Influence of train composition on crack propagation at structural components of welded railway bridges

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Abstract

The application of fracture mechanics allows a detailed assessment of structural details of existing railway bridges. By using crack propagation calculations, the residual service life and respective safe inspection intervals can be determined. For this purpose, cyclic loading due to train passings is needed as an input parameter. Furthermore, an initial crack length and material parameters need to be assumed. In this paper, the focus lies on the loadings generated by each passing train. The influence of single trains as well as the composition of trains and their order on crack propagation is investigated. Train models in the Eurocode [1] are considered and the effects are analysed in the frame of linear elastic fracture mechanics. Combined with the span length, the influence of service trains is varying and an impact of train composition is present. Sequence effects are if at all only slightly visible and therefore may be neglected within the considered calculations.

Keywords: welded railway bridges; linear elastic fracture mechanics (LEFM); crack propagation calculations; train composition; load sequence effects; assessment of existing bridges; Paris' law.

1 Introduction

A variety of concepts is available for determining the residual service life of existing railway bridges. In many cases, the application of the nominal stress concept with the corresponding S-N curves results in too conservative results. This in turn leads to very short calculated remaining lifetimes or a verification is not possible at all. By applying methods based on linear elastic fracture mechanics (LEFM), a more detailed analysis is possible, which results in more realistic lifetimes and therefore more sustainable assessment. This includes the derivation of inspection intervals ensuring a controlled crack growth and thus a safe operation between two intervals. For this purpose, crack propagation calculations are conducted, using an assumed initial defect size. Based on the stress intensity factor at the crack tip, the stepwise growth of the crack due to cyclic loading can be described by the Paris' law. The risk of brittle fracture is covered by means of the failure assessment diagram (FAD). As input parameters, the acting stress ranges as well as an initial defect size and material parameters are needed.

This paper focuses on cyclic loading due to train passings and resulting crack propagation. Each train generates several applied forces, depending amongst others on the distance between the axles and the axle loading. From the resulting time series of stresses, the corresponding stress ranges can be obtained by rainflow counting. These must be endured by the considered construction detail. Obviously, assumptions of the characteristics of

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