

Sika at work



Prestressed CFRP Plates

Strengthening of a Sports Hall Roof

Case Study



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Summary

Prestressed CFRP plates were used to strengthen the roof of the sports hall at Thörl secondary school (Styria, Austria). They reduced the deflection and improved both the structural integrity and the serviceability. The visible condition of the structure and the results of the structural analysis showed a need to strengthen the roof downstand beams longitudinally. Due to the deflection under existing loads, a solution involving prestressing was the only practical and viable option.

Project

The secondary school at Thörl (Upper Styria) was built in the 1960s and was being fully refurbished. The structural investigation and survey carried out prior to the refurbishment included the sports hall, which had six structural bays. The sports hall roof loads were supported by single span reinforced concrete trusses on columns into the foundations. With a span length of 12.20 m, the trusses are 50 cm thick and 20 cm wide. The survey found that the 5 existing reinforced concrete downstands at the centre of the beams had deformed by 5 cm under dead load (without live load). The ceiling and beam slope was 3%.



Fig. 1: Front view of the sports hall with the 6 structural bays



Fig. 2: Interior view: 5 reinforced concrete trusses to be strengthened

Problem

A review in accordance with current standards showed that the bending resistance and flexural rigidity in the transverse direction of the sports hall were insufficient, which explained the deflection of the beams. According to the structural engineer, about 30% of the necessary steel reinforcement area was missing from each beam. The objectives of the refurbishment and strengthening were as follows:

- To repair the damage and defects
- To correct the cause of the defects
- To make the building structurally safe and serviceable for the future

The strengthening was designed in accordance with Austrian Structural Standard B4700:

- The sports hall roof downstand beams were strengthened for sagging moments
- The deflection under both dead and live loads had to be reduced



Fig. 3: Truss-column detail from inside the hall



Fig. 4: Truss-column detail from outside

Sika Solution

Different options, such as load reduction, concreting on top of the roof, modifying the structural design, prestressing the beams as well as supplementing the existing reinforcement by steel rebars or bonded FRP, were compared.

The new specifications were best met by installing prestressed composite CFRP plates. The CFRP plates were applied on the beam soffits and laterally on the web.

The prestressing force was specified as 3x120 kN per beam with the higher ductility of the plates in mind.

The existing reinforcement was stress relieved by applying the prestressing and this could be fully utilised to take the live loads. By interacting with the composite CFRP plates applied, this repair system enabled the structural safety to be assured, and the serviceability to be greatly improved.

The key to any prestressing is the anchorage and the transmission of the forces into the structure. In CFRP plate prestressing, repeatability, quality and efficiency - particularly of the final anchorage of the tie bar - are the key to system durability and performance. With the prestressing system selected, the final anchorage of the plate is ensured by a pre assembled stress head (Fig. 10) made of corrosion resistant carbon fibre material. The **Sika® CarboStress®** prestressing system used contains a tendon consisting of a CFRP plate and a stress head at both ends.

The prestressing tendons are traceable all through their production, right down to each individual fibre, via a batch number printed on the CFRP plate.

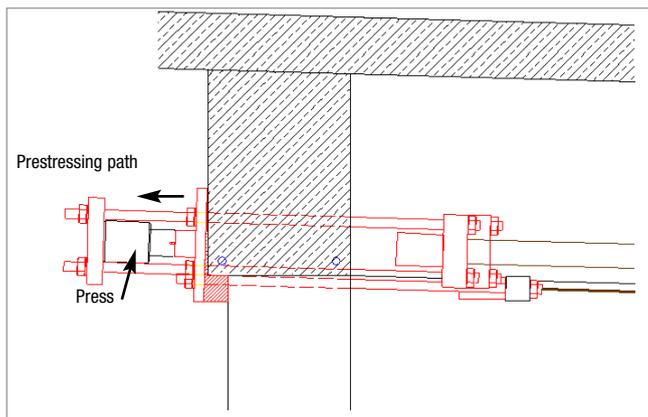


Fig. 5: Configuration on prestressing side

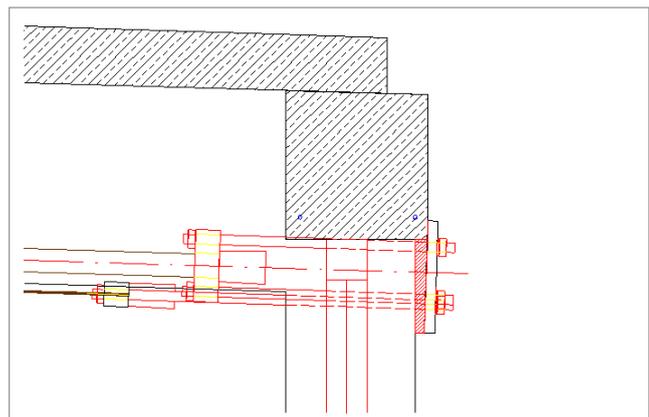


Fig. 6: Configuration on fixed side

After reaching the design prestressing force of 120 kN per tendon, the nuts on the base plates on the prestressing side were tightened to fix the CFRP plates in their position. The press was then moved away and dismantled.

The areas between plate and structure were then grouted and sealed with Sikadur 30 (Fig. 10). This finally provided the composite action with the structure. The same adhesive is generally used to install non prestressed CarboDur plates and has proved effective for many years.



Fig. 7: Base plate on prestressing side in the roof space



Fig. 8: Base plate on fixed side outside



Fig. 9: Hydraulic presses in the roof space pulling the threaded rods outwards



Fig. 10: Prestressed CFRP plates before bonding

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Conclusion

The load bearing capacity and flexibility in design of the end anchors of the Sika® CarboStress® carbon fibre plastic prestressing system, gave the engineer the necessary freedom for the detailed design of the strengthening system with safe and secure transmission of the loads. The decision to use this prestressing system was made on the basis of its low installation cost and the careful transfer of the prestressing forces into the structure, without damaging the existing reinforcement.

Technical Data of Sika® CarboStress® prestressing System used:

CFRP plate	Sika - CarboDur S624
Cross section	60 mm x 2.4 mm
Characteristic tensile strength f_{tk}	2800 N/mm ²
Elastic modulus	170 kN/mm ²
Plate anchorage (stress head)	StressHead
Dimensions of stress head	60 / 80 mm x 110 mm
Maximum anchorable force	300 kN
Initial prestressing force P_0	3 x 120 kN
Stress in the plate at P_0	3 x 840 N/mm ² (0.30 f_{tk})
Strain of the plate at P_0	0.52%

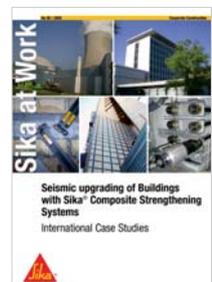
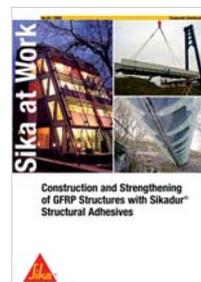


Fig. 11: Sports hall after completion of the strengthening works

Project Participants:

Client:	Municipality of Thörl (Austria)
Main contractor:	Hitthaller GmbH, Kapfenberg (Austria)
Prestressing design:	Schaur ZT GmbH, Thaur (Austria)
Application of CFRP plates:	BAM, Götzis (Austria)
Prestressing:	Grund , Pfafl und Sonderbau, Himberg bei Wien (Austria)
CFRP prestressing system:	Sika® CarboStress®

Also available



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