Structural Strengthening with Prestressed Sika® CarboDur® CFRP Plate Systems
Principle of prestressing

The prestressed CFRP plate combines the advantages of the bonded CFRP plate strengthening with those of conventional prestressing. The tensioned CFRP plate superimposes compressive stress in the tensile zone of the cross-section, thus reducing tensile stress in steel reinforcement under service load and consequently crack width and deflection will be reduced. For calculation of the load-bearing capacity the tensile force in the tensioned CFRP plate is added to the tensile strength of the steel.

Advantages of prestressed Sika® CarboDur® CFRP plates

As compared to prestressing steel
- Easy prestressing of existing structures
- Low weight for easy handling
- Low loss of prestress due to higher initial tensile strain
- Compact because of thin section
- Comparable stress level for CFRP plates and prestressing steel
- No stress corrosion cracking risk
- Corrosion resistant tendon
- Bonded or non-bonded

As compared to CFRP plates applied without pretensioning
- Optimal use of the high tensile strengths of the Sika® CarboDur® CFRP plates
- 30% to 50% less plates needed
- Optimal cost/performance ratio for strengthening of concrete structure
- Increased serviceability: reduction of crack width, tensile steel strain and corrosion
- Strengthening effect can also be “appropriate” for dead and permanent load
- Reduction of tensile strain of existing steel reinforcements
- Possibility of structural strengthening at low substrate temperatures and high humidity without the special measures
- Plate thickness up to 2.4 mm
- Short end-anchors of the plates

- Longitudinal and transversal strengthening of bridges
- Seismic strengthening of masonry and concrete walls
- Strengthening of industrial and commercial buildings
- Strengthening in all climatic conditions
- Increased durability
## Prestressing systems for Sika® CarboDur® CFRP plates

### Sika® LEOBA CarboDur® LC II
- **Manufacturing of CFRP plate tendons**: Plate can be cut from roll and made ready for use, not necessary to keep ready-made tendons in stock.
- **Anchor**: The tensioning anchor can be placed anywhere on the plate. Flat anchor plate.
- **Force transfer**: Prestressing force transfer in a manner that is appropriate to concrete through the integral surface of the base plate bonded and bolted onto the concrete.
- **Recess in the concrete**: Base plate for force transfer, tensioning plate for hydraulic jack and levelling aid are placed in a pocket in the concrete.
- **Tensioning procedure**: Tensioning in two operations, change over from temporary to permanent anchorage.
- **Quality control**: Quality control on site.
- **Bond**: Can be used bonded or non-bonded. Anchorage zone of LC II always bonded.
- **Handling**: Easy for site use due to low weight of components.
- **Plate**: Plate cross-section 90 × 1.4 mm.
- **Tensioning force**: Tensioning force 200 kN.
- **Minimum ultimate load**: Plate failure before anchorage failure.
- **Costs**: Low manufacturing and application costs.
- **Efficiency**: Quick installation: Application of approx. 10 tendons per team and jack per day.
- **Patents**: Patents: “Method and strip-shaped tensional member for strengthening and/or restoring reinforced or prestressed concrete supporting structures and device for carrying out said method.” (DE 198 49 605 A1).
- **Approvals**: Approval in Germany expected in September 2002.

### Sika-StressHead
- **Manufacturing of CFRP plate tendons**: Ready-made plate delivered to site.
- **Anchor**: Anchorage of plate in carbon fibre (non-metallic) anchor head, without adhesive.
- **Force transfer**: Concentrated force transfer into the substrate, adaptable to structural conditions. Independent from local concrete surface properties.
- **Recess in the concrete**: No need for a recess in the concrete.
- **Tensioning procedure**: Short installation time, tensioning in one operation.
- **Quality control**: Quality control in the factory during manufacturing of the tendons.
- **Bond**: Can be used bonded or non-bonded (for instance at low substrate temperatures and high humidity).
- **Handling**: Appropriate for site use due to adaptable anchorage possibilities.
- **Plate**: Plate cross-section 60 × 2.4 mm.
- **Tensioning force**: Tensioning force 220 kN.
- **Minimum ultimate load**: 300 kN.
- **Costs**: Low application costs.
- **Efficiency**: Quick installation: Application of approx. 10–15 tendons per team and jack per day.
- **Approvals**: Approval in Switzerland (ASTRA, SBB) expected in 2002.
Application procedure Sika LEOBA / Sika-StressHead

Preparatory work

- Take the measurements and check the quality of the structure to be strengthened
- Determine the anchorage points on basis of geometry and position of reinforcements
- Crack injection if necessary

Tensioning (within open time)

- Apply tension with hydraulic jack. Prestressing force verified via jack pressure and elongation
- Fix the anchorage by means of the locking screws, remove jack

Finishing

- Reprofile
- Bond the protruding end from the mechanically secured bonded plate to serve as back-up anchorage
- Apply coating if necessary
Reference projects

**Project**
Körschtalbrücke near Stuttgart-Möhringen (D). Length- and crosswise prestressed double T cross-sections with two coupling joints.

**Problem**
Cracks in the coupling joints, risk of failure by fatigue of longitudinal tendons.

**Project**
Bank in Langen near Frankfurt (D). In July 1999 two door openings had to be cut into an existing concrete wall.

**Problem**
Tensile forces in the lintel zone of the new doors, caused by the change of the structural system, had to be carried.

**Project**
Longitudinally prestressed concrete bridge over the river Lauter near Gomadingen, Baden-Württemberg (D).
Year of construction 1970, skew-slab and -beam bridge continuous over four spans.

**Problem**
Too high prestressing of the internal tendons produced cracks in the underside of the deck above the columns.

**Sika solution**
Injection of the cracks with Sika injection resin. Structural integrity restored by prestressing with 5 Sika® LEOBA CarboDur® LC II systems every coupling joint.

**Sika solution**
The wall above the new door openings has been centrically precompressed with a total of 8 superficial Sika® LEOBA CarboDur® LC I CFRP tendons placed at the level of the expected tensile force caused by deviation of compression force trajectories. The plates were covered with fire resistant cladding.

**Sika solution**
In October 1998, for the first time in the world, pretensioned CFRP plates were used to solve this problem. The system Sika® LEOBA CarboDur® LC I was used.
Project
In the course of repair work on the Zurich–Chur motorway, the Escherkanal Bridge (CH), built in the fifties, has to be rehabilitated and strengthened.

Problem
The bridge deck slab over the box girder is very thin and insufficiently reinforced, which is the cause of longitudinal cracking.

Project
Trade Building Amsterdam (NL). During construction of the 8-storey high office building in precast concrete elements in 2001, wide cracks appeared in the main girders in the ground floor above the columns.

Problem
Upper reinforcement above the columns was insufficient to take the eccentric load caused by the façade panels.

Project
Seismic strengthening of Lucerne police headquarters (CH) in autumn 2000.

Problem
A new reinforced concrete wall was erected from bottom to top of the building. The new wall had to be solidly fixed into the existing walls in the basement.

Sika solution
In 2002, the bridge deck slab was prestressed transversally using the Sika-StressHead System. Because of the handy tendon, operations inside the box girder turned out to be particularly easy.

Sika solution
The girders are strengthened on the façade side with short CFRP plates tensioned by Sika-StressHead System.

Sika solution
For this purpose Sika-StressHead system tendons were used on both sides of the wall.

Literature
9 StressHead 2001: Prestressing system for CFRP plates”, 8.2001;
10 Berset T., “Approval and testing of CFRP plate prestressing systems”, bonded and tensioned CFRP plate reinforcements, Kolloquium, ETH Zürich, 27. November 2001;
Prestressed Sika® CarboDur®
plates

Tests performed at the Swiss Federal Laboratories for Materials Testing and Research EMPA (Deuring M., 1993) revealed the problems of anchoring the ends of prestressed plates. The plate debonds like a zipper from the end by exceeding concrete tensile strength. It is therefore necessary to hold the ends of a tensioned CFRP plate by means of an anchor head.

To solve this problem, Sika offers the two systems described in this documentation:

* Sika LEOBA CarboDur® LC II and Sika-StressHead.

### System Specifications

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<th>System</th>
<th>Sika LC II</th>
<th>Sika-StressHead</th>
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<tr>
<td>Sika® CarboDur® plate</td>
<td>V914</td>
<td>V624</td>
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<tr>
<td>Cross-section</td>
<td>126 mm²</td>
<td>144 mm²</td>
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<tr>
<td>Tensioning force</td>
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<td>220 kN</td>
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<td>Pretensioning strain</td>
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<td>9.5‰</td>
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<tr>
<td>Tensioning anchor</td>
<td>Leoba LC II</td>
<td>StressHead 220</td>
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### Also available from Sika

*Concrete restoration
* Structural strengthening
* Seismic upgrading
*Solutions with Sika Systems

The Circum Pacific Belt
“The Ring of Fire”
The Alpide Belt
“The Hot Line”

Also available from Sika

All orders are accepted subject to our current terms of sale and delivery. Users should always refer to the most recent issue of the Product Data Sheet for the product concerned, copies of which will be supplied on request.

Sika AG
Corporate Construction
CH-8048 Zürich
Switzerland
Phone +41 1 436 40 40
Fax +41 1 436 46 86
www.sika.com