monumental staircase vibration control using tuned mass damper-4

DEICON implemented and commissioned a tuned damping system designed to mitigate vibrations in a monumental staircase at an upscale hotel. The primary objective was to add damping to the first mode of vibration in two sections of the staircase: the segment connecting Level 1 to Level 2 (L1-L2) and the segment connecting Level 2 to Level 3 (L2-L3).

Given the participating mass of the structure, a decision was made to deploy two TMDs, each with a moving mass of 1000 lb. Figure 1 illustrates the placement of one of these TMDs, installed beneath the landing of the L2-L3 staircase segment.

The commissioning process for the TMDs involved a series of measurements and adjustments to ensure optimal performance. Initially, with the TMDs in a locked state, the inherent first natural frequencies of the staircase system were carefully measured. This was achieved by introducing controlled perturbations to the staircase landings and recording the acceleration responses at two critical locations: one on the landing and the other on the ninth tread of each staircase segment. The blue traces presented in Figure 2 visually represent the power spectral density and time response data derived from the acceleration measurements taken at the landing of the L2-L3 segment. Following these initial assessments, the TMDs were unlocked, and the measurement process was repeated. The resulting vibration data for the L2-L3 segment, with the TMDs actively engaged, is depicted by the red traces in Figure 2.

Figure 1 L2-L3 staircase and its corresponding TMD installed underneath the landing

A comparison between the red and blue traces in Figure 2 demonstrates the significant impact of the TMDs, highlighting that their integration introduced a considerable amount of damping to the first vibrational mode of the staircase. This substantial increase in damping is crucial for enhancing the serviceability and comfort of individuals using the staircase. To account for the anticipated increase in mass upon the full completion of the staircase, the TMDs were tuned to a frequency slightly lower than the frequencies measured during the nearly completed construction phase. This foresight ensures that the TMDs will continue to effectively mitigate vibrations even after the staircase reaches its final operational configuration.

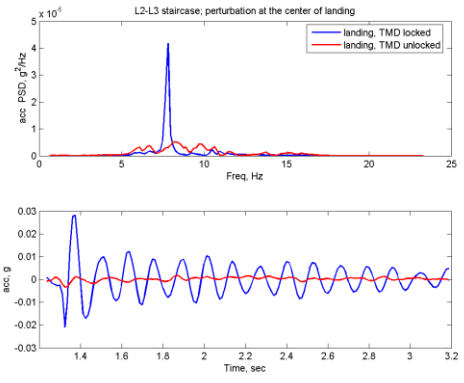

Figure 2 PSDs and time traces of L2-L3 landing acceleration with TMD locked (blue traces) and unlocked (red traces)