Strengthening of structures with carbon fibre strips

Strengthening of Structures with Carbon Fibre Strips

Juergen HAASIS
Civil Engineer
Sika Chemie
Stuttgart, Germany

Juergen Haasis, born 1943 in Tuebingen, received his civil engineering degree from the Technical University Munich in 1969. Lateron he issued structural safety approvals and since 1971 he is Field Manager for concrete refurbishment.

Summary

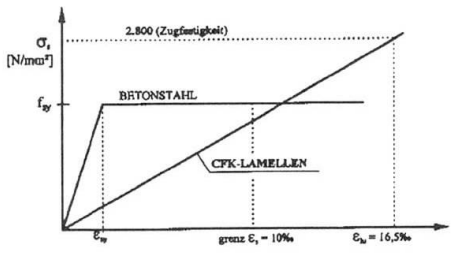
Structural strengthening has always been state-of-the-art technology. Various reasons and causes such as change of use, damages or calculation errors are only some examples for cases where strengthening will become necessary. Conventional measures like strengthening with reinforced shotcrete are costly and often result in disturbingly enlarged cross-sections. Measures using bonded steel plates permit smaller cross-sections: A height increase will only become necessary if the safety margins in the compression section of the concrete are exhausted. Similar to the above described strengthening method with steel plates, but more elegant and thereby more versatile is the use of carbon fibre strips, a material which has proved ist test of practice long ago, especially in aircraft construction and in the formula-one, as well as in the manufacturing of sports articles (tennis-rackets, etc.)

Structural Strengthening with Carbon Fibre Strips

The classical theory of steel reinforced concrete is based on the model of a truss girder with horizontal ties and struts and diagonal members. The function of the horizontal as well as of the diagonal struts (as far as the values „remain within certain limits") is taken over by the concrete, the function of the horizontal tie is taken over by the reinforcement . In case of change of use, damages or calculation errors it may become necessary to strengthen the horizontal tie, for adding tensile strength to the above truss girder model. This works only under condition that the cross-section in the compression section retains the appropriate reserves.

Bonded, additional external reinforcements, based on carbon fibre strips, are worldwide proved for approx. 10 years and have reached break-through in reinforced concrete construction. A general Technical Approval with the Number Z-36.12-29 of the „Deutsches Institut für Bautechnik (DIBt)", Berlin, is available for the carbon fibre strips and for the adhesive. No matter which type of girders on cantilevered sections are concerned, the carbon fibre strip can in principle always be used wherever tensile forces have to be dealt with in the sense of truss girder analogy. The higher material cost of carbon fibre strips compared to steel plates is compensated by much easier application and by special advantages line unlimited lengths, easy handling and corrosion resistance. The strengthening on the rear side of a wrongly dimensioned supporting

wall is therefore an example for unrestricted use of carbon fibre strips , whereas bonded steel plates are unsuitable because they cannot safeguard longterm corrosion protection.



Contrary to steel, (see characteristic tension-elongation diagramme in Fig. 1), the carbon fibre strip shows an ideal elastic behaviour until break . The tension σ is ideally proportional to elongation ε until break. The break occurs after approx. 16‰, the permissable elongation when strengthening a beam is limited to 8‰ in the Approval.

Fig. 1: Tension/elongation line steel/carbon fibre

As long as the ongoing research is not yet completed, transmission of compressive forces must be distributed with steel plates for the time being, analogous to the principles of steel reinforced concrete with the incorporation of ring bars. Carbon fibre strips are suitable for reinforced concrete, pre-stressed concrete, timber and steel. Strips are available with various E-moduli (3 types with 170, 210 and 300 Gpa). The thixotropic, filled epoxi adhesive is universally suitable for concrete, steel and wood. Two practical examples of strengthening measures on bridge constructions show the possibilities for the use of carbon fibre strips:

- Bridge Niederwartha (Dresden)
Unlimited use is now re-established after extensive repair measures in combination with carbon fibre strip strenghtening.

- Bridge Meiningen

On this project re-strucuring relied on combined measures: For the transmission of compressive forces, reinforced concrete wa cast on top whereas the tensile strength on the underside was increased to the required level by carbonfibre strips as can be seen in fig. 3.

- Bridge Luzern

Wooden bridges are often classified as monuments. It is therefore essential that the increased safety demands are met with almost unvisible measures without changing exferion appearance.

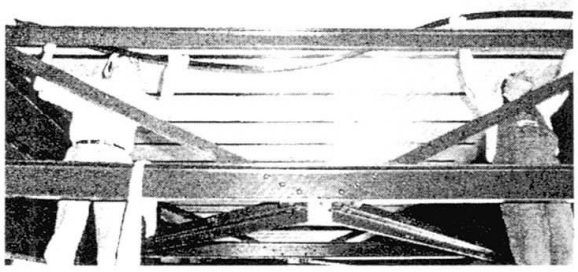


Fig. 2: Bridge Meiningen

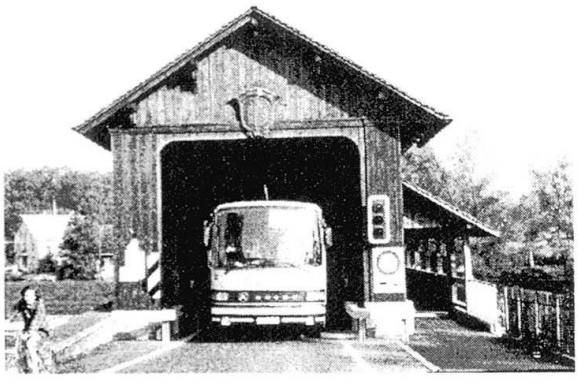


Fig. 3: Bridge Luzern