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DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS  
OFFICE OF THE SECRETARY  
MANILA

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DEPARTMENT ORDER )  
No. **119** )  
Series of 2016 )

SUBJECT: DPWH Standard Specification for  
ITEM 1043 – GLASS FIBER  
REINFORCED CONCRETE (GFRC)  
CLADDING PANELS

In line with the mandate of the Department in providing effective standard specifications in the implementation of various infrastructure projects and in view of the need of setting a standard specification for interior cementitious fireproofing, the attached **DPWH Standard Specification for Item 1043 – Glass Fiber Reinforced Concrete (GFRC) Cladding Panels** is hereby prescribed, for the guidance and compliance of all concerned.

This specification shall form part of the on-going revision of the DPWH Standard Specifications for Public Works Structures (Buildings, Ports and Harbors, Flood Control and Drainage Structures and Water Supply Systems), Volume III, 1995 Edition.

This Order shall take effect immediately.

  
**ROGELIO L. SINGSON**  
Secretary

Department of Public Works and Highways  
Office of the Secretary



WIN6U01311

**DPWH Standard Specification for  
Item 1043 – Glass Fiber Reinforced Concrete (GFRC)  
Cladding Panels**

**1043.1 Description**

This Item shall consist of furnishing all materials, labor, tools, and equipment required in undertaking proper installation of glass fiber reinforced concrete cladding panels as shown on the Plans and in accordance with this Specification.

The materials in this Item shall include glass fiber reinforced concrete (GFRC) cladding panels, panel frames, anchors, and connection hardware.

**1043.1.1 Definition**

For the purpose of this Item, the following terms shall be defined:

***GFRC Cladding Panel.*** A prefabricated cementitious, composite material, cast into thin, lightweight non-structural exterior panel commonly produced by spray-up process either manually using hand equipment or mechanically on a production line. It is composed of portland cement, aggregate, water, alkali-resistant glass fibers, polymer and additives. GFRC have a high strength and good fire retardant property.

***Fibers.*** Slender and elongated filaments in the form of bundles, networks, or strands of any natural or manufactured material that can be distributed throughout freshly mixed concrete.

**1043.2 Material Requirements**

GFRC can be manufactured using different combinations of materials to meet the required properties, varied mix composition/proportion, type of cement, length, and orientation of glass fibers.

The supplier shall secure copies of certification letters or letters of compliance of each materials being used with standard requirements, issued by the supplier to the manufacturer/fabricator. These shall form part of the submittals stated in Section 1043.2.4 Submittals.

**1043.2.1 GFRC Materials**

**1043.2.1.1 Portland Cement**

Cement shall conform to the applicable requirements of Item 700, Hydraulic Cement. The use of Type I Portland Cement is recommended and shall be of one type, brand and source throughout the GFRC panel production, and meeting the requirements of ASTM C 150 "Specification for Portland Cement."

**1043.2.1.2 Alkali-Resistant Glass Fibers**

Glass fibers shall be resistant to aqueous alkaline solutions and corrosion attacks, environmental and other harmful effects. A certification from the producer shall be provided showing that the glass fiber conforms to ASTM C 1666M "Standard Specification for Alkali Resistant (AR) Glass Fiber for GFRC and Fiber-Reinforced Concrete and Cement." The properties of alkali-resistant glass fiber in accordance to the ASTM standards and in reference to PCI MNL 130 are shown in Table 1.

**Table 1. Properties of Alkali-Resistant Glass Fiber**

Property	Requirement
Zirconia Content	16% Minimum
Length	25 to 50 mm
Density	2.7 g/cm <sup>3</sup>
Tensile Strength	1.0 – 1.7 GPa
Young's Modulus	78 GPa
Elongation	2 ± 0.5 %

#### **1043.2.1.3 Fine Aggregate**

The fine aggregate to be used shall be a natural sand or sand manufactured from coarse aggregate. Its shall conform to ASTM C33 "Specification for Concrete Aggregates," except for gradation with a maximum size of 5% passing No. 100 (0.15 mm) sieve and maximum of 3% passing No. 200 (0.075 mm) sieve, and in accordance with the applicable requirements of PCI MNL 130, Precast/Prestressed Concrete Institute Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products.

#### **1043.2.1.4 Coarse Aggregate**

The coarse aggregate shall be clean, hard, strong, durable and inert, free from deleterious or staining material and shall comply with ASTM C 33 "Specification for Concrete Aggregates," except for gradation. The nominal maximum size shall 6 mm diameter as recommended in the applicable requirements of PCI MNL 130.

#### **1043.2.1.5 Sand for GFRC Backing**

The sand for GFRC backing shall be washed and dried, free from contaminants and lumps, and conforms with the compositional requirements of ASTM C 144 "Specification for Aggregate for Masonry Mortar." All fines shall pass through a No. 20 (0.85 mm) sieve and limited to a maximum of 2% passing a No.100 (0.15 mm) sieve. The recommended composition of silica sand shall be as shown in Table 2 in accordance with the applicable requirements of PCI MNL 130. All sand shall be obtained from one source for the entire GFRC panel production.

**Table 2. Recommended Silica Sand Composition**

Property	Requirement
Silica Content	96% to 98%
Soluble Salts (Sulfates, Chlorides, and Alkalies such as Na <sub>2</sub> O, K <sub>2</sub> O, CaO)	1% Maximum
Clay & Organic Matter	0.5% Maximum
Loss on Ignition	0.5% Maximum
Moisture Content	2% Maximum

#### **1043.2.1.6 Water**

The mixing water to be used shall conform to the requirements of Item 714, Water. It shall be clean, potable and free of any deleterious material that may affect color, stability, setting, staining or strength of GFRC backing or face mix.

### **1043.2.1.7 Admixtures**

The admixtures to be used shall be in accordance with the recommendations of supplier. The manufacturer must ensure that it is of one type, brand and source throughout the GFRC panel production, has no adverse effect on the product, and shall not contain more than 0.1 percent (0.1%) chloride ions.

It shall conform to the requirements of ASTM C 494 "Specification for Chemical Admixtures for Concrete" for chemical admixtures, ASTM C 260 "Standard Specification for Air-Entraining Admixtures for Concrete" for air entrainment, and ASTM C 618 "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete" for fly ash or natural pozzolan admixtures.

### **1043.2.1.8 Polymer Curing Admixture**

Acrylic Thermoplastic Copolymer shall be used in accordance with the manufacturer's instructions and shall conform to the specifications in Table 3 in reference to Appendix G, PCI MNL 130.

**Table 3. Specification for Polymer Curing Admixture**

<b>Property</b>	<b>Requirement</b>
Compound Type	Aqueous thermoplastic co-polymer dispersion
Polymer type	Acrylic based
Solids	45% - 55% by weight
pH	8 – 10
Appearance	Milky white, creamy, free from lumps
Minimum film-formation temperature	7 – 12 °C
Ultraviolet resistance	Good
Alkali resistance	Good

### **1043.2.1.9 Coloring pigments**

Powder pigments or dispersions shall conform to the requirements of ASTM C 979 "Specification of Pigments for Integrally Colored Concrete." Pigments shall not affect concrete strength and setting time. It shall be stable at high temperatures, colorfast in sunlight, resistant to alkalis and weak acids, virtually free of calcium sulfate, and shall not exceed 10% of amount of cement.

### **1043.2.2 Steel Framing Materials**

The welded prefabricated steel frame system shall be produced in accordance with the approved shop drawings, fabricated to meet design loads, wind loads, handling and erection loads. All fixings components shall conform to the required properties of steel framing system in Table 4 and shall be supplied by cladding manufacturer as prescribed in Section 1043.2.4, Submittals.

### 1043.2.2.1 Metal Studs and Track

**Table 4. Properties of Steel Framing System**

Material	Requirements
1. Galvanized steel	<ul style="list-style-type: none"> <li>Conforms to ASTM A 653M*</li> </ul>
2. Galvanized coating	<ul style="list-style-type: none"> <li>Conforms to ASTM A 653M*</li> <li>Minimum G-60 coating</li> </ul>
3. Studs	<ul style="list-style-type: none"> <li>Conforms to ASTM A 653M*</li> <li>Minimum Yield Strength : 276 MPa</li> <li>Indexed and spaced at approximately 609.6 mm on center</li> </ul>
4. Track	<ul style="list-style-type: none"> <li>Conforms to ASTM A 653</li> <li>Minimum Yield Strength : 207 MPa</li> </ul>
5. Members	<ul style="list-style-type: none"> <li>100 mm x 16 gauge and 152 mm x 16 gauge or as required per design calculations</li> </ul>
6. Light gage steel materials	<ul style="list-style-type: none"> <li>Prime-painted conforming to MP 179 or SSPC Paint 25 per ASTM A 1011</li> <li>Thickness : less than 5 mm, painted or galvanized to inhibit corrosion.</li> </ul>

\*ASTM A 653M "Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process"

### 1043.2.2.1 Structural Tubing

Structural tubing shall be shop prime painted and formed from steel which conforms to ASTM A 500M Grade B "Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes," or ASTM A 513M "Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing." It shall have a minimum yield strength of 317 MPa.

### 1043.2.2 Flex Anchors

Flex anchors shall conform to ASTM A 29M "Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought" or ASTM A 108 "Standard Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality" and ASTM B 633 "Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel" for flex anchors that are zinc plated. The minimum diameter of bent rod shall be 6 mm, with a minimum yield strength of 248 MPa.

### 1043.2.2.3 Miscellaneous Steel (e.g. Channels, Angles)

The surface shall be shop prime painted and conform to ASTM A 36M "Standard Specification for Carbon Structural Steel," with a minimum yield strength of 248 MPa and minimum ultimate strength of 400 MPa, except tube shapes.

### 1043.2.2.4 Reinforcing (Deformed) Bars

Deformed billet steel bars, Grade 60 shall conform to ASTM A 706M "Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement" while galvanized rebar, Class II, Grade 40 shall conform to ASTM A 767M "Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement."

### **1043.2.2.5 Headed Stud Embed Anchors**

Headed stud embed anchors shall conform to ASTM A 108 "Standard Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality," with a minimum yield strength of 345 MPa and minimum ultimate yield strength of 414 MPa.

### **1043.2.2.6 Anchor Bolts**

Anchor bolts shall conform to ASTM A 307 "Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength" or ASTM A 325 "Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength."

## **1043.2.3 Properties/Characteristics of GFRC Composites**

### **1043.2.3.1 Typical Mixes**

The GFRC mix shall be composed of Portland Cement, glass fibers, sand and selected admixtures combined in proper proportions to meet design requirements. Mixture shall be asbestos-free with alkali-resistant glass fiber content of not less than 4% but not more 6% by weight of total GFRC mix. The typical design mix of GRFC mix consists of 5% by weight (of total mix) of alkali-resistant glass fiber randomly distributed throughout the Portland Cement/sand mix.

### **1043.2.3.2 GFRC Properties**

The supplier shall provide copies of certified tests of all the properties of GFRC composites being tested complying with the requirements of ASTM standards. These shall form part of the submittals stated in Section 1043.2.4, Submittals.

**Table 5. GFRC Properties at 28 Days**

<b>Property</b>	<b>Requirement</b>
Tensile stresses	Not more than 40 percent (<40%) of the flexural strength of GFRC
Ultimate flexural Strength	17.2 to 27.6 MPa
Yield Flexural Strength	6.9 to 12.4 MPa
Ultimate Tensile Strength	6.9 to 11.0 MPa
Yield Tensile Strength	4.8 to 6.9 MPa
Compressive Strength (edgewise)	48.3 to 82.8 MPa
Shear Strength (interlaminar)	2.8 to 5.5 MPa
Shear Strength (in-plane)	6.9 to 11.0 MPa
Coefficient of Thermal Expansion	152.4 to 228.6 mm/°F x 10 <sup>6</sup>
Modulus of Elasticity	1.5x10 <sup>6</sup> to 2.9x10 <sup>6</sup>
Density	2240 kg/cu.m.
Surface Burning Characteristics	Flame spread index of 0 Smoke developed index of 5 Fuel contribution of 3

**Table 6. Recommended Test Methods to Determine the Physical Properties of GFRC Composites**

Physical Property	Test Method	Description
Surface Burning	ASTM E 84 -15b	Standard Test Method for Surface Burning Characteristics of Building Materials
Impact Resistance	ASTM D 256-10e1	Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics
Flexural Strength	ASTM C 947-03 (2009)	Standard Test Method for Flexural Properties of Thin-Section Glass-Fiber-Reinforced Concrete (Using Simple Beam with Third-Point Loading)
Compressive Strength	ASTM C 109M-13e1	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
Hardness	ASTM D 2853-13a	Standard Test Method for Indention Hardness of Rigid Plastics by Means of a Barcol Impressor
	ASTM D 785-08 (2015)	Standard Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials
Thermal Expansion	ASTM D 696-08e1	Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between – 30°C and 30°C with a Vitreous Silica Dilatometer
Humidified Deflection	ASTM C 473-15	Standard Test Method for Physical Testing of Gypsum Panel Products
Weather Resistance	ASTM G 152-13	Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
Glass Fiber Content	ASTM C 1229	Standard Test Method for Determination of Glass Fiber Content in Glass Fiber Reinforced Concrete (GFRC) (Wash-Out Test)
Tensile Load Capacity of GFRC Bonding Pads Used for Attaching Steel Anchors to GFRC panels.	ASTM C 1230	Standard Test Method for Performing Tension Tests on Glass-Fiber Reinforced Concrete (GFRC) Bonding Pads

#### **1043.2.3.3 Facing Mix**

Face mix shall be proportioned in compliance with the design requirements. Thickness shall, generally, be the minimum possible to achieve the desired finish requirement.

#### **1043.2.3.4 GFRC Skin**

Panel skin shall not be less than 13 mm thick, per skin design requirements and backup mixes shall have same proportion as that of facing mixes to eliminate the possibility of bleeding through of a different colored backup.

## **1043.2.4 Submittals**

### **1043.2.4.1 Product Data**

The Contractor shall provide manufacturer's product data which shall include the following:

1. Details of concrete mix design and reinforcement used.
2. Structural analysis prepared, signed and sealed by the qualified professional engineer responsible for their preparation. This includes design calculations for typical panels such as:
  - a. Loads: point loadings and wind loading calculations, as well as deflection limit for checking of Project Engineer. Panel frames shall be designed to withstand design loads without lateral deflections greater than  $1/240$  of wall span or  $L/240$ ;
  - b. GFRC skin design;
  - c. Metal stud frame design;
  - d. Connection hardware design; and
  - e. Back-up data submitted upon request: test data on which GFRC is based, and data on GFRC insert and anchor tests.
3. Materials' Certificate of Compliance to the requirements of ASTM standards and PCI MNL 130 of all raw materials, which include aggregates, admixtures, fiberglass reinforcement, cement, metal framing components, and connection hardware. The tests conducted by raw material suppliers or others should detail the procedures and processes used in the preparation of the test samples.
4. Test reports on the applicable recommended tests on the properties of GFRC composite in Tables 5 and 6 of Subsection 1043.2.3.2–GFRC Properties to attest its compliance with the design requirements.
5. Certification from GFRC manufacturer attesting the same material as produced and tested.
6. Other informational submittals such as qualification certificate of GFRC manufacturer, certificates qualifying welding procedure and personnel, steel sheet certifications, and mill certificates.
7. Details of all recognized Standards used in design and manufacture of GFRC panel.
8. Repair and cleaning procedure and patch mix design to be used on repairing and/or cleaning panels.
9. Details of fabrication methodology of GFRC panels.

### **1043.2.4.2 Shop Drawings**

The Contractor shall submit shop drawings showing fabrication and installation details for GFRC panels, including the following:

1. Panel elevations, sections, and dimensions;
2. Thickness of facing mix, GFRC backing, and bonding pads for typical panels;
3. Finishes;



4. Joint and connection details;
5. Erection details, including erection tolerances;
6. Panel frame / steel stud frame details for typical panels, including size, spacing, thickness, and yield strength of various members;
7. Locations and details of connection hardware attached to the structure;
8. Size, location, and details of flex, gravity, and seismic anchors for typical panels;
9. Other items sprayed into panels;
10. Erection sequence for special conditions;
11. Relationship to adjacent materials; and
12. Description of loose, cast-in, and field hardware.

Detailed drawings shall fully describe the layout, large scale cross and longitudinal sections, as well as the proposed method of anchorage to structure, and connecting of all the various members together including types, sizes, gauges, and finishes of all screws, bolts and brackets. Cladding system shall be designed so that individual panels may be taken out and replaced for whatever reason without damaging existing adjacent.

Shop drawings shall also show the method of providing trickle ventilation behind the cladding to allow the intermittent escape of condensation through evaporation, as well as the design details to allow the insulation boarding to be installed in one continuous layer without interruption except at edges of panels and fixing points.

#### **1043.2.4.3 Representative Samples**

Prior to manufacturing, the manufacturer shall prepare two (2) 300 mm by 300 mm samples representing the proposed finished product showing actual thickness, finish, color and textures of exposed surfaces. One (1) sample to be submitted to the contractor subject for approval of the DPWH Project Engineer, and one (1) to be retained at the plant for manufacturer's reference.

#### **1043.3 Construction Requirements**

##### **1043.3.1 Fabrication**

Homogeneous GFRC bonding pads shall be built up over inserts and embedments to develop their strength and provide sufficient anchorage and embedment that comply with the design requirements. There shall be no waste material such as over-spray for bonding pads or to encapsulate inserts. Rigid embedded items bonded to the GFRC shall not create undesirable restraint to volume changes.

Steel stud frame shall be a prefabricated welded frame produced in accordance with the approved erection drawings and all accessible welds shall be touched up after welding.

Units shall comply with the specified dimensional tolerances and performance within generally accepted limits required by the Engineer or the design specification provided by the manufacturer as noted in the contract documents.

Exposed face of panels shall match the sample representative approved by the Project Engineer prior to manufacturing. It shall be free of joint marks, "grain" or other obvious defects.

A proper curing method that complies with the standard procedures in PCI MNL 130 should be employed to ensure sufficient strength for removing the units from the form.

Each GFRC panel should be marked with date cast and identification that corresponds to the identification marks on shop drawings for panel location.

Panel frames shall be fabricated according to Shop Drawings, as well as the accessories which are plumbed square and true to line, and the components securely fastened.

### **1043.3.2 Quality Control**

A quality control program shall be established and maintained for manufacturing of GFRC panels in accordance to PCI MNL 130, Precast/Prestressed Concrete Institute Manual for Quality Control for Plants and Production of Glass Fiber Reinforced Concrete Products.

The contractor shall submit test reports on the applicable recommended tests in Tables 5 and 6 for the properties of GFRC composite to attest its compliance with the design requirements.

Manufacturer's test samples should be representative of actual production procedures and materials. Test results may vary from different GFRC manufacturer, which requires evaluation and comparison of the results in relation to individual job requirements.

GFRC units which do not meet the color and texture range or the dimensional tolerances shall be rejected at the option of the Project Engineer if they cannot be satisfactorily corrected.

### **1043.3.3 Project Condition**

The work shall be protected from staining effects such as rain showers prior to completion. Panels shall be protected from any mechanical damage and any damaged panels shall be removed and replaced at Contractor's expense, provided any such damage is caused by Contractors negligence.

Work shall be organized so that no scaffolding, ladders or suchlike will bear on the panels during the course of the works. Installation of cladding panels shall be coordinated in sequence with curtain walling and other adjacent components to ensure proper installation of all components in relation to one another. Installation shall not commence until the following works have been completed:

1. Formation of openings, chases or other apertures required for services.
2. Completion of fixing for pipes, fixing pads and plugs.
3. Application of bituminous paint system on adjacent concrete and installation of insulation boarding over same.
4. Installation of lighting conductors and other services located behind cladding.

### **1043.3.4 Pre-installation Examination**

The substrates and the conditions under which work is to be installed shall be examined first. Work shall not proceed until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected. Before installing cladding, background shall be adequately formed true and level to achieve specified tolerances, free from contamination and loose areas, and adequately cast to a good fixing. Fixings shall be properly anchored and

accurately located before installing cladding units. Any damaged improperly set or otherwise defective shall be replaced.

### **1043.3.5 Mockups**

Prior to installation of the work, two (2) full size mock up panels shall be provided as selected by the Engineer. One (1) to be erected on site at location directed by or acceptable to the Engineer and one (1) to be retained at the plant. Samples to be used shall represent the specified materials, design, color, texture, and the quality of workmanship expected in the completed work. Once mock-up has been approved by the Project Engineer, retention is required until the work has been completed and accepted.

Mock-up shall not be part of permanent works. Demolition and removal shall take place and as directed by the Engineer.

### **1043.3.6 Delivery, Storage and Handling**

#### **1043.3.6.1 Delivery and Handling**

Cladding panels shall be delivered to project site in original packages, containers, or bundles, labeled with the name of the manufacturer and lot number. Each panel shall have its own schedule number to identify its location.

Units shall be handled and transported in a position consistent with their shape and design in order to avoid excessive stresses or damage. It shall be lifted or supported only at the points shown on the erection shop drawings. Non-staining resilient spacers shall be placed on even thickness between units. Units shall be supported during shipment on non-staining shock-absorbing material. It shall be protected from dirt and damage during handling and transport.

#### **1043.3.6.2 Storage**

The materials shall be stored inside, kept off the ground, under cover, dry, and protected from weather, direct sunlight, surface contamination, aging, corrosion, and damage from construction traffic and other causes. Units shall be stored, unless otherwise specified, with non-staining, resilient supports located in same positions as when transported.

Units shall be stored in a manner that identification marks are easily seen and readable.

### **1043.3.7 Installation of Panels**

Recommendations for cladding installation given by the manufacturer shall be strictly followed. Representative from the manufacturer shall proceed to the project site for preparation and commencement of installation.

#### **1043.3.7.1 Setting**

GFRC units shall be lifted with suitable lifting devices at points provided by the manufacturer. It shall be set level, plumb, square and true within the allowable tolerances described in Plans and shop drawings.

#### **1043.3.7.2 Supports and Bracing**

The erector shall provide temporary supports and bracing as required to maintain position, stability and alignment as units are being connected.

#### **1043.3.7.3 Fastening**

GFRC units shall be fastened in place by bolting or welding or both as shown on the approved erection drawings. Field welding shall be done by qualified welders using equipment and materials compatible to the base material. Fastening shall be completely free and independent of adjacent materials.

#### **1043.3.7.4 Components and Fittings**

The components' size and fittings of GFRC cladding panels shall have tolerances which are compatible with the contract specifications for the concrete structural frame as a whole to ensure that on completion, all components provide a smooth and flush finish. The fixings shall be designed and installed with tolerances specified in manufacturer's installation details to provide any necessary adjustments.

Any necessary adjustments to fixings during progress of work shall be carried out using laser technology or any equipment applicable and available on site to maintain plumbness and trueness to line of installation with respect to contract drawings and contract tolerances.

#### **1043.3.7.5 Finishing & Patching**

External finish shall be fair-faced and smooth with consistent color and texture as per approved site sample. All external and internal corners to be ninety degrees (90°) square but with three (3) mm arris.

Patch mixture shall be mixed and placed to match the color and texture of surrounding concrete. If patching is not possible or if unacceptable to the Engineer, GFRC unit shall be replaced. Nevertheless, patching is permitted provided structural adequacy of the unit is not impaired. Damage caused by other trades that requires replacement or patching shall be performed by the GFRC manufacturer and paid for by others after written authorization to perform said work.

#### **1043.4 Cleaning and Repair**

The erector shall be responsible for protection of the panels from damage by the erection crews, field welding or cutting operations by providing non-combustible shields as necessary during these operations. In addition, he shall be responsible also for any chipping, spalling, cracking or other damage to the units after delivery to the jobsite unless damage is caused by others during site storage.

After installation is complete and after any damaged or soiled panels have been cleaned, repaired, inspected and approved, further damage incurred is already the responsibility of the general contractor.

### **1043.5 Acceptance**

Certificate of completion shall be issued at each payment stage determined through final inspection and acceptance of erected GFRC panels conducted by the Project Engineer. This verifies whether the cladding system supplied and fixed conforms to the contract plans and specification. Completed installation shall be turned over clean with no spatters or stains.

Panels may be rejected for any one of the following product defects or installation deficiencies remaining after repairs and cleaning have been accomplished. "Visible" means visible to a person with normal eyesight when viewed from a distance of six (6) meters in broad daylight.

1. Nonconformance to specified tolerances
2. Air voids (bug-holes or blowholes) larger than ten (10) mm in diameter
3. Visible casting lines
4. Visible form joints
5. Visible irregularities
6. Visible stains on panel surface
7. Visible differences between panel and approved sample
8. Visible non-uniformity of textures or color
9. Visible areas of backup concrete bleeding through the facing concrete
10. Visible foreign material embedded in the face
11. Visible repairs or cracks
12. Visible reinforcement shadow lines

### **1043.6 Warranty**

The Contractor shall furnish the Owner a written guaranty stating that the installed glass fiber reinforced concrete cladding panel system are free from defects. The warranty shall be for the period of one (1) year from the date of the final acceptance of the work. Any part of the cladding panels that becomes defective during the term of the warranty period shall be replaced and made good by the Contractor at his own expense in a manner satisfactory to the Owner.

### **1043.7 Method of Measurement**

The area to be paid for under this Item shall be the number of surface square meters (m<sup>2</sup>) of installed in placed and accepted to the satisfaction of the Engineer. In computing the quantity, the dimensions shall be those as measured in place and completed based on the preceding requirements.

### **1043.8 Basis of Payment**

The accepted quantity, measured as prescribed in Section 1043.7, shall be paid for at the Contract Unit Price for Glass Fiber Reinforced Concrete Cladding Panels which price and payment shall be full compensation for furnishing and placing all materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
1043	Glass Fiber Reinforced Concrete Cladding Panels	Square meter

**References:**

**1. American Society for Testing and Materials (ASTM)**

- ASTM A 29M "Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought"
  - ASTM A 36M "Standard Specification for Carbon Structural Steel"
  - ASTM A 108 "Standard Specification for Steel Bars, Carbon, Cold-Finished, Standard Quality"
  - ASTM A 307 "Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength"
  - ASTM A 325 "Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength"
  - ASTM A 500M Grade B "Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes"
  - ASTM A 513M "Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing"
  - ASTM A 653M "Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process"
  - ASTM A 706M "Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement"
  - ASTM A 767M "Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement"
  - ASTM B 633 "Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel"
  - ASTM C 33 "Specification for Concrete Aggregates"
  - ASTM C 109M-13e1 "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)"
  - ASTM C 473-15 "Standard Test Method for Physical Testing of Gypsum Panel Products"
  - ASTM C 947-03 (2009) "Standard Test Method for Flexural Properties of Thin-Section Glass-Fiber-Reinforced Concrete (Using Simple Beam with Third-Point Loading)"
  - ASTM C 144 "Specification for Aggregate for Masonry Mortar"
  - ASTM C 150 "Specification for Portland Cement"
  - ASTM C 260 "Standard Specification for Air-Entraining Admixtures for Concrete"
  - ASTM C 494 "Specification for Chemical Admixtures for Concrete"
  - ASTM C 618 "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete"
  - ASTM C 979 "Specification of Pigments for Integrally Colored Concrete"
  - ASTM C 1229 "Standard Test Method for Determination of Glass Fiber Content in Glass Fiber Reinforced Concrete (GFRC) (Wash-Out Test)"
  - ASTM C 1230 "Standard Test Method for Performing Tension Tests on Glass-Fiber Reinforced Concrete (GFRC) Bonding Pads"
  - ASTM C 1666M "Standard Specification for Alkali Resistant (AR) Glass Fiber for GFRC and Fiber-Reinforced Concrete and Cement"
  - ASTM E 84 -15b "Standard Test Method for Surface Burning Characteristics of Building Materials"
  - ASTM D 256-10e1 "Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics"
  - ASTM D 696-08e1 "Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between – 30°C and 30°C with a Vitreous Silica Dilatometer"
  - ASTM D 785-08 (2015) "Standard Test Method for Rockwell Hardness of Plastics and Electrical Insulating Materials"
  - ASTM D 2853-13a "Standard Test Method for Indention Hardness of Rigid Plastics by Means of a Barcol Impressor"
  - ASTM G 152-13 "Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials"
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