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SERVICEABILITY RESPONSE OF A BENCHMARK CABLE-STAYED FOOTBRIDGE: COMPARISON OF AVAILABLE METHODS

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Summary

In order to familiarise designers at early stages of their design with the order of magnitude of the serviceability response of cable-stayed footbridges, this paper characterises the response of these footbridges with geometry similar to that most frequently considered by designers of this type of footbridges.

The characteristics of the benchmark cable-stayed footbridge are extracted from a compiled dataset of footbridges designed and built until recently. The paper highlights the number of methodologies most frequently used by bridge designers together with a proposal recently developed by the authors of this paper. Based on these, the performance of this bridge in vertical and lateral direction when subjected to a number of different pedestrian events is outlined and comfort levels are attributed to this accordingly.

Keywords: cable-stayed footbridge; response; vertical acceleration; lateral acceleration; dynamics; serviceability appraisal; benchmark footbridge

1. Characteristics of the conventional cable-stayed footbridge

The cable-stayed footbridge considered to be representative of footbridges with this structural type (see Fig. 1) has geometric and material characteristics that have been extracted from the parameters observed in a compilation of 38 constructed cable-stayed footbridges that have been found in literature (see [1]).

This footbridge has a main span (L_m) of length 50m (median value of those of the database) and a side span (L_s) of length $0.20L_m$. The deck consists of steel girders with concrete slab (alternative that is more popular than steel box girders and steel girders with slabs with materials other than concrete. Its depth has a value equivalent to $L_m/100$. The pylon has a single vertical mono-pole configuration with an elevation above the deck equivalent to $0.36L_m$. The cables are arranged in a modified disposition (anchored at the pylon at different locations rather than at a single point). At the deck, cables are anchored every 7m (median value of those of the database), value that is not related to the main span length of the bridge. Finally, the boundary conditions of the footbridge consist of LEBs and a shear key restricting lateral movements at each embankment and deck and pylon have joint displacements (rotations are not transmitted).

An evaluation of the dynamic characteristics of the structure shows that cable-stayed footbridges with characteristics similar to that considered as benchmark of this structural type have vertical vibration modes with frequencies considered as critical ([2] or [3]), *e.g.*, mode V2 (2.02Hz when the structure is empty). Torsional and lateral modes are well beyond these ranges, *e.g.*, L1 has a modal frequency of 2.23Hz when the structure is empty and T1 2.98Hz.

2. Serviceability response of the conventional cable-stayed footbridge and main conclusions

The methodologies that designers most commonly used to appraise during design the likely serviceability response of a footbridge in vertical direction correspond to [2] and [3] or [4]. In lateral direction, there is only the proposal of [3], and [2] describes an assessment to appraise the possibility of the bridge developing unstable lateral response. Nonetheless, this second alternative poses a question in relation to the possibility of a footbridge deemed by that proposal as adequate developing large lateral movements (providing minimum comfort to users) without these being unstable.

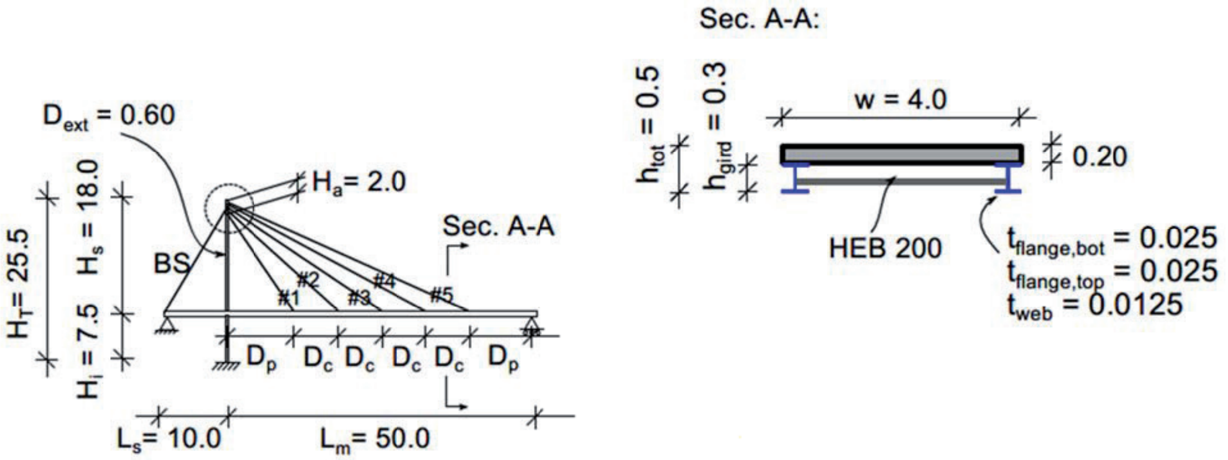

Fig. 1. Geometric and structural characteristics of the conventional cable-stayed footbridge. Dimensions in [m].

As an alternative, the authors of this article have recently proposed a novel pedestrian load model that is capable of representing the vertical and lateral pedestrian loads including the intra-subject variability, inter-subject variability and collective behaviour in a realistic manner. This proposal has been developed from a meta-analysis of the state-of-the-art multidisciplinary research related to these topics that has been recently published (further details can be found in [1]).

Considering that the conventional cable-stayed footbridge might be located at different settings, several pedestrian scenarios are considered: 0.2, 0.6 or 1 pedestrian per deck metre squared (ped/m^2) while commuting or strolling for leisure (walking faster or slower depending on the aim of their journey).

Results show that the serviceability response of this footbridge (when considering peak accelerations) in vertical direction is equivalent to minimum or unacceptable depending on the density of the pedestrian flow. In lateral direction the response is equivalent to medium or minimum comfort depending on the density of the pedestrian flow. If instead of peak accelerations, values weighted with time are considered (e.g., 1s-RMS accelerations), this assessment is less severe.

3. Acknowledgements

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4. References

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