Vibration Control of a Medical Center Floor System Using the Combination of Stiffening and Tuned Damping

Tuned mass dampers (TMDs) are tuned damping devices commonly used for dampening the vibration of a structure at a particular resonant frequency. TMDs come in various configurations. The commonality between all of them is their make-up which includes an inertia element (mass) suspended by an energy dissipating (damping) device and a restoring (resilient) element.

The vibration of an elevated floor system with long span trusses housing a sensitive medical imaging equipment was mitigated using tuned damping in conjunction with stiffening of the floor framing and load spreading between adjacent bays.

With the very stringent criterion on vibration levels associated with the medical imaging floor systems *neither stiffening (even by a large factor) nor tuned damping (of a reasonable extent) alone would enable the floor to comply with such stringent criterion*.

Figure 1 The medical center

The numerical analysis of four bays of the floor system, pointed to a pronounced mode engaging two of the bays with the shape shown in Figure 2, having the natural frequency of ~4.8 Hz. Such a low natural frequency would have subjected the floor system to the 2nd harmonic of footfall perturbation of a fast walker. Quieting this mode required significant stiffening, addition of tuned mass dampers, and a bridging truss to spread out vibration between bays.

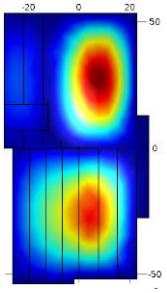

Figure 2 The mode shape

Stiffening increased the resonant frequencies of the floor system and tuned damping quieted the first (target) resonance. Stiffening placed the target resonance out of the reach of the lower harmonics of perturbation caused by walking and tuned damping lowered the peak velocity in the floor.

The vibration measurement of the stiffened floor system, identified the new first natural frequency of the two bays at ~7.9 Hz. Four tuned mass dampers (two per bay) were designed, manufactured and installed at the center of the two bays.

Figure 3 shows two tuned mass dampers bolted to a sub-frame structure bridging the two wide flange beams, underneath one of the bays of the floor system. All four tuned mass dampers were tuned to the natural frequency of the mode they were designed to dampen.

The primary source of nuisance vibrations in sensitive medical equipment is generally people walking down the corridor. Each step creates a forcing function at the walking pace rhythm (frequency) and its higher order harmonics.

If footfall frequency or any of its higher order harmonics is close to the natural frequency of the floor system, objectionable vibration will occur.

To ensure effective coupling between the TMDs and the floor, the bridge structure to which each TMD was fastened was welded to the wide flange beams and also Hilti-bolted to the concrete deck.

Figure 4 presents the measured vibration responses of the floor to a heel drop perturbation without (blue trace) and with (red trace) the TMDs operational.

Figure 3 Two TMDs installed underneath one of the bays

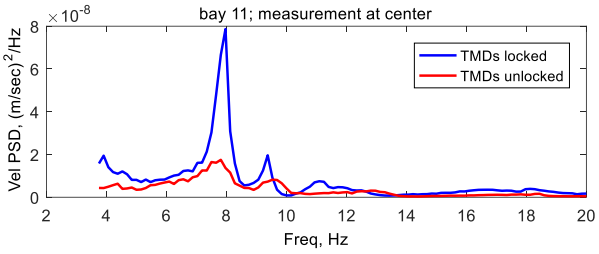

Figure 4 Power spectral density plots of acceleration measured at the center of one of the bays, without (blue) and with (red) the TMDs operational

Clear from Figure 3, the large reduction in the vibration power at the target frequency indicates that the tuned mass dampers dampened the first vibration mode they were targeting, effectively.