DOI: 10.24904/footbridge2017.09694

COMPUTING SERVICEABILITY PREDICTORS FOR AN IN-SERVICE FOOTBRIDGE

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Summary

In order to analyse the in-service response of a footbridge, several vibration predictors may be computed, such as peak acceleration, running Root Mean Square acceleration, Maximum Transient Vibration Value, Response Factors and Crest Factors. These predictors have been derived from controlled and uncontrolled tests on Veterinary Faculty Footbridge, sited in Madrid, using frequency weighted and unweighted raw data.

Prior to the in-service serviceability assessment, the structure has been analysed, firstly, using an FFT-mobile application (by obtaining the frequency spectrum as a first approach to natural frequency estimation), and secondly, from operational data (by applying operational modal analysis techniques) and free vibration response tests. In-service vibration analysis has been carried out employing only 2 sensors, placed on the structure according to modal shapes, weighted by means of frequency-dependent functions accounting for input frequency properties (dynamic loading factors of human loading) and output frequency perception (taken from ISO 2631-1). The vibration serviceability has been assessed and discussed from all the predictors, extracting conclusions about their convenience.

Keywords: operational modal analysis; vibration serviceability assessment; vibration predictors; sensor placement

1. Introduction

The dynamic behaviour of Veterinary Footbridge (Fig. 1) (Madrid) is analysed via Operational Modal Analysis (OMA) and free vibration response tests. Once the properties of the structure are estimated, a method to obtain the most convenient sensor location for the serviceability assessment is proposed. The method makes use of the modal shapes weighted by means of frequency-dependent functions accounting for input frequency properties (dynamic loading factors of human loading) and output frequency perception (taken from ISO 2631-1).Thus, only few sensors (as opposed to the dynamic characterization in which many sensors are used) are placed onto the structure for this purpose. Then, serviceability tests, synchronised and unsynchronised tests for footbridge natural frequency, are carried out. Vibration predictors proposed in ISO 2631: peak acceleration, running Root Mean Square (RMS) acceleration, Maximum Transient Vibration Value (MTVV), Response Factors and Crest Factors, are computed. The values of these vibration predictors give a general idea of the structure behaviour in relation with its comfort rate.

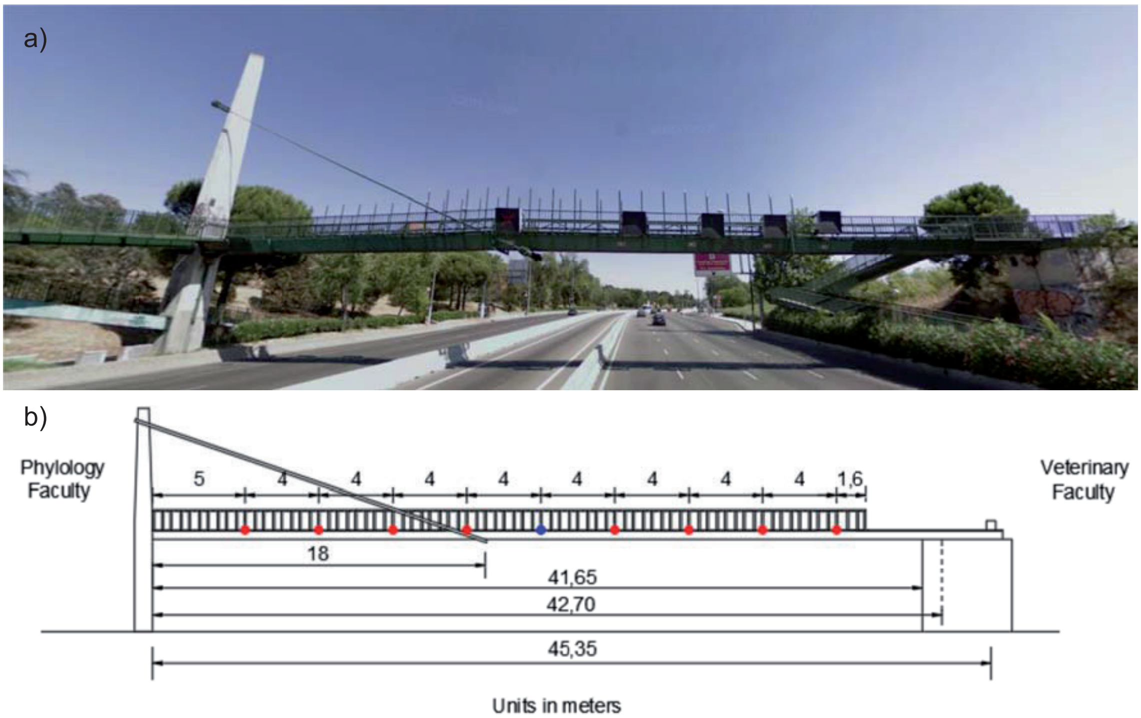

Fig. 1. Veterinary Footbridge sited over the A-6 motorway in Madrid. a) On-road view. b) Sensor placement for OMA.

2. Dynamic characterization of the structure y serviceability assessment

Table 1 shows the estimated natural frequencies and damping ratios. Similar results are obtained from free response test and jumping tests recording from a mobile application.

Vibration modes	Frequency (Hz)	Damping ratio (%)
1 (vertical)	1.8298	0.7987
2 (vertical)	3.8320	1.3891
3 (vertical)	5.9838	0.9138
4 (vertical)	10.5127	1.0623
5 (torsional)	13.5011	3.7915

Table 1. Modal estimation for vertical acceleration from OMA.

Comfort levels of the structure are determined from MTVV values. The possible comfort levels are maximum, medium, minimum or non-acceptable, depending whether the acceleration value is smaller than 0.5 m/s^2, around 0.5 to 1.0 m/s^2, around 1.0 to 2.5 m/s^2, or higher than 2.5 m/s^2. These levels are proposed for peak acceleration value. Thus, the comfort level of the footbridge using the MTVV is stablished by multiplying the obtained MTVV by square root of two, for each test. Table 2 shows the comfort level for each test carried out.

	Pedestrians walking			Pedestrians jumping		
	1	2	4	1	2	4
Comfort level	Maximum	Maximum	Maximum	Medium	Minimum	Minimum

Table 2. Comfort level of the footbridge, depending on the type of test performed.