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V SPECS VERIFIED SPEC NOTE: This Section has been scored against "Industry Standard Practices", using V SPECS proprietary 35pt Inspection and Scoring Methodology within its Product Master Specification Report Card.

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PETRA PREFACE SPEC NOTE: This Product Master Specification Section includes PETRA SPEC NOTES for information purposes and to assist the editor in making appropriate decisions. PETRA SPEC NOTES always immediately precede the text to which it is referring.

PETRA PREFACE SPEC NOTE: Optional text is indicated by square brackets []; Delete the optional text including the brackets in the final copy of the Specification. Delete all PETRA SPEC NOTES in the final copy of the Specification, prior to Project Tendering/Pricing. The Section content serves as a guideline only and should be edited (by additions, deletions, and modifications) to meet specific project requirements.

PETRA PREFACE SPEC NOTE: This Specification Section follows the recommendations of the Construction Specifications Canada (CSC), Manual of Practice including MasterFormat names and numbers, SectionFormat layout guidelines, and PageFormat paragraph numbering.

PETRA PREFACE SPEC NOTE: This Specification includes the materials and installation procedures for Glass Fiber Reinforced Concrete (GFRC). GFRC is a specialized form of concrete. It is a cement based composite material reinforced with alkali-resistant glass fibers. GFRC consists of cement, fine aggregates, water, polymers, and glass fibers. GFRC is recognized for its lightweight, durability, and versatility, making it ideal materials for various applications, including facades, sculptures, and architectural features. PETRA offers GFRC products in different colours and textures.

PETRA PREFACE SPEC NOTE: PETRA has the capabilities to perform in-house testing to CSA A23.2 standards, ensuring compliance with industry quality and performance benchmarks. PETRA is able to conduct in-house testing of the following:

- Air content of freshly mixed plastic concrete*
- Compressive strength testing of concrete cylinders*
- Temperature of freshly mixed plastic concrete*
- Slump of freshly mixed plastic concrete.*

1 General

1.1 GENERAL REQUIREMENTS

- .1 The General Conditions, the Supplementary Conditions, the Instructions to Bidders and Division 1 General Requirements shall be read in conjunction with and govern this section.

PETRA SPEC NOTE: Edit the following paragraph to select either Contractor or Construction Manager, and Subcontractor or Trade Contractor, depending on the Contract Type used on the Project.

- .2 The Specification shall be read in its entirety by all parties concerned. Each Section may contain more or less than the complete work of any trade. The [Contractor] [Construction Manager] is solely responsible to make clear to the [Subcontractor] [Trade Contractor] the extent of their work.
- .3 The Consultant and Owner assume no responsibility to act as arbiters or to establish subcontract limits between Sections or Divisions of the Work. Any references to related work items contained in this Section are provided for convenience only.

1.2 SUMMARY

- .1 The Work of this Section includes, but is not limited to the following:

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .1 Furnish all labour, materials, services, and equipment necessary to supply, fabricate and install glass fiber reinforced concrete (GFRC) precast components including:
 - .1 [GFRC Wall Panels]
 - .2 [GFRC Countertops]
 - .3 [GFRC Benches]
 - .4 [GFRC Planters]
 - .5 Decorative components including [GFRC Columns and Column covers], [GFRC cornices], [GFRC Moulding], [GFRC Balustrade system], [GFRC porticos], [GFRC Fountains], [GFRC Quoins], [GFRC Signs], [GFRC Dome], [other elements].

1.3 REFERENCE STANDARDS

PETRA SPEC NOTE: Edit the following paragraph to reflect reference standards for this Project.

- .1 The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- .2 All reference amendments adopted prior to the bid closing date of this Project shall be applicable to this Project.
- .3 All materials, installation and workmanship shall comply with all applicable requirements and standards.
- .4 American Society for Testing and Materials (ASTM):
 - .1 ASTM A29/A29M: Standard Specifications for General Requirements for Steel Bars, Carbon, and Alloy, Hot-Wrought
 - .2 ASTM A36/A36M: Standard Specifications for Carbon Structural Steel
 - .3 ASTM A108: Standard Specification for Steel Bar, Carbon, and Alloy, Cold-Finished
 - .4 ASTM A153/A153M: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

- .5 ASTM A307: Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength
- .6 ASTM A325: Standard Specifications for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength (withdrawn 2016)
- .7 ASTM A780/780M: Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
- .8 ASTM C33/C33M: Standard Specification for Concrete Aggregates
- .9 ASTM C109/C109M: Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 50 mm [2 in.] Cube Specimens)
- .10 ASTM C150/150M: Standard Specification for Portland Cement
- .11 ASTM C185: Standard Test Method for Air Content of Hydraulic Cement Mortar
- .12 ASTM C260/260M: Standard Specification for Air Entraining Admixtures for Concrete
- .13 ASTM C947: Standard Test Method for Flexural Properties of Thin-Section Glass-Fiber-Reinforced Concrete (Using Simple Beam with Third-Point Loading)
- .14 ASTM C948: Standard Test Method for Dry and Wet Bulk Density, Water Absorption, and Apparent Porosity of Thin Sections of Glass-Fiber Reinforced Concrete
- .15 ASTM C979/C979M: Standard Specification for Pigments for Integrally Concrete
- .16 ASTM C1666/C166M: Standard Specification for Alkali Resistant (AR) Glass Fiber for GFRC and Fiber-Reinforced Concrete and Cement
- .17 ASTM C1228: Standard Specification for Preparing Coupons for Flexural and Washout Tests on Glass Fiber Reinforced Concrete
- .18 ASTM C1229: Standard Test Method for Determination of Glass Fiber Reinforced Concrete (GFRC) (Wash-out Test)
- .19 ASTM C1230: Standard Test Method for Performing Tension Tests on Glass-Fiber Reinforced Concrete (GFRC) Bonding Pads
- .20 ASTM F568M: Standard Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners (Withdrawn 2012).
- .5 Canadian Standards Associations (CSA):
 - .1 CSA A23.1/A23.2: Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete
 - .2 CSA A23.4: Precast Concrete – Materials and Construction
 - .3 CSA A3001: Cementitious materials use in concrete
- .6 Precast/Prestressed Concrete Institute (PCI):
 - .1 PCI MLN-128: Recommended Practice for Glass Fiber Reinforced Concrete Panels
 - .2 PCI MLN-130: Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products
- .7 American Iron and Steel Institute (AISI):
 - .1 AISI 1018 Steel, Cold Drawn

- .8 Society for Protective Coatings (SSPC):
 - .1 SSPC SP 2-2018, Hand Tool Cleaning
 - .2 SSPC SP 6-2007; Commercial Blast Cleaning

1.4 DEFINITIONS

PETRA SPEC NOTE: Retain terms that remain after Section has been edited for the project.

- .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 (ZrO₂) 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 Design Reference Sample: sample of GFRC colour, finish, and texture, preapproved by Architect or Consultant.
- .6 Face Coat: An initial layer without fibres but containing decorative sands or aggregates and / or pigments.
- .7 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.
- .8 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.
- .9 Mist Coat: An initial cementitious sprayed coating without glass fibres.
- .10 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.
- .11 Premix GFRC: A method of manufacture in which the pre-cut AR glass fibres and the cementitious slurry are blended during mixing.
- .12 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.
- .13 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.
- .14 Slump Test: A test for checking the consistency of the cementitious slurry.
- .15 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.

- .16 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.
- .17 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.
- .18 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.
- .19 'Wash Out' Test: A method for the determination of glass fibre content of Uncured GFRC.
- .20 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.

1.5 ADMINISTRATIVE REQUIREMENTS

- .1 Coordination: Coordinate site dimensions affecting work of other Sections and provide data, dimensions and components installed by other Sections in sufficient time for installation of products specified in this Section.
 - .1 Coordinate sizes and locations of framing, blocking, furring, and reinforcements provided by work that is specified in other Sections, ensuring their completeness before starting work of this Section.

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .2 Pre-Construction Meeting: Arrange a preconstruction meeting in accordance with [Division 01] [Section 01 31 19 Project Meetings], attended by [Contractor] [Construction Manager], Consultant, and the panel [Subcontractor] [Trade Contractor] to discuss the following:
 - .1 Establishing procedures to maintain optimum working conditions and to coordinate Work of this Section with related and adjacent work.
 - .2 Installation requirements;
 - .3 Coordination of structural support requirements in relation to the Work;
 - .4 Installation of any separate air/water barriers, and treatment of fenestration;
 - .5 Special surface effects and finishing;
 - .6 Installation of specialty architectural elements offered by the manufacturer;
 - .7 Coordination of work with adjacent finishes and wall assemblies;
 - .8 Protection of finishes; and
 - .9 Acceptability of substrates and quality of materials being used for the project.

1.6 INFORMATIONAL SUBMITTALS

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .1 Provide submittals as indicated in [Division 01] [Section 01 33 00 Submittal Procedures].

- .2 Action Submittals: Provide the following submittals before starting work of this Section:
 - .1 Product Data: Manufacturer's data sheets on each product to be used, including:
 - .1 Detailed technical data for materials, fabrication, and installation, including anchors, hardware, fasteners, and accessories.
 - .2 Storage and handling requirements and recommendations.
 - .3 Installation instructions.
 - .2 Samples:
 - .1 Submit 305 mm x 305 mm (12" x 12") panel sample indicating finish, colour, and texture, supplied by the manufacturer.
 - .3 Shop Drawings: Submit detailed drawings showing the following:
 - .1 Panel elevation, sections, and dimensions.
 - .2 Joint and connection details.
 - .3 Erection details.
 - .4 Location and details of connection hardware attached to structure.
 - .5 Size, location, and details of flex, gravity, and seismic anchors for panels.
 - .6 Locations and type of sealants.
 - .7 Relationship to adjacent materials.
 - .8 Loose, cast, and field hardware.
 - .9 Coordination Drawings: Provide elevation drawings and building sections which show panels in relationship to required locations for structural support. Include panel details and details showing attachment to structural support.
 - .10 Other details as may be required for a weathertight installation.
 - .11 Prepare Shop Drawings under direct supervision of a Professional Structural Engineer experienced in design of this work and licensed at the place where the Project is located.
- .3 Information Submittals:
 - .1 Design and Performance Data: Indicate panel profile characteristics and dimensions, and structural properties of assembled panels.
 - .2 Installation Data: Manufacturer's special installation requirements, including special handling criteria, installation sequence, and cleaning procedures.

PETRA SPEC NOTE: Retain certificates (welding, sheet steel, and mill) if applicable to the project and if retained in "Quality Assurance" Article.

- .3 Welding: Conforming to [CSA W59].
- .4 Steel Sheet Certification. For steel sheet used in cold-formed steel panel framing.
- .5 Mill Certificated: For structural-steel shapes and hollow structural sections used in panel framing.
- .6 Source Quality-Control Program: For GFRC manufacturer.
- .7 Test Reports: Provide report for inserts, and anchors.

1.7 CLOSEOUT SUBMITTALS

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .1 Closeout Submittals: In accordance with [Division 01] [Section 01 78 00].
- .2 Operating and Maintenance Data: Submit care and maintenance instructions for system description to be included in building operation and maintenance manual.
- .3 Warranty Documentation: Submit copy of extended warranties specified in this Section.

1.8 QUALITY ASSURANCE

- .1 Manufacturer/Supplier Qualifications:
 - .1 Performed by a fully experience and recognized manufacturer of GFRC Products whose manufacturing plant and facilities are currently certified to CSA Precast requirements at the time of bidding and maintain that certification throughout the duration of the Contract.
 - .2 Must be designated a CSA-Certified Plant under CSA Precast requirements, and having minimum 5 years experience in manufacturing of Products specified in this Section.

PETRA SPEC NOTE: Retain subparagraph below if requiring manufacturer to install GFRC.

- .1 Manufacturer's responsibility includes fabricating [and installing] GFRC panels and providing professional engineering services needed to assume engineering responsibility for GFRC panels, including preparation of Shop Drawings and engineering analysis, based on GFRC production test values.
- .3 Have adequate financing, equipment, plant, and skilled personnel to detail, fabricate and erect the work of this Section as required by the Specifications and Drawings.

PETRA SPEC NOTE: Retain subparagraph below if installation is performed by trades other than GFRC manufacturer.

- .2 Erector Qualifications:
 - .1 Installers shall be authorized by the manufacturer and the work shall be supervised by a person having a minimum of 5 years experience installing similar type and size projects.
- .3 Steel Sheet Certification: Obtain mill certificates, signed by manufacturer of steel sheet or test reports from a qualified testing agency confirming cold-formed metal framing complies with requirements of this Section.
- .4 Mill Certificates: Obtain certified mill test reports from manufacturer of structural-steel shales and hollow structural sections used in panel framing complies with the requirements of this Section.

PETRA SPEC NOTE: Mock-ups establish quality of the work for the materials indicated in this Section. Delete the following paragraph if the scope of work in this Section is minimal and a mock-up is not required.

1.9 MOCK-UP:

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .1 Mock-Ups: In accordance with [Division 01] [Section 01 43 39].
- .2 Construct mock-ups to demonstrate constructability, coordination of trades, and sequencing of Work; and to ensure materials, components, subassemblies, assemblies, and interfaces integrate into a system complying with indicated performance and aesthetic requirements.
- .3 Build integrated mock-ups using products, installers and construction methods that will be used in completed construction of this Section.
- .4 Coordinate installation of materials and products specified in other Sections of the Project Manual, that are required to be integrated into mock-ups of this Section, to provide a complete system.
- .5 Prior to commencing work, erect a sample panel mock-up consisting of specified materials and including the following:
 - .1 Substrate support framing and/or sheathing;
 - .2 Attachment to building structure;
 - .3 Joint sealants;

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .4 [Air and weather barriers;]
- .5 [Thermal insulation;]
- .6 Flashing and sheet metal trim;
- .7 Adjacent wall facades that require tie-in with this Section.
- .6 Provide and document modifications to construction details and interfaces between components and systems required to properly sequence the Work, or to pass performance testing requirements.
 - .1 Obtain Consultant's approval for all modifications prior to proceeding with work.

PETRA SPEC NOTE: Panels supplied for Mock-ups are "Project Panels", and therefore should remain part of the Work once workmanship, quality control measures, and finishes have been approved.

PETRA SPEC NOTE: If Mock-ups are required on the Project, keep the following subparagraphs.

- .7 Mock-up Review Meeting:
 - .1 Schedule mock-up review meeting, attended by [Contractor] [Construction Manager], [Subcontractor] [Trade Contractor], Panel Manufacturer's Representative and Consultant.

- .2 Review mock-up for quality of workmanship, detailing and fastening, adjacent materials tie-in, and accessories installation. Do not proceed with remaining work until workmanship, colour, and texture are approved by [Architect] [Consultant].
- .3 Retain approved mock-ups constructed in place as part of the Work. Seamlessly incorporate approved mock-up panels into remaining Work.

PETRA SPEC NOTE: PETRA will coordinate the shipping and delivery of panels to site with the Installer. Material must be checked by the site supervisor on receipt at site.

PETRA SPEC NOTE: PETRA must be informed in writing within a reasonable time of any deficiencies.

1.10 DELIVERY, STORAGE, HANDLING AND PROTECTION

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .1 Follow packaging, shipping and product handling requirements recommended by the manufacturer, and as indicated in [Division 01] [Section 01 45 43].
- .2 Coordinate deliveries to comply with construction schedule and arrange ahead for off the ground, under cover storage location. Do not load any area beyond the design limits.
- .3 Materials shall be carefully checked, unloaded, stored, and handled to prevent damage. Protect materials with suitable non-staining waterproof coverings.
- .4 Store material in original, undamaged containers or wrappings with manufacturer's seals and labels intact, protected from exposure to harmful weather conditions and at temperature levels as recommended by manufacturer.
- .5 Delivery: At the time of delivery, visually inspect all materials for damage. Note any damaged to materials on the receiving ticket and immediately report to the shipping company and the material manufacturer.
 - .1 Remove damaged materials from the site immediately.
- .6 Storage:
 - .1 Store materials as recommended by manufacturer and conforming to applicable safety regulatory agencies. Refer to all applicable data including but not limited to Safe Use Instruction Sheets, Product Data sheets, product labels, and specific instructions for personal protection.
 - .2 Store materials in original packaging, on a dry, level, firm, and clean surface. Stack no more than two bundles high. Elevate one end of bundle to allow moisture run-off, cover and ventilate to allow air to circulate and moisture to escape.
 - .3 Store GFRC panels with non-staining spacers on level and firm supporting surfaces.
- .7 Handling:
 - .1 Material shall be handled in accordance with sound material handling practices and in accordance with manufacturer's written instructions, and applicable health and safety guidelines for the location of the Project.
- .8 Lifting Device:
 - .1 Use lifting devices capable of maintaining unit shape during manufacture, storage, transportation, erection, and in position for fastening.

- .9 Protection:
 - .1 Restrict traffic by other trades during installation.
 - .2 Provide adequate protection of completed Work of this Section, to prevent damage by other trades.
 - .3 Protect edges of unit to prevent staining, chipping, or spalding.

1.11 SEQUENCING

- .1 Ensure that locating templates and other information required for installation of products of this Section are furnished to affected trades in time to prevent interruption of construction progress.
- .2 Ensure that products of this Section are supplied to affected trades in time to prevent interruption of construction progress.

1.12 SITE CONDITIONS

- .1 Site Measurements: Verify dimensions by site measurements before fabrication and indicate measurements on Shop Drawings where Work of this Section is indicated to fit walls and other construction.
 - .1 Coordinate fabrication schedule with construction progress to avoid delaying the Work.
 - .2 Locate all concealed framing, blocking, anchoring, plates, and reinforcements that support Work of this Section by site measurements before being enclosed and indicate measurements on Shop Drawings.
- .2 Established Dimensions: Establish dimensions and proceed with fabricating Work of this Section without confirmed site measurements where site measurements cannot be made without delaying the Work.
 - .1 Coordinate with the construction to ensure that actual dimensions correspond to established dimensions. Allow for trimming and fitting.

1.13 WARRANTY

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .1 Provide extended warranties in accordance with [Division 01] [Section 01 78 36].
- .2 Manufacturer's Material Warranty: Provide a manufacturer's Limited Liability Material Warranty, executed by the authorized company official. The warranty shall commence upon successful completion of Manufacturer's project inspection and the Date of Substantial Completion.

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .3 Workmanship Warranty: Manufacturer agrees to repair or replace GFRC [panel] [components] that fail in workmanship within the warranty period identified below.
 - .1 Items covered by the warranty include cracking, deformation, and discoloration.

PETRA SPEC NOTE: The manufacturer offers a standard 10 warranty. Extended warranties up to 20 years can be selected, if required, at additional expense.

PETRA SPEC NOTE: Select one of the following warranty options below and delete the warranty option not required.

- .4 Warranty Type and Duration:
 - .1 Standard Warranty Period: 10 years from date of [Substantial Completion] [Ready-for-Takeover].
- .5 General Warranty Information:
 - .1 The manufacturer or the installer shall not be liable for any consequential or incidental damages as defined within the Manufacturer's Warranty document.
 - .2 Manufacturer's liability shall be limited to repair, replacement, or correction of defective workmanship and materials, as defined within the terms of the Manufacturer's Warranty.
 - .3 The Manufacturer's warranty excludes leaks or other defects due to causes stated within the warranty document, including but not limited to structural failure, and movement of the structure.

2 Products

2.1 MANUFACTURER

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .1 Basis-of-Design Products: Products named in this Section were used as the basis-of-design for the project; additional manufacturers offering similar products may be incorporated into the work of this Section provided they meet the performance requirements established by the named products, and provided they submit requests for substitution in accordance with [Division 01][Section 01 33 00 Submittal Procedures].
- .2 Acceptable Materials Manufacturers: Subject to compliance with requirements specified in this Section and as established by the Basis-of-Design Materials, manufacturers offering products that may be incorporated into the Work include but are not limited to, the following:
 - .1 Petra Design Inc.
47 St. Regis Crescent, Toronto, ON, M3J 1Y6
Phone:1-416-746-9668

2.2 DESCRIPTION

- .1 Glass Fiber Reinforced Concrete (GFRC) is cement-based composite material reinforced with glass fibers and consists of the following:
 - .1 Cementitious Binder (Portland cement or other suitable binders).
 - .2 Fine Aggregates (Silica sand).
 - .3 Water-Reducing Admixtures.
 - .4 Glass-Fibers (typically alkali-resistant AR glass fibers).
 - .5 Polymer Additives (enhanced durability and workability).

PETRA SPEC NOTE: PETRA has in-house capability to test to CSA A23.2 for the following:

- Compressive strength testing of concrete cylinders
- Air content of freshly mixed plastic concrete
- Temperature of freshly mixed plastic concrete
- Slump of freshly mixed plastic concrete.

- .2 GFRC components: Meet or exceed the following properties and values:
 - .1 Compressive Strength (ASTM C39): 30-50 MPa
 - .2 Flexural Strength (ASTM C947): 17-21 MPa
 - .3 Tensile Strength (ASTM C1230): 4-6 MPa
 - .4 Unit Weight (ASTM C138): 1700-2000 kg/m³
 - .5 Water Absorption (ASTM C948): < 5%
 - .6 AR Glass-Fiber Content (PCI MLN-128): 5% min

2.3 PERFORMANCE CRITERIA

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .1 Engage a qualified Professional Engineer, licenced and practicing in the Place of the Work, as defined in [Division 01] [Section 01 40 00 Quality Requirements], to design GFRC panels, including panel frames, anchors, and connections.
- .2 CSA: Comply with requirements and recommendations in the CSA A23.4, unless more stringent requirements are indicated.

2.4 MATERIALS

- .1 Portland Cement: Conforming to ASTM C150/C150M, Type 1, II, or III.
- .2 Metakaolin: Conforming to ASTM C618, Class N.
- .3 Glass Fibers:
 - .1 Alkali resistant, with a minimum zirconia content of 16 percent, 25 to 50 mm (1 to 2 inches) long, specifically produced for use in GFRC, and complying with ASTM C1666/C1666M.
- .4 Sand:
 - .1 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.
- .5 Facing Aggregate:
 - .1 Coarse Aggregate: Conforming to ASTM C33/C33M, 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 sample.
 - .2 Fine Aggregate: Natural sand or sand manufactured from coarse aggregate, conforming to ASTM C33/C33M, 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.

- .6 Colouring Admixture:
 - .1 Conforming to ASTM C979/C979M, synthetic mineral-oxide pigments or coloured water-reducing admixtures, temperature stable, nonfading, and alkali resistant.

PETRA SPEC NOTE: Revise below to suit Project requirements and remove square brackets.

- .2 [Colour: As selected by [Consultant] [Architect] [As indicated on Drawings] [As indicated in the Finishes Schedule] [Colour: _____].]
- .7 Water:
 - .1 Potable; free from deleterious material that may affect colour stability, setting, or strength of GFRC and complying with chemical limits of PCI MNL 130.
- .8 Polymer Curing Admixture:
 - .1 Acrylic thermoplastic copolymer dispersion complying with PCI MNL 130.
- .9 Air-Entraining Admixture:
 - .1 Conforming to ASTM C260/C260M, containing not more than 0.1 percent chloride ions.
- .10 Water-Reducing Admixture: Conforming to ASTM C494/C494M, Type A and F.

PETRA SPEC NOTE: Structural Engineer to design and select the type of anchors and connectors for the project. Modifications to anchoring shall be reviewed prior to start of production.

PETRA SPEC NOTE: Select only the options below that apply for the Project and delete all items not required on this Project.

2.5 ANCHORS, CONNECTORS, AND MISCELLANEOUS ACCESSORIES

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

PETRA SPEC NOTE: Select one of the following finishing options, and delete items not required on this Project.

PETRA SPEC NOTE: Hot-dip galvanized finishes provide better corrosion resistance protection than Electrodeposited zinc coating.

- .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].
- .2 Finish: Shop primed with MPI 79 paint on surfaces prepared to comply with SSPC-SP2, "Hand Tool Cleaning," or better.
- .2 Anchors and Inserts:
 - .1 Steel for anchors shall conform to the appropriate requirements of ASTM A29/A29M or ASTM A108 with a minimum diameter of 6 mm (1/4 inch). 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.

PETRA SPEC NOTE: Select one of the following finishing options, and delete items not required on this Project.

- .2 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] [electrodeposited cadmium according to ASTM B 766, Type II, Class 25.]
- .3 Carbon-Steel Bars (Flex, Gravity, and Seismic Anchors): Conforming to ASTM A108, AISI Grade 1018. Finish steel bars less than 4.76 mm (3/16 inch) thick as follows:

PETRA SPEC NOTE: Select one of the following finishing options, and delete items not required on this Project.

- .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].
- .2 Finish: Shop primed with MPI 79 paint on surfaces prepared to comply with SSPC-SP2, "Hand Tool Cleaning," or better.
- .4 Bolts: Conforming to ASTM A307 or ASTM A325.
- .5 Sealant: As specified in Section 07 92 00 Joint Sealant.
- .6 Galvanizing Repair Paint: Touch up damaged galvanized surfaces according to ASTM A780/A780M.

2.6 PANEL FRAME MATERIALS

- .1 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 1.37 mm (0.0538 inch), of web depth indicated, with stiffened flanges, U-shaped steel track, and of the following steel sheet:
 - .1 Exterior Face of Panel: Metallic-Coated Steel Sheet conforming to ASTM A653/A653M, structural-steel sheet, G90 (Z275) zinc coating, of grade required by structural performance of framing.
 - .2 Painted, Non-Metallic-Coated Steel Sheet: conforming to 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.
- .2 Hollow Structural Sections: Steel tubing, conforming to ASTM A500, Grade B, or ASTM A513. Finish hollow structural sections with wall thickness less than 4.76 mm (3/16 inch) 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.
- .3 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.

2.7 GFRC MIXES

- .1 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.
- .2 Face Mix: Proportion face mix of Portland cement, fine and coarse aggregates, and admixtures to comply with design requirements.
- .3 Mist Coat Mix: Portland cement, sand slurry, and admixtures, of same proportions as backing mix without glass fibres.
- .4 Polymer Curing Admixture: 6 to 7 percent by weight of polymer-curing admixture solids to dry Portland cement.

PETRA SPEC NOTE: Air content range below is based on PCI MNL 130 recommendations for freeze-thaw conditions.

PETRA SPEC NOTE: Retain below paragraph if GFRC is exposed to freeze-thaw conditions and if mix does not use polymer curing admixture.

- .5 Air Content: 8 to 10 percent; conforming to ASTM C185; when required.
- .6 Colouring Admixture: Not to exceed 10 percent of cement weight.

2.8 FABRICATION

- .1 Mould Fabrication:
 - .1 Fabricate moulds that will result in finished GFRC complying with profiles, dimensions, and tolerances indicated on Shop Drawings and in this Section, without damaging GFRC during stripping.
 - .2 Moulds shall be constructed to prevent water leakage and loss of cement paste.
 - .1 Coat contact surfaces of moulds with form-release agent.

PETRA SPEC NOTE: Usually retain subparagraph above.

PETRA SPEC NOTE: Delete the paragraph below unless exposed-aggregate surfaces require surface retarder to achieve desired finish.

- .2 Coat contact surfaces of moulds with surface retarder where required.

PETRA SPEC NOTE: Retain paragraph below if using form liners on project.

- .3 Place form liners 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.
- .2 GFRC Fabrication:
 - .1 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.
 - .2 Spray Application:
 - .1 Spray mist coat over moulds to a nominal thickness of 3 mm (1/8 inch) on planar surfaces.

PETRA SPEC NOTE: Revise below to suit Project requirements and remove square brackets.

- .2 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.
- .3 Consolidate backing mix by rolling or other technique to achieve complete encapsulation of glass fibres and compaction.
- .4 Measure thickness with a pin gage or other acceptable method at least once for each 0.5 sq. m (5 sq. ft.) of panel surface. Take not less than six measurements per panel.
- .3 Hand form and consolidate intricate details, incorporate formers, or infill materials, and over spray before material reaches initial set to ensure complete bonding.
- .4 Attach panel frame to GFRC before initial set of GFRC backing, maintaining a minimum clearance of 13 mm (1/2 inch) from GFRC backing, and without anchors protruding into GFRC backing.
- .5 Build up homogeneous GFRC bonding pads over anchor feet, maintaining a minimum thickness of 13 mm (1/2 inch) over top of anchor foot, before initial set of GFRC backing. Measure pad thickness at 25 percent of anchor locations.
- .6 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.
- .7 Curing: Employ initial curing method that will ensure sufficient strength for removing units from mould. Comply with PCI MNL 130 procedures.
 - .1 Keep moisture of the surface of mixes with polymer curing admixtures during first 3 hours of curing. Maintain temperature between 16 and 49 Degree Celsius during the first 12 to 16 hours.

PETRA SPEC NOTE: The following paragraph is to be coordinated with Shop Drawings.

- .8 Panel Identification: Mark each GFRC panel to correspond with identification mark on Shop Drawings.

2.9 FABRICATION TOLERANCES

- .1 Manufacturing Tolerances: Unless otherwise specified, GFRC panel shall be manufactured to comply with CSA A23.4 for dimension, position, and tolerances.
 - .1 Overall Height and Widths of Units, measured at face adjacent to mould:
 - .1 3 m (10 feet) or under, ± 3 mm (1/8 inch).
 - .2 More than 3 m (10 feet), ± 3 mm per 3 m (1/8 inch per 10 feet); 6 mm (1/4-inch) maximum.
 - .2 Edge Return Thickness: Plus 13 mm (1/2 inch), minus 0 mm (0 inch).
 - .3 Architectural Facing Thickness: plus 3 mm (1/8 inch), minus 0 inch (0 mm).
 - .4 Backing Thickness: Plus 6 mm (1/4 inch), minus 0 inch (0 mm).
 - .5 Panel Depth from Face of Skin to Back of Panel Frame or Integral Rib: Plus 10 mm (3/8 inch), minus 6 mm (1/4 inch).

- .6 Angular Variation of Plane of Side Mould: ± 0.8 mm per 75 mm (1/32 inch per 3 inches) of depth or ± 1.5 mm (1/16-inch) total, whichever is greater.
- .7 Variation from Square or Designated Skew (Difference in Length of Two Diagonal Measurements): ± 3 mm per 1800 mm (1/8 inch per 72 inches) or ± 6 mm (1/4-inch) total, whichever is greater.
- .8 Local Smoothness: 6 mm per 3 m (1/4 inch per 10 feet).
- .9 Bowing: Not to exceed L/240 unless unit meets erection tolerances using connection adjustments.
- .10 Length and Width of Block outs and Openings within One Unit: ± 6 mm (1/4 inch).
- .11 Location of Window Opening within Panel: ± 6 mm (1/4 inch).
- .12 Maximum Permissible Warpage of One Corner out of the Plane of the Other Three: 1.5 mm per 300 mm (6 mm per 3 m) of distance from nearest adjacent corner.
- .2 Position Tolerances: Measured from datum line locations, as indicated on Shop Drawings.
 - .1 Panel Frame and Track: ± 6 mm (1/4 inch).
 - .2 Inserts: ± 13 mm (1/2 inch).
 - .3 Special Handling Devices: ± 75 mm (3 inches).
 - .4 Location of Bearing Devices: ± 6 mm (1/4 inch).
 - .5 Block outs: ± 10 mm (3/8 inch).
- .3 Panel Frame Tolerances:
 - .1 Vertical and Horizontal Alignment: 6 mm per 3 m (1/4 inch per 10 feet).
 - .2 Spacing of Framing Member: ± 10 mm (3/8 inch).
 - .3 Squareness of Frame: Difference in length of diagonals of 10 mm (3/8 inch).
 - .4 Overall Size of Frame: ± 10 mm (3/8 inch).

2.10 FINISHES

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .1 Exposed-face surfaces of GFRC shall be free of joint marks, grain, or other obvious defects. Finish exposed-face surface of GFRC to match approved [design reference sample] [and] [mock-ups].

PETRA SPEC NOTE: Revise below to suit Project requirements and remove square brackets.

- .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.

2.11 SOURCE QUALITY CONTROL

- .1 Quality-Control Testing: Establish and maintain a quality control program for manufacturing of GFRC in accordance with CSA A23.1-19 Annex U.
 - .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.
 - .1 For each test board, determine glass-fibre content according to ASTM C1229, and flexural yield and ultimate strength according to ASTM C947.

3 Execution

3.1 EXAMINATION

- .1 Verification of Conditions:
 - .1 Examine substrates to receive work and surrounding adjacent surfaces for conditions affecting installation. Coordinate with related sections to ensure proper dimensions are maintained.
 - .2 Verify site dimensions by accurate field measurements, true and level, so that work will be accurately designed, fabricated, and fitted to the structure.
 - .3 Verify that framing members and structural alignment are within recommended tolerances and ready to receive panel system.

PETRA SPEC NOTE: Edit the following paragraph to make the required selections and remove square brackets indicated below.

- .2 Notify [Architect] [Consultant] in writing of any conditions that are not acceptable.
- .3 Proceed with installation after verification and correction of surface conditions acceptable to manufacturer.

3.2 PREPARATION

- .1 Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- .2 Perform additional preparation procedures as required by manufacturer's instructions.

3.3 ERECTION

- .1 Install clips, hangers, and other accessories required for connecting GFRC panels to supporting members and backup materials.
- .2 Lift GFRC panels and install without damage.
- .3 Install GFRC panels level, plumb, square, and in alignment, shim where necessary. 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.
- .4 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.
- .5 At bolted connections, use lock washers or other acceptable means to prevent loosening of nuts.
- .6 Provide expansion joints where moving joints occurs in substrates.
- .7 Patch exposed anchor points to texture of unit.

3.4 ERECTION TOLERANCES

- .1 Erect GFRC panels to comply with the following noncumulative tolerances:
 - .1 Plan Location from Building Grid Datum: ± 13 mm (1/2 inch).
 - .2 Top Elevation from Nominal Top Elevation:
 - .1 Exposed Individual Panel: ± 6 mm (1/4 inch).
 - .2 Nonexposed Individual Panel: ± 13 mm (1/2 inch).
 - .3 Exposed Panel relative to Adjacent Panel: 6 mm (1/4 inch).
 - .4 Nonexposed Panel relative to Adjacent Panel: ± 13 mm (1/2 inch).
 - .3 Support Elevation from Nominal Elevation:
 - .1 Maximum Low: ± 13 mm (1/2 inch).
 - .2 Maximum High: 6 mm (1/4 inch).
 - .4 Maximum Plumb Variation over the Lesser of Height of Structure or 30 m (100 Feet): 25 mm (1 inch).
 - .5 Plumb in Any 10 Feet (3 m) of Element Height: 6 mm (1/4 inch).
 - .6 Maximum Jog in Alignment of Matching Edges: 6 mm (1/4 inch).
 - .7 Maximum Jog in Alignment of Matching Faces: 6 mm (1/4 inch).
 - .8 Face Width of Joint: As follows (governs over joint taper):
 - .1 Panel Dimension 6 m (20 Feet) or Less: ± 6 mm (1/4 inch).
 - .2 Panel Dimension More Than 20 Feet (6 m): ± 10 mm (3/8 inch).
 - .9 Maximum Joint Taper: 10 mm (3/8 inch).
 - .10 Joint Taper in 10 Feet (3 m): 6 mm (1/4 inch).
 - .11 Differential Bowing, as Erected, between Adjacent Members of Same Design: 6mm (1/4 inch).

3.5 REPAIRS

- .1 Repairs are permitted provided the structural adequacy of GFRC panel is not impaired.
- .2 Repairs to be consistent with the colour, texture, uniformity, and appearance of adjacent exposed surfaces.
- .3 Prepare and repair accessible damaged galvanized coatings with galvanizing repair paint according to ASTM A780/A780M.
- .4 Surface shall be clean and dry prior to applying finish.
- .5 Use wire brush to clean welded areas on prime-painted components. Use same type of shop primer on prime-painted components.
- .6 Remove and replace damaged GFRC panels or component when repairs do not comply with requirements.

3.6 CLEANING

- .1 Perform cleaning procedures, if necessary, according to GFRC manufacturer's written instructions.
- .2 Clean soiled GFRC surfaces with detergent and water, using soft fibre brushes and sponges, and rinse with clean water.
- .3 Progress Cleaning: Leave work area clean at the end of each workday, ensuring safe movement of passing pedestrians.
 - .1 Remove excess sealant with solvent recommended by manufacturer.
 - .2 Clean installation of residue and remove unused materials and products. Remove site cuttings from finish surfaces.
 - .3 Touch-up, repair or replace panels and trim that have been damaged.
- .4 Final Cleaning:
 - .1 At completion of installation, clean all surfaces so they are free of foreign matter using cleaners recommended by panel manufacturer.
 - .2 Do not use cleaning materials or processes that could change the appearance of exposed finishes.
 - .3 Clean and wash prefinished surfaces with mild soap and water; rinse with clean water.
 - .4 After panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.
- .5 Waste Management:
 - .1 Coordinate recycling of waste materials and packaging at appropriate facility, diverting waste from landfill.
 - .2 Certified installer shall be responsible for ensuring waste management efforts are practiced.

3.7 PROTECTION

- .1 Protect installed products until completion of project.
- .2 Clean all exposed surfaces of wall panels and touch-up, repair or replace damaged products before Substantial Completion. Do not use abrasive cleaners.

END OF SECTION