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Damage detection and quantification using transmissibility

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ABSTRACT

Structures experience various types of loads along their lifetime, which can be either static or dynamic and may be associated to phenomena of corrosion and chemical attack, among others. As a consequence, different types of structural damage can be produced; the deteriorated structure may have its capacity affected, leading to excessive vibration problems or even possible failure. It is very important to develop methods that are able to simultaneously detect the existence of damage and to quantify its extent. In this paper the authors propose a method to detect and quantify structural damage, using response transmissibilities measured along the structure. Some numerical simulations are presented and a comparison is made with results using frequency response functions. Experimental tests are also undertaken to validate the proposed technique.

1. Introduction

The objective of structural health monitoring is to assess the working condition of a structure, to detect in advance any incipient damage that may exist and therefore to prevent any possibility of a catastrophic failure.

There are five questions that researchers try to answer: (i) Does damage exist? (Detection), (ii) Where is the damage? (Localization), (iii) How much and how serious is the damage? (Quantification), (iv) What sort of damage? (Classification) and (v) How long will the structure remain operational? (Prediction).

The application of health monitoring techniques to machinery is well established, namely vibration-based condition monitoring; the same does not hold true with structures, especially large and complex ones, like buildings and bridges.

Structural health monitoring is often based on local and off-line non-destructive evaluations, such as visual inspection, ultra-sound, eddy-current and X and Gamma rays. However, this may imply high costs and intermittent exploration.

During the last twenty years or so the focus of the investigations has been the global and on-line non-destructive evaluation. Amongst the techniques under development one can outline those using mechanical vibrations, smart materials, image processing, optical fibers, novelty-based and statistical pattern recognition. One of the main objectives of using such techniques is to reach less costs and continuous exploration of the structures.

The fundamental basis of mechanical vibrations methods relies on the fact that damage alters the dynamic properties of the structure. Defining proper indicators that take into due account modifications in natural frequencies, damping ratios, stiffnesses, mode shapes and operational mode shapes allow us to have a measure of damage. Many methods are based

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