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Dynamic identification of a reinforced concrete damaged bridge

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ABSTRACT

The results of a series of harmonically forced tests carried out on a reinforced concrete single-span bridge subjected to increasing levels of damage are interpreted in this paper. The deck structure of the bridge 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 variation of lower natural frequencies shows an anomalous increase in the transition from one intermediate damage configuration to the next ones. Vibration mode shapes show an appreciable asymmetry in the reference configuration, despite the nominal symmetry of the bridge. A justification of this unexpected dynamic behavior is presented in this paper. The analysis is based on progressive identification of an accurate finite element model of the reference configuration and on reconstruction of damage evolution from natural frequency and vibration mode measurements. Changes in modal curvature of the first two vibration modes evaluated along the main beams are successfully used to identify the location of the damage.

1. Introduction

Damage changes the vibratory behavior of a structure and, therefore, structural diagnostics based on dynamic methods has potentially great importance in engineering applications [3,4,13,14,22]. Recent technological progress has generated extremely accurate and reliable experimental methods, enabling a good estimate of changes in the dynamic behavior of a structural system caused by possible damage. Although experimental techniques are now well-established, the interpretation of measurements still lags somewhat behind. This particularly concerns identification and structural diagnostics by dynamic data due to their nature of inverse problems in vibration [8]. Indeed, in these applications one wishes to determine some mechanical properties of a system on the basis of measurements of its response, in part exchanging the role of the unknowns and data compared to the direct problems of structural analysis. Hence, concerns typical of inverse problems arise, such as non-uniqueness or non-continuous dependence of the solution on the data. When identification techniques are applied to the study of real-world structures, additional obstacles arise given the complexity of structural modeling, the inaccuracy of the analytical models used to interpret experiments, measurement errors and incomplete field data. Furthermore, the results of the theoretical mathematical formulation of problems of identification and diagnostics, given the present state-of-knowledge in the field, focus on quality, while practical needs often require more specific estimates of quantities to be identified.

It is probably because of these difficulties that a limited number of studies have investigated so far the effect of damage on modal parameters of full-scale bridges and have developed suitable strategies for damage identification. Without claim of completeness, here we recall the interesting researches developed in [2,7,9–12,18–21,25]. A critical review of the

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