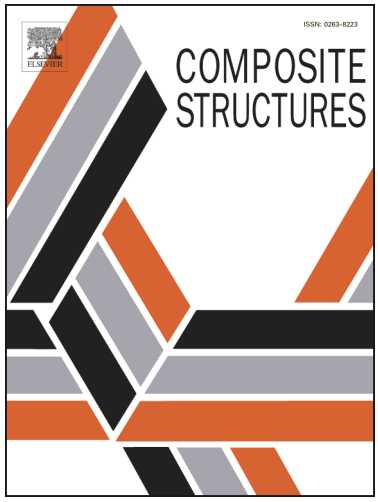

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Mode I Fatigue Crack Arrest in Tensile Steel Members Using Prestressed CFRP Plates

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Abstract

Numerous studies in the literature have shown that the strengthening of steel members using carbon fiber reinforced polymer (CFRP) composites can significantly extend the fatigue life of these structures. However, not enough attention has been focused on the potential of prestressed CFRP reinforcements for fatigue crack arrest in such members. In the current study, a simple analytical model is proposed to calculate the required prestressing level in the CFRP reinforcements in order to arrest the propagation of an existing fatigue crack in tensile steel members. Furthermore, a novel mechanical unbonded system is developed to anchor the high prestressing forces in CFRP reinforcements to the steel substrate using friction. A set of fatigue tests are performed on unstrengthened and strengthened precracked steel plates to verify the proposed model. The experimental results of the current study showed that the application of nonprestressed ultra-high modulus CFRP plates as externally bonded reinforcements can increase the fatigue life of precracked steel plates by a factor of 4.3. However, fatigue crack arrest is only possible when prestressed CFRPs of a certain prestressing level are used. Based on the analytical, numerical, and experimental results of the current study, it can be concluded that existing fatigue cracks in tensile steel members can be arrested using the proposed prestressed unbonded reinforcement system with the initial prestressing level calculated using the proposed model. In addition, some design recommendations are provided for fatigue crack arrest in practical cases.

Keywords: Steel structures, fatigue strengthening, crack arrest, carbon fiber reinforced polymer (CFRP), prestressed unbonded reinforcement (PUR)

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