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Dynamic testing of a damaged bridge

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ABSTRACT

In this paper the results of a campaign of dynamic tests carried out on an existing reinforced concrete single-span bridge subjected to increasing levels of damage are presented. The deck structure consists of a slab and three simply supported beams. The damage is represented by a series of notches made on a lateral beam to simulate the effect of incremental concentrated damage. The modal parameters of the lower vibration modes were estimated from frequency response measurements obtained under harmonic excitation. The variation of natural frequencies shows an anomalous increase in the transition from one intermediate configuration to the next damage configurations. Changes in vibration modes are appreciable from the earliest level of damage. In particular, changes in modal curvature of lower modes do provide indication on the damage location.

1. Introduction

Non-destructive vibrational methods are frequently used as diagnostic tool to detect damage in structures [23,33]. Repeated tests over time can indicate the emergence of possible damage occurring during the structure lifetime and provide quantitative estimates of the level of residual safety.

Structural damage is often thought as a decay of the mechanical properties of the structure and it is represented by a decrease of stiffness. Accordingly, a common way to solve inverse problems posed in structural diagnostics is to determine the change in the stiffness coefficient caused by the damage such that a given set of natural frequencies are closest in some least square sense to those found experimentally, see, for example [27,22,7,5,43,40,38] for detailed studies on beam structures. A method based on the rank-ordering of the modes according to the fractional eigenfrequency changes was proposed in [1] to detect cracks in beams. Assuming that the damage configuration is a perturbation of the undamaged one, it was shown in [31,13,14] that natural frequency shifts and antiresonant frequency shifts induced by the damage contain information on certain generalized Fourier coefficients of the unknown stiffness variation.

Mode shapes have also been used, even in conjunction with frequency data, to detect damage [36]. Pandey et al. demonstrated in [35] that changes in the curvature of mode shapes may be useful for damage detection in beams. Gladwell and Morassi [21] and Dilena and Morassi [11] show that the direction by which nodal points of vibration modes of beams under longitudinal or bending vibration move can be used for predicting the location of a single, concentrated damage. Caddemi et al. proposed in [3] a method for identification of multiple cracks in bending beams from a suitable set of mode shape amplitudes.

One of the main difficulties connected with the use of above vibrational methods lies in the small sensitivity of the dynamic parameters to damage. This is an intrinsic feature of structural diagnostics based on dynamic data. It represents a source of important indeterminacy, such as the strong dependence of the results of identification on the experimental errors and on the accuracy of the structural model that is chosen to interpret measurements. These facts are nowadays

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