ICC EVALUATION SERVICE®

# ICC-ES Evaluation Report

**ESR-3573**

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**DIVISION: 03 00 00—CONCRETE**
**Section: 03 01 00—Maintenance of Concrete**

**REPORT HOLDER:**

**V2 COMPOSITES, INC.**

**EVALUATION SUBJECT:**

**CONCRETE STRENGTHENING USING THE V2 COMPOSITES STRUCTUREWRAP™ FIBER-REINFORCED COMPOSITE SYSTEMS**

## 1.0 EVALUATION SCOPE

**Compliance with the following codes:**

- 2015 and 2012 *International Building Code*® (IBC)
- 2015 and 2012 *International Residential Code*® (IRC)

**Properties evaluated**

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

## 2.0 USES

The V2 Composites StructureWrap™ Fiber Reinforced Composite Systems are used externally to strengthen normal-weight reinforced concrete structural elements as an alternative to those systems permitted in the IBC. The systems are also used as an interior finish. For structures regulated under the IRC, the composite systems may be used where an engineering design is submitted in accordance with Section R301.1.3 and may be used where approved by the code official in accordance with IRC Section R104.11.

## 3.0 DESCRIPTION

### 3.1 General:

The V2 Composites StructureWrap™ systems are fiber reinforced polymer (FRP) systems consisting of uni-directional carbon and glass fabrics combined in the field with epoxy resin to create the FRP composite system.

### 3.2 Materials

**3.2.1 Fabrics:** The V2 Composites StructureWrap™ fabrics are composed of either carbon or glass fibers which have been stitch bonded into proprietary uni-directional fabrics. Standard rolls measuring 25 inches wide by 300 feet long [675 square feet (62.1 $m^2$)] for the glass fabrics and 24 inches long by 300 feet long [600 square feet (55.1 $m^2$)] for the carbon fabrics are shipped in individual boxes. Special roll sizes and widths are available. Material properties vary with fabric designation.

**3.2.2 V2 Composites StructureWrap™ Resin V2-200 Matrix:** The V2-200 resin is an ambient cure epoxy resin mix used to bind the fabrics. Components A and B of the matrix are shipped in either 5-gallon (18.9 L) buckets or 55-gallon (208 L) drums and must be mixed at the jobsite or the facility of the approved fabricator at a volumetric rate of 2:1 (A:B) for three (3) to five (5) minutes with a low-speed (400 to 600 rpm) mixer prior to application. Mixed resin must be allowed to sit for ten (10) minutes prior to application. One gallon pot life is two to four hours at 68ºF (20ºC).

**3.2.3 Composite Systems:**

**3.2.3.1 V2 Composites StructureWrap™ V2 140 UG System:** The V2 Composites StructureWrap™ V2 140 UG System consists of the V2 140 UG glass fiber fabric. In the primary direction (0º), the glass fiber composite has a minimum ultimate tensile strength of 580 MPa (84,250 psi), a minimum tensile modulus of 33,475 MPa (5,435 ksi) and a corresponding elongation of 1.55 percent. Layer thickness is 0.51 mm (0.020 in.).

**3.2.3.2 V2 Composites StructureWrap™ V2 280 UG System:** The V2 Composites StructureWrap™ V2 280 UG System consists of the V2 280 UG glass fiber fabric. In the primary direction (0º), the glass fiber composite has a minimum ultimate tensile strength of 670 MPa (97,140 psi), a minimum tensile modulus of 50,360 MPa (7,304 ksi) and a corresponding elongation of 1.33 percent. Layer thickness is 0.85 mm (0.035 in.).

**3.2.3.3 V2 Composites StructureWrap™ V2 090 UC System:** The V2 Composites StructureWrap™ V2 090 UC System consists of the V2 090 UC carbon fiber fabric. In the primary direction (0º), the carbon fiber composite has a minimum ultimate tensile strength of 724 MPa (105,000 psi), a minimum tensile modulus of 74,635 MPa (10,825 ksi) and a corresponding elongation of 0.97 percent. Layer thickness is 0.51 mm (0.020 in.).

**3.2.3.4 V2 Composites StructureWrap™ V2 190 UC System:** The V2 Composites StructureWrap™ V2 190 UC System consists of the V2 190 UC carbon fiber fabric. In the primary direction (0º), the carbon fiber

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composite has a minimum ultimate tensile strength of 1,245 MPa (180,280 psi), a minimum tensile modulus of 116,170 MPa (16,849 ksi) and a corresponding elongation of 1.07 percent. Layer thickness is 0.85 mm (0.035 in.).

**3.2.4 V2 Composites StructureWrap™ Patch and Fill:** Any filling, feathering or patching of the substrates prior to V2 Composite systems application shall be done with a paste comprised of V2-200 saturating resin thickened to the appropriate consistency with fumed silica (Aerosil, Cabosil, etc.).

**3.2.5 V2 Composites StructureWrap™ Primer:** V2 Composites V2-200 is a resin utilized as a primer on freshly prepared concrete and masonry substrates.

**3.2.6 V2 Composites StructureWrap™ Base Coat:** The base coat used on V2 structural composite systems shall be comprised of V2 Composites V2-200 thickened to the appropriate consistency with fumed silica. (Aerosil, Cabosil, etc.).

**3.2.7 Finish Coat**: A final layer of fumed silica (Aerosil, Cabosil, etc.) thickened V2-200 is applied as a protective layer.

**3.2.8 Storage Recommendations:** For the both the fabrics and resins, water contamination and exposure to temperatures above 90ºF (32ºC) or below 40ºF (4ºC) must be avoided. The maximum life is 1 year for the resins and 5 years for the fabrics. For other coating products, storage life must not exceed the published recommendations of the product manufacturer's published guidelines.

## 4.0 DESIGN AND INSTALLATION

### 4.1 Design:

**4.1.1 General**. Design of the composite systems must be based on required tensile loads at designated concrete strain values. The strength design requirements for concrete must be in accordance with Chapter 19 of the IBC. The owner and registered design professional must be responsible for determining through analysis, the strengths and demands of the structural elements to be enhanced by the composite systems, subject to the approval of the code official.

**4.1.2 Composite Design Properties:** Structural design properties are found in the V2 Composites StructureWrap™ Design and Installation manual (DIM), revision 1, dated February 2015.

**4.1.3 Design Details:** Design of the composite system is based on test results and principles of structural analysis as set forth in Section 1604.4 of IBC. The bases of the 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 August 2014, and in the StructureWrap™ Design and Installation manual (DIM), revision 1, dated February 2015.

**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 of the IBC.

**4.1.5 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 provided in Section 21.2 of ACI 318-14 (2015 IBC), or Section 9.3 of ACI 318-11 (2012 IBC).

**4.1.6 Columns:**

**4.1.6.1 Potential Applications:** The composite systems are applied to both round and rectangular columns to increase and enhance their axial strengths.

**4.1.6.2 Structural Design Requirements:** Concrete column design must comply with the DIM and Chapter 19 of the IBC.

**4.1.7 Beams and Slabs:**

**4.1.7.1 Potential Applications:** The composite systems are applied to beams to increase and enhance their flexural and shear strength for gravity load resistance only, and applied to slabs to enhance flexural strength for gravity load resistance only.

**4.1.7.2 Structural Design Requirements:** Concrete design must comply with the DIM and Chapter 19 of the IBC.

**4.1.8 Walls:**

**4.1.8.1 Potential Applications:** The composite systems are applied to concrete walls to enhance out-of-plane flexural strength, only if walls are subjected to uniformly distributed loads (a behavior similar to horizontal slabs subjected to gravity loads).

**4.1.8.2 Structural Design Requirements:** Concrete wall design must comply with the DIM and Chapter 19 of the IBC.

**4.1.9 Bond Strength:** Where the performance of the FRP composite material depends on bond, the bond strength of the FRP composite material to the concrete must not be less than 200 psi (1,378 kPa). Bond testing must exhibit failure in the concrete substrate. Testing in accordance with ASTM D7234, C297 or D7522 may be used to estimate the bond strength of bond-critical installations.

### 4.2 Installation:

**4.2.1 General:** Installation must be by manufacturer approved applicators and in accordance with this report, the DIM and all applicable codes and standards.

**4.2.2 Saturation:** All design criteria and assumptions are based on full saturation of the constituent fibers with the matrix resin mixed at the prescribed ratios. The saturation of the fibers with the resin can be by either mechanical saturation equipment or by hand layup methods.

**4.2.3 Application:** Manual methods must be used to apply the saturated composite fabric prior to cure of the epoxy. Surface preparation, fiber orientation, and removal or air bubbles and voids, must take place in accordance with specifications noted in the installation guide.

**4.2.4 Finishing:** The composite systems may be painted to satisfy aesthetic and environmental considerations.

**4.2.5 Flame Spread:** When applied to structural elements to satisfy requirements of the applicable code, five (5) layers of the composite systems (without any finishing described in Section 4.2.4, above) yields a

flame-spread index of 25 or less and a smoke density that corresponds to the Class A flame-spread classification in accordance with Section 803.1.1 of the IBC.

**4.2.6 Cure Time Prior to Loading:** The cure time for the FRP and subsequent loading of the structure is dependent on structure temperature at the time of application and cure. The registered design professional and the inspector must be consulted prior to loading the structure after application. At a minimum, 72 hours, regardless of temperature, is required prior to loading of the structural member.

**4.2.7 Health Effects:** V2 200 epoxy resin (Part A and Part B) is formulated for potable water contact and complies with Section 605 of the *International Plumbing Code* (IPC) based on ANSI/NSF 61. The material must be applied in one coat to a total thickness of 0.3 inch. All surfaces must be clean, dry and free of contaminants. Concrete surfaces must be prepared by water-blasting, sandblasting or shot-blasting. 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 residues. Maximum surface-area-to-volume ratio is 19.4 $in^2/L$.

**4.3 Special Inspections:** Special inspection must comply with the applicable requirements in Sections 1704 through 1707 of the IBC. 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 Reinforced and Unreinforced Masonry Strengthening Using Fiber-reinforced Polymer (FRP) Composite Systems (AC178), dated December 2013. Inspection must also comply with the installation instruction document of the V2 composites. A statement of special inspection must be prepared in accordance with Sections 1704.3 of the 2015 and 2012 IBC.

## 5.0 CONDITIONS OF USE

The V2 Composites StructureWrap™ systems described in this report comply with, or are suitable alternatives to what is specified in, the 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 V2 Composites StructureWrap™ Design and Installation Manual, dated February 2015; The V2 Composites Quality Manuals dated September 20, 2013 and September 1, 2014, and the IBC.

**5.2** A copy of the V2 Composites StructureWrap™ Design and Installation Manual must be submitted to the code official in conjunction with each project implementing the systems.

**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 the 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** Special inspections for jobsite application of the V2 Composites StructureWrap™ systems must be provided in accordance with Section 4.3 of this report.

**5.5** The fire-resistance rating of the assembly must comply with Chapter 7 of the IBC, and is not reduced by the application of the V2 Composites StructureWrap™ system. The structural load-carrying capacities of fire-resistant-rated assemblies must be based on the design of the concrete without the V2 Composites StructureWrap™ system. Fire resistance of assemblies with structural load-carrying capabilities increased beyond the levels permitted by the IBC is beyond the scope of this report.

**5.6** Application of the V2 Composites StructureWrap™ system to concrete members at a fabricator's facility must be by an approved fabricator complying with section 1704.2.2 of the IBC, or at the jobsite with continuous special inspections in accordance with Section 1704.4 of the IBC.

**5.7** V2 Composites StructureWrap™ system materials must be manufactured by V2 Composites in Auburn, Alabama, under an inspection program with inspections by ICC-ES.

## 6.0 EVIDENCE SUBMITTED

Test results 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), August 2014, including reports of fire-resistance tests and surface burning tests.

## 7.0 IDENTIFICATION

**7.1** V2 Composites StructureWrap™ components are labeled in accordance with the V2 Composites quality manual and contain, at a minimum: company name, company address, product name, expiration date and ICC-ES evaluation report number (ESR-3573).

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

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