Multi-mode vibration
Control of a Floor System
Using Tuned Mass Dampers

The composite floor system of a large multipurpose room on the third floor of the admission building at a state university, exhibited noticeable vibration caused by walking. The composite floor system consists of three long and narrow bays.

The vibratory attributes of the floor system established by numerical analyses and measurement revealed the presence of three modes contributing to the perceptible vibration of the floor; the shapes of these modes are shown in Figure 2.

In mode 1, also known as the ‘trampoline mode’, the entire floor vibrates with the peak of vibration at around the center of the floor. When the floor vibrates with mode 2 pattern, half of the floor goes up and the other half goes down, with a quiet (nodal) line in the middle of the floor. This pattern of vibration, has the nodal line in the middle of the room. Mode 3 divides the floor in 3 segments (along the bay lines) with one segment (bay) moving in one direction and the other two moving in the other direction. Depending on the location and the walking pace of the walker, two or all three of these modes could be excited, making the floor vibrate at their corresponding frequencies.

Three pairs of tuned mass dampers (TMDs) targeting the three modes of vibration were designed using the dynamic parameters of the floor system, namely natural frequencies and modal shapes, evaluated by numerical analyses and verified by measurement.

The TMDs were fabricated, shipped to the job site, and installed underneath the floor system at locations where their target modes have the highest vibration level. Following the installation, the TMDs were commissioned and fine-tuned.

Floor vibration without and with the TMDs operational were measured; the results are presented in Figure 3 with blue and red traces relating to the TMDs locked and unlocked, correspondingly.

Comparison of the red and blue traces in Figures 3 clearly points to the effectiveness of the tuned mass dampers in adding substantial amount of damping to their three target modes, quieting the vibration of the floor system.