



New multiphase methodology for fatigue damage screening of aging metallic railway bridges

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ABSTRACT

This paper proposes an integrated methodology for fatigue assessment of existing metallic railway bridges, consisting of four sequential phases to be progressively implemented. Advanced fatigue life prediction tools based on local methods are suggested, aiming to analyse fatigue critical details, fully considering the local characteristics of the existing loading transfer mechanisms. A real case study is investigated using the new integrated methodology, demonstrating the relevance of efficient local fatigue analyses in this context, as well as the importance of data resulting from the multiphase fatigue assessment for the management authorities to optimise the maintenance of existing railway bridges.

1. Introduction

Presently, environmental concerns influence decisively the political agenda worldwide, in particular when it comes to mobility policies. The Green Deal proposed by the European Commission in 2019 [1] gives the railway a critical role in the movement of passengers and goods, suggesting that the expected increase in traffic demand should be supported in part by the existing network to address economical and sustainability issues. Aiming to reduce the direct cost of the planned railway corridors, infrastructure of interest should be kept in service for as long as possible, some of which is approaching the end of the planned service life. Among these, bridges composed by old materials and built using ancient technologies lead to special concerns, requiring detailed structural analyses to ensure safe performance during the remaining time in full operation.

In metallic railway bridges, the fatigue damage is one of the main threats to structural integrity and limits the capacity to support increasingly heavier trains at growing speeds [2,3]. International standards suggest stress-life methods based on nominal stresses for fatigue assessment, considering the local stress raisers in S-N curves, which allows overcoming the difference between the global scale of structures and the local nature of fatigue phenomena (m or km vs. mm or bellow, respectively). Nonetheless, the respective implementation to investigate existing bridges may be doubtful for certain details, not properly addressing the real local characteristics, which has been leading to the proposal of local fatigue methods to overcome this issue [4–8]. In this

context, Kuhn et al. [9] outlined a multistep approach, suggesting a probabilistic philosophy related to local fatigue concepts to perform analyses complementary to the global ones, but the articulation between global and local methods is unclear, and no specific calculation algorithms to implement the latter are provided. Despite the basic principles suggested, important advances are mandatory towards the efficient and reliable application of interdependent multiphase assessment strategies to real bridges, which may have critical environmental and economic impacts. Therefore, the current work is meant to provide a clear and systematised methodology to be used in structural engineering, particularly with the aim of maximising the fatigue life of aging metallic railway bridges, involving different fatigue methods whose reliability of results is increased by the consideration of experimental data.

In order to overcome the drawbacks of global methods, Horas et al. [10,11] proposed two local fatigue approaches considering submodelling techniques leveraged by modal superposition principles and local notch methods or Linear Elastic Fracture Mechanics concepts (LEFM) to investigate the initiation or the propagation of cracks, respectively. However, applying these calculation strategies to multiple connections may not be an efficient computational procedure for some bridges, but such local fatigue approaches can be assumed as advanced calculations, following the implementation of conservative normative global methods. These latter can be used to classify as fatigue-safe a relevant number of details of a given structure, logically limiting the necessity of performing a costly local fatigue assessment for a large number of connections. Afterwards, those defined as fatigue-critical

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