Prediction of Floor Vibration Response due to Walking Excitation

Mehdi Setareh

Virginia Tech, Blacksburg, VA, USA

Kaushik Panchal

Virginia Tech, Blacksburg, VA, USA

Contact: setareh@vt.edu

Abstract

Excessive vibrations of floor structures have become an important serviceability issue in recent years that need to be addressed by engineers and designers. Therefore, it is important that engineers would be able to predict the floor response due to walking excitation with reasonable accuracies during the structural design. Using the results of several walk tests conducted by a group of volunteers on a laboratory floor, this paper presents a study of the generated floor vibrations and how the human-structure interactions can affect the floor response. The subjects' ground reaction forces were measured, and the floor vibrations were simulated using a computer model of the test structure. The damping ratios for the forced and free vibration segments of the floor vibrations were measured and the level of increase in the floor damping ratio for each walk excitation was computed. Comparison of the measured and computed floor responses validated the results.

Keywords: floor vibrations; excessive vibrations; human-structure interactions; response prediction; damping ratio; dynamic analysis; forced vibrations.

1 Introduction

Effects of passive humans (not in motion) on the dynamic properties and response of floor structures due to human induced excitations have been studied by different researchers as related to biomechanics and civil structures and are mainly well understood [1-5].

Even though there have been several studies on the effect of the walking humans on the dynamic properties of structures such as building floors or footbridges, there has not been any conclusive outcome [6].

Zivanovic et al. [7] studied vibration of three footbridges and used single-degree-of-freedom (SDOF) models to represent the modal behavior of the structures subjected to ground reaction forces (GRFs) measured using an instrumented treadmill. They found that the interactions between the pedestrians and the footbridge resulted in a reduction in footbridge vibration by up to 90%. They concluded that the reduction in the vibration due to the human-structure interactions (HSI) can be considered as an increase in the modal damping ratios or modifications in the human-induced harmonic force.

Most HSI studies as related to vibrations in civil structures were conducted after the problem associated with the Millennium bridge over the Thames River in 2000, which was due to the excessive lateral vibrations. Few such studies have been conducted as related to vertical vibrations.

To simulate the interactions between walking people and structure, different modeling approaches have been used [6]. Some considered linear oscillators using SDOF and multi-degree-of-freedom (MDOF) models. Some models used rigid stationary masses to represent humans which showed a decrease in the floor natural frequency; however, they could not explain the increase in the