Assessment and Strengthening of the Kreekrakbrug

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Summary

The Kreekrak bridge was constructed in 1974. It suffers from fatigue damage in its orthotropic deck and has insufficient static strength for future traffic loads. It therefore requires to be renovated and a combination of applying a high strength concrete (HSC) overlay, jacking and strengthening of the main steel members of the bridge has been designed for this purpose. The sequence in which the renovation is executed has been developed to ensure an efficient strengthening design.

Keywords: Steel bridges, assessment, refurbishment, jacking, bypass, strengthening, fatigue, tension bearings, clearance, retrofit, HSC overlay

1. Introduction

The Kreekrak bridge is one of eight landmark bridges that have been selected for renovation by Rijkswaterstaat (RWS), the Dutch national transport authority.

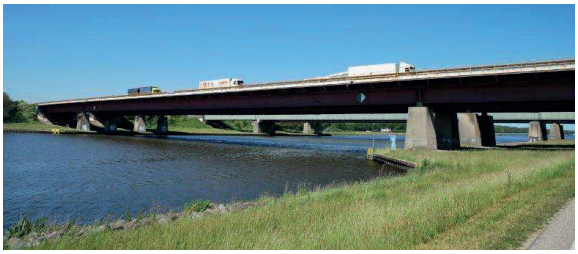

Fig. 1: Kreekrakbrug

The two structures are twin plate girder bridges with steel orthotropic decks. The relatively short side spans compared to the main span result in a tension force at the abutments under permanent loads. Tension-compression bearings are used to accommodate this.

The reason for the renovation of these 40 year old steel bridges is that they suffer from fatigue cracks in the orthotropic deck due to the increased weight and number of heavy vehicles using the highway network. The bridge is subject to a stringent regime of inspections and repairs have been carried out to ensure a sufficient safety level until it is renovated.

2. Existing behaviour and condition

An assessment of the bridge found that the bridge does not have sufficient capacity to carry future loads specified by RWS to ensure a remaining life of 30 years, with significant deficiencies in some elements. The main such problem is an overstress in the main girders resulting from direct stress. The assessment made use of innovative methods in order to ensure all reserves of capacity within the existing structure were utilised. Assessment calculations were performed in accordance with the Eurocodes as modified by Dutch National Annexes.

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3. Strengthening

It was decided to adopt a recently developed method for strengthening orthotropic steel decks with the application of a High Strength Concrete (HSC) overlay on top of the deck. The project, contract setup, first on site experiences and the HSC design are described in reference [1].

Several initial concepts were developed for static strengthening of the bridge. The merits of each were judged on the basis of risk, hindrance to traffic and cost. Ultimately a solution which reinforced the existing supporting structure of the bridge was selected. The design consists of a combination of three measures – strengthening of main girders by adding steelwork, jacking at the piers and removal of traffic during renovation.

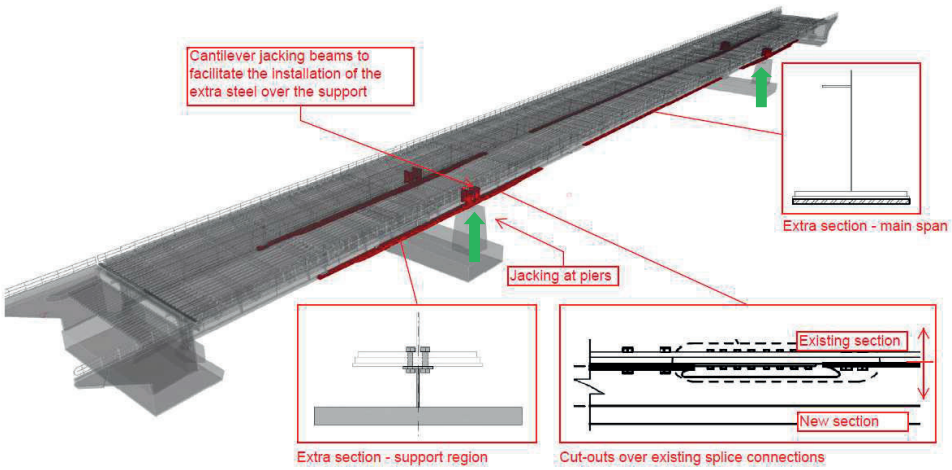

Fig. 2: Overview of strengthening design

4. Discussion, Conclusions

The strengthening design maximises the capacity of the existing structure and ensures a useful remaining life for a bridge which – aside from fatigue damage in the orthotropic deck – is in relatively good condition. Subtle modifications to the superstructure, optimised by the construction sequence, boost the traffic load capacity of the bridge by more than thirty percent. The clearance beneath the bridge is improved by the same measures.

Several of the design challenges stem from the philosophy employed during the original design of the bridge. The level of optimisation seen, for example, in the build up of plates in the main girders illustrates the desire to minimise material costs. The use of lower grade steel in the webs of the same girders is another example, but the most striking is the span arrangement itself. Relatively short side spans were chosen despite the blank canvas that the site presented at the time of construction. The resulting cycling between tension and compression at the abutments was dealt with through the use of innovative bearings. These features added complexity to the design.

5. Reference

[1] DOOREN van F., NAGTEGAAL G, ASHURST D., GRATION D., KUNST P. and BLANKEN DEN S.M., *"Orthotropic Deck Fatigue: Renovation of 8 Bridges in the Netherlands" , Structural Faults + Repair Symposium, Edinburgh, 2010.*

6. Acknowledgement

In 2009 Rijkswaterstaat appointed the Managing Contractor for the assessment, inspections, engineering, procurement, stakeholder management and construction supervision of eight bridges. The JV Managing Contractor consists of three parties: Arup, Royal Haskoning and Greisch.