# Cycling Studio/Gymnasium Floor Vibration Mitigation Using Tuned Mass Dampers

Tuned mass dampers (TMDs) are tuned damping devices commonly used for abating 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 composite floor system of an indoor cycling studio was experiencing excessive vibration during group cycling sessions. When up to 40 cyclists pedaled rhythmically at approximately 60 rpm, staff observed noticeable vibration. A detailed analytical and experimental study was performed to identify the source of the vibration and develop a targeted tuned-damping solution.

The dynamic loads generated by synchronous pedaling were found to excite the first natural mode of the floor system as 4.3 Hz. With cyclists pedaling at ~60 rpm (1 rev/sec), two downward pedal strokes per revolution produce a harmonic floor excitation near 2 Hz, whose first harmonic (~4 Hz) closely aligns with the floor's natural frequency, causing resonant amplification. This resonance caused vibration levels that exceeded acceptable limits for the gym environment.



DEICON first constructed a numerical model of the floor and validated it through vibration measurements:

- The principal mode, including its mode shape and frequency, was confirmed experimentally.
- Approximately 40% of the total floor area, or nearly 70% of the area in front of the middle girder, was found to participate in the dominant vibration mode.

Power spectral density (PSD) analysis confirmed strong energy concentration at the resonant frequency. Subsequently, DEICON designed and fabricated two tuned mass dampers (TMDs) for the floor system and had them installed underneath the floor; Figure 1 shows one of the TMDs. The TMDs were tuned to the identified natural frequency of the first mode (≈4.3 Hz) to effectively absorb energy from that mode.



Figure 1 One of the TMDs installed underneath the floor

The floor's vibration was measured before and after the TMD installation/commissioning. The results showed:

- A significant ~80% reduction in vibration at the target location; see Figure 2.
- Strong attenuation of resonance effects at the natural frequency.
- Noticeable improvement in comfort for both staff and gym participants during cycling sessions.

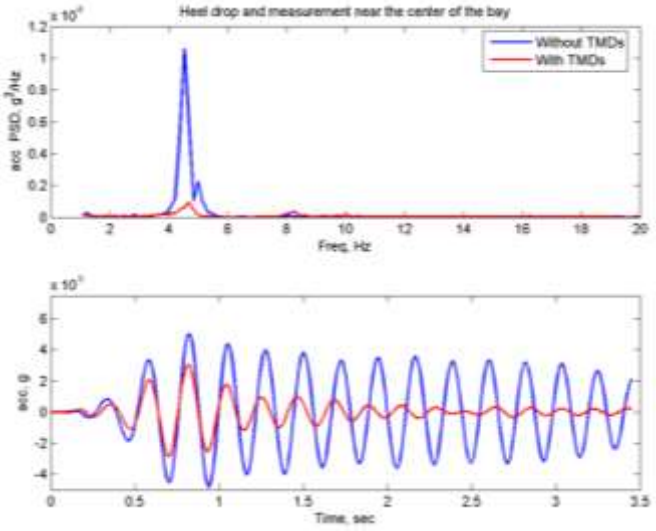



Figure 2 Measured vibration without and with the TMDs