



Fatigue Crack Propagation Characteristics of the Deck to Longitudinal Rib Weld in Orthotropic Steel Bridge Deck

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Abstract

In order to investigate the fatigue crack propagation characteristic of the rib-to-deck joint considering welding residual stress, the finite element model of the orthotropic steel bridge deck was established for the typical box girder of a cable-stayed bridge. Considering the effect coupled with the residual stress field, the initial crack and the fatigue load, the fatigue crack propagation at the rib-to-deck joint was simulated based upon the extended finite element method (XFEM). The simulation result of the residual stress shows that there is a large residual tensile stress in the welding area of the rib-to-deck detail, and the peak value of the Von-Mises stress at the rib-to-deck joint close to the yield stress of Q345 material. The results of fatigue crack propagation behaviour display that the fatigue crack at the weld toe is led by mode I, which could keep in the plane during the crack propagation. And the fatigue crack at the weld root is mix mode I-III crack led by mode I, which cannot keep in the plane during the crack propagation, but slightly deflection.

Keywords: orthotropic steel bridge deck; rib to deck weld joint; numerical fracture simulation; XFEM; welding residual stress; fatigue crack.

1 Introduction

The orthotropic steel bridge deck is widespread applied in the large and medium span municipal and highway bridge construction due to its convenient construction, excellent mechanical properties, light weight, and beautiful appearance[1]. However, the fatigue problems of orthotropic steel bridge deck are remarkable[2,3], due to wheel load, many weld joints and several initial cracks[4]. Moreover, fatigue cracks are prone to be growth at the weld joint of rib to deck, and difficult to be detected. And the crack has propagated a large length when it comes to be found. It has been one of the complicated cracking modes in the structure of the orthotropic steel bridge deck. Therefore, it is significant

to research the fatigue problems at the welding joint of rib-to-deck.

Fatigue tests were widely applied in the research of steel bridge fatigue problems and anti-fatigue design[5,6]. However, anti-fatigue design and steel bridge maintenance cannot be suited by Fatigue tests research due to its need of large man power and material resources. Hence, numerical simulation based on fracture mechanics theory was applied in the fatigue research gradually. Zhu[7] made the 2D fatigue crack propagation simulation at U-rib to deck joint of the Orthotropic Steel Bridge Deck. Liu[8] established the 3D finite element model of rib to deck of orthotropic steel bridge deck, and researched the fatigue crack propagation characters of this detail. The element near crack