Stress Distribution of Orthotropic Steel Bridge Decks under Vehicle Wheel Loading

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ABSTRACT

Orthotropic steel bridge decks are widely used in modern medium- and large-span steel bridges. Higher stress concentration resulting from out-of-plan bending is generated in typical deck weld joints under the wheel loading, it made the orthotropic steel bridge decks quite susceptible to fatigue cracks. In this study, the three-dimensional finite element model is used for analysis the stress concentration at upper and bottom of decks under the different loading conditions. It considered that the variation of the wheel contact area and the same action of the double rear axels for the influence of orthotropic deck stress. The results show that horizontal stress affects area of local wheel loading is limited in three trough ribs. The wheel loading riding on the trough rid is the most adverse condition. The severer stress concentration locate at trough to deck plate weld connections and crossbeam to deck plate weld connections. When the double rear axels wheel loading are same action, stress concentration is higher at the condition of one wheel loading on the crossbeam. Through the stress distribution and concentration of orthotropic steel bridge decks under local wheel loading, it leads to a better understanding the reason of fatigue crack.

KEY WORDS: Steel Bridge; orthotropic deck; wheel loading; stress concentration; Trough rib; Numerical model.

INTRODUCTION

Orthotropic steel bridge decks are widely used in modern steel bridges. In China, the orthotropic steel bridge decks are used in many large-span bridges, such as Humen Bridge, Jiangyin Yangtze River Bridge, the Second Nanjing Yangtze River Bridge, Runyang Yangtze River Bridge, Sutong Yangtze River Bridge, Hangzhou Bay Bridge, and so on. However, under the wheel loading, the stress distribution of orthotropic steel bridge decks is complex, which makes the weld connection details quite susceptible to fatigue cracks. Along with traffic flow increasing, specially the heavy vehicle and overweight vehicle increasing, the fatigue cracks problem of orthotropic steel bridge decks becomes more prominent. Higher stress concentration resulting from bridge decks partial transverse bending is generated in typical deck weld joints under the wheel loading. The suty on stress concentration has been done by many researchers (G Cullimore,1981; Qian,2004; Pfeila,2005; Xiao,2008), but the stress concentration level of bridge decks is still unknown.

In this paper, the stress distribution of bridge decks under the wheel loading is studied. The geometric construction of stiffening girder and trough rib is shown in Figure 1.

In the study, shell element is used to simulate the orthotropic steel bridge deck, and the stress concentration level of bridge decks is analyzed when hind axle locates at different position of transverse deck and longitude deck direction, which prepares for the precise appraisement to fatigue performance of weld connection details of bridge decks.

Fig.1 Stiffen girder and trough rib of suspension bridge (Unit: mm)

FINITE ELEMENT ANALYSIS MODEL

The finite element software ANSYS is used to model. Shell63 elements are used in the simulation of orthotropic steel bridge deck, which includes 4 nodes, each node has 6 degrees of freedom. The element both can manifest the bending stress characteristic of bridge decks and the membrane stress of structure, which answers for the stress characteristic and the geometry characteristic of the steel bridge decks.

Wheel Loading Model

The fatigue design load has not included in the code for design of highway bridge and culverts in China, therefore, in the finite element computation, the local wheel loading uses the intensity design load of "General Code for Design of Highway Bridge and Culverts " (JTGD60-