Monitoring of Bridges Based on Vibration Frequencies

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Summary

This paper outlines research aimed at developing an effective and reliable monitoring method for structural damage identification. A computational procedure for the direct iteration technique based on the non-linear perturbation theory is proposed to identify structural damage, when information about only natural frequencies for the damaged structure is required. The presented damage identification technique is applied to several concrete girder bridges of different ages in Croatia. It is found that the proposed approach is quite sensitive to the quality of measured natural frequencies for structural damage identification due to the ill-conditioned system of governing equations.

Keywords: monitoring; bridges; vibration frequencies; structural damage identification.

1. Introduction

For condition monitoring and detecting degradation in structures there are a number of non-destructive techniques available or being developed. Most of the non-destructive evaluation techniques that are in use today are *local* inspection techniques, such as mechanical, radiographic, electromagnetic, magnetic and ultrasonic. For evaluation of complex structures, such as bridges, methods of vibration testing offer the opportunity for *global* inspection techniques that may be able to detect critical local failures. The overall dynamic response provides a measure of the condition of the structure. Existence of damage in a structure leads to the changes in the vibration response and dynamic characteristics of the structure such as the natural frequencies, mode shapes and the modal dampings. Therefore, the changes in dynamic characteristics of a structure can be used in turn to detect, locate and quantify the structural damage if damage occurs.

In the literature, there have been appeared a variety of structural damage identification methods depends on the type of experimental data used to detect, locate and quantify structural damage. They include the changes in modal data [1], the strain energy [2], the flexibility matrix [3], the residual forces [4] and the frequency response function [5]. Modal frequencies and mode shapes are the most popular parameters used in the identification. Furthermore, since the natural frequencies are rather easy to measure with a relatively high level of accuracy, the methods based on the measurements of natural frequencies are potentially attractive. The authors [1] proposed a novel perturbation-based approach using the exact relationship between the changes of structural parameters and the changes of modal parameters in order to avoid the insufficiency of the first-order sensitivity analysis. For damage detection, the first-order approximation may be inaccurate since a large change of structural parameters due to damage might need to be detected.

In this paper the direct iteration technique based on the above non-linear perturbation theory is utilized to identify structural damage, when only natural frequencies for the damaged structure are required. The effectiveness of the proposed numerical procedure was already demonstrated by numerical example of the real concrete girder bridge with simulated damage and also through laboratory testing of a simply supported reinforced concrete beam subjected to various levels of static load [6]. Here, the application of the proposed technique to structural inspection by vibration frequencies monitoring is described in the following.

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