Vibration Control of a Concert Venue Floor System Using Tuned Mass Dampers

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.

Tuned mass dampers (TMDs) were used to abate resonant vibration of the floor system induced by the rhythmic (dancing) perturbation at an upscale intimate concert venue/night club. The composite floor system is made up of 2.5" lightweight concrete on 3" deep, 20 gauge steel deck supported by wide flange steel beam and girder framing. The typical dimensions of the bays are 30'x32'. The first resonant frequencies of the five bays with the most severe vibration are in 5.5-7.5 Hz range, with the typical damping ratio of 2.7%.

When one of the harmonics of a rhythmic perturbation (such as stepping load in dancing) matches one of resonant frequencies of a floor system, that floor vibrates excessively (resonates).

Figure 1 The concert venue/night club

With the floor vibration measurement results identifying the first natural frequencies of the 5 target bays on hand, 10 tuned mass dampers (2 per bay) were designed, manufactured and installed at the center of the bays. The rather large load density on the floor necessitated the use of rather large 750 Kg (1700 lb) TMDs.

Dancing load density (load/area) depends on the type of dance, the number and weight of people dancing as well as the size of dancing area. The frequency of dancing load depends on the tempo of the music (normally between 1.5-3.5 Hz and even as high as 4 Hz).

Figure 2 shows two tuned mass dampers bolted to a sub-frame structure bridging the two center wide flange beams, underneath each bay. Each pair of tuned mass dampers were tuned to the natural frequency of the bay they were designed for.

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

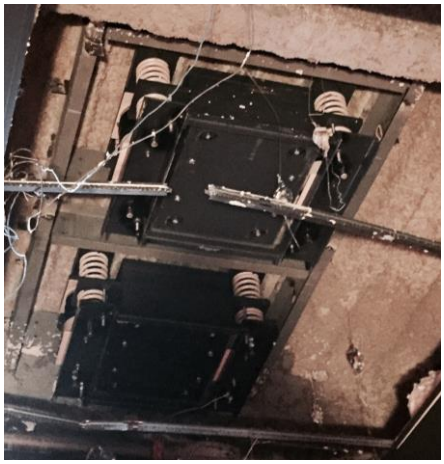

Figure 2 Two TMDs installed underneath one of the bays of the floor system

The blue trace in Figure 3 presents the vibration response of the floor to a heel drop perturbation without the TMDs operational (TMDs locked). The red traces in Figure 3 depicts the same measurements when the TMDs are operational (TMDs unlocked).

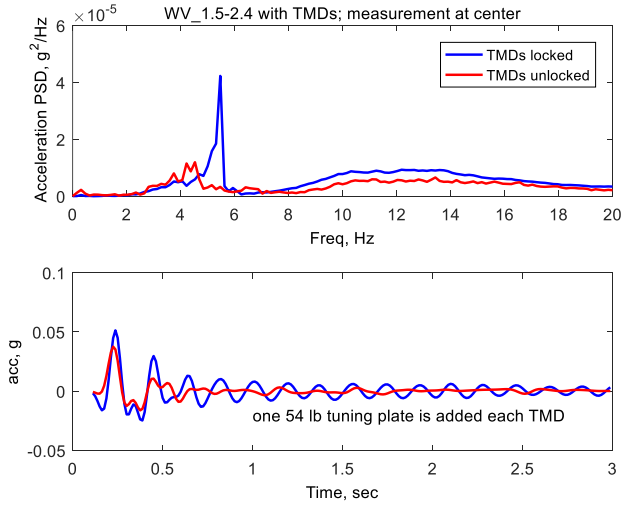

Figure 3 Power spectral density and time traces of acceleration measured, at the center of one of the bays, without and with the TMDs operational

As shown in Figure 3, the large reduction in the vibration power at the target frequency indicates that the tuned mass dampers have dampened the first vibration mode they were designed for and tuned to, effectively.