Multi-setup Operational Modal Testing of a Multi-span Viaduct

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Abstract

Multi-setup operational modal testing has been performed on a multi-span viaduct in Bruges, Belgium. The viaduct consists of two curved integral bridges with a length of about 800 m in parallel with each other. Each bridge has 23 spans and consists of nearly periodic parts. During the measurement, a number of reference sensors is kept fixed, while the other so-called roving sensors are moved in different setups. Modal identification is first carried out for each setup separately. Next, the identified modal data of different setups are merged. It is observed from the stabilization diagrams that the modes are very closely spaced, resulting in a very high modal density, even under 2 Hz. This results in challenges in the modal identification. First, a high model order needs to be considered, leading to a high computational cost. Second, it is difficult to match the partial mode shapes obtained from different setups, due to the closely spaced natural frequencies. This problem is resolved by comparing both the natural frequencies and the mode shapes at the reference locations in the mode matching.

Keywords: Multi-setup modal testing, periodic structure, mode clustering, mode matching.

1 Introduction

Multi-setup modal testing [1,2] is usually performed for large structures, where a number of reference sensors is kept fixed during the entire measurement and the other so-called roving sensors are moved in different setups. An important step in multi-setup modal analysis is the data merging. The classical approach for data merging in multi-setup Operational Modal Analysis (OMA) is the Post Separate Estimation Re-scaling (PoSER) approach [3]. The partial mode shapes are first identified for all setups separately and merged next to obtain the global mode shapes. The natural frequencies and damping ratios are averaged.

In the present study, multi-setup operational modal testing was performed for a multi-span viaduct in Bruges: the K032 viaduct of the A11 highway. It consists of two curved integral bridges in parallel with each other. Each bridge consists of nearly periodic parts with nearly identical span. For this kind of structures, clustered modes with closely spaced natural frequencies and similar mode shapes occur [4]. This results in several challenges for multi-setup modal analysis. First, the high modal density requires a high model order, leading in turn to a high computational cost. Second, it is difficult to pair the modes from different setups due to the closely spaced natural frequencies. This paper presents the difficulties encountered in the modal identification of the viaduct, the attempts made to solve the problems, and the final identification results.

https://doi.org/10.2749/nantes.2018.s6-37
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