Application of Operational Modal Analysis to a large span roof structure, using OROS Modal 2

OROS
APPLICATION NOTE

Pr Lingmi Zhang, Nanjing University of Aeronautics & Astronautics, China
Séverine Colas, Application Engineer, OROS

Dynamic characterization of civil engineering structures becomes increasingly important for dynamic response prediction, finite element model updating, structural health monitoring, as well as passive and active vibration control of the high/middle-rise buildings, towers, long-span bridges, etc. A civil engineering structure can adequately be excited by non-measurable ambient, or natural, excitation such as wind, turbulence, traffic, and/or micro-seismic tremors. Ambient vibration tests have two major advantages compared to forced vibration test to obtain dynamic characteristics of large civil engineering structures. One is that no expensive and heavy excitation devices are required, and, therefore it is easy and economic to implement. The other advantage is that all (or part) of measurement DOFs can be used as references. The identification algorithm used for operational modal analysis must so be MIMO. The closed-spaced or even repeated modes can easily be handled.


Figure 1: The Tokyo Horse Racing Stadium

An ambient modal testing was conducted with respect to the roof of the Tokyo Horse Racing Stadium. This test has been realized right after finishing remodelling one third of the stadium.
The roof can be modelized as a plane for which dimensions are 108×49 meters.

66 accelerometers have been used for the test measurement. They were placed uniformly on the square-shaped roof. The test procedure is organized in 4 steps during which the group of 66 accelerometers is moved to acquire vertical vibration on the 264 DOFs.
Three accelerometers were used as references.


Figure 2: The roof of the stadium

The analysis of these measurements shows many modes in the frequency range of interest. Nevertheless, high quality Modal Indicator Function (MIF) implemented in OROS Modal 2 was used to show clearly all the structural modes.
For further analysis, the OMA identification method existing in OROS Modal 2 is used. This technique is called Spatial and Frequency Domain Decomposition (SFDD).

In the SFDD technique, the Power Spectral Density (PSD) matrix is formed at first from ambient response measurements. In a second step, the PSD matrix is decomposed at each frequency line via a Singular Value Decomposition (SVD). SVD has a powerful property: the capability to process noisy data. Disturbance in the data can be caused by unmodeled dynamics in the structure environment and measurement noise process.

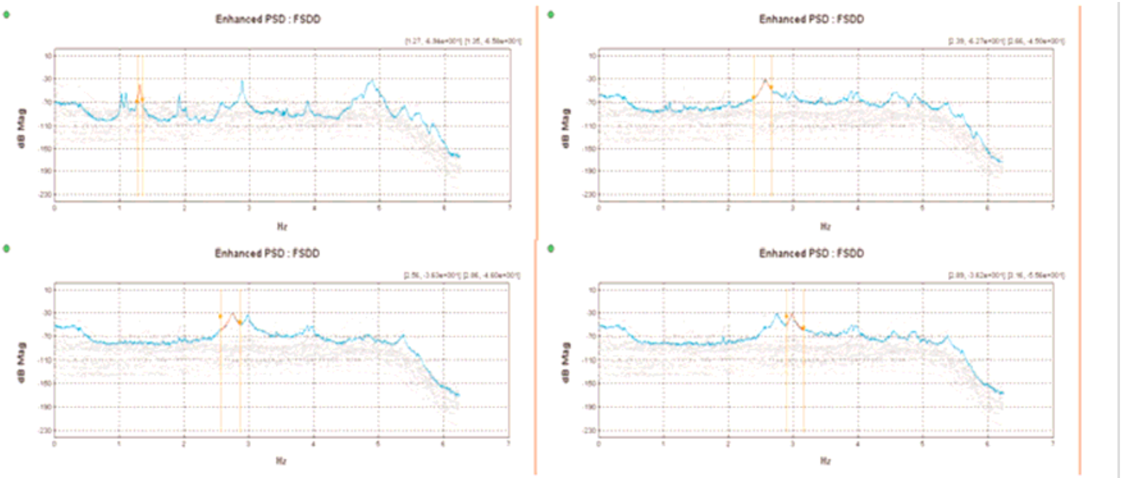

Figure 3: Modal Indication Function of the HRS roof

The singular vector corresponding to the local maximum singular value is an unscaled mode shape. The method assumes that the excitation can be considered as white Noise in the frequency rage of interest. Orthogonality is also assumed in this method. The results in this application story show 16 modes identified in the range [0; 5.6Hz]. Figure 4 shows the relevant mode shapes. These modes are unscaled.

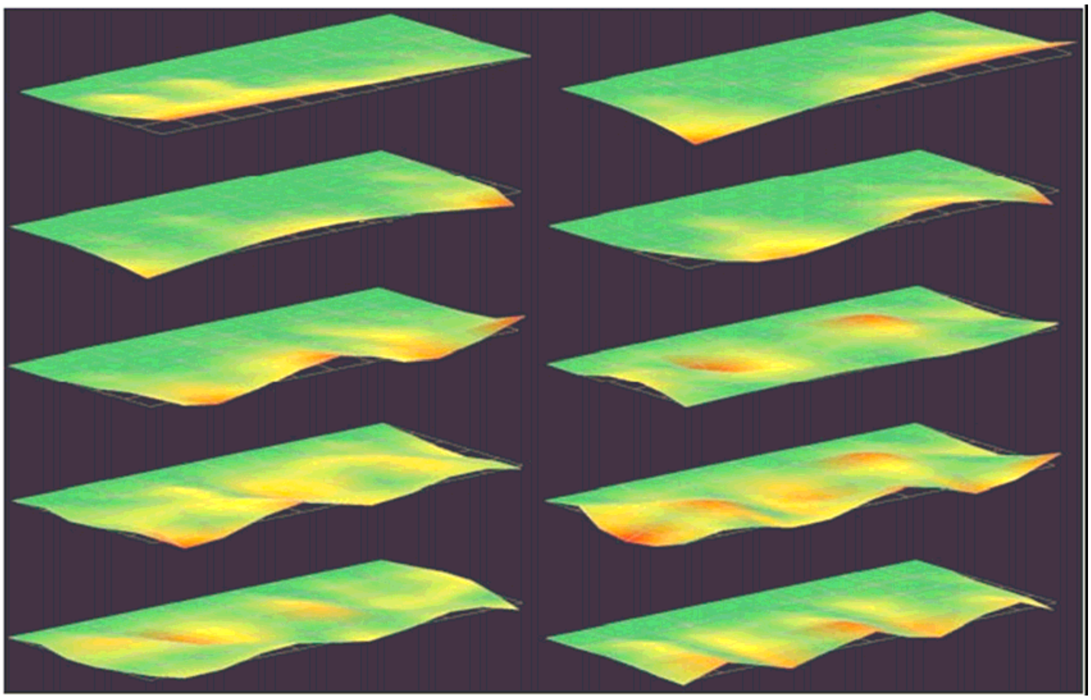

Figure 4: Identified mode shapes