



The FRP Retrofit Experts

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## Company Profile

QuakeWrap Inc. (QWI) is a leading **designer, supplier and installer** of quality, innovative Fiber Reinforced Polymer (FRP) products for the repair and strengthening of structures. The company is also a pioneer research and development firm committed to providing economical solutions and unparalleled service to engineers, architects, and owners.

QWI was founded in 1994 by Dr. Mo Ehsani, an internationally recognized expert and researcher in the use of FRPs and a professor of structural engineering at the University of Arizona. Dr. Ehsani has been featured on CNN, the History Channel, National Public Radio, and in other media, including Engineering News Record (ENR) for his expertise on the strengthening of structures, particularly related to earthquakes, terrorist attacks and other potential structural disasters.

Since the company's inception, QuakeWrap's revolutionary FRP products have been used on projects all over the world, from Alcatraz in San Francisco to high-rise towers in the Midwestern United States and the largest Nuclear Power Plant to multiple retrofit projects overseas. Today, QuakeWrap is a one-stop shop for engineers, architects and owners seeking economical solutions for repair and retrofit of concrete, masonry, wood, and steel structures and pipes.

QWI has always been at the cutting edge of the composites technology in construction through the active participation of its principal in the latest research and development in this field. QWI constantly strives to improve its services and products above those of the competitors to serve its customers and clients in the best manner possible.

In most cases, when you contact us, we can recommend a retrofit for your project, and offer you a lump sum figure for Materials and Installation by our certified contractors. This process may take as little as a few hours! This one-stop **Turnkey** approach will allow you to easily compare our solution with conventional alternatives. Among the services we offer are:

- Supply of complete line of materials (glass or carbon fabrics, carbon plates, resins, and top coatings)
- Assistance with design or complete sealed designs including Auto CAD drawings
- Installation by our own construction crew or training and certifying your contractors

For additional technical information about our products and past projects, please visit our web site at [www.QuakeWrap.com](http://www.QuakeWrap.com)



## Significant Dates in the History of QuakeWrap, Inc.

The following summary provides a list of events and activities of Prof. M. Ehsani that led to the formation of QuakeWrap, Inc.

- 1987 Pioneered R&D on strengthening concrete beams with FRPs & published the first paper on this subject to be published by ACI in 1990: "Fiber Composite Plates Can Strengthen Concrete Beams," *Concrete International*, 12(3), 65-71.
- 1991 Was awarded a \$200,000 grant from the National Science Foundation (the first such award given by NSF on this topic) to study "Strengthening of Concrete Columns with Fiber Composites," NSF, \$199,770, Grant No. MSS-9022667, 1991-94.
- 1992 Was awarded a \$35,000 grant (and two years later a \$75,000 grant) from the National Science Foundation (the first such award given by NSF on this topic) to study "Seismic Strengthening of Unreinforced Masonry Structures with Fiber Composite Fabrics," NSF Grant No. BCS-9201110, 1992-93.
- 1994 Incorporated Structural Rehabilitation Group (that was subsequently renamed QuakeWrap, Inc. in 2003). QuakeWrap™ products were successfully used to strengthen major buildings in southern California.
- 1996 Chaired an ACI subcommittee and was the primary author for ACI-440 State of the Art Report on Fiber Reinforced Plastic Reinforcement for Concrete Structures (see enclosure).
- 1997 Received US Patent #5,640,825, "Method of Strengthening Masonry and Concrete Walls with Composite Strap and high-Strength Random Fibers." (see enclosure)
- 2003 Renamed the company QuakeWrap, Inc. and obtained Contractors' Licenses in Arizona and California and started to offer a complete "turnkey" solution including design, materials, and installation.
- 2004 Received Award of Excellence in Retrofit from the Structural Engineers Association of Arizona for Retrofit of Coolidge High School Gymnasium.
- 2005 The History Channel highlighted the innovative QuakeWrap™ products in a show focusing on the retrofit of a historical theatre. The show aired on Saturday, March 26, 2005 and a video of the show is available on our website at: [www.QuakeWrap.com/news.htm](http://www.QuakeWrap.com/news.htm)

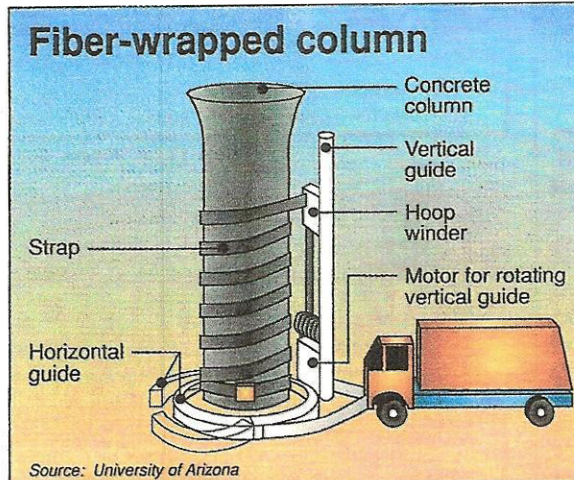
# Engineer says agency leaked idea

In tests that may result in an innovative way to strengthen California's bridges, concrete columns will be wrapped with a high-strength fiber now used in bullet-proof vests. But the research contract has come under fire, with officials at the California Dept. of Transportation getting flak for allegedly taking proprietary information from the University of Arizona and sharing that material with prospective bidders in California.

The university's attorneys have filed a bid protest with Caltrans regarding its award of the contract for testing fiber-wrapped concrete columns. Caltrans officials have denied that any of the university's material they shared with other bidders was proprietary. But the university's allegations are being investigated, and if they are found to be true the contract will be canceled and rebid, says Caltrans attorney Nicholas G. Tinning.

Caltrans awarded the \$42,000 research contract in June to Fyle Associates Inc., a one-man firm in Del Mar. The firm plans to subcontract the testing to the University of California at San Diego, which leads the state in Caltrans-funded research into the retrofitting of concrete columns.

The successful bidder, Edward R. Fyfe, says there is no truth to assertions that he profited from the intellectual property of the University of Arizona. "Using fibers to wrap a column is kind of like a motherhood thing—



Proposal was submitted after Loma Prieta Earthquake.

lots of people have thought about it," he says. There may be some truth to that. In a 1987 technical paper, Japanese researchers discussed wrapping concrete columns in carbon fibers. But as they admitted in that paper, carbon fibers are brittle.

In comparison, Kevlar is stronger and more ductile, with a tensile strength of 500,000 psi, says Mohammad R. Ehsani, an associate professor in the University of Arizona's civil engineering department. He claims he was the first to inform Caltrans officials about weaving belts of Kevlar and then winding and post-tensioning them around bridge columns for increased lateral strength. He says he sent them a pre-proposal last fall just weeks after the Loma Prieta Earth-

quake near San Francisco. Caltrans officials then disclosed this idea to California firms and requested formal proposals from them, to keep the contract in-state, he says.

Although the dollar amount of this research contract is small, the results might have widespread application. State and local agencies in California are planning to retrofit concrete columns in an estimated 1,000 bridges within the next few years. Caltrans itself plans to spend \$500 million for repairs to the state's concrete bridges, says James E. Roberts, the agency's chief bridge engineer.

An estimated one-third of that \$500 million in repairs will be spent on columns, although agency officials have not decided on how to proceed. Last month, for instance, work was halted on two quake-damaged San Francisco viaducts, in part because of concerns about using steel-plate jackets (ENR 8/2 p. 13).

Besides retrofitting columns, Caltrans plans to reinforce its concrete bridges in other ways as well. Probably half of the \$500 million will be spent on reinforcing footings, Roberts says. Furthermore, connections will be upgraded to prevent bridge girders from slipping off bearing pads in the event of an earthquake. Most of the repairs will be made to state bridges that were designed before the 1971 San Fernando quake, he says. ■

By David B. Rosenbaum

# State-of-the-Art Report on Fiber Reinforced Plastic (FRP) Reinforcement for Concrete Structures

Reported by ACI Committee 440

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Chairman

H. Saadatmanesh\*  
Secretary

M. R. Ehsani\*  
Subcommittee chairman  
for the State-of-the-Art  
Report

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\* Members of the subcommittee on the State-of-the-Art Report.

† Deceased.

In addition to those listed above, D. Barno contributed to the preparation of the report.

*The use of FRP as reinforcement for concrete structures has been growing rapidly in recent years. This state-of-the-art report summarizes the current state of knowledge on these materials. In addition to the material properties of the constituents, i.e. resins and fibers, design philosophies for reinforced and prestressed elements are discussed. When the available data warrants, flexure, shear and bond behavior, and serviceability of the members has been examined. Strengthening of existing structures with FRPs and field applications of these materials are also presented.*

The American Concrete Institute does not endorse products or manufacturers mentioned in this report. Trade names and manufacturers' names are used only because they are considered essential to the objective of this report.

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Reference to this document shall not be made in contract documents. If items found in this document are desired by the Architect/Engineer to be a part of the contract documents, they shall be restated in mandatory language for incorporation by the Architect/Engineer.

**Keywords:** analysis; composite materials; concrete; concrete construction; design; external reinforcement; fibers; fiber reinforced plastic (FRP); mechanical properties; polymer resin; prestressed concrete; reinforcement; reinforced concrete; research; structural element; test methods; testing.

## CONTENTS

### Chapter 1—Introduction and history, p. 440R-2

- 1.1—Introduction
- 1.2—History of the U.S. pultrusion industry
- 1.3—Evolution of FRP reinforcement in the U.S.A.
- 1.4—FRP materials

### Chapter 2—FRP composites: An overview of constituent materials, p. 440R-6

- 2.1—Introduction
- 2.2—The importance of the polymer matrix
- 2.3—Introduction to matrix polymers
- 2.4—Polyester resins
- 2.5—Epoxy resins

ACI 440R-96 became effective January 1, 1996.

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US005640825A

# United States Patent [19]

[11] Patent Number: 5,640,825

Ehsani et al.

[45] Date of Patent: Jun. 24, 1997

[54] METHOD OF STRENGTHENING MASONRY AND CONCRETE WALLS WITH COMPOSITE STRAP AND HIGH STRENGTH RANDOM FIBERS

[76] Inventors: **Mohammad R. Ehsani**, 5630 E. Via Arbolada, Tucson, Ariz. 85715; **Hamid Saadatmanesh**, 5121 E. Paseo Del Bac, Tucson, Ariz. 85718

[21] Appl. No.: 387,136

[22] Filed: Feb. 10, 1995

### Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 226,495, Apr. 12, 1994, abandoned.

[51] Int. Cl.<sup>6</sup> ..... E04B 1/00

[52] U.S. Cl. .... 428/408; 428/408

[58] Field of Search ..... 52/746.1; 156/71, 156/91, 92; 428/902, 408

### [56] References Cited

#### U.S. PATENT DOCUMENTS

4,851,277 7/1989 Valkenburg et al. .

#### FOREIGN PATENT DOCUMENTS

0378232 7/1990 European Pat. Off. .

### OTHER PUBLICATIONS

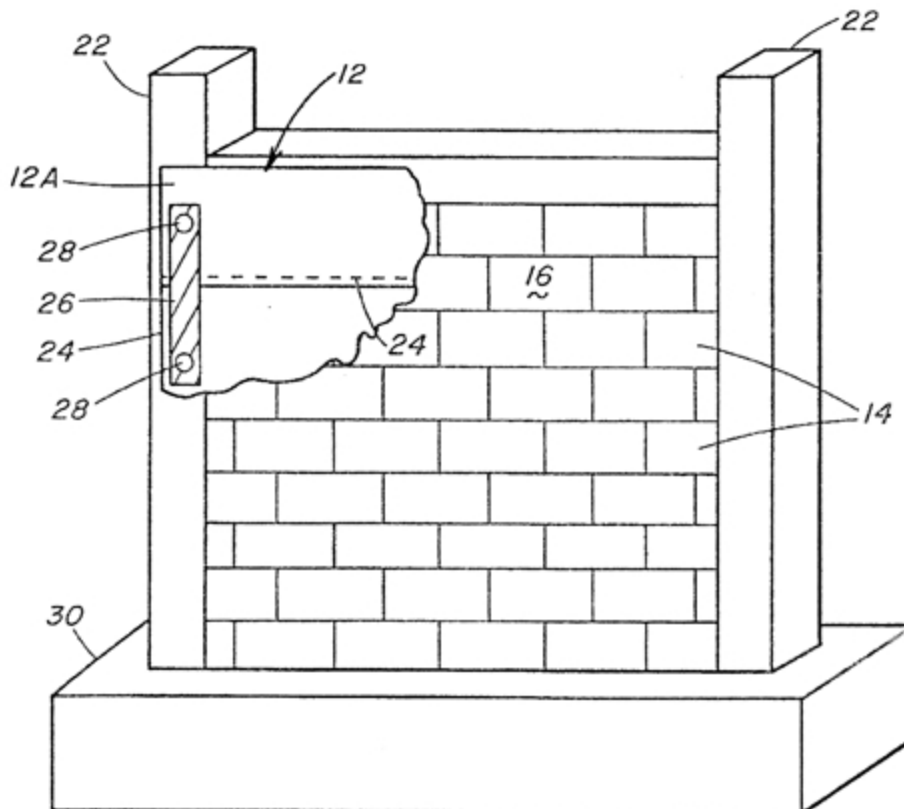
"Plastics Technology" by Robert Milby.

Primary Examiner—Creighton Smith  
Attorney, Agent, or Firm—John R. Flanagan

### [57] ABSTRACT

A method of strengthening a wall includes the steps of preparing a portion of a surface of a wall to be strengthened by cleaning the surface, providing a plurality of straps of flexible nonmetallic fiber composite material, and fixedly attaching the straps of nonmetallic fiber composite material to the wall portion along at least lengthwise portions of the straps and opposite end portions thereof by epoxy bonding the straps onto the surface. Also, the straps are impregnated with the epoxy in preparation for bonding the strap to the wall surface. Also, edge portions of the straps are fastened to an adjacent structure which supports the wall being strengthened so as to facilitate transfer of loads from the wall to the adjacent structure. Another method of strengthening a wall includes the steps of providing a mixture of randomly-oriented short fibers and liquid resin or adhesive matrix and applying the mixture to the surface of the wall. The mixture can be applied either by spraying or troweling the mixture onto the surface of the wall. The liquid resin or adhesive matrix is a material that cures fast so as to prevent the fibers from running with the liquid down the height of the wall surface.

40 Claims, 3 Drawing Sheets





## TECHNICAL DATA

QuakeWrap™ products have been tested at various laboratories since the late 1980s. The tests on material properties include:

- Physical/mechanical properties
- Durability under severe environmental conditions
- Smoke generation
- Flame spread

The results of the above tests are included here.

In addition, Professor Ehsani and his research associates have conducted extensive structural tests on the following applications:

- R/C Beams Strengthened with FRP (flexure & shear)
- R/C Columns Strengthened with FRP (flexure, shear & confinement under simulated earthquake loading)
- Unreinforced Masonry Walls Strengthened with FRP (in-plane shear & out-of-plane bending under simulated earthquake loading)
- Steel Girders Strengthened with Carbon Plates (static & fatigue loading)
- Glulam Beams Strengthened with FRP (shear & flexure)

The results of the above investigations have been published in the highest quality peer-reviewed professional journals such as *ASCE Journal of Structural Engineering*, *ACI Structural Journal*, and *Earthquake Spectra*. Considering the large volume of published studies, the inclusion of these reports in this document is not practical.

All of the above publications are available as downloadable PDF files that can be accessed through the following link: [www.QuakeWrap.com/papers.htm](http://www.QuakeWrap.com/papers.htm). This site also includes a large number of technical papers by other researchers on various aspects of analysis and design of FRP.



### QuakeWrap™ Fabric & Plate Specifications†

This table summarizes the properties of some of the QuakeWrap™ products; other products are available or can be developed to meet specific project requirements.

Product Designation	VU20G	VB24G		VU18C	VU23C	DU50C
Packaging	See Materials Sheets for Available Sizes					3-in. wide
Description	Fabric					Plate
Fiber Orientation‡	0	0/90	0/90	0	0	0
Fiber Type	Glass	Glass	Glass	Carbon	Carbon	Carbon
Effective Thickness per Ply (in.)	0.04	0.04	0.04	0.04	0.05	0.05
Density; ASTM-D792 (g/cm <sup>3</sup> )	1.54	1.54	1.54	1.54	1.28	1.3
Direction Tested (Long. or Trans.)	L	L	T	L	L	L
Maximum Load per in. width (lb.)§	2,365	1,880	1,420	4,100	5,250	15,400
Tensile Strength;ASTM-D3039 (ksi)	63.7	45.6	30.0	102.7	113.4	309.0
Modulus of Elasticity;ASTM-D3039 (ksi)	2,940	2,130	1,600	9,950	9,900	20,800
Elongation at Failure (%)	2.2	2.1	1.9	1.1	1.1	1.5

**Notes:**

† The above results were obtained based on samples produced with two plies of fabric and under ideal laboratory conditions from a single lot. The average resin content of samples measured in accordance with ASTM-D2584 varied from 55% to 60% by weight. Due to variation in material properties from different lots, it is recommended that a **strength reduction factor of 20%** be applied to the above values.

‡ Unidirectional fabrics have negligible strength and stiffness in the transverse direction.

§ Values are reported for a single ply of fabric.

Narrower width fabrics are available by special order.



**Product Data Sheet**  
**QuakeWrap™ VU20G Glass Fabric**  
**for Structural Strengthening**

**DESCRIPTION**

QuakeWrap™ VU20G is a high-strength unidirectional glass fabric. The fabric is white and is impregnated in the field using QuakeBond™ J300SR Saturating Resin to form a glass fiber reinforced polymer (GFRP) used to strengthen structural elements. The fabric weighs 20 oz/yd<sup>2</sup> (677 g/m<sup>2</sup>).

**USE**

- Increased live load capacity in buildings and bridges, hospital floors, roofs of buildings, etc.
- Seismic retrofit of structural elements such as columns, unreinforced masonry walls, etc.
- Repair of large diameter pipes to achieve strengthening and water-proofing
- Repair of damaged structural components caused by aggressive environments, fire, vehicle impact, aging, etc.
- Changes in structural system: new openings in floors, removal of existing walls, etc.
- Correction of design or construction errors: misplaced reinforcing bars, insufficient structural depth

**ADVANTAGES**

- Strong and lightweight fabric ideal for confined spaces.
- Used for flexure and shear strengthening as well as confinement.
- Fully compatible and excellent adhesion to QuakeBond™ resins.
- Non-corrosive.
- Versatile; can be wrapped around complex shapes.
- Light weight; does not alter mass & dynamic loads on structure.
- Special manufacturing of the fabric makes it very stable & prevents fraying.

**PACKAGING**

Rolls: 50 in. X 50 yards (1.27 m X 45 m) or 25 in. X 100 yards (635 mm X 90 m) or 12 in. X 100 yards (305 mm X 90 m). The fabric can be easily cut in the field to various lengths.

**SHELF LIFE**

Unlimited shelf life in proper storage conditions.

**STORAGE CONDITIONS**

Store in dry place at 45°-95° F (7°-35° C).

**APPLICATION**

Surface must be clean and sound; it may be dry or damp, but must be free of standing water and frost. Remove dust, laitance, grease, curing compounds, disintegrated materials and other bond inhibiting materials from the surface. Existing uneven surfaces must be filled with an appropriate repair mortar. The adhesive strength of the substrate must be verified after surface preparation by random pull-off testing (ACI 503R) at the discretion of the engineer. Minimum tensile strength of 200 psi (1.4 MPa) with substrate failure is required.

Blast clean, shot-blast, scarify or use other approved mechanical means to clean the substrate surface. Any sharp edges (i.e. fins, form-marks, etc.) must be ground smooth and flush. Sharp edges must be rounded to a minimum radius of ¼ in. (19 mm). Apply QuakeBond™ J200TC onto the substrate with a trowel or spatula to a nominal thickness of 40 mil (1 mm). A notched trowel may be used for this application.

Saturate QuakeWrap™ VU20G fabric thoroughly with QuakeBond™ J300SR; for more details, refer to the Product Data Sheet for J300SR. Before the epoxies harden, apply saturated fabric to the substrate surface that has been coated with J200TC. Using gloved hands, carefully remove any entrapped air bubbles under the fabric; a plastic laminating roller can be used for this purpose. If required, additional layers of saturated fabric can be directly applied on top of previous layers. Feather the edges of the fabric with QuakeBond™ J200TC.

Installation of QuakeWrap™ fabrics must be performed only by specially trained and approved contractors.

Fabric can be cut to appropriate length using a commercial quality heavy duty scissor. Since dull or worn cutting tools can damage, weaken or fray the fiber, their use should be avoided.

**LIMITATIONS**

Design calculations must be made and certified by an independent licensed professional engineer. System is a vapor barrier. Concrete should not be encapsulated in areas of freeze/thaw.

**CAUTION**

QuakeWrap™ VU20G is non-reactive. However, caution must be used when handling since a fine glass dust may be present on the surface. Gloves must therefore be worn to protect against skin irritation. Caution must also be used when cutting the fabric to protect against airborne glass dust generated by the cutting procedure. Use of an appropriate, properly fitted NIOSH approved respirator is recommended.

PROPERTIES OF FABRIC LAMINATED WITH J300SR: *		
	US Units	SI Units
Aerial Weight	20 oz/yd <sup>2</sup>	677 g/m <sup>2</sup>
Tensile Strength	63.7 ksi	439 MPa
Tensile Modulus	2,940 ksi	20,270 MPa
Ultimate Elongation	2.2%	2.2%
Breaking Force	2,365 lb/in.	414 N/mm
Ply Thickness	0.037 in.	0.94 mm

\* Results based on tests of two plies of fabrics saturated with J300SR. Data reported represent values for a single ply of fabric.

KEEP OUT OF REACH OF CHILDREN.  
NOT FOR INTERNAL CONSUMPTION.

FOR INDUSTRIAL USE ONLY.  
KEEP CONTAINER CLOSED TIGHTLY.

QuakeWrap, Inc. warrants this product for one year from date of installation to be free from manufacturing defects and to meet the technical properties on the current technical data sheet if used as directed within shelf life. User determines suitability of product for intended use and assumes all risks. Buyer's sole remedy shall be limited to the purchase price or replacement of product exclusive of labor or cost of labor. NO OTHER WARRANTIES EXPRESS OR IMPLIED SHALL APPLY INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. QUAKEWRAP, INC. SHALL NOT BE LIABLE UNDER ANY LEGAL THEORY FOR SPECIAL OR CONSEQUENTIAL DAMAGES.





**Product Data Sheet**  
**QuakeWrap™ VB24G Glass Fabric**  
**for Structural Strengthening**

**DESCRIPTION**

QuakeWrap™ VB24G is a high-strength biaxial glass fabric with slightly different strengths in 0° and 90° directions. The fabric is white and is impregnated in the field using QuakeBond™ J300SR Saturating Resin to form a glass fiber reinforced polymer (GFRP) used to strengthen structural elements. The fabric weighs 24 oz/yd<sup>2</sup> (813 g/m<sup>2</sup>).

**USE**

- Increased live load capacity in buildings and bridges, hospital floors, roofs of buildings, etc.
- Seismic retrofit of structural elements such as columns, unreinforced masonry walls, etc.
- Repair of large diameter pipes to achieve strengthening and water-proofing
- Repair of damaged structural components caused by aggressive environments, fire, vehicle impact, aging, etc.
- Changes in structural system: new openings in floors, removal of existing walls, etc.
- Correction of design or construction errors: misplaced reinforcing bars, insufficient structural depth

**ADVANTAGES**

- Strong and lightweight fabric ideal for confined spaces.
- One application adds strength in two orthogonal directions.
- Used for flexure and shear strengthening as well as confinement.
- Fully compatible and excellent adhesion to QuakeBond™ resins.
- Non-corrosive.
- Versatile; can be wrapped around complex shapes.
- Light weight does not alter mass & dynamic loads on structure.
- Special manufacturing of the fabric makes it very stable & prevents fraying.

**PACKAGING**

Rolls: 50 in. X 50 yards (1.27 m X 45 m). The fabric can be easily cut in the field to various lengths.

**SHELF LIFE**

Unlimited shelf life in proper storage conditions.

**STORAGE CONDITIONS**

Store in dry place at 45°-95° F (7°-35° C).

**APPLICATION**

Surface must be clean and sound; it may be dry or damp but must be free of standing water and frost. Remove dust, laitance, grease, curing compounds, disintegrated materials and other bond inhibiting materials from the surface. Existing uneven surfaces must be filled with an appropriate repair mortar. The adhesive strength of the substrate must be verified after surface preparation by random pull-off testing (ACI 503R) at the discretion of the engineer. Minimum tensile strength of 200 psi (1.4 MPa) with substrate failure is required.

Blast clean, shot-blast, scarify or use other approved mechanical means to clean the substrate surface. Any sharp edges (i.e. fins, form-marks, etc.) must be ground smooth and flush. Sharp edges must be rounded to a minimum radius of ¼ in. (19 mm). Apply QuakeBond™ J200TC onto the substrate with a trowel or spatula to a nominal thickness of 40 mil (1 mm). A notched trowel may be used for this application.

Saturate QuakeWrap™ VB24G fabric thoroughly with QuakeBond™ J300SR; for more details, refer to the Product Data Sheet for J300SR. Before the epoxies harden, apply saturated fabric to the substrate surface that has been coated with J200TC. Using gloved hands, carefully remove any entrapped air bubbles under the fabric; a plastic laminating roller can be used for this purpose. If required, additional layers of saturated fabric can be directly applied on top of previous layers. Feather the edges of the fabric with QuakeBond™ J200TC.

Installation of QuakeWrap™ fabrics must be performed only by specially trained and approved contractors.

Fabric can be cut to appropriate length using a commercial quality heavy duty scissor. Since dull or worn cutting tools can damage, weaken or fray the fiber, their use should be avoided.

**LIMITATIONS**

Design calculations must be made and certified by an independent licensed professional engineer. System is a vapor barrier. Concrete should not be encapsulated in areas of freeze/thaw.

**CAUTION**

QuakeWrap™ VB24G is non-reactive. However, caution must be used when handling since a fine glass dust may be present on the surface. Gloves must therefore be worn to protect against skin irritation. Caution must also be used when cutting the fabric to protect against airborne glass dust generated by the cutting procedure. Use of an appropriate, properly fitted NIOSH approved respirator is recommended.

PROPERTIES OF FABRIC LAMINATED WITH J300SR: *		
	US Units	SI Units
Aerial Weight	24 oz/yd <sup>2</sup>	812 g/m <sup>2</sup>
Ply Thickness	0.0412 in.	1.05 mm
<b>Longitudinal (0°) Direction:</b>		
Tensile Strength	45.6 ksi	314 MPa
Tensile Modulus	2,130 ksi	14,685 MPa
Ultimate Elongation	2.1%	2.1%
Breaking Force	1,880 lb/in	329 N/m
<b>Transverse (90°) Direction:</b>		
Tensile Strength	30.0 ksi	207 MPa
Tensile Modulus	1,600 ksi	11,030 MPa
Ultimate Elongation	1.9%	1.9%
Breaking Force	1,420 lb/in.	248 N/mm

\* Results based on tests of two plies of fabrics saturated with J300SR. Data reported represent values for a single ply of fabric.

KEEP OUT OF REACH OF CHILDREN.  
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FOR INDUSTRIAL USE ONLY.  
KEEP CONTAINER CLOSED TIGHTLY.

QuakeWrap, Inc. warrants this product for one year from date of installation to be free from manufacturing defects and to meet the technical properties on the current technical data sheet if used as directed within shelf life. User determines suitability of product for intended use and assumes all risks. Buyer's sole remedy shall be limited to the purchase price or replacement of product exclusive of labor or cost of labor. NO OTHER WARRANTIES EXPRESS OR IMPLIED SHALL APPLY INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. QUAKEWRAP, INC. SHALL NOT BE LIABLE UNDER ANY LEGAL THEORY FOR SPECIAL OR CONSEQUENTIAL DAMAGES.



**Product Data Sheet**  
**QuakeWrap™ VU18C Carbon Fabric**  
**for Structural Strengthening**

**DESCRIPTION**

QuakeWrap™ VU18C is a high-strength unidirectional carbon fabric. The fabric is black and is impregnated in the field using QuakeBond™ J300SR Saturating Resin to form a carbon fiber reinforced polymer (CFRP) used to strengthen structural elements. The fabric weighs 18.5 oz/yd<sup>2</sup> (627 g/m<sup>2</sup>) and the fibers are primarily in the longitudinal (0°) direction.

**USE**

- Increased live load capacity in buildings and bridges, hospital floors, roofs of buildings, etc.
- Seismic retrofit of structural elements such as columns, unreinforced masonry walls, etc.
- Repair of large diameter pipes to achieve strengthening and water-proofing
- Repair of damaged structural components caused by aggressive environments, fire, vehicle impact, aging, etc.
- Changes in structural system: new openings in floors, removal of existing walls, etc.
- Correction of design or construction errors: misplaced reinforcing bars, insufficient structural depth

**ADVANTAGES**

- Very strong and lightweight fabric ideal for confined spaces.
- Used for flexure and shear strengthening as well as confinement.
- Fully compatible and excellent adhesion to QuakeBond™ resins.
- Non-corrosive.
- Versatile; can be wrapped around complex shapes.
- Light weight does not alter mass & dynamic loads on structure.
- Alkali resistant.
- Special manufacturing of the fabric makes it very stable & prevents fraying.

**PACKAGING**

Rolls: 50 in. X 50 yards (1.27 m X 45 m) or 24 in. X 100 yards (610 mm X 90 m) or 12 in. X 100 yards (305 mm X 90 m). The fabric can be easily cut in the field into narrower widths of various lengths.

**SHELF LIFE**

Unlimited shelf life in proper storage conditions.

**STORAGE CONDITIONS**

Store in dry place at 45°-95° F (7°-35° C).

**APPLICATION**

Surface must be clean and sound; it may be dry or damp but must be free of standing water and frost. Remove dust, laitance, grease, curing compounds, disintegrated materials and other bond inhibiting materials from the surface. Existing uneven surfaces must be filled with an appropriate repair mortar. The adhesive strength of the substrate must be verified after surface preparation by random pull-off testing (ACI 503R) at the discretion of the engineer. Minimum tensile strength of 200 psi (1.4 MPa) with substrate failure is required.

Blast clean, shot-blast, scarify or use other approved mechanical means to clean the substrate surface. Any sharp edges (i.e. fins, form-marks, etc.) must be ground smooth and flush. Sharp edges must be rounded to a minimum radius of ¼ in. (19 mm). Apply QuakeBond™ J200TC onto the substrate with a trowel or spatula to a nominal thickness of 40 mil (1 mm). A notched trowel may be used for this application.

Saturate QuakeWrap™ VU18C fabric thoroughly with QuakeBond™ J300SR; for more details, refer to the Product Data Sheet for J300SR. Before the epoxies harden, apply saturated fabric to the substrate surface that has been coated with J200TC. Using gloved hands, carefully remove any entrapped air bubbles under the fabric; a plastic laminating roller can be used for this purpose. If required, additional layers of saturated fabric can be directly applied on top of previous layers. Feather the edges of the fabric with QuakeBond™ J200TC.

Installation of QuakeWrap™ fabrics must be performed only by specially trained and approved contractors.

Fabric can be cut to appropriate length using a commercial quality heavy duty scissor. Since dull or worn cutting tools can damage, weaken or fray the fiber, their use should be avoided.

**LIMITATIONS**

Design calculations must be made and certified by an independent licensed professional engineer. System is a vapor barrier. Concrete should not be encapsulated in areas of freeze/thaw.

**CAUTION**

QuakeWrap™ VU18C is non-reactive. However, caution must be used when handling since a fine carbon dust may be present on the surface. Gloves must therefore be worn to protect against skin irritation. Caution must also be used when cutting the fabric to protect against airborne carbon dust generated by the cutting procedure. Use of an appropriate, properly fitted NIOSH approved respirator is recommended.

FIBER & LAMINATE PROPERTIES		
	US Units	SI Units
<b>Fiber Properties:</b>		
Tensile Strength	550 ksi	3,800 MPa
Tensile Modulus	33,500 ksi	231,000 MPa
Ultimate Elongation	1.64%	1.64%
Density	0.065 lb/in <sup>3</sup>	1.8 g/cm <sup>3</sup>
<b>Laminated with J300SR: *</b>		
Aerial Weight	18.5 oz/yd <sup>2</sup>	627 g/m <sup>2</sup>
Tensile Strength	102.7 ksi	708 MPa
Tensile Modulus	9,950 ksi	68,600 MPa
Ultimate Elongation	1.1%	1.1%
Breaking Force	4,100 lb/in.	717 N/mm
Ply Thickness	0.0399 in.	1.01 mm

\* Results based on tests of two plies of fabrics saturated with J300SR. Data reported represent values for a single ply of fabric.

KEEP OUT OF REACH OF CHILDREN.  
NOT FOR INTERNAL CONSUMPTION.

FOR INDUSTRIAL USE ONLY.  
KEEP CONTAINER CLOSED TIGHTLY.

QuakeWrap, Inc. warrants this product for one year from date of installation to be free from manufacturing defects and to meet the technical properties on the current technical data sheet if used as directed within shelf life. User determines suitability of product for intended use and assumes all risks. Buyer's sole remedy shall be limited to the purchase price or replacement of product exclusive of labor or cost of labor. NO OTHER WARRANTIES EXPRESS OR IMPLIED SHALL APPLY INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. QUAKEWRAP, INC. SHALL NOT BE LIABLE UNDER ANY LEGAL THEORY FOR SPECIAL OR CONSEQUENTIAL DAMAGES.



**Product Data Sheet**  
**QuakeWrap™ VU23C Carbon Fabric**  
**for Structural Strengthening**

**DESCRIPTION**

QuakeWrap™ VU23C is a high-strength unidirectional carbon fabric. The fabric is black and is impregnated in the field using QuakeBond™ J300SR Saturating Resin to form a carbon fiber reinforced polymer (CFRP) used to strengthen structural elements. The fabric weighs 23 oz/yd<sup>2</sup> (779 g/m<sup>2</sup>) and the fibers are primarily in the longitudinal (0°) direction.

**USE**

- Increased live load capacity in buildings and bridges, hospital floors, roofs of buildings, etc.
- Seismic retrofit of structural elements such as columns, unreinforced masonry walls, etc.
- Repair of large diameter pipes to achieve strengthening and water-proofing
- Repair of damaged structural components caused by aggressive environments, fire, vehicle impact, aging, etc.
- Changes in structural system: new openings in floors, removal of existing walls, etc.
- Correction of design or construction errors: misplaced reinforcing bars, insufficient structural depth

**ADVANTAGES**

- Very strong and lightweight fabric ideal for confined spaces.
- Used for flexure and shear strengthening as well as confinement.
- Fully compatible and excellent adhesion to QuakeBond™ resins.
- Non-corrosive.
- Versatile; can be wrapped around complex shapes.
- Light weight does not alter mass & dynamic loads on structure.
- Alkali resistant.
- Special manufacturing of the fabric makes it very stable & prevents fraying.

**PACKAGING**

Rolls: 50 in. X 50 yards (1.27 m X 45 m) or 24 in. X 100 yards (610 mm X 90 m) or 12 in. X 100 yards (305 mm X 90 m). The fabric can be easily cut in the field into narrower widths of various lengths.

**SHELF LIFE**

Unlimited shelf life in proper storage conditions.

**STORAGE CONDITIONS**

Store in dry place at 45°-95° F (7°-35° C).

**APPLICATION**

Surface must be clean and sound; it may be dry or damp but must be free of standing water and frost. Remove dust, laitance, grease, curing compounds, disintegrated materials and other bond inhibiting materials from the surface. Existing uneven surfaces must be filled with an appropriate repair mortar. The adhesive strength of the substrate must be verified after surface preparation by random pull-off testing (ACI 503R) at the discretion of the engineer. Minimum tensile strength of 200 psi (1.4 MPa) with substrate failure is required.

Blast clean, shot-blast, scarify or use other approved mechanical means to clean the substrate surface. Any sharp edges (i.e. fins, form-marks, etc.) must be ground smooth and flush. Sharp edges must be rounded to a minimum radius of ¼ in. (19 mm). Apply QuakeBond™ J200TC onto the substrate with a trowel or spatula to a nominal thickness of 40 mil (1 mm). A notched trowel may be used for this application.

Saturate QuakeWrap™ VU23C fabric thoroughly with QuakeBond™ J300SR; for more details, refer to the Product Data Sheet for J300SR. Before the epoxies harden, apply saturated fabric to the substrate surface that has been coated with J200TC. Using gloved hands, carefully remove any entrapped air bubbles under the fabric; a plastic laminating roller can be used for this purpose. If required, additional layers of saturated fabric can be directly applied on top of previous layers. Feather the edges of the fabric with QuakeBond™ J200TC.

Installation of QuakeWrap™ fabrics must be performed only by specially trained and approved contractors.

Fabric can be cut to appropriate length using a commercial quality heavy duty scissor. Since dull or worn cutting tools can damage, weaken or fray the fiber, their use should be avoided.

**LIMITATIONS**

Design calculations must be made and certified by an independent licensed professional engineer. System is a vapor barrier. Concrete should not be encapsulated in areas of freeze/thaw.

**CAUTION**

QuakeWrap™ VU23C is non-reactive. However, caution must be used when handling since a fine carbon dust may be present on the surface. Gloves must therefore be worn to protect against skin irritation. Caution must also be used when cutting the fabric to protect against airborne carbon dust generated by the cutting procedure. Use of an appropriate, properly fitted NIOSH approved respirator is recommended.

FIBER & LAMINATE PROPERTIES		
	US Units	SI Units
<b>Fiber Properties:</b>		
Tensile Strength	550 ksi	3,800 MPa
Tensile Modulus	33,500 ksi	231,000 MPa
Ultimate Elongation	1.64%	1.64%
Density	0.065 lb/in <sup>3</sup>	1.8 g/cm <sup>3</sup>
<b>Laminated with J300SR: *</b>		
Aerial Weight	23 oz/yd <sup>2</sup>	779 g/m <sup>2</sup>
Tensile Strength	113.4 ksi	782 MPa
Tensile Modulus	9,900 ksi	68,300 MPa
Ultimate Elongation	1.1%	1.1%
Breaking Force	5,250 lb/in.	919 N/mm
Ply Thickness	0.0463 in.	1.18 mm

\* Results based on tests of two plies of fabrics saturated with J300SR. Data reported represent values for a single ply of fabric.

KEEP OUT OF REACH OF CHILDREN.  
NOT FOR INTERNAL CONSUMPTION.

FOR INDUSTRIAL USE ONLY.  
KEEP CONTAINER CLOSED TIGHTLY.

QuakeWrap, Inc. warrants this product for one year from date of installation to be free from manufacturing defects and to meet the technical properties on the current technical data sheet if used as directed within shelf life. User determines suitability of product for intended use and assumes all risks. Buyer's sole remedy shall be limited to the purchase price or replacement of product exclusive of labor or cost of labor.

NO OTHER WARRANTIES EXPRESS OR IMPLIED SHALL APPLY INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. QUAKEWRAP, INC. SHALL NOT BE LIABLE UNDER ANY LEGAL THEORY FOR SPECIAL OR CONSEQUENTIAL DAMAGES.



**Product Data Sheet**  
**QuakeWrap™ TB20C Carbon Fabric**  
**for Structural Strengthening**

**DESCRIPTION**

QuakeWrap™ TB20C is a high-strength biaxial carbon fabric. The fabric is black and is impregnated in the field using QuakeBond™ J300SR Saturating Resin to form a carbon fiber reinforced polymer (CFRP) used to strengthen structural elements. The fabric weighs 23 oz/yd<sup>2</sup> (779 g/m<sup>2</sup>) and the fibers are primarily in the longitudinal (0°) direction.

**USE**

- Increased live load capacity in buildings and bridges, hospital floors, roofs of buildings, etc.
- Seismic retrofit of structural elements such as columns, unreinforced masonry walls, etc.
- Repair of large diameter pipes to achieve strengthening and water-proofing
- Repair of damaged structural components caused by aggressive environments, fire, vehicle impact, aging, etc.
- Changes in structural system: new openings in floors, removal of existing walls, etc.
- Correction of design or construction errors: misplaced reinforcing bars, insufficient structural depth

**ADVANTAGES**

- Very strong and lightweight fabric ideal for confined spaces.
- Used for flexure and shear strengthening as well as confinement.
- Fully compatible and excellent adhesion to QuakeBond™ resins.
- Non-corrosive.
- Versatile; can be wrapped around complex shapes.
- Light weight does not alter mass & dynamic loads on structure.
- Alkali resistant.
- Special manufacturing of the fabric makes it very stable & prevents fraying.

**PACKAGING**

Rolls: 50 in. X 50 yards (1.27 m X 45 m). The fabric can be easily cut in the field to various lengths.

**SHELF LIFE**

Unlimited shelf life in proper storage conditions.

**STORAGE CONDITIONS**

Store in dry place at 45°-95° F (7°-35° C).

**APPLICATION**

Surface must be clean and sound; it may be dry or damp but must be free of standing water and frost. Remove dust, laitance, grease, curing compounds, disintegrated materials and other bond inhibiting materials from the surface. Existing uneven surfaces must be filled with an appropriate repair mortar. The adhesive strength of the substrate must be verified after surface preparation by random pull-off testing (ACI 503R) at the discretion of the engineer. Minimum tensile strength of 200 psi (1.4 MPa) with substrate failure is required.

Blast clean, shot-blast, scarify or use other approved mechanical means to clean the substrate surface. Any sharp edges (i.e. fins, form-marks, etc.) must be ground smooth and flush. Sharp edges must be rounded to a minimum radius of ¼ in. (19 mm). Apply QuakeBond™ J200TC onto the substrate with a trowel or spatula to a nominal thickness of 40 mil (1 mm). A notched trowel may be used for this application.

Saturate QuakeWrap™ TB20C fabric thoroughly with QuakeBond™ J300SR; for more details, refer to the Product Data Sheet for J300SR. Before the epoxies harden, apply saturated fabric to the substrate surface that has been coated with J200TC. Using gloved hands, carefully remove any entrapped air bubbles under the fabric; a plastic laminating roller can be used for this purpose. If required, additional layers of saturated fabric can be directly applied on top of previous layers. Feather the edges of the fabric with QuakeBond™ J200TC.

Installation of QuakeWrap™ fabrics must be performed only by specially trained and approved contractors.

Fabric can be cut to appropriate length using a commercial quality heavy duty scissor. Since dull or worn cutting tools can damage, weaken or fray the fiber, their use should be avoided.

**LIMITATIONS**

Design calculations must be made and certified by an independent licensed professional engineer. System is a vapor barrier. Concrete should not be encapsulated in areas of freeze/thaw.

**CAUTION**

QuakeWrap™ TB20C is non-reactive. However, caution must be used when handling since a fine carbon dust may be present on the surface. Gloves must therefore be worn to protect against skin irritation. Caution must also be used when cutting the fabric to protect against airborne carbon dust generated by the cutting procedure. Use of an appropriate, properly fitted NIOSH approved respirator is recommended.

FIBER & LAMINATE PROPERTIES		
	US Units	SI Units
<b>Fiber Properties:</b>		
Tensile Strength	550 ksi	3,800 MPa
Tensile Modulus	33,500 ksi	231,000 MPa
Ultimate Elongation	1.64%	1.64%
Density	0.065 lb/in <sup>3</sup>	1.8 g/cm <sup>3</sup>
<b>Laminated with J300SR: *</b>		
Aerial Weight	20 oz/yd <sup>2</sup>	677 g/m <sup>2</sup>
Tensile Strength	45.1 ksi	311 MPa
Tensile Modulus	6,440 ksi	44,400 MPa
Ultimate Elongation	1.0%	1.0%
Breaking Force	2,250 lb/in.	394 N/mm
Ply Thickness	0.0499 in.	1.27 mm

\* Results based on tests of two plies of fabrics saturated with J300SR. Data reported represent values for a single ply of fabric.

KEEP OUT OF REACH OF CHILDREN.  
NOT FOR INTERNAL CONSUMPTION.

FOR INDUSTRIAL USE ONLY.  
KEEP CONTAINER CLOSED TIGHTLY.

QuakeWrap, Inc. warrants this product for one year from date of installation to be free from manufacturing defects and to meet the technical properties on the current technical data sheet if used as directed within shelf life. User determines suitability of product for intended use and assumes all risks. Buyer's sole remedy shall be limited to the purchase price or replacement of product exclusive of labor or cost of labor. NO OTHER WARRANTIES EXPRESS OR IMPLIED SHALL APPLY INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. QUAKEWRAP, INC. SHALL NOT BE LIABLE UNDER ANY LEGAL THEORY FOR SPECIAL OR CONSEQUENTIAL DAMAGES.



**Product Data Sheet**  
**QuakeWrap™ DU50C Carbon Laminate**  
**for Structural Strengthening**

**DESCRIPTION**

QuakeWrap™ DU50C is a high-strength unidirectional pultruded laminate constructed with carbon fibers. The CFRP laminates are bonded to the substrate using QuakeBond™ J200TC (Tack Coat). The laminates are ideal for strengthening concrete, wood and steel structures.

**USE**

- Increased live load capacity in buildings and bridges, hospital floors, roofs of buildings, etc.
- Seismic retrofit of structural elements such as columns, unreinforced masonry walls, etc.
- Repair of large diameter pipes to achieve strengthening and water-proofing
- Repair of damaged structural components caused by aggressive environments, fire, vehicle impact, aging, etc.
- Changes in structural system: new openings in floors, removal of existing walls, etc.
- Correction of design or construction errors: misplaced reinforcing bars, insufficient structural depth

**ADVANTAGES**

- Very strong and lightweight laminates ideal for confined spaces.
- Used for flexure and shear strengthening.
- High modulus of elasticity.
- Fully compatible and excellent adhesion to QuakeBond™ resins.
- Non-corrosive.
- Light weight does not alter mass & dynamic loads on structure.
- Alkali resistant.
- Thin sections can be easily crossed and overlapped.

**PACKAGING**

Rolls: 3 in. X 250 ft (76 mm X 76 m). Smaller quantities can also be accommodated. The laminates can be easily cut in the field to desired length.

**SHELF LIFE**

Unlimited shelf life in proper storage conditions.

**STORAGE CONDITIONS**

Store in dry place at 45°-95° F (7°-35° C).

**COVERAGE**

Application requires QuakeBond™ J200TC Tack Coat at a rate of 1 gallon per 65 feet (1 liter per 5.2 m) of laminate.

**APPLICATION**

Surface must be clean and sound; it may be dry or damp but must be free of standing water and frost. Remove dust, laitance, grease, curing compounds, disintegrated materials and other bond inhibiting materials from the surface. Existing uneven surfaces must be filled with an appropriate repair mortar. The adhesive strength of the substrate must be verified after surface preparation by random pull-off testing (ACI 503R) at the discretion of the engineer. Minimum tensile strength of 200 psi (1.4 MPa) with substrate failure is required.

Blast clean, shot-blast, scarify or use other approved mechanical means to clean the substrate surface. Any sharp edges (i.e. fins, form-marks, etc.) must be ground smooth and flush.

- 1) Wipe DU50C with appropriate cleaner (e.g. acetone or MEK) using clean cloth.
- 2) Apply QuakeBond™ J200TC onto the substrate with a trowel or spatula to a nominal thickness of 50 mil (1.3 mm). A notched trowel may be used for this application.
- 3) Apply QuakeBond™ J200TC to the cleaned surface of DU50C to a thickness of 50 mil (1.3 mm).
- 4) Within the open time of the epoxy, considering ambient temperature, place the coated DU50C on top of the substrate and press firmly.
- 5) Use a hard rubber roller and press the laminate into the epoxy until the adhesive is forced out on both sides.
- 6) Remove excess epoxy; final epoxy thickness should not exceed 1/8 in. (3 mm).
- 7) The bonded DU50C laminates should not be disturbed for 24 hours.

Installation of QuakeWrap™ products must be performed only by specially trained and approved contractors.

Laminates can be cut to appropriate length using a commercial quality heavy duty shears. Care must be taken to support both sides of the laminate to avoid splintering. Since dull or worn cutting tools can damage, weaken or fray the fiber, their use should be avoided.

**LIMITATIONS**

Design calculations must be made and certified by an independent licensed professional engineer.

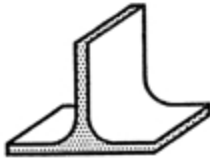
**CAUTION**

QuakeWrap™ DU50C is non-reactive and fully cured. They do not require a Material Safety Data Sheet (MSDS). However, caution must be used when handling since a fine carbon dust may be present on the surface. Gloves must therefore be worn to protect against skin irritation. Caution must also be used when cutting the laminates to protect against airborne carbon dust generated by the cutting procedure. Use of an appropriate, properly fitted NIOSH approved respirator is recommended.

FIBER & LAMINATE PROPERTIES		
	US Units	SI Units
<b>Fiber Properties:</b>		
Tensile Strength	550 ksi	3,800 MPa
Tensile Modulus	33,500 ksi	231,000 MPa
Ultimate Elongation	1.64%	1.64%
Density	0.065 lb/in <sup>3</sup>	1.8 g/cm <sup>3</sup>
<b>Laminate Properties:</b>		
Density	0.047 lb/in <sup>3</sup>	1.3 g/cm <sup>3</sup>
Tensile Strength	309 ksi	2,130 MPa
Tensile Modulus	20,800 ksi	143,400 MPa
Ultimate Elongation	1.5%	1.5%
Breaking Force	15,400 lb/in.	2,695 N/mm
Ply Thickness	0.0498 in.	1.27 mm

KEEP OUT OF REACH OF CHILDREN.  
NOT FOR INTERNAL CONSUMPTION.

FOR INDUSTRIAL USE ONLY.  
KEEP CONTAINER CLOSED TIGHTLY.



# STRUCTURAL COMPOSITES, INC.

7705 TECHNOLOGY DRIVE, WEST MELBOURNE, FLORIDA 32904 • USA  
PHONE (407) 951-9464 • FAX (407) 728-9071

Report No. SCL9015-202  
Dated 28 Sept 99

External Reinforcement Inc.  
Resin Casting Testing  
Data Summary  
QuakeBond J200TC - Tack Coat

## Resin Casting - ~ 1/8" thickness

### ASTM D 638 Tensile Properties

Type III specimen

Strength (psi)	2,337
Modulus (mpsi)	0.05
Elongation at Break (%)	31.6

### ASTM D 790 Flexural Properties

3-point bending, L/d = 16/1

Strength (psi)	4,995
Modulus (mpsi)	0.13

### ASTM D 695 Compressive Properties

Strength (psi)	5,555
Modulus (mpsi)	0.24

### ASTM D 256 Izod Impact unnotched

Strength (ft-lb/in)	19.3
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### ASTM D 2240 Shore Hardness

Shore D Hardness	79
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### ASTM D 2566 Linear Shrinkage

Linear Shrinkage (%)	0.1
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### ASTM D 570 Water Absorption

24 hours, 75 °F, distilled water

Water Absorption (% by weight)	0.5
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## Mixed Liquid Resin Properties

### ASTM D 2393 Viscosity

A:B mixed 1:1 by volume

Brookfield LVTD, #4 spindle

Viscosity (centipoise)	> 500,000
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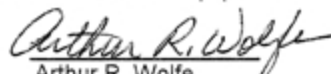
## Notes on Testing :

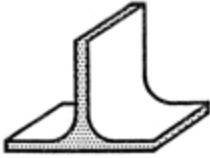
Values represent the average of 1-6 test specimens.

Resin mixed A:B, 1:1 by volume.

Resin casting post-cured 2 hours at 40 °C prior to test.

We hereby certify that the test results contained in this report are true and accurate within the limits of the measuring devices employed. All load and strain measuring devices are calibrated according to ASTM E 4 and ASTM E 83. The test equipment is calibrated with standards traceable to NIST.

  
Arthur R. Wolfe  
Director, Testing Services



# STRUCTURAL COMPOSITES, INC.

7705 TECHNOLOGY DRIVE, WEST MELBOURNE, FLORIDA 32904 • USA  
PHONE (407) 951-9464 • FAX (407) 728-9071

Report No. SCL9015-213B  
Dated 11 Oct 99

External Reinforcement Inc.  
Resin Casting Testing  
QuakeBond Saturating Resin

Resin Casting - ~ 1/8" thickness

ASTM D 638 Tensile Properties

Type III specimen

Strength (psi)	5,424
Modulus (mpsi)	0.18
Elongation at Break (%)	13.3

ASTM D 790 Flexural Properties

3-point bending, L/d = 16/1

Strength (psi)	8,433
Modulus (mpsi)	0.22

ASTM D 695 Compressive Properties

Strength (psi)	7,664
Modulus (mpsi)	0.29

ASTM D 256 Izod Impact  
unnotched

Strength (ft-lb/in)	24.6
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ASTM D 2240 Shore Hardness

Shore D Hardness	82
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ASTM D 2566 Linear Shrinkage

Linear Shrinkage (%)	0.1
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ASTM D 570 Water Absorption

24 hours, 75 °F, distilled water

Water Absorption (% by weight)	0.3
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Mixed Liquid Resin Properties

ASTM D 2393 Viscosity

A:B mixed 2:1 by volume

Brookfield LVTD, #2 spindle, 12 rpm

Viscosity (centipoise)	1,790
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Notes on Testing :

Values represent the average of 1-6 test specimens.

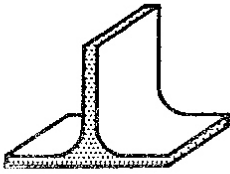
Resin mixed A:B, 2:1 by volume.

Resin casting post-cured 2 hours at 40 °C prior to test.

(J300SR, AMP 79272-2)

We hereby certify that the test results contained in this report are true and accurate within the limits of the measuring devices employed. All load and strain measuring devices are calibrated according to ASTM E 4 and ASTM E 83. The test equipment is calibrated with standards traceable to NIST.

Arthur R. Wolfe  
Director, Testing Services



# STRUCTURAL COMPOSITES, INC.

7705 TECHNOLOGY DRIVE, WEST MELBOURNE, FLORIDA 32904 • USA

PHONE (407) 951-9464 • FAX (407) 728-9071

Report No. SCL7175-02

Dated 17 Apr 97

Client : External Reinforcement Inc.  
P.O. Box 64757  
Tucson, AZ 85728

Attention : Mr. Mo Ehsani

Subject : Tensile Testing

## Summary

A set of tensile test specimens was received for an analysis of mechanical properties under tensile loading conditions. The specimens were fabricated of fiber-reinforced plastic (FRP), using E-glass reinforcement (0/90 biaxial, 18 oz/yd<sup>2</sup>) in an epoxy resin matrix. The nominal specimen dimensions were 1" width x 14" length x 0.07" thickness.

The specimens were identified by the type of accelerated environmental conditioning to which they had been subjected. Six different environmental conditions were utilized, with the exposure period for all being 6216 hours. The conditions were as shown :

- a) Immersion in an alkaline solution , ambient temperature (~70° F), pH = 12.5
- b) Immersion in an acidic solution, ambient temperature (~70° F), pH = 3.0
- c) Immersion in a simulated sea water solution, ambient temperature (~70° F), pH = 8.2
- d) Burial in alkaline soil containing microorganisms, pH = 6.5 - 7.5, moisture content = 25% - 30%, ambient temperature (~70° F)
- e) Exposure to Ultraviolet-A lamp (340 nm peak) in closed chamber, ambient relative humidity (~10%), temperature = 85° F
- f) Exposure to constant elevated temperature of 140° F, ambient relative humidity (~10%)

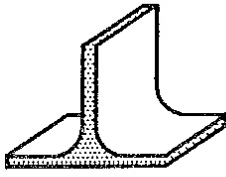
Fifteen E-glass specimens were provided, 3 control and 2 for each environmental condition.

FRP tabs were bonded to the specimen ends, to facilitate gripping and reduce the possibility of failure within the tensile holding grips. ASTM D 3039 procedure was used to determine the tensile strength, modulus, and strain-to-failure. This report contains the results of this testing program.

Respectfully Submitted,

*Arthur R. Wolfe*  
Arthur R. Wolfe  
Lab Manager





# STRUCTURAL COMPOSITES, INC.

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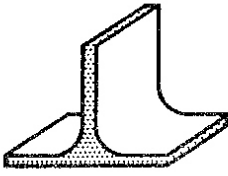
Report No. SCL7175-02

Dated 17 Apr 97

## External Reinforcements Inc. Tensile Specimens Data Summary

1 ply QuakeWrap CCC-090-18/epoxy

<u>Specimen Identification</u>	<u>Conditioning</u>	<u>Original Mass (gr)</u>	<u>Final Mass (gr)</u>	<u>Change (%)</u>
1 8	pH 12.5	22.54	22.41	-0.58%
1' 6	pH 12.5	22.81	22.59	-0.96%
2 7	pH 3.0	22.49	21.84	-2.89%
2' 9	pH 3.0	22.92	22.06	-3.75%
3 15	sea water	22.79	21.96	-3.64%
3' 10	sea water	22.40	21.73	-2.99%
4 3	soil	22.47	22.75	1.25%
4' 1	soil	22.22	22.75	2.39%
5 11	high temp	21.85	22.43	2.65%
5' 13	high temp	21.40	21.74	1.59%
6 14	UV light	22.50	21.96	-2.40%
6' 12	UV light	21.83	21.78	-0.23%
7 5	control	21.79	22.80	4.64%
7' 2	control	22.02	22.77	3.41%
7" 4	control	21.66	22.91	5.77%



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7705 TECHNOLOGY DRIVE, WEST MELBOURNE, FLORIDA 32904 • USA

PHONE (407) 951-9464 • FAX (407) 728-9071

Report No. SCL7175-02

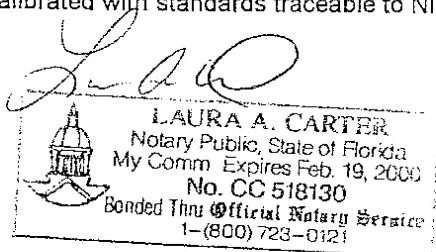
Dated 17 Apr 97

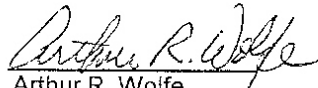
## External Reinforcements Inc. Tensile Specimens Data Summary

1 ply QuakeWrap CCC-090-18/epoxy

Specimen Identification	Conditioning	ASTM D 3039 Tensile Strength (psi)	ASTM D 3039 Tensile Modulus (mpsi)	ASTM D 3039 Strain to Failure (%)
1 8	pH 12.5	8,435	1.046	0.60
1' 6	pH 12.5	8,919	1.311	-
2 7	pH 3.0	10,481	1.012	1.13
2' 9	pH 3.0	11,911	1.034	1.25
3 15	sea water	10,653	0.972	1.05
3' 10	sea water	11,014	1.044	1.01
4 3	soil	10,991	1.022	1.01
4' 1	soil	12,443	1.039	1.20
5 11	high temp	12,388	1.118	1.06
5' 13	high temp	10,987	1.027	1.01
6 14	UV light	10,384	1.129	0.99
6' 12	UV light	12,431	1.114	1.20
7 5	control	12,981	1.128	1.24
7' 2	control	12,697	1.070	1.24
7" 4	control	11,343	1.058	1.11

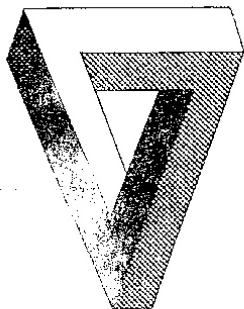
We hereby certify that the test results contained in this report are true and accurate within the limits of the measuring devices employed. All load and strain measuring devices are calibrated according to ASTM E 4 and ASTM E 83. The test equipment is calibrated with standards traceable to NIST.



  
Arthur R. Wolfe  
Director, Testing Services

7175-02b

ASTM E1317 TESTING  
FOR  
EXTERNAL REINFORCEMENT INC.  
ON  
QUAKEWRAP™  
VTEC #100-1777-2  
TESTED: JUNE 18, 2003  
REVISION 1.0: JULY 8, 2003



# VTEC Laboratories Inc.

June 18, 2003

Client: External Reinforcement Inc.  
P.O. Box 64757  
Tucson, AZ 85728-4757

Attention: Mo Ehsani

Subject: ASTM E1317 Flammability of Marine Surface Finishes  
Testing of QuakeWrap™.

## SPECIMEN DESCRIPTION BY CLIENT

The samples were prepared by the client as follows:

1. A ½-in. thick Marinite I sheet was cut into dimensions for each ASTM test.
2. The two-component QuakeBondT Tack Coat (J200TC) was mixed and applied with a thickness of approximately 40 mil to one face of the ½-in. thick Marinite I sheets.
3. A unidirectional carbon fabric (QuakeWrapT TU08C) was saturated with the two-component QuakeBondT Saturating Resin (J300SR) and placed on the tackcoat surface. The saturated surface was pressed into the tack coat, and all bubbles were smoothed out.
4. The samples were left in the laboratory (75 °F and 70% humidity) for 5 days.
5. The edges of the samples were trimmed with a band saw.
6. The samples were post cured at 180 °F for 3 hours before they were shipped to the laboratory for testing.

**Disclaimer:** This is a factual report of the results obtained from the laboratory test of sample products. The results may be applied only to the products tested and should not be constructed as applicable to other similar products of the manufacture. The report is not a recommendation or a disapprobation by VTEC Laboratories, Inc. of the material tested. While this report may be used for obtaining product acceptance, it may not be used in advertising.

**Notice:** VTEC Laboratories Inc. will not be liable for any loss or damage resulting from the use of the data in this report, in excess of the invoice. This report pertains to the sample tested only. Such report shall not be interpreted to be a warranty, either expressed or implied as to the suitability or fitness of said sample for such uses or applications, as the party contracting for the report may apply such sample.

EXTERNAL REINFORCEMENT INC.

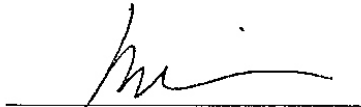
ASTM E1317 TEST DATA

<u>PRODUCT:</u>	QuakeWrap™	<u>VTEC #</u>	100-1777-2
<u>SOURCE:</u>	EXTERNAL REINFORCEMENT INC.	<u>COLOR:</u>	Grey
<u>DIMENSIONS:</u>	155 mm X 800 mm	<u>AL FOIL ?</u>	Yes
<u>SPECIMEN THICKNESS:</u>	13.9 mm	<u>DATE:</u>	6/18/2003
<u>COATING THICKNESS:</u>	2 mm		

OBSERVATIONS: No unusual observations.

TIME TO:	150 mm	200 mm.	250 mm.	300 mm.	350 mm.	400 mm.
<u>Specimen #</u>	<u>sec.</u>	<u>sec.</u>	<u>sec.</u>	<u>sec.</u>	<u>sec.</u>	<u>sec.</u>
1	32	34	38	40	62	85
2	47	50	53	56	67	105
3	47	50	55	67	80	115

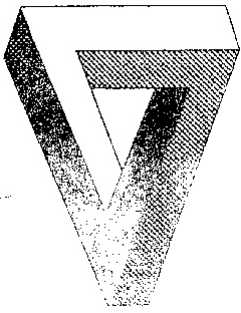
	SPECIMEN 1	SPECIMEN 2	SPECIMEN 3	AVERAGE
Nonimpinging Pilot flame used?	YES	YES	YES	
Test Duration (min.)	12.17	23.48	20.08	18.58
Heat of Ignition (MJ/m <sup>2</sup> )	1.12	1.64	1.64	1.47
Heat of Sustained Burning at (MJ/m <sup>2</sup> ):				
150 mm	1.12	1.64	1.64	1.47
200 mm	1.09	1.61	1.61	1.44
250 mm	1.07	1.49	1.55	1.37
300 mm	0.96	1.34	1.61	1.30
350 mm	1.13	1.22	1.46	1.27
400 mm	1.30	1.61	1.76	1.56
Specimen Average:	1.11	1.49	1.60	1.40
Time of Extinguishment (min.)	9.17	20.48	17.08	15.58
Distance burned (mm)	490	515	520	508
Critical Flux at Extinguishment (kW/m <sup>2</sup> )	9.16	7.91	7.75	8.28
Total Heat Release (MJ)	1.88	2.25	2.48	2.20
Peak Heat Release (kW)	5.94	5.49	5.72	5.72
Heat for Sustained Burning (MJ/m <sup>2</sup> )	0.96	1.22	1.46	1.21

 Rev 1.0  
 Neil Schultz  
 Executive Director

  
 Amirudin Rahim  
 Technical Director

REVISION 1.0: ADDED SECTION "SPECIMEN DESCRIPTION BY CLIENT"

ASTM E662 TESTING  
FOR  
EXTERNAL REINFORCEMENT INC.  
QUAKEWRAP™  
VTEC #100-1777-1  
TESTED: JUNE 17, 2003  
REVISION 1.0: JULY 8, 2003



# VTEC Laboratories Inc.

June 17, 2003

**Client:** External Reinforcement Inc.  
PO Box 64757  
Tucson, AZ 85728-4757

**Attention:** Mo Ehsani

## I. INTRODUCTION:

The following Scope, Summary of Method, Test Specimens, and Specimen Conditioning sections are abridged from the Standard Test Method for Specific Optical Density of Smoke Generated by Solid Material- ANSI/ASTM E662.

## II. SCOPE:

The method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including one inch. The test is based on the attenuation of a light beam by smoke accumulating within a closed chamber. Both non-flaming and flaming exposures are conducted. Results are expressed in terms of specific optical density, which is derived from measuring optical density (absorbance).

The photometric scale used to measure smoke by this method is similar to the optical density scale for human vision.

The test is intended for use in research and development and not as a basis for ratings for regulatory purposes. At the present time, no means are provided for predicting the density of smoke, which may be generated by the materials exposed to heat and flame under other fire conditions.

### III. SUMMARY OF METHOD:

This method employs an electrically-heated radiant energy source mounted within an insulated ceramic tube and positioned so as to produce an irradiance level of 2.2 BTU/sec. Ft<sup>2</sup> (2.5 w/cm<sup>2</sup>) averaged over the central 1.5" diameter area of a vertically mounted specimen facing the radiant heater. The nominal 3" X 3" specimen is mounted within a holder, which exposes an area 2-9/16" X 2-9/16". The holder can accommodate specimens up to one inch thick. This exposure provides the non-flaming exposure of the test.

For the flaming condition, a six-tube burner is used to apply a row of air-propane flamelets across the lower edge of the exposed specimen area and into the specimen holder trough. The application of flame in addition to the specified irradiance level from the heating element constitutes the flaming combustion exposure.

The test specimens are exposed to the flaming and non-flaming conditions within a closed 18 cubic foot chamber. A photometric system with a 36" vertical light path measure the continuous decrease in light transmission as smoke accumulates.

### IV. TEST SPECIMENS:

The test specimens measure 3" X 3" +/- .03" and can be up to 1" thickness, depending on the particular sample thickness. Materials in thicknesses over 1" in thickness are sliced to 1" and the original uncut surface is tested. Multi-layer materials thicker than 1" with surface facings of different materials are sliced to 1", and each original (uncut) surface tested separately, if both surface facings are exposed to the fire.

### SPECIMEN DESCRIPTION BY CLIENT

The samples were prepared by the client as follows:

1. A ½-in. thick Marinite I sheet was cut into dimensions for each ASTM test.



2. The two-component QuakeBondT Tack Coat (J200TC) was mixed and applied with a thickness of approximately 40 mil to one face of the ½-in. thick Marinite I sheets.
3. A unidirectional carbon fabric (QuakeWrapT TU08C) was saturated with the two-component QuakeBondT Saturating Resin (J300SR) and placed on the tackcoat surface. The saturated surface was pressed into the tack coat, and all bubbles were smoothed out.
4. The samples were left in the laboratory (75 °F and 70% humidity) for 5 days.
5. The edges of the samples were trimmed with a band saw.
6. The samples were post cured at 180 °F for 3 hours before they were shipped to the laboratory for testing.

#### V. SPECIMEN CONDITIONING:

Specimens are predried for 24 hours at 140°+/-5°F (60°+/-3°C) and then conditioned to equilibrium (constant weight) at an ambient temperature of 73° +/- 5°F(23°+/-3°C) and a relative humidity of 50+/-5 percent.

#### VI. DISCLAIMER:

*This test result alone does not assess the fire hazard of the material, or a product made from this material, under actual fire conditions. Consequently, the results of this test alone are not to be quoted in support of claims with respect to the fire hazard of the material or product under actual fire conditions. The results when used alone are only to be used for research and development, quality control and material specifications.*

NOTICE: VTEC Laboratories Inc. will not be liable for any loss or damage resulting from the use of the data in this report, in excess of the invoice. This report pertains to the sample tested only. Such report shall not be interpreted to be a warranty, either expressed or implied as to the suitability of fitness of said sample for such uses or applications, as the party contracting for the report may apply such sample.

## TEST DATA: LIGHT TRANSMITTANCE

TEST: Time (min.)	NON-FLAMING			FLAMING		
	Test #1	Test #2	Test#3	Test#4	Test#5	Test#6
0.0	1.00120	1.00196	1.00338	1.00146	1.00189	1.00130
0.5	1.00120	1.00195	1.00133	1.00089	0.99776	0.98950
1.0	1.00114	1.00132	1.00337	0.61157	0.42007	0.40480
1.5	0.99694	1.00101	1.00249	0.05446	0.03801	0.02040
2.0	0.98546	1.00098	1.00149	0.00818	0.01617	0.00420
2.5	0.96583	0.99194	0.99136	0.00053	0.01616	0.00420
3.0	0.94532	0.96200	0.96922	0.00005	0.01617	0.00420
3.5	0.91486	0.93105	0.94526	0.00388	0.01780	0.00420
4.0	0.88412	0.89699	0.91310	0.00420	0.01643	0.00420
4.5	0.83011	0.84439	0.87565	0.00006	0.01616	0.00010
5.0	0.76796	0.78916	0.82607	0.00005	0.01233	0.00420
5.5	0.68476	0.72107	0.75578	0.00005	0.01173	0.00001
6.0	0.62132	0.64085	0.66505	0.00077	0.00819	0.00001
6.5	0.55121	0.55301	0.58808	0.00030	0.00818	0.00250
7.0	0.46546	0.46899	0.50916	0.00004	0.00821	0.00001
7.5	0.40732	0.39141	0.43072	0.00005	0.00817	0.00001
8.0	0.35687	0.30847	0.37224	0.00005	0.01232	0.00001
8.5	0.31196	0.25642	0.31277	0.00005	0.01234	0.00010
9.0	0.27002	0.21268	0.27389	0.00005	0.01234	0.00001
9.5	0.24113	0.17656	0.24059	0.00005	0.01233	0.00010
10.0	0.21038	0.14919	0.20525	0.00005	0.01235	0.00001
10.5	0.18703	0.12826	0.17722	0.00005	0.01501	0.00010
11.0	0.16700	0.10523	0.15293	0.00005	0.01616	0.00001
11.5	0.15276	0.09260	0.13027	0.00005	0.01745	0.00360
12.0	0.13593	0.08032	0.11658	0.00005	0.02033	0.00360
12.5	0.12512	0.07233	0.10049	0.00005	0.02033	0.00420
13.0	0.11734	0.06060	0.08844	0.00005	0.02032	0.00420
13.5	0.10867	0.05585	0.08031	0.00005	0.02430	0.00420
14.0	0.10133	0.04887	0.07233	0.00005	0.02432	0.00420
14.5	0.09314	0.04450	0.06834	0.00005	0.02844	0.00420
15.0	0.08787	0.04032	0.06419	0.00005	0.02845	0.00420
15.5	0.08434	0.04032	0.06060	0.00005	0.03219	0.00420
16.0	0.08003	0.03637	0.06061	0.00005	0.03219	0.00420
16.5	0.07634	0.03412	0.05247	0.00005	0.03632	0.00420
17.0	0.07322	0.03219	0.04867	0.00005	0.03634	0.00420
17.5	0.07194	0.02849	0.04831	0.00005	0.04034	0.00420
18.0	0.06803	0.02846	0.04831	0.00005	0.04032	0.00420
18.5	0.06791	0.02846	0.04831	0.00005	0.04450	0.00420
19.0	0.06560	0.02848	0.04832	0.00005	0.04450	0.00420
19.5	0.06122	0.02847	0.04756	0.00005	0.04450	0.00420
20.0	0.02912	0.02429	0.04450	0.00005	0.04450	0.00420

DATE: 6/17/2003  
 PROJECT #: 100-1777-1  
 SUPPLIED BY: External Reinforcement Inc.  
 PRECONDITIONING TEMP: 140 deg. F  
 CONDITIONING TEMP: 70 deg. F  
 RADIOMETER READING: 7.01 volts  
 FURNACE VOLTS: 110 volts  
 BURNER FUEL: 500 cc/min air; 50 cc/min. propane  
 SPECIAL PREPARATION: None  
 DESCRIPTION OF MATERIAL: QuakeWrap™

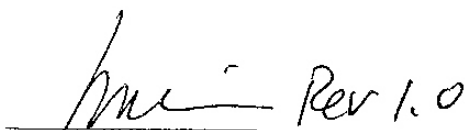
SAMPLE #:	NON-FLAMING			FLAMING		
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
Type of Holder:	no trough	no trough	no trough	no trough	no trough	no trough
Thickness (in):	0.55	0.55	0.55	0.55	0.55	0.55
Weight (g):	57	59.6	58.2	59.9	58.3	60.4
T 100%:	1.001	1.002	1.003	1.001	1.002	1.001
Tmin:	0.029	0.024	0.045	0.000	0.008	0.000
Tmin (%):	2.91	2.42	4.44	0.00	0.82	0.00
Dm (20.0 min.):	202.80	213.24	178.61	580.61	275.69	660.07
T (clear):	0.965	0.981	0.954	0.518	0.557	0.534
T% (clear):	96.4	97.9	95.1	51.7	55.6	53.3
Dc (clear):	2.1	1.2	2.9	37.8	33.7	36.0
Dm (corr):	200.68	212.02	175.72	542.82	242.04	624.04
Ds (1.5 min.):	0.24	0.05	0.05	166.92	187.56	223.20
Ds (4.0 min.):	7.13	6.34	5.41	313.81	235.64	313.81
Color of smoke:	Gray	Gray	Gray	Gray	Gray	Gray

**OBSERVATIONS:**

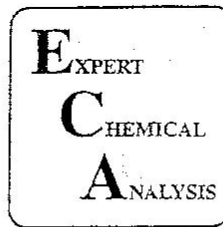
During the flaming mode, the samples ignited at about 17 seconds and burned for approx. 20 min.

**OPTICAL DENSITY TEST RESULT SUMMARY**

	<u>NON-FLAMING</u>	<u>FLAMING</u>
Ds @ 1.5 min. (average):	0.1	192.6
Ds @ 4.0 min. (average):	6.3	287.8
Dm(corr) (average):	196.1	469.6

  
 Neil Schultz  
 Executive Director

  
 Amirudin Rahim  
 Technical Director



10366 Roselle St., Suite C  
San Diego, CA 92121

## Certificate of Analysis

Mo Ehsani, PhD.  
External Reinforcement Inc.  
P.O. Box 64757  
Tucson, AZ 85728-4757

09-27-99

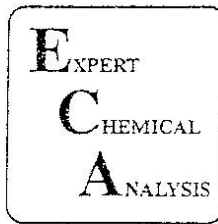
ECA# 990178

The analysis of the coating material(s) has been completed and the results are in the table on the following page. The sample information is:

Customer Identification	ECA Lab Identification #
Quakebond Primer/ Part A	990178A
Quakebond Primer/Part B	990178B
Quakebond Primer/Part A+B	990178C
Quakebond Tack Coat/Part A	990178D
Quakebond Tack Coat/Part B	990178E
Quakebond Tack Coat/Part A+B	990178F
Quakebond HCR/Part A	990178G
Quakebond HCR/Part B	990178H
Quakebond HCR/Part A+B	990178I

Date Received: 9-20-99

Analysis Requested: 1. Determination of Volatile Matter Content per EPA Method 24;  
2. Determination of Water (Karl Fischer) per EPA Method 24 (samples 990178A- 990178C only)



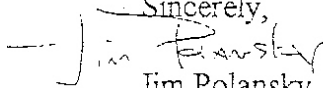
10366 Roselle St., Suite C  
San Diego, CA 92121

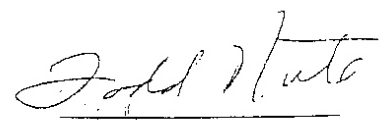
### Results of Analysis

Sample	Test	Results
Quakebond Primer Part A	EPA Method 24/ Volatile Matter	0.0 %
	Water (Karl Fischer)	54.5%
Quakebond Primer Part B	EPA Method 24/ Volatile Matter	0.0 %
	Water (Karl Fischer)	47.3%
Quakebond Primer Part A + B	EPA Method 24 Volatile Matter	0.0%
Quakebond Tack Coat Part A	EPA Method 24 Volatile Matter	3.7%
Quakebond Tack Coat Part B	EPA Method 24 Volatile Matter	0.0%
Quakebond Tack Coat Part A + B	EPA Method 24 Volatile Matter	0.0%
Quakebond HCR Part A	EPA Method 24 Volatile Matter	0.5 %
Quakebond HCR Part B	EPA Method 24 Volatile Matter	5.4 %
Quakebond HCR Part A + B	EPA Method 24 Volatile Matter	0.0%

If you have any questions concerning these results, please call us at (619) 535-9979.  
We appreciate your business!

Sincerely,

  
Jim Polansky  
Scientist

  
J.C. Officer



**Northbrook Division**  
333 Pfingsten Road  
Northbrook, IL 60062-2096 US  
www.ul.com  
tel: 1 847 272 8800

December 20, 2006

Mr. Mo Ehsani  
President  
Quakewrap, Inc.  
237 N Vine Ave  
Tucson, AZ 85719

Our Reference: SV16575/06CA55589

Subject: Report Of Surface Burning Characteristics Tests On Samples As  
Submitted By Quakewrap, Inc.

Dear Mr. Ehsani:

This is a Report summarizing the results of a test conducted under the Commercial Inspection and Testing Services (CITS) program identified as Assignment No. 06CA55589.

#### GENERAL:

The results relate only to items tested.

#### METHOD:

Each test was conducted in accordance with Standard ANSI/UL723, ninth edition, dated August 29, 2003, "Test for Surface Burning Characteristics of Building Materials" (ASTM E84).

The test determines the Surface Burning Characteristics of the material, specifically the flame spread and smoke developed indices when exposed to fire.

The maximum distance the flame travels along the length of the sample from the end of the igniting flame is determined by observation. The Flame Spread Index of the material is derived by plotting the progression of the flame front on a time-distance basis, ignoring any flame front recession, and using the equations described below:

- A.  $CFS = 0.515 A_T$  when  $A_T$  is less than or equal to 97.5 minute-foot.
- B.  $CFS = 4900/(195-A_T)$  when  $A_T$  is greater than 97.5 minute-foot.

Where  $A_T$  = total area under the time distance curve expressed in minute-foot.

The Smoke Developed Index (SDI) is determined by rounding the Calculated Smoke Developed (CSD) as described in UL 723. The CSD is determined by the output of photoelectric equipment operating across the furnace flue pipe. A curve is developed by plotting the values of light absorption (decrease in cell output) against time. The CSD is derived by expressing the net area under the curve for the material tested as a percentage of the area under the curve for untreated red oak.

The CSD is expressed as:

$$\text{CSD} = (A_m/A_{ro}) \times 100$$

Where:

CSD = Calculated Smoke Developed

$A_m$  = The area under the curve for the test material.

$A_{ro}$  = The area under the curve for untreated red oak.

#### SAMPLES:

The samples utilized in this investigation were neither prepared nor selected by a Laboratories' representative such that no verification of composition can be provided.

#### Sample Description

Test No.	System
1	Quakewrap w/ carbon fabric applied to cement board

Due to the rigidity of the test samples, supplementary means of support was not required.

#### RESULTS:

The results are tabulated below are considered applicable only to the specific samples tested.

Data sheets and graphical plots of flame travel versus time and smoke developed versus time are also enclosed.

Table 1: Test Summary

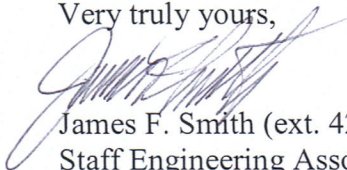
Test No.	Test Code	Sample Description	CFS Calculated Flame Spread	FSI Flame Spread Index	CSD Calculated Smoke Developed	SDI Smoke Developed Index
1	12190624	Quakewrap w/ carbon fabric applied to cement board	26.33	25	301.6	300

The Classification Marking of Underwriters Laboratories Inc. on the product is the only method provided by Underwriters Laboratories Inc. to identify products which have been produced under its Classification and Follow-Up Service. No use of a Classification Marking has been authorized as a result of this investigation.

Since the anticipated work has been completed, we have instructed our Accounting Department to terminate the investigation and invoice you for the charges incurred to date.

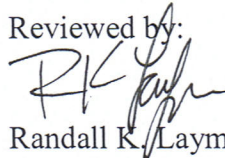
Should you have any questions, please contact the undersigned.

Very truly yours,



James F. Smith (ext. 42666)  
Staff Engineering Associate  
Fire Protection Division

Reviewed by:



Randall K. Laymon  
Senior Staff Engineer  
Fire Protection Division



**Underwriters Laboratories Inc.**

Project: 06CA55589  
Tested by: HISLOP  
Employee #: 7036

File: SV16575  
Engineer: SMITH III  
Emp. #: 77664

Test Code: 12190624  
Date: 12/19/06

TEST METHOD: The test was conducted in accordance with UL 723, 9th Edition

Client Name: Quakewrap			
Test Duration: 10 Minutes	Test No.: 1		Hot Test: No
Mounting: RCB	Test Type: CITS		Burn-Out Required: No

**Test Sample:** Quakewrap w/ carbon fabric applied to cement board

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FLAME SPREAD RESULTS

**Flame Spread Data**

Distance (Feet)		Time (Sec)		Distance (Feet)		Time (Sec)
Ignition		40		5.5		348
1		48		6		384
2		56		6.5		412
3		64		7		416
4		82		8		420
5		338				

Calculated Flame Spread (CFS): 26.33  
Flame Spread Index (FSI): 25  
  
Time to Ignition (sec): 40  
Maximum Flame Spread (ft): 8.0  
Area Under the Flame Spread Curve (ft.-min): 51.1

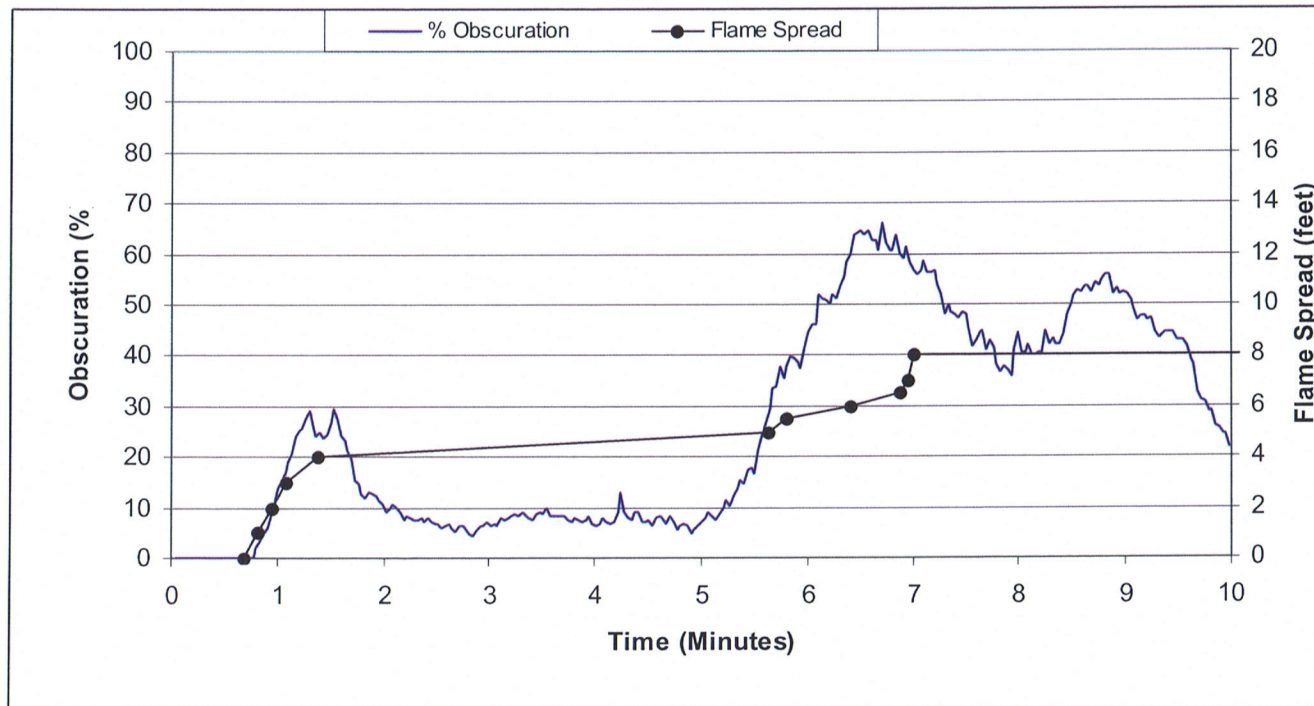
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SMOKE RESULTS

Calculated Smoke Developed (CSD): 301.6  
Smoke Developed Index (SDI): 300  
  
Area Under the Smoke Curve (sq. in.): 13.03  
Area Under Red Oak Curve (sq. in.): 4.32

# Flame Spread / Smoke Results

## Quakewrap Quakewrap w/ carbon fabric applied to cement board



Test No. 1  
06CA55589 / SV16575  
12190624

Flame Spread Index: 25  
Smoke Developed Index: 300  
Max. Flame Spread: 8.0

MATERIAL SAFETY DATA SHEET (MSDS)

Section 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **QuakeBond™ J100WP Epoxy Resin (Part “A”)**

CHEMICAL FAMILY: Epoxy Resin Mixture

SUPPLIER'S NAME: QuakeWrap, Inc., P.O. Box 64757, Tucson, AZ 85728

EMERGENCY PHONE: 800/535-5053 (Infotrac) GENERAL INFORMATION: (866) QuakeWrap [782-5397]

Section 2: COMPOSITION, INFORMATION ON INGREDIENTS

INGREDIENT	%	CAS #	EXPOSURE LIMITS
Bisphenol A Reaction Product	>80	25085-99-8	N/E
Glycidyl Ether	>10	68609-97-2	N/E
Proprietary ingredients	<10	Trade secret	N/E

Section 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Epoxy resin solution. Certain individuals may have pre-existing skin or respiratory conditions causing a sensitivity or allergy which manifests as various reactions. Heating or spraying this product or the mixed parts increases potential health hazards. Health and Safety personnel should examine the handling procedures and remedy any existing or potential health and safety hazards.

POTENTIAL HEALTH EFFECTS:

EYE:

- May cause irritation.

SKIN:

- May cause irritation. Low dermal absorption hazard.

INGESTION:

- May inflame or damage the G.I. tract. Large quantities may be harmful.

INHALATION:

- May cause irritation.

CHRONIC EFFECTS:

- Repeated exposure may cause irritation and sensitization.

SIGNS & SYMPTOMS:

- Skin rash, irritation, reddening, or eczema; breathing irritation or difficulty.

Section 4: FIRST AID MEASURES

◆USE APPROPRIATE BLOOD-BORNE PATHOGENS PROTECTIONS◆

EYE:

- Hold eyelids apart and flood with copious amounts of water. Seek medical attention.

SKIN:

- Remove excess product. Wash thoroughly with soap and water. If irritation persists, seek medical attention.

INGESTION:

- Do not induce vomiting unless directed by medical personnel. Seek medical attention.

INHALATION:

- Remove to fresh air. Seek medical attention.

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

## Section 5: FIRE FIGHTING MEASURES

FLASH POINT: 100°C 212°F UEL: NDA LEL: NDA VAPOR DENSITY: NDA  
NFPA FLAMMABILITY RATING: 1 AUTOIGNITION: 300°C 570°F  
COMBUSTION PRODUCTS: CO, CO<sub>2</sub>, NO<sub>x</sub>, & misc. hydrocarbons.  
SPECIAL HAZARDS: Pre-sensitization to epoxy.  
EXTINGUISHING MEDIA: Use foam, CO<sub>2</sub>, dry chemical, water fog.  
FIRE FIGHTER INSTRUCTIONS: Stay upwind. Wear at least full bunker gear and SCBA.

## Section 6: ACCIDENTAL RELEASE MEASURES

Isolate spill area. Keep out of sewer and storm drains. Stop the leak and contain the spill. Vacuum, scoop, or absorb spill with non-combustible materials. Clean up spill residues with soap and water.

## Section 7: HANDLING AND STORAGE

Avoid skin and eye contact and breathing vapors or mists by appropriate measures. Do not eat or smoke while handling this product. Wash thoroughly after handling or exposure to this product.

Store in original sealed container at ambient temperatures (65°-80°F) in dry, well-ventilated areas.

## Section 8: EXPOSURE CONTROLS, PERSONAL PROTECTION

For Personal Exposure Limits (PEL), Threshold Limit Values (TLV) or other exposure limits, see Sec. 2.

GENERAL: Provide ventilation that will keep airborne concentration at a minimum.

EYE/FACE: Safety glasses or splash goggles with face shield.

SKIN: Butyl or nitrile rubber chemical gloves. Don chemical resistant clothing where exposure may occur.

RESPIRATORY: NIOSH approved respirator with organic vapor/HEPA filter cartridges.

OTHER: Decontaminate or discard clothing and materials that have come in contact with this product.

## Section 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: straw yellow

ODOR: slightly sweet

PHYSICAL STATE: liquid

VAPOR PRESS: N.D.A.

SPECIFIC GRAVITY: 1.11

pH: N.D.A.

BOILING PT: N.D.A.

MELT PT: N/A

SOLUBILITY IN H<sub>2</sub>O: slightly

## Section 10: STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable.

INCOMPATIBILITY: Strong acids, caustics, oxidizers, and epoxy hardeners in an uncontrolled condition.

HAZARDOUS POLYMERIZATION: Will not occur.

HAZARDOUS DECOMPOSITION: None known, other than Sec. 5's Combustion Products.

## Section 11: TOXICOLOGICAL INFORMATION

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

Oral: N.D.A.  
Dermal: N.D.A.  
Inhalation: N.D.A.  
Carcinogens under OSHA, ACGIH, NTP, IARC, or Other: None  $\geq$  0.1%.

Section 12: ECOLOGICAL INFORMATION

N.D.A.

Section 13: DISPOSAL CONSIDERATIONS

Dispose of in accordance with applicable federal, state, and local laws and regulations.

Section 14: TRANSPORT INFORMATION

DOT: Not Regulated.  
IATA:  
IMO:

Section 15: REGULATORY INFORMATION

OSHA: 29 CFR 1910.1200 Hazardous Chemical "Irritant", "Sensitizer".  
TSCA: Ingredients listed.  
SARA III: Sec311 & 312 Immediate Health Hazard; Sec313 None.  
CA PROP. 65 NOTICE: Not listed.  
NFPA: Health 1 Fire 1 Reactivity 0 Other N/A

Section 16: CANADIAN REGULATORY INFORMATION

WHMIS: Hazard Classification: Class D2B Skin Sensitizer. Refer to MSDS for specific warnings.  
WHMIS Symbols: Stylized T.  
WHMIS Trade Secret Registry Numbers: None.  
Hazardous Products Act Information: This product MSDS contains ingredients which are Controlled and/or on the Ingredient Disclosure List (HPA sections 13 and 14).

ABBREVIATIONS: N/A = not applicable; N.D.A. = no data available; NE = not established

END OF MSDS

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ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

MATERIAL SAFETY DATA SHEET (MSDS)

Section 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **QuakeBond™ J100WP Hardener (Part “B”)**

CHEMICAL FAMILY: Polyetherdiamines

SUPPLIER'S NAME: QuakeWrap, Inc., P.O. Box 64757, Tucson, AZ 85728

EMERGENCY PHONE: 800/535-5053 (Infotrac) GENERAL INFORMATION: (866) QuakeWrap [782-5397]

Section 2: COMPOSITION, INFORMATION ON INGREDIENTS

INGREDIENT	%	CAS #	EXPOSURE LIMITS
Nonylphenol	<45	84852153	N/E
Polyoxypropylenediamine	<45	9046-10-0	N/E
Proprietary ingredients	>10	Trade secret	N/E

Section 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Corrosive epoxy hardener. Certain individuals may have pre-existing skin or respiratory conditions causing a sensitivity or allergy which manifests as various reactions. Heating or spraying this product or the mixed parts increases potential health hazards. Health and Safety personnel should examine the handling procedures and remedy any existing or potential health and safety hazards.

POTENTIAL HEALTH EFFECTS:

EYE:

- Can cause irritation. Significant, prolonged, or repeated contact can damage the cornea.

SKIN:

- Can cause irritation. Significant, prolonged, or repeated exposure can cause severe irritation.

INGESTION:

- Can inflame or damage the G.I. tract. Ingestion can be harmful.

INHALATION:

- Can cause irritation. Significant, prolonged, or repeated exposure to mist or vapor can damage the respiratory system.

CHRONIC EFFECTS:

- Repeated exposure can cause irritation and sensitization.

SIGNS & SYMPTOMS:

- Skin rash, irritation, reddening, or eczema; Breathing irritation or difficulty.

Section 4: FIRST AID MEASURES

◆USE APPROPRIATE BLOOD-BORNE PATHOGENS PROTECTIONS◆

EYE:

- Hold eyelids apart and flood with copious amounts of water. Seek medical attention.

SKIN:

- Remove excess product. Wash thoroughly with soap and water. If irritation persists, seek medical attention.

INGESTION:

- Do not induce vomiting unless directed by medical personnel. Seek medical attention.

INHALATION:

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

- Remove to fresh air. Seek medical attention.

### Section 5: FIRE FIGHTING MEASURES

FLASH POINT: 205°C 400°F UEL: N.D.A.% LEL: N.D.A. VAPOR DENSITY: N.D.A.  
NFPA FLAMMABILITY RATING: 1 AUTOIGNITION: N.D.A.  
COMBUSTION PRODUCTS: CO, CO<sub>2</sub>, NO<sub>x</sub>, & misc. hydrocarbons  
SPECIAL HAZARDS: Pre-sensitization to epoxy anaphylactic reaction. Toxic and irritating combustion products. Use DOT Response Guide #153.  
EXTINGUISHING MEDIA: Use foam, CO<sub>2</sub>, dry chemical, water fog.  
FIRE FIGHTER INSTRUCTIONS: Stay upwind. Wear at least full bunker gear and SCBA. DOT RGN 153.

### Section 6: ACCIDENTAL RELEASE MEASURES

Isolate spill area. Keep out of sewer and storm drains. Stop the leak and contain the spill. Vacuum, scoop, or absorb spill with non-combustible materials. Clean up spill residues with soap and water.

### Section 7: HANDLING AND STORAGE

Avoid skin and eye contact and breathing vapors by appropriate measures. Do not eat or smoke while handling this product. Wash thoroughly with soap and water after handling or exposure to this product.

Store in original sealed container at ambient temperatures (65°-80°F) in dry, well-ventilated areas.

### Section 8: EXPOSURE CONTROLS, PERSONAL PROTECTION

For Personal exposure Limits (PEL), Threshold Limit Values (TLV), or other exposure limits, see Sec.2.  
GENERAL: Provide adequate ventilation that will keep airborne concentration at a minimum.  
EYE/FACE: Safety glasses or splash goggles with face shield.  
SKIN: Chemical resistant gloves. Don chemical resistant clothing where exposure may occur.  
RESPIRATORY: NIOSH approved respirator with organic vapor/HEPA filter cartridges.  
OTHER: Decontaminate or discard clothing and materials that have come in contact with this product.

### Section 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: clear liquid	ODOR: faint amine odor	PHYSICAL STATE: liquid
VAPOR PRESS: N.D.A.	SPECIFIC GRAVITY: 1.01	pH: alkaline
BOILING PT: N.D.A.	MELT PT: N/A	SOLUBILITY IN H <sub>2</sub> O: slightly

### Section 10: STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable.  
INCOMPATIBILITY: Strong oxidizers, acids, epoxy resins in uncontrolled conditions; contact with other unpolymerized monomers or polymers.  
HAZARDOUS POLYMERIZATION: Will not occur.  
HAZARDOUS DECOMPOSITION: None known, other than Sec. 5's Combustion Products.

### Section 11: TOXICOLOGICAL INFORMATION

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

Oral: N.D.A.  
Dermal: N.D.A.  
Inhalation: N.D.A.  
Carcinogens under OSHA, ACGIH, NTP, IARC, or Other: None  $\geq$  0.1%.

Section 12: ECOLOGICAL INFORMATION

N.D.A.

Section 13: DISPOSAL CONSIDERATIONS

Dispose of in accordance with applicable federal, state, and local laws and regulations.

Section 14: TRANSPORT INFORMATION

DOT: Amines, Liquid, Corrosive n.o.s. (Nonylphenol), 8, UN 2735, PGIII.  
IATA: Regulated.  
IMO: Regulated.

Section 15: REGULATORY INFORMATION

OSHA: 1910.1200 Hazardous Chemical "Corrosive", "Sensitizer".  
TSCA: Contains listed ingredients.  
SARA III: Sec311 & 312 Immediate Health Hazard; Sec313 Chemicals above de minimus level: None.  
CA PROP. 65 NOTICE: Not listed.  
NFPA: HEALTH 3 FIRE 1 REACTIVITY 0 OTHER N/A

Section 16: CANADIAN REGULATORY INFORMATION

WHMIS: Hazard Classification: Class D Division 2A, Class D Division 2B, Class E Corrosive.  
WHMIS Symbols: Stylized T.  
Trade Secrets: N/A.  
Hazardous Products Act Information: This product MSDS contains ingredients which are Controlled and/or on the Ingredient Disclosure List (HPA sections 13 and 14).

ABBREVIATIONS: N/A = not applicable; N.D.A. = no data available; NE = not established

END OF MSDS

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## Product Data Sheet QuakeBond™ J201TC Tack Coat

### DESCRIPTION

QuakeBond™ J201TC (Tack Coat) is a two-component high-strength structural epoxy designed for vertical and overhead applications. J201-TC has an immediate high tack consistency, allowing it to hold heavy weight fabrics impregnated with J300-SR Saturating Resin in place during cure. QuakeBond™ J201TC trowels easily and has a long pot life for coverage of large areas. The convenient color-coded ("A" yellow and "B" blue) 2:1 volumetric mix ratio is user friendly. QuakeBond™ J201TC is a 100% solids formulation with low toxicity and low odor during cure.

### USE

- Adhesive for bonding external reinforcement to concrete, masonry, wood, stone, steel, etc.
- Structural bonding of carbon laminates, e.g. QuakeWrap™ DU50C.
- Structural bonding of fabrics saturated with QuakeBond™ J300SR resin on vertical and overhead surfaces.
- As a binder for epoxy mortar repairs.

### ADVANTAGES

- Long pot life.
- High strength, high modulus, structural paste adhesive.
- Fully compatible and excellent adhesion to QuakeWrap™ DU50C carbon laminate plates and glass or carbon fabrics saturated with QuakeBond™ J300SR resin.
- Paste consistency ideal for vertical and overhead applications.
- Convenient easy mix ratio, 2:1 by volume.
- 100% solvent free.
- Color coded components (Yellow & Blue) to ensure proper mixing control.
- Nearly odor-free.
- Low toxicity during cure.

### COVERAGE

Applied at a thickness of 40 mil (1 mm) results in 40 square feet per gallon (1 liter per square meter). Rough and uneven surfaces result in lower yields.

### PACKAGING

Component "A" is supplied in 2-gallon (7.58L) containers and component "B" in 1-gallon (3.79L) containers, resulting in 3-gallon kits. Ships DOT non-regulated.

### MIXING

Proportion 2 parts component "A" to 1 part component "B" by volume into a clean container. Mix thoroughly for 3 minutes using a paddle at low speed (400-600 rpm) drill until uniform color is achieved. Mix only the quantities that can be used within pot life. **DO NOT THIN**; solvents will prevent proper cure.

### SHELF LIFE

Two years in original, unopened and properly stored containers.

### STORAGE CONDITIONS

Store at 45°-100° F (7°-38° C). Avoid freezing.

### CERTIFICATE OF COMPLIANCE

- Material Safety Data Sheet (MSDS) will be supplied upon request and is included with each shipment.
- Possesses 0% volatile content per EPA Test Method 24.

### SURFACE PREPARATION

Surface must be clean and sound. It may be dry or damp but free from standing water and frost. Remove dust, laitance, grease, curing compounds, impregnations, waxes, foreign particles and other bond inhibiting materials from the surface. Existing uneven surfaces must be filled with an appropriate repair mortar. The adhesive strength of concrete must be verified after surface preparation by random pull-off testing (ACI 503R) at the discretion of the engineer. Minimum tensile strength of 200 psi (1.4 MPa) with concrete substrate failure is required. Blast clean, shot-blast, scarify or use other approved mechanical means to clean the substrate surface. Any sharp edges (i.e. fins, form-marks, etc.) must be ground smooth and flush. Sharp edges must be rounded to a minimum radius of 3/4 in. (19 mm).

### APPLICATION

Apply QuakeBond™ J201TC onto the substrate with a trowel or spatula to a nominal thickness of 40 mil (1 mm). A notched trowel may be used for this application. Before the epoxy hardens, apply saturated fabric or DU50C strips to the epoxy-coated surface. The external reinforcement must not be disturbed for a minimum of 24 hours.

### LIMITATIONS

Minimum application temperature of the epoxy is 40° F (4°C). **DO NOT THIN** this epoxy with solvents.

### FIRST AID

In case of skin contact, wash thoroughly with soap and water. For eye contact, flush immediately. For respiratory problems, remove to fresh air. Wash clothing before reuse. Consult MSDS for detailed information.

### CLEANUP

Collect with absorbent material, flush with water. Dispose of in accordance with local disposal regulations. Uncured materials can be removed with approved solvent. Cured materials can only be removed mechanically.

EPOXY PROPERTIES	
Color	Part A is yellow paste Part B is blue paste
Viscosity	Non-sagging thixotropic paste
Pot Life at 77° F (25° C)	90 minutes
Full cure time	48 hours
Density at 68° F (20° C)	Part A: 9.8 lbs/gal (1.18 kg/L) Part B: 9.4 lbs/gal (1.13 kg/L)
Tensile Strength (ASTM D-638)	4360 psi (30.06 MPa)
Tensile Modulus (ASTM D-638)	329,000 psi (2268.45 MPa)
Compressive Strength (ASTM D-695)	8006 psi (55.2 MPa)
Compressive Modulus (ASTM D-695)	278,900 psi (1923.02 MPa)
Flexural Strength (ASTM D-790)	8025 psi (55.33 MPa)
Flexural Modulus (ASTM D-790)	250,100 psi (1724.44 MPa)
Shear Strength (ASTM D-3165)	1453 psi (10.02 MPa)
Water absorption (% gain) in 24 hours	< 1%
Expansion Coefficient [-40° to 0° C]	61.21 *10 <sup>-6</sup> m/m °C
Expansion Coefficient [50° to 175° C]	210.58 *10 <sup>-6</sup> m/m °C

KEEP OUT OF REACH OF CHILDREN.  
NOT FOR INTERNAL CONSUMPTION.

CONSULT MATERIAL SAFETY DATA SHEET FOR MORE INFORMATION.

FOR INDUSTRIAL USE ONLY.  
KEEP CONTAINER CLOSED TIGHTLY.

QuakeWrap, Inc. warrants this product for one year from date of installation to be free from manufacturing defects and to meet the technical properties on the current technical data sheet if used as directed within shelf life. User determines suitability of product for intended use and assumes all risks. Buyer's sole remedy shall be limited to the purchase price or replacement of product exclusive of labor or cost of labor. NO OTHER WARRANTIES EXPRESS OR IMPLIED SHALL APPLY INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. QUAKEWRAP, INC. SHALL NOT BE LIABLE UNDER ANY LEGAL THEORY FOR SPECIAL OR CONSEQUENTIAL DAMAGES.

## MATERIAL SAFETY DATA SHEET (MSDS)

### Section 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **QuakeBond™ J201TC Tack Coat Resin (Part “A”)**  
CHEMICAL FAMILY: Epoxy Resin Mixture

SUPPLIER'S NAME: QuakeWrap, Inc., P.O. Box 64757, Tucson, AZ 85728  
EMERGENCY PHONE: 800/535-5053 (Infotrac) GENERAL INFORMATION: (866) QuakeWrap [782-5397]

### Section 2: COMPOSITION, INFORMATION ON INGREDIENTS

INGREDIENT	%	CAS #	EXPOSURE LIMITS
Bisphenol A Reaction Product	>60	25085-99-8	N/E
Proprietary Ingredients	<40	Trade Secret	N/E

### Section 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Epoxy resin solution. Certain individuals may have pre-existing skin or respiratory conditions causing a sensitivity or allergy which manifests as various reactions. Heating or spraying this product or the mixed parts increases potential health hazards. Health and Safety personnel should examine the handling procedures and remedy any existing or potential health and safety hazards.

#### POTENTIAL HEALTH EFFECTS:

##### EYE:

- May cause irritation.

##### SKIN:

- May cause irritation. Low dermal absorption hazard.

##### INGESTION:

- May inflame or damage the G.I. tract. Ingestion may be harmful.

##### INHALATION:

- May cause irritation.

##### CHRONIC EFFECTS:

- Repeated exposure may cause irritation and sensitization.

##### SIGNS & SYMPTOMS:

- Skin rash, irritation, reddening, or eczema; breathing irritation or difficulty.

### Section 4: FIRST AID MEASURES

#### ◆USE APPROPRIATE BLOOD-BORNE PATHOGENS PROTECTIONS◆

##### EYE:

- Hold eyelids apart and flood with copious amounts of water. Seek medical attention.

##### SKIN:

- Remove excess product. Wash thoroughly with soap and water. If irritation persists, seek medical attention.

##### INGESTION:

- Do not induce vomiting unless directed by medical personnel. Seek medical attention.

##### INHALATION:

- Remove to fresh air. Seek medical attention.

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

### Section 5: FIRE FIGHTING MEASURES

FLASH POINT: 177°C 350°F UEL: N/A LEL: N/A VAPOR DENSITY: N/A  
NFPA FLAMMABILITY RATING: 1 AUTOIGNITION: 300°C 570°F  
COMBUSTION PRODUCTS: CO, CO<sub>2</sub>, NO<sub>x</sub>, & misc. hydrocarbons.  
SPECIAL HAZARDS: Pre-sensitization to epoxy.  
EXTINGUISHING MEDIA: Use foam, CO<sub>2</sub>, dry chemical, water fog.  
FIRE FIGHTER INSTRUCTIONS: Stay upwind. Wear at least full bunker gear and SCBA.

### Section 6: ACCIDENTAL RELEASE MEASURES

Isolate spill area. Keep out of sewer and storm drains. Stop the leak and contain the spill. Vacuum, scoop, or absorb spill with non-combustible materials. Clean up spill residues with soap and water.

### Section 7: HANDLING AND STORAGE

Avoid skin and eye contact and breathing vapors or mists by appropriate measures. Do not eat or smoke while handling this product. Wash thoroughly after handling or exposure to this product.

Store in original sealed container at ambient temperatures (55°-95° F) in dry, well-ventilated areas.

### Section 8: EXPOSURE CONTROLS, PERSONAL PROTECTION

For Personal Exposure Limits (PEL), Threshold Limit Values (TLV) or other exposure limits, see Sec. 2.

GENERAL: Provide ventilation that will keep airborne concentration at a minimum.

EYE/FACE: Safety glasses or splash goggles with face shield.

SKIN: Butyl or nitrile rubber chemical gloves. Don chemical resistant clothing where exposure may occur.

RESPIRATORY: Provide adequate ventilation in work area. Use NIOSH respirator (organic vapor cartridges) where local ventilation is inadequate. Provide laminar flow ventilation where possible.

OTHER: Decontaminate or discard clothing and materials that have come in contact with this product.

### Section 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: pigmented paste  
pH: N.D.A.

ODOR: slightly sweet

PHYSICAL STATE: paste

BOILING PT: >300°F

VAPOR PRESS: N.D.A. SPECIFIC GRAVITY: 1.16

MELT PT: N/A

SOLUBILITY IN H<sub>2</sub>O: slightly

### Section 10: STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable.

INCOMPATIBILITY: Strong acids, caustics, oxidizers, and epoxy hardeners in an uncontrolled condition.

HAZARDOUS POLYMERIZATION: Will not occur.

HAZARDOUS DECOMPOSITION: None known, other than Sec. 5's Combustion Products.

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

### Section 11: TOXICOLOGICAL INFORMATION

Oral: N.D.A.  
Dermal: N.D.A.  
Inhalation: N.D.A.  
Carcinogens under OSHA, ACGIH, NTP, IARC, or Other: None  $\geq$  0.1%.

### Section 12: ECOLOGICAL INFORMATION

N.D.A.

### Section 13: DISPOSAL CONSIDERATIONS

Dispose of in accordance with applicable federal, state, and local laws and regulations.

### Section 14: TRANSPORT INFORMATION

DOT: Not Regulated.  
IATA: Not Regulated  
IMO:

### Section 15: REGULATORY INFORMATION

OSHA: 29 CFR 1910.1200 Hazardous Chemical "Irritant", "Sensitizer".  
TSCA: Ingredients listed.  
SARA III: Sec311 & 312 Immediate Health Hazard; Sec313 Not listed.  
CA PROP. 65 NOTICE: None.  
NFPA: Health 1 Fire 1 Reactivity 0 Other N/A

### Section 16: CANADIAN REGULATORY INFORMATION

WHMIS: Hazard Classification: Class D2B Skin Sensitizer. Refer to MSDS for specific warnings.  
WHMIS Symbols: Stylized T.  
WHMIS Trade Secret Registry Numbers: None.  
Hazardous Products Act Information: This product MSDS contains ingredients which are Controlled and/or on the Ingredient Disclosure List (HPA sections 13 and 14).

ABBREVIATIONS: N/A = not applicable; N.D.A. = no data available; NE = not established

END OF MSDS

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ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

## MATERIAL SAFETY DATA SHEET (MSDS)

### Section 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **QuakeBond™ J201TC Hardener (Part “B”)**

CHEMICAL FAMILY: Polyethylenepolyamine Mixture

SUPPLIER'S NAME: QuakeWrap, Inc., P.O. Box 64757, Tucson, AZ 85728

EMERGENCY PHONE: 800/535-5053 (Infotrac) GENERAL INFORMATION: (866) QuakeWrap [782-5397]

### Section 2: COMPOSITION, INFORMATION ON INGREDIENTS

INGREDIENT	%	CAS #	EXPOSURE LIMITS
Polyoxypropylenediamine	<45	9046-10-0	N/E
Isophoronediamine	<20	2855-13-2	N/E
Rubber Polymer	>5	68683-29-4	N/E
Proprietary Amine Blend	<20	N/A	N/E
Petroleum Distillates	<1	64742-47-8	N/E * (* 300 ppm supplier recommended)

### Section 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Corrosive epoxy hardener. Certain individuals may have pre-existing skin or respiratory conditions causing a sensitivity or allergy which manifests as various reactions. Heating or spraying this product or the mixed parts increases potential health hazards. Health and Safety personnel should examine the handling procedures and remedy any existing or potential health and safety hazards.

#### POTENTIAL HEALTH EFFECTS:

##### EYE:

- Can cause irritation. Significant, prolonged, or repeated contact can damage the cornea.

##### SKIN:

- Can cause irritation. Significant, prolonged, or repeated exposure can cause severe irritation.

##### INGESTION:

- Can inflame or damage the G.I. tract. Ingestion can be harmful.

##### INHALATION:

- Can cause irritation. Significant, prolonged, or repeated exposure to mist or vapor can damage the respiratory system.

##### CHRONIC EFFECTS:

- Repeated exposure can cause irritation and sensitization.

##### SIGNS & SYMPTOMS:

- Skin rash, irritation, reddening, or eczema; Breathing irritation or difficulty. Sensitization.

### Section 4: FIRST AID MEASURES

◆USE APPROPRIATE BLOOD-BORNE PATHOGENS PROTECTIONS◆

##### EYE:

- Hold eyelids apart and flood with copious amounts of water. Seek medical attention.

##### SKIN:

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

- Remove excess product. Wash thoroughly with soap and water. If irritation persists, seek medical attention.

**INGESTION:**

- Do not induce vomiting unless directed by medical personnel. Seek medical attention.

**INHALATION:**

- Remove to fresh air. Seek medical attention.

### **Section 5: FIRE FIGHTING MEASURES**

FLASH POINT: >138°C >280°F UEL: N.D.A.% LEL: N.D.A. VAPOR DENSITY: N.D.A.

NFPA FLAMMABILITY RATING: 1 AUTOIGNITION: N.D.A.

COMBUSTION PRODUCTS: CO, CO<sub>2</sub>, NO<sub>x</sub>, & misc. hydrocarbons

SPECIAL HAZARDS: Firefighters should wear butyl rubber boots, gloves, and body suit with SCBA. May generate toxic and irritating combustion products. Use DOT Response Guide #153.

EXTINGUISHING MEDIA: Use foam, CO<sub>2</sub>, dry chemical, water fog.

FIRE FIGHTER INSTRUCTIONS: Stay upwind. Wear at least full bunker gear and SCBA.

### **Section 6: ACCIDENTAL RELEASE MEASURES**

Isolate spill area. Keep out of sewer and storm drains. Stop the leak and contain the spill. Vacuum, scoop, or absorb spill with non-combustible materials. Clean up spill residues with soap and water.

### **Section 7: HANDLING AND STORAGE**

Avoid skin and eye contact and breathing vapors by appropriate measures. Do not eat or smoke while handling this product. Wash thoroughly with soap and water after handling or exposure to this product.

Store in original sealed container at ambient temperatures (65°-80°F) in dry, well-ventilated areas.

### **Section 8: EXPOSURE CONTROLS, PERSONAL PROTECTION**

For Personal exposure Limits (PEL), Threshold Limit Values (TLV), or other exposure limits, see Sec.2.

GENERAL: Provide adequate ventilation that will keep airborne concentration at a minimum.

EYE/FACE: Safety glasses or splash goggles with face shield.

SKIN: Chemical resistant gloves. Don chemical resistant clothing where exposure may occur.

RESPIRATORY: NIOSH approved respirator with organic vapor/HEPA filter cartridges.

OTHER: Decontaminate or discard clothing and materials that have come in contact with this product.

### **Section 9: PHYSICAL AND CHEMICAL PROPERTIES**

APPEARANCE: Blue paste

ODOR: faint amine

PHYSICAL STATE: paste

pH: alkaline VAPOR PRESS: N.D.A.

VAPOR DENSITY: N.D.A.

SPECIFIC GRAVITY: 1.07

BOILING PT: N.D.A.

MELT PT: N/A

SOLUBILITY IN H<sub>2</sub>O: moderate

### **Section 10: STABILITY AND REACTIVITY**

CHEMICAL STABILITY: Stable.

INCOMPATIBILITY: Strong oxidizers, acids, epoxy resins in uncontrolled conditions; contact with other unpolymerized monomers or polymers.

HAZARDOUS POLYMERIZATION: Will not occur.

HAZARDOUS DECOMPOSITION: None known, other than Sec. 5's Combustion Products.

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

### Section 11: TOXICOLOGICAL INFORMATION

Oral: N.D.A.  
Dermal: N.D.A.  
Inhalation: N.D.A.  
Carcinogen under OSHA, ACGIH, NTP, IARC, or Other: None  $\geq$ 0.1%.

### Section 12: ECOLOGICAL INFORMATION

N.D.A.

### Section 13: DISPOSAL CONSIDERATIONS

Dispose of in accordance with applicable federal, state, and local laws and regulations.

### Section 14: TRANSPORT INFORMATION

DOT: Amines, Liquid, Corrosive, n.o.s. (Polyoxypropylenediamine), 8, UN 2735 PGIII  
IATA: Regulated.  
IMO: Regulated.

### Section 15: REGULATORY INFORMATION

OSHA: 1910.1200 Hazardous Chemical "Irritant", "Sensitizer".  
TSCA: Contains listed ingredients.  
SARA III: Sec311 & 312 Immediate Health Hazard; Sec313 Chemicals above de minimus level: None.  
CA PROP. 65 NOTICE: None Listed.  
VOLATILE ORGANIC COMPOUND (VOC) %: Zero.  
NFPA: HEALTH 3 FIRE 1 REACTIVITY 0 OTHER N/A

### Section 16: CANADIAN REGULATORY INFORMATION

WHMIS: Hazard Classification: Class D Division 2A, Class D Division 2B, Class E Corrosive.  
WHMIS Symbols: Stylized T.  
Trade Secrets: N/A.  
Hazardous Products Act Information: This product MSDS contains ingredients which are Controlled and/or on the Ingredient Disclosure List (HPA sections 13 and 14).

ABBREVIATIONS: N/A = not applicable; N.D.A. = no data available; NE = not established

END OF MSDS

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ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.



## Product Data Sheet QuakeBond™ J300SR Saturating Resin

### DESCRIPTION

QuakeBond™ J300SR (Saturating Resin) is a two-component, high-strength, low-viscosity structural epoxy. The low viscosity and long pot life, with fast cure time is designed for high volume saturating of heavy reinforcement fabrics using our impregnator machine. Combined with carbon or glass reinforcement, J300SR Saturating Resin produces fiber composite laminates with exceptional strength, durability and chemical resistance. The convenient color-coded components and the 2:1 volumetric mix ratio is user friendly. QuakeBond™ J300SR is a 100% solids formulation with low toxicity and low odor during cure.

### USE

- Saturating carbon and glass fabrics for structural retrofit applications.
- Adhesive for bonding external reinforcement to concrete, masonry & wood.
- A moisture barrier (water-proofing) system in conjunction with QuakeWrap™ carbon or glass fabrics.
- As a binder for epoxy mortar repairs.

### ADVANTAGES

- Long pot life.
- High strength, high modulus, low-viscosity structural adhesive.
- Fully compatible and excellent adhesion to QuakeWrap™ carbon and glass fabrics.
- Convenient easy mix ratio, 2:1 by volume.
- 100% solvent free.
- Color coded components (pigmented syrup & amber liquid) to ensure proper mixing control.
- Nearly odor-free.
- Low toxicity during cure.

### COVERAGE

Applied as a saturating resin to a fabric with a density of 24 oz/yd<sup>2</sup> (813 gram /m<sup>2</sup>) achieves a yield of 75 square feet per gallon (0.55 liter per square meter). Yield varies slightly for different fabric densities.

### PACKAGING

Each of the components is supplied in 55-gallon (208L) drums or 5-gallon (19L) containers, resulting in 165-gallon or 15-gallon kits. Ships DOT non-regulated.

### MIXING

Proportion 2 parts component "A" to 1 part component "B" by volume into a clean container. Mix thoroughly for 3 minutes using a paddle at low speed (400-600 rpm) drill until uniform color is achieved. Mix only the quantities that can be used within pot life. **DO NOT THIN**; solvents will prevent proper cure.

### SHELF LIFE

Two years in original, unopened and properly stored containers.

### STORAGE CONDITIONS

Store in dry place at 45°-100° F (7°-38° C).

### CERTIFICATE OF COMPLIANCE

- Material Safety Data Sheet (MSDS) will be supplied upon request and is included with each shipment.
- Possesses 0% volatile content per EPA Test Method 24.

### APPLICATION

Use QuakeBond™ J300SR in conjunction with our saturating machines to impregnate carbon or glass fabrics (wet lay-up process); please contact us for detailed information on operation of saturating machines. For smaller projects, the fabrics may be saturated by hand; pour mixed J300SR onto the fabric and use a trowel or spatula to spread the resin into the fabric; it may be necessary to turn the fabric over and repeat this process, ensuring that the fabric is thoroughly saturated. Use a squeegee to remove excess resin from the fabric before installing the fabric on the structural element. Once the saturated fabric is installed, remove all entrapped air bubbles with gloved hands; a plastic laminating roller can be used as well. Do not disturb installed saturated fabric for 24 hours.

### LIMITATIONS

Minimum application temperature of the epoxy is 40° F (4°C). **DO NOT THIN** this epoxy with solvents.

### FIRST AID

In case of skin contact, wash thoroughly with soap and water. For eye contact, flush immediately. For respiratory problems, remove to fresh air. Wash clothing before reuse. Consult MSDS for detailed information.

### CLEANUP

Collect with absorbent material, flush with water. Dispose of in accordance with local disposal regulations. Uncured materials can be removed with approved solvent. Cured materials can only be removed mechanically.

EPOXY PROPERTIES	
Color	Part A is pigmented syrup Part B is amber liquid
Viscosity Mixed at 77° F (25° C)	1500-1600 cps
Pot Life at 77° F (25° C)	3-4 hours (thin film set time)
Full cure time	48 hours
Density at 68° F (20° C)	Part A: 9.4 lbs/gal (1.13 kg/L) Part B: 8.3 lbs/gal (1.00 kg/L)
Tensile Strength (ASTM D-638)	7150 psi (49.3 MPa)
Tensile Modulus (ASTM D-638)	289,300 psi (1995 MPa)
Compressive Strength (ASTM D-695)	9490 psi (65.4 MPa)
Compressive Modulus (ASTM D-695)	472,000 psi (3250 MPa)
Flexural Strength (ASTM D-790)	11,140 psi (76.8 MPa)
Flexural Modulus (ASTM D-790)	252,400 psi (1740 MPa)
Shear Strength (ASTM D-3165)	Unable to force a shear failure mode; samples fail in tension.
Water absorption (% gain) in 24 hours	< 1%
Expansion Coefficient [-37.4° to 40.1° C]	78 *10 <sup>-6</sup> m/m °C
Expansion Coefficient [120° to 222° C]	151.8 *10 <sup>-6</sup> m/m °C

KEEP OUT OF REACH OF CHILDREN.  
NOT FOR INTERNAL CONSUMPTION.

CONSULT MATERIAL SAFETY DATA SHEET FOR MORE INFORMATION.

FOR INDUSTRIAL USE ONLY.  
KEEP CONTAINER CLOSED TIGHTLY.

QuakeWrap, Inc. warrants this product for one year from date of installation to be free from manufacturing defects and to meet the technical properties on the current technical data sheet if used as directed within shelf life. User determines suitability of product for intended use and assumes all risks. Buyer's sole remedy shall be limited to the purchase price or replacement of product exclusive of labor or cost of labor.

NO OTHER WARRANTIES EXPRESS OR IMPLIED SHALL APPLY INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. QUAKEWRAP, INC. SHALL NOT BE LIABLE UNDER ANY LEGAL THEORY FOR SPECIAL OR CONSEQUENTIAL DAMAGES.



## MATERIAL SAFETY DATA SHEET (MSDS)

### Section 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **QuakeBond™ J300SR Saturating Resin (Part "A")**

CHEMICAL FAMILY: Epoxy Resin Mixture

SUPPLIER'S NAME: QuakeWrap, Inc., P.O. Box 64757, Tucson, AZ 85728

EMERGENCY PHONE: 800/535-5053 (Infotrac) GENERAL INFORMATION: (866) QuakeWrap [782-5397]

### Section 2: COMPOSITION, INFORMATION ON INGREDIENTS

INGREDIENT	%	CAS #	EXPOSURE LIMITS
Bisphenol A Reaction Product	<80	25068-38-6	N/E
Proprietary ingredients	>20	Trade secret	N/E

### Section 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Epoxy resin solution. Certain individuals may have pre-existing skin or respiratory conditions causing a sensitivity or allergy which manifests as various reactions. Heating or spraying this product or the mixed parts increases potential health hazards. Health and Safety personnel should examine all handling procedures and remedy the existing and potential health and safety hazards.

#### POTENTIAL HEALTH EFFECTS:

##### EYE:

- May cause irritation.

##### SKIN:

- May cause irritation. Low dermal absorption hazard.

##### INGESTION:

- May inflame or damage the G.I. tract. Large quantities may be harmful.

##### INHALATION:

- May cause irritation.

##### CHRONIC EFFECTS:

- Repeated exposure may cause irritation and sensitization.

##### SIGNS & SYMPTOMS:

- Skin rash, irritation, reddening, or eczema; breathing irritation or difficulty.

### Section 4: FIRST AID MEASURES

#### ◆USE APPROPRIATE BLOOD-BORNE PATHOGENS PROTECTIONS◆

##### EYE:

- Hold eyelids apart and flood with copious amounts of water. Seek medical attention.

##### SKIN:

- Remove excess product. Wash thoroughly with soap and water. If irritation persists, seek medical attention.

##### INGESTION:

- Do not induce vomiting unless directed by medical personnel. Seek medical attention.

##### INHALATION:

- Remove to fresh air. Seek medical attention.

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## Section 5: FIRE FIGHTING MEASURES

FLASH POINT: 177°C 350°F UEL: N/A LEL: N/A VAPOR DENSITY: N/A  
NFPA FLAMMABILITY RATING: 1 AUTOIGNITION: 300°C 570°F  
COMBUSTION PRODUCTS: CO, CO<sub>2</sub>, NO<sub>x</sub>, & misc. hydrocarbons.  
SPECIAL HAZARDS: Pre-sensitization to epoxy.  
EXTINGUISHING MEDIA: Use foam, CO<sub>2</sub>, dry chemical, water fog.  
FIRE FIGHTER INSTRUCTIONS: Stay upwind. Wear at least full bunker gear and SCBA.

## Section 6: ACCIDENTAL RELEASE MEASURES

Isolate spill area. Keep out of sewer and storm drains. Stop the leak and contain the spill. Vacuum, scoop, or absorb spill with non-combustible materials. Clean up spill residues with soap and water.

## Section 7: HANDLING AND STORAGE

Avoid skin and eye contact and breathing vapors or mists by appropriate measures. Do not eat or smoke while handling this product. Wash thoroughly with mild soap and water after product handling or exposure.

Store in original sealed container at ambient temperatures (65°-80°F) in dry, well-ventilated areas.

## Section 8: EXPOSURE CONTROLS, PERSONAL PROTECTION

For Personal Exposure Limits (PEL), Threshold Limit Values (TLV) or other exposure limits, see Sec. 2.  
GENERAL: Provide ventilation that will keep airborne concentration at a minimum.  
EYE/FACE: Safety glasses or splash goggles with face shield.  
SKIN: Butyl or nitrile rubber chemical gloves. Don chemical resistant clothing where exposure may occur.  
RESPIRATORY: NIOSH approved respirator with organic vapor/HEPA filter cartridges.  
OTHER: Decontaminate or discard clothing and materials that have come in contact with this product.

## Section 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: pigmented syrup	ODOR: slightly sweet	PHYSICAL STATE: liquid
pH: N.D.A. VAPOR PRESS: N.D.A.	VAPOR DENSITY: N.D.A.	SPECIFIC GRAVITY: 1.05
BOILING PT: N.D.A.	MELT PT: N/A	SOLUBILITY IN H <sub>2</sub> O: slightly

## Section 10: STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable.  
INCOMPATIBILITY: Strong acids, caustics, oxidizers, and epoxy hardeners in an uncontrolled condition.  
HAZARDOUS POLYMERIZATION: Will not occur.  
HAZARDOUS DECOMPOSITION: None known, other than Sec. 5's Combustion Products.

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### Section 11: TOXICOLOGICAL INFORMATION

Oral: N.D.A.

Dermal: N.D.A.

Inhalation: N.D.A.

Carcinogens under OSHA, ACGIH, NTP, IARC, or Other: Epichlorohydrin <1.95ppm.

### Section 12: ECOLOGICAL INFORMATION

N.D.A.

### Section 13: DISPOSAL CONSIDERATIONS

Dispose of in accordance with applicable federal, state, and local laws and regulations.

### Section 14: TRANSPORT INFORMATION

DOT: Not Regulated.

IATA:

IMO:

### Section 15: REGULATORY INFORMATION

OSHA: 29 CFR 1910.1200 Hazardous Chemical "Irritant", "Sensitizer".

TSCA: Ingredients listed.

SARA III: Sec311 & 312 Immediate Health Hazard; Sec313: Not listed.

CA PROP. 65 NOTICE: Warning: This product contains a material known to the State of California to cause cancer. (<1.95ppm Epichlorohydrin)

VOLATILE MATTER: Part "A" = 9.0%, Mixed Parts "A" & "B" = 5.9% EPA Method 24 .

NFPA: Health 1 Fire 1 Reactivity 0 Other N/A

### Section 16: CANADIAN REGULATORY INFORMATION

WHMIS: Hazard Classification: Class D2B Skin Sensitizer. Refer to MSDS for specific warnings.

WHMIS Symbols: Stylized T.

WHMIS Trade Secret Registry Numbers: None.

Hazardous Products Act Information: This product MSDS contains ingredients which are Controlled and/or on the Ingredient Disclosure List (HPA sections 13 and 14).

ABBREVIATIONS: N/A = not applicable; N.D.A. = no data available; NE = not established

END OF MSDS

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

## MATERIAL SAFETY DATA SHEET (MSDS)

### Section 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **QuakeBond™ J300SR Hardener (Part “B”)**

CHEMICAL FAMILY: Polyamines

SUPPLIER'S NAME: QuakeWrap, Inc., P.O. Box 64757, Tucson, AZ 85728

EMERGENCY PHONE: 800/535-5053 (Infotrac) GENERAL INFORMATION: (866) QuakeWrap [782-5397]

### Section 2: COMPOSITION, INFORMATION ON INGREDIENTS

INGREDIENT	%	CAS #	EXPOSURE LIMITS
Triethylenetetramine	<10	112-57-2	N/E
Benzyl alcohol	>20	100-51-6	N/E
Proprietary ingredients	<70	Trade secret	N/E

### Section 3: HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Epoxy hardener solution. Certain individuals may have pre-existing skin or respiratory conditions causing a sensitivity or allergy which manifests as various reactions. Heating or spraying this product or the mixed parts increases potential health hazards. Health and Safety personnel should examine all handling procedures and remedy the existing and potential health and safety hazards.

#### POTENTIAL HEALTH EFFECTS:

##### EYE:

- May cause irritation.

##### SKIN:

- May cause irritation.

##### INGESTION:

- May inflame or damage the G.I. tract. Ingestion may be harmful.

##### INHALATION:

- May cause irritation.

##### CHRONIC EFFECTS:

- Repeated exposure may cause irritation and sensitization.

##### SIGNS & SYMPTOMS:

- Skin rash, irritation, reddening, or eczema; Breathing irritation or difficulty.

### Section 4: FIRST AID MEASURES

#### ◆USE APPROPRIATE BLOOD-BORNE PATHOGENS PROTECTIONS◆

##### EYE:

- Hold eyelids apart and flood with copious amounts of water. Seek medical attention.

##### SKIN:

- Remove excess product. Wash thoroughly with soap and water. If irritation persists, seek medical attention.

##### INGESTION:

- Do not induce vomiting unless directed by medical personnel. Seek medical attention.

##### INHALATION:

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

- Remove to fresh air. Seek medical attention.

## Section 5: FIRE FIGHTING MEASURES

FLASH POINT: >400°F UEL: N.D.A.% LEL: N.D.A. VAPOR DENSITY: N.D.A.  
NFPA FLAMMABILITY RATING: 1 AUTOIGNITION: N.D.A.  
COMBUSTION PRODUCTS: CO, CO<sub>2</sub>, NO<sub>x</sub>, & misc. hydrocarbons  
SPECIAL HAZARDS: Firefighters should wear butyl rubber boots, gloves, and body suit with SCBA. May generate toxic and irritating combustion products. Use DOT Response Guide #153.  
EXTINGUISHING MEDIA: Use foam, CO<sub>2</sub>, dry chemical, water fog.  
FIRE FIGHTER INSTRUCTIONS: Stay upwind. Wear at least full bunker gear and SCBA.

## Section 6: ACCIDENTAL RELEASE MEASURES

Isolate the spill area. Keep out of sewer and storm drains. Stop the leak and contain the spill. Vacuum, scoop, or absorb spill with non-combustible materials. Clean up spill residues with soap and water.

## Section 7: HANDLING AND STORAGE

Avoid skin and eye contact and breathing vapors by appropriate measures. Do not eat or smoke while handling this product. Wash thoroughly with mild soap and water after product handling or exposure.

Store in original sealed container at ambient temperatures (65°-80°F) in dry, well-ventilated areas.

## Section 8: EXPOSURE CONTROLS, PERSONAL PROTECTION

For Personal exposure Limits (PEL), Threshold Limit Values (TLV), or other exposure limits, see Sec.2.  
GENERAL: Provide adequate ventilation that will keep airborne concentration at a minimum.  
EYE/FACE: Safety glasses or splash goggles with face shield.  
SKIN: Butyl or nitrile rubber chemical gloves. Don chemical resistant clothing where exposure may occur.  
RESPIRATORY: NIOSH approved respirator with organic vapor/HEPA filter cartridges.  
OTHER: Decontaminate or discard clothing and materials that have come in contact with this product.

## Section 9: PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: amber liquid	ODOR: faint amine	PHYSICAL STATE: liquid
VAPOR PRESS: N.D.A.	SPECIFIC GRAVITY: 1.03	pH: alkaline
BOILING PT: N.D.A.	MELT PT: N/A	SOLUBILITY IN H <sub>2</sub> O: slightly

## Section 10: STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable.  
INCOMPATIBILITY: Strong oxidizers, acids, epoxy resins in uncontrolled conditions; contact with other unpolymerized monomers or polymers.  
HAZARDOUS POLYMERIZATION: Will not occur.  
HAZARDOUS DECOMPOSITION: None known, other than Sec. 5's Combustion Products.

## Section 11: TOXICOLOGICAL INFORMATION

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.

Oral: N.D.A.  
Dermal: N.D.A.  
Inhalation: N.D.A.  
Carcinogens under OSHA, ACGIH, NTP, IARC, or Other: None  $\geq$  0.1%.

#### Section 12: ECOLOGICAL INFORMATION

N.D.A.

#### Section 13: DISPOSAL CONSIDERATIONS

Dispose of in accordance with applicable federal, state, and local laws and regulations.

#### Section 14: TRANSPORT INFORMATION

DOT: Not Regulated.  
IATA: Not Regulated.  
IMO: Not Regulated.

#### Section 15: REGULATORY INFORMATION

OSHA: 1910.1200 Hazardous Chemical "Irritant", "Sensitizer".  
TSCA: Contains listed ingredients.  
SARA III: Sec311 & 312 Immediate Health Hazard; Sec313 Chemicals above de minimus level: None.  
CA PROP. 65 NOTICE: Not listed.  
VOLATILE MATTER: Part "B" = 24%, Mixed Parts "A" & "B" = 5.9% EPA Method 24.  
NFPA: HEALTH 2 FIRE 1 REACTIVITY 0 OTHER N/A

#### Section 16: CANADIAN REGULATORY INFORMATION

WHMIS: Hazard Classification: Class D2B Skin Sensitizer. Refer to MSDS for specific warnings.  
WHMIS Symbols: Stylized T.  
Trade Secrets: N/A.  
Hazardous Products Act Information: This product MSDS contains ingredients which are Controlled and/or on the Ingredient Disclosure List (HPA sections 13 and 14).

ABBREVIATIONS: N/A = not applicable; N.D.A. = no data available; NE = not established

END OF MSDS

ATTENTION: No representation is made as to the accuracy or correctness of the information contained herein, other than to state that it is presented by this organization in good faith and we believe it to be correct and accurate per the limits of our understanding and training as of the date of first publication. The user or handler of this product is warned to take the most conservative and safest interpretation possible of all information contained herein and to use the most extreme personal protection measures and exposure limitations prudently dictated by the specific usage or handling situation, this MSDS information and good industrial safety and hygiene practices.



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# Installation Specifications for QuakeWrap™

*(Note: This document is available in electronic format for our clients.)*

## 1 DEFINITION

The following Terms used in these specifications are primarily taken from ACI 440.2R02 with some changes:

Batch- A quality of material formed during the same field installation in one continuous process and having identical characteristics throughout.

Bidirectional Laminate- Reinforced polymer laminate with fibers oriented in two different directions in its plane.

Bond-Critical Applications- Applications of FRP systems for strengthening structures that rely on bond to the concrete substrate. Examples are flexural and shear strengthening of beams and slabs.

Catalyst- A substance that initiates a chemical reaction and enables it to proceed under milder conditions than otherwise required that does not, itself, alter or enter into the reaction. See Hardener.

Composite- A combination of two or more materials differing in form or composition on a macro scale. The constituents retain their identities; they do not dissolve or merge completely into one another, although they act in concert. Normally, the components can be physically identified and exhibit an interface between one another. See Composite FRP.

Composite FRP- A polymer matrix, either thermosetting or thermoplastic, reinforced with a fiber or other material with a sufficient aspect ration (length to thickness) to provide a discernible reinforcing function in one or more directions. See Composite.

Contact-Critical Applications- Applications of FRP systems that rely on intimate contact between concrete substrate and the FRP system to function as intended. An example is the confinement of columns for seismic retrofit. In these specifications are treated in the same way as bond-critical applications. See Bond Critical Applications.

Creep Rupture- Failure of an FRP system resulting from a gradual, time-dependended reduction of capacity due to sustained loading.

Cure- The process of causing irreversible changes in the properties of a thermosetting resin by chemical reaction. Cure is typically accomplished by addition of curing agents or initiators, with or without heat and pressure. Full cure is the point at which a resin reaches its specified properties. Resin is undercured if its specified properties have not been reached.

Cure Time- The time necessary to cure a thermosetting resin system, thermoset-based composite, or prepreg at a given temperature.

Curing Agent- A catalytic or reactive agent that, when added to resin, causes polymerization. Also called Hardener.

Debonding- A separation at the interface between substrate and the reinforcing layer.

Delamination- Separation of the layers of the FRP laminate from each other.

Developmental Length- The bonded distance required for transfer of stresses from concrete to the FRP to the develop tensile capacity of FRP.

Durability- The ability of a material to resist cracking, oxidation, chemical degradation, delamination, wear, or the effects of foreign object damage for a specified period of time, under the appropriate load conditions and specified environmental conditions.

Epoxy- A polymerizable thermosetting polymer containing one or more epoxide groups, cured by reaction with phenols, anhydrides, polyfunctional amines, carboxylic acids, or mercaptans. An important matrix resin in FRP, also used as structural adhesive.

Fabric- Arrangement of fibers held together in two or three dimensions. It may be woven, non-woven, knitted or stitched. Fabric architecture is the specific description of the fibers, their directions and construction.

Fiber- A general term used to refer to filamentary materials. The smallest unit of a fibrous material. Often, fiber is used synonymously with filament.

Fiber Content- The amount of fiber present in a composite usually expressed as a volume fraction or a mass fraction of the composite.

Fiber Fly- Short filaments that break off dry fiber tows or yarns during handling and become airborne, classified as nuisance dust.

Fiber-Reinforced Polymer (FRP) System- Composite material consisting of a polymer matrix reinforced with cloth, mat, strands, or any other fiber form.

Filament- See Fiber.

Filler- A relatively inert substance added to a resin to alter its properties or to lower cost or density. Also used to term particulate additives. Also called extenders.



Fire Retamiant - Chemicals used to reduce the tendency of resin to burn. They can be added to the resin or coated on the surface of the FRP.

Flow- The movement of uncured resin under pressure or gravity loads.

Glass Transition Temperature (Tg)- The approximate midpoint of the temperature range over which a transition in material response from elastic to viscoelastic takes place.

Hardener- Substance added to thermosetting resin to cause polymerization. Usually applies to epoxy resins.

Impregnation- The process of saturating the interstices of a reinforcement or substrate with a resin.

Inhibitor- A substance that retards a chemical reaction, such as ultraviolet degradation. Also used to prolong shelf life of certain resins.

Initiator- Chemicals, most commonly peroxides, used to initiate the curing process for unsaturated polyester and vinyl ester resins. See Catalyst.

Laminate- One or more layers or plies of fiber, bonded together in a cured resin matrix.

Lay Up- The process of placing the FRP reinforcing material in position for installation.

Lot- A quantity of material manufactured during the same plant production in one continuous process and having identical characteristics throughout. In these specifications, batch is used interchangeably. See Batch.

Mat- A fibrous material for reinforced polymer consisting of randomly oriented chopped filaments, short fibers (with or without a carrier fabric), or long random filaments loosely held together with a binder.

Matrix- The essentially homogenous resin or polymer material in which the fiber system of a composite is embedded.

Micro-Cracking- Cracks formed in composites when stresses locally exceed the strength of the matrix.

MSDS- Material Safety Data Sheet.

Pin Holes- A small cavity, typically less than 0.06 in. in diameter, that penetrates the surface of a cured composite part.

Pitch- Petroleum or coal tar precursor base used to make carbon fiber.

Polyester- A thermosetting polymer synthesized by the condensation reaction of certain acids with alcohols and subsequently cured by additional polymerization initiated by free radical generation. Polyesters are used as binders for resin mortars and concretes, fiber laminates, and adhesives. Commonly referred to as “unsaturated polyester”.

Polymer- A compound formed by the reaction of simple molecules that permit their combination to proceed to high molecular weights under suitable conditions.

Polyurethane- A thermosetting resin prepared by the reaction of diisocyanates with polyols, polyamides, alkyd polymers, and polyether polymers.

Postcure- Additional elevated-temperature cure to increase the level of polymer cross linking; final properties of the laminate or polymer are enhanced.

Pot Life- Time that a catalyzed resin retains a viscosity low enough to be used in processing. Also called working life.

Prepreg- A fiber or fiber sheet material containing resin whose reaction has progressed to the stage where consistency is tacky. Multiple plies of prepreg are typically cured with applied heat and pressure. Also preimpregnated fiber or sheet.

Pultrusion- A continuous process that combines pulling and extrusion for manufacturing composites that typically have a constant cross-sectional shape. The process consists of pulling a fiber material through a resin bath and then through a heated shaping die, where the resin is cured.

Resin- A component of a polymeric system that requires a catalyst or hardener to polymerize or cure for use in composites. Resin often refers to the mixed polymer component or matrix of the FRP.

Resin Content- The amount of resin in a laminate expressed as a percentage of either total mass or total volume.

Roving- A number of yarns, strands, tows, or ends of fibers collected into a parallel bundle with little or no twist.

Shelf Life- The length of time a material, substance, product, or reagent can be stored under specified environmental conditions and continue to meet all applicable specifications or remain suitable for its intended function. Also called storage life.

Structural Adhesive- A resinous bonding agent used for transferring required loads between adherents.

Substrate- The original concrete and any cementitious repair materials used to repair or replace the original concrete. It can consist entirely of original concrete, entirely of repair materials, or of a combination of the two. The FRP is installed on the surface of the substrate.

Thermoplastic- A non-cross-linked polymer capable of being repeatedly softened by an increase of temperature and hardened by a decrease in temperature. Examples are nylon, polypropylene, and polystyrene.

Thermoset- A cross-linked polymer that cannot be softened and reformed by an increase in temperature. Cross linking is an irreversible process; thermosets cannot be returned to a molten state. Examples are epoxy, phenolic, and vinyl ester.

Tow- An untwisted bundle of continuous fibers.

Unidirectional Laminate- A reinforced polymer laminate in which substantially all of the fibers are oriented in the same direction.

Vinyl Ester- A polymerizable thermosetting resin containing vinyl and ester components, cured by additional polymerization initiated by free-radical generation. Vinyl esters are used as binders for fiber laminates and adhesives.

Viscosity- The property of resistance to flow exhibited within the body of a material, expressed in centipoises. A higher viscosity has higher resistance to flow.

Volatiles- Materials such as water and solvents in a resin formulation that are capable of being driven off as vapor.

Wet Lay-Up- A method of making a laminate system by applying the resin system as a liquid, when the fabric or mat is put in place.

Wet-Out- The process of coating or impregnating roving, yarn, or fabric in which all voids between the strands and filaments are filled with resin. It is also the condition at which this state is achieved.

Wetting Agent- A substance capable of lowering surface tension of liquids, facilitating the wetting of solid surfaces and permitting the penetration of liquids into the capillaries.

Witness Panel- A small FRP panel, manufactured on site under conditions similar to the actual construction. The panel may be later tested to determine mechanical and physical properties to confirm the expected properties for the full FRP structure.

## **2 RECOMMENDED REFERENCES**

The following standards or documents are referred to in these specifications:

### **2.1 ACI—American Concrete Institute**

- 116R-00: Cement and Concrete Terminology.
- 117-90: Specifications for Tolerances for Concrete Construction and Materials, and Commentary.
- 224.1R-93: Causes, Evaluation, and Repair of Cracks in Concrete Structures.

- 224R-01: Control of Cracking in Concrete Structures.
- 440R-96: State-of-the-Art Report on Fiber Reinforced Plastic Reinforcement for Concrete Structures.
- 440.2R-02: Guide for the Design and Construction of Extremely Bonded FRP Systems for Strengthening of Concrete Structures.
- 503R-93: Use of Epoxy Compounds with Concrete.
- 503.4-92: Standard Specifications for Repairing Concrete with Epoxy Mortars.
- 503.5R-92: Guide for the Use of Polymer Adhesives in Concrete.
- 503.6R-97: Guide for the Application of Epoxy and Latex Adhesives for Bonding Freshly.
- 546R-96: Concrete Repair Guide.

## **2.2 ASTM- American Society for Testing and Materials**

- D3039: Test Method for Tensile Properties of Polymer Matrix Composite Materials.
- D3418: Test Method for Transition Temperatures of Polymers by Differential Scanning Calorimetry.
- D4541: Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Tester.
- D5687: Guide for Preparation of Flat Composite Panels with Processing Guidelines for Specimen Preparation.

## **2.3 ICBO- International Conference of Building Officials**

- AC125: Acceptance Criteria for Concrete and Reinforced and Unreinforced Masonry Strengthening Using Fiber-Reinforced Polymer (FRP) Composite Systems.
- AC178: Acceptance Criteria for inspection and Verification of Concrete and Reinforced and Unreinforced Masonry Strengthening Using Fiber-Reinforced Polymer (FRP) Composite Systems.

## **2.4 ICRI- International Concrete Repair Institute**

- No. 03730: Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion.
- No. 03732: Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays.
- No. 03733: Guide for Selecting and Specifying Materials for Repairs of Concrete Surfaces.

## **2.5 NCHRP- National Cooperative Highway Research Program**

- Report 514: Bonded Repair and Retrofit of Concrete Structures Using FRP Composites (Recommended Construction Specifications and Process Control Manual).

## **3 SITE CONSIDERATIONS**

The Contractor shall provide necessary pathways; scaffoldings; and other means of access to the general project site and to the specific repair area for the personnel, equipment, and materials. All obstructions such as pipes, conduits, and wiring shall be removed at the expense of the Contractor, upon approval of the Engineer and after making records for subsequent reinstallation by the Contractor at the completion of the project. Plants, fences, and other obstructions that prevent access for repair shall be removed and, upon approval of

the Engineer, reinstalled or disposed of according to Section 5.4 at the expense of the Contractor.

#### **4 SUBMITTALS**

The Contractor shall submit the following documents for the Engineer's approval before starting the work.

##### **4.1 Work Drawings**

Work (shop) drawings shall include the type of FRP system, repair locations, relevant dimensions of the system and the work plan including the necessary preparations of the existing structure. The drawings must be accompanied by the design calculations, the MSDS, and the manufacturer's system data sheet identifying mechanical, physical, and chemical properties of all components of the FRP system; application guide, including the installation and maintenance procedures; and time schedule for various steps in the repair process. The installation procedure must clearly identify the environmental and substrate conditions that may affect the application and curing of the FRP system.

##### **4.2 Sample**

Finished, fully cured samples of the CFRP and GFRP repairs system on concrete substrate shall be provided by the Contractor. Three samples of the CFRP repair as it would be installed on the surface of substrate including the protective coating system.

##### **4.3 Quality Control/Quality Assurance Plan**

The Contractor shall be responsible for the quality control of all materials and processes in the project. The quality control and quality assurance (QC/QA) plan must be approved by the owner or its representative. It shall include specific procedures for personnel safety, tracking and inspection of all FRP components prior to installation, inspection of all prepared surfaces prior to FRP application, inspection of all completed work including necessary tests for approval, repair of any defective work, and clean-up. Any part of the work that fails to comply with the requirements of the contract documents shall be rejected by the Engineer and shall be remedied or removed and replaced by the Contractor at his own expense to be in full compliance with the contract documents.

###### **4.3.1 Site-Specific Health and Safety Plan.**

The manufacturer/supplier shall submit a Site-Specific Health and Safety plan (HASp) for acceptance by the Engineer.

##### **4.4 Qualifications**

The manufacturer/supplier must be prequalified by the owner or its representative for each of its FRP systems after providing the following necessary information:

- a. System data sheets and MSDS for all components of the FRP system.
- b. Large-scale laboratory test results of structural components identical to the proposed applications for this project.
- c. A minimum of 5 years of documented experience or 10 documented similar field applications with acceptable reference letters from respective owners.

- d. A comprehensive hands-on training program for each FRP system to qualify Contractors/applicators.

The Contractor/applicator must be prequalified by the owner or its representative for each FRP system after providing the following necessary information:

- a. A minimum of 3 years of documented experience or 10 documented similar field applications with acceptable reference letters from respective owners.
- b. A certificate of completed training from the manufacturer/supplier for at least one field representative who will be present onsite throughout the project.

## **5 STORAGE, HANDLING AND DISPOSAL**

### **5.1 Storage**

#### *5.1.1 Storage Requirements*

All components of the FRP system must be delivered and stored in the original factory-sealed, unopened packaging or in containers with proper labels identifying the manufacturer, brand name, system identification number, and date. Catalysts and initiators should be stored separately. All components must be protected from dust, moisture, chemicals, direct sunlight, physical damage, fire, and temperatures outside the range specified in the system data sheets. Any component that has been stored in a condition different from that stated above must be disposed of, as specified in Section 5.4.

#### *5.1.2 Shelf Life*

All components of the FRP system, especially resins and adhesives, that have been stored longer than the shelf life specified on the system data sheet shall not be used and must be disposed of, as specified in Section 5.4.

### **5.2 Handling**

All components of the FRP system, especially fiber sheets, must be handled with care according to the manufacturer recommendations to protect them from damage and to avoid misalignment or breakage of the fibers by pulling, separating, or wrinkling them or by folding the sheets. After cutting, sheets shall be either stacked dry with separators or at a radius no tighter than 12 in. or as recommended by the manufacturer.

#### *5.2.1 Safety Hazards*

All components of the FRP system, especially resins and adhesives, must be handled with care to avoid safety hazards, including but not limited to skin irritation and sensitization and breathing vapors and dusts. Mixing resins shall be monitored to avoid firming and inflammable vapors, fire hazards, or violent boiling. The Contractor is responsible for ensuring that all components of the FRP system at all stages of work conform to the local, state, and federal environmental and worker's safety laws and regulations. The Contractor is advised that a forced ventilator system may be required inside enclosed sections and that provision for ventilation, if any, shall be included in the cost of the work.

### 5.2.2 Material Safety Data Sheets

The MSDS for all components of the FRP system shall be accessible to all at the project site. Specific handling hazards and disposal instructions shall be specified in the MSDS 3.2.3.

*Personnel and Workplace Protection.* The Contractor is responsible for providing the proper means of protection for safety of the personnel and the workplace. The Contractor shall inform the personnel of the dangers of inhaling fumes of primer, putty, or resin and shall take all necessary precautions against injury to personnel. The resin mixing area shall be well vented to the outside.

### 5.3 Clean-Up

The Contractor is responsible for the cleanup of the equipment and the project site from hazardous and aesthetically undesirable FRP components using appropriate solvents, as recommended in the system data sheet.

### 5.4 Disposal

Any component of the FRP system that has exceeded its shelf life or pot life or has not been properly stored, as specified in Section 5.1, and any unused or excess material that is deemed waste shall be disposed of in a manner amiable to the protection of the environment and consistent with the MSDS.

## 6 MATERIALS

FRP reinforcement shall be carbon or glass fiber fabric and pre-cured carbon plates. The following suppliers have been approved for use on this project:

- QuakeWrap, Inc., PO Box 64757, Tucson, AZ 85728 - Phone: (866)QuakeWrap [782-5397] ([www.QuakeWrap.com](http://www.QuakeWrap.com))

These will be the only systems permitted, used in accordance with the manufacturer's recommendations, subject to the requirements of the plans and this specification.

Quality Control-Testing and Certification: Manufacturer shall certify that every batch or lot of material conforms to this specification and shall submit test results for every batch or lot of materials.

Labeling, packaging and storage shall include any health hazard warnings, precautions for handling and recommended first aid procedures in case of contact.

All materials used shall conform to this specification and other specifications referenced within and subject to the approval of the Engineer.

## 7 CONSTRUCTION METHODS

### 7.1 Substrate Repair and Surface Preparation

The concrete substrate shall be repaired, if necessary, and all concrete surfaces shall be cleaned and prepared prior to installing the FRP system.

### 7.1.1 Removal of Defective Concrete

All defective areas of concrete substrate shall be removed according to ACI 546R-96 and ICRI No. 03730, using appropriate equipment such as an air- or electric-powered jack hammer or saw, at a sufficient depth of at least ½ in. beyond the repair area in exposed sound aggregates. If any reinforcing or prestressing steel is exposed in the process and either it is deteriorated or its bond with the concrete is broken in the process, an additional nominal depth of ¾ in. or at least ¼ in. larger than the largest aggregate in repair material shall be cut from its underneath. If any deterioration is noticed in the repair area, its source shall be located and treated to the satisfaction of the Engineer prior to restoring the section. Upon removing defective concrete, and before restoring the section, the substrate shall be cleaned from any dust, laitance, grease, oil, curing compounds, impregnations, foreign particles, wax, and other bond-inhibiting materials, as per Section 7.1.9.

### 7.1.2 Repair of Defective Reinforcement

All defective reinforcements shall be repaired according to ICRI No. 03730 and to the satisfaction of the Engineer. FRP systems shall not be applied to concrete suspected of containing corroded reinforcement. Corroded or otherwise defective reinforcement that is to be supplemented shall be cleaned to a near white appearance. Damaged reinforcement that needs to be replaced shall be cut at sufficient length, according to the contract documents and the approval of the Engineer, to ensure full section and sound material in the remaining portion. Splice for the ruptured or cut reinforcing or prestressing steel shall be provided at sufficient length, according to the contract documents and approval of the Engineer.

Mechanical Anchorage- Mechanical anchorage of the repair material shall not be used nor shall any system that requires drilling into the existing concrete substrate.

### 7.1.3 Restoration of Concrete Cross Section

The area of removed concrete substrate, and any void larger than ½ in. in diameter and depth, shall be filled with repair material that conforms to ICRI No. 03733. The repair material shall have a compressive strength equal to or greater than that of the original concrete, but no less than 4,500 and 5,500 psi at 7 and 28 days, respectively. The design mix for all repair materials shall be approved by the Engineer. The bond strength of the repair material to the existing concrete shall be a minimum of 200 psi in the pull-off test according to ASTM D-4541. The concrete substrate and the exposed reinforcing or prestressing steel shall be clean, sound, and free of surface moisture and frost before restoring the section. Before placement of patching materials, a water-based epoxy cementitious bonding agent shall be applied to concrete and exposed reinforcement. Also, cracks within solid concrete in the substrate shall be stabilized using epoxy injection methods, as specified in Section 7.1.9. If the water leak through cracks or concrete joints is significant, water protection and a water conveyance and weep holes shall be provided before restoring the section. The repair material shall be cured a minimum of 7 days before installing the FRP system unless its curing and strength are verified by tests.

### 7.1.4 Surface Preparation

All necessary repair and restoration of a concrete section shall be approved by the Engineer prior to surface preparation. In these specifications, contact-critical applications are treated in the same way as bond-critical applications. An adhesive bond with adequate strength shall always be



provided between FRP and concrete. Surface preparation shall also promote continuous intimate contact between FRP and concrete by providing a clean, smooth, and flat or convex surface. Surface preparation for FRP shell systems where grout is pumped into the gap between the shell and the existing column surface is specified in Section 7.1.9. All surface preparations shall be approved by the Engineer before installing the FRP system.

#### *7.1.5 Surface Grinding*

All irregularities, unevenness, and sharp protrusions in the surface profile shall be ground away to a smooth surface with less than 1/32 in. deviation. Disk grinders or other similar devices shall be used to remove stain, paint, or any other surface substance that may affect the bond. Voids or depressions with diameters larger than 1 ½ in. or depths greater than 1/8 in., when measured from a 12-in. straight edge placed on the surface, shall be filled according to Section 7.1.8.

#### *7.1.6 Chamfering Corners*

All inside and outside corners and sharp edges shall be rounded or chamfered to a minimum radius of 10 in. Ridges, form lines, and sharp or roughened edges greater than ¼ in. shall need to be ground down or filled with putty, as specified in Section 7.1.8. Obstructions and embedded objects shall be removed before installing the FRP system if required by the Engineer.

#### *7.1.7 Crack Injection*

All interior cracks in the surface of concrete or the substrate that are wider than 0.010 in. and all exterior cracks wider than 0.006 in. shall be filled using pressure injection of epoxy according to ACI 224R and 224.1R. The FRP system shall be installed no earlier than 24 hours after crack injection. Any surface roughness caused by injection shall be removed as per Section 7.1.5. The Limit of crack injection shall be as indicated on the plans.

#### *7.1.8 Surface Profiling*

After surface grinding, any remaining unevenness in the surface greater than that specified in Section 7.1.7, including out-of-plane variations, fins, protrusions, bug holes, depression voids, and roughened corners, shall be filled and smoothed over by using putty made of epoxy resin mortar or polymer cement mortar with strength equal to or greater than the strength of the original concrete.

#### *7.1.9 Surface Cleaning*

Substrate concrete and finished surface of concrete shall be cleaned to the approval of the Engineer. Cleaning shall remove any dust, laitance, grease, oil, curing compounds, wax, impregnations, stains, paint coatings, surface lubricants, foreign particles, weathered layers, or any other bond-inhibiting material. If power wash is used, the surface shall be allowed to dry thoroughly before installing the FRP system. The cleaned surface shall be protected against redeposit of any bond-inhibiting materials. Newly repaired or patched surfaces that have not cured a minimum of 7 days shall be coated with a water-based epoxy paint or other approved sealers.

## **7.2 Installation of CFRP System**

This section specifies general installation procedures for the wet lay-up CFRP and GFRP systems.

### *7.2.1 Environmental Conditions*

Environmental conditions for installation shall be examined before and during installation of the FRP system to ensure conformity to the contract documents and manufacturer's recommendations. Do not apply primers, putty, saturating resins, or adhesives on cold, frozen, damp, or wet surfaces. Ambient and concrete surface temperatures shall be within 50-95 degrees F. Moisture level on all contact surfaces shall be less than 10 percent at the time of installation of the FRP system, as evaluated according to ACI 503R-93. Moisture restrictions may be waived for resins that have been formulated for wet applications.

### *7.2.2 Moisture Vapor Transmission*

Application of bonded FRP systems shall not proceed if any moisture vapor transmission is present. Concrete dryness is necessary when using elevated temperature cure. Any bubble that develops from moisture vapor transmission can effectively be injected with the same adhesive material used for the FRP system following the procedure specified in Section 9.2.

### *7.2.3 Applications in Inclement Weather*

When inclement weather does not allow installation of the FRP system, as specified in Section 7.2.1, auxiliary measures may be employed to correct the conditions. An auxiliary heat source may be used in cold weather to raise the ambient and concrete surface temperatures to acceptable levels, as recommended by the manufacturer, but not higher than the glass transition temperature (T<sub>g</sub>). Pressurized air may be used to dry the surface dampness.

## **7.3 Equipment**

The Contractor shall provide all necessary equipment in sufficient quantities and in clean operating conditions for continuous uninterrupted FRP installation.

## **7.4 Applications of Wet Lay-Up CFRP or GFRP Systems**

This section specifies the necessary measures for installing wet lay-up systems using dry fiber sheets and saturants.

### *7.4.1 Mixing of Resin Components*

All resin components, including the main agent and hardener, shall be mixed at the proper temperature using the appropriate weight ratio and for a duration specified by the manufacturer until thorough mixing with uniform color and consistency is achieved. Resins shall not be diluted with any organic solvents such as thinner. Manual stirring and small electrically powered mixing blades are allowed. Resin shall be mixed in quantities sufficiently small to ensure that it can be used within its pot life. Any mixed resin that exceeds its pot life or begins to generate heat or show signs of increased viscosity shall not be used and shall be disposed of according to Section 5.4. Mixing of some resins may be accompanied by noxious fumes. Precautions must be taken, as specified in Section 5.2.1, regarding the resin's impact on the environment, including emission of volatile organic compounds and toxicology.

### *7.4.2 Primer and Putty*

When necessary, apply one or two coats of primer on the concrete surface to penetrate its open pores. Ambient and concrete surface temperatures must be within the range specified in Section

7.2.1. The putty shall be applied as soon as the primer becomes tack free or is not sticky to the fingers. The putty shall be applied within 7 days after primer application; otherwise, the primer-coated surface shall be roughened with sandpaper or a similar tool. The resulting surface shall be cleaned according to Section 7.1.9. before applying the putty. Apply 40-mil thick coat of putty in one layer, and smooth over the surface to fill in any small voids, cracks, or uneven areas. Any swelling on the surface after applying the putty shall be corrected to meet surface profile as specified in Section 7.1.8. The surfaces of primer and putty shall be protected from dust, moisture, and any other contaminants before applying the FRP.

#### 7.4.3 *Saturant*

The saturant shall have sufficiently low viscosity to ensure full impregnation of the fiber sheets prior to curing. To maintain proper viscosity of the saturant, the ambient and concrete surface temperatures must be within the range specified in Section 7.2.1. Any mixed saturant that exceeds its pot life shall be disposed of according to Section 5.4.

#### 7.4.4 *Applying Fiber Sheet and Saturant*

The fabric will be uniformly saturated with the saturant using the Saturating Machine. The fabric will be cut to the length specified in the contract documents and shall be installed in place and gently pressed onto the wet putty. Any entrapped air between the fiber sheet and the concrete surface shall be released or rolled across the sheet in the direction parallel to the fibers while allowing the resin to impregnate the fibers and achieve intimate contact with the substrate. Rolling perpendicular to the fiber direction is not allowed. In bi-directional fabrics, rolling shall be initially in the fill direction end to end and then in the warp direction. Subsequent layers of fabric (if called for in the design) shall be properly saturated with saturant and applied on top of the first sheet of fabric with no interruption.

#### 7.4.5 *Multiple-Fiber Plies*

In multiple-ply installations, subsequent layers of fabric (if called for in the design) shall be properly saturated with saturant and applied on top of the first sheet of fabric with no interruption. The amount of resin overcoat for intermediate plies is approximately 15-20 percent greater than a single-ply installation because the saturant serves as overcoat for the applied ply and undercoat for the next ply. Follow the contract documents for the fiber orientation and ply stacking sequence. Each ply shall be applied before the onset of complete gelation of the previous layer. The number of plies that can be applied in a single day shall be based on the manufacturer's recommendation and the approval of the Engineer. Multiple plies can also be applied in several days. When previous layers are cured, interlayer surface preparation, such as light sanding and filling with putty, may be required, as specified in Section 7.4.2.

#### 7.4.6 *Overlapping*

A lap joint shall be constructed when an interruption occurs in the direction of the fibers. The length of the lap splice shall be as specified by the contract documents, but must be at least 12 in. Staggering of lap splices on multiple plies and adjacent strips shall be required unless permitted by contract documents. No lap joint is necessary in the transverse direction unless specified in the contract documents.

#### 7.4.7 Alignment of FRP Materials

The fiber plies shall be aligned on the structural member according to the contract documents. Any deviation in the alignment more than 5 degrees (approximately 1 in./ft) is not acceptable, as specified in Section 8.3. Once installed, the fibers shall be free of kinks, folds, and waviness.

### 7.5 Application of Pre-Cured Carbon Strips

Surface preparation for installation of pre-cured carbon strips, such as QuakeWrap™ DU50C, shall follow the same procedure outlined in Sections 7.1 and 7.2. The bonding surface of the carbon plate shall be cleaned by wiping the plate with clean cloth and solvent. Allow the cleaned plates to dry in air and prevent them from contamination. Apply a 30-mil thick layer of putty directly onto the concrete surface where it is to receive the carbon plate. Apply a 30-mil thick layer of putty on one side of the carbon plate and spread it to a uniform thickness. Affix the plate to the concrete, starting from one end and gradually progressing towards the other end, pressing the carbon plate in position. Apply uniform pressure on the top surface of the plate from one end to the other to remove any air bubbles getting trapped under the plate.

### 7.6 Curing

The FRP system shall be allowed to cure for seventy two (72) hours before full loads are applied. Field modification of resin chemistry for rapid curing is not allowed. Elevated cure temperature may be used, as specified in Section 7.2.3, if rapid curing is necessary. Cure of installed plies shall be monitored before placing subsequent plies. In case of any curing irregularity, installation of subsequent plies shall be halted. Unless otherwise noted in the contract documents and approved by the Engineer, the full load shall not be applied until curing is complete. Protect the FRP system while curing, as specified in Section 7.8.

### 7.7 Protective Coating and Finishing

The protective coating system shall be applied only to the FRP repair material installed on the exterior surface of the webs.

#### 7.7.1 Protective Coating and Finishing

When required, the coating shall be a non-vapor-barrier, flexible, waterproof, U-V-resistant and compatible with the FRP system. The coating may be a polymer-modified Portland cement coating or polymer-based latex coating. The mortar finish shall be made with silicate sand between sieves No. 40 (1/64 in.) and No. 6 (1/8 in.) and spread over the FRP system before the resin hardens. Appropriate methods shall be used for vertical or overhead work. The thickness of the coating shall be specified per the coating manufacturer's instructions. Final appearance is closely match the color and texture of the adjacent concrete. For each protective coating system submitted by the Contractor, he shall supply three (3) samples of the FRP material finished as it will be installed in the field and coated with the recommended coating system for acceptance by the Engineer. The samples shall be approved by the Engineer prior to the start of repairs.

#### 7.7.2 Protective Coating Field Application

Surface preparation shall be as recommended by the manufacturer. Solvent wipes shall not be used to clean the FRP surface unless approved by the FRP manufacturer. If abrasive cleaning is necessary, air pressure shall be limited to avoid any damage to fibers. Ambient and surface temperatures shall be within the range specified in Section 7.2.1, prior to applying the protective

coating. Do not apply the coating when surface moisture is present or when rainfall or condensation is anticipated.

### 7.7.3 Temporary Protection

Temporary protection shall be installed on the exterior web surface to protect the installed FRP system against rain, dust, dirt, excessive sunlight, extreme temperatures and high humidity until the resin has fully cured, as approved by the Engineer

## 8 INSPECTION AND QUALITY ASSURANCE

A specific QA plan shall be developed from the tests identified in this section. All inspection and tests in this section will be performed by a trained inspector acting on behalf of the Department for QA of the project in the presence of the Contractor and the Engineer. The Contractor may have its own inspector for QC.

### 8.1 Inspection of Materials

The manufacturer's certifications for all delivered and stored FRP components will be inspected for conformity to the contract documents before starting the project. Materials testing will be conducted on samples of pre-cured FRP or witness panels of wet lay-ups, if specified in the contract documents. Any material that does not meet the requirements of the contract documents will be rejected. Additional witness panels may be taken during the installation process if specified in the contract documents.

### 8.2 Daily Inspection

Daily inspection will include date and time of repair; ambient and concrete surface temperatures; relative humidity; general weather conditions; surface dryness per ACI 503.4; surface preparation and surface profile using ICRI surface profile chips; qualitative description of surface cleanliness; type of auxiliary heat source, if any; widths of cracks not injected with epoxy; fiber or procured laminate batch numbers and their locations in the structure; batch numbers, mixture ratios, mixing times, and qualitative descriptions of the appearance of all mixed resins, primers, putties, saturants, adhesives, and coatings; observations of the progress of the cure of resins; conformance with installation procedures; adhesion test results of bond strength, failure mode, and location; FRP properties from tests of field sample panels or witness panels, if required; location and size of any delaminations or air voids; and the general progress of work.

### 8.3 Inspection for Fiber Orientation

Fiber or ply orientation, fiber kinks, and waviness will be examined by visual inspection for conformity to the contract documents. Tolerances will follow Installation of CFRP System (7.4.7). Nonconforming FRP area will be removed and required as per Repair of Defective Work (9.4).

### 8.4 Inspection for Debonding

After at least 24 hours for the initial curing of the resin, a visual inspection of the surface will be performed for any swelling, bubbles, voids, or delaminations. If an air pocket is suspected, an acoustic tap test will be carried out with a hard object to identify delaminated areas by sound, with at least one strike per 1 ft<sup>2</sup>. Defects smaller than ¼ in. in diameter will require no corrective

action, unless as specified in Section 9.2. Defects larger than ¼ in. but smaller than 1 ¼ in. in diameter will be repaired as per Section 9.2. Defects larger than 1 ¼ in. but smaller than 6 in. in diameter, and with a frequency of less than 5 per any unit surface area of 10-ft length or width, will be repaired as per Section 9.3. Larger defects will be repaired as per Section 9.4.

### **8.5 Inspection for Cure of Resin**

If specified in the contract documents, the relative cure of resin in FRP systems will be examined by visual inspection or by laboratory testing of witness panels or resin-cup samples using ASTM D3418. Follow recommendations of the resin manufacturer for acceptance criteria. If the cure of resin is found unacceptable, the entire area will be marked and repaired as per Section 9.4.

### **8.6 Inspection for Adhesion**

After at least 24 hours for the initial cure of the resin and before applying the protective coating, a direct pull-off test will be performed following ASTM D4541 to verify tensile bond between the FRP system and the concrete. Test locations and sampling frequency are as specified in the contract documents or as recommended by the Contractor and approved by the Engineer. At a minimum, three pull-off tests with at least one test per span or one test per 1,000 ft<sup>2</sup> of the FRP system, and one test per substrate concrete type, will be performed. Inspect the failure surface of the core specimen to ensure that the failure surface is by cohesive failure within concrete. Failure at the bond line at tensile stresses below 200 psi is unacceptable. If one or more of the pull-off tests is found unacceptable, the work will be rejected and repair will follow Section 9.4. Repair cored areas as per Section 9.3.

### **8.7 Inspection for Cured Thickness**

Core samples ½-in. diameter will be taken to inspect the cured laminate thickness and the number of plies. Sampling frequency will be as specified in the contract documents. Repair cored areas as per Section 9.3. The FRP system will not be accessible if the number of plies is less than that specified in the contract documents or if the cured thickness of the FRP system is less than that specified in the contract documents by more than 1/32 in. The entire area of the FRP system that is marked unacceptable will be repaired as per Section 9.4.

### **8.8 Tests**

Tests on witness panels will be carried out. The most common is the tensile test following ASTM D 3039 on at least five witness panels for each type of FRP system to measure strength, elastic modulus, and ultimate strain. The measured thickness of the FRP laminate will also be recorded. The FRP system will be unacceptable if the average tensile strength and the lowest tensile strength are more than 5% and 10% below that specified in the contract documents, respectively.

## **9 REPAIR OF DEFECTIVE WORK**

This section specifies the conditions and types of defects that require repair and the acceptable methods of repair. Defects are of different types and may be generally classified as aesthetic, short-term critical, or long-term critical. Repair procedure depends on the type, size, and extent of defects. Repair procedures for any conditions not addressed in these specifications or in the contract documents shall be submitted by the Contractor and approved by the Engineer prior to proceeding with the work.

### **9.1 Repair of Protective Coating**

Defects in protective coating can be of three types: small hairline cracks, blistering, and peeling. In all cases, moisture content of the substrate should be below 0.05% before applying a new coating. Prior to any repair of protective coating, the FRP system shall be examined visually or otherwise to ensure that no defect exists within or on the surface of the FRP. Defects in FRP, if found, shall be repaired as per Section 9.3 & 9.4. If protective coating appears to show small areas with cracks, the local surface shall be lightly sanded. Then, a new coating with appropriate primer shall be applied according to the manufacturer's recommendations. At the minimum, the coating shall be applied over an area extending 1 in. on either side of the defect. If the protective coating shows signs of blistering, the entire area of blisters as well as the surrounding area to a distance of at least 12 in. shall be carefully scraped clean. In no case should a blistered surface be recoated without complete removal of the existing coating. The area shall be wiped clean and then dried thoroughly. Once dry, the area can be recoated after application of the primer coat if required by the manufacturer. If the surface shows signs of excessive peeling, the entire coating shall be scraped off and the surface lightly sanded, wiped clean, and thoroughly dried before applying a new coat according to the manufacturer's recommendations.

### **9.2 Epoxy Injection of Small Defects**

Small entrapped voids or surface discontinuities no larger than ¼ in. in diameter shall not be considered defects and require no corrective action unless they occur next to edges or when there are more than five such defects in an area of 10 ft<sup>2</sup>. Small defects of size between ¼ and 1 ¼ in. in diameter shall be repaired using low-pressure epoxy injection as long as the defect is local and does not extend through the complete thickness of the laminate in case of multiple-ply FRP systems. If any delaminations growth is suspected between the FRP plies due to injection, the procedure shall be halted, and repair shall follow Section 9.3.

### **9.3 Patching of Minor Damage**

Minor defects are those with diameters between 1 ¼ and 6 in. and a frequency of less than five per any unit surface area of 10-ft length or width. The area surrounding the defects to an extent of at least 1 in. on all sides shall be carefully removed. The area shall be wiped clean and thoroughly dried. The area shall then be patched by adding an FRP patch of the same type as original laminate and extending at least 1 in. on all sides of the removed area. Repair can also be conducted using the procedure in Section 9.4.

### **9.4 Replacement of Large Defects**

Defects larger than 6 in. in diameter shall be carefully marked and scarfed out extending to a minimum of 1 in. on all sides. Scarfing shall be progressing through the layers in the case of multiple-ply FRP systems until past the defective area. In case the defect extends to the first FRP ply adjacent to the concrete, the entire thickness of the FRP and primer shall be removed. The substrate shall be approximately prepared and primer reapplied after ensuring that the surface and FRP are clean and dry. Application of a new FRP system within the scarfed area shall follow procedures for the original FRP system, except that an additional layer extending a minimum of 6 in. on all sides of the scarfed area shall be added as a patch. Once cured, the protective coating shall be applied over the entire area.

## **10 METHOD OF MEASUREMENT**

Carbon Fiber Reinforced Polymer (CFRP) and Glass Fiber Reinforced Polymer (GFRP) shall be measured for payment by square feet measured in place in accordance with the Plans and/or as directed by the Engineer. Pre-Cured Carbon Strips shall be measured for payment by linear feet measured in place. In both cases, surface preparation of substrates shall be included in the price.

Built-up Corner with Thickened Epoxy shall be measured for payment by the cubic foot measured in place in accordance with Plans and/or as directed by the Engineer.

## **11 BASIS OF PAYMENT**

Payment for Carbon Fiber Reinforced Polymer (CFRP) and Glass Fiber Reinforced Polymer (GFRP) shall be made at the Contract Unit Price per square foot as designated in the Proposal. Payment for Built-up Corner with Thickened Epoxy shall be made at the Contract Unit Price per Cubic Foot as designated in the Proposal. The prices so stated shall constitute full compensation for surface preparation, all tools, tests, labor, materials, equipment, staging, scaffolds, and any other incidentals necessary for proper completion of the work specified, show on the plans, or as directed by the Engineer, complete and accepted.





The FRP Retrofit Experts

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## SATURATOR MACHINE

The saturator machine shown to the right is available on a rental basis for projects where large quantities of fabric need to be impregnated (saturated) with resin.

The advantages of the saturator equipment are as follows:

- The speed of construction is significantly improved;
- The fabric is uniformly saturated with the same amount of resin, producing uniform fabric/resin content ratio;
- The ratio of the resin to fabric (i.e. resin content) can be controlled and set at a constant rate for each job;
- The design of the equipment is such that it forces the resin into the fabric, ensuring full saturation;
- There will be no excess resin on the saturated fabric that would result in dripping and non-uniform finish;
- The equipment is shipped in a container on casters and can be easily assembled in the field.

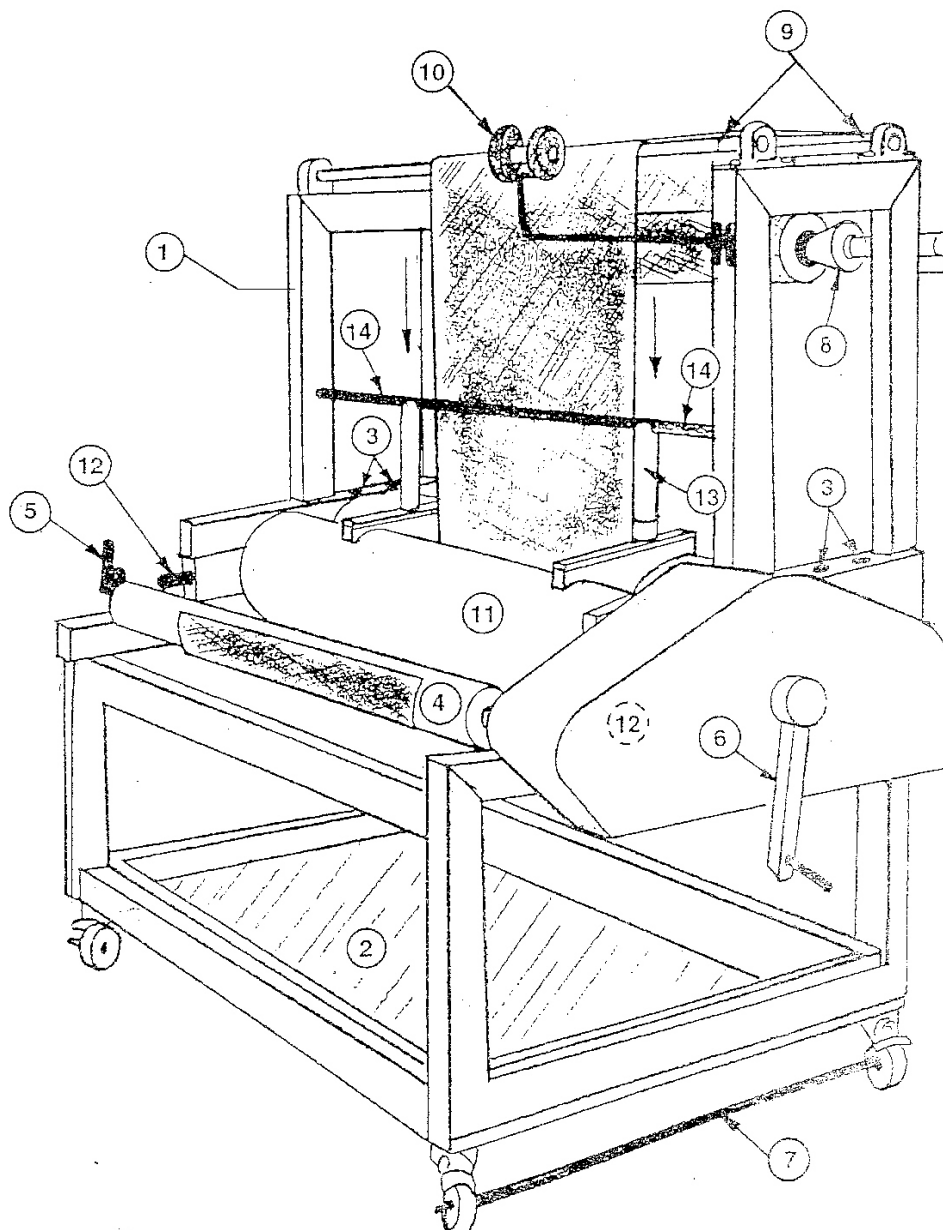


In the following pages, the instructions for assembly and operation as well as how to set the adjustment for the desired level of resin content are provided.

## INSTRUCTIONS FOR ASSEMBLY AND OPERATION OF SATURATOR MACHINE

### ASSEMBLY:

1. Remove the top portion of the frame [1] which during shipment is placed in the drip-tray [2].
2. Place the top portion of the frame [1] as shown and line up and tighten the four bolts [3].
3. Insert the end of the take-up reel [4] onto the fittings and engage the pin [5] to secure the take-up reel.
4. Insert and secure the lever [6] with the provided bolt.
5. The above steps can be followed in reverse order to disassemble the machine. In addition, to keep the wheels straight, the two bars [7] must be attached as shown before placing the machine in the container.



## OPERATION:

1. Place the fabric roll onto the feed reel and engage the cones [8] to secure the fabric. Note that the cones must be placed in a loose position to allow rotation of the fabric roll.
2. Pass the fabric over the two rollers [9] and under the counter [10] in through the gap between the two main cylinders [11]. Turn the lever [6] to pull the fabric in between the two main cylinders. Adjust the gap between the two main cylinders [11] using the two turn-screws [12] on both ends of the machine so that the fabric cannot freely slide between the two main cylinders.
3. Place a plastic sheet or tarp above the drip-tray [2] to catch spilled epoxy.
4. Place the Teflon dams [13] on both ends of the fabric by squeezing the spring-loaded bars attached to the Teflon dams and anchoring them under the center bar [14]. This will prevent the unnecessary spread of the epoxy. Note that the dam faces in the right direction so that its bottom surface is in full contact with both cylinders.
5. Pour the epoxy in the trough between the two main cylinders [11] and turn the lever [6] to pull the fabric in between the two main cylinders.
6. Grab the end of the fabric and wrap it around the take-up reel [4]. If the fabric end is not fully saturated, add a small amount of epoxy to it to help it grip the take-up reel.
7. Turn the lever [6] until the fabric is fully wrapped around the take-up reel [4].
8. If necessary, adjust the gap between the two main cylinders [11] using the two turn-screws [12] to achieve full fabric saturation without excessive epoxy on the fabric.
9. Turn the lever [6] until the desired length of fabric is saturated. Note: you can measure the length of the fabric that has been saturated with the counter [10].
10. Cut the fabric with a pair of scissors.
11. Remove the take-up reel [4] with the saturated fabric wrapped around it and carry it to the job site where the fabric can be unrolled.

### IMPORTANT NOTE:

***It is very important that the excess epoxy does not remain on any part of the machine for more than half an hour. It would be extremely difficult to remove the cured epoxy from the machine. If the machine is to be idle for periods more than half an hour, it should be completely cleaned before any epoxy can harden on the machine. The cleaning can be accomplished by applying generous amount of acetone and wiping with a rag. If at anytime you notice accumulation of old epoxy (more than half an hour old), the epoxy must be removed and the affected part of the machine cleaned before the continuation of the operation. In addition, common sense must be used at all times to make sure that the machine will remain clean and operational.***

## PROCEDURE FOR SETTING THE GAP SIZE

The size of the gap between the two main cylinders [11] directly affects the resin content of the saturated fabric. In order to achieve a resin content of 50% by volume, the following procedure should be carried out.

1. Start with a gap size approximately equal to the thickness of the dry fabric.
2. Select a piece of a fabric approximately 1-foot wide by 3-foot long and measure its dry weight in grams.
3. Saturate the fabric by running it through the saturator machine.
4. Measure the weight of the saturated fabric in grams. A small portable scale covered with a thin sheet of protective plastic can be used for this purpose.
5. Subtract the weight of the dry fabric from that of the saturated fabric. The result will be the weight of the resin in the composite.
6. Divide weight of dry fabric by 1.80; call this number  $V_F$
7. Divide weight of resin by 1.13; call this number  $V_R$
8. The objective is to get these two values (i.e.  $V_F$  and  $V_R$ ) as close as possible.
9. Take the difference between these two numbers and divide it by the sum of the two numbers. Multiply the result by 100 to obtain the percentage error. The percentage error should be less than 5. If not, continue with the following step.
10. If  $V_F$  is greater than  $V_R$ , increase the size of the gap. Otherwise, reduce the gap size and repeat the above steps 1 through 9 until the percentage error is less than 5.