EVALUATION SUBJECT:

SIMPSON STRONG-TIE COMPOSITE STRENGTHENING SYSTEMS ™ (CSS) FOR STRENGTHENING OF CONCRETE DIAPHRAGMS, CHORDS, AND COLLECTORS

REPORT HOLDER:

SIMPSON STRONG-TIE COMPANY INC.
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(800) 999-5099
www.strongtie.com

CSI Sections:
03 01 00 — Maintenance of Concrete
03 01 30 — Maintenance of Cast-in-Place Concrete

1.0 SCOPE OF EVALUATION

1.1 Compliance with the following codes & regulations:

- 2021, 2018, 2015, 2012, and 2009 International Building Code® (IBC)
- 2021, 2018, 2015, 2012, and 2009 International Residential Code® (IRC)
- 2022 California Building Code (CBC) – attached Supplement
- 2022 California Residential Code (CRC) –attached Supplement
- 2023 Los Angeles Building Code (LABC) – attached Supplement
- 2023 Los Angeles Residential Code (LARC) –attached Supplement

1.2 Evaluated in accordance with:

- IAPMO UES EC 038, Evaluation Criteria for Diaphragm Strengthening Using Fiber Reinforced Polymers

1.3 Properties assessed:

- Structural

2.0 PRODUCT USE

The Simpson Strong-Tie Composite Strengthening Systems (CSSs) described in this report have been evaluated for use in strengthening normal-weight reinforced concrete diaphragms, chords, and collectors and comply with the intent of the provisions of the IBC. The Simpson Strong-Tie Composite Strengthening Systems may be used for the IRC, where an engineering design is submitted in accordance with Section R301.1.3, subject to approval by the building official in accordance with Section R104.11.

3.0 PRODUCT DESCRIPTION

3.1 General: The Simpson Strong-Tie Composite Strengthening Systems are carbon fiber reinforced polymer (CFRP) and glass fiber reinforced polymer (GFRP) composite materials, comprising an epoxy resin polymer matrix reinforced with a carbon or glass fiber fabric.

3.2 Materials:

3.2.1 General: All material shall conform to the approved specifications outlined in the Simpson Strong-Tie Quality Documents.

3.2.2 CSS Fabrics: The CSS fabrics are composed of carbon or glass fibers. Dimensions and properties differ with fabric type.

3.2.2.1 CSS-CUCF11 and CSS-CUCF22 are unidirectional carbon reinforcing fabrics, weighing 11 oz./yd^2 (373 g/m^2) and 22 oz./yd^2 (746 g/m^2) respectively, and produced in either 12-inch by 300-foot (305 mm by 91.4 m) or 24-inch by 150-foot (610 mm by 45.7 m) rolls.

CSS-CUCF44 and CSS-CUCF44F are unidirectional carbon reinforcing fabrics weighing 44 oz/yd^2 (1492 g/m^2), and produced in either 12-inch x 150-foot (305 mm by 45.7 m) or 24-inch x 75-foot (610 mm x 22.9 m) rolls. The CSS-CUCF44 has a plain weave and the CSS-CUCF44F has a flat weave.

3.2.2.2 CSS-CUGF27 is a unidirectional glass reinforcing fabric weighing 27 oz./yd^2 (915 g/m^2) and produced in 25-inch or 50-inch x 140-foot (635 mm or 1270 mm by 43 m) rolls.

3.2.3 Epoxy Saturants:

3.2.3.1 CSS-ES Epoxy Primer and Saturant: The CSS-ES epoxy primer and saturant is a two-component, epoxy resin system. The resin is used to saturate CSS fabrics and anchors, fill vertical downward FRP anchor holes in concrete, and as a primer for the concrete surfaces. Provided in three-gallon (11.4 L) kits, Component A is provided as two gallons (7.6 L) in a five-gallon (18.9 L) container to allow enough room for mixing full kits of epoxy. Component B is provided

in one-gallon (3.8 L) pails. Components A and B are mixed at a 2:1 ratio by volume. Mixing and installation shall occur when the ambient and substrate temperatures are between 45 ºF (7 ºC) and 95 ºF (35 ºC). Pot life is one hour at 70 ºF (21ºC).

3.2.3.2 CSS-ESLPL Long Pot-Life Epoxy Primer and Saturant: The CSS-ESLPL is a two-component, long pot-life epoxy resin system. The resin is used to saturate CSS fabrics and anchors, fill vertical downward FRP anchor holes in concrete, and as a primer for the concrete surfaces. Provided in 2.96 gallon (11.2 L) kits, Component A is provided as two gallons (7.6 L) in a five-gallon (18.9 L) container to allow enough room for mixing full kits of epoxy. Component B is provided in 0.96 gallon (3.6 L) pails. Components A and B are mixed at a 2:0.96 ratio by volume. Mixing and installation shall occur when the ambient and substrate temperatures are between 70 ºF (21 ºC) and 110 ºF (43 ºC). Pot life is four hours at 72 ºF (22 ºC) or 45 minutes at 95 ºF (35 ºC).

3.2.4 CSS-EP Epoxy Paste and Filler: The CSS-EP epoxy paste and filler is a two-component, epoxy resin system. The paste is intended to level and transition irregular substrates and horizontal, upwardly inclined, or overhead FRP anchor holes. CSS-EP is provided in three-gallon (11.4 L) sets. The sets consist of a box, which includes Components A and B in 1-gallon (3.8 L) pails. Components A and B are blended at a 2:1 ratio by volume. Mixing and curing shall occur under ambient conditions. Pot life is one hour at 70ºF (21ºC).

3.2.5 CSS Composites:

3.2.5.1 CSS-CUCF Composites: In the main direction (0°), the carbon-fiber-reinforced polymer composites exhibit a minimum tensile strength of 128,000 psi (880 MPa), a minimum tensile modulus of 14,200 ksi (98 GPa), and an elongation at break of 0.9 percent. The minimum thicknesses after curing are 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 or CSS-CUCF44F, respectively.

3.2.5.2 CSS-CUGF27 Composite: In the main direction (0°), the glass-fiber-reinforced polymer composite exhibits a minimum tensile strength of 56,000 psi (390 MPa), a minimum tensile modulus of 3,300 ksi (23 GPa), and an elongation at break of 1.7 percent. The minimum thickness after curing is 0.05-inch (1.3 mm).

3.2.5.3 CSS-PCA Pre-cured Carbon Fiber Anchors: The Simpson Strong-Tie CSS-PCA is a pre-cured carbon fiber anchor. The pre-cured carbon anchor (CSS-PCA2512-4) has a diameter of ¼ inch (6.4 mm), a total length of 12 inches (305 mm), a fan length of 8 inches (203 mm), and an embedment length of 4 inches (102 mm). The pre-cured carbon anchor (CSS-PCA5012-4) has a diameter of ½ inch (12.7 mm), a total length of 12 inches (305 mm), a fan length of 8 inches (203 mm), and an embedment length of 4 inches (102 mm). The pre-cured carbon anchor (CSS-PCA6212-4) has a diameter of ⅝ inch (15.9 mm), a total length of 12 inches (305 mm), a fan length of 8 inches (203 mm), and an embedment length of 4 inches (102 mm). The pre-cured carbon anchor (CSS-PCA7512-4) has a diameter of ¾ inch (19.1 mm), a total length of 12 inches (305 mm), a fan length of 8 inches (203 mm), and an embedment length of 4 inches (102 mm). The embedment length of the PCA anchors is factory saturated and pre-cured. CSS-PCA pre-cured anchors have a minimum ultimate tensile strength of 128 ksi (883 MPa), a minimum tensile modulus of 14,200 ksi (98 GPa), and an elongation at break of 0.9 percent. In addition, CSS-PCA pre-cured anchors have a minimum shear strength of 50 ksi (345 MPa), a minimum bond shear strength of 3,000 psi (20.7 MPa) in uncracked concrete, and a minimum bond shear strength of 1,600 psi (11.0 MPa) in cracked concrete with a crack width of 0.020 inch (0.51 mm). The bond shear strength has been evaluated for exposure to an elevated temperature of 120ºF (49ºC).

3.2.5.4 CSS-CA Carbon Fiber Anchors: The Simpson Strong-Tie CSS-CA is a carbon fiber anchor intended to be field-laminated with the CSS-ES or CSS-ESLPL epoxy saturant. The CSS-CA anchor has a diameter of up to 1 inch (25.4 mm) and various lengths, as needed to fit field conditions. CSS-CA anchors have a minimum ultimate tensile strength of 128 ksi (883 MPa), a minimum tensile modulus of 14,200 ksi (98 GPa), and an elongation at break of 0.9 percent. See Section 3.2.3 of this report for epoxy installation temperatures, pot life, and cure time.

3.2.5.5 Storage Recommendations: Epoxies and fabrics shall be stored in dry locations at temperatures between 45°F and 95°F (7°C and 35°C). Shelf life is two years for epoxies and ten years for fabrics.

4.0 DESIGN AND INSTALLATION

4.1 Design

4.1.1 General: Composite Strengthening Systems shall be designed to safely resist loads defined in the IBC without exceeding the strength limit states and serviceability requirements. The strength limit states include designated concrete strains. designated composite strains, the composite interaction at the concrete substrate (bond), and the equilibrium of the tension in the composite and the compression stresses in the concrete. The strength design of reinforced concrete shall comply with Chapter 19 of the IBC and Section 4.1 of this evaluation report. In accordance with IBC Section 1604.4, the registered design professional shall provide an analysis to the building official, which determines the load effects on the structure and the capacities of the reinforced concrete strengthened with the CSS composites.

4.1.2 Composite Design Values: The CSS Composite design properties and values are provided in the Simpson Strong-Tie CSS Design Manual, dated February 22, 2023.

4.1.3 Design Procedures: The structural design procedures for the CSS composite system are established from testing and the principles of structural analysis. Designs shall account for strain compatibility, load equilibrium, and limit states. The FRP reinforcement shall be designed for tension as a force-controlled, nonductile action. All designs for nominal strengths shall comply with the IBC; ACI 318; IAPMO UES Evaluation Criteria for Diaphragm Strengthening Using Fiber Reinforced Polymers (IAPMO UES EC 038-2022), and the Simpson Strong-Tie CSS Design Manual.

4.1.4 Design Strengths: The design strengths shall be calculated as the product of the nominal strength, computed in accordance with Section 4.1.3 of this report, and the strength reduction factors in Section 21.2 of ACI 318-19 (2021 IBC), Section 21.2 of ACI 318-14 (2018 and 2015 IBC), Section 9.3 of ACI 318-11 (2012 IBC) or ACI 318-08 (2009 IBC), the modifications in IAPMO UES EC-038, Chapter 19 of the IBC, and the Simpson Strong-Tie CSS Design Manual, as applicable.

4.1.5 Load Combinations: The structures shall be designed to resist the applicable load combinations in Section 1605.2 of the IBC.

4.1.6 Diaphragms:

4.1.6.1 Uses: CSS-CUCF and CSS-CUGF Composite Strengthening Systems are applied to reinforced concrete diaphragms to increase in-plane shear strengths.

4.1.6.2 Structural Design: The diaphragm design shall comply with Chapter 19 of the IBC, ACI 318, IAPMO UES EC 038-2022, and the Simpson Strong-Tie CSS Design Manual.

4.1.7 Chords and Collectors

4.1.7.1 Uses: CSS-CUCF and CSS-CUGF Composite Strengthening Systems are applied to reinforced concrete chords and collectors to increase axial tensile strengths.

4.1.7.2 Structural Design: The chord and collector design shall comply with Chapter 19 of the IBC, ACI 318, IAPMO UES EC 038-2022, and the Simpson Strong-Tie CSS Design Manual.

4.1.8 Fiber Anchors:

4.1.8.1 Uses: CSS-PCA pre-cured carbon anchors are used to transfer tensile and shear forces from Simpson Strong-Tie Composite Strengthening Systems into concrete (as bent embedded fiber anchors into pre-drilled holes). CSS-CA carbon anchors are used to transfer tensile forces from CSSs to bypass an obstacle that prevents the continuity of the CSS Composite Strengthening Systems (as splice-through fiber anchors). When drilling into concrete, care shall be taken to avoid damage to any existing post-tensioned tendons or conventional reinforcement where present in concrete diaphragm elements.

4.1.8.2 Structural Design: The concrete diaphragm design shall comply with Chapter 19 of the IBC, ACI 318, IAPMO UES EC 038-2022, and the Simpson Strong-Tie CSS Design Manual. FRP anchors shall be located and designed to ensure the transfer of the required tension forces in the load combinations for diaphragm design as set forth in Section 4.1.5 of this report.

4.1.9 Bond Strength: Where the capacities of the CSS reinforcement are limited by bond (bond-critical), the bond strength of CSS Composite material to concrete shall be at least 200 psi (1378 kPa). Bond test results shall demonstrate failure in the concrete substrate. Either ASTM D7234 or D7522 may be used to test the bond strength of bond-critical installations. The number of tests and locations shall be specified by the registered design professional and approved by the building official. The bond strength has been evaluated for environmental exposures, including dry heat at 140ºF (60ºC).

4.1.10 Load Path and Detailing: The design professional shall provide a complete load path from the strengthened horizontal elements to the vertical support elements of the seismic force-resisting system.

4.1.10.1 The design professional shall submit design calculations and related details to the building official for approval for the strengthened diaphragm elements based on principles of mechanics for diaphragm openings, holes, and penetrations.

4.1.10.2 The design professional shall provide detailing for additional anchorage at any areas of known stress concentration or horizontal irregularities, as the corners of large openings or re-entrant corners.

4.1.10.3 The strengthening of each of the orthogonal directions of a concrete diaphragm shall be designed independently and shall not be assumed to have any contribution to the other direction.

4.1.10.4 The use of FRP reinforcement for force transfer across cold joints or between precast panels shall have fibers resisting tension in each direction of seismic loading. For example, multiple layers of fibers may be provided at 45-degree orientations relative to cold joints. Shear

strengthening of untopped precast diaphragms shall be designed such that flexibility between precast panels is negligible relative to global diaphragm shear flexibility.

4.2 Installation

4.2.1 Simpson Strong-Tie Composite Strengthening Systems shall be installed by applicators approved specifically for this system. Installation methods shall conform to the Simpson Strong-Tie Approved Applicator Training Program.

4.2.2 Fabric Saturation: The CSS fabrics shall be saturated with the CSS-ES Epoxy Saturant or CSS-ESLPL Long Pot-Life Epoxy Saturant using a calibrated mechanical saturator or manual saturation methods in accordance with Simpson Strong-Tie's published requirements and applicator training program.

4.2.3 Fabric Application: Manual methods shall be used to install the saturated CSS fabrics. Surface preparation and fabric installation, including orientation and removal of bubbles/voids, shall be done in accordance with published requirements and the approved applicator training program.

4.2.4 Anchor Saturation and Installation: The CSS-PCA and CSS-CA anchors shall be saturated with the CSS-ES or CSS-ESLPL Epoxy Saturant using manual saturation methods in accordance with Simpson Strong-Tie's Installation Instructions for CSS-CA and CSS-GA Anchors, dated June 2020. Surface preparation, drilled hole preparation, hole cleaning, anchor transitioning, anchor insertion, and anchor fan splaying shall be in accordance with the Installation Instructions for CSS-CA and CSS-GA Anchors.

4.2.5 Limitations: CSS installation shall only occur when the ambient and substrate temperatures are between 45°F (7°C) and 95°F (35°C). The epoxy shall cure for at least 72 hours at 70°F (21°C).

4.2.6 Covering: Composite Strengthening Systems may be painted or coated for appearance, fire exposure, or environmental durability purposes. Information supporting these applications shall be submitted to the building official for approval.

4.3 Special Inspection

Special inspection and testing are required for the preparation of the materials and substrates, and installation of the Simpson Strong-Tie CSS Composite Strengthening Systems. The special inspections shall comply with Sections 1704 and 1705 of the 2021, 2018, 2015, and 2012 IBC, Section 1704 through 1707 of the 2009 IBC, and the IAPMO UES Evaluation Criteria for Diaphragm Strengthening Using Fiber Reinforced Polymers (IAPMO UES EC 038-2022). Special inspectors shall provide written documentation demonstrating their qualifications for inspection of FRP systems in accordance with IBC Section 1704. A statement of special inspection shall be prepared in accordance with Section 1704.3 of the 2021, 2018, 2015, and 2012 IBC or Section 1705 of the 2009 IBC. The responsibilities of the special inspector shall be prepared in accordance with ICC-ES AC178 and ACI 440.2. Testing shall comply with Section 4.2 of EC 038, AC178, and ACI 440.2. Structural observations shall be provided where required in 2021, 2018, and 2015 IBC Section 1704.6, or 2012 IBC Section 1704.5.

5.0 LIMITATIONS

The use of the Simpson Strong-Tie Composite Strengthening Systems (CSSs) recognized in this report is subject to the following limitations:

5.1 Design and installation of the Simpson Strong-Tie Composite Strengthening Systems (CSS) shall comply with this report, the Simpson Strong-Tie CSS Design Manual dated February 22, 2023, and the IBC or IRC, as applicable. Where there is a conflict, the more restrictive requirements shall govern.

5.2 Copies of the Simpson Strong-Tie Composite Strengthening Systems published installation requirements and the CSS Design Manual shall be submitted to the building official.

5.3 Complete construction documents, including plans and calculations verifying compliance with this report, shall be submitted to the building official with the permit application for approval. The construction documents shall be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

5.4 Diaphragm shear strengthening with the Simpson Strong-Tie Composite Strengthening Systems shall only apply to the following structural elements:

- Cast-in-place, composite concrete topping slab diaphragms on precast floors or roofs at least two inches (50.8 mm) thick, provided the cast-in-place topping slab placed is clean, free of laitance, and intentionally roughened.
- Cast-in-place, non-composite concrete topping slab diaphragms at 2½ inches (63.5 mm) thick, provided the cast-in-place topping slab is detailed for continuous seismic load path to vertical lateral-force-resisting elements.
- Only the topped concrete portion of non-prismatic diaphragm systems shall be considered effective for seismic shear strength, such as in concrete over the

metal deck or waffle slab applications, unless specific component testing is provided to justify alternative values.
- Monolithically cast-in-place concrete diaphragms.

5.5 Special Inspection of the Composite Strengthening Systems products at the job site or the premises of a fabricator shall be conducted in accordance with Section 4.3 of this report. Alternatively, special inspection may be waived where the fabricator is approved to perform such work in accordance with IBC Section 1704.2.5.1.

5.6 Measures shall be taken to mitigate thermal stresses that may develop from the Simpson Strong-Tie Composite Strengthening Systems' exposure to direct sunlight. For example, at roof diaphragm applications, shade or emissive coating may need to be provided to minimize the potential for temperature elongation or shrinkage.

5.7 Weather protection of Simpson Strong-Tie Composite Strengthening Systems is beyond the scope of this report, and is subject to the review and evaluation for site-specific exposure conditions by the registered design professional for compliance with IBC Section 1402.2.

5.8 The Composite Strengthening Systems components recognized in this report are manufactured by Simpson Strong-Tie Company Inc. in West Chicago, Illinois.

6.0 SUBSTANTIATING DATA

- Data in accordance with IAPMO UES Evaluation Criteria for Diaphragm Strengthening Using Fiber Reinforced Polymers (EC 038-2022). Test data includes diaphragms, collectors, chords, and anchors.
- Test reports are from laboratories in compliance with ISO/IEC 17025.

7.0 IDENTIFICATION

The Simpson Strong-Tie Composite Strengthening Systems (CSSs) materials (carbon and glass fabrics, epoxy saturant, epoxy paste, and pre-cured carbon anchors) are identified with labels containing the name and address of the manufacturer (Simpson Strong-Tie), the product name, expiration date, if applicable, and the IAPMO UES evaluation report number (UES ER-701).

Either IAPMO UES Mark of Conformity may also be used as shown below:

or

IAPMO UES ER-701

For additional information about this evaluation report please visit www.uniform-es.org or email at info@uniform-es.org

CALIFORNIA SUPPLEMENT

REPORT HOLDER:

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SIMPSON STRONG-TIE COMPOSITE STRENGTHENING SYSTEMS ™ (CSSs) FOR STRENGTHENING OF CONCRETE DIAPHRAGMS, CHORDS, AND COLLECTORS

CSI Sections:

03 01 00 — Maintenance of Concrete
03 01 30 — Maintenance of Cast-in-Place Concrete

1.0 RECOGNITION

The Simpson Strong-Tie Composite Strengthening Systems as evaluated and represented in IAPMO UES Evaluation Report ER-701 and with changes as noted in this supplement are satisfactory alternatives for use in buildings built under the following codes:

- 2022 California Building Code (CBC)
- 2022 California Residential Code (CRC)

2.0 LIMITATIONS

Use of the Simpson Strong-Tie Composite Strengthening Systems recognized in this report supplement is subject to the following limitations:

2.1 Simpson Strong-Tie Composite Strengthening Systems shall comply with the provisions applicable to the 2021 IBC or 2021 IRC in IAPMO UES ER-701

2.2 Use of the systems in the exterior design and construction of new buildings located in a Very High Fire Hazard Severity Zone as defined in CBC Section 702A or CRC Section R337.2A is beyond the scope of this report supplement.

2.3 California Department of Health Care Access and Information (HCAI) (formerly Office of Statewide Health Planning and Development (OSHPD)) and Division of State Architect (DSA) provisions shall be observed where applicable.

2.4 Systems used in existing concrete structures shall comply with CBC Section 1911.3.

2.5 Systems used in existing concrete structures under the jurisdiction of HCAI or DSA shall comply with CBC Section 1911A.3.

2.6 This supplement expires concurrently with ER-701.

CITY OF LOS ANGELES SUPPLEMENT

REPORT HOLDER:

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CSI Sections:
03 01 00 — Maintenance of Concrete
03 01 30 — Maintenance of Cast-in-Place Concrete

1.0 RECOGNITION

The Simpson Strong-Tie Composite Strengthening Systems as evaluated and represented in IAPMO UES Evaluation Report ER-701 and the California Supplement and with changes as noted in this supplement are satisfactory alternatives for use in buildings built under the following codes:

- 2023 Los Angeles Building Code (LABC)
- 2023 Los Angeles Residential Code (LARC)

2.0 LIMITATIONS

Use of Simpson Strong-Tie Composite Strengthening Systems recognized in this report supplement is subject to the following limitations:

2.1 Simpson Strong-Tie Composite Strengthening Systems shall comply with the provisions applicable in the California Supplement to IAPMO UES ER-701.

2.2 Use of the systems in the exterior design and construction of new buildings located in a Very High Fire Hazard Severity Zone Wildland–Urban Interface Fire Area as defined in CBC Section 702A or CRC Section R337.2A is beyond the scope of this report supplement.

2.3 Prior to installation, calculations and details demonstrating compliance with this report supplement and the 2023 LABC or 2023 LARC shall be submitted to the structural plan check section for review and approval. The calculations and details shall be prepared, stamped, and signed by a California registered design professional.

2.4 Special Inspections are required in accordance with LABC Section 1705.3, Concrete Construction. Continuous special inspection shall be provided in accordance with AC178. The continuous special inspection shall be performed by registered deputy building inspectors.

2.5 Structural Observation is required in accordance with LABC Section 1704.6.

2.6 Systems used in existing concrete structures shall comply with LABC Section 1911.3.

2.7 This supplement expires concurrently with ER-701.