Identification of Wind-Excited Suspension Bridges for SHM: a Feasibility Study

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Summary

The paper presents an investigation on the accuracy of a sophisticated system identification technique in providing the modal parameters of wind-excited suspension bridges, using pseudo-experimental data. The aim is to quantify the bias produced by colored wind excitations, measurement noise and wind-structure interaction effects on the modal parameter estimates. In addition, as the accurate estimation of structural damping ratios is a priority for safety evaluations and structural health monitoring of long-span bridges, a particular attention is posed on the feasibility of the considered system identification technique for separating structural from aerodynamic damping.

Keywords: bridges; wind; aeroelastic effects; aerodynamic damping; SHM; system identification.

1. Introduction

System identification is a fundamental diagnostic technique for the structural health monitoring (SHM) of strategic structures and infrastructures. Particularly, in the case of newly built ones, operational modal analysis (OMA) provides a distinctive opportunity to build “baseline” models of the undamaged structure that can be adopted as references for identifying the onset of damage as well as for comparing design assumptions with numerical predictions. Such baseline models are generally provided either in the form of a set of modal parameters or in the form of updated finite element (FE) models.

It is well-known that modal parameters estimated in the OMA, assuming that the input is a stationary white Gaussian noise, contain a certain amount of inevitable bias and errors. In the specific case of long-span bridges, for example, the main source of excitation is the turbulent wind action, which is certainly not white, though such wind action can be reasonably idealized as stationary and Gaussian [1]. Moreover, aeroelastic effects [2] produce apparent modifications of the structural modal parameters (e.g. aerodynamic damping) which must be paid close attention to [3]. Finally, measurements noise [4] and environmental effects (e.g. temperature and humidity variations) also produce fluctuations of modal parameters.

Therefore, a systematic evaluation of the effects of the aforementioned error sources on the modal parameter estimates could be a key point for the SHM of such long-span bridges, as it dictates, for instance, the minimum detectable level of damage and the possibility of separating structural from aerodynamic damping. On this respect, the paper is mainly devoted to an investigation of the bias produced by colored wind excitations, measurement noise and wind-structure interactions on the estimated modal parameters of wind-excited suspension bridges. In the identification of modal parameters, a classical stochastic subspace identification algorithm [5], complemented with a noise mode elimination procedure [6] and a mode clustering approach [7], is applied to pseudo-experimental data obtained by means of full-bridge aeroelastic simulations using an updated FE model of a long-span suspension bridge. The case study structure is represented by the New Carquinez bridge (NCB), USA, for which some of the authors have been recently involved in the baseline system identification and FE model updating [6][8].

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