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Numerical Analysis of Stress Concentration Factors of CFRP-Strengthened Fillet Welded T-joints

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Abstract

A few past studies indicated that fatigue behaviour of welded joints in steel bridge strengthened using carbon fiber reinforced polymer (CFRP) sheet could be improved obviously. The authors in this paper try to verify the issue of how CFRP decreasing stress concentration at weld toe in fillet welded T-joints through numerical analysis. Stress concentration factors (SCFs) in fillet welded T-joints before and after CFRP strengthening were investigated respectively by 1560 finite element models using ABAQUS, with different parameters varying, such as fillet weld toe radius, CFRP reinforcing ratio and CFRP elastic modulus. It is concluded that all the parameters are important affecting the SCF of fillet welded T-joint, and using high elastic modulus CFRP can be the most efficient approach to decrease SCF. Parametric equations were proposed to calculate SCFs of fillet welded T-joints with and without CFRP strengthening.

Keywords: fillet welded T-joint; carbon fiber reinforced polymer (CFRP); strengthening; stress concentration factor (SCF); numerical analysis; parametric equation; fatigue.

1 Introduction

There are many types of welded joints in steel bridge structures including main girders, orthotropic deck plates and so on, which are liable to fatigue cracking. Fillet welded T-joints are found in a wide variety of bridge structure components, where fatigue cracking is usually observed at weld toe. Stop holes, welding repair or steel plate attachment are conventional methods to extend the fatigue life of cracked components. However, they may cause new problems such as difficulties in manufacturing complex shapes of steel plate with heavy weight, requirement of electrical equipment, and additional defects introduced by welding or drilling. Recently, a new material called fiber reinforced polymer (FRP), including carbon fiber reinforced polymer (CFRP) and glass fiber reinforced polymer (GFRP), is increasingly used to strengthen or retrofit steel structures for its high strength, durability, light weight, and ease of installation [1]. Nevertheless, research on using CFRP to strengthen steel structures is still in the early stage. Most of previous investigations were focused on steel members and there was very limited work on CFRP strengthened welded joints [2].

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