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ICC-ES Evaluation Report

ESR-3403

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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:

SIMPSON STRONG-TIE COMPANY, INC.

**5956 WEST LAS POSITAS BOULEVARD
PLEASANTON, CALIFORNIA 94588**

EVALUATION SUBJECT:

SIMPSON STRONG-TIE COMPOSITE STRENGTHENING SYSTEMS (CSS)



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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:

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(800) 925-5099
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EVALUATION SUBJECT:

SIMPSON STRONG-TIE COMPOSITE STRENGTHENING SYSTEMS (CSS)

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2015, 2012, 2009 and 2006 *International Building Code*® (IBC)
- 2015, 2012, 2009 and 2006 *International Residential Code*® (IRC)
- 1997 *Uniform Building Code*™ (UBC)

Property evaluated:

- Structural
- Durability
- Interior finish
- Toxicity
- Fire resistance

2.0 USES

The Simpson Strong-Tie Composite Strengthening Systems (CSS) are used to strengthen normal-weight reinforced concrete and masonry structural elements as alternatives to those systems described in the IBC and UBC. For structures regulated under the IRC, the Simpson Strong-Tie Composite Strengthening Systems (CSS) may be used where an engineering design is submitted in accordance with Section [R301.1.3](#) and where approved by the building official in accordance with Section [R104.11](#). The CSS-CUCF and CSS-CUGF systems are also used as an interior finish.

3.0 DESCRIPTION

3.1 General:

The Composite Strengthening Systems (CSS) are externally bonded fiber-reinforced polymer (FRP) systems applied to concrete and masonry structural elements. CSS consist of carbon fabrics or glass fabrics combined with epoxy resin to create the FRP composite system, or a carbon fiber precured laminate applied with an epoxy paste.

3.2 Materials:

3.2.1 General: All material must conform to the approved specifications outlined in the Simpson Strong-Tie CSS Quality Control Manual, dated June 18, 2015, Revision 0.

3.2.2 CSS Fabrics: The CSS fabrics are composed of carbon or glass fibers. CSS-CUCF11 and CSS-CUCF22 unidirectional carbon fabrics come in either 12-inch x 300-foot (305 mm x 91.4 m) or 24-inch x 150-foot (610 mm x 45.7 m) rolls. CSS-CUCF44 unidirectional carbon fabric comes in either 12-inch x 150-foot (305 mm x 45.7 m) or 24-inch x 75-foot (610 mm x 22.9 m) rolls. CSS-CUGF27 unidirectional glass fabric comes in 25-inch or 50-inch x 150-foot (635 mm or 1,270 mm x 100 m) rolls. CSS-CBGF424 bidirectional glass fabric comes in 25-inch or 50-inch x 302-foot (635 mm or 1,270 mm x 92 m) rolls. Material properties vary with fiber type designation.

3.2.3 CSS-ES Epoxy Saturant: The CSS-ES epoxy saturant and primer is a two-component, ambient cure, epoxy resin system used to prime substrates and saturate CSS fabrics. It is available in 3 gallon (11.4 L) kits. Component A is packaged with 2 gallons (7.6 L) in a 5-gallon (18.9 L) bucket to allow enough room for mixing full kits of epoxy. Component B is packaged in 1 gallon (3.8 L) containers. Mixing ratio is two-to-one for components A and B, respectively.

3.2.4 CSS-CUCL Precured Laminates: The CSS-CUCL unidirectional carbon laminates are comprised of carbon fibers, precured in an epoxy resin. CSS precured laminates come in 0.047 inch (1.2 mm), 0.055 inch (1.4 mm) and 0.110 inch (2.8mm) thicknesses and various widths ranging from 0.39 inch to 5.90 inches (10 mm to 150 mm), and a standard length of 492 feet (150 m).

3.2.5 CSS-EP Epoxy Paste: The CSS-EP epoxy paste is a two-component, epoxy paste system used to fill and transition irregular substrates and adhere CSS-CUCL precured laminates. CSS-EP is available in 3-gallon (11.4 L) kits. Components A and B are packaged in

1-gallon (3.8 L) containers and entire kits are packaged in one carton. Mixing ratio is two-to-one for components A and B, respectively.

3.2.6 CSS Composites:

3.2.6.1 CSS-CUCF Composites: In the primary direction (0°), the carbon fiber composites have a minimum ultimate tensile strength of 128,000 psi (880 MPa), a minimum tensile modulus of 14,200 ksi (97 MPa) and a corresponding elongation of 0.9 percent. Cured composites have a thickness of 0.02 inch (0.5 mm), 0.04 inch (1 mm) and 0.08 inch (2 mm) for CSS-CUCF11, CSS-CUCF22 and CSS-CUCF44, respectively.

3.2.6.2 CSS-CUGF Composite: In the primary direction (0°), the glass-fiber composite has a minimum ultimate tensile strength of 56,000 psi (386 MPa), a minimum tensile modulus of 3,300 ksi (22 MPa) and a corresponding elongation of 1.7 percent. Cured composite has the minimum thickness of 0.05-inch (1.3 mm.)

3.2.6.3 CSS-CBGF Composite: In both directions ($\pm 45^\circ$ from the roll length), the glass fiber composite has a minimum ultimate tensile strength of 40,000 psi (275 MPa), a minimum tensile modulus of 2,900 ksi (20 MPa) and a corresponding elongation of 1.4 percent. Cured composite has the minimum thickness of 0.034 inch (0.86 mm.).

3.2.6.4 CSS-CUCL Laminate Composite: In the primary direction, the precured laminate has a minimum ultimate tensile strength of 181,000 psi (1,250 MPa), a minimum tensile modulus of 23,600 ksi (163 MPa) and a corresponding elongation of 0.77 percent. The thickness of the precured laminate is 0.047 inch (1.2 mm), 0.055 inch (1.4 mm) and 0.110 inch (2.8mm).

3.2.7 FX-207 Finish Coating: The Simpson Strong-Tie proprietary FX-207 finish coating is a two-component, polymer-modified cementitious coating. Component A comes in a 1-gallon (3.8 L) container and Component B comes in a 40-pound (18 kg) bag. Pot life is 30 minutes.

3.2.8 GCP Z-106 HY Finish Coating: The GCP Applied Technologies Monokote Z-106 HY finish coating is a Portland cement based cementitious fireproofing coating. This product is available in 49 lb (22.2 kg) bags.

3.2.9 Firebond Concentrate Primer: The Firebond Concentrate Primer is a bonding agent used to bond GCP Applied Technologies Monokote Z-106 HY to the substrate or installed composite. This primer is available in either 5 gal (19 L) or 55 gal (208.2 L) containers

3.2.10 Storage Recommendations: Epoxies, coating, fabrics and precured laminates should be stored in temperatures between 45°F and 95°F (7°C and 35°C) with no exposure to moisture. Shelf life is one year for coating, two years for epoxies and ten years for fabrics and precured laminates.

4.0 DESIGN AND INSTALLATION

4.1 Design:

4.1.1 General: Design of the Composite Strengthening Systems must be based on required tensile loads at designated concrete strain values. The strength design requirements for concrete and masonry must be in accordance with [Chapters 19](#) and [21](#) of the IBC or UBC, respectfully. The registered design professional must be responsible for determining, through analysis, the strengths and demands of the structural elements to be strengthened with CSS composites, subject to the approval of the building official.

4.1.2 Composite Design Properties: Composite structural design properties are found in the CSS Design Manual, dated July 24, 2017.

4.1.3 Design Details: Structural design provisions for the composite system are based on test results and principles of structural analysis as set forth in Section [1604.4](#) of the IBC and Section 1605 of the UBC. Bases of design include strain compatibility, load equilibrium and limit states. All designs must follow procedures as detailed in the IBC or UBC; 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 August 2014 (editorially revised November 2015); and applicable procedures detailed in the CSS Design Manual.

4.1.4 Design Strength: Design strengths must be taken as the nominal strength, computed in accordance with Section 4.1.3 of this report, multiplied by strength reduction factors provided in Section 21.2 of [ACI 318-14](#) (2015 IBC), Section 9.3 of [ACI 318-11](#) (2012 IBC) or [ACI 318-08](#) (2009 IBC) or ACI 318-05 (2006 IBC), or Chapter 19 of the UBC, and modified by AC125, as applicable (for concrete), and Chapter 21 of the IBC (TMS 402) or Chapter 19 or Section 2108 of the UBC (for unreinforced masonry), as applicable.

4.1.5 Load Combinations: The load combinations used in design must comply with Section [1605.2](#) of the IBC or Section 1612.2 of the UBC, as applicable. Strength reduction factors must comply with Chapter 19 (ACI 318) or Chapter 21 (TMS 402 of the IBC or Chapter 19 or Section 2108 of the UBC, as applicable.

4.1.6 Columns:

4.1.6.1 Potential Applications: CSS-CUCF, CSS-CUGF and CSS-CBGF Composite Strengthening Systems are applied to circular or rectangular columns to enhance their axial strengths for gravity loads only.

4.1.6.2 Structural Design Requirements: Concrete column design must comply with the CSS Design Manual and with Chapter 19 of the IBC or UBC.

4.1.7 Beams and Slabs:

4.1.7.1 Potential Applications: CSS-CUCF and CSS-CUCL Composite Strengthening Systems are applied to beams and slabs to enhance their flexural strength for gravity and wind-load resistance only. The CSS-CUCF Composite System applied to beams is also used to enhance their shear strengths for gravity load or wind load resistance only.

4.1.7.2 Structural Design Requirements: Concrete beam design must comply with the CSS Design Manual and with Chapter 19 of the IBC or UBC.

4.1.8 Walls:

4.1.8.1 Potential Applications: CSS-CUCF and CSS-CUCL Composite Strengthening Systems are applied to reinforced concrete walls to enhance their out-of-plane flexural strengths. CSS-CUGF Composite Strengthening Systems are applied to reinforced masonry walls to enhance their out-of-plane flexural strengths; and unreinforced masonry walls to enhance their in-plane shear strengths. Out-of-plane strengthening of concrete walls with CSS-CUCF and CUCL is limited to single layer application with a maximum concrete compressive strength of 3,000 psi (21 MPa), all other conditions are outside the scope of this report. Out-of-plane masonry wall strengthening with CSS-GUGF is limited to single layer application and maximum 1,500 psi (10 MPa) masonry

compressive strength, all other conditions are outside the scope of this report.

4.1.8.2 Structural Design Requirements: Concrete design must comply with the CSS Design Manual and Chapter 19 of the IBC or UBC, as applicable. Masonry design must comply with the CSS Design Manual and Chapter 21 of the IBC or UBC, as applicable.

4.1.9 Wall-to-Floor joints:

4.1.9.1 Potential Applications: CBGF Composite Strengthening Systems are applied to concrete wall-to-floor joints to enhance their shear strength.

4.1.9.2 Structural Design Requirements: Concrete design must comply with the CSS Design Manual and Chapter 19 of the IBC or UBC, as applicable.

4.1.10 Bond Strength: Where the performance of the CSS composite systems defined in this report depends on bond, the bond strength of CSS Composite material to concrete must not be less than 200 psi (1378 kPa). Bond testing must exhibit failure in the concrete substrate. Testing in accordance with [ASTM D7234](#) or [D7522](#) may be used to estimate the bond strength of bond-critical installations.

4.2 Installation:

Simpson Strong-Tie CSS Composite Strengthening Systems installations must be performed by approved applicators specific to this composite system. Installation recommendations are detailed in the approved applicator training program and Section 2.0 of the Quality Control Manual dated June 18, 2015, Revision 0.

4.2.1 Saturation: CSS fabrics and saturating epoxy of the CSS Composites are combined in accordance with published literature and applicator training program using a calibrated mechanical saturator or manual saturation methods. CSS precured laminates come to the site in precured form ready to apply to substrate once cut to required length and cleaned.

4.2.2 Application: Manual methods must be used to apply saturated CSS Composite fabrics to the substrate prior to epoxy cure. Surface preparation, fiber orientation and removal of bubbles/voids must be done in accordance with published literature and approved applicator training program. For precured laminates, CSS-EP paste must be applied to the laminate with paste thickness of approximately 3 mm ($\frac{1}{8}$ in.).

4.2.3 Finishing: Composite Strengthening Systems are typically painted or coated for aesthetic, fire-resistance or environmental durability considerations.

4.2.3.1 Health Effects Coating: The CSS-ES epoxy saturant and CSS-EP are formulated for potable water contact and comply with [ANSI/NSF 61](#) requirements, as referenced by Section 605 of the *International Plumbing Code* (IPC). CSS-ES epoxy saturant must be applied over the CSS composites to a maximum thickness of 10 wet mills (0.025 mm). CSS-EP epoxy paste must be applied over the installed CSS precured laminates to a maximum thickness of 40 wet mills (0.1 mm). All surfaces must be clean, dry and free of contaminants. Final cure is 72 hours at 70°F (21°C).

4.2.3.2 Flame Spread / Smoke Developed:

CSS-CUCF and CSS-CUGF composite systems coated with FX-207 finish coating yields a Class 1 and Class A flame-spread classification and smoke-developed classification in compliance with the UBC and IBC. The CSS-CUCF composite is limited to a maximum thickness

of 0.8-inch (20 mm) of carbon fabric (maximum 10 layers of CSS-CUCF44, 20 layers of CSS-CUCF22 and 30 layers of CSS-CUCF11). The CSS-CUGF composite is limited to a maximum thickness of 0.3-inch (7.8 mm) of glass fabric (maximum 6 layers of CSS-CUGF27). Coating must be applied minimum 40 mils at a rate of 0.4 lbs/ft² (2 kg/m²).

4.3 Fire-resistance rating:

4.3.1 Roller or Spray-applied Fire-resistant Material:

The use of FX-207 finish coating provides up to a four-hour fire-resistance rating in accordance with [ASTM E119](#) when loaded up to 72 percent of ultimate design load for the following structural systems. The two-component coating is applied over the composite system and concrete in accordance with Simpson Strong-Tie installation instructions. The FX-207 coating must be applied to concrete T-beams with the following properties: 12-inch (305 mm) wide web thickness, 10-inch (254 mm) deep web depth, 6-inch (152 mm) flange thickness, 48-inch (1219 mm) flange width, a 28-day concrete compressive strength between 3,500 psi (24 MPa) and 5,000 psi (34 MPa), reinforced with 2 No. 5 bottom longitudinal reinforcing steel in the web, flange short direction transverse reinforcement is No.3 at 6-inch o/c top and bottom, top longitudinal reinforcement is No. 3 at 6-inch o/c, and stirrup reinforcement No. 3 at 6-inch o/c with minimum 1.75 inch (44 mm) cover depth between reinforcement and concrete surface. The concrete surface to receive fabric must be primed with CSS-ES. CSS-CUCF and CSS-CUGF fabrics must be saturated with CSS-ES. The saturated CSS-CUCF fabric must be applied to the bottom of the web and the saturated CSS-CUGF fabric must be applied to the web at the ends of the T-beam in a U-wrap configuration. FX-207 coating is applied over the lightly sanded installed fabrics and CSS-ES coated concrete at an application rate of 0.4 lbs/ft² (2 kg/m²). Other assembly configurations are beyond the scope of this report.

4.3.2 Spray-applied Fire-resistant Material:

The use of GCP Applied Technologies system provides up to a four-hour fire-resistance rating in accordance with ASTM E119 when loaded up to 72 percent of ultimate design load for the following structural systems. The coating system is applied over the composite system and concrete in accordance with Simpson Strong-Tie installation instructions. The coating system must be applied to concrete T-beams with the following properties: 12-inch (305 mm) wide web thickness, 10-inch (254 mm) deep web depth, 6-inch (152 mm) flange thickness, 48-inch (1219 mm) flange width, a 28-day concrete compressive strength between 3,500 psi (24 MPa) and 5,000 psi (34 MPa), reinforced with 2 No. 5 bottom longitudinal reinforcing steel in the web, flange short direction transverse reinforcement No. 3 at 6-inch o/c top and bottom, top longitudinal reinforcement No. 3 at 6-inch o/c, and stirrup reinforcement No. 3 at 6-inch o/c with minimum 1.75 inch (44 mm) cover depth between reinforcement and concrete surface. The concrete surface to receive fabric must be primed with CSS-ES. CSS-CUCF and CSS-CUGF fabrics must be saturated with CSS-ES. The saturated CSS-CUCF fabric must be applied to the bottom of the web and the saturated CSS-CUGF fabric must be applied to the web at the ends of the T-beam in a U-wrap configuration. The coating system is applied over the lightly sanded installed fabrics and CSS-ES coated concrete by first priming the prepared surfaces with Firebond Concentrate Primer and then spray-applying the GCP Z-106 HY material at a minimum average thickness of $\frac{1}{2}$ -inch (13 mm) and a minimum average dry density of 23 lbs/ft³

(368 kg/m³). Other assembly configurations are beyond the scope of this report.

4.4 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 December 2013 (editorially revised May 2017). A statement of special inspection must be prepared in accordance with Sections [1704.3](#) of the 2015 and 2012 IBC or Section [1705](#) of the 2009 IBC and 2006 IBC. Inspection must also comply with Sections [1704](#) and [1705](#) of the 2015 and 2012 IBC, Section [1704](#) through [1707](#) of the 2009 and 2006 IBC, or Section 1701 of the UBC.

5.0 CONDITIONS OF USE

The Simpson Strong-Tie Composite Strengthening Systems (CSS) 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 of the structural systems recognized in this report must be in accordance with this report, the CSS Quality Control Manual dated June 18, 2015, the CSS Design Manual dated July 24, 2017, and the IBC, IRC or UBC, as applicable.
- 5.2 Copies of the Simpson Strong-Tie Composite Strengthening Systems installation instructions and the CSS Design Manual must be submitted to the code official for each project where these products are used.
- 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 Fire-resistance rating of the CSS composite strengthening systems must be in accordance with Section 4.3 of this report.

5.5 Special Inspection for application of the Composite Strengthening Systems products must be provided in accordance with Section 4.4 of this report.

5.6 Application of the Composite Strengthening Systems products to concrete at a fabricator's facility must be by an approved fabricator complying with [Chapter 17](#) of the IBC or UBC, or at a jobsite with continuous special inspections in accordance with Chapter 17 of the IBC or UBC and Section 4.4 of this report.

5.7 Multi-layer applications and lap splices of CSS-CUCL precured laminates are outside the scope of this report. Composite Strengthening Systems (CSS) must be manufactured by Simpson Strong-Tie Company, Inc. 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 Externally Bonded Fiber-Reinforced Polymer (FRP) Composite Systems (AC125), dated August 2014 (editorially revised November 2015), including alkali-soil resistance, fuel-resistance and drinking water exposure tests.

7.0 IDENTIFICATION

The components of the Simpson Strong-Tie Composite Strengthening Systems (CSS) (fabric, epoxy saturant, precured laminate and epoxy paste) described in this report are identified with a label indicating the name and address of the manufacturer's (Simpson Strong-Tie), the product name, expiration date and the number of the ICC-ES evaluation report (ESR-3403).

The proprietary FX-207 finish coating is labeled with manufacturer's name (Simpson Strong-Tie) and address, the product name, and expiration date.