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Cable-Stayed GFRP Footbridge across Railway Line

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Abstract

The use of fibre reinforced plastic (FRP) in bridge building is fairly novel. The first European example the 113 m long Aberfeldy Footbridge, a cable-stayed bridge spanning 63 m over a stream on a Scottish golf course, installed in the early nineties.

In June 1997 a new FRP bridge for pedestrians and cyclists was opened at Strandhuse near the Danish town Kolding. As the first advanced composite bridge in Scandinavia it has the further distinction of being the first FRP bridge crossing a busy railway trunkline. The cable-stayed bridge is constructed entirely of glass fibre reinforced plastic (GFRP), and it is the result of a collaboration between a local producer of pultruded GFRP profiles, a major consulting engineering company, and a public owner who was willing to consider an innovative replacement of a footbridge removed due to the increased clearance profile resulting from electrification of the railway. The erection of the bridge was carried out in just 18 hours.

Description

The width of the bridge is 3.2 m, and the length is 40.3 m, with spans of 27 m and 13 m. The 1.5 m deep girder and the 18.5 m high, asymmetrically placed pylon are constructed from standard GFRP profiles joined by stainless steel bolts, and the stays are 100 x 100 mm^2 GFRP cables. The only steel components are the bolts and the foundation inserts. The total weight is 12.5 t, less than half of a corresponding steel structure. The total capital costs are 5 - 10 % higher than alternative designs in steel or concrete, but this is offset by the resistance of the GFRP material to water, frost, and de-icing salts, implying that cosmetic maintenance only is envisaged for the next 50 years. The bridge, known as the Fiberline Bridge after the producer, is shown in Fig 1.

Design

The bridge is designed for a live load of 5 kN/m^2 plus a 50 kN moving point load, representing a snowplough or the occasional ambulance. In accordance with Danish code tradition limit state design based upon the partial coefficient method is used. The two pairs of stays on either side of the pylon minimize the deflections which would otherwise result from the low stiffness of the GFRP material.

Fig. 1. Fiberline Bridge at Kolding, Denmark

Manufacture

The GRFP stays, as well as the profiles used for bridge girder and pylon, are produced by pultrusion, a process whereby the fibreglass reinforcement is pulled trough a permanent form, into which the polyester resin matrix is injected and cured. The profiles are cut to length and shaped by ordinary hand tools, and bolted together.

Installation

The bridge was brought to site in three pieces (pylon and two girder sections), and erected during three of the 8 hour Saturday night sessions allowed by the railway authorities.

Monitoring

The fact that the bridge crosses a busy railway line causes sharp focus on safety and reliability, and a system is established to monitor stresses and deformations due to changing loads. Key bridge components, including the stays, are fitted with strain gauges wired to a permanent control station, and universities are invited to use the bridge as a test site.

Conclusion

Data on long-term performance are still outstanding, but the experience indicates that FRP is a viable material for minor bridges with a premium on swift erection and minimal maintenance.