ICC-ES Evaluation Report

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DIVISION: 03 00 00—CONCRETE **Section: 03 01 00—Maintenance of Concrete** **DIVISION: 04 00 00—MASONRY** **Section: 04 01 20—Maintenance of Unit Masonry**	**REPORT HOLDER:** **RUREGOLD S.R.L.**	**EVALUATION SUBJECT:** **C-MESH GOLD 84/84 AND PBO-MESH GOLD 70/18 FABRIC-REINFORCED CEMENTITIOUS MATRIX (FRCM) COMPOSITE SYSTEMS**	

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2018, 2015, 2012 and 2009 *International Building Code*® (IBC)
- 2013 *Abu Dhabi International Building Code* (ADIBC)†

†The ADIBC is based on the 2009 IBC. 2009 IBC code sections referenced in this report are the same sections in the ADIBC.

Properties evaluated:

- Structural
- Durability
- Interior finish

2.0 USES

The C-MESH GOLD 84/84 (with C-MX GOLD 25) and PBO-MESH GOLD 70/18 (with PBO-MX GOLD CALCESTRUZZO/CONCRETE) are composite systems used as alternatives to systems described in the IBC as structural reinforcement to strengthen normal-weight reinforced concrete columns, beams and slabs, and brick and reinforced concrete-masonry-unit (CMU) masonry walls. Both composite systems may also be used as an interior finish.

3.0 DESCRIPTION

3.1 General:

The C-MESH GOLD 84/84 and PBO-MESH GOLD 70/18 are externally bonded fabric-reinforced cementitious matrix (FRCM) composite systems applied to concrete and masonry substrates. The systems consist of either carbon or polyparaphenylene benzobisoxazole (PBO) fabrics, with cementitious matrices (epoxy-free) which, in combination, create the FRCM composite system.

3.2 Materials:

3.2.1 Fabric:

3.2.1.1 C-MESH GOLD 84/84: C-MESH GOLD 84/84, herein referred to as "C-MESH", is a carbon fiber fabric (0°/90°) for masonry structural reinforcement, with a carbon weight of 168 g/m^2. The fabric is a balanced

network with fiber rovings disposed along two orthogonal directions at a nominal spacing of 0.394 in. (10 mm), and equivalent nominal fiber thickness of 0.0019 in. (0.047 mm) in both primary and secondary directions. Standard rolls measuring 50 feet (15 m) in length and 3.3 feet (1 m) in width, for a total area of 161.5 square feet (15 m^2), are available. This material is part of a system comprising the cementitious matrix C-MX GOLD 25.

3.2.1.2 PBO-MESH GOLD 70/18: PBO-MESH GOLD 70/18, herein referred to as "PBO-MESH", is a polyparaphenylene benzobisoxazole (PBO) fiber fabric with an unbalanced network made of 0.394 and 0.747 in. (10 and 20 mm) spaced fiber rovings, where the primary direction has the spaced fiber rovings at 0.394 in. (10 mm). The free space between rovings is roughly 0.197 and 0.591 in. (5 and 15 mm) in the primary and secondary directions, respectively, and the nominal thickness in the two fiber directions is 0.02 in. (0.046 mm) in the primary direction and 0.0004 in. (0.011 mm) in the secondary direction. Standard rolls measuring 50 feet (15 m) in length and 3.3 feet (1 m) in width, for a total area of 161.5 square feet (15 m^2), are available, where the primary direction is the roll length. This material is part of a system comprising cementitious matrix PBO-MX GOLD CALCESTRUZZO/CONCRETE.

3.2.2 Inorganic Cementitious Matrix:

3.2.2.1 C-MX GOLD 25: C-MX GOLD 25, herein referred to as "C-MX", is an inorganic cementitious matrix for masonry structural reinforcement. Standard bags of 55 pounds (25 kg) are available. This material is part of a system comprising C-MESH GOLD 84/84.

3.2.2.2 PBO-MX GOLD CALCESTRUZZO/CONCRETE: PBO-MX GOLD CALCESTRUZZO/CONCRETE, herein referred to as "PBO-MX", is an inorganic cementitious matrix for concrete flexural and shearing stress reinforcement. Standard bags of 55 pounds (25 kg) are available. This material is part of a system comprising the PBO-MESH GOLD 70/18.

3.2.2.3 Mixing Ratio: The water-to-matrix ratio for the inorganic matrices C-MX and PBO-MX, used for the preparation of the product, is 1.59 gallons to 1.70 gallons (6.0 L to 6.5 L) of water to 55 pounds (25 kg) of dry matrix. Mixing must utilize a full bag. For one 50-foot (15 m) roll of fabric, approximately five bags of cementitious matrix are required.

3.2.3 Composites:

3.2.3.1 C-MESH - C-MX: In the primary and secondary directions, the carbon fabric–reinforced cementitious matrix composite has an effective tensile strength of 99.4 ksi (685.6 MPa) and an ultimate tensile strain of 0.86 percent. The cracked modulus of elasticity for design purposes corresponds to 11,563 ksi (79,726 MPa). The fabric area by unit width is 0.0020 $in.^2/in.$ (51.4 mm^2/m), and the FRCM layer thickness must be between 0.12 and 0.16 inch (3 and 4 mm).

3.2.3.2 PBO-MESH – PBO-MX: In the primary direction, the PBO fabric–reinforced cementitious matrix composite has an effective tensile strength of 222.2 ksi (1,532 MPa), and the ultimate tensile strain is limited at 1.20 percent. The cracked modulus of elasticity for design purposes corresponds to 18,513 ksi (127, 647 MPa). The fabric area by unit width is 0.0020 $in.^2/in.$ (51.4 mm^2/m), and the FRCM layer thickness must be between 0.12 and 0.16 inch (3.0 and 4.0 mm).

3.2.4 **Storage Recommendations:** All FRCM materials are sensitive to humidity; therefore, the FRCMs must be kept indoors in a dry place. Storage must be at a temperature range between 41°F and 95°F (5°C to 35°C). When properly stored under these conditions, C-MESH GOLD 84/84 and PBO-MESH GOLD 70/18 have an unlimited shelf life. C-MX GOLD 25 and PBO-MX GOLD CALCESTRUZZO/CONCRETE have a shelf life of two years under the same conditions and in unopened containers.

4.0 DESIGN AND INSTALLATION

4.1 Design:

4.1.1 General: Design of the FRCM composite system must be based on strength design in accordance with Chapter 19 (Concrete) or Chapter 21 (Masonry) of the IBC. The registered design professional is responsible for determining, through analysis, the strengths and demands of the structural elements to be enhanced by the FRCM composite systems, subject to the approval of the code official.

4.1.2 Design Strength: Structural design properties for the FRCM composite systems are found in Section 2.0 of the Ruregold Design Manual (herein referred to as the DM), Revision 1.0, dated July 9, 2019.

4.1.3 Design Details: Design equations in the DM are based on test results and principles of structural analysis. Bases of the design include strain compatibility, load equilibrium and limit stress. All designs must follow procedures as detailed in the IBC; in the ICC-ES Acceptance Criteria for Masonry and Concrete Strengthening Using Fiber-reinforced Cementitious Matrix (FRCM) Composite Systems (AC434), dated August 2014 (editorially revised October 2019); and in the DM.

4.1.4 Load Combinations: The load combinations used in design must comply with Section 1605 of the IBC. Strength reduction factors must comply with Chapter 19 or Chapter 21 of the IBC, as applicable.

4.1.5 Columns:

4.1.5.1 Potential Applications: FRCM composite systems are applied to columns to enhance their axial compressive strength.

4.1.5.2 Structural Design Requirements: Concrete column design must comply with the DM and with Chapter 19 of the IBC. Column design must be limited to gravity load resistance only.

4.1.6 Beams and Slabs:

4.1.6.1 Potential Applications: The FRCM composite systems are applied to beams to enhance their ductility and their flexural and shear strengths; or to slabs to enhance flexural strength.

4.1.6.2 Structural Design Requirements: Concrete design must comply with the DM and with Chapter 19 of the IBC. Beam and slab design must be limited to wind or gravity load resistance only.

4.1.7 Walls:

4.1.7.1 Potential Applications: The FRCM composite systems are applied to brick or concrete-masonry-unit (CMU) masonry walls to enhance out-of-plane flexural, in-plane flexural and in-plane shear strengths.

4.1.7.2 Structural Design Requirements: Masonry wall design must comply with the DM and with Chapter 21 of the IBC. Wall design must be limited to lateral wind or gravity load resistance only.

4.1.8 Bond Strength: Where bond is critical to system design as determined by the registered design professional, the bond strength of the FRCM composite system applied to a properly prepared surface must be at least 200 psi (1.38 MPa). Bond testing in accordance with ASTM C1583 can be used to estimate bond strength of bond-critical installations. The test results can exhibit failure in the concrete or masonry substrate, as well as at the interface of the FRCM and substrate. When failure is at the interface between the structural reinforcement grid and matrix within the FRCM, strength computed on the net matrix area (i.e., total area under the disk minus the area covered by the fiber mesh) must be at least 400 psi (2.76 MPa).

4.2 Installation:

The PBO-MESH GOLD 70/18 and C-MESH GOLD 84/84. FRCM composite systems must be installed on structural elements following this report and Chapter 9 of the DM.

4.2.1 Saturation: The FRCM systems are to be installed by hand using the corresponding cementitious matrix with the dry fiber mesh.

4.2.2 Application: Manual methods must be used to apply a layer of the cementitious matrix directly to the surface of the structural member being strengthened, where surface preparation follows ACI 549.4R Section 7.4 guidelines. Following surface preparation, the matrix is first applied uniformly to all prepared surfaces with a thickness of 0.12 to 0.16 inch (3 to 4 mm). The reinforcing mesh is then gently pressed into the cementitious matrix with the flat surface of a trowel or similar tool to embed the fabric in the matrix. Successive layers of cementitious matrix and fabric are placed before the complete cure of the previous layer of matrix.

4.2.3 Finishing: The PBO-MESH GOLD 70/18 and C-MESH GOLD 84/84 FRCM composite systems can be typically painted to satisfy aesthetic and environmental considerations.

4.2.4 Flame Spread: When applied to structural elements to satisfy requirements of the applicable code for interior finish, four-plies of the Ruregold C-MESH - C-MX or PBO-MESH – PBO-MX composite system without any additional coating or finishing yields a Class A flame spread and smoke-developed index in accordance with Section 803.1.1 of the IBC.

4.3 Special Inspection:

Special inspection during the installation of the FRCM system must be in accordance with IBC Sections 1704 through 1709, and Chapter 10 of the DM.

5.0 CONDITIONS OF USE:

The PBO-MESH GOLD 70/18 and C-MESH GOLD 84/84 systems described in this report comply with, or are suitable alternatives to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 Design and installation must be in accordance with this report; the manufacturer's instructions; the Design Manual (DM), Revision 1.0, dated July 9, 2019; and the IBC. A copy of the DM must be submitted to the code official for each project that is to use the systems.

5.2 Complete construction documents, including plans and calculations verifying compliance with this report, must be submitted to the code official for each project at the time of permit application. The construction documents must be prepared and sealed by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

5.3 Special inspection for the jobsite application of the FRCM composite systems must be provided in accordance with Section 4.3 of this report.

5.4 Fire-resistance ratings of the concrete and masonry assemblies strengthened with FRCM systems as defined in the report are outside the scope of this report.

5.5 Application of the systems to concrete members at a fabricator's facility must be by an approved fabricator complying with Section 1704.2 of the IBC, or at a jobsite with continuous special inspections in accordance with Section 1704.4 of the IBC and with the DM.

5.6 PBO-MESH GOLD 70/18 and C-MESH GOLD 84/84 materials are manufactured by Ruregold S.R.L. under a quality control program with inspections by ICC Evaluation Service, LLC.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Masonry and Concrete Strengthening Using Fiber-reinforced Cementitious Matrix (FRCM) and Steel Reinforced Grout (SRG) Composite Systems (AC434), dated October 2019.

7.0 IDENTIFICATION

7.1 Components of the C-MESH GOLD 84/84 and PBO-MESH GOLD 70/18 FRCM composite systems are labeled with the Ruregold S.R.L. name and address, product name, expiration date, and the evaluation report number (ESR-3265).

7.2 The report holder's contact information is the following:

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