EVALUATION OF THE LATERAL VIBRATION RESPONSE OF FOOTBRIDGES UNDER UNCERTAINTY CONDITIONS

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Summary

The prediction of the dynamic response of footbridges due to walking pedestrians plays a fundamental role in the footbridge design, as excessive vibrations produce negative effects on the comfort and emotional reactions of pedestrians. The growing trend of slender footbridges with long spans and light materials has led to serviceability problems in lateral vibrations, which occur when the number of pedestrians reaches a "critical number". Considering the mode of vibration in which the lateral instability is more likely to develop, the structural response will depend on the modal characteristics of the footbridge, in particular the natural frequency f_b (Hz) and the damping ratio ξ (%). These parameters are stochastics variables that do not have a fixed value during the footbridge overall life cycle due to environmental and operational changes. Thus, the purpose of this paper is the evaluation of the lateral dynamic response of slender footbridges considering the uncertainties associated to the natural frequency and the modal damping ratio. This is done using a probabilistic approach . A sample set of "n" uncorrelated values of f_b and ξ, are randomly generated following a normal probabilistic distribution function. Consequently, the structural response will also be described by a probabilistic distribution function, which can be estimated through Monte Carlo numerical simulations. As a result, the study allows the footbridge lateral response and the critical number of pedestrians to be calculated for different confidence levels and load scenarios, especially for crowd densities above the "critical number". The method is applied using the Pedro e Inês footbridge (Portugal,2005) as benchmark. Figure 1 represents the results of the full-scale pedestrian tests performed on this footbridge together with the maximum acceleration response calculated considering four confidence levels (50th, 67th, 95th and 99th). The main conclusions of the study suggest that the external factors that affect the modal parameters of a footbridge are more significant when evaluating the lateral response in the case of crowd densities above the critical number. Moreover, the method used for assessing the lateral response under postlock-in conditions results very useful to highlight the impact of environmental and operational changes on the lateral response of the footbridge, which implies an important advantage over most current design guidelines.

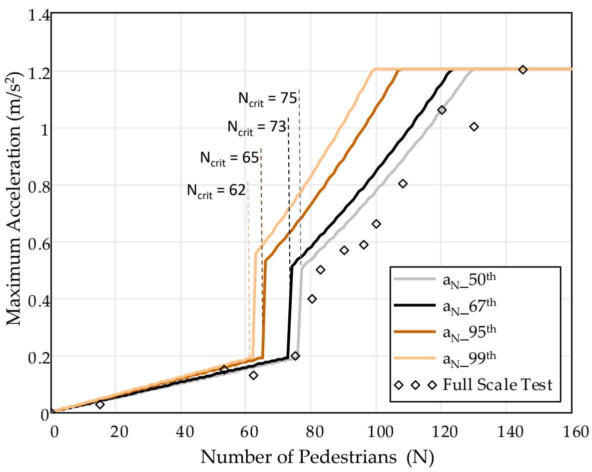

Fig. 1. Maximum acceleration response under uncertainties conditions of Pedro e Inês footbridge

Keywords: footbridges, lateral vibration assessment, modal parameters uncertainties, confidence level.

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