The Influence of Pedestrian Loading on Footbridges: An Endeavour to Improve the Accuracy of Response Models

Brian Mullarney,

Athlone Institute of Technology, Ireland

Abstract. The emergence of new materials, the greater understanding of existing ones, and the evolution of advanced engineering technologies have jointly facilitated the structural engineer to design footbridges more slender, lighter, and more aesthetically daring than ever before. These new slim-line and elegant footbridges are typically quite flexible and lightweight, often rendering them sensitive to pedestrian induced vibrations vertically and/or laterally (perpendicular to the direction of bridge span). Essentially, such vibrations often arise because many footbridges have natural frequencies coinciding with the pacing frequency of crossing pedestrians, hence increasing the risk of resonance [1-3]. These unwanted vibrations can often cause discomfort for crossing pedestrians (themselves the producers of these vibrations), essentially meaning the bridge has failed in terms of serviceability; perhaps the most famous example of this occurred on the London Millennium Bridge (LMB) in 2000. According to [4] the cost to fix the problem on the LMB drove the final cost up by 30% - cost of construction was €48 million, quoted as a 2010 equivalent by [5]. Intuitively, if the structural engineer during the design stage could determine the vibration response (usually measured in terms of acceleration) of the bridge due to crossing pedestrians then instances that occurred with the LMB would become less common. However, in order to accurately predict any responses quantitative and qualitative data and knowledge is required on the following: (a) forces induced by crossing pedestrians and what influences such forces; (b) pedestrian-pedestrian interaction and the synchronisation of crossing pedestrians; (c) the pedestrian-structure interaction of crossing pedestrians; (d) the determination of what an acceptable response limit/range should be. Unfortunately, there is currently a dearth of reliable data regarding a, b, and c; and huge reported variations regarding d, rendering if quite difficult for the structural engineer to come up with a solution during the design stage. Furthermore, the response models within the current international guidelines are deficient; as input data is lacking. Hence, the ultimate objective of the research project is to provide the structural engineer with advanced models in order to calculate the vibration response of any bridge due to crossing pedestrians. Such models will be developed and useable probabilistically. In order for this objective to be met a, b, and c highlighted in the introduction shall be determined.

References

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