System Identification of Long-Span Suspended Footbridges

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1 Abstract

Long-span suspended footbridges are gaining traction for their low cost, minimum impact to the surrounding environment and landmark value. Without specific guidelines in the general bridge design code governing these structures, there is a need for detailed vibration testing and analysis for individual structures. These structures are highly elastic and light-weighted compared to typical bridges, and thus display unique behaviors that are not generally observed in large-scale cable bridges. Such behaviors include coupled modes and observable change in natural frequency from pedestrian loading. Thus, detailed system identification is needed to gain a better understanding of their complex dynamic characteristics and behavior. Operational modal analysis (OMA) based techniques such as frequency domain decomposition (FDD), natural excitation technique (NExT) and eigensystem realization algorithm (ERA) were used to extract modal shapes, natural frequencies and damping ratios from sensor data. The results from OMA analyses are compared with results from finite element models and discussed. Damping ratios and structural responses near the pedestrian excitation frequency are also discussed.

Keywords: Footbridges; Monitoring; System Identification; Damping Estimation;

2 Introduction

Long-span suspended footbridges are highly elastic and light-weighted structures that are fairly unique compared to typical bridges. Because of their low cost, minimum impact to the environment and landmark value, municipal governments are enthusiastic about construction of such structures.[1] While these suspended footbridges may be considered cousins to their large-scale counterparts the suspension bridges, we cannot classify nor analyze them as such due to significant differences in scale, importance, load and dynamics characteristics. Furthermore, diverse sites of construction- whether they be urban or rural- have resulted in footbridges with varying geometric shapes and materials. Thus, detailed vibration testing and analysis procedure must be performed for individual footbridges. Finite element models may be helpful in pinpointing effective points of measurement and excitation frequencies in advance. In this paper, dynamic characteristics (modal frequencies, shapes and damping ratios) of long-span suspended footbridges are analyzed with operational modal analysis techniques such as natural excitation technique (NExT) – eigensystem realization algorithm (ERA) and frequency domain decomposition (FDD).

https://doi.org/10.2749/newyork.2019.1667
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