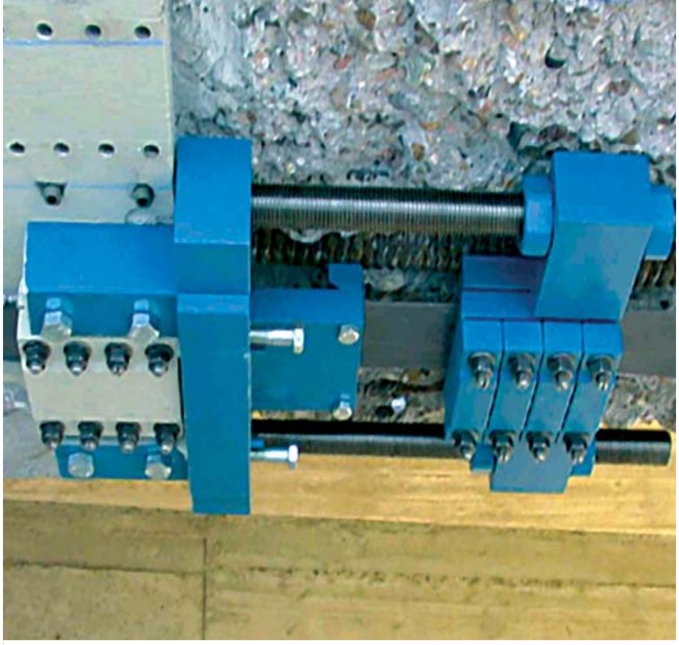
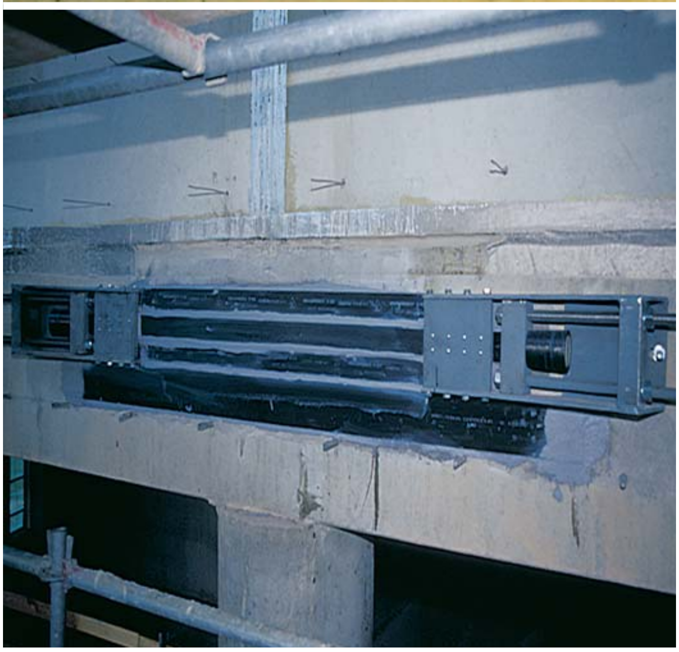
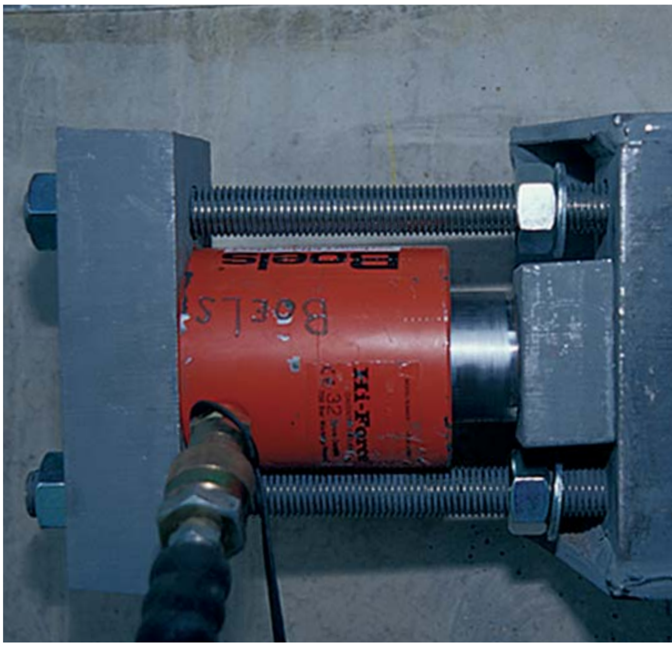
Construction

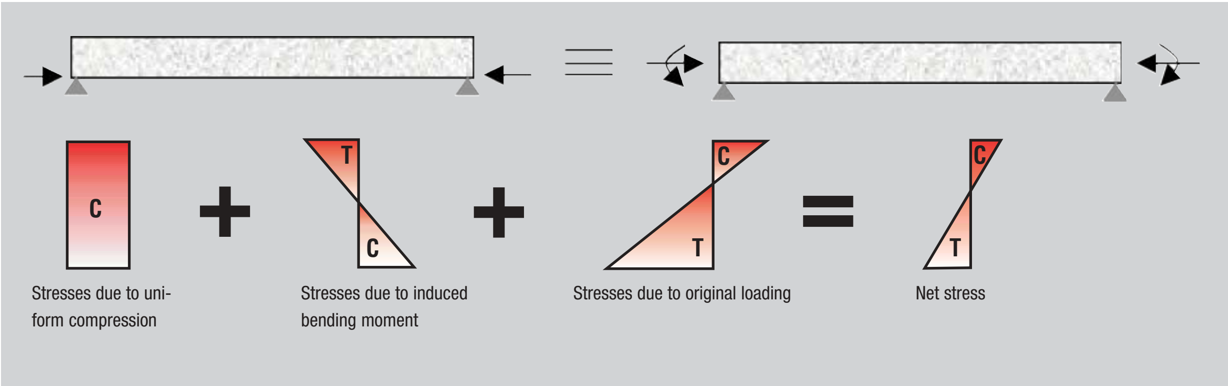






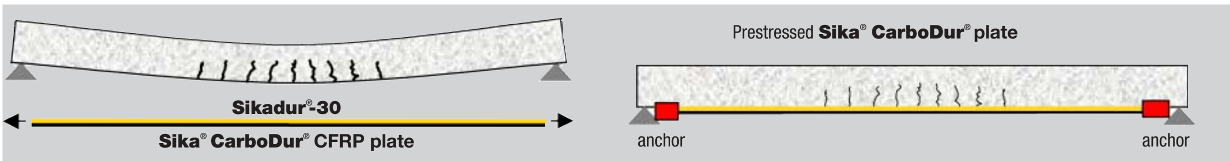
Structural Strengthening with Prestressed Sika® CarboDur® CFRP Plate Systems

Principle of prestressing



Principle

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

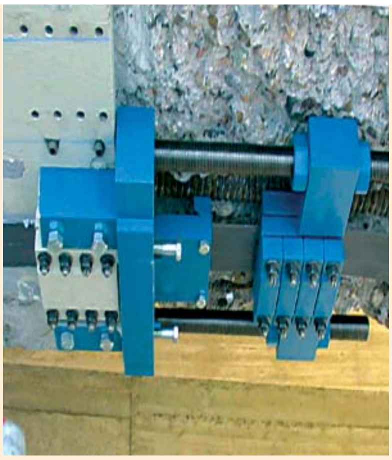
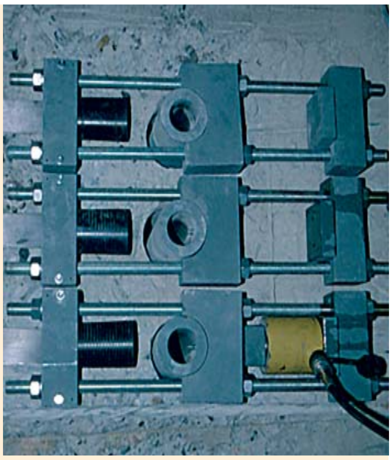
- Easy prestressing of existing structures
- Low weight for easy handling
- Low loss of prestress due to higher initial tensile strain
- Compact because of thin section
- Comparable stress level for CFRP plates and prestressing steel
- No stress corrosion cracking risk
- Corrosion resistant tendon
- 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	**Sika-StressHead**
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	Ready-made plate delivered to site
Anchor	The tensioning anchor can be placed anywhere on the plate. Flat anchor plate	Anchorage of plate in carbon fibre (non-metallic) anchor head, without adhesive
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	Concentrated force transfer into the substrate, adaptable to structural conditions. Independent from local concrete surface properties
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	No need for a recess in the concrete
Tensioning procedure	Tensioning in two operations, change over from temporary to permanent anchorage	Short installation time, tensioning in one operation
Quality control	Quality control on site	Quality control in the factory during manufacturing of the tendons
Bond	Can be used bonded or non-bonded. Anchorage zone of LC II always bonded.	Can be used bonded or non-bonded (for instance at low substrate temperatures and high humidity)
Handling	Easy for site use due to low weight of components	Appropriate for site use due to adaptable anchorage possibilities
Plate	Plate cross-section 90 × 1.4 mm	Plate cross-section 60 × 2.4 mm
Tensioning force	Tensioning force 200 kN	Tensioning force 220 kN
Minimum ultimate load	Plate failure before anchorage failure	300 kN
Costs	Low manufacturing and application costs	Low application costs
Efficiency	Quick installation: Application of approx. 10 tendons per team and jack per day	Quick installation: Application of approx. 10 – 15 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)	Patents: "Reinforcement device for supporting structures" (EP-Patent N° 1007 809). "Device for splitting of the ends of a fibre strand consisting of a bonded fibre material." (WO 005 07 06)
Tests	First tests: EMPA 1998	First tests: EMPA 1999, ETHZ 2000
Approvals	Approval in Germany expected in September 2002	Approval in Switzerland (ASTRA, SBB) expected in 2002

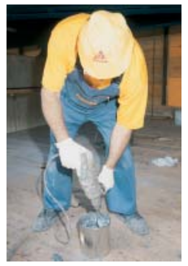
Sika prestressing systems

Sika® LEOBA CarboDur® LC II

System components
CFRP plate

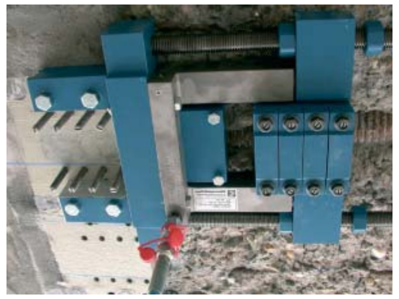
Sika® CarboDur® plate: V914
Cross-section: 126 mm²
Tensioning force: 200 kN
Pretensioning strain: 9.5 ‰
Tensioning anchor: LEOBA LC II

Adhesive
Sikadur®-30



Anchors

Hydraulic jack



Sika-StressHead

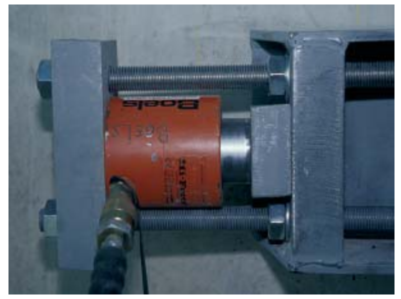
System components
CFRP plate

Sika® CarboDur® plate: V624
Cross-section: 144 mm²
Tensioning force: 220 kN
Pretensioning strain: 9.5 ‰
Tensioning head: StressHead 220

Adhesive
Sikadur®-30

Anchors

Hydraulic jack



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

Sika LEOBA	Sika-StressHead
	Prepare tendons (plate and tensioning head) to specified length in the factory
Security: Plate failure before anchorage failure (tested up to 365 kN)	Factory test of tendon with a 10% higher load (Po +10%) as part of quality control
Substrate preparation only in anchorage zone. Substrate preparation for bonded application according to requirements	No substrate preparation when applying non-bonded, else analogue non-pretensioned plates
Set dowels for base plate	Drill holes for anchorage (only one core per anchor)
Install base plate with bolts and **Sikadur®-30** adhesive	Fix anchor
Plate application as for non-tensioned plate with **Sikadur®-30**	Plate application as for non-tensioned plate with **Sikadur®-30** or install plate with protective duct

Tensioning (within open time)

Sika LEOBA	Sika-StressHead
Install tensioning anchor	Install tendon in anchorage

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

Sika LEOBA	Sika-StressHead
Install end-anchorage	
Transfer prestressing force after hardening of the adhesive from tensioning anchor to the end-anchorage	

Finishing

Sika LEOBA	Sika-StressHead
Reprofile	Reprofile if necessary
Bond the protruding end from the mechanically secured bonded plate to serve as back-up anchorage	
Apply coating if necessary	If necessary install anchor cover or coat the plate

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.

Sika solution

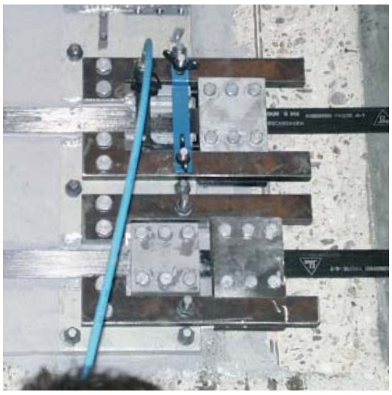
Injection of the cracks with Sika injection resin. Structural integrity restored by prestressing with 5 Sika® LEOBA CarboDur® LC II systems every coupling joint.

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.



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 tensional force caused by deviation of compression force trajectories. The plates were covered with fire resistant cladding.

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

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.

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.

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.

Sika solution

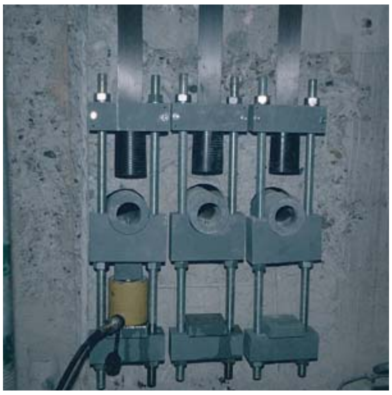
The girders are strengthened on the façade side with short CFRP plates tensioned by Sika-StressHead System.

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

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

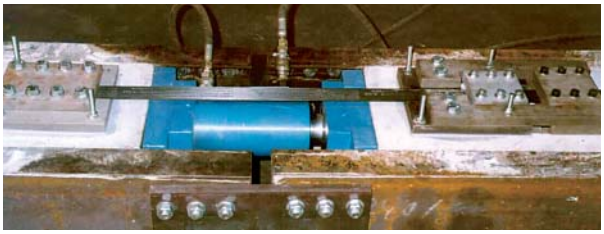
Literature

1 Deuring M.: “Strengthening of reinforced concrete by means of tensioned composite fibre materials”, Dissertation, EMPA Bericht 224, Eidgenössische Materialprüfungs- und Forschungsanstalt Zürich 1993; **2** Maissen A., Czaderski C.: “Testing of tensioned CFRP plates”, EMPA Bericht Nr. 172745‘/2.1998, Eidgenössische Materialprüfungs- und Forschungsanstalt Zürich 1998; **3** Andrä H.P., Maier M.: “Trend-setting development for structural strengthening and rehabilitation, LEOBA-CarboDur surface tendon”, IBK-Fachtagung 241. Darmstadt 1999; **4** Andrä H.P., Maier M.: “Post Strengthening of R/C Structures by means of Prestressed Externally Bonded Carbon Fibre Reinforced Polymer Strips”, Conference Proceedings of Structural Faults & Repair 99, Commonwealth Institute London, July 1999; **5** Andrä H.P., Maier M.: “Post-strengthening with Externally Bonded Prestressed CFRP Strips”, Conference Proceedings of 16th Congress of IABSE, Lucerne September. 2000; **6** Andrä H.P., König G., Maier M.: “Tensioned CFRP surface tendons”, Beton und Stahlbetonbau Jahrgang 96 (2001) Heft 12, Verlag Ernst & Sohn, Berlin, Seite 737 – 747; **7** Berset T., Schwegler G., 2000: “The use of pre-stressed CFRP-Laminates as post-strengthening.” 16th Congress of IABSE, Lucerne, 2000; **8** Glaus P., Schwegler G., 2001: “Seismic upgrading of masonry building with fibre composites”. 20th European Regional Earthquake Engineering Seminar, Sion 2001; **9** StressHead 2001: Prestressing system for CFRP plates”, 8.2001; **10** Schwegler G., Glaus P., Berset T.: “Use of tensioned CFRP plates” bonded and tensioned CFRP plate reinforcements, Kolloquium, ETHZ, Zürich, 27. November 2001; **11** Berset T., “Approval and testing of CFRP plate prestressing systems”, bonded and tensioned CFRP plate reinforcements, Kolloquium, ETHZ, Zürich, 27. November 2001; **12** Federal roads department ASTRA: “Anchoring of tensioned CFRP plates”, IABSE Symposium, Melbourne, September 2002

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	Sika LC II	Sika-StressHead
Sika® CarboDur® plate	**V914**	**V624**
Cross-section	126 mm²	144 mm²
Tensioning force	200 kN	220 kN
Pretensioning strain	9.5 ‰	9.5 ‰
Tensioning anchor	**Leoba LC II**	**StressHead 220**

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.

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