THE FATIGUE PERFORMANCE OF STEEL RAILWAY BRIDGES BASED ON THE FRACTURE MECHANICS APPROACH

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ABSTRACT

Fatigue failure of steel structures is one of the timeliest research topics due to the catastrophic nature of the failure. Engineers and researchers have made significant contributions towards understanding the fatigue phenomenon from different perspectives. When it comes to the steel railway bridges, they experience heavy cyclic loads frequently which cause cracks and leads to complete structural failure. Since it is not always possible to continuously monitor bridges, an accurate life prediction method is needed to predict the failure and reduce major accidents.

Several life prediction approaches have been proposed over the years by researchers and engineers for the life estimation of bridges. The stress/strain-based approach combined with Miner's rule is widely used for the life estimation for steel bridges. To predict the life of the bridges, loading histories need to be considered. For many variable amplitude loading conditions, Miner's rule has been found to be unreliable since Miner's rule does not properly consider the loading sequence effect.

This research focused on the fracture mechanics approach for fatigue life prediction of steel railway bridges. The fracture mechanics approach considers crack initiation and crack propagation period of a material when it is under cyclic loading. In this research, C(T) specimens were prepared with the pre-crack to test the fatigue crack growth with the specific number of cycles and the stress level. Crack length a versus Number of cycles N were plotted and crack growth rate da/dN was determined. Stress intensity factor range ΔK for the C(T) specimen was determined in accordance with ASTM E647-15.

An empirical relationship between da/dN and ΔK can be formed by modifying Paris law under constant amplitude loading conditions and validated with experimental results. Finite element model of the railway bridge was validated with the vibrational analysis results. Identified critical member of the bridge was analysed using the finite element model and life time of the member was estimated.