Dynamic measurement on stay-cables using microwave interferometry

Carmelo Gentile
Associate Professor
Politecnico di Milano
Milan, Italy
gentile@stru.polimi.it

Summary

The paper addresses the application of microwave remote sensing to the measurement of the vibration response in the stay-cables of cable-stayed bridges. The investigation clearly highlights the simplicity of use of the radar technique (especially when compared with conventional approaches), its effectiveness to simultaneously measuring the dynamic response of all the stay-cables of an array, and the accuracy of the results in terms of natural frequencies and tension forces.

Keywords: Dynamic testing; interferometry; radar; remote sensing; stay-cable.

1. Introduction

Stay cables are main load-carrying elements of cable-stayed bridges and dynamic measurements of cable vibration are often required with different objectives, such as: (1) the experimental identification of local natural frequencies and damping ratios; (2) the evaluation of cable tensions, either to check the correct distribution of internal forces in the bridge at the end of construction or to track the possible change of cable tensions in time for structural health monitoring; (3) the assessment of potential fatigue problems in stay cables caused by long-term traffic loads; (4) the evaluation of the amplitude of cable vibrations.

The measurement of cable vibrations is generally based on the use of accelerometers. Although wireless transmission of measured data is now possible for the accelerometer, it remains a contact type of sensor that needs to be conveniently attached to the external cable surface; hence, the installation requires significant effort, especially when dealing with a large number of stay cables, and might interfere with traffic if the bridge is under service. Hence, it is of primary importance to develop and apply new measurement techniques, that enable accurate and systematic dynamic measurements on stay cables in a simple and safe way; as a consequence, the measurement of cable vibrations has become a standard benchmark for the application of innovative non-contact systems [1-4].

Examples of non-contact sensors successfully employed in the dynamic assessment of stay cables include Laser Doppler Vibrometer (LDV) [1-2] and vision-based systems using digital image processing techniques [3-4]. Furthermore, the microwave interferometry [5] has recently emerged as a technology, suitable to the remote sensing of large structures [6-10]. A new radar sensor, based on high resolution waveform [11] and interferometric principles [12], was developed by the Italian company IDS (Ingegneria Dei Sistemi, Pisa, Italy), in collaboration with various partners [5]. The main characteristic of the microwave interferometer, named IBIS-S (*I*mage *B*y *I*nterfeometric *S*urvey of *S*tructures), is the possibility of measuring the static or dynamic displacement at multiple locations within its applicable distance.

After some preliminary tests on full-scale structures [5], a joint research between IDS and the Dept. of Structural Engineering of Politecnico di Milano was carried out to validate the equipment results both in laboratory tests [7] and in ambient vibration tests (AVT) of full-scale bridges [6-9].

The paper first describes the radar equipment and its technical characteristics in order to highlight

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