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Dynamic Tests on Vasco da Gama Cable-Stayed Bridge

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Abstract

The Vasco da Gama Bridge is the new Tagus River crossing in Portugal, 17300m long, including three interchanges, a 5km long section on land and a continuous 12300m long bridge, recently constructed close to the area of EXPO-98 international exhibition. It includes a cable-stayed component (Figure 1) over the main navigation channel with 420m central span and three lateral spans (62+70.6+72m) on each side, corresponding to a total length of 829.2m between transition piers. The bridge deck is 31m wide and is formed by two lateral prestressed girders, 2.6m high, connected by a slab and by transverse steel I girders. It is continuous along its total length and it is suspended at level 52.5m by two plans of 48 stays connected to each tower. The two towers are H shaped and 147m high above a massive zone at their base as protection against ship collision.

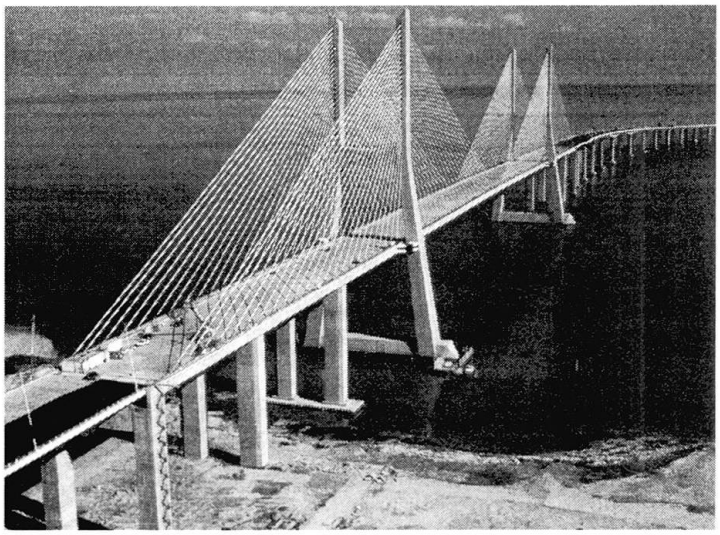

Figure 1: View of Vasco da Gama cable-stayed bridge

Due to the high proneness of long span bridges to be affected by aerodynamic instability problems, as well as to the high seismic risk of the Southern part of Portugal, the dynamic behaviour of Vasco da Gama cable-stayed bridge has been extensively studied using both experimental and numerical approaches. In particular, dynamic tests have been performed by the University of Porto in order to experimentally identify the most relevant modal parameters of the cable-stayed bridge from the aerodynamic and seismic behaviour point of view, and correlate them with the corresponding parameters provided by the 3-D numerical model developed by EEG (Europe Études Gecti, Villeurbanne, France), using the finite element program Hercules.

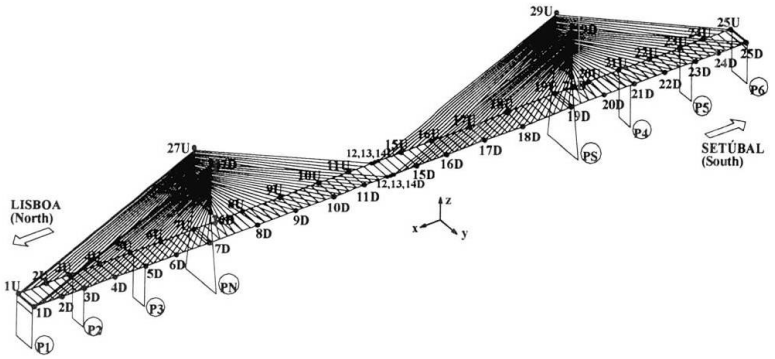

Figure 2: Schematic representation of the bridge with indication of the measurement sections used in the ambient vibration test

These dynamic tests, involved the following main tasks:

- preliminary measurements for evaluation of the levels of acceleration signals and identification of an appropriate reference section;
- development of an ambient vibration test for identification of natural frequencies and mode shapes, involving tri-directional measurements at 58 distinct points along the deck and towers;
- performance of response measurements under the passage of heavy trucks, passing over a hood plank, to increase the vertical accelerations;
- development of a free vibration test by sudden release of a mass of 60t suspended from the deck, in order to accurately indentify modal damping factors;
- performance of dynamic measurements on some of the longest stay cables so as to identify global and local natural frequencies, both using conventional piezoelectric accelerometers and a laser Doppler velocity transducer;
- experimental evaluation of dynamic amplification factors (DAFs) associated to the passage of heavy traffic at different speeds and along several lanes.

This paper makes a brief presentation of these dynamic tests, which permitted, in particular, (i) to evidence the efficiency of the measurement system applied in the ambient and free vibration tests, based on the use of independent triaxial accelerographs conveniently programmed and synchronised by a portable PC; (ii) to obtain very accurate estimates of natural frequencies, mode shapes and damping factors, despite the rather low level of signal captured, the low range of natural frequencies of interest (0-1Hz) and the relatively high number of different modes of vibration in that range (iii) to achieve modal parameters estimates that present an excellent correlation with the corresponding parameters calculated on the basis of the 3D finite element model developed at the design stage; (iv) to stress the interest of application of a laser Doppler velocity transducer to perform dynamic measurements in stay cables, providing a simple and accurate alternative procedure for systematic performance of dynamic measurements in stay cables without direct contact with the cable surface; (v) to show the feasibility of experimental evaluation of DAFs.