Advanced analysis of a pedestrian bridge and considerations on crowd-structure interaction

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Abstract

Pedestrian bridges, grandstands, and other long-span structures may be subjected to crowd loading. Crowds have the dual effect to produce large forces and alter the structure's modal properties and damping. Vibration testing of full-scale structures allows the verification of the modelling assumptions and design criteria.

This paper discusses the case study of a pedestrian bridge structure subjected to crowd loading. The results of the design finite element model of the bridge and the bridge performance were validated through field testing. The theoretical effects of crowds were analysed and compared to the experimental test data.

Keywords: pedestrian bridge, dynamic analysis, vibrations, comfort, monitoring, crowd-structure interaction, CORE R&D.

1 Introduction

Pedestrian bridges may experience high vibration amplitudes due to walkers and/or wind excitations. The anticipated in-service acceleration levels of the bridge deck have to be evaluated and compared to acceptable limits during the early stages of the design. Various cases of excessive vibrations affecting the serviceability of footbridges around the world led to the development of design guidelines to assess user comfort in footbridges.

Currently, there are no design guidelines universally accepted in the United States to evaluate comfort in footbridges. The interpretation and application of the available design guidelines is often left to the design engineer. Design recommendations can often be challenged based on the individual's interpretation of the guidelines, which may lead to legal disputes.

Recent innovations in the field of sensor technology allow for autonomous and continuous monitoring of structures. Wireless systems offer numerous advantages in terms of sensor deployment, management, and cost. Pedestrian bridges are relatively simple structures to monitor and test.

Dynamic testing allows the identification of the modal properties of a structure and the verification that the structure is behaving as intended by design. In certain circumstances, establishing a long-term, vibration monitoring plan could provide valuable data to owners and property managers for proactively maintaining their structure.