Vibration Control of a Grand Ballroom Floor System Using Tuned Mass Dampers

Tuned mass dampers (TMDs) are tuned damping devices used for mitigating structural vibration at specific natural frequencies. They can be made in various configurations, while sharing a fundamental composition comprising of an inertia element (mass) supported by a restoring element (resilient component) alongside a damping mechanism for energy dissipation.

To lower the vibration of a 17,000+ square ft grand ballroom floor system subject to crowd rhythmic loading, the structural engineers of the project prescribed a combined stiffening plus damping solution for the floor. DEICON supplied quantity 18 of 1700 lb tuned mass dampers (TMDs) installed at designated locations underneath the floor to abate resonant vibration of the floor system induced by the rhythmic activities of the crowd. The first resonant frequencies of the floor system at various bays were predicted to be in the 4-6.25 Hz range, depending on the size of the crowd and their activities.

Crowd loading of a floor system depends on how passively or actively the people on a floor are engaged with that floor. When people are engaged in activities such as jumping (or running) their mass does not vibrate with the floor and their involvement is more like a repetitive load with a certain rhythm/frequency (without much impact on the dynamic attributes of the structure).

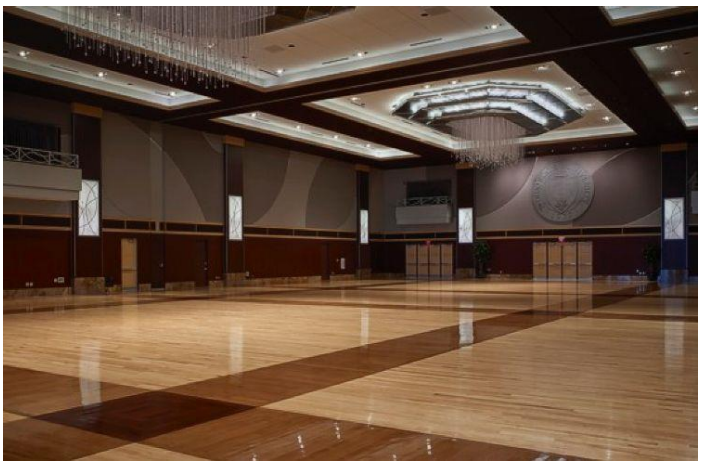

Figure 1 The grand ballroom

Figure 2 shows a pair of TMDs bolted to a sub-structure bridging two wide flange beams, underneath one of the designated bays of the floor. To ensure effective coupling between the TMDs and the floor system, the bridge structures to which the pairs of TMDs were appended were fastened to the wide flange beams using no-slip (slip-critical) connections.

When a harmonic of rhythmic perturbation (such as dancing) matches one of resonant frequencies of a floor system, that floor vibrates excessively (resonates).

Figure 2 Two TMDs installed underneath the floor system

The TMDs were all tuned to 4 Hz (the low end of the predicted frequency range) at the shop, with the provisions built into them to increase their frequencies, during the fine-tuning process at the job site, by introducing additional fine-tuning springs into the make-up of the units.

The acceleration of the floor system at five locations were logged for the duration of the crowd rhythmic activity, i.e. 1 hour. The spectra of one such measured acceleration is shown in Figure 3. The spectra points to 2.1 Hz as the rhythm of the crowd activity, with the largest acceleration at 4.2 Hz, revealing 4.2 Hz as the natural frequency of the loaded floor corresponding to the bay where the acceleration was recorded.

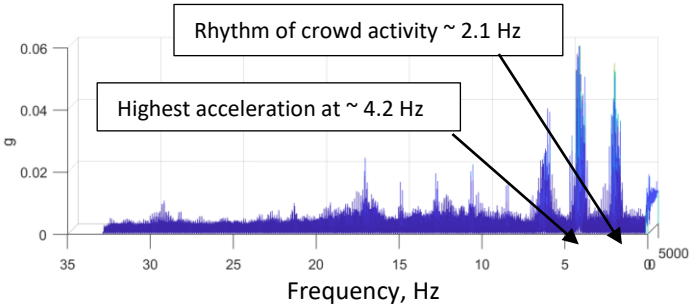

Figure 3 Measured acceleration waterfall during the crowd rhythmic loading

The TMDs were fine-tuned to the frequencies of 4.2 to 4.7 Hz, depending on their location.

The vibration of the ceiling and walls beneath the ballroom floor, before and after 2 of the 18 TMDs were unlocked and become operational, are depicted in these two videos.