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SEISMIC BEHAVIOR OF ARCH DAMS AND APPURTENANT WORKS. MONITORING AND MODELLING

Sérgio Oliveira(*), André Silvestre, Margarida Espada, Romano Câmara
National Laboratory for Civil Engineering (LNEC), Lisbon, Portugal
(*)*Email:* soliveira@lnec.pt

ABSTRACT

The best way to get useful experimental information about the dynamic response of dam-reservoir-foundation systems and appurtenant works (Espada et. al, 2011), under seismic loads and ambient/operational excitation, is the use of Automatic Data Acquisition Systems (ADAS) for long-term dynamic monitoring. From the measured acceleration records on dam body and at the rock mass foundation we can:

(i)- study the correlation between modal parameters and structural changes (due to extreme events like earthquakes or due to slow deterioration processes, e.g. swelling);

(ii)- study the evolution of the main modal parameters due to water level variations and thermal waves;

(iii)-get the data we need to calibrate new numerical models for the simulation of the dynamic response of dam-reservoir-foundation systems under seismic loads.

These dynamic monitoring systems are expected to cover the current lack of experimental reliable data about the dynamic response of such structures, which is a fundamental step for addressing the remaining questions about the dynamic modelling of dam-reservoir-foundation systems, particularly as refers to the hypotheses related with the simulation of water-structure interaction and damping effects.

Keywords: dynamic monitoring systems, dam-foundation-reservoir systems, seismic behavior, ambient excitation, modal identification, FE state space modelling

INTRODUCTION

In the scope of LNEC research program on dam safety control, late 2008, a long-term dynamic monitoring system was installed in the highest Portuguese arch dam - Cabril dam (60 years old; 132 m high; significant horizontal cracking near the crest; concrete swelling process under development) (Oliveira, 2011). The acceleration records that have been continuously measured (on 16 points over the dam body and on 2 points near the insertion) are automatically processed using modal identification techniques (Peeters, 2000), in order to obtain experimental information about the evolution of natural frequencies, modal damping, and mode shapes (stationary or non-stationary modes).

This system was designed not only for recording continuously the dam dynamic response under ambient and operational excitation but also for recording seismic events, namely for recording seismic accelerations on dam body and at the rock mass foundation, near the insertion.

RESULTS AND CONCLUSIONS

In this work a numerical model of Cabril dam is presented. This model was analyzed with DySSA1.1 (Dynamic State Space Analysis) that is a 3D finite element program developed in MATLAB for the dynamic analysis of coupled systems dam-reservoir-foundation considering water finite elements for the reservoir (displacement formulation). A sate space formulation is used allowing the consideration of non proportional damping and the computation of complex vibration modes.

The numerical model was calibrated in order to get a good matching between the peak frequencies and mode shapes obtained experimentally and numerically, with DySSA1.1 (Fig. 1). The calibrated model was then used to simulate the seismic dam response measured during the Sousel earthquake (March 2010).

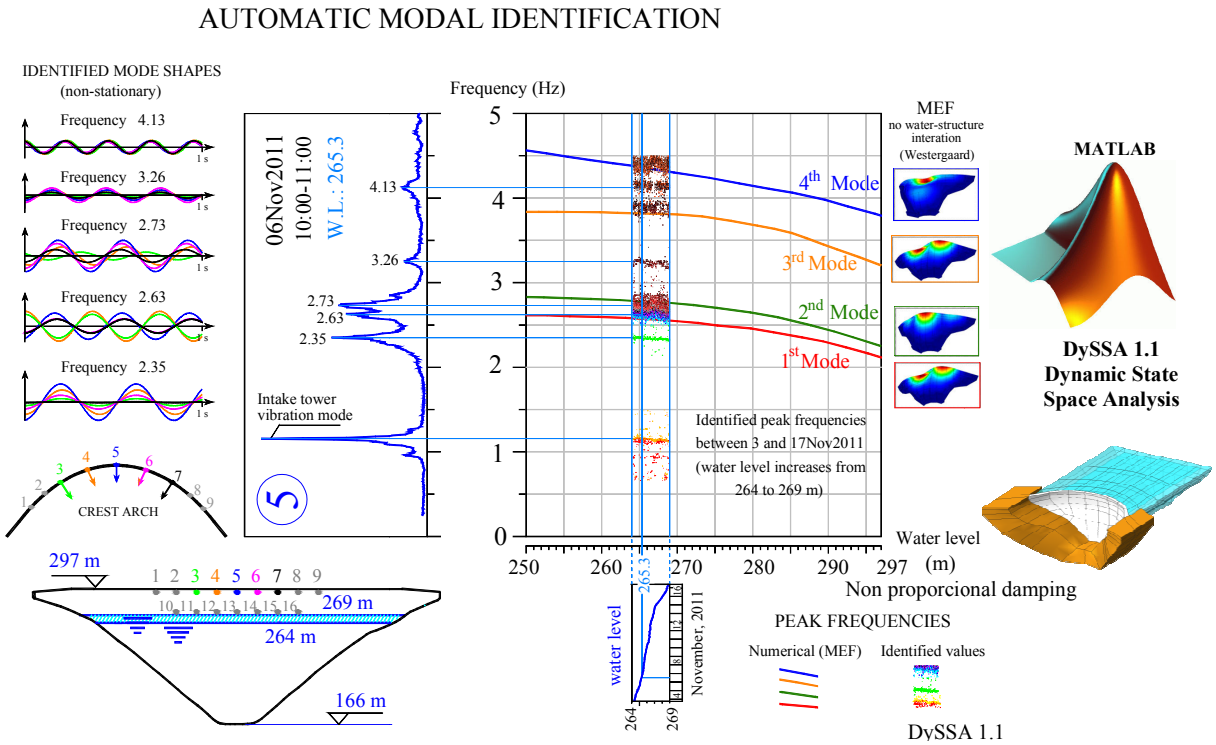

Fig. 1 - Results from automatic modal identification and comparison with numerical results from DySSA1.1 (3DFE program).

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