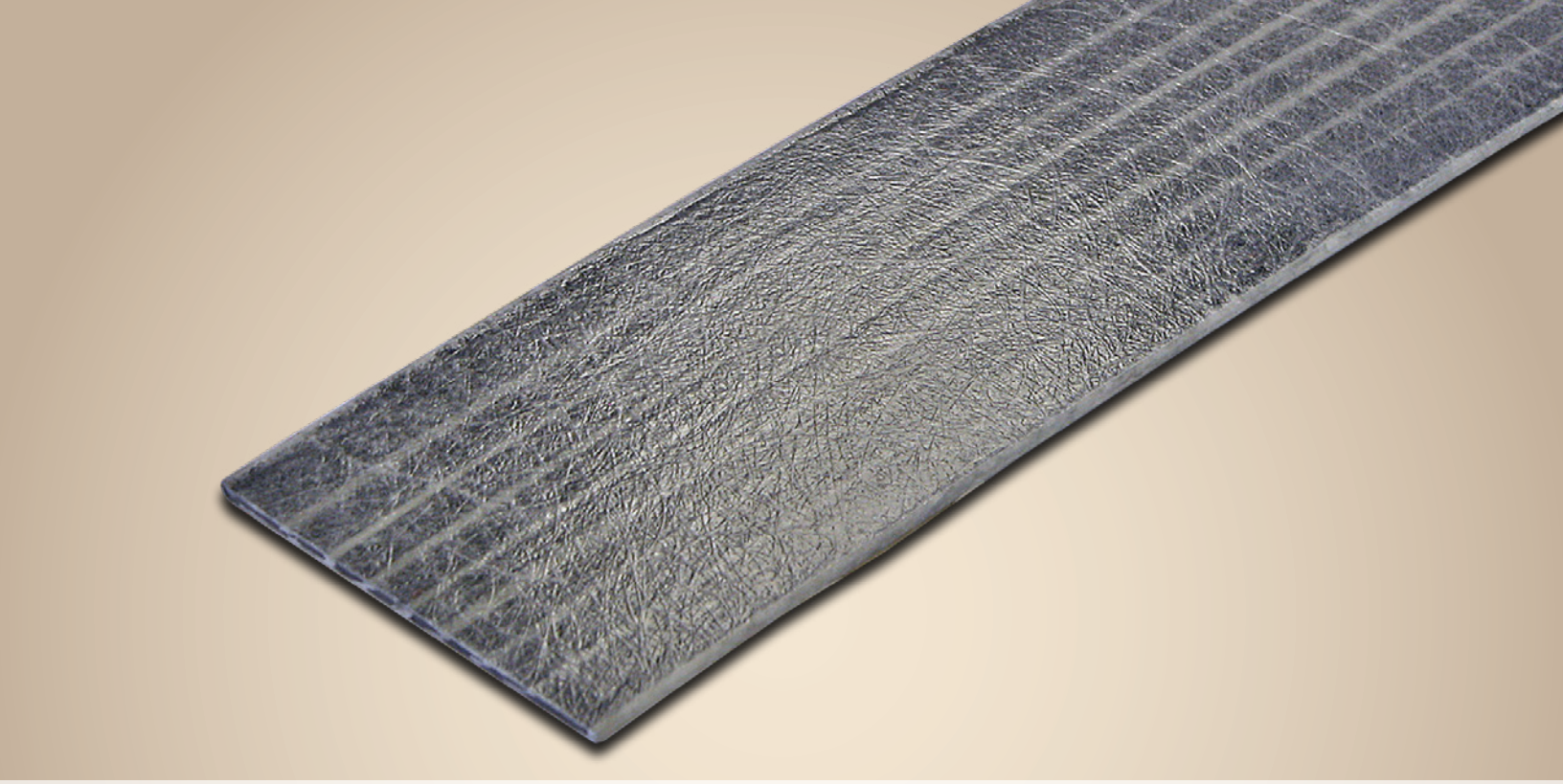


STRONGWELL®

EXCLUSIVELY MADE IN THE USA

SAFSTRIP®

FIBER REINFORCED STRENGTHENING STRIP

SAFSTRIP® is a pultruded composite strip that improves the strength of an existing structural member when mechanically fastened to the structure. SAFSTRIP® has high bearing and longitudinal properties and is designed to strengthen the flexural capacity on the tension face of concrete girders, slabs, and decks. Installation on bridges can occur without any interruption of service.

SAFSTRIP® is supplied in rolls and may be pre-drilled with holes at the required fastener spacing to receive fasteners. SAFSTRIP® measures 4" wide x 1/8" thick and is shipped in rolls up to 100 ft. long. SAFSTRIP® is designed to be easily field cut by the customer into shorter lengths using standard carpenter tools.

SAFSTRIP® provides these features:

- Easy to install, no skilled labor necessary
- Minimal surface preparation is needed for installation
- Structure is usable immediately after installation
- Cost effective system for increasing load capacity of bridges
- Will not split or delaminate when drilled

FIBER REINFORCED STRENGTHENING STRIP

Workers installed SAFSTRIP® on this bridge in Edgerton, Wisconsin, using the MF-FRP system. The load rating for the bridge increased from HS-17 to HS-25 as a result.

The posted load for this bridge that spans the Meramec River in Missouri was increased from 10 tons to 18 tons by installing SAFSTRIP® using the MF-FRP system.

The abutment and deck of this bridge in Phelps County, Missouri, was strengthened using SAFSTRIP®. As a result, the existing 12-ton load posting was removed.

Materials of Construction

SAFSTRIP® is composed of carbon tows sandwiched between layers of fiberglass mats and rovings. The materials are bonded together by a highly corrosion resistant vinyl ester resin. Carbon fibers increase the stiffness of the strip while glass mat provides the proper bearing strength. These combined properties allow SAFSTRIP® to be mechanically attached to a structural member. A synthetic surfacing veil is also incorporated into the composite to improve resistance to corrosion and UV degradation.

What is MF-FRP?

SAFSTRIP® is designed to be installed using an attachment method known as mechanically-fastened fiber reinforced polymer (MF-FRP). Using this method, SAFSTRIP® is attached to an existing concrete girder, slab, or deck using closely spaced powder actuated fastening pins or steel expansion anchors. The pins are applied by using a powder actuated fastener gun or other portable fastener gun. Expansion anchors are installed with a pneumatic powered torque wrench. If desired, rubber or neoprene washers may be used between the fasteners and the strip prior to inserting the fastener through the strip.

MF-FRP is an alternative to externally bonded fiber reinforced polymer (EB-FRP). As opposed to the MF-FRP system, in which the load is transferred to the composite strip through a fastener, the EB-FRP system uses an adhesive.

Research and Development

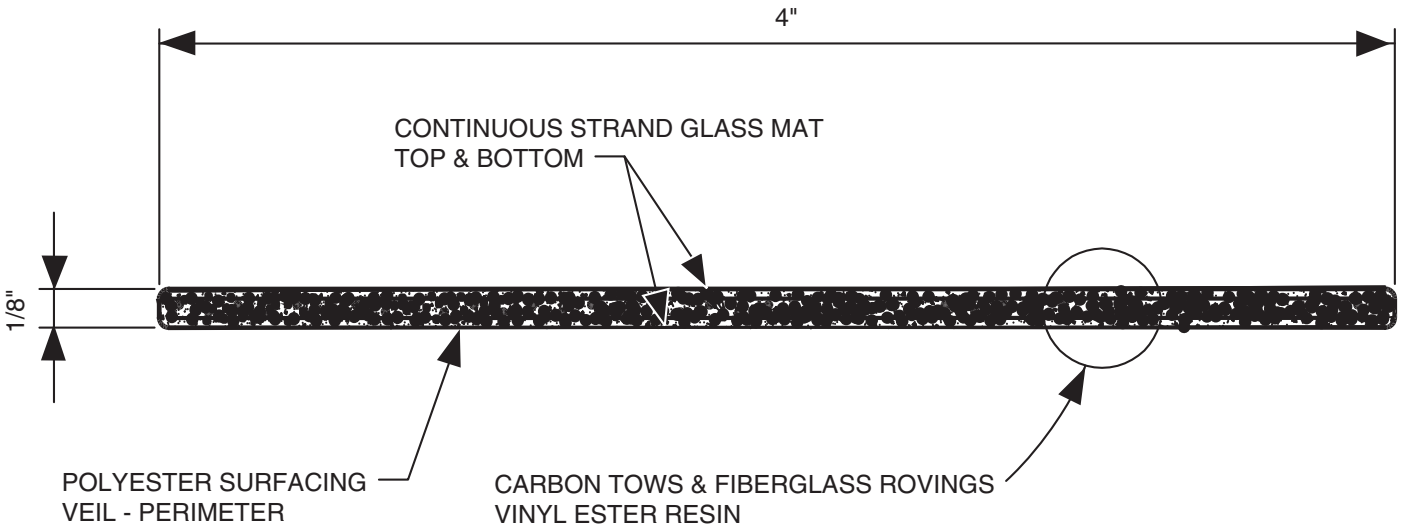
Research and development for SAFSTRIP® was funded by the U.S. Army Engineer Research and Development Center (ERDC). Laboratory research was conducted at the University of Wisconsin Structures and Materials Testing Laboratory and at ERDC's test laboratories. Bridge demonstration projects were conducted in Wisconsin and Missouri.

Engineering Design

The repair of concrete structures using SAFSTRIP® is dependent upon the concrete's condition. The local engineer must determine the strength of the existing concrete. It must then be determined how much SAFSTRIP® is required and the spacing of fasteners.

Design of MF-FRP systems follows the methodology of *ACI PRC-440.2: Design and Construction of Externally Bonded Fiber-Reinforced Polymer (FRP) Systems for Strengthening Concrete Structures*. Design assistance can be obtained by contacting Strongwell – Chatfield Location.

MECHANICAL PROPERTIES



Property	ASTM Test Method	Average Value[1] psi (MPa)	Design Value[2] psi (MPa)
Tensile Strength*	D-638	123,613 (852)	92,902 (640)
Tensile Modulus*[3]	D-638	9.02 x 10^6 (62,190)	9.02 x 10^6 (62,190)
Clamped Bearing Strength*	D-5961	50,955 (351)	40,540 (279)
Unclamped Bearing Strength**	D-5961	31,044 (214)	26,046 (180)
Open Hole Strength*	D-5766	94,641 (652)	78,846 (543)

* 20 Sample coupons per test series
** 17 Sample coupons per test series
[1] Average value of test series
[2] Average value minus three standard deviations
[3] Modulus design values are not reduced in accordance with ACI 440.2R-17

This underground parking garage for an apartment complex in Ontario, Canada, recently underwent a concrete support renovation. To provide the necessary improvements, SAFSTRIP® was installed with a small team and minimal onsite equipment.

This bridge, located in St. James, Missouri, was load posted at the time of strengthening. After mechanically attaching SAFSTRIP® with concrete wedge bolts and anchors, the bridge load limit was raised to 20 tons.

Severe deterioration prevented the application of a bonded strengthening system to this bridge in Pulaski County, Missouri, but MF-FRP applied SAFSTRIP® was able to repair the bridge.

	MF-FRP INSTALLATION	EB-FRP INSTALLATION
FASTENING SYSTEM	Mechanical - concrete wedge bolts and anchors or powder actuated fasteners.	Adhesive - usually epoxy.
SURFACE PREPARATION	Minimal	Requires the time consuming process of sandblasting, cleaning, and application of epoxy putty that must be ground down for a smooth surface.
WEATHER CONDITIONS FOR APPLICATION	No restrictions. Can be installed even during inclement weather.	Application surface must be moisture-free. Cannot be properly installed in extreme temperatures.
INSTALLATION TIME	Minimal - generally a few hours	Extensive due to the surface preparation, mixing of adhesives, and care required to properly apply the adhesive.
LABOR COSTS	Unskilled labor using standard carpenter tools for cutting and installing strips reduces labor costs.	Skilled labor required to properly prepare the surface and mix the adhesives, which results in higher labor costs.
BOND STRENGTH	Not highly affected by poor condition of the existing outer/superficial concrete substrate.	Dependent on the quality of the concrete substrate.
AVAILABILITY OF STRUCTURE	Available for immediate use upon application.	May require up to seven days to achieve full adhesive strength.
DURABILITY	Tests show excellent retention strength for anchor bolts. Very good fatigue strength.	Research suggests high strain gradient is found in adhesive layer where strips terminate or in proximity of substrate discontinuity (such as cracks). Debonding can be problematic.

STRONGWELL

ISO 9001 Quality Certified Manufacturing Plants

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