An XFEM Based Parametric Study on Crack Growth Rate in Welded Joints with Defects

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Summary

Welded joints are the most fatigue-prone parts of the steel structures, especially for the long-span bridges with orthotropic steel decks(OSDs). One of the most important internal causes might be the defects introduced by welding processes, which may significantly affect the crack growth rate(CGR). Assuming that the welded joints have randomly distributed defects, i.e. inclusions and pores, representative volume elements (RVEs) were generated and studied based on extended Finite Element Method (XFEM).A coefficient that modifies the Paris constant C was introduced, and a parametric study on this coefficient was conducted to present the effects on CGR. The analysis showed that the location of defects is so significant on this issue that the incapability of taking account to it using volume fractions may lead to inaccurate or scattered results.

Keywords: XFEM, Crack growth rate, Welded joints, Weld-defects.

1. Introduction

Fatigue is a key factor to consider for designing and constructing steel structures, among which the OSDs are the most frequently reported sufferers from premature fatigue damage. The widely known ones are the Severn Bridge in Great Britain[1], the Second Van Brienenoord Bridge in the Netherlands[2], and the Hanshin Expressway in Japan[3].The reason could be attributed to two parts: the external causes and internal ones. The external causes, such as the high cycle number due to the short influence line and the increasing vehicle amount, certainly deteriorates the fatigue performances of OSDs. However, the internal causes, from our perspective, are a part that designers cannot afford to ignore. Due to the large quantity of welded joints, OSDs have a bigger risk of suffering from residual stresses and initial defects, which may accelerate the crack growth and shorten the fatigue life[4] [5] .Miki et al.[6] listed five kinds of defects that significantly affect the fatigue performance and calculated the crack initiation in butt weld with FEM. However, in consideration of the differences in scale of civil engineering structures and welded defects, a method that fits multi-scale problems seemed necessary. Homogenization, as an important option among all the multi-scale methods, was a simplified method for practical use. With the help of XFEM, homogenization becomes quite efficient to study the mechanical performance[7]and fatigue performance[8]of heterogeneous materials.

The purpose of this paper is to proposea way to homogenize the possible defects in welded joints with XFEM, and present the effect with a parametric analysis. This paper is organized as follows: in Section

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