Numerical modeling strategy for deteriorated concrete decks in SHM applications

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Abstract

The scarce availability of experimental data is a common issue faced by researchers involved in the study of vibration-based methods for damage identification in reinforced concrete structures. Such methods are often investigated and validated using data generated by numerical models where damage is simulated as a localized or global reduction of the material mechanical characteristics. In this paper, a strategy to realistically model the behavior of a cracked reinforced concrete bridge deck is proposed. This modeling strategy, albeit relatively straightforward to implement, allows to consider several complex phenomena and at the same time does not entail heavy computational effort. The modeling strategy is applied to simulate the dynamic behavior of a reinforced concrete multiple T-section girder bridge. Several types of damages are simulated and the sensitivity of modal frequencies and load-carrying capacity to different damage scenarios is investigated.

Keywords: finite element model, damage simulation, reinforced concrete beams, natural frequencies.

1 Introduction

Effective management of bridge integrity through the identification, prioritization, and planning of maintenance interventions is essential to keep the required levels of safety and serviceability throughout the bridge service life. The knowledge of damage and deterioration processes affecting the managed structure is pivotal to this aim since it enables the planning of maintenance based on the actual structural condition rather than on preventively scheduled interventions. The aim of inspections and monitoring is to support integrity management through information about the onset and development of damage and degradation.

Damage due to vehicle impacts or corrosion causes loss of section area in reinforced concrete bridge deck beams that can significantly reduce their stiffness leading to adverse effects on the bridge functionality. Aggressive environments and increased frequency of events related to climate change may escalate the effects of this type of damage. In the last thirty years, non-destructive tests (NDT) for the identification of damage have been developed to identify damage at an early stage. Among those, dynamic tests based on the analysis of the response to forced or ambient vibrations are the most effective to detect damage induced by losses of stiffness of the structural components. The damage identification procedure involves the processing of vibration data to extract damage-sensitive features and identify possible deviations from reference values [1], [2]. The comparison of the values of these features in a reference and in a potentially damaged state in principle provides information about damage [3]–[7]. Several vibration-based methods for damage detection are based on changes of the natural frequencies which, among modal parameters, can