Fatigue reliability assessment of welded bridge details using probabilistic fracture mechanics

John Leander

KTH Royal Institute of Technology, Stockholm, Sweden

Farshid Zamiri, Mohammad Al-Emrani

Chalmers University of Technology, Gothenburg, Sweden

Contact: john.leander@byv.kth.se

Abstract

The safe life method for the fatigue life prediction of steel bridges has for several cases been shown to render misleading results. To improve the accuracy, a probabilistic model based on linear elastic fracture mechanics (LEFM) is suggested. The model is used for a sensitivity analysis on the influence of different modelling options pertinent for a fatigue assessment of bridge details. The influence of material parameters and the crack growth threshold have been investigated. The analyses have been performed for a bridge detail frequently occurring in old steel bridges and a stress range spectrum based on measurements. The results show a significant difference in the estimated fatigue life depending on the modelling options. Furthermore, the omission sensitivity factors have been estimated for the probabilistic model showing the influence of the uncertainties of the variables and which of them that needs to be determined with care.

Keywords: Life prediction; Reliability; Linear elastic fracture mechanics (LEFM).

1 Introduction

The aging infrastructure in developed countries is an impending economic burden. Many structures have reached their expected service life which forces decisions on remedial actions. To support these decisions and avoid costs and resource depletion due to ill-judged actions, accurate service life predictions are required.

For steel bridges, the service life is typically limited by fatigue. The safe life method is the prevailing philosophy for assessment where the remaining fatigue life is calculated using load models, resistance parameters and partial safety factors specified in design codes for the design of new bridges. All the input parameters and the model itself are afflicted with uncertainties. In particular the load history is rarely known in detail for existing bridges which makes the service life prediction highly unreliable. Examples from practice have shown a theoretically exhausted fatigue life while no signs of damage have been found during inspection [1]. In other examples, unanticipated fatigue cracking has been reported for various bridge details due to secondary effects, sometimes already after few years in service [2].

The damage tolerant method is an alternative approach which allows an assessment of the service life in the presence of a fatigue crack, assumed or existing. The load history can with this method be disregarded. The previous accumulated damage is represented by an initial

https://doi.org/10.2749/stockholm.2016.0231