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LONG-TERM VIBRATION SERVICEABILITY ASSESSMENT OF A STEEL-PLATED STRESS-RIBBON FOOTBRIDGE

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Summary

The research group is working on vibration cancellation of pedestrian structures with time varying modal properties. As a previous step of the design and installation of a semi-active vibration control device, the Vibration Serviceability Assessment (VSA) of a real case of time-varying modal-parameter footbridge is studied throughout this paper. The structure is a steel-plated stress-ribbon footbridge sited in Valladolid (Spain). This structure is particularly lively in vertical direction exhibiting several frequency closely-space vibration modes that might be excited by human excitation.

A continuous vibration monitoring system that measures the acceleration and the environmental factors was installed and one-year measuring raw data is analysed here. From the modal analysis of the structure, the location of the control device is proposed. Then, the long-term VSA for this particular location is carefully analysed. Thus, predictors described in general standards for human exposure evaluation to whole-body vibration are used.

Keywords: dynamic behaviour; vibration serviceability assessment; human-induced vibrations; time-varying modal parameters

1. Structure description and its dynamic behaviour

Pedro Gómez Bosque footbridge, sited in Valladolid (Spain), is a slender and lightweight structure that creates a pedestrian link over the Pisuerga River between a sport complex and the city centre. This bridge, built in 2011, is a singular stress-ribbon footbridge of 85 m span born by a pre-tensioned catenary-shape steel band (of only 30 mm thick) and precast concrete slabs lying on the band. A structural vibration monitoring system was devised in order to continuously estimate the modal parameters of the structure and to assess their changes under varying environmental conditions. The monitoring system is explained in detail in reference [1]. The novelty of this system is that low-cost MEMS accelerometers properly conditioned were used resulting finally in a cheap monitoring system. The natural frequency estimates for the more lingering modes over 1-year of continuous dynamic monitoring were derived in [4]. For future work, it is decided that the STMD will be at the point of maximum displacement of a most important mode. Because of this, the VSA presented is only carried out for the accelerometer corresponding to that node.

2. Vibration serviceability analysis

The vibration serviceability analysis presented in this Section is for one year monitoring. Tests of 2-min duration have been analysed (exposure time). Figure 1 shows the mean cumulative distributed curve obtained for R-Factor computed for weighted vertical acceleration. This curve represents the percentage of time that an R-value, 0.005 m/s^2, is not exceeded (cumulative distribution). It can be observed a spreading area that illustrates the difference between extreme cumulative curves. It is worth mentioning that although the average curve may seem appropriate, there are many tests in which very high amplitudes are experienced (in addition, it is an analysis for a single accelerometer).

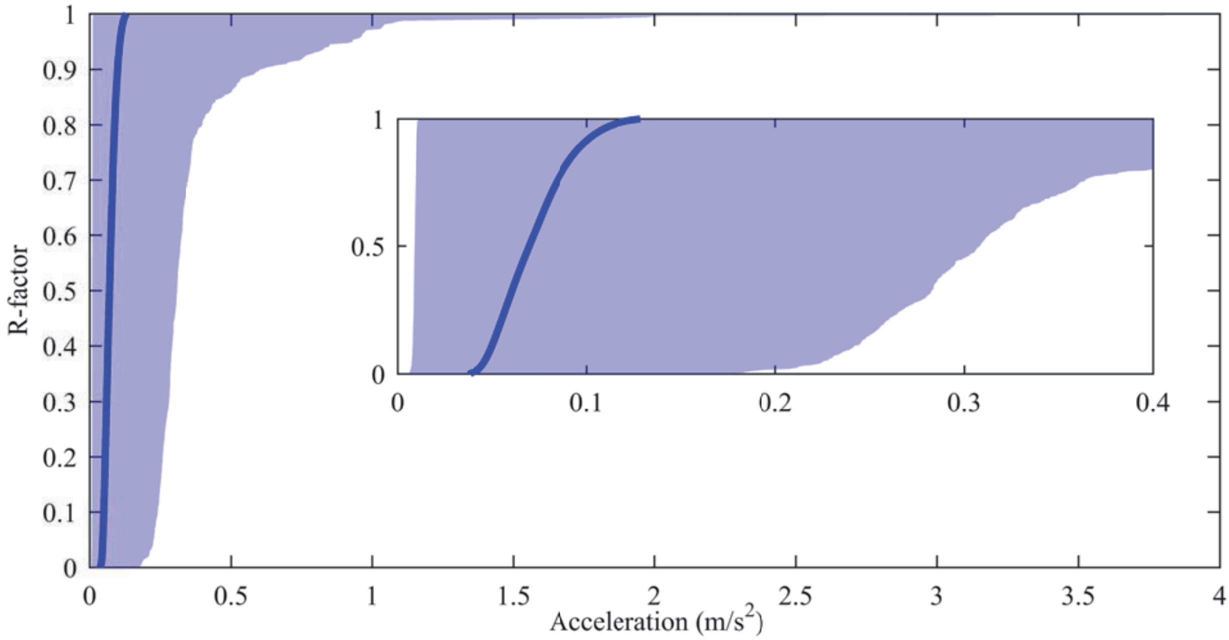

Fig. 1. Mean curve of R-Factor for weighted vertical acceleration. The shaded area indicates the range between the minimum and maximum curves for one-year monitoring.

3. Conclusions

An analysis of VSLS accelerations in the vertical direction has been presented for a particular accelerometer. The different predictors indicate, for certain service occasions, high or very high values of vibration. The following comments can be obtained: i) Mean values may not be representative in this type of cases. Although the average value during the day of the crest factor is around 6, this value is often exceeded. This fact means that a normal evaluation based on RMS values is not enough. MTVV and VDV are more appropriate predictors in this case. ii) Taking into account the MTVV values in its time history graph, it can be seen that a high value obtained frequently can be 0.50 m/s^2. This value is multiplied by root of 2 in order to be compared with accelerations values of different standards tables and to determine the comfort level of the footbridge. A value of 0.71 m/s^2 is obtained, which means that the structure has a medium level of comfort.

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