Sika® CarboDur®

Heavy-Duty CFRP Strengthening System

| Description | Heavy-duty CFRP strengthening system for reinforced concrete, masonry, stonework, steel, aluminum and timber. System components:  
|             |  - Sika CarboDur CFRP plates  
|             |  - SikeDur-30 adhesive for bonding reinforcement |

| Uses | As a result of intensive research work at the Federal Testing and Research Centre (EMPA) in Dübendorf, it is now possible to make bonded reinforcement for reinforced concrete, masonry, stonework, steel, aluminum and timber structures with corrosion-resistant plates made of carbon fibre reinforced polymers (CFRP). Economically development work by Sika AG was made so that it is possible to apply the CarboDur system, after preparation of the surface, without any other installations. To strengthen structures for:  
|       |  - Loading increase  
|       |  - Increasing the live loads  
|       |  - Increased traffic loads  
|       |  - Installation of heavy machinery in industrial buildings  
|       |  - Changes of building utilization  
|       |  - Damage to structural parts  
|       |  - Ageing of construction materials  
|       |  - Steel reinforcement corrosion  
|       |  - Vehicle impact  
|       |  - Fire  
|       |  - Earth quakes  
|       |  - Serviceability improvement  
|       |  - Decrease of deformation  
|       |  - Stress reduction in steel reinforcement  
|       |  - Crack width reduction  
|       |  - Change in structural system  
|       |  - Removal of walls or columns  
|       |  - Removal of slab sections for openings  
|       |  - Change of specifications  
|       |  - Earthquakes  
|       |  - Adjustment to changed design philosophy  
|       |  - Design or construction defects  
|       |  - Insufficient reinforcement  
|       |  - Insufficient structural depth |

| Characteristics / Advantages | Low in weight  
|                             | Available in any length, no joints required  
|                             | Low overall thickness  
|                             | Easy to transport (rolls)  
|                             | Laminate intersections are simple  
|                             | Economical application – no heavy handling and installation equipment  
|                             | Very high strength  
|                             | Available in various moduli of elasticity  
|                             | Outstanding fatigue resistance  
|                             | No corrosion  
|                             | Clean edges without exposed fibers  
|                             | General construction approval in many countries |
### Test reports/Approvals
- EMPA, Report No. 154 490/1, 1994: Static loading tests on concrete beams
- EMPA, Report No. 154 490, 1994: Testing the Sika roll-on process on voids by infrared thermography
- EMPA, Report No. 170 569e-1, 1999: Application of Sika Carboudur plates under dynamic load
- EMPA, Report No. 172’745/2 1998: Testing of prestressed Carboudur CFRP plate, beam V1
- UCSD, SSRP Report, 2000: Post-strengthening of concrete slabs with externally bonded Carboudur CFRP plates-analytical approach and design recommendation
- NTNV, Report No. R-9-00, 2000: Strengthening prestressed concrete beams with Carboudur CFRP plates
- Deutsches Institut für Bautechnik Z-36.12 – 29, 1997: General construction Authorisation for Sika Carboudur
- SOCCOTEC, Rapport No. HX0823, 2000: Rapport d’enquete technique/ cahier des charges – Sika Carboudur/SikaWrap (French)

### Literature
- **Bänziger H., Steiner W., 1989:** Epoxy adhesives for load bearing jointing. 
  Schweizer Baublatt No. 64, August 1989.

- **Deuring M., 1993:** (German)
  Strengthening reinforced concrete with prestressed composite fibre materials. 

- **Deuring M., 1994:**
  CFRP laminates in the construction industry. Strengthening concrete structures.

- **Meier, U., 1994:** (German)
  Strengthening structures with composite fibre materials.

- **SIA/EMPA:** (German)
  Reinforcement of structures with CarbouDur-laminates.
  Documentation D 0128, 21.9.95.

- **Sika 1997:** (German)

- **Kropf W., Meier H., 1999:** (German)

- **Andrä H.-P., 1999:** (German)

- **Seim W., Karbhari V., Seible F., 1999:** (German)
  Post Strengthening of concrete slabs using Externally Bonded Fiber Reinforced Polymers. Beton- und Stahlbetonbau 94 (1999), No. 11

- **Meier H., 2000:** (German)
  Reinforced structure with composite fibre materials: 
### Availability

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Width [mm]</th>
<th>Thickness [mm]</th>
<th>Cross sectional area [mm²]</th>
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<tbody>
<tr>
<td>Sika CarboDur S512</td>
<td>50</td>
<td>1.2</td>
<td>60</td>
</tr>
<tr>
<td>Sika CarboDur S612</td>
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<td>1.2</td>
<td>72</td>
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<td>Sika CarboDur S812</td>
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<td>1.2</td>
<td>96</td>
</tr>
<tr>
<td>Sika CarboDur S1012</td>
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<td>1.2</td>
<td>120</td>
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<td>Sika CarboDur S1212</td>
<td>120</td>
<td>1.2</td>
<td>144</td>
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<tr>
<td>Sika CarboDur S1512</td>
<td>150</td>
<td>1.2</td>
<td>180</td>
</tr>
<tr>
<td>Sika CarboDur S614</td>
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<td>1.4</td>
<td>84</td>
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<td>Sika CarboDur S914</td>
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<tr>
<td>Sika CarboDur S1214</td>
<td>120</td>
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<td>168</td>
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</table>

### Sika CarboDur M (steel equivalent)

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Width [mm]</th>
<th>Thickness [mm]</th>
<th>Cross sectional area [mm²]</th>
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<td>1.4</td>
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<tr>
<td>Sika CarboDur M614</td>
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<td>84</td>
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<td>Sika CarboDur M914</td>
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<td>1.4</td>
<td>126</td>
</tr>
<tr>
<td>Sika CarboDur 1214</td>
<td>120</td>
<td>1.4</td>
<td>168</td>
</tr>
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</table>

### Sika CarboDur H

<table>
<thead>
<tr>
<th>TYPE</th>
<th>Width [mm]</th>
<th>Thickness [mm]</th>
<th>Cross sectional area [mm²]</th>
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</thead>
<tbody>
<tr>
<td>Sika CarboDur H514</td>
<td>50</td>
<td>1.4</td>
<td>70</td>
</tr>
</tbody>
</table>

### Technical Data

#### Sika CarboDur plates

- **Shelf Life**: Unlimited (no exposure to direct sunshine)
- **Base**: Carbon fiber reinforced plastic with an Epoxy matrix.
- **Color**: Black
- **Surface**: Grinded on one side
- **Fiber volumetric content**: >68%
- **E-Modulus* (mean value)**
  - Sika CarboDur S: 165 000 N/mm²
  - Sika CarboDur M: 210 000 N/mm²
  - Sika CarboDur H: 300 000 N/mm²

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**Packaging**

- **Sika CarboDur plates**: Cut to size according parts list in reusable packaging
- Supply in rolls of 250m in reusable packaging
- **Sikadur-30 adhesives**: Pre-dosed units (Comp. A+B) at 5 kg
- Pallets at 400 kg (80 x 5 kg)
- Not pre-dosed industrial packaging: Comp. A 30 kg pails, Comp. B 10 kg pails
- Pallets at 560kg (14 x 30 kg Comp. A and 10 kg Comp. B)
- **Colma Cleaner**: In 1 and 5 kg palls, 20 kg mini drum and 160 kg drum
- **Sika CarboDur Rubber Roller**: sales unit 1 pc.
- **Sika Mixing Spindle**: sales unit 1 pc.
### Mechanical Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Tensile Strength (min. value)</th>
<th>Mean value of tensile Strength at break (min. value)</th>
<th>Elongation at break (min. value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sika CarboDur S</td>
<td>2 800 N/mm²</td>
<td>3 050 N/mm²</td>
<td>1.7%</td>
</tr>
<tr>
<td>Sika CarboDur M</td>
<td>2 400 N/mm²</td>
<td>2 900 N/mm²</td>
<td>1.2%</td>
</tr>
<tr>
<td>Sika CarboDur H</td>
<td>1 350 N/mm²</td>
<td>1 450 N/mm²</td>
<td>0.45%</td>
</tr>
</tbody>
</table>

*Mechanical values obtained from longitudinal direction of fibers.

### Sikadur-30 adhesives for bonding reinforcement

- **Appearance**: Comp. A: White paste, Comp. B: Black paste, Comp. A+B: Light grey when mixed
- **Mixed Ratio**: Comp. A : Comp. B = 3 : 1 (parts by weight)
  Exact mixing ratio to be safeguarded by using Scales.
- **Consistency**: Comp. A + B mixed: creamy, pasty
- **Shelf life**: In original packaging stored at +5°C to +25°C: 12 months from date of handling out from Sika AG factory.
- **Application temperature**: Substrate and ambient +10°C to +35°C.
- **Density**: 1.65 kg/l (A+B)
- **Pot Life**: (to F.I.P.*) 120 minutes (at +10°C), 40 minutes (at +35°C)
- **Open time**: (to F.I.P.*) 30 minutes (at +35°C)
- **Sag flow**: (to F.I.P.*) 3-5 mm (at +35°C)
- **Compressive strength**: (to EN 196) Develop of compressive strength

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![Compressive strength chart](image)
Shrinkage (to F.I.P.*) 0.04%

Glass transition temperature (to F.I.P.*) +62°C

Heat distortion resistance (to ASTM D 648)

<table>
<thead>
<tr>
<th>Curing</th>
<th>HDT</th>
</tr>
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<tbody>
<tr>
<td>7d, +10°C</td>
<td>+36°C</td>
</tr>
<tr>
<td>7d, +35°C</td>
<td>+53°C</td>
</tr>
<tr>
<td>6h, +60°C</td>
<td>+53°C</td>
</tr>
<tr>
<td>3h, +80°C</td>
<td>+53°C</td>
</tr>
</tbody>
</table>

Static E-modulus (to F.I.P.*) 12'800 N/mm²

Adhesive strength (wet) (to F.I.P.*) Concrete failure (approx. 4 N/mm²)

Shear strength (to F.I.P.*) Concrete failure (approx. 15 N/mm²)

Thermal coefficient of expansion (to Sika) $9 \times 10^{-5}$ per °C (-10°C to +40°C)

Note The values given may vary according to the mixing intensity and amount of air entrained (through mixing).

Notes on design

A Sika CarboDur-plate has no plastic deformation reserve. Therefore the maximum bending resistance of a strengthened section is reached when plate failure occurs during steel yield and before concrete failure. The mode of failure if influenced by the plate cross-section. To limit crack widths and deformation the yield point should not be reached in the reinforcing bars under service conditions. Any shear cracks which occur must be prevented from causing displacement on the strengthened surface and shearing of the laminate. Stress and deformation calculations can be made by the normal methods. They should be verified in accordance with standards SIA 160 (1989) and 162 (1989).

Procedure for assessing the condition of the structure

Dimensions (geometry, reinforcement, evenness of surface to be strengthened), quality of existing construction materials, ambient climatic conditions, agreed conditions of service.

Verifications

- Loading safety:
  - Non-strengthened structure (with allowance for a reduced total safety factor $\gamma \geq 1.0$)
  - Strengthened structure (with the mode of failure described above, check on the strains)
  - Shearing of plate
  - Anchorages
- Failure resistance:
  - Check on concrete and steel stresses
- Serviceability:
  - Deformation (with average strains, assuming elastic behaviour of the structure and time-based strain changes in the concrete)
  - Steel stresses (no plastic deformation in service conditions)
  - Check widths (by limiting the steel stresses under service conditions)
Application

Important notes
- Medium adhesive tensile strength of the prepared concrete substrate is 2.0 N/mm², min. 1.5 N/mm².
- The Sika CarboDur system must be protected from permanent exposure to direct sunlight.
- Maximum admissible service temperature is +50°C. When using Sika CarboDur Heating device together with SikaDur-30 LP it may be increased to max. +70°C.
- Max. substrate moisture content 4%. Min. application temp. +10°C.
- Ambient and substrate temperature during application must be min. 3°C above dew point.
- The instructions in the Technical Data Sheet must be followed when applying SikaDur-30 adhesive.

Substrate

Reinforced concrete:
Clean, free from grease and oil, dry, no loose particles or laitance.
Preparation: Blast-clean, scabble or grind.

Timber, brickwork:
Clean, free from grease and oil, no loose particles.
Preparation: Blast-clean or grind, plane or grind.
After preparation, remove all dust from the surface with an industrial vacuum cleaner. The surface to be coated must be level, with steps and form work marks not greater than 0.5 mm. Planeness of substrate to be checked with a metal batten. Tolerance for 2 m length max. 10 mm.

Mixing Sikadur-30

Pre-dosed packs:
Add component B to component A and stir with a mixing spindle fitted to an electric low speed mixer (max. 500 rpm) to avoid entrapping of air. Mix thoroughly for about 3 minutes to uniform appearance. Then, pour the whole mix into a clean container and stir again for approx. 1 more minute at low speed to keep air entrapment at a minimum.

Bulk packing, not pre-dosed:
Add the components in the correct proportion using a scale. Pour them into a suitable mixing container and stir correctly using an electric low speed mixer as indicated for ready to use pre-dosed packs.

The pot life begins when the resin and hardener are mixed. It is shorter at high temperatures and longer at low temperatures. The greater the quantity mixed, the shorter the pot life. To obtain longer workability at high temperatures, the mixed adhesive may be divided into portions. Another method is to chill components A and B before mixing them.

Application of Sika CarboDur CFRP-plates

If there are large blowholes or honeycombs on the concrete surface, these must first be filled CarboDur CFRP-plates with a repair mortar. The Sikadur-30 adhesives must be used as a bonding layer to ensure a good bond with the concrete substrate. A repair mortar use Sikadur-41 or Sikadur-30 adhesives, filled max. 1 : 1 by weight with Sikadur-501 quartz sand.

Place the Sika CarboDur plate on a table and clean the grinded side with Colma Cleaner using a white rag. Apply the Sikadur-30 adhesive with a roof shaped spatula onto the CarboDur laminate. Apply the well-mixed SikaDur-30 adhesive carefully to the properly prepared, dust free substrate with a spatula to form a very thin layer.

Within the open time of the adhesive, depending on temperature, place the coated Sika CarboDur plate onto the prepared concrete surface. Using a Sika rubber roller, press the plate into the epoxy adhesive until the material is forced out on both sides of the laminate. Remove surplus epoxy adhesive. Samples should be made up on site to check the adhesive used in respect of curing rate and final strength. Measure the compressive and flexural tensile strength after curing.

Average Standard values are: Curing 7d at +23°C
- Compressive strength >75 N/mm²
- Flexural tensile strength > 35 N/mm²

In case of plate intersections the first applied Sika CarboDur plate is to be grinded in the crossing zone and decreased with Colma Cleaner.
If required Sika CarboDur plates may be protected with fire resistant material. When the Sikadur-30 adhesives has cured, the Sika CarboDur plate has to be checked for hollows by tapping lightly or impulse-thermography. The exposed plate-surface can be painted with a coating material such as Sikagard-550 W elastic or Sikagard-ElastoColor W.

<table>
<thead>
<tr>
<th>Consumption</th>
<th>Width of plate</th>
<th>Sikadur-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm</td>
<td>0.35 kg/m²</td>
<td></td>
</tr>
<tr>
<td>60 mm</td>
<td>0.40 kg/m²</td>
<td></td>
</tr>
<tr>
<td>80 mm</td>
<td>0.55 kg/m²</td>
<td></td>
</tr>
<tr>
<td>90 mm</td>
<td>0.70 kg/m²</td>
<td></td>
</tr>
<tr>
<td>100 mm</td>
<td>0.80 kg/m²</td>
<td></td>
</tr>
<tr>
<td>120 mm</td>
<td>1.00 kg/m²</td>
<td></td>
</tr>
<tr>
<td>150 mm</td>
<td>1.20 kg/m²</td>
<td></td>
</tr>
</tbody>
</table>

Depending on plane and roughness as well as plate crossings, actual consumption of adhesive may be higher.

### Recommendations for Sika CarboDur plates

**Cutting**
The cutting to length of Sika CarboDur plates is preferably done with a diamond cutting disk.

**Grinding**
The laminate surface, eg. If intersections have to be carried out, can be carefully ground with Emery paper type 180 and afterwards cleaned with Colma Cleaner.

**Protection measures**
During cutting and grinding of Sika CarboDur plates wear goggles and dustmasks with filter for finest dust, as well as one way gloves.

### Safety Instructions Sikadur-30

**Safety precautions**
The product can cause skin irritation (dermatose)!
Apply barrier cream to hands and unprotected skin before starting work. Wear protective Clothing (gloves, safety glasses). In contact with eyes or mucous membranes rise immediately with clean warm water and seek medical attention without delay.

**Ecology**
Uncured components are contaminating of water and may therefore not be discharged drains, waterways or the ground. Leftovers of the Cola-Cleaner and Sikadur-30 must be disposed of according to local regulations.

**Toxicity**
Comp. A: Please observe indications on packing.
Comp. B: Mon-toxic.

**Transport**
Comp. A: Non-hazardous.
Comp. B: (8/65 c), free quantity: 500 kg

For particles please demand the material safety data sheet.

### Legal Notice

The information, and, in particular, the recommendations relating to the application and end-use of Sika products, are given in good faith based on Sika’s current knowledge and experience of the products when properly stored, handled and applied under normal conditions in accordance with Sika’s recommendations.
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