Duality between time and frequency domains for vibration serviceability analysis of floor structures

Atheer F. Al-Anbaki & Aleksandar Pavic

Abstract

For vibration serviceability of floors, current design guidelines adopt different criteria to assess vibration levels due to human walking dynamic excitation. Whatever the adopted criterion is, it requires a quantified vibration response of the structure. This quantification could be achieved following either a time- or a frequency-domain approach to response analysis. Each approach has its advantages and disadvantages. For instance, when using the time-domain analysis, exact time-domain amplitudes of the response time histories could be quantified but the process could take time. On the other hand, a frequency-domain analysis approach could reduce the calculation time, but it is impossible to recover exact time-domain amplitudes of the response, which is essentially averaged by the process of calculation. In this paper, the theoretical duality between time and frequency domains is examined practically in the context of vibration serviceability of a floor structure. Weight-normalised vertical ground reaction force (GRF) measured on an instrumented treadmill due to walking is used for that purpose because it has realistic distribution of energy in the frequency domain. This GRF is applied on a finite element model of a reinforced concrete high-frequency floor and the responses are calculated via both time and frequency domain analyses. Comparison of these two methods reveals that time-domain analysis could introduce significant errors in the calculated vibration responses. This is due to the errors in the numerical solution of equation of motion.