Comparison of Deterministic and Probabilistic Fatigue Assessment Methods: A Case Study of a Road Bridge

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Abstract

The objective of this paper is to compare the predictions of deterministic and probabilistic fatigue assessment methods. The paper focuses on the nominal stress method in the stress-life approach. Three different assessment methods are presented and compared, the traditional deterministic method, the closed form method and the probabilistic method. The traditional method is the one described in Eurocode. The closed form method involves using a Weibull distribution to represent the stress spectrum. The probabilistic method involves the use of Monte Carlo simulations to obtain the probability of failure, P_f . An alternative fatigue load model is newly proposed in this paper. The associated procedures of the three assessment methods were verified and then used for fatigue analysis of a road bridge. Finally, the limitations, shortcomings and recommendation are concluded based on the research and the obtained results.

Keywords: fatigue; road bridge; deterministic method; probabilistic method.

1 Introduction

A recent review of metallic bridge failure statistics has been recognized that dominant mode is fatigue (67%), followed by impact (10%) and fracture (5%) [1]. The fatigue assessment of structures is mainly done by either deterministic or probabilistic approach. Most of deterministic fatigue assessment approaches of bridges are generally based on the combination of measured stress histories under actual traffic load [2,3], Miner's rule and railway code provided fatigue curve (also referred *S-N* or Wöhler curve). Although the mentioned deterministic approach predicts the fatigue behaviour, the uncertainties inherent in the fatigue evaluation process are not captured.

Probabilistic fatigue models are an alternative method to model these uncertainties as those take the variation in the variables into account. The probabilistic method of fatigue assessment is increasingly being used by the industry. In recent years, at least two standards involving probabilistic analysis have been introduced [4,5]. However, these standards are only defined for offshore structures, and focus more on probabilistic inspection planning for fatigue cracks in existing structures, structural integrity and life extension. Any standard covering probabilistic fatigue analysis on land-based structures has yet to be made. However, proper comparison of these two approaches have not been done for road bridges. The code given fatigue load models are based on heavy truck traffics. However, importance of entire traffic spectrum apart to heavy traffic is questionable among the bridge designers.

To overcome above problems to some extent, main objective of this paper is to establish a good understanding of the different approaches and implement them into asses fatigue damage of a road bridge. An alternative fatigue load model is newly proposed in this paper and significance of consideration of entire traffic spectrum for fatigue assessment is confirmed.

https://doi.org/10.2749/stockholm.2016.0275