Maintenance of orthotropic steel bridge decks with longitudinal Y-stiffeners

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Summary

This paper gives an overview on research realized for orthotropic steel bridge decks, especially considering longitudinal Y-stiffeners. In a running research project fatigue cracks observed at existing bridges with Y-stiffeners were documented together with the original shop drawings based on literature and personal research. Furthermore, existing methods of repairing of cracks between stiffener and crossbeam have been summarized. Promising innovative methods of maintenance were identified and fatigue tests on these details and their repairing methods were realized. Thereby, the construction detail in the original condition and the construction detail in the repaired condition are tested and compared to each other in order to estimate the effectiveness of the maintenance method. First results of this running research program are presented.

Keywords: Longitudinal Y-stiffeners, orthotropic steel bridge, fatigue, maintenance.

1. Introduction

Orthotropic steel highway bridges were built since the 1950s and some of these bridges are still in use today. Typically, orthotropic steel bridge decks (orthogonal and anisotropic) consist of a deck plate, longitudinal stiffeners, crossbeams and main girders, Fig. 1 left. Originally, a fatigue assessment of orthotropic steel highway bridges was formerly not necessary in Germany, in contrast to railway bridges and adversely to the requirements of today. Fatigue assessment was not seen as decisive due to the reduced traffic load compared to railway traffic and due to traffic prognoses that estimated only a minor increase for the next twenty years. Nowadays, it is known that the former assumptions were too optimistic. The unexpected and rapid increase of freight traffic in the last years has lead to many fatigue cracks primarily at welded joints due to the cyclic traffic load. Dependent on the crack location following categories may be differentiated: Category 1 (cracks at deck plate), Category 2 (cracks at longitudinal stiffener), Category 3 (cracks at crossbeam) and so on. Furthermore, for longitudinal Y-stiffeners the Category 2 may be differentiated into Category 2a (cracks at welded splice joint with steel plate backing), Category 2b (cracks at welded joint between fitting longitudinal Y-stiffeners and crossbeam web) and Category 2c (cracks at the cut-out in the crossbeam web), Fig. 1 right.

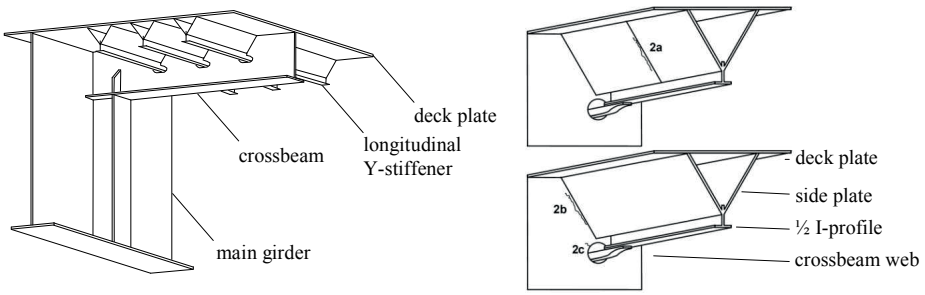

Fig. 1: Schematic illustration of an orthotropic steel highway bridge deck with longitudinal Y-stiffeners

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2. Existing bridges with longitudinal Y-stiffeners

2.1 Construction details of longitudinal Y-stiffeners

At the beginning of the development only open stiffeners were used. With increasing distance between the crossbeams and for reducing manufacturing costs, closed stiffeners with a higher stiffness have shown to be advantageous. Tab. 1 provides an overview of various shapes of closed stiffeners which have been used in Germany. Because of the large amount of bridges with Y-profiles in Germany, there is a strong demand for maintenance and rehabilitation of these bridges.

Tab. 1: Shapes of closed longitudinal stiffeners in Germany

Number of bridges	Shapes of closed longitudinal stiffeners	Year of construction
about 6	U-profile	1954 - 1972
about 2	V-profile	1961 - 1962
about 25	Y-profile	1957 - 1976
since 1975 more than 30	trapezoidal-profile	1954 - today

3. Investigations

3.1 Test program

Scope of the research project is evaluating innovative maintenance (repair and strengthening) methods for the fatigue prone details of Y-shape longitudinal stiffeners of orthotropic steel decks. Therefore, test specimens have been fabricated according to construction plans of existing bridges and will be tested under fatigue loading until failure, repaired and tested again under the same loading condition, in order to estimate the effectiveness of the maintenance methods, Tab. 2.

Tab. 2: Test-program at University of Stuttgart, Germany

Fatigue crack category	2a	2b	2c
Detail description	Window joint	Strap plugged through	½ I-profile continuous
Reference tests	3 pieces	3 pieces	3 pieces
Maintenance method on cracked reference	3 pieces	3 pieces	3 pieces
Maintenance method directly fabricated	3 pieces Ceramic backing	-	-
Sum of all tests	21 pieces		

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