CONSOLIDATION USING CARBON-FIBER REINFORCED POLYMER (CFRP).

IS IT:

- [X] *Product*
- [ ] *Technology*
- [ ] *Equipment*

APPLICABLE FOR:

- [ ] *Restoration*
- [X] *Rehabilitation*
- [ ] *New Construction*

APPLICABLE ON:

- [ ] *1. Foundations and underground structures*
- [X] *2. Vertical structures*
- [ ] *3. Horizontal structures and vertical connections*
- [ ] *4. Roof and terraces*
- [ ] *5. Façade and building envelope*
- [ ] *6. Finishes and completion elements*
- [ ] *7. Integrated services*
- [ ] *8. General strategies for building recovery*

Related companies: *Sika CarboDur®*

DESCRIPTION

Load increases:

- Increased live loads in warehouses
- Increased traffic volumes on bridges
- Installation of heavy machinery in industrial buildings.
- Vibrating structures
- Changes of building utilization

Damage to structural parts:

- Aging of construction materials
- Steel reinforcement corrosion
- Vehicle impact
- Fire

Serviceability improvements:

- Decrease in deformation
- Stress reduction in steel reinforcement
- Crack width reduction

Change in structural system:

- Removal of walls or columns
- Removal of slab sections for openings

Design or construction defects:

- Insufficient reinforcements
- Insufficient structural depth.

WHY TO USE

Carbon-fibers reinforced polymer (CFRP) is used for reliable and high-performance structural strengthening systems. CFRP based solutions consist of CFRP plates and rods, plus structural epoxy resin-based adhesives. These systems are widely used for flexural strengthening of dynamically and statically loaded buildings and other structures such as bridges, beams, ceilings, and walls, providing outstanding long-term durability in service.

HOW TO USE AND APPLY

Apply the neat mixed Sikadur 30 epoxy onto the concrete with a trowel or spatula to a nominal thickness of 1/16” (1.5 mm). Apply the mixed Sikadur 30 epoxy onto the CarboDur laminate with a “roof shaped” spatula to a nominal thickness of 1/16” (1.5 mm). Within the open time of the epoxy, depending on the temperature, place the CarboDur laminate onto the concrete surface. Using a hard rubber roller, press the laminate into the epoxy resin until the adhesive is forced out on both sides. Remove excess adhesive. Glue line should not exceed 1/8 inch (3 mm). The external reinforcement must not be disturbed for a minimum of 24 hours. The epoxy will reach its design strength after 7 days.

Surface must be clean and sound. It may be dry or damp, but free of standing water and frost. Remove dust, laitance, grease, curing compounds, impregnations, waxes, foreign particles, disintegrated materials, and other bond inhibiting materials from the surface. Existing uneven surfaces must be filled with an appropriate repair mortar (e.g., mixed Sikadur 30 epoxy with the addition of 1 part oven-dried sand). The adhesive strength of the concrete must be verified after surface preparation by random pull-off testing (ACI 503R) at the discretion of the engineer. Minimum tensile strength, 200 psi (1.4 MPa) with concrete substrate failure. Surface Levelness/Irregularities: Maximum allowable deviation in 6 ft. shall be limited to 1/4” (6 mm) but no greater than 1/8” (3 mm) per foot. Any sharp edges (i.e., fins, form-marks, etc.) must be ground smooth and flush. Preparation Work: Concrete - Blast clean, shotblast or use other approved mechanical means to provide an open roughened texture. CarboDur - Wipe clean with appropriate cleaner (e.g., MEK). Cutting the CarboDur Laminate: Preferred: CarboDur laminates should be cut with tools using a “shearing” force (e.g., guillotine or heavy-duty shears). Care must be taken to support both sides of the CarboDur laminate to avoid splintering. Alternate: A hack saw or other abrasive cutting method may be used. However, extra care must be taken to support the CarboDur laminate on both sides to avoid splintering. In addition, extra care must be taken to avoid exposure to carbon dust (see Caution).

TECHNICAL CHARACTERISTICS

Typical Data

RESULTS MAY DIFFER BASED UPON STATISTICAL VARIATIONS DEPENDING UPON MIXING METHODS AND EQUIPMENT, TEMPERATURE, APPLICATION METHODS, TEST METHODS, ACTUAL SITE CONDITIONS AND CURING CONDITIONS.

Base	Carbon fiber reinforced polymer with an epoxy resin matrix.
Shelf Life	Unlimited (no exposure to direct sunlight).
Color	Black
Tensile Strength	
Mean Value	4.49 x 10^5 psi (3,100 MPa)
Design Value	4.06 x 10^5 psi (2,800 MPa)
Modulus of Elasticity	
Mean Value	23.9 x 10^6 psi (165,000 MPa)
Design Value	23.2 x 10^6 psi (160,000 MPa)
Elongation at Break	1.69%
Design Strain	0.85%
Thickness	0.047 in. (1.2 mm)
Temperature Resistance	>300°F (>150°C)
Fiber Volumetric Content	>68%
Density	0.058 lbs./in³ (1.60 g/cm³)

Physical Properties

Product	*Thickness (mils)*	*Width (inches)*	*Cross Sectional Area*	*Tensile Strength*
Type S 512	47.2 (1.2 mm)	1.97 (50 mm)	0.093 sq. in. (60 mm²)	37.8 x 10^3 lbs. (168 kN)
Type S 812	47.2 (1.2 mm)	3.15 (80 mm)	0.149 sq. in. (96 mm²)	60.4 x 10^3 lbs. (269 kN)
Type S 1012	47.2 (1.2 mm)	3.94 (100 mm)	0.186 sq. in. (120 mm²)	75.5 x 10^3 lbs. (336 kN)

RECOMMENDATIONS AND OTHER INFORMATION

Design calculations must be made and certified by an independent licensed professional engineer. Design guidelines are available from Sika Corporation.

CarboDur strips are non-reactive and fully cured. They do not require a material safety data sheet. However, caution must be used when handling the CFRP laminates since a fine “carbon dust” may be present on the strips. Gloves must therefore be worn to protect against skin irritation. Caution must also be used when cutting CarboDur laminates to protect against airborne carbon dust generated by the cutting procedure. Use of an appropriate, properly fitted NIOSH approved respirator is recommended.

EXAMPLES

In May 2001, a wooden roof to a traditional house has been strengthened using Sika CarboDur plates S1012 for flexure, as is shown in Figure1.

Fig.1: Renovation of wooden roof.

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In May 2002, the upgrade of flexural loading capacity of a slab was carried out in a tobacco factory. For the flexural strengthening, the Sika CarboDur S512 plates were used (Figure 2).

Fig.2: Renovation of tobacco factory.

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The famous wooden bridge over the river Reuss in Sins in Switzerland is more than 200 years old and was built in 1807 with an original design capacity of 12 tons. The structural strengthening of this timber bridge was also part of a long-term study, and it was one of the first Sika CarboDur® strengthening projects on wooden structures. The system was selected for its excellent mechanical properties and minimal visual impact, as retaining the visual appearance of the bridge was also a key decision factor. To refurbish the bridge the deck was removed and rebuilt, and Sika CarboDur® CFRP plates were bonded to the bottom of the crossbeams to reduce deflection. The installed plates were left exposed and uncoated to facilitate inspection and assessment, but to date the installation remains maintenance free (Figure 3).

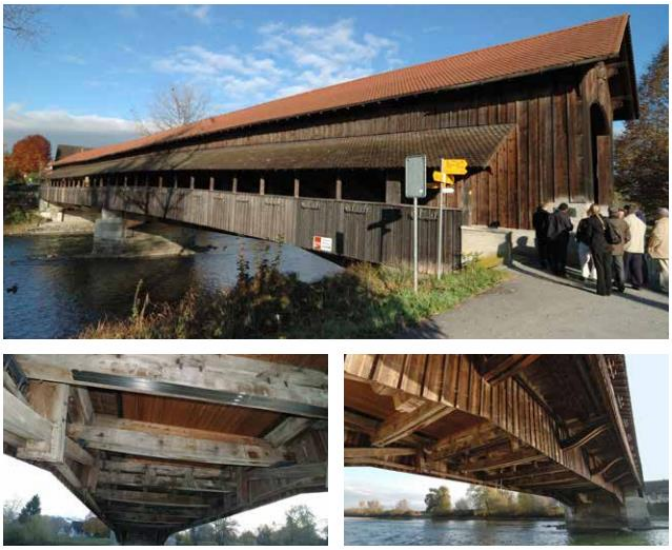

Fig.3: Renovation of wooden bridge over the river Reuss in Sins in Switzerland.

© https://www.byggematerialer.dk/sika-carbodur-1177779/fil-files/Carbodur_2017_web.pdf

REFERENCES / SOURCES AND LITERATURE

https://www.sika.com/en/construction/structural-strengthening/carbon-fiber-reinforced-polymer-plates.html

https://coastalone.com/sika-carbodur.html

https://coastalone.com/media/wysiwyg/Data_Sheets/Sika_Carbodur_Product_Data_Sheet.pdf

WEBSITE OF THE COMPANY

https://www.sika.com/

IMAGES AND CAPTIONS

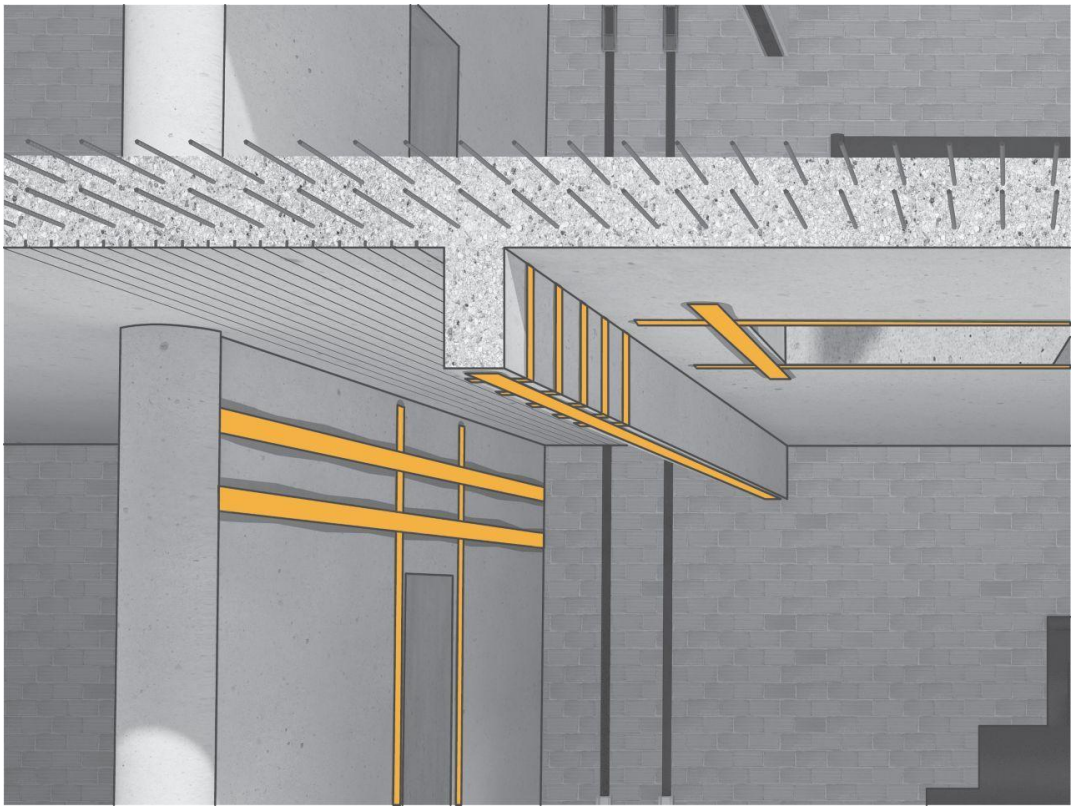

Fig.4: Structural strengthening. © *https://www.sika.com/en/construction/structural-strengthening.html*

Fig.5: Product application. © *https://www.sika.com/en/construction/structural-strengthening/carbon-fiber-reinforced-polymer-plates.html*