

Reliability under the Serviceability Limit State of Footbridges Subjected to Human-Induced Vibrations

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Abstract

Codes of practices aim to achieve a relatively consistent and sufficient level of safety for structural members with minimum total costs over a design working life. Traditionally, reliability-based calibration of the design codes is performed to ensure an acceptable level of safety, usually represented by a target reliability index. Specification of the target reliabilities is one of the key steps required for the calibration process. Target reliabilities for ultimate limit state (ULS) design are well explored by the international codes, which suggest a wide range of target reliabilities depending on the reference period and failure consequence. On the other hand, little research has been undertaken towards establishing target reliabilities for serviceability limit state (SLS) design of structures under normal use. International standards suggest the use of a single target reliability index under SLS design, which is independent of the reference period. The design of lightweight footbridges is often dominated by SLS under human-induced vibrations rather than the ULS. In the current study, the sufficiency of the target reliability for SLS under excessive vibrations is investigated for footbridges designed using the SÉTRA guideline. With this objective in mind, reliabilities for different footbridge classes such as suburban and urban are evaluated under the design as well as non-frequent traffic loadings and the results are compared with existing target indices for SLS design. The results point towards the specification of higher reliability indices for different footbridge classes under their respective design traffics in order to achieve sufficient reliability under non-frequently occurring heavy traffic loadings. The possibility for overdesign that may result can be mitigated by adopting traffic dependent comfort limits.

Keywords: footbridges; serviceability design; human-induced vibration; reliability

1 Introduction

Use of limit states in structural design now has become well accepted by most design standards. The development of limit state design provisions is often followed by reliability-based calibration of load and resistance factors in order to achieve sufficient and uniform reliability levels for all design applications covered by the standard. For the design of structures, both the ultimate limit state (ULS) and the serviceability limit state (SLS)

are important. Reliability-based calibration for ULS design has been well recognized internationally by different design codes [1,2]. However, very little attention has been given to reliability for SLS design and only a few codes and guideline have specified the target reliability index for SLS design [3,4]. While a few studies in the literature investigate the reliabilities embodied in different SLS design provisions for beam deflection, crack width etc. [5], limited effort has been made to perform similar investigations on the serviceability of footbridges under excessive vibration.