Numerical model updating of an aging steel bridge based on a multidisciplinary experimental campaign

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Abstract

A large part of the European bridge stock is reaching the end of its design service life. Currently, several applications for numerical models have been emerged, such as damage detection or structural safety assessment, among others. However, accurate numerical modeling is still a challenge. Model input uncertainties can cause large differences between numerical model predictions and actual measured responses from the structure. This fact makes model updating or calibration techniques essential for the aim of reducing such discrepancies. In this study, a model updating methodology is developed and implemented in an aging steel bridge located in a corrosive environment. An extensive and multidisciplinary experimental campaign was first carried out for collecting the necessary geometrical and material properties as well as dynamic data that will be used as a reference for the calibration process. A good agreement was found between the updated numerical model and the experimental modal data obtaining an average frequency error of 2.09% and average MAC (Modal Assurance Criterion) of 0.97.

Keywords: Model updating, Sensitivity analysis, Multidisciplinary experimental campaign, Aging steel bridge.

1 Introduction

Within the transportation network, bridges are one of the most important assets. In the European framework, a great number of bridges currently overpass their expected lifetime or are very close to. Moreover, many of them are subjected to heavy traffics loads and are located in areas where the salinity, humidity, and highs winds cause significant corrosion effects. For these reasons, bridge maintenance has turned into a critical task.

The development of numerical models is a very useful tool to assess the current state of a structure, investigate causes of damage, or perform robustness analysis. Ancient structures require obtaining a significant amount of data to perform accurate numerical modeling. For this reason, the deployment of extensive experimental campaigns is usually needed, targeted to an accurate geometrical characterization and/or to the reduction of uncertainties in material properties or connections' stiffness, among others.

Numerical model updating is a procedure that allows approximating simulation outcomes to the real observed mechanical behavior of the bridge. For this purpose, operational modal analysis is commonly adopted to obtain the modal properties (natural frequencies, mode shapes, and damping ratios) that enable characterizing the overall system response. These data can then be employed as "ground truth" in the calibration process. In this work, a deterministic approach is adopted to perform the Finite Element (FE)