Pedestrian Bridge Vibration Mitigation Using Tuned Mass Dampers

Tuned mass dampers (TMDs) are specialized tuned damping devices commonly used for abating the vibration of a structure at a particular natural frequency. TMDs come in various configurations. The feature shared by all of them is their composition which includes an inertia element (mass) suspended by a restoring (resilient) element and an energy dissipating (damping) device.

Pedestrian bridges are often designed to be lightweight and architecturally elegant, but those same characteristics can make them susceptible to vibration. When excessive motion affects user comfort, tuned mass dampers (TMDs) can provide an effective solution.

A recent bridge project presented precisely this challenge. Analysis performed during the design phase identified the key dynamic characteristics of the bridge, including its natural frequencies, mode shapes, and modal masses. These predictions revealed two dominant vibration modes: a vertical bending mode and a torsional mode with closely spaced natural frequencies.

Using these predicted dynamic properties, DEICON designed and fabricated two tuned mass dampers with a combined moving mass of 500 kg. The dampers were installed at the bridge midspan adjacent to the two main girders. Because the target bending and torsional modes occurred at nearby frequencies, the tuned dampers were tuned to an intermediate frequency between the two, allowing a single implementation to provide damping to both vibration modes simultaneously.

Figure 1 shows one of the TMDs being lowered into its housing cavity. Integrating the units within the bridge structure allowed the vibration-control system to remain concealed while maintaining direct influence over the dominant modal responses.

Following installation, field measurements were conducted to evaluate performance. Acceleration data were collected at midspan close to the edge, with the TMDs locked (inactive) and then repeated with the TMDs unlocked and operational.

Figure 1 TMDs installed underneath, near the edge of, the balcony

The measurement results presented in Figure 2 identified dominant modes near 1.1 Hz and 2.4 Hz, corresponding to the bridge's primary bending and twisting modes. Despite being tuned between these frequencies, the TMDs successfully added damping to both modes.

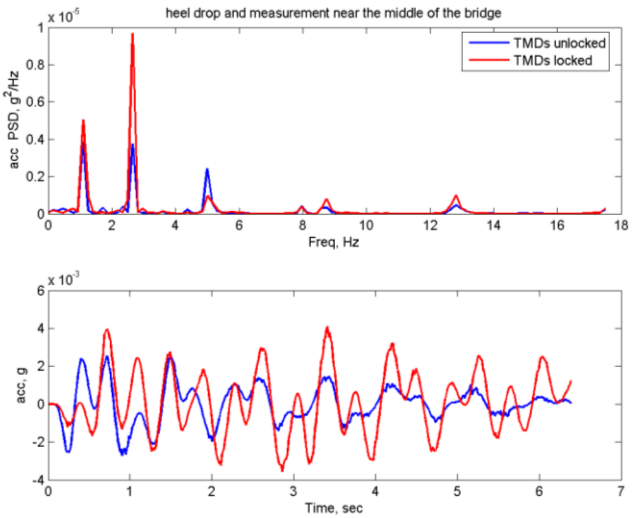

Figure 3 Power spectra and time traces of measured acceleration at midspan of the bridge with and without the TMDs operational

Analysis of the filtered time histories indicates that the effective damping increased by nearly a factor of 3 for the 1.1 Hz mode and nearly doubling for the 2.8 Hz mode.