Renovation design of the Bridge at Ewijk in The Netherlands

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Summary

This paper elaborates on the assessment and renovation design of the steel box girder of the Bridge at Ewijk. The bridge is renovated to apply a high strength concrete overlay to provide a sustainable solution for fatigue damage in the deck. The clearance for navigation traffic is also to be increased and a new porous asphalt surfacing will be applied. The paper describes the lifting of the bridge and the effective strengthening concept which was developed from a detailed understanding of the structural behaviour of the bridge.

Keywords: Renovation, steel, box girder, bridge, design, HSC, concrete overlay, assessment, fatigue, cable stay.

1. Introduction

The Bridge at Ewijk is a 1055m long cable stayed steel bridge which opened in 1976. It carries five lanes of traffic over the river Waal and its flood plains in 10 spans without intermediate joints (Fig. 1, Fig. 2, Fig. 3).

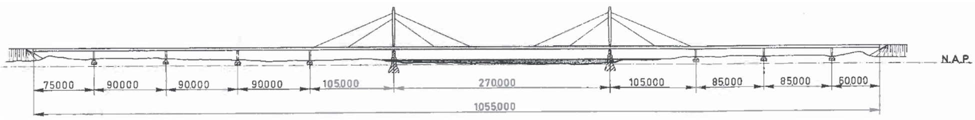

Fig. 1: Elevation of the bridge [1].

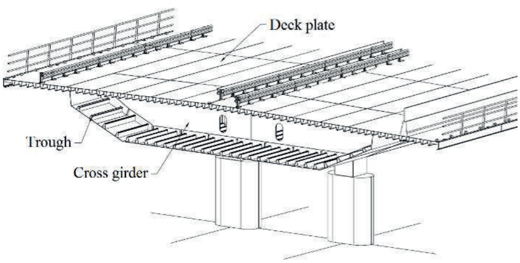

Fig. 2: 3D view of the typical bridge structure.

Fig. 3: Bridge at Ewijk.

The bridge requires renovation to provide a sustainable solution to local fatigue damage in the deck through application of a HSC overlay. Together with the porous asphalt overlay, this increases the dead load on the structure by approximately 50%. The live load requirements have increased

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significantly from the values used in the original design. The static global resistance of the box girder bridge deck must therefore be increased. The static local capacity of the deck plate to wheel loads and the global fatigue resistance of the structure proved sufficient.

2. Assessment and renovation

The reduced stress method from the Eurocode [2] was used to check the capacity of the steel panels in the box girder bridge deck. This method can use the stress output from the finite element models directly. This showed to be an efficient way of working for a steel box girder structure.

An effective strengthening concept was developed from a detailed understanding of the structural behaviour of the bridge. The static shear capacity of the box girder is insufficient and the top and bottom flanges show concentrations of longitudinal stresses resulting from shear lag effects. Instability of large steel panels causes issues in the bottom flange and inclined panel.

One support location in the southern approach is found to be the governing area. Other locations on the bridge have similar issues, but never to a greater extent. The cable stayed area sees little issues, as the box girder deck is supported relatively frequently by the stay cables.

Strengthening was developed for the governing location and repeated elsewhere as required. The strengthening concept activates more of the existing steel in the structure by stabilising large panels and by applying two lines of bracing (Fig. 5). The bracing changes the stress distribution in the box girder to relieve shear stresses in the webs and distribute bending stresses in the top and bottom flanges (Fig. 4).

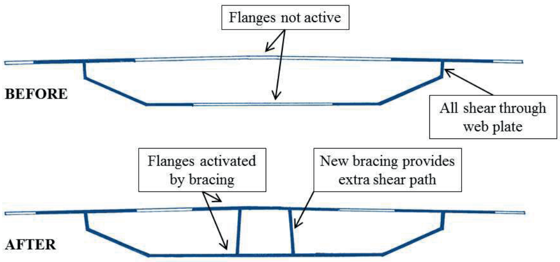

Fig. 4: Bracing concept

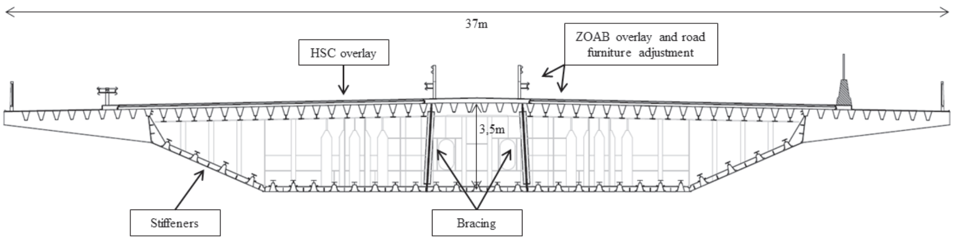

Fig. 5: Typical section of the box girder (after strengthening).

The bridge is lifted to achieve a 1250mm raise at midspan to increase navigation clearance. The structural continuity of the bridge was used in the jacking design to obtain the required clearance within tight constraints. Other elements of the renovation include the replacement of the stay cables, the application of porous asphalt and the replacement of bearings and joints. Construction started in the autumn of 2012 and is to be completed in 2014.

3. References

[1] VAN DER SCHAAF T., SPOELSTRA J.S., DE WITTE J., and WOLTERS H.W., *Stalen tuibrug over de Waal bij Ewijk*, Rijkswaterstaat, Voorburg, The Netherlands, 1976.

[2] Eurocode 3: Design of steel structures - Part 1-5: Plated structural elements, Nederlands Normalisatie-instituut, 2006.