

# Vibration Control of a Pharmaceutical Laboratory Floor System Using 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.

Extensive vibration measurements and numerical analysis of the 2<sup>nd</sup> floor of a pharmaceutical laboratory floor system conducted by the acoustics consultant of the project revealed that the vibration levels at various bays were well above the laboratory vibration criteria. In coordination with the structural design team, contractor, and client, a two-phase retrofit scheme was proposed by the consultant to reduce the floor vibration amplitudes. The retrofits consisted of 1) attaching supplemental steel to the underside of the existing steel members to stiffen the floor structure and 2) appending tuned mass dampers (TMDs) to the underside of the floor to further decrease the vibration amplitudes at the resonance of the bay.

With stringent criterion on waking-induced vibration levels associated with laboratories, housing sensitive equipment, i.e., VC-A criterion (50  $\mu\text{m/s RMS}$ ), *neither stiffening (by a reasonable factor) nor tuned damping (of a reasonable extent) alone would enable the floor to comply with such stringent criterion.*



Figure 1 The Laboratory building

The vibration measurement of the stiffened floor system, indicated an increase in natural frequencies of the five target bays by about 30-40%. Ten tuned mass dampers (two per bay) were designed, manufactured and installed close to the centers of five bays of the floor system.

Figure 2 shows two tuned mass dampers installed underneath one of the bays of the floor system. All ten tuned mass dampers were tuned to the natural frequency of the mode they were designed to dampen.

Figure 3 shows the power spectral densities (PSDs) of the velocity as well as the time traces of acceleration of one of the stiffened bays 'before' and 'after' the commissioning of the TMDs.

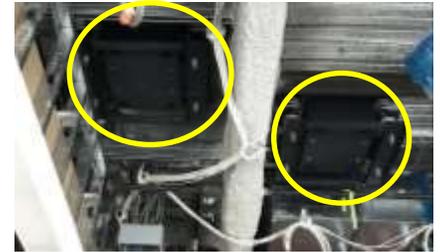


Figure 2 Two TMDs installed underneath one of the bays

The comparison of red ('before') and blue ('after') traces in Figures 3 points to the effectiveness of the TMDs in adding tuned damping at their target frequencies.

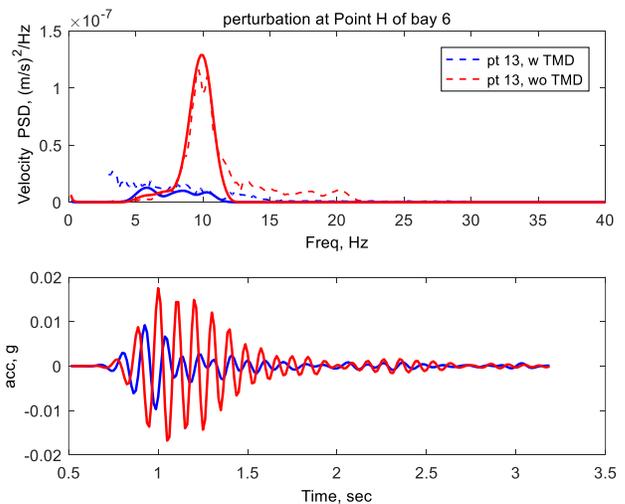


Figure 3 PSDs of velocity (top) and acceleration traces (bottom) measured at the center of one of the bays, without (red) and with (blue) the TMDs operational

Vibration measurement of the laboratory floor system showed that the walking induced vibration in the bays with increased stiffness and added TMDs was reduced significantly meeting the VC-A criterion (50  $\mu\text{m/s RMS}$ ).