Fatigue Reinforcement with Attaching UFC Panels on Orthotropic Steel Deck

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Summary

There is a pressing need to identify the causes and to retrofit orthotropic steel bridges for realizing the sustainable structures. This paper discusses our investigation of the mechanism of fatigue damage. This paper also discusses the retrofit method for the fatigue cracks on weld bead between the deck plate and trough rib. We addressed the stress reduction by attaching UFC(Ultra-high-strength Fiber-reinforced Concrete: Ex. Ductal) panels onto deck plate. Our method could reduce stress at scallop of transverse rib up to 30%.

Keywords: Fatigue, Orthotropic steel deck, Crack, Retrofit, UFC panel, Ductal

1. Introduction

Since orthotropic deck structures are lightweight, they have been extensively constructed for long span bridges. However, many cases of fatigue damage have been reported [1]. The orthotropic deck systems are composed of many thin plates. Because the deck system directly supports the traffic load, severe stress conditions, which lead to the serious fatigue damage, have occurred everywhere. The identification of the mechanism of the fatigue cracks on the orthotropic deck bridge is the first purpose of this study. The objects of our study are the longitudinal weld of the deck plate and trough ribs. Second purpose is to propose the retrofit technique for the cracks by controlling the deck deformation with UFC panels.

2. Local Stress and Deformation

The target bridge consists of the orthotropic deck with two box girders and three continuous spans. The numerical models were composed in three steps as shown in Fig. 1. Fig. 2 shows the deformation and analytical result by moving the load in the transverse direction. We can see the severe stress concentration on the weld root corresponding to the complex deformation of the deck plate. At about the position of the load, the highest stress occurred,

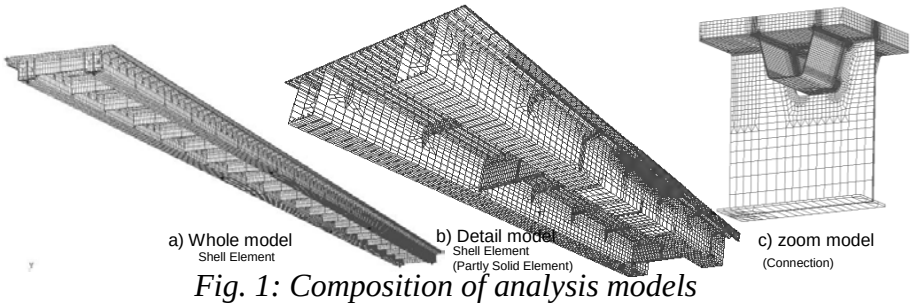

Fig. 1: Composition of analysis models

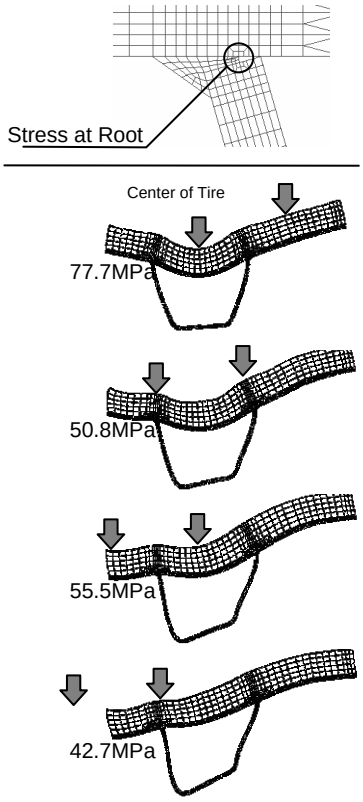

Fig. 2: Deformation and stress at root

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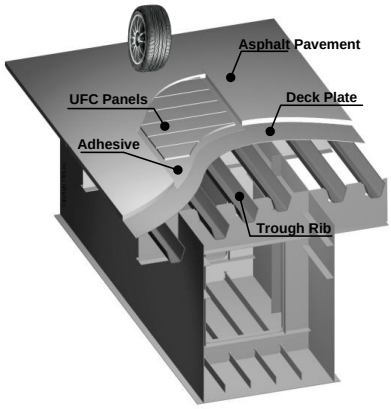

Fig. 3: Retrofit idea with UFC Panels

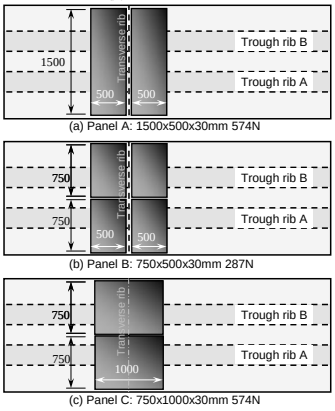

Fig. 4: Layouts of UFC panels

when the web of the trough rib on the opposite side was subjected to the centre of the wheels. A relatively high tensile stress also occurred, when the trough rib beside the object rib was subjected to the load.

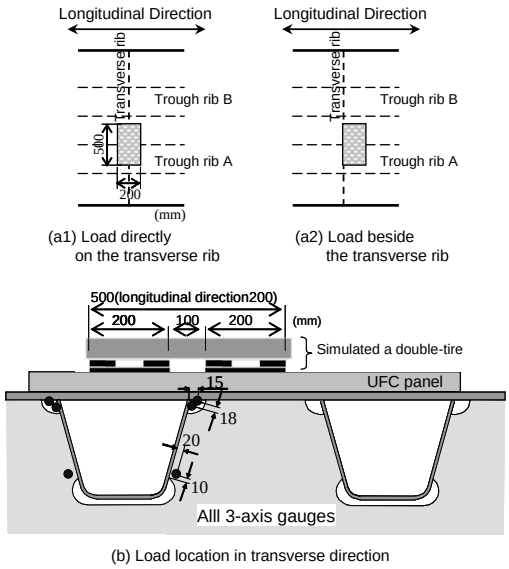

Fig. 5: Load and gauge location

3. Control of Deformation

The mutual deformation of the trough rib, which followed the deflection of the deck plate, produced the local stress. We propose the retrofit technique as shown in Fig. 3. The UFC panel has possibility to realize the stiffened deck plate. Adhesion of precast UFC panels enables rapid application.

4. Stress reduction effectiveness of UFC panel

The stress of orthotropic steel deck structure is strongly influenced of the composition of members. Therefore, static load test with an actual size specimen was carried out in order to examine the effectiveness for stress reduction. 3 arranged UFC panels, 2 load patterns are considered as shown in Figs. 4, 5. All panel thicknesses are 30mm.

Stress distributions in transverse direction on backside of deck plate are shown in Fig. 6, when 40kN load was applied. Comparing to un-reinforced case, panel A, B and C under un-bonded condition performed 60, 95, 80% stress reduction correspondingly. When the panel A was bonded with adhesive, stress reduction ratio that was 60% under un-bonded was improved to about 70%. Even if the panels are not bonded to the deck plate, stress reduction is sufficiently expected, however, it is possible by considering it as composite structure to heighten the stress reduction effect further.

FEM analysis results followed the results from the static load test.

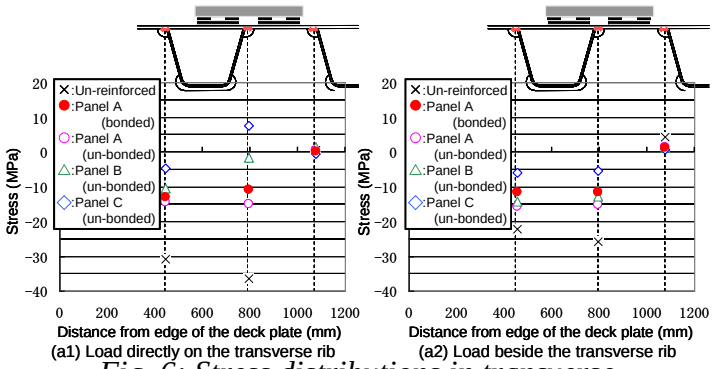

Fig. 6: Stress distributions in transverse direction on backside of deck plat

5. Conclusions

Mutual deformation of the trough ribs caused fatigue cracks at the root of the weld in the longitudinal direction. Reducing the deformation of the deck slab will be an effective retrofit method. UFC panels is effective to reduce the deformation. About 70% stress reduction was observed on the backside of steel deck plate by bonding UFC panels. Even in non-composite case with each panel, same level of stress reduction was observed.

Reference

[1] Gurney T., *Fatigue of steel Bridge Decks*, TRL State of the Art Review/8, HMSO Publications, 1992