Part 3 : 1986
7. Proof Load of Structural Fixings in Concrete and Masonry
8. Pull Out Testing of Structural Fixings in Concrete and Masonry

B. Submit the following to the Project Manager to approval before fabrication:

1. Product Data: Provide product data for each system component, including

manufacturer's instructions for installation.

2. Design Mixtures: For each concrete mixture.
3. Structural Calculations: Including live, dead and other loads, deflection, and comprehensive engineering analysis for Project Manager's approval and subject to the approval of Buildings Department submission for External Cladding system.
4. Shop Drawings: Show fabrication and installation details for GFRC panels, including the followings for Project Manager's approval and subject to the approval of Buildings Department submission for External Cladding system:
   a) Dimensioned elevations, sections, and assembly details of all panels and GFRC panel cladding assemblies.
   b) Thickness of facing mix, GFRC backing, and bonding pads for typical panels.
   c) Finishes.
   d) Items sprayed into panels.
   e) Description of loose, cast-in, and field hardware.
   f) Joint and connection details.
   g) Relationship to adjacent materials.
   h) Panel support details for typical panels, including sizes, spacings, thickness, and material used for all members.
   i) Locations and connection hardware where panel supports are attached to building structure.
   j) Size, location, and details of flex, gravity, and seismic anchors for typical panels.
   k) Erection sequence for special conditions.

5. Samples: For each selected colour, finish, and texture; submit two samples of each type in GFRC, 400 x 400 mm in size, of actual thickness to be installed, with finished faces representing full range of colours and textures expected.

6. Welding certificates.
7. Steel Sheet Certification: For steel sheet used in cold-formed steel panel framing.
8. Mill Certificates: For structural-steel shapes and hollow structural sections used in panel framing
9. Qualification Data: For GFRC manufacturer, including proof of current GRCA

certification.

10. The Contractor shall appoint RSE to prepare all necessary structural calculations, drawings and details for Buildings Department approval.
11. Mock Up for Grand Aquarium External Architectural Fins:
    a) Physical model made of Foam and/or Polymer Clay in scale 1:200
    b) Computer model drawn by software of AutoCAD, 3D Studio or Architectural Desktop for Setting out of architectural fins.
    c) Full scale Off Site Clay Model 1:1 as positive mold for GFRC Panel.
12. Mock Up for Internal Rock Work:
    a) Physical model made of Foam and/or Polymer Clay in scale 1:50
    b) Full scale Off Site Clay Model 1:1 as positive mold for GFRC panel system.

1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer who participates in PCI's Plant Certification Program and is designated a PCI-Certified Plant for Group G – Glass Fiber Reinforced Concrete.
B. Engineering design and structural calculations shall be done under the supervision of and signed by a structural engineer licensed in Hong Kong, appointed and paid by Contractor.
C. Manufacturer's responsibility includes fabricating and installing GFRC panels and providing professional engineering services needed to assume engineering responsibility for GFRC panels.
D. 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.
E. Steel Sheet Certifications: Obtain mill certificates, signed by manufacturers of steel sheet, or test reports from a qualified testing agency indicating that 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.
F. 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.
G. Source Limitations: Obtain GFRC panels through one source from a single manufacturer.
H. Welding: Qualify procedures and personnel according to AWS D1.1, and AWS

D1.3

I. Reference Standards: Comply with requirements and recommendations of PCI MNL 128, and PCI MNL 130 unless more stringent requirements are indicated:

J. Mockups: Build mockups to demonstrate aesthetic effects and set quality standards for materials and execution.
    1. Build mockup of typical panel area about 2m by 2m.
    2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Project Manager specifically approves such deviations in writing.
    3. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

K. Pre-installation Conference: Conduct conference at Project site to comply with requirements in Construction Manager's Procedure Manual.

L. All GFRC panel should have minimum thickness of 10mm subject to structural calculation. For the panel below 2m from finished floor and within touch by the visitors, the GFRC panel should have minimum thickness of 20mm

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project in manufacturer's original, labeled packaging, in undamaged condition. Place stored panels so identification marks are clearly visible.
    1. Protect panels from dirt and damage during handling and transport.
    2. Place non-staining resilient spacers between panels.
    3. Support panels during shipment on non-staining material.

B. Store and handle materials off the ground, under cover, and in a dry location to prevent their deterioration or damage due to moisture, temperature changes, contaminants, corrosion, staining, and other causes. If materials become damaged by moisture replace with same kind. Do not install until materials are in an air-dried condition.
    1. Store panels with non-staining resilient supports in same positions as when transported.
    2. Store panels on firm, level, and smooth surfaces.

C. Protect materials from freezing and overheating in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.01 MANUFACTURER

Yeung's Fiberglass Company or approved equivalent
Unit F, 23/FL., CNT Tower, 338 Hennessy Road, Wanchai, Hong Kong
Contact : Ir. Herbert Yeung 2893 8865

2.02 MOLD MATERIALS

A. Molds: Rigid, dimensionally stable, non-absorptive material, warp and buckle free, that will provide continuous and true GFRC surfaces; non-reactive with GFRC and capable of producing required finish surfaces.

B. 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.

2.03 GFRC/GRC CLADDING SYSTEM

A. Design, fabricate and install component parts in conformance with Performance Criteria specified herein.

B. Design Safety Factors: The minimum safety factors to be used in the flexural design of the the anchorages shall be as specified herein.

1. Flexural Safety Factor (F.S.F.): The minimum safety factor to be used in the flexural design of cladding panels shall be as specified herein. The Architect will review the production cladding testing data and may further modify the safety factor as he deems appropriate.
2. Anchorage Safety Factor (A.S.F.): The minimum safety factor to be used in checking cladding stresses at anchorage zones shall be calculated as follows:

$$A.S.F. = F.S.F. \times 1.4$$

C. The exterior wall cladding work shall accommodate the following movements without any permanent deformation or reduction in the specified performance:

1. Deflection under design loads.
2. The effects of repeated wind and internal pressure loading including pressures related to the movements of trains.
3. Changes in dimension and shape of components arising from

building movements, including settlement, creep, twisting and racking.

4. Movement of any joint whether designed to permit movement or not.

D. Dead Loads: The exterior wall cladding work shall be capable of accommodating the following dead loads without any reduction in performance:

1. The dead loads derived from permanent fixtures or services attached to either the internal or external surfaces of the exterior wall cladding work.
2. When calculating loads it shall be ensured that the worst combination load cases have been considered, bearing in mind that the pressure coefficients at various locations may determine more than one design criteria.

E. Live Loads: The exterior wall cladding work shall be capable of accommodating the following live loads without any reduction in performance:

1. All loads resulting from movements of the building structure and cladding support structure.
2. Horizontally applied loads acting on the surface arising from maintenance and cleaning operations. The exterior wall cladding work shall sustain safely, without reduction in performance and without permanent deformation to any component, a static 500N load applied horizontally through a square of 100mm sides on any part of the framing.
3. Impact loads, or transferred impact loads, that occur during its service life, without deterioration in performance and without sustaining nonrepairable damage.
4. Loads imposed during replacement of panels/units.
5. When calculating loads the worst combination shall be considered, taking account of the fact that the pressure coefficients at various locations may determine more than one design criteria.

F. Deflections

1. The exterior wall cladding work shall not deflect under loading

in any way that is detrimental to any element of the Exterior wall cladding work or adjacent structural or building elements.

2. All components, couplings and fixings shall be capable of accommodating all specified deflections without permanent distortion, deformation or failure.
3. The exterior wall cladding work shall accommodate differential structural movements arising from any loads imposed by adjacent structures.
4. The magnitude of the allowable deflections shall be reduced if they are detrimental to any part of the Exterior wall cladding work, its support structure or internal finishes.

G. Moisture Movement: The exterior cladding system shall withstand the following movement without permanent deformation or any reduction in the specified performance:

1. Due to changes in the moisture content of its components, resulting from variations in the moisture content of the air. Refer also to BS 8297 section 3.7, BS 8298 and BS 81 1 0: Part 2: section 7.
2. Due to drying shrinkage in cladding components or supporting structures, both short term and long term to BS 8297 section 3, and BS 8298.

H. Anchorage: The ultimate strength of anchors, inclusive of the derived or specified safety factor shall be developed completely by the mechanical action of the anchor. Adhesives shall not be allowed to contribute to the structural capacity of the anchor assembly.

I. Control of Corrosion and Staining: Prevent galvanic and other forms of corrosion as well as staining by isolating metals and other materials from direct contact with incompatible materials. Use materials that do not stain exposed surfaces of cladding and joint materials.

J. All fixings shall be capable of providing adequate adjustment with the minimal use of packing shims, which shall be agreed with the Design Consultant. All necessary movement joints shall be designed to accommodate the maximum movements that can be derived from the

specified and determined design loads and movements. Under maximum movements the joints shall meet all the performance requirements of the Performance Specification.

K. The exterior wall cladding work shall resist all specified static and dynamic design loads likely to be encountered without causing permanent deformation of components or the failure of members or seals and shall transmit such loads safely to the points of support.

L. The exterior wall cladding work shall not deflect under loading in any way that is detrimental to any element of the Works or adjacent structural or building elements

M. Shipping and Handling: The cladding and the cladding anchorage shall not be compromised to any degree by distress in the assembly which may occur as a result of shipping and handling of the assembly.

N. Design Modifications: Make design modifications of work shown only as may be necessary to meet performance requirements and coordinate the work. Variations in details and materials which do not adversely affect appearance, durability or strength shall be submitted to the Architect for review. Maintain the general exterior design concept without altering profiles and alignments shown.

O. Anchors: Comply with BS 8298, clauses 2.3 and 3.10 unless more stringent requirements are specified herein. Metal components in contact with cladding shall be stainless steel. Exterior metal components not in contact with exterior cladding may be stainless steel or ferrous steel hot-dip galvanized in accordance with BS 729. Ferrous metals may be used for purposes not in contact with interior cladding and shall be either galvanized or shop prime painted. Select metals to be compatible with adjacent materials and to be non-staining to cladding. Separate dissimilar metals in contact by using appropriate separators to prevent galvanic action. Provide anchors embedded within cladding in sizes, configurations and profiles as shown or as required to sustain imposed loads without exceeding allowable design stresses, and install anchorages and supports free from rattle or displacement.

1. Exterior Cladding Anchors: BS 1449, Part 2, Type 316 stainless steel, 5mm minimum thickness. Provide cladding anchors complying with the"Performance Criteria" specified hereinbefore.

2. Fixings and Anchorage Devices: Type, grade, class and style best suited for the respective purpose.
   a. Fixings for Steel Subframe Components: either hot-dip or mechanically zinc coated.
   b. Fixings for Stainless Steel Anchors: Fixings for stainless-Steel
      Anchors: Stainless steel fasteners, bolts, screws, nuts and other fixings shall be either grade A2 or grade A4 to BS 6105 (ISO 3506).

   The property class of fastenings shall be selected to meet the performance requirements as specified.

P. Contractor submission shall include the required submission as required by Buildings Department under current regulations on structural performance with reference to Practice Note for Authorized Person No. 59 on Cladding Works.

2.04 GFRC MATERIALS

A. Portland Cement : ASTM C 150, Type I, II, or III for surfaces exposed to view in finished structure, use white of same type, brand, and source throughout GFRC production

B. Metakaolin : ASTM C 618, Class N for supplementary cementing material if ts use by GFRC manufacturer has been proven in service to maintain GFRC ductility

C. Glass Fibers: Alkali resistant, produced under a quality management system approved to ISO 9001 standard

D. Sand: Washed and dried silica, complying with composition requirements of ASTM C 144; passing No. 20 (0.85-mm) sieve with a maximum of 2 percent passing No. 100 (0.15-mm) sieve.

E. Coloring Admixture: ASTM C 979, Maximum of 10% synthetic mineral-oxide

pigments or colored

F. Water-reducing Admixtures: Temperature stable, non-fading, and alkali resistant.

G. 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.

H. Polymer-Curing Admixture: Acrylic thermoplastic copolymer dispersion complying with PCI MNL 130 if wet curing is not used.

I. Chemical Admixtures: ASTM C 494/C 494M, containing not more than 0.1 percent chloride ions.

J. Traditionally sprayed GRC shall achieve Grade 18 or 18P as per GRCA specification or equivalent.

2.05 GFRC SPRAY APPLICATION

A. Portland Cement: ASTM C 150. Use only one brand and type of cement for Project.

B. Fly Ash: ASTM C 618, Class C or F.

C. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

D. Blended Hydraulic Cement: ASTM C 595

E. Silica Fume: ASTM C 1240, amorphous silica.

F. Normal-Weight Aggregates: ASTM C 33, from a single source, and as follows:

G. Aggregate Gradation: ACI 506R, Gradation No. 2 with 100 percent passing 13-mm sieve.

H. Lightweight Aggregates: ASTM C 330.

I. Aggregate Gradation: ACI 506R, Gradation No. 2 with 100 percent passing 13-mm sieve.

J. Coloring Agent: ASTM C 979, synthetic mineral-oxide pigments or colored, waterreducing admixtures, free of carbon black; color stable, nonfading, and resistant to lime and other alkalis.

K. Color: As selected by Architect from manufacturer's full range

L. Water: Potable, complying with ASTM C 94/C 94M, free from deleterious materials that may affect color stability, setting, or strength of shotcrete.

M. Carbon-Steel Fiber: ASTM C 1116, Type 1, carbon-steel fiber and ASTM A 820, Type 1, not less than 25 mm long.

N. Synthetic Fiber: Fibrillated polypropylene fibers engineered and designed for use in shotcrete, complying with ASTM C 1116, Type III, not less than 19 mm long.

O. Ground Wire: High-strength steel wire, 0.8 to 1 mm in diameter.

P. Joint Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork.

2.06 ANCILLARY MATERIALS

A. Supports, Anchors, and Attachments for GFRC: All components shall be Grade 304 stainless steel complying with the following:

1. Sheet, Strip, Plate, and Flat Bars: ASTM A 666.
2. Bars and Shapes: ASTM A 276.
3. Rolled Floor Plate: ASTM A 793
4. Bolts, Nuts, and Washers: ASTM F 593 (ASTM F 738M) for bolts and ASTM F 594 (ASTM F 836M) for nuts, Alloy Group 1 (A1).
5. Fasteners: ASTM A 962.

B. Sealants: Silicon sealant complying with requirements of 07 90 00 “Joint Sealers”.

2.07 GFRC MIXES

A. Backing- and Face-mix Proportions: As determined by GFRC fabricator to meet performance requirements.

B. Backing Mix: Proportion backing mix of Portland cement, glass fibers, sand, and admixtures to comply with performance requirements. Provide nominal glass-fiber. GRC.

C. Face Mix: Proportion face mix of Portland cement, sand, facing aggregates, and admixtures to comply with design requirements.

D. Polymer-Curing Admixture: 6 to 7 percent by weight of polymer-curing admixture solids to dry Portland cement only needed if wet curing is not used.

E. Coloring Admixture: Not of exceed 10 percent of cement weight.

2.08 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 andloss of cement paste.

B. Coat contact surfaces of molds with form-release agent.

2.09 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 or place face mix in thickness indicated on Shop Drawings.
   2. Proceed with spraying backing mix before face mix has set, using procedures that produce a uniform thickness and even distribution of glass fibers and matrix.
   3. Consolidate backing mix by rolling or other technique to achieve complete encapsulation of glass.

C. Fibers and compaction:
   1. 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.
   2. Hand form and consolidate intricate details, incorporate formers or infill materials, and over spray before material reaches initial set to ensure complete bonding.

D. Inserts and Embedded items: Build up homogeneous GFRC bosses or bonding pads over inserts and embedded items to provide sufficient anchorage and embedment to comply with design requirements.

E. Curing: Employ initial curing method that will ensure sufficient strength for removing units from mold as set out in the PCI/GRCA handbook.
   1. After initial curing, remove panel from mold and place in a controlled curing environment.
   2. Keep GFRC panels continuously moist for a minimum of seven days unless polymer-curing admixture was used. Maintain temperature between 60 and 120 deg F (16 and 49 deg C) during this period.

F. Panel Identification: Mark each GFRC panel to correspond with identification mark on Shop Drawings. Mark each panel with its casting date / mould number and PSD number.

2.10 FABRICATION TOLERANCES

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

B. Dimensional tolerances. For dimensional tolerances not listed below, comply with PCI MNL 130.

C. Overall Height and Width of Units, Measured at the Face Adjacent to Mold:
   1. 10 feet (3m) or less, plus or minus 1/8 inch (3 mm).
   2. 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.

D. Edge Return Thickness: Plus 1/2 inch (13 mm), minus 0 inch (0 mm).

E. Project Managerural Facing Thickness: Plus 1/8 inch (3 mm), minus 0 inch (0 mm).

F. Backing Thickness: Plus 1/4 inch (6 mm), minus 0 inch (0 mm).

G. Panel Depth form Face of Skin to Back of Panel Frame or Integral Rib: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).

H. 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.

I. 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.

J. Local Smoothness: 1/4 inch per 10 feet (6 mm per 3 m).

K. Bowing: Not to exceed L/240 unless unit meets erection tolerances using connection adjustments.

L. Length and Width of Block Outs and Openings within One Unit: Plus or minus 1/4 inch (6 mm).

M. Location of Window Opening within Panel: Plus or minus 1/4 inch (6 mm).

N. Maximum Permissible Warp 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.

O. Position Tolerances: Measured from datum line locations, as indicated on Shop Drawings.

P. Panel Frame and Track: Plus or minus 1/4 inch (6 mm).

Q. Flashing Reglets at Edge of Panel: Plus or minus 1/4 inch (6 mm).

R Inserts: Plus or minus 1/2 inch (13 mm).

S. Special Handing Devices: Plus or minus 3 inches (75 mm).

T. Location of Bearing Devices: Plus or minus 1/4 inch (6 mm).

U. Blockouts: Plus or minus 3/8 inch (10 mm).

V. 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

A. Finish exposed-face surfaces and returns of GFRC as follows to match approved Design Reference Sample and mockups.
B. Panel faces shall be free of joint marks, grain, and other defects.
C. Textured-surfaces Finish: Impart by form liners to provide surfaces free of sand streaks, honeycombs, and excessive air voids, with uniform color and texture.

2.12 SOURCE QUALITY CONTROL

A. Quality-Control Testing: Establish and maintain a quality-control program of manufacturing GFRC panels.

B. Test materials and inspect production techniques:

1. 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.
2. Prepare test specimens and test according to ASTM C 1228, PCI MNL 130, and PCI MNL 128 procedures.
3. Test GFRC inserts and anchors according to ASTM C 1230 to validate design values.
4. Produce test boards at a rate not less than one per work shift per operator for each spray machine and for each mix design.
5. For each test board, determine glass-fiber content according to ASTM C 1229, and flexural yield and ultimate strength according to ASTM C 947.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements of Sections in which substrates and related work are specified, and for compliance with requirements for installation tolerances, true and level bearing surfaces, other conditions affecting performance.

1. Report unacceptable conditions to the Project Manager
2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Confirm that work specified in other sections that will be concealed by GFRC has been completed.

C. Take field measurements to verify as-built conditions.

3.02 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.

D. Maintain horizontal and vertical joint alignment and uniform joint width.
E. Remove projecting hoisting devices.
F. Connect GFRC panels in position as indicated on Shop Drawings.
G. Bolted Connections: Use bolted connections wherever feasible as preferred method of connection.
    1. Use lock washers or other means to prevent loosening of nuts.
H. Welded Connections: Use welded connections only where bolting is not feasible due to inadequate access or other reasons.
    1. Welding: Comply with applicable AWS D1.1 and AWS D1.3 requirements for welding, appearance, quality of welds, and methods used in correcting welding work.
    2. Protect GFRC panels from damage by field welding or cutting operations. Provide noncombustible shields as required.
I. Remove temporary shims, wedges, and spacers as soon as possible after connecting is completed.

3.03 ERECTION TOLERANCES

A. Erect GFRC panels to comply with the following non-cumulative 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:
    3. Exposed Individual Panel: Plus or minus 1/4 inch (6 mm).
    4. Non-exposed Individual Panel: Plus or minus 1/2 inch (13 mm).
    5. Exposed Panel Relative to Adjacent Panel: 1/4 inch (6 mm).
    6. Non-exposed Panel Relative to Adjacent Panel: 1/2 inch (13 mm).
    7. Support Elevation from Nominal Elevation: As follows:
        a) Maximum Low: 1/2 inch (13 mm).
        b) Maximum High: 1/4 inch (6 mm).
        c) Maximum Plumb Variation over the lesser of Height of Structure or 100 Feet (30 m): 1 inch (25 mm).
        d) Plumb in Any 10 Feet (3 m) of Element Height: 1/4 inch (6 mm).
        e) Maximum Jog in Alignment of Matching Edges: 1/4 inch (6 mm).
        f) 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 5/16 inch (8 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).

3.04 REPAIRS

A. Repair production blemishes at manufacturer's plant.
B. Repair blemishes that occur after delivery before final joint cleaning and sealing.
C. Repairs by means that will not impair structural adequacy of GFRC panel.
D. Mix patching materials, and repair GFRC so that cured patches uniformly blend with color, texture of adjacent exposed surfaces.
E. Remove damaged GFRC panels and provide identical undamaged panels when repairs do not comply with requirements.

3.05 CLEANING AND PROTECTION

A. Perform cleaning procedures, if necessary, according to GFRC manufacturer's written instructions.
B. Clean soiled GFRC surfaces with detergent and water, using soft fiber brushes and sponges, and rinse with clear water. Prevent damage to GFRC surfaces and staining of adjacent materials.