Renovation of Orthotropic Steel Bridge Decks

Paul QUIST
Civil Engineer
Breijn B.V.
Rosmalen, The Netherlands
pquist@breijn.nl

Paul QUIST, born 1981, received his civil engineering degree from Delft University of Technology in 2009. He has been working for Breijn since his graduation.

Ron PEPERS
Civil Engineer
Heijmans Civiel B.V.
Rosmalen, The Netherlands
rpepers@heijmans.nl

Ron PEPERS, born 1974, received his civil engineering degree from Delft University of Technology in 2004. He has been working for Heijmans since his graduation.

Albert REITSEMA
Civil Engineer
Breijn B.V.
Rosmalen, The Netherland
areitsema@breijn.nl

Albert REITSEMA, born 1985, received his structural design degree from Eindhoven University of Technology in 2012. He has been working for Breijn since his graduation.

Summary

This paper is about the renovation of orthotropic steel deck bridges. It proposes a new solution for placing an overlay of prefabricated HSRC elements on the bridge deck to prevent fatigue damage.

Keywords: Orthotropic steeldeck bridges; fatigue; renovation; prefab overlay; high strength reinforced concrete (HSRC); no shear connection; flexible interlayer

1. Introduction

Several orthotropic steel bridges were built in the primary road network of the Netherlands during the 1960s and 1970s. These steel bridge decks have reached the end of their lifetime earlier than expected, due to fatigue damage in specific locations of the structure.

2. Overlay with flexible interlayer

Due to the configuration of the bridges and the loads they bear, fatigue cracks appear at specific locations. These locations are: Deckplate, connection through and deckplate, connection trough and cross-girder, the connecting piece of the trough.

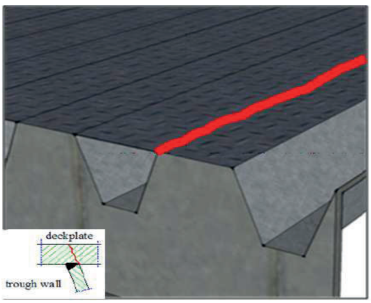

Figure 1 Deck plate crack 1 above cross-girder

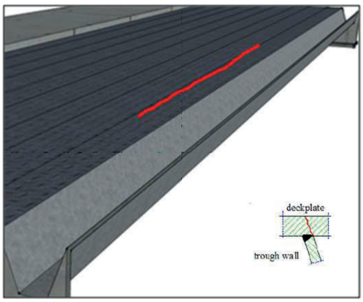

Figure 2 Deck plate crack 2 in the middle of the span

The cracks in the deck plate are located above the connection between the web of the trough and the deck plate itself.

The current solution, which has already been applied to several bridges in the Netherlands, consists of an in situ HSRC layer that is fully connected to the steel deck of the bridge. The connection is achieved by gluing bauxite to the steel deck before pouring the concrete over the bridge deck. The HSRC layer contains steel fibres and is reinforced.

Many problems occurred during the process of making the in situ concrete overlay. The consequences include traffic obstructions, quality issues and high (or higher) costs.

A new prefab HSRC solution has been proposed to solve the problems that occur during, or as a result of, the execution. The solution consists of an overlay of HSRC prefab elements, connected to the steel deck by a relatively thick, flexible interlayer.

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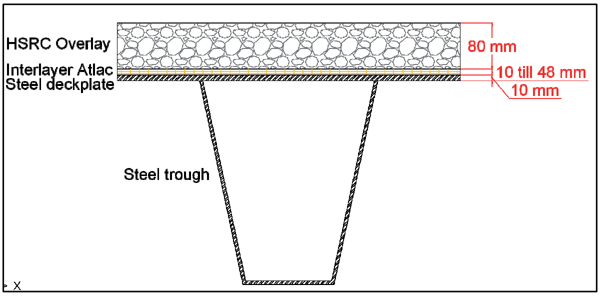

Figure 3 The overlay

The concrete plates are 80 mm thick, with two layers of reinforcement of Ø10-75 in an orthogonal direction. The concrete quality is C90/105. The variable surface of the steel deck is followed by the flexible interlayer. The thickness of the flexible interlayer is expected to vary by 38 mm, so the minimum thickness of the interlayer is 10mm and the maximum thickness is 48mm. [1]

The interlayer is a polyester resin, which is specifically composed for this purpose by DSM. It is based on a resin and has a stiffness of 1000 Mpa. [1]

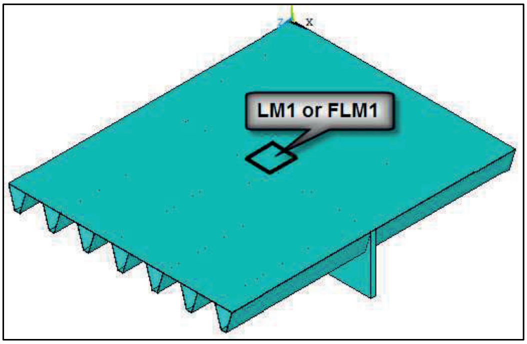

Figure 4 Model for the normative stresses

The section shown in figure 4 is modelled in a finite element program, since this renders the normative hot spot stress.

Calculations were made for the configuration of figure 3 according to the Eurocode [2]. Load Model 1 is normative for the concrete stresses, while Fatigue Load Model 1 is normative for the steel stresses at the hot spots identified in figures 1 and 2. The normative situation theoretically occurs when the loads are placed above the cross girder.

If the load is placed directly on the steel deck, the stresses in the steel deck plate reach 249 N/mm2 (maximum tension) and 279 N/mm2 (maximum compression).

The results after installing the HSRC prefab elements with the flexible interlayer on the steel deck plate are shown in table 1.

Table 1Stresses with the new prefab HSRC solution [1]

	HSRC stress		Interlayer stress		Deck plate stress		Shear stress in HSRC			Shear stress in interlayer		
N/mm²	σ1;max	σ_3;max	σ_1;max	σ_3;max	σ_1;max	σ_3;max	τ;xy	τ;yz	τ;xz	τ;xy	τ;yz	τ;xz
10mm interlayer	**7,2**	**-7,5**	**1,1**	**-3,5**	*35,99*	*-47,9*	**1,22**	**1,05**	**1,4**	**0,95**	**1,05**	**0,15**
48mm interlayer	*5,7*	*-6,9*	*0,8*	*-2,2*	**44,48**	**-54,27**	*0,9*	*1*	*1,4*	*0,7*	*0,77*	*0,15*

3. Acknowledgement

This product has been engineered by Heijmans. The interlayer is developed by DSM.

References:

[1] Paul Quist, Albert Reitsema, Ron Pepers; “Conceptontwerprapport overlagen met prefab HSB; Prefab HSB platen op orthotrope stalen rijdekken met behulp van een flexibele hechtlaag”, *Kenmerk HCI-12-0001*, 3 mei 2012.

[2] NEN-EN 1991-2+C1; Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges + NA+C1 (the Netherlands)”, December 2011