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Modal parameter identification of stay cables from output-only measurements

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ABSTRACT

Stay cables are one of the most critical structural components in modern cable-stayed bridges and the cable tension plays an important role in the construction, control and monitoring of cable-stayed bridges. We propose a time domain and a time–frequency domain approaches for modal parameter identification of stay cables using output-only measurements. The time domain approach uses the subspace algorithm which is improved with a new modal coherence indicator. The time–frequency approach uses the wavelet transform of signals which is improved with a new analyzing wavelet. The wavelet transform is applied to the free response of ambient vibration which is obtained using the random decrement technique. Two experiments of stay cables are presented. The first experiment concerns a stay cable in laboratory where the external load is applied through an impact hammer and the vibratory signals are acquired through four accelerometers. The second experiment concerns the Jinma cable-stayed bridge that connects Guangzhou and Zhaoqing in China. It is a single tower, double row cable-stayed bridge supported by 112 stay cables. Ambient vibration of each stay cable is carried out using accelerometers. From output-only measurements, the modal parameters of stay cables are extracted. Once the eigenfrequencies and the damping coefficients are obtained, the cable forces and the Scruton number are derived. In a continuous monitoring and modal analysis process, the tension forces and Scruton numbers could be used to assess the health of stay cables in cable-stayed bridges.

1. Introduction

Identification of modal parameters: eigenfrequencies, damping ratios and mode shapes from empirical data is of fundamental engineering importance in the dynamical analysis of stay cables, and more generally in the dynamical analysis of mechanical structures. These modal parameters will serve as reference to the finite element model updating, to perform structural health monitoring, damage detection and safety evaluation of structures. The extraction of modal parameters from frequency response function measurements requires knowledge of both: the input and the output from the system under test. However, in real operational conditions the input cannot be measured and an artificial excitation needs to be applied. This is very difficult to realize from an instrumental point of view and the resulting responses are often of poor quality, the useful signals being contaminated by the noise caused by the system's operation. Hence, in many cases, only operational response data are measurable and the system identification process will need to base itself on response only data. This identification based on the knowledge of output-only responses, without using excitation information, is

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