Evaluation of load model for crowd-induced vibrations of footbridges

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Abstract

Due to a trend in designing light and slender structures, many modern footbridges are prone to excessive vibrations. Severely vibrating footbridges can give rise to discomfort for the pedestrians. Therefore, during the last decades, pedestrian-induced vibrations of footbridges have become a subject of great interest. In this study, the performance of a coupled crowd-structure model, where the bridge is described using its first two modes of vibrations and each pedestrian is described as a moving mass-spring-damper system, in combination with a walking load, is evaluated. The model is used to estimate vertical deck accelerations of a real footbridge which is known to be susceptible to vibrations, and the results are then compared to measurements. The model performs satisfactory in the time domain, but poorly in the frequency domain, which is concluded to be mainly due to discrepancies in the simulated load compared to the measured load.

Keywords: load model; pedestrian-induced vibrations; footbridge; walking load.

1 Introduction

Serviceability problems of the Millennium Bridge in London [1] and the Solférino Bridge in Paris [2] resulted in an increased interest in pedestrian-induced vibrations of footbridges. Therefore, a substantial amount of research has been performed within the field, including several extensive measurement campaigns as well as modelling efforts [3]. Both lateral and vertical vibrations are of interest; however, this study focuses on vertical vibrations only.

Modelling pedestrian-induced vertical vibrations of footbridges involves several challenges. Firstly: the evolvement of a crowd along a footbridge. Crowd modelling requires taking into account the pedestrians' ability to interact with each other and the surroundings, their ability to adjust their velocity depending on the situation and also the inhomogeneity in their interaction with the surroundings [4]. Secondly: the pedestrian loading [5,6]. The load from a pedestrian footstep, and in the extension from a whole crowd, has to be accurately described. And lastly: coupling of the

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