Fatigue Crack Propagation Analysis of Orthotropic Steel Bridge with Crack Tip Elastoplastic Consideration

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October 10, 2020

Abstract

Abstract: Due to the complex structure of the orthogonal steel bridge deck and dense weld, fatigue cracks are prone to occur in the typical welding details. Welding residual stress will cause a plastic zone at the crack tip. In this paper, an elastoplastic constitutive model of Chaboche material was introduced, and the extended finite element method (XFEM) was used to study the influence of material elastoplasticity and crack tip plastic zone on the law of fatigue crack propagation. By judging the stress state of the residual stress field at the crack tip and selecting different crack propagation rate models to investigate the crack propagation law when plastic deformation was considered, the propagation path and propagation rate of fatigue crack of the orthotropic bridge deck were obtained. The results show that, whether the residual stress field is considered or not, the plastic deformation at the crack tip will not cause the obvious closure of the fatigue crack at the U-rib toe during the crack propagation process, but will significantly affect the crack propagation path. When material plasticity is considered, the propagation angle of fatigue crack at the U-rib toe basically remains unchanged along the short-axis direction of the initial crack, but increases along the long-axis direction, and the crack tip plastic zone inhibits the propagation of the crack tip on one side. Compared with linear elastic materials, the crack propagation law considering material plasticity is more consistent with the actual fatigue crack propagation law in bridge engineering. In terms of the propagation rate, if the residual stress field is not considered, the fatigue crack propagation rate at U-rib toe with plasticity considered is slightly higher than that without plasticity considered, because plastic deformation will affect the amplitude of energy release rate. When considering the welding residual stress field, the fatigue crack propagation rate at U-rib toe is increased due to the combined actions of plastic deformation and stress ratio R.

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