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Ambient vs Forced Excitation & Continuous vs Discrete Sampling of Data for Structural Health Monitoring

Maas Stefan, Nguyen Viet-Hà, Kebig Tanja, Schommer Sebastian

University of Luxembourg, FSTC, Engineering Sciences, Luxembourg

Zürbes Arno

Technische Hochschule Bingen, Fachbereich 2, Bingen, Germany

Contact: stefan.maas@uni.lu

Abstract

Structural Health Monitoring with analysis of dynamic characteristics intends to detect stiffness changes caused by damage. As local stiffness loss itself cannot directly be measured, the modal parameters i.e. eigenfrequencies, damping, modeshapes with modal masses allow to obtain residua of the transfer matrix. One row of transfer matrix is equivalent to physical description based on mass-, damping- and stiffness-matrix, where the latter is of interest to identify and localize changes due to damage. Today several practical options for tracking modal parameters are used. Changing ambient temperature has important influence on modal parameters and hence on stiffness, which should be separated from damage. Furthermore, reinforced concrete shows dependency on excitation force, which is a non-linear phenomenon to be considered. After presenting these effects, the paper will focus on ambient excitation compared to forced excitation including appropriate exciters. Then continuous monitoring will be discussed versus discrete testing in distinct time-intervals. The intention is to give an overview to localize and quantify damage later on.

Keywords: ambient excitation; forced excitation; modal analysis; structural health monitoring; dynamic damage indicators

1 Introduction

Experimental Modal Analysis (EMA) is traditionally based on measurement of input (forces) and output signals (displacement, velocity or acceleration) at discrete points or Degrees Of Freedom (DOFs), in order to extract the modal parameters: eigenvalues, modeshapes and modal masses. In principle, a full set of modal parameters (n-modes for an n-DOF-system) may be used to deduce the stiffness matrix, or at least to its inverse, the so-called flexibility matrix as detailed for instance in Ref. [1]. Thus stiffness loss may - in principle - be detected, localized and quantified based on EMA which indeed is an indicator for damage. (Load carrying capacity of a bridge or its decrease is more difficult and outside the scope of this paper).

The eigenfrequencies are the imaginary part of the eigenvalues and are well known and very often used as the first damage indicator in addition to visible cracks in the concrete. Hence traditional visual inspections of bridges may be amended by tracking of eigenfrequencies, which means in

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