

ICC-ES Evaluation Report


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<p>DIVISION: 03 00 00— CONCRETE</p> <p>Section: 03 01 00— Maintenance of Concrete</p> <p>Section: 03 01 30— Maintenance of Cast-in- Place Concrete</p> <p>DIVISION: 04 00 00— MASONRY</p> <p>Section: 04 01 00— Maintenance of Masonry</p> <p>Section: 04 01 20— Maintenance of Unit Masonry</p>	<p>REPORT HOLDER: FISCHERWERKE GMBH & CO. KG</p>	<p>EVALUATION SUBJECT: fischer C-Fiber Force Strengthening System with carbon fiber fabric and with carbon fiber precured laminates</p>	
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1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2024, 2021, 2018, 2015, 2012, 2009 and 2006 [International Building Code® \(IBC\)](#)
- 2024, 2021, 2018, 2015, 2012, 2009 and 2006 [International Residential Code \(IRC\)](#)
- 2013 *Abu Dhabi International Building Code (ADIBC)*[†]

[†]The ADIBC is based on the 2009 IBC as referenced under the ADIBC.

Properties evaluated:

- Structural
- Toxicity
- Interior Finish
- Durability

2.0 USES

The fischer C-Fiber Force Strengthening Systems are used to externally strengthen normal-weight reinforced concrete and masonry elements as an alternative to systems described in the IBC, as permitted by Section 104.2.3 of the 2024 IBC (Alternative Materials, Designs, and Methods of Construction and Equipment) (Section 104.11 of the 2021, 2018, 2015, 2012, 2009 and 2006 IBC). For structures regulated under the IRC, the fischer C-Fiber Force Strengthening Systems may be used where an engineering design is submitted in accordance with IRC Section R301.1.3 and where approved by the building official in accordance with IRC Section R104.2.2. For use as an interior finish, see Section 4.2.5.

3.0 DESCRIPTION

3.1 General:

The fischer C-Fiber Force Strengthening Systems are externally bonded fiber-reinforced polymer (FRP) composite systems applied to concrete and masonry structural elements. The fischer C-Fiber Force Strengthening System consists of carbon fabrics combined with an epoxy saturating resin to create the FRP composite system, or a carbon fiber precured laminate applied and adhered with an epoxy paste.

3.2 Materials:

3.2.1 All materials must comply with the approved specifications outlined in the “fischer C-Fiber Force Strengthening System” Quality Control Manual, dated September 16, 2024, Revision 1.

3.2.2 FRS-W Fabrics: The FRS-W U300 and U600 fabric sheets are made of high strength, unidirectional carbon fiber sheets with a minimum nominal fiber sheet area density of 8.85 and 17.70 oz/yd² (300 and 600 gsm), respectively, designed for dry lay-up or wet lay-up application. The FRS-W Fabrics are used as an externally bonded reinforcement saturated and adhered using the fischer FRS-CF saturating resin. FRS-W Fabrics come in standard rolls of fabric available in widths of either 7.9 or 19.7 inches (200 or 500 mm) and lengths up to 164 yards (150 m). The rolls of fabric are packaged in boxes.

3.2.3 FRS-CF Saturating (epoxy) Resin: FRS-CF is a two-component, ambient cure epoxy resin used for impregnating the dry carbon fiber fabrics and binding the fibers together for the transfer of stresses. The FRS-CF Saturating Resin is available in 2.00-gallon (7.576 liter, equals to 10 kg total filling weight) and 1.00-gallon (3.788 liter, equals to 5 kg total filling weight) kits.

For the 2.00-gallon (10 kg) kit, component A is composed of 1.31 gallons (4.96 liter) stored in a 2.64-gallon (10 liter) container; and for the 1.00-gallon (5 kg) kit, component A is composed of 0.66 gallons (2.48 liter) stored in a 1.16-gallon (4.4 liter) container. Larger containers are provided to allow enough room for mixing the full kit of epoxy.

The components A and B are mixed at the jobsite prior to application in accordance with the corresponding Technical Datasheet and the Installation Manual for “C-Fiber Force Strengthening System with Carbon Fiber Fabrics (dated July, 2024). Mixing ratio is three-to-one for components A and B by weight, respectively.

3.2.4 FRS-L-S and FRS-L-H Precured Laminates: The FRS-L-S and FRS-L-H are high strength, unidirectional carbon fiber precured laminates in an epoxy resin. The FRS-L-S and FRS-L-H precured laminates come in 0.047 and 0.055 inch (1.2 and 1.4 mm) thicknesses, and widths ranging from 2.0 to 3.9 inches (50 to 100 mm). FRS-L-S and FRS-L-H are coiled to a standard length of either 109 or 164 yards (100 or 150 m). The FRS-L-S and FRS-L-H are provided in coils and packaged in boxes.

3.2.5 FRS-CS Epoxy Paste: The FRS-CS epoxy paste is a two-component, epoxy paste system used to fill, transition irregular substrates, and adhere FRS-L-S and FRS-L-H precured laminates to the substrate. FRS-CS is available in 1.42-gallon (5.376 liter, equals to 10 kg total filling weight), and 0.71-gallon (2.688 liter, equals to 5 kg total filling weight) kits. FRS-CS is also available in prefilled, two-component injection cartridges.

For the 1.42-gallon (10 kg) kit, component A is composed of 1.10 gallons (4.17 liter) stored in a 2.64-gallon (10 liter) container; and for the 0.71-gallon (5 kg) kit, component A is composed of 0.55 gallons (2.09 liter) stored in a 1.16-gallon (4.4 liter) container. Larger containers are provided to allow enough room for mixing the full kit of epoxy. The FRS-CS prefilled two-component injection cartridge (FRS-CS 585S) is provided in a 0.154 gallon (0.585 liter) cartridge. The FRS-CS 585 S prefilled cartridge system should be used together with the mixing-nozzle FRS UMR. Mixing ratio is four-to-one for components A and B by weight, respectively.

3.2.6 C-Fiber Force Composite Strengthening Systems:

3.2.6.1 Fiber Force U300 Composite: C-Fiber Force U300 Composite is comprised of the FRS-W U300 carbon fabric sheet and FRS-CF saturating resin. In the primary direction (0°), the carbon fiber composite has a design tensile strength of 133 ksi (918 MPa), a design tensile modulus of 12,000 ksi (83 GPa), and a corresponding elongation of 1.28 percent. Cured composites have a thickness of 0.02 inch (0.51 mm).

3.2.6.2 C-Fiber Force U600 Composite: C-Fiber Force U600 Composite is comprised of the FRS-W U600 carbon fabric sheet and FRS-CF saturating resin. In the primary direction (0°), the carbon fiber composite has a design tensile strength of 115 ksi (794 MPa), a design tensile modulus of 11,200 ksi (77 GPa), and a corresponding elongation of 1.26 percent. Cured composites have a thickness of 0.04 inch (1.02 mm).

3.2.6.3 C-Fiber Force S-Laminate Composite: C-Fiber Force S-Laminate Composite is comprised of the FRS-L-S Precured Laminates and FRS-CS Epoxy Paste. In the primary direction, the precured laminate has a design tensile strength of 375 ksi (2,585 MPa), a design tensile modulus of 24,400 ksi (168 GPa), and a corresponding elongation of 1.77 percent. The available thickness of the precured laminate includes 0.047 and 0.055 inch (1.2 and 1.4 mm).

3.2.6.4 C-Fiber Force H-Laminate Composite: C-Fiber Force H-Laminate Composite is comprised of the FRS-L-H Precured Laminates and FRS-CS Epoxy Paste. In the primary direction, the precured laminate has a design tensile strength of 407 ksi (2,808 MPa), a design tensile modulus of 28,700 ksi (198 GPa), and a corresponding elongation of 1.68 percent. The available thickness of the precured laminate includes 0.047 and 0.055 inch (1.2 and 1.4 mm).

3.2.7 FRS-FP Finish Coating: The fischer FRS-FP finish coating is a one-component, water-based, intumescent coating used to prevent smoke development in case of a fire event. The product is available in 2.2 lbs (25 kg) buckets.

3.2.8 Storage Recommendations: C-Fiber Force material constituents (including epoxies, coating, fabrics and precured laminates) should be stored in a clean, dry, moisture-free area at an ambient temperature between 41°F (5°C) and 104°F (40°C), protected from direct sunlight. When properly stored under these conditions, the precured laminates have an infinite shelf life and the carbon fabrics have 24 months shelf life. The FRS-CF and FRS-CS epoxy resins have a shelf life of 3 years under the same conditions when containers remain unopened. The FRS-FP Finish Coating has 9-month shelf life under the above storage conditions.

4.0 DESIGN AND INSTALLATION

4.1 Design:

Design of the composite system is based on strength design in accordance with Chapter 19 or 21 of the IBC, as applicable. The registered design professional is responsible for determining, through analysis, the strengths and demands of the structural elements to be enhanced by the fischer C-Fiber Force Strengthening System, subject to the approval of the code official.

4.1.1 Design Details: Design of the Fisher FRP strengthening system is based on test results and principles of structural analysis as set forth in Section 1604.4 of the IBC. The bases of design include strain compatibility, load equilibrium and limit states. All designs must follow procedures as detailed in the IBC, and in the fischer FRP strengthening system Design Manual (dated December 2024). A copy of the Design Manual must be submitted to the code official for approval of each project that uses Fisher FRP strengthening system.

4.1.2 Design Strength: Design strengths must be taken as the nominal strength, computed in accordance with Section 4.1.1 of this report, multiplied by strength reduction factors in Section 21.2 of ACI 318-19 for the 2024 and 2021 IBC and ACI 318-14 for 2018 and 2015 IBC (Section 9.3 of ACI 318-11 for the 2012 IBC, ACI 318-08 for the 2009 IBC, and ACI 318-05 for the 2006 IBC), as applicable.

4.1.3 Load Combinations: The load combinations used in design must comply with Section 1605 of the IBC and Section 5.3 of ACI 318-19 and ACI 318-14 (Section 9.2 of ACI 318-11, ACI 318-08, and ACI 318-05).

4.1.4 Columns:

4.1.4.1 Potential Applications: The C-Fiber Force U300 and U600 Composite strengthening systems are applied to circular or rectangular concrete columns to enhance axial strength and ductility. The fischer C-Fiber Force U300 and U600 composite systems can also be utilized to improve the confinement of concrete columns.

4.1.4.2 Structural Design Requirements: Concrete column design must comply with the fischer C-Fiber Force Strengthening system Design Manual and with Chapter 19 of IBC, as applicable.

4.1.5 Beams and Slabs:

4.1.5.1 Potential Applications: The C-Fiber Force U300, U600, S-Laminate and H-Laminate composite strengthening systems, are applied to concrete beams or slabs to enhance their flexural strengths for gravity loads only, as applicable. The U300 and U600 composite systems applied to beams are also used to enhance the beam shear strength for gravity or wind loads resistance only.

4.1.5.2 Structural Design Requirements: Concrete beam and slab design must comply with the fischer C-Fiber Force Strengthening system Design Manual and Chapter 19 of IBC, as applicable.

4.1.6 Bond Strength: Where the performance of the FRP composite material depends on bond, the bond strength must not be less than 200 psi (1378 kPa) for concrete, or $2.5\sqrt{f'_m}$ for masonry. Bond testing must exhibit failure in the concrete or masonry substrate. Testing in accordance with ASTM D7234 or D7522 may be used to estimate the bond strength of bond-critical installations.

4.2 Installation:

Installation of the fischer C-Fiber Force Strengthening system must be performed by certified applicators specific to this composite system. Installation recommendations are detailed in the Installation Manual "C-Fiber Force Strengthening System with Externally Bonded CFRP laminates" and in the Installation Manual "C-Fiber Force Strengthening System with carbon fiber fabrics" (Dated 07/2024).

4.2.1 Saturation: The fibers and the epoxy matrix must be combined in accordance with an established weight ratios, as defined in the Installation Manual for fischer C-Fiber Force Strengthening system with carbon fiber fabrics (dated July 2024). Saturation can be achieved using a saturator machine or manual methods.

4.2.2 Application: The saturated C-Fiber Force Strengthening system fabric sheet or laminate can be applied to the substrate using manual methods. Surface preparation, fiber/laminate orientation and removal of air voids and bubbles must be performed in accordance with installation procedures detailed in the Installation Manual for fischer C-Fiber Force Strengthening system with carbon fiber fabrics (dated July 2024). The standard pot life for resin is listed in the corresponding Technical Datasheet of FRS-CS Saturating Resin. The actual pot life varies with temperature and processed quantity: higher temperatures usually result in a shorter pot life while lower temperatures can result in a longer pot life.

4.2.3 Finishing: A final protective layer of thickened epoxy resin shall be applied as a finish coat. Paints can be applied to the composite system as required for environmental and aesthetic considerations. For use as an interior finish, see Section 4.2.5.

4.2.4 Health Effects Coating: FRS-CF epoxy resins are formulated for potable water contact and comply with ANSI/NSF 61 as referenced by Section 605 of the 2024, 2021, 2018, and 2015 *International Plumbing Code* (IPC). The topcoat of the FRS-CF epoxy resin material must have a maximum total thickness of 40 wet mils (1.02 mm). All surfaces must be cleaned, dry, and free of contaminants. Surfaces must be prepared by abrasive blasting. Cured composite surfaces must be prepared by hand-sanding the surface to remove the gloss of the cured composite, and then cleaning with water to remove the residues. The final curing must be 24 hours at 75°F (24°C).

4.2.5 Surface Burning Characteristics (Interior Finish):

4.2.5.1 Class A (IBC Section 803.1):

The fischer C-Fiber Force U300 Strengthening System and the waterborne intumescent FRS-FP Finish Coating applied in two coats with a minimum wet film thickness of 1 mm each, has a Class A rating according to ASTM E84, for a maximum of seven carbon fabric plies.

The fischer C-Fiber Force U600 Strengthening System and the waterborne intumescent FRS-FP Finish Coating applied in two coats with a minimum wet film thickness of 1 mm each, has a Class A rating according to ASTM E84, for a maximum of four carbon fabric plies.

The fischer C-Fiber Force S-Laminate and H-Laminate Strengthening Systems and the waterborne intumescent FRS-FP Finish Coating applied in two coats with a minimum of 1 mm each, has a Class A rating according to ASTM E84.

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 June 2024). A statement of special inspection must be prepared in accordance with Section 1704.3 of the 2024, 2021, 2018, 2015 or 2012 IBC (Section 1705 of the 2009 or 2006 IBC). Inspection must also comply with Sections 1704 and 1705 of the 2024, 2021, 2018, 2015 or 2012 IBC (Section 1704 through 1707 of the 2009 or 2006 IBC), with the Fisher FRP strengthening system Design Manual (dated December 2024).

5.0 CONDITIONS OF USE:

The fischer C-Fiber Force Strengthening System 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:

- 5.1** Design and installation must be in accordance with this report, the manufacturer's instructions, the fischer C-Fiber Force Strengthening System Design Manual (dated December 2024) as referenced in Section 4.1.1, and the IBC.
- 5.2** Copies of the fischer C-Fiber Force Strengthening System Design Manual (dated December 2024) must be submitted to the code official for approval on each project that uses the system.
- 5.3** The use of fischer C-Fiber Force Strengthening System in exterior applications with direct or reflective exposure to sunlight and ultraviolet light is outside the scope of this report.
- 5.4** 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.
- 5.5** Use of fischer C-Fiber Force Strengthening Systems in fire-resistance-rated assemblies 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 the systems to concrete members at a fabricator's facility must be performed 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.
- 5.8 The fischer C-Fiber Force FRP strengthening system is manufactured 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 2024, and quality documentation.

7.0 IDENTIFICATION

- 7.1 The ICC-ES mark of conformity, electronic labeling, or the evaluation report number (ICC-ES ESR-4774) along with the name, registered trademark, or registered logo of the report holder must be included in the product label.
- 7.2 In addition, components of the fischer C-Fiber Force Strengthening System are labeled with the fischerwerke GmbH & Co. KG name and address; the product name and shelf life; and epoxy resins mixing ratio.
- 7.3 The report holder's and additional listee's contact information is the following, respectively:

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