Innovative Methods for Railway Steel Bridge Remaining Life Estimation

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Summary

Assessment of remaining life of railway steel bridges is a key issue in order to manage a relevant stock of bridges built between the last 18th and the one half of 19th. Historical traffic usually changes in patterns, volume, and any degradation of structural components can influence the fatigue life of the bridge. For these reasons, innovative methods on evaluating remaining life of steel bridges are required, in order to give to owners precise indications of bridge intervention priority along the network. In this paper, an innovative method is presented: it is based on the precise historical traffic estimation and on a modified Miner's rule. The methodology is then applied on an actual case study. Stress data from critical structural members were used to estimate the remaining fatigue life of selected bridge components. The results indicate that most of the identified critical details seem to have a very long remaining safe fatigue life and others have a limited fatigue life.

Keywords: Steel bridge; fatigue; railways; remaining life; reliability methods.

1. Introduction

The average age of sixty percent of Italian railway steel bridges is about one hundred years as they were built between 1900 and 1920. Moreover the ASCE Committee on Fatigue and Fracture Reliability (1982) reported that 80–90% of failures in steel structures are related to fatigue and fracture, and this data is confirmed by Byers et al. (1997). Among historical metal bridges, riveted structures are the most representatives, and in this case several factors play an important role in the fatigue assessment as documented by several researches, such as Bruhwiler et al. (1990) [5], Kulak (1992) [13], Akesson and Edlund (1996) [3], Di Battista et al. (1997) [7], Bursi et al. (2002) [6], Matar and Greiner (2006) [15], Pipinato et al (2009a) [17], Pipinato et al (2009b) [18], Boulent (2008) [4], Albrecht and Lenwary (2008) [1], Albrecht and Lenwary (2009) [2]. Fatigue safety depends on the following three main parameters: the stress range amplitude due to rail traffic load, related to the structural behaviour of the bridge; the geometry of the construction details, that leads to a more or less pronounced stress concentration which may trigger or accelerate fatigue crack propagation; the number of stress cycles due to the past rail traffic that influences directly the remaining fatigue life of a structure.

Comprehensive examination of fatigue safety and remaining service life of railway bridges is based on these three main parameter and includes theoretical studies of the structural reliability, bridge inspection and, in more advanced studies, field testing. A rational procedure for the examination of fatigue safety which proceeds by stages using both deterministic and probabilistic methods of increasing sophistication is appropriate in most cases. Probabilistic methods enable the explicit consideration of the scatter of the parameters that influence the fatigue strength and the fatigue damaging effect. Inspection methods and intervals are an integral part of a comprehensive fatigue examination. The main objective of this paper is to introduce an innovative method that allow examination of the fatigue safety and determination of the remaining fatigue life based on a procedure by stages. Corresponding characteristic values will be suggested and discussed. An application of this procedure is presented at the end.

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