ICC-ES Evaluation Report

ESR-4071

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DIVISION: 03 00 00—CONCRETE **Section: 03 01 00—Maintenance of Concrete** **Section: 03 01 30—Maintenance of Cast-in-place Concrete** **DIVISION: 04 00 00—MASONRY** **Section: 04 01 00—Maintenance of Masonry** **Section: 04 01 20—Maintenance of Unit Masonry**	**REPORT HOLDER:** **RHINO CARBON FIBER™**	**EVALUATION SUBJECT:** **RHINO CARBON FIBER™ CFRP SYSTEMS**	

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2021 and 2018 *International Building Code® (IBC)*
- 2021 and 2018 *International Residential Code® (IRC)*

Properties evaluated:

- Structural
- Durability

2.0 USES

The Rhino Carbon Fiber™ CFRP Systems are used to externally strengthen existing normal-weight reinforced concrete beam flexural strengths and unreinforced masonry walls out-of-plane flexural strengths as an alternative to those systems permitted in the IBC, as described in Section 4.1 of this report. For structures regulated under the IRC, the Rhino Carbon Fiber™ CFRP Systems may be used where an engineering design is submitted in accordance with Section R301.1.3 and where approved by the code official in accordance with Section R104.11.

3.0 DESCRIPTION

3.1 General:

The Rhino Carbon Fiber CFRP Systems are externally bonded carbon fiber-reinforced polymer (FRP) composites applied to normal-weight reinforced concrete beam and unreinforced masonry wall substrates. The Rhino Carbon Fiber CFRP Systems consist of carbon fabric adhered to the substrate with RCF™ Saturant-Adhesive Epoxy to create a FRP composite system.

3.2 Material:

3.2.1 General: All materials must comply with the approved specifications outlined in the Rhino Carbon Fiber™ CFRP Systems Quality Documentation.

3.2.2 Rhino Carbon Fabrics: The Rhino Carbon Fiber™ CFRP Systems are composed of 400U unidirectional carbon fiber fabric (400gr/1000m), 710U unidirectional carbon fiber fabric (710gr/1000m) and 560B bidirectional carbon fiber fabric (560gr/1000m), available in various widths.

3.2.3 Saturant-Adhesive Epoxy: RCF™ Saturant-Adhesive Epoxy is a two-component, liquid epoxy adhesive resin used to saturate the fabric sheets. The mixing ratio is 1:1 by volume for components A and B, respectively, provided in a self-mixing cartridge.

3.3 Rhino Carbon Fiber CFRP Composites:

3.3.1 Rhino Carbon Fiber™ CFRP 400U: In the primary direction, the Rhino Carbon FRP Composite has a design ultimate tensile strength of 129 ksi (887.8 MPa), design tensile modulus of 8,790 ksi (60.6 GPa), and a corresponding design elongation of 1.17 percent. The layer thickness is 0.027 inches (0.68 mm).

3.3.2 Rhino Carbon Fiber™ CFRP 710U: In the primary direction, the Rhino Carbon FRP composite has a design ultimate tensile strength of 131.5 ksi (906.8 MPa), design ultimate tensile modulus of 9,640 ksi (66.2 GPa), and a design corresponding elongation of 0.98 percent. The layer thickness is 0.040 inches (1.02 mm).

3.3.3 Rhino Carbon Fiber™ CFRP (Bidirectional) 560B: In both directions (0°/90°), the Rhino Carbon FRP Composite has a design ultimate tensile strength of 94 ksi (647 MPa), design tensile modulus of 5,750 ksi (39.7 GPa), and a corresponding design elongation of 1.25 percent. The layer thickness is 0.019 inches (0.48 mm).

3.4 Storage Recommendations: The materials must be stored in temperatures between 32°F and 104°F (0°C and 40°C) with no exposure to moisture. When properly stored under these conditions, unopened adhesive epoxy saturant has a shelf life of 24 months, and carbon fabric has an unlimited shelf life.

4.0 DESIGN AND INSTALLATION

4.1 Design:

4.1.1 General: Design of the composite system must be based on required tensile loads at designated concrete or masonry strain values. The strength design requirements for concrete or masonry must be in accordance with Chapter 19 or 21, respectively, of the IBC, as applicable. The registered design professional must be responsible for determining, through analysis, the strengths and demands of the structural elements to be strengthened by the Rhino Carbon Fiber CFRP Systems, subject to the approval of the code official.

4.1.2 Composite Design Properties: Structural design properties for the Rhino Carbon Fiber CFRP Systems can be found in this report and Rhino Carbon Fiber CFRP Systems Design Manual, dated June 7, 2023, Revision 4.

4.1.3 Design Details: Structural design provisions for the composite system, as described in the Rhino Carbon Fiber™ CFRP Systems Design Manual, are based on test results and principles of structural analysis as prescribed in IBC Section 1604.4. Bases of design include strain compatibility, load equilibrium and limit states. All designs must follow procedures as detailed in the IBC; in the ICC-ES Acceptance Criteria for Concrete and Reinforced and Unreinforced Masonry Strengthening Using Externally Bonded Fiber-Reinforced Polymer (FRP) Composite Systems (AC125), dated November 2021 (editorially revised March 2022); and applicable procedures detailed in the Rhino Carbon Fiber CFRP Systems Design Manual, dated June 7, 2023, Revision 4.

4.1.4 Design Strength: The design strengths must be taken as the nominal strength, computed in accordance with Section 4.1.3 of this report, multiplied by the strength reduction factors as prescribed in Chapter 19 and 21 of the IBC, as applicable.

4.1.5 Load Combination: The load combinations used in design must comply with Section 1605 of the IBC, as applicable.

4.1.6 Beams:

4.1.6.1 Potential Applications: The Rhino Carbon Fiber™ CFRP Systems is applied to reinforced concrete beams to enhance their ductility and flexural strengths for gravity loads.

4.1.6.2 Structural Design Requirements: Concrete design must comply with the Rhino Carbon™ CFRP Systems Design Manual and Chapter 19 of the IBC.

4.1.7 Bond Strength: Where the performance of the FRP composite material depends on bond, as defined by the registered design professional, the bond strength of Rhino Carbon Fiber™ material to a properly

prepared surface must exceed the tensile strength of the concrete substrate and must not be less than 200 psi (1378 kPa). Testing in accordance with ASTM D7234 or D7522 may be used to estimate the bond strength of bond-critical installations. The test must indicate failure in the masonry wall substrate. Sufficient bond area must be used to prevent bond failure.

4.1.8 Walls:

4.1.8.1 Potential Applications: The Rhino Carbon Fiber™ CFRP Systems is applied to unreinforced masonry walls to enhance out-of-plane flexural strengths.

4.1.8.2 Structural Design Requirements: Masonry design must comply with the Rhino Carbon Fiber™ CFRP Systems Design Manual and with Chapter 21 of the IBC, as applicable.

4.1.9 Bond Strength: Where the performance of the FRP composite material depends on bond, as determined by the registered design professional, the bond strength of the Rhino Carbon Fiber™ CFRP Systems to a properly prepared surface must exceed the tensile strength of the masonry substrate and must not be less than $2.5x(f'_m)^{0.5}$. Testing in accordance with ASTM C237, D7234 or D7522 may be used to estimate the bond strength of bond-critical installations. The test must indicate failure in the masonry wall substrate. Sufficient bond area must be used to prevent bond failure.

4.2 Installation:

4.2.1 General: The Rhino Carbon Fiber™ CFRP Systems must be installed on reinforced concrete beams or unreinforced masonry walls, as detailed in Installation Manual, dated January 1, 2022, Revision 1. A copy of the Installation Manual must be submitted to the code official for approval of each project that uses the Rhino Carbon Fiber™ CFRP Systems. Installation must be performed by approved applicators trained by the manufacturer in accordance with the published literature. Installation of the system is detailed in the Installation Manual.

4.2.2 Saturation: The Rhino Carbon Fiber CFRP Systems must be saturated with RCF™ Saturant-Adhesive Epoxy.

4.2.3 Application: The RCF™ Saturant-Adhesive Epoxy is applied to the reinforced concrete beam or unreinforced masonry wall substrates using manual methods. Surface preparation, fiber orientation and removal of air bubbles and voids must be done in accordance with the Rhino Carbon Fiber CFRP Systems installation instructions.

4.2.4 Finishing: The Rhino Carbon Fiber™ CFRP Systems are fully adhered and covered with the RCF™ Saturant-Adhesive Epoxy which may be coated with paints that may be required for environmental and aesthetic reasons.

4.2.5 Surface Burning Characteristics (Interior Finish):

The Rhino Carbon Fiber™ CFRP Systems, consisting of Albi Cote FRL-X by StanChem Inc. top coat and RCF™ Saturant-Adhesive Epoxy applied with a maximum of five (5) layers of Rhino Carbon Fiber™ CFRP 400U has a Class A interior finish per IBC Section 803.1. Albi Cote FRL-X must be applied in one coat of minimum 10 mils wet film thicknesses [one coat of 0.01 inch (0.25 mm)].

The Rhino Carbon Fiber™ CFRP Systems, consisting of Albi Cote FRL-X by StanChem Inc. top coat and RCF™ Saturant-Adhesive Epoxy applied with a maximum of three (3) layers of Rhino Carbon Fiber™ CFRP 560B has a Class A interior finish per IBC Section 803.1. Albi Cote FRL-X must be applied in one coat of minimum 10 mils wet film thicknesses [one coat of 0.01 inch (0.25 mm)].

The Rhino Carbon Fiber™ CFRP Systems, consisting of Albi Cote FRL-X by StanChem Inc. top coat and RCF™ Saturant-Adhesive Epoxy applied with a maximum of three (3) layers of Rhino Carbon Fiber™ CFRP 710U has a Class A interior finish per IBC Section 803.1. Albi Cote FRL-X must be applied in one coat of minimum 10 mils wet film thicknesses [one coat of 0.01 inch (0.25 mm)].

4.2.6 Cure Time Prior to Loading: The Rhino Carbon Fiber™ CFRP Systems must be allowed a minimum of 72 hours of cure time (depending on temperatures) prior to application of superimposed loading onto the structural element. Final determination of required cure time must be made by the registered design professional.

4.3 Special inspection:

Special inspection during the installation of the system must be in accordance with the ICC-ES Acceptance Criteria for Inspection and Verification of Concrete and Unreinforced Masonry Strengthening Using Fiber-reinforced Polymer (FRP) Composite Systems (AC178), dated October 2017 (editorially revised December 2020). A statement of special inspection must be prepared in accordance with Sections 1704.3 of the IBC. Inspection must also comply with Sections 1704 and 1705 of the IBC, as applicable.

5.0 CONDITIONS OF USE:

The Rhino Carbon Fiber CFRP Systems described in this report complies with or is a suitable alternative to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions. In case of conflict, this report governs.

5.1 Design and installation must be in accordance with this report, the manufacturer's Design Manual dated June 7, 2023, Revision 4 and Installation Manual dated January 1, 2022, Revision 1, and the IBC, or IRC, as applicable.

5.2 Copies of the Rhino Carbon Fiber™ CFRP Systems Design Manual and Installation Manual must be submitted to the code official for approval with each project using the system.

5.3 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.

5.4 Use of Rhino Carbon Fiber™ CFRP Systems in fire-resistance-rated assemblies has not been evaluated and is outside the scope of this evaluation report.

5.5 Use of Rhino Carbon Fiber™ CFRP Systems in full contact with drinking water has not been evaluated and is outside the scope of this evaluation report.

5.6 Special inspection must be provided in accordance with Section 4.3 of this report.

5.7 Application of Rhino Carbon Fiber™ CFRP Systems to reinforced concrete beams and unreinforced masonry walls at a fabricator's facility must be by an approved fabricator complying with Chapter 17 of the IBC, or at a jobsite with continuous special inspections in accordance with Chapter 17 of the IBC and Section 4.3 of this report.

5.8 Rhino Carbon Fiber™ CFRP Systems are provided by Rhino Carbon Fiber™ under a quality control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Concrete and Reinforced and Unreinforced Masonry Strengthening Using Fiber-reinforced Polymer (FRP) Composite Systems (AC125), dated November 2021 (editorially revised March 2022).

7.0 IDENTIFICATION

7.1 The ICC-ES mark of conformity, electronic labeling, or the evaluation report number (ICC-ES ESR-4071) along with the name, registered trademark, or registered logo of the report holder must be included in the product label.

7.2 In addition, the components of the Rhino Carbon Fiber™ CFRP Systems described in this report are identified with a label indicating the address of the manufacturer, product names (fabric & saturant), and saturant expiration date.

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

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