

Case Studies

Hütten Bridge, Werthenstein, Lucerne (Switzerland)

Structure and Problem

The Hütten Bridge was built in the 1950's and was designed for vehicles with a maximum total load of 28 tonnes. The management of the surrounding forests now required the bridge to carry heavier loads of timber on trucks up to 40 tonnes. Neither of the two main bridge beams on the three span bridge could take this stress and had to be strengthened for bending and shear.

Solution

Both beams were strengthened with prestressed CFRP plates up to 30 metres long on both sides. The end anchorage of the prestressed plates consisted of continuous shear connectors through the beams which introduced the tensioning forces into the beam in concentrated form. CFRP fabric loops were used for the shear strengthening. Slots were first cut vertically in the deck slab so that the loops could completely surround the tension and compression zones of the beams. The loops were inserted in several layers and bonded.



Sports Hall Roof, Thörl (Styria / Austria)

Structure and Problem

The roof of the sports hall at Thörl secondary school (Styria, Austria) had to be strengthened to repair damage and to meet current standards. Assessment showed that the tensile resistance and flexural stiffness in the transverse beams across the sports hall were insufficient. An on-site inspection and the results of the structural analysis showed a need to strengthen these roof support beams longitudinally. Due to deflection under the existing loads, a solution involving prestressing was the only practical and viable option.

Solution

The **VSL® CarboStress®** pre-stressing system was selected to fulfil the refurbishment and strengthening requirements. The load bearing capacity and flexibility in design of the end anchors of the **VSL® CarboStress®** system gave the engineer sufficient choice in the anchor positioning to ensure safe and secure transmission of the loads. The final decision to use this system was made on the basis of its comparatively low cost and the fact that it could be installed very quickly and without damaging the existing reinforcement.



Fire Station, Visp (Switzerland)

Structure and Problem

Visp fire station was built in 1974. The load bearing design of the structure was now seriously defective in terms of earthquake resistance to the latest standards. The reinforced concrete frames of the gable end walls, with masonry infill, would be unsafe in earthquakes and could not transfer the seismic forces to the ground. The works also had to cause minimum disruption to the normal daily operation of the fire station.

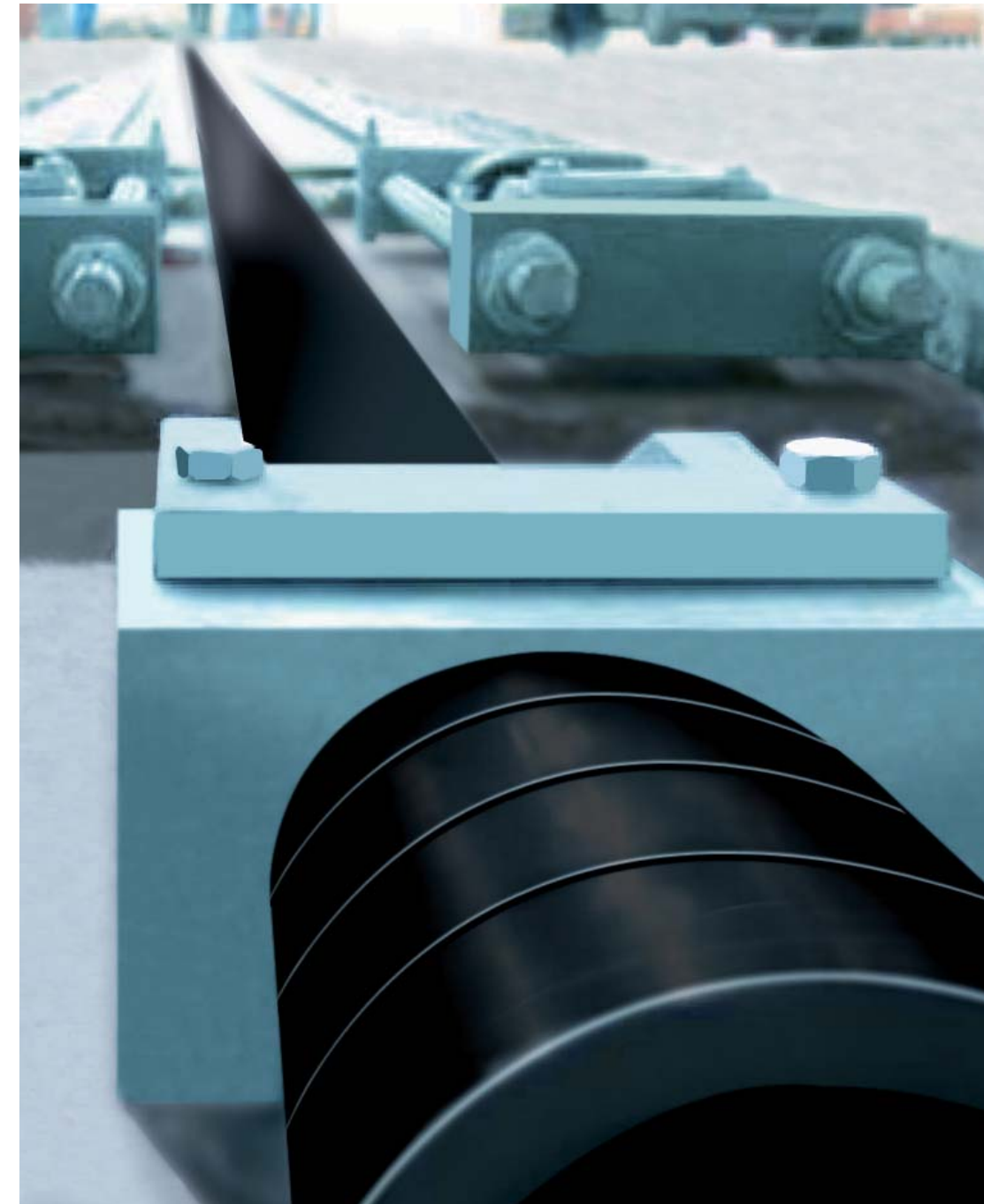
Solution

Increased earthquake resistance of the gable end walls was achieved with 4 vertical CFRP plates on the ends of each wall. The plates were anchored and tensioned in the roof and in the basement walls. The extra vertical force of the prestressed CFRP plates was sufficient to increase the shear resistance of the masonry and provide earthquake resistance in accordance with the latest standards.



VSL CARBOStRESS®

STRENGTHENING WITH POST-TENSIONED CFRP



- INCREASED LOADING
- NEW REGULATIONS AND STANDARDS
- INCREASED DURABILITY AND EARTHQUAKE RESISTANCE
- CHANGE OF STRUCTURAL DESIGN
- STRUCTURAL DAMAGE
- DESIGN OR CONSTRUCTION DEFECTS

VSL (Switzerland) Ltd. and Sika Services AG are partners in the marketing and application of the CarboStress® System



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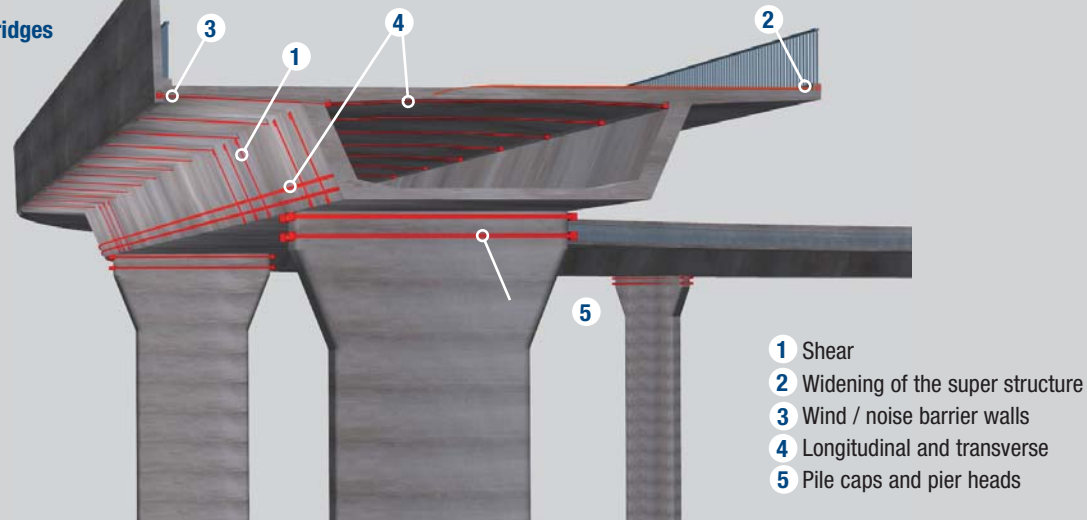
VSL CarboStress® – Strengthening with post-tensioned CFRP

Areas of Application for post-tensioned CFRP Plates

Since the development of CFRP (Carbon Fibre Reinforced Polymers) in the late sixties these materials have been used increasingly for structural strengthening, during the last ten years they have also been used as post-tensioned (PT) strengthening tendons for applications on bridges and other structures.

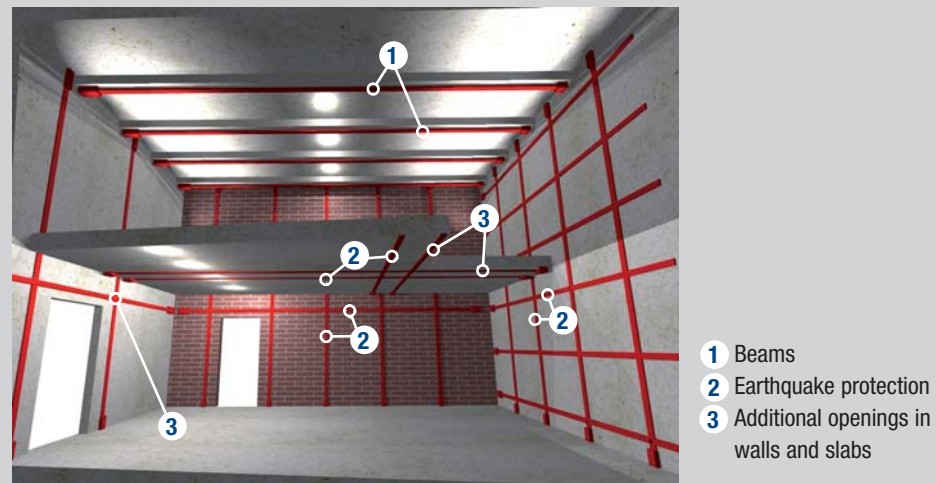
Reasons for the Strengthening of Bridges

- Increased live loads / traffic
- Change of design requirements
- Deterioration due to corrosion, fire, earthquake
- Change of static system
- Excessive deformation and cracks
- Extension of design life



Reasons for the Strengthening of other Structures

- Increased life loads incl. earthquake resistance
- Change of use (conversion)
- Change of design requirements
- Deterioration due to corrosion, fire, earthquake, etc.
- Excessive deformation and cracks
- Change of structural system (such as removal of load bearing walls or columns)



Technical Data - CarboStress® System

StressHead 220

Material	CFRP
Dimension	60/80 x 110mm
Guaranteed max. load	300 kN
Prestressing force	220 kN



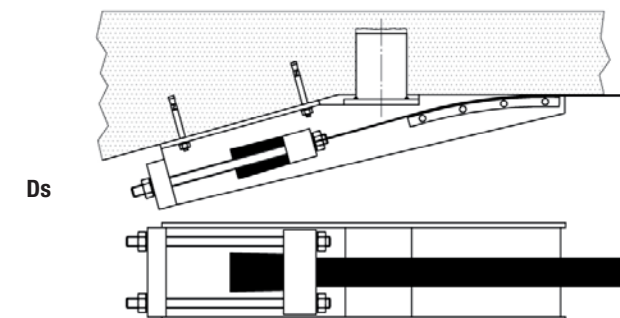
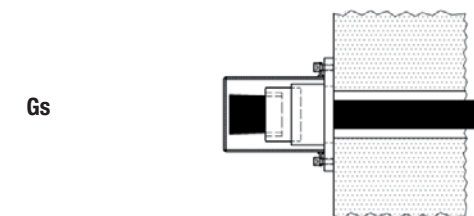
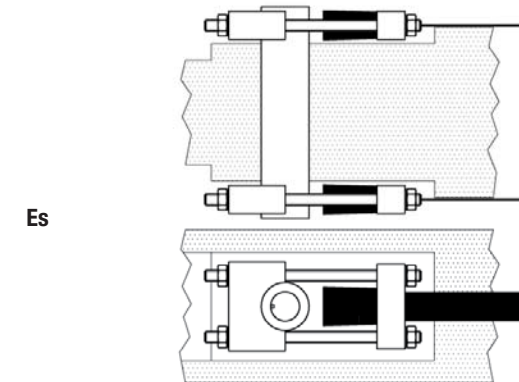
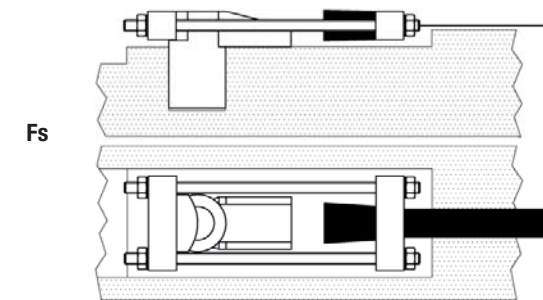
CarboDur® Plate

Material	CFRP
Cross Section	60mm x 2.4mm = 144mm ²
Tensile strength	2'800 N/mm ²
Nominal breaking load	403 kN
E-Modulus	165 kN/mm ²

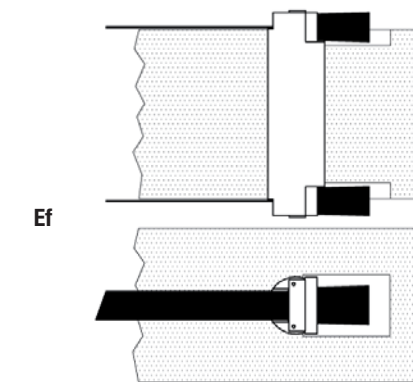
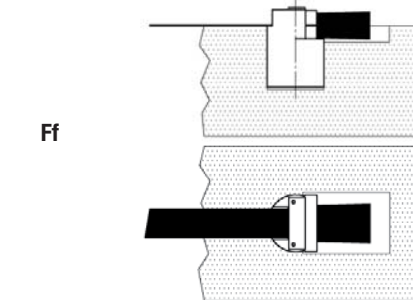
CarboStress® Anchorage System

The load from the CFRP plate is transferred via a steel anchorage into the structure. The actual connecting element of the anchorage to the structure is either a steel shear pin or a steel plate. The tensioning operation of the CFRP tendon is done on the stressing anchorage. Depending on the specific requirements for the load to be transferred to a structure, several different types of anchorage can be used:

Stressing Anchorage



Fix Anchorage



Advantages of the CarboStress® CFRP post-tensioned System:

Designer:

- High flexibility in anchorage design to suit specific structural situations
- Standard solutions for bridges, roofs, floors and walls
- Thin CFRP plates make tendon cross overs possible

- Easy and economic to bond to the structure
- Can also be used non-bonded
- Short load transfer of external PT force into sound concrete
- Increased ductility for non-prestressed structures

Contractor:

- Very light weight: A 10m tendon weighs only 3.5kg
- Can be rolled easily: no limitation on length
- Good solution for difficult access sites / structures
- Easy and fast installation without special equipment
- Strengthening at low temperatures (down to -10°C non-bonded) without additional curing equipment
- Minimal breakout on site

Owner:

- Longer life expectancy and low maintenance due to:
 - Non-corrosive CFRP tendons, no stress corrosion
 - Good fatigue characteristics
 - Pre-assembly in quality controlled factory conditions
- Active PT force: reduction of passive steel stress, crack widths and stress amplitude
- Cost effective and safe strengthening solutions for external prestressing

