

Shear strengthening of reinforced concrete with CFRP L-shaped plates

A systematic large scale test program confirmed the feasibility of CFRP (Carbon Fiber Reinforced Plastic) L-shaped plates for shear strengthening of reinforced concrete T-beams. The interaction between CFRP L-shaped plates and reinforced concrete was studied in detail. As an important basis for the planning of retrofitting projects, a design proposal was presented.

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Post-strengthening of reinforced concrete structures like bridges or buildings with CFRP plates, in contrast to steel plates, have the advantage of being substantially lighter. The handling on site is therefore much easier. The CFRP plates are also corrosion-resistant and exhibit excellent fatigue strength.

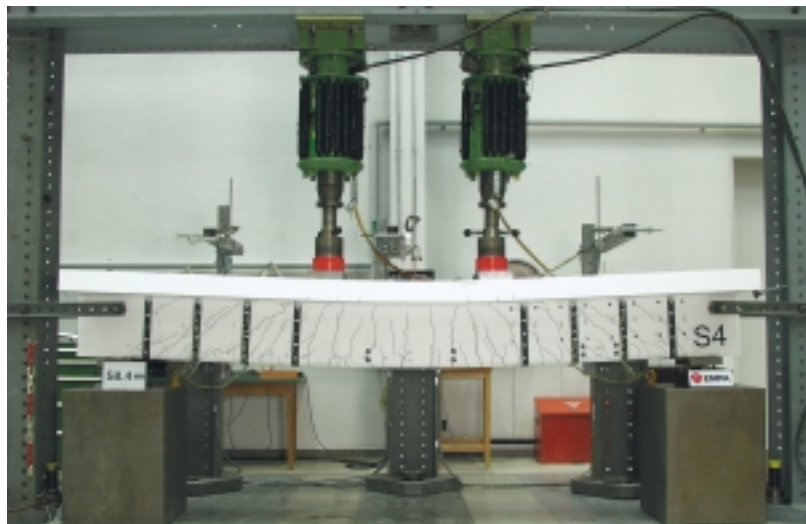


Fig. 1: Shear strengthened test beam.

Prefabricated “CFRP L-shaped plates” (Sika® CarboShear L®) can be used to shear strengthen reinforced concrete T-beams. In a previous test series, EMPA was able to demonstrate the feasibility of these CFRP L-shaped plates for shear strengthening. To obtain a better understanding of the load-bearing behavior of this strengthening system, a further systematic test program was performed in partnership with a Swiss industrial company (Sika AG, Zurich). A test beam specially designed for high shear stresses was tested with different arrangements of the shear reinforcement (Fig. 1). Consequently, the influence of the CFRP L-shaped plates on the shear resistance of the test beams could be shown (Fig. 2). The results were used to improve the design concept for the shear strengthening of reinforced concrete structures using CFRP L-shaped plates.

From the investigation, the following conclusions can be drawn: through the use of the CFRP L-shaped plates, the brittle failure mode “shear failure” of the beam can be changed to a ductile behavior with yielding of the internal flexural reinforcement (Fig. 2). The CFRP L-shaped plates can increase the shear failure load so that a structure can bear higher live loads. The CFRP L-shaped plates can also be used to obtain better behavior in the serviceability limit state with a reduction of the shear deformations of the beam, the strains in the internal steel stirrups and the crack width. Furthermore, important for the design, the concrete, the internal steel stirrups and the externally applied CFRP L-shaped plates act together to bear the shear load.

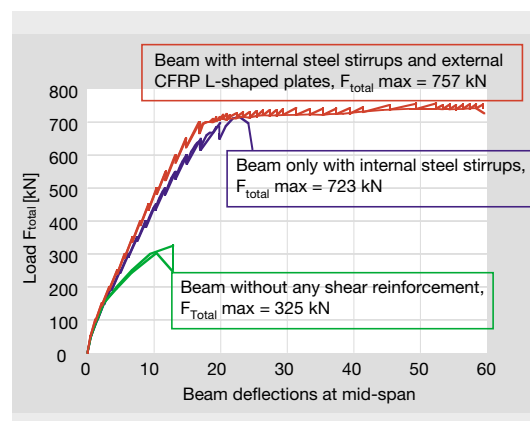


Fig. 2: Comparison of loading tests on beams with different shear reinforcements.

The proposed simple design concept describes the load-strain behavior of the shear reinforcement and the possible failure modes of the CFRP L-shaped plates. Design verifications were presented for ultimate limit state, serviceability limit state and accidental situation.

In order to evaluate the mechanical behavior of the strengthening system, it is intended to carry out appropriate numerical analysis.

Support: BBT-KT1 3930.1

Links: www.empa.ch/retrofitting
www.sika.ch

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