Fatigue damage evaluation using S-N curves obtained by different data fitting methods

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Abstract

This paper investigates the differences in the predicted fatigue life of transverse butt weld joints and cover-plated beams considering statistically based fitting methods on fatigue test data and comparing the results with the S-N relation proposed in international standards. The test data fitting are performed by employing the Least Square Method (LSM) and the Maximum Likelihood Method (MLM) taking into account the contribution of the runouts. The Mean curve, the characteristic curve and the design curve have been derived. In order to consider the effect of Variable Amplitude loading, the S-N curves have been extended and the fatigue damage according to the Palmgren-Miner cumulative damage rule is evaluated for a load spectrum that follows a Rayleigh distribution. The results have been compared and discussed together with a Linear Elastic Fracture Mechanics (LEFM) based fatigue prediction.

Keywords: Steel; Bridges; Fatigue Damage; Welds; Fracture Mechanics;

1 Introduction

In steel bridges, the fluctuating load introduced by heavy vehicles (trains, lorries) is usually significant in comparison with the dead load. Moreover, the number of fluctuating load cycles is large (>10^7). This makes steel bridges prone to (high-cycle) fatigue. Thus, fatigue life prediction is relevant in order to assure the required safety level. Performing fatigue tests under constant amplitude (CA) loading and fitting a proper S-N model to the obtained data is the first step to carry out the fatigue analysis if an S-N curve for the selected detail is not available. In general, the data may be obtained either as right-censored or uncensored. The former refers to a test terminated before the specimen's failure. It provides information on the lower bound on lifetime and it is known as runout, whereas an uncensored observation is denoted failure. Currently, the S-N curves proposed in the Eurocode 3 [1] are fitted to the test data only by considering the contribution of the failures [2]. Indeed, considering a runout as failure or excluding it from the analysis are both inappropriate decisions. Therefore, the constant amplitude fatigue limit (CAFL), i.e. the maximum stress range

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