Physical Nonlinear Model Adaptation in Long-Term Structural Health Monitoring: Proposals of Experimental Studies on a Reinforced Concrete Beam

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Summary

In this paper a model adaptation approach for concrete bridge superstructures is presented. The approach aims at identifying structural characteristics during long-term structural health monitoring, i.e. when the bridge is open for traffic and weights and locations of passing vehicles are unknown. Thus, system and load properties of the structure have to be determined at the same time. To verify the approach, proposals of experiments on a reinforced concrete beam are presented. The proposed specimen is a single span beam loaded by 2 single forces. During load application structural responses (strains, deflections and reaction forces) are recorded. In the progress of the experiments, damage is induced in the longitudinal reinforcement by cutting reinforcement bars. Based on the recorded responses, numerical models are adapted. Goal of the adaptation is the localization of the induced damage, the quantification of its extent and the determination of magnitude and location of the respective single force. Prior to the tests on the specimen, the experiments are numerically simulated by carrying out physical nonlinear finite element analysis. Based on the simulations, test runs of the model adaptation process had been performed.

Keywords: Structural health monitoring; model adaptation; model-updating; system identification; physical nonlinear analysis; evolutionary algorithms.

1. Introduction

1.1 Structural health monitoring

In contrast to conventional methods, which are based on visual inspection, structural health monitoring (SHM) is computer-aided monitoring of civil engineering structures by acquiring and processing measurement data. The fundamental objective of SHM is the early detection and localization of structural damage, classification of the damage, quantification of its extent as well as estimation of the remaining life time of the structure [1]. Usually, in civil engineering SHM is associated with bridge superstructures.

Generally, two different approaches to SHM can be distinguished: (1) Model-free and (2) model-based techniques. Model-free methods detect anomalies by comparing structural responses measured before and after an occurrence of damage. These methods do not employ any numerical model of the structure. An overview of different model-free techniques is presented and compared in [2]. Model-based SHM techniques rely on creation and improvement of a numerical model representing the structure. During this process, often referred to as system identification, the uncertain parameters of the model are calibrated, until the calculated responses of the model (prediction) match the responses observed at the real structure (observation). Commonly, the

https://doi.org/10.2749/222137810796063562
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