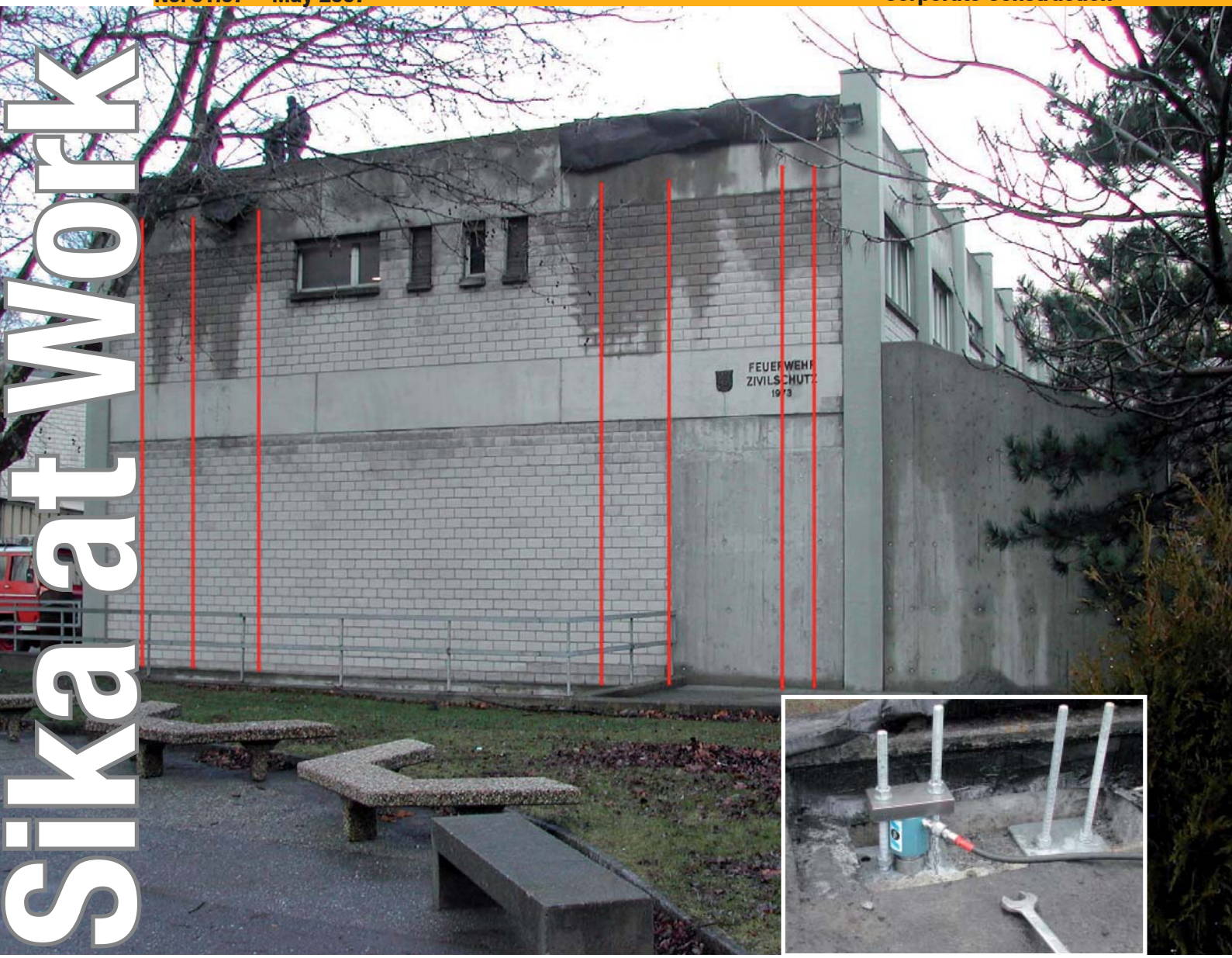
Sika at Work



Strengthening with Post–Tensioned CarboDur CFRP Plates

Increasing Earthquake Resistance

Strengthening with Post–Tensioned CarboDur CFRP Plates

It is well known that most buildings in Switzerland have not been designed to withstand earthquakes and therefore, according to some experts, there is a need for action which should not be underestimated. The municipality of Visp in Valais has decided to act and has recently increased the earthquake resistance of its municipal fire station by relatively simple structural strengthening.

The Visp municipal fire station was originally built in 1974 and in addition to the fire service it also houses the civil defence force which has regional responsibilities for major fires or disasters. The civil defence facilities and equipment are accommodated in the reinforced concrete basement. The two fire service floors are above ground and consist of a reinforced concrete framed structure with reinforced concrete floor slabs and façade cladding units. The building is 13.5 m wide and 42 m long with a flat roof.

During routine maintenance and structural assessment and inspection of the building, major earthquake safety standard deficiencies in the load–bearing structure were identified, along with typical minor building defects in structures of this type and age. The reinforced concrete frames with sand–lime brick infill panels on the gable ends of the building were the main weak points of concern.

The behaviour in earthquakes of reinforced concrete frames with masonry infill is well known to be poor. The infill panels can collapse quite easily as movement of the RC frames is impeded by the rigid wall panels, leading to very high stresses on the columns and eventually to their failure.

Suitable Strengthening

The building has been partially stabilised against the effects of earthquakes by the building of an extension on the north side. A suitable and cost effective strengthening method for the infilled gable wall on the south side was therefore also desirable. The use of the working fire station and the other facilities also had to be disrupted as little as possible during the strengthening works.

Various strengthening options were examined, including the use of CFRP plates bonded to the masonry. However, because the infilled rein–forced concrete frame only had slight deformation potential, the high tensile strength of bonded plates could not be fully utilised.

The Visp fire station building was post–strengthened to increase its earthquake resistance.

Finally the most efficient and cost effective method selected was an innovative solution with post–tensioned CFRP plates arranged vertically. This vertical post–tensioning of the masonry has increased the load resistance to horizontal forces so much that the stress from earthquakes can now be dissipated entirely through the masonry in accordance with the latest European Standards. This also secures and prevents the infill panels collapsing out of the frame.

The eight post–tensioned CFRP plates run up the inside of the external wall and are designed as un–bonded external post–tensioning. The transfer of force is through compact end anchors in the ceiling slab above the 1st floor and in the ceiling/floor slab above the basement.

Rapid Completion

The installation and post–tensioning works were each completed within one day. The building was in normal use throughout, with only minor restrictions, during that time. The preliminary design, detailed planning and correct preparation were all important in achieving this.

For the anchors on the roof slab, the waterproofing was removed locally and an anchor plate was installed. The threaded rods for the tensioning anchors were fed through the slab using two holes for each anchor.

The slots in the slab above the ground floor only had to be 8 cm wide to allow the CFRP plates to be fed through.

Some of the fixed anchors in the slab above the basement were fixed with threaded rods which were fed through the slab and anchored on the underside with steel plates. Where this was not possible, the CFRP StressHead was countersunk in a recess cut in to the slab. In this case the tensioning force was transmitted to the slab by bonded links made of standard reinforcing steel.

Before post–tensioning, the CFRP plates were suspended loosely in the anchors, lifted off the walls and coated with **Sikadur®-30** structural adhesive. The bond in this case is not designed for the transfer of force from the wall to the plate, but only to protect the plate from mechanical damage.

The post–tensioning began at the roof. The CFRP tendon was tensioned through the threaded rods by a hydraulic jack supported on the end anchorage anchor plate. The tensioning path and force were recorded and monitored to the specified values. When the required tensioning level was reached, the threaded rods were fixed with the locking nuts and the jack was removed.

High Performance and Durability

By vertical post–tensioning of the masonry with CFRP plates, the wall could be secured and the stability of the building in an earthquake could be assured. Disturbance to the occupants and use of the building was minimal during the works and non–existent after completion.

The high performance and durability of this post–tensioning method is ensured by the production and inspection of the tendons in a controlled process at the plant. The application flexibility results from its capability to make the transfer of force from the tendons to the structure in each individual situation.

The solution with post–tensioned CFRP plates arranged vertically was the best. The photo shows a view of the gable wall with the CFRP plates installed.

The CFRP Plates and System

CarboStress post–tensioning system:

CFRP plate tendons consisting of:

- CFRP plate: **Sika® CarboDur® S624** 60 mm x 2.4 mm = 144 mm²
- CFRP StressHead on both sides

Stressing anchorage consisting of:

- a stressing support structure for the StressHead with two tie rods
- an anchor for the two tie rods

Fixed anchorage consisting of:

- a fixed, self–regulating support structure for the StressHead
- a shear connector for transfer of force into the concrete

These components have the following characteristics:

StressHead 220:
Material CFRP
Weight 550 g
Dimensions 60/80 x 110 mm

CFRP plates 624:
Type **Sika® CarboDur® S624**
Tensile strength 2800 N/mm²
Dimensions 60 x 2.4 mm

CarboStress system:
Tension force Po, max. 220 kN
Anchored force Pu, max. 300 kN
Plate deflection radius min. 1.0 m without any additional measures

The CFRP tendon systems are prefabricated in controlled production processes at the VSL (Switzerland) AG plant in Subingen.

The movable end anchorage from above.

Project Details

Client:
Municipality of Visp

Project Management:
Biag Visp

Specialist for the strengthening system installation:
SikaBau AG, Steg, VSL (Switzerland) AG, Subingen

Post–tensioning system:
VSL / Sika CarboStress

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