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WIND AND PEDESTRIAN VIBRATION ASSESSMENT ON THE NEW SWAN RIVER PEDESTRIAN BRIDGE

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Summary

The paper presents the problems related to wind and pedestrian induced vibration that have been faced during the design of the Swan River Pedestrian Bridge (SRPB) in Perth (Australia).

It is a three-span arch structure (approximately 80-140-80 m length, respectively). Arches are made by lattice steel structures and the deck is suspended to the arches by sub-vertical strands. Each span has two crossed arches with triangular cross-sections that vary dimensions along the arch. Two cantilever extensions are connected to the crown of the central arch. Arches are supported by quite flexible piles.

Keywords: long span footbridge; arch bridge; multi span footbridge; pedestrian induced vibration; wind induced vibration; numerical modelling; vibration mitigation; design assisted by testing

1. Introduction

A perspective view of the bridge is reported in Fig. 1. A unique feature of this bridge is that each span has two crossed arches with triangular cross-sections that vary dimensions along the arch. In addition, two cantilever extensions are connected to the crown of the central arch for aesthetic purposes. Considering the complex shape and the lightness of the structure several aerodynamic issues should be assessed. To this end, several scales models were tested to investigate specific issues and design countermeasures, if necessary [1]. In addition, due to its flexibility and lightness, the footbridge is potentially prone to vibration induced by human activities. The analysis and the design process have to account for evaluating the pedestrian induced vibration and have to provide solutions to confine their amplitude to acceptable values.

Fig. 1. Architectural render of the bridge

2. Wind induced vibration assessment

As regard the deck, using the Tailored deck section (see Fig. 2) VIV are negligible. As regard the arched and the cantilever extension, the most critical response is the vibration of the central span arch. However, the following considerations should be done during the assessment of the expected vibration levels: (i) the vibration of the arch is coupled to the vibration of the deck; (ii) deck not only contributes as dead mass, but also with its aerodynamic damping. A Sc = 11.1 may be reached considering the aerodynamic damping of the deck. For this Sc value, VIV are reduced to an acceleration level of 1.28 m/s^2 and a displacement of 0.04 m. A similar approach shows that lateral arches are less critical. Moreover, the cantilever extension has limited VIV at its structural damping.

3. Pedestrian induced vibration assessment

The analysis performed are oriented to check if:

- vibrations due to pedestrian traffic are acceptable for the users,
- the lock-in phenomenon does not arise.

Three methods have been used to estimate the acceleration corresponding to the different traffic classes, according to [2]: the Response Spectra Method, the Single Degree of Freedom (SDOF) method and the Finite Element (FEM) method. The modal superposition has been considered by performing time history analyses, with an appropriate frequency band. With this analysis, each pedestrian is simulated with an sinusoidal force, that is characterized by a Gaussian distributed frequency (around the frequency of the considered mode) and a uniformly distributed phase.

Central span seem to be close to the lock-in trigger acceleration, in case of crowded conditions. Hence, due to the particularly annoying effect of lateral vibration induced by the lock-in, a transverse-direction TMD has been implemented. In addition, provisions for a future installation of additional dampers is made. Finally, the design of the bridge contains provision also for vertical damping devices (TMD).

4. Conclusions

It shows how wind tunnel results can be used during the design stage, and provides some guidelines and an innovative solution to suppress negative effects like vortex-induced vibrations.

As regard the pedestrian induced vibration, uncertainties are still notable, in both theoretical approaches and design parameters. Hence, reliable tests and information can be achieved only after the completion of the structure.

5. References

[1] ARGENTINI T., DIANA G., GIAPPINO S., MUGGIASCA S., ROCCHI D., COSENTINO N., MAJOWIECKI M., "*Wind effects of a pedestrian arch bridge with complex shape*", Proc. of 19th IABSE Congress Stockholm, September 2016.

[2] EUR 23318 EN, "*Advanced load models for synchronous pedestrian excitation and optimised design guidelines for steel footbridges*", European Commission, Directorate-General For Research, 2008

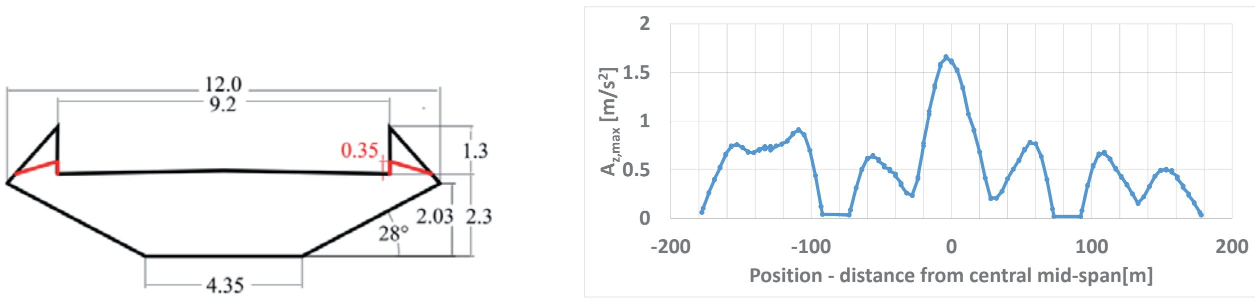

Fig. 2. On the left, Original and Tailored deck cross section (in red); on the right, example of time history analysis results.