Observability Method for Structural System Identification

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Summary

The structural response of any structure is traditionally predicted by simplistic physics-based models. In these models the mechanical and geometrical properties are assumed as known. Nevertheless, this is not the case in most actual structures where the values of the actual properties (such as axial or flexural stiffness) are unknown due to uncertainties in the materials, in the construction methods or in the stress state. In some cases, a calibration of the computer models is required to improve de accuracy of the predicted structural response. To carry out this task Structural System Identification (SSI) methods can be used.

In this paper, a new parametric method for SSI from static excitation response is proposed. This method is based on the observability of the structure, understanding as such the problem of identifying which is the subset of characteristics of the structure, such as Young's modulus, area, inertia, and/or products of them (axial or flexural stiffnesses) that may be uniquely determined when a subset of deflections and forces at nodes is provided. This method has lead to the development of a powerful mathematical tool to deal efficiently with polynomial systems of equations with a number of applications in many fields of science and engineering.

To illustrate the applicability of the proposed method, the analysis of the SSI of two structures of growing complexity is presented.

Keywords: Structural system identification, observability technique, stiffness matrix, damage.

1. Introduction

Traditionally simplistic physics-based models, e.g. Finite Element (FE) Models, are used to predict the structural behaviour of the structures. In these models the mechanical and the geometrical properties of the elements are assumed as known. Nevertheless, this is not the case in most actual structures, where the actual characteristics are unknown due to uncertainties in the materials, construction procedures and stress state. To increase the accuracy of the simulation, the mechanical and geometrical properties of these models might be calibrated from monitoring information. This process is known as Structural System Identification (SSI) [1].

Adeli and Jiang [2] classified the SSI methods as parametric (e.g. [3]), in which the set of equations has a physical meaning, and non-parametric (e.g. [2]), in which it has not. According to the type of excitation, the SSI methods can be also classified as input-output methods or only output methods. The main difference between both groups refers to the information of the excitation loads. In the input-output method, the excitation loads might be assumed known while in the output-only methods they are unknown. Multiple examples of input-output methods have been presented in the literature for dynamic, static or mixed excitation. Static methods can identify only stiffness parameters and are not able to capture any changes in mass and damping parameters, while dynamic methods can identify changes in all structural parameters. Nevertheless, many applications only require element stiffness identification for condition assessment. In these cases, static methods can prove simpler and more adequate for economical and computational time reasons [3].

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