Fatigue Strength Evaluation Method of Connection between Longitudinal Closed Ribs and Cross-Beam Web Cutouts in Orthotropic Steel Bridge Decks

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Summary

This study investigated fatigue strength evaluation methods based on the structural hot spot stress concept, focusing on a crack at a crossing between a longitudinal closed rib and a cross-beam (transverse rib) web cutout in an orthotropic steel bridge deck. The results indicated the possibility that the fatigue strength of the connection can be evaluated with the hot spot stress range. And also, it was revealed that the hot spot stress range hardly decreases with increasing of deck plate thickness and decreasing of transverse rib distance.

Keywords: orthotropic steel bridge deck; connection between longitudinal closed rib and cross-beam web cutout; fatigue crack; structural hot spot stress.

1. Fatigue strength evaluation methods

This study, focusing on the cracks at the connections between longitudinal closed ribs and cross-beam web cutout, fatigue strength evaluation methods based on the structural hot spot stress concept was analytically investigated by using fatigue test results in the previous research. Please see the full-pater on the detail of each test.

Finite element analyses were performed to calculate the structural hot spot stress in the specimen of the previous tests. An example of the model is shown in Fig. 1. The model was created with solid elements to simulate the weld bead in detail. The elements around the weld toe in the cutout were about 1mm×1mm×1mm. Young's modulus and Poisson's ratio were 200GPa and 0.3, respectively. The boundary conditions and the loading pattern were the same as the fatigue tests.

In this study, several types of hot spot stress calculation methods were investigated. There are two types of calculation methods; one is the single reference point type, another is the multi-reference point type.

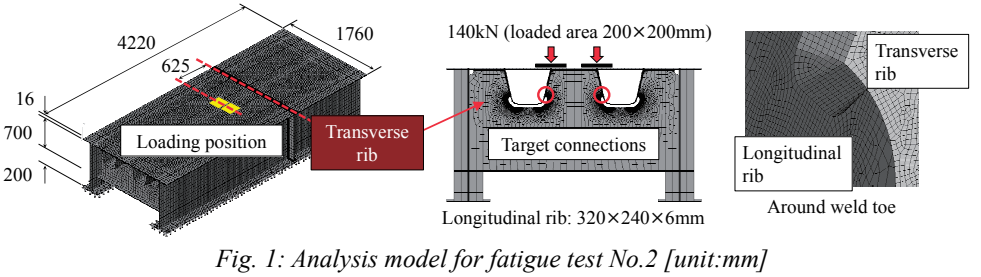
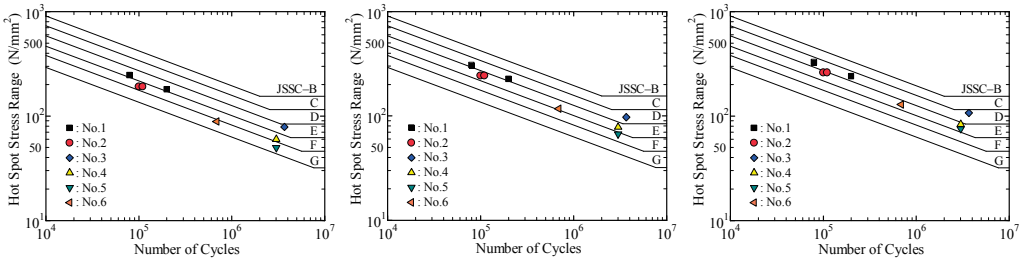


Fig. 1: Analysis model for fatigue test No.2 [unit:mm]

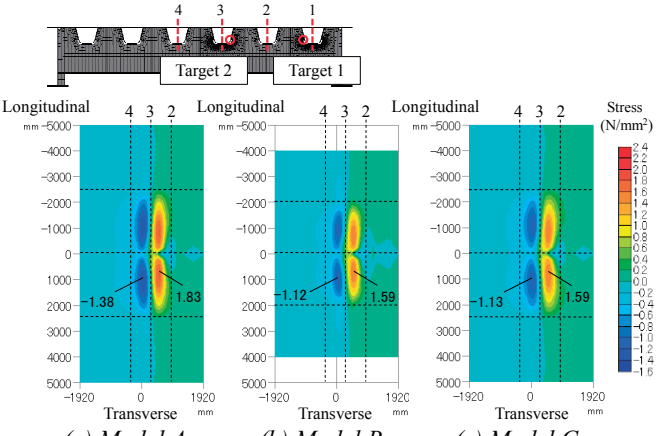


(a) 3mm method *(b) 0.5t-1.0t method* *(c) IIW 3 points method*

Fig. 2: Arrangement of fatigue test results by hot spot stress

Table 1: Analysis cases

	Distance of transverse ribs (mm)	Deck plate thickness (mm)
A	2500	12
B	2000	12
C	2500	16



(a) Model A *(b) Model B* *(c) Model C*

Fig. 3: Influence surfaces

The fatigue test results in the previous study were arranged with the hot spot stress calculated by several methods. Examples of the results are indicated in Fig. 2 Obvious differences among the method can be hardly observed in the graphs. It can be mentioned that the fatigue strength of the connection can be evaluated by the hot spot stress, for example, by comparing the hot spot stress from 0.5t-1.0t calculation method with the JSSC fatigue strength curve of E-class.

2. Influential Surfaces of Hot Spot Stress

The hot spot stress at the connection is related to its fatigue strength. In this chapter, influential factors on the hot spot stress were investigated. This study selected the distance of transverse ribs and the thickness of a deck plate as listed in Table 1. The distance of transverse ribs is 2000mm and 2500mm, and the deck plate thickness is 12mm and 16mm. Fig. 3 shows the influential surfaces of the hot spot stress at the connection No.2. Compared with the result of Model A, there is small difference due to the changes of the distance of transverse ribs and the deck plate thickness.

3. Conclusions

This study showed the possibility that the fatigue strength can be evaluated by using the hot spot stress and its fatigue strength curve. In addition, it was revealed that the distance of the transverse ribs and the thickness of the deck plate have small effect on the hot spot stress at the connection.

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