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MODAL IDENTIFICATION METHODS IN TIME DOMAIN NUMERICAL TESTS AND APPLICATIONS IN CIVIL ENGINEERING

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ABSTRACT

This work intends to contribute to the development and use of time domain modal identification methods, namely the Maximum Likelihood Method (MLM) and the Covariance-Driven Stochastic Subspace Identification Method (SSI-Cov). Both methods are studied using numerically generated data and the SSI-Cov method is applied to the analysis of dam vibration records, due to environmental excitation.

Keywords: time domain modal identification, Maximum Likelihood Method, dam vibrations.

INTRODUCTION

In order to characterize the degradation state of existing structures, ambient vibration tests are used to the identification of the main modal parameters, based on the so-called modal identification methods. Modal parameters (natural frequencies, modal damping and mode shapes) are directly related to the actual conditions of conservation / deterioration of the structures, since they depend on their characteristics of rigidity, mass and damping. The methods of modal identification are divided into two main categories - time domain and frequency domain methods. In this work are presented the time-domain methods, namely the Maximum Likelihood Method (MLM) (Prior, A. 2015; Prior *et al*., 2017) and the Covariance-driven, Stochastic Subspace Identification method (SSI-Cov) (Juang and Phang, 2001).

The MLM is implemented for fully observed systems and the SSI-Cov for partially observed systems, using MATLAB. Firstly both methods are used in order to study simple structures, such as N-storey buildings, as fully observed systems. Subsequently, the SSI-Cov method is applied to simple structures partially observed and is tested on the Cabril dam, based on numerically generated records, using a 3D finite element model of the dam (considering white noise type excitation). Finally the method is used for the analysis of actual vibration records measured at the Cabril dam, with a continuous vibration monitoring system, installed on site since 2008.

RESULTS AND CONCLUSIONS

For a simple 3 storey building, numerically generated records of displacements and velocities under ambient excitation are used to compute the average trajectories that illustrate the MMV convergence process over a time period of 200 s as presented in Figure 1, in terms of natural frequencies f_n and modal damping coefficients ξ_n (obtained from the eigenvalues λ_n estimated state matrix: $f_n = |\lambda_n| / 2\pi$ e $\xi_n = -Re(\lambda_n)/| \lambda_n |$).

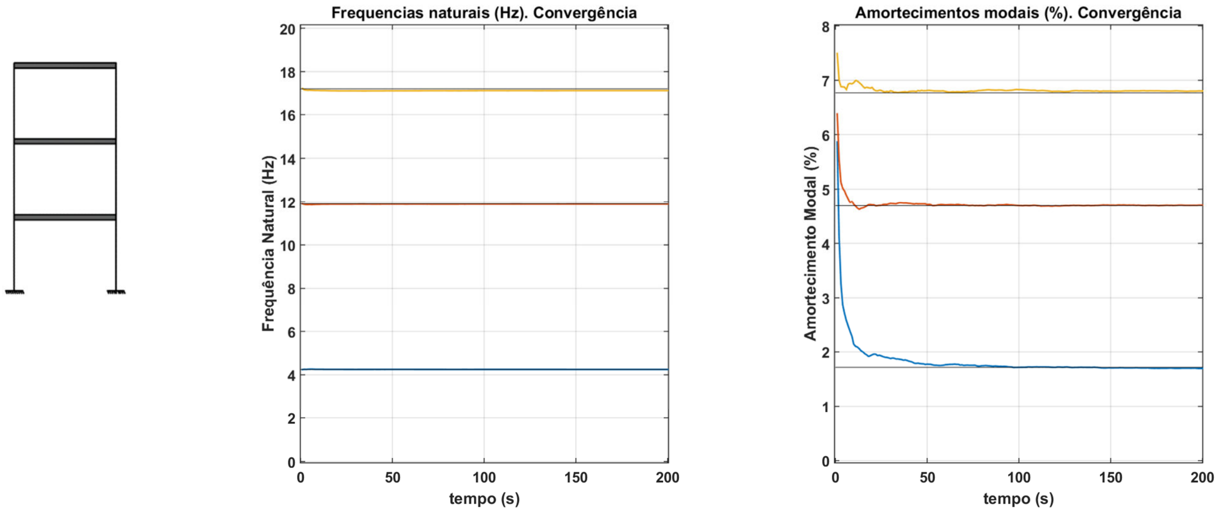

Fig. 1 - MMV convergence for natural frequencies and modal damping.

This study shows the good agreement between numerical reference values of natural frequencies and modal damping and the estimated correspondent values. Using the SSI-Cov method for the analysis of these data, frequencies can also be well obtained, but the modal damping is not very well captured.

Tests with acceleration histories numerically generated with a FEM3D of a dam (simulating "observed" histories) have shown that the SSI-Cov method can be of great interest in the analysis of data of dam vibrations monitoring systems.

Finally, the SSI-Cov method was used in the analysis of Cabril dam measured accelerations (Oliveira *et al*., 2012) and the identification results, namely, natural frequencies and mode shapes, showed a good agreement with results obtained by spectral analysis and results of numerical models of EF3D.

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