Dynamic Monitoring of a Large Span Wood Roof

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Abstract The roof of the Atlantic Pavilion in Lisbon is a large span glue laminated wood structure with a characteristic shape inspired on the shell of a horseshoe crab. It was one of the first large wood constructions to be designed according with Eurocode 5.
This paper presents the work that is being developed concerning the implementation of a permanent dynamic monitoring system for the Atlantic Pavilion Roof, which is part of a research project on "Dynamic Monitoring for Structural Safety Assessment".
A permanent dynamic monitoring system consisting of 1 triaxial and 14 uniaxial accelerometers, temperature and humidity sensors and one anemometer has been installed in the roof.
A complete tridimensional finite element model of the roof structure was also developed.
The paper also briefly refers the strategies that are being implemented for the continuous analysis of the data recorded with the permanent dynamic monitoring system.

Keywords dynamic monitoring, large span wood roof, vibration based structural monitoring

1. INTRODUCTION

This paper presents some important contributions for the objectives of the Dynamic Monitoring System of the Atlantic Pavilion Roof, which is being developed within the framework of a research project on "Dynamic Monitoring for Structural Safety Assessment". Essentially, the development of a tridimensional numerical finite element model of the roof, the identification of its dynamic characteristics from the data obtained in ambient vibration tests performed as part of this work and the consideration of those modal properties in the calibration of the finite element model, adjusting the computed values to the identified ones.

2. MODELING OF THE STRUCTURAL BEHAVIOR

The structural behavior of the Atlantic Pavilion Roof was modeled using a tridimensional numerical finite element software, SAP2000. The model was developed with the main purpose of computing the dynamic characteristics of the structure, which were going to be compared with the ones experimentally identified.
The developed finite element model has a total of 7256 joints, 11308 beam elements and 96 restraints to model the bearings. A total of 334 body constraints are also defined. The model has therefore a total of 38300 independent degrees of freedom.

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3. DYNAMIC TESTS AND MODAL IDENTIFICATION

The main purpose of the dynamic tests performed in the Atlantic Pavilion Roof was the experimental evaluation of the global dynamic characteristics of the structure. They consisted in the measurement of ambient vibrations, induced in the structure, essentially, by the effects of the wind, but also by the traffic of vehicles in the vicinity of the structure and by the organizing and cleaning works that were being done inside the pavilion. The acceleration records obtained in the tests were analyzed using a stochastic modal identification method to identify the dynamic characteristics of the roof.

Since there was the intention of doing a good identification of the natural vibration modes shape, the dynamic tests involved acceleration measurements in a total of 27 points, located in the 9 frames with larger span and height. The permanent equipments were used in 15 of those points and the temporary equipments in the other 12 points. In each of the systems, the accelerations were recorded independently but almost simultaneously. The sampling frequency used in the tests was 833.33 Hz and the obtained acceleration records have a total duration of 1 hour.

The identification of the dynamic characteristics of the Atlantic Pavilion roof was performed with the enhanced frequency domain decomposition method (EFDD) implemented in the software ARTeMIS Extractor. For that purpose, the spectral density functions of the acceleration records were estimated considering samples with 1024 values, which correspond to a frequency resolution of 0.0163 Hz in the spectral density functions estimates. From the singular values and vectors decomposition of the matrices of those functions, singular values spectra were obtained.

The EFDD method procedures were applied to the amplitude peaks detected in the singular values spectra. With such approach, 6 vibration modes of the structure were identified.

4. MODEL CORRELATION AND CALIBRATION

The calibration and updating of the model was started after the first measurements, which were taken after the installation of the permanent equipments. In fact, from the analysis of those initial records it was possible to obtain a first estimate for the frequencies of the first modes. The difference between these values and the computed ones allowed to detect some aspects needing improvement and after their correction, a model already closer to the experimental values, was obtained, which is however named as the initial model.

The final calibration of the model was concluded based on the results of the dynamic characterization tests. This calibration was performed on the initial model, resulting in a calibrated model, where the mounting joints in the main beams of the transverse frames were modeled as elastic connections.

The correlation of the identified dynamic characteristics with the computed ones was checked using different ways to establish a comparison between the two sets of results, namely: the comparison of the frequency values presented in a table; the graphical comparison of the computed frequencies with the identified ones; the graphical representation of the mode shapes; 45º plots where the computed modal components are compared with the identified ones; the MAC coefficient; and the COMAC coefficient.

5. CONCLUSIONS

A permanent dynamic monitoring system consisting of accelerometers, temperature and humidity sensors and one anemometer was installed in the Atlantic Pavilion Roof. Ambient vibration tests were performed, where, besides the permanent transducers, additional accelerometers were used, increasing the total number of instrumented points. Experimental modal identification techniques were used to analyze the data collected in the tests in order to identify the dynamic characteristics of the roof.

The identified dynamic characteristics are in good agreement with those computed with the model, after calibration, both in terms of frequencies and of their respective vibration modes shapes. Thus, it can be considered that the developed tridimensional finite element model is reasonably well validated. It was therefore satisfactorily accomplished, the purpose of making an initial characterization of the structure, which is important for the future development of the Dynamic Monitoring System of the Atlantic Pavilion Roof.