INTRODUCING A NEW TUNED MASS DAMPER SYSTEM

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Tuned mass dampers (TMD) are effective and reliable structural vibration control devices commonly attached to a vibrating primary system for suppressing undesirable vibrations induced by winds and earthquake loads. The tuned mass damper (TMD) systems have been a major means for the vibration control of civil engineering structures (Housner et al., 1997). They have been successfully installed in different structures from high rise buildings to long bridges such as the CN Tower (535 m) in Canada, the John Hancock Building (sixty stories) in Boston, Center-Point Tower (305 m) in Sydney, and also the largest one in the Taipei 101 Tower (101 stories, 504 m) in Taiwan, in order to reduce the vibrations due to earthquakes and wind.

The natural frequency of the TMD is tuned in resonance with the first vibration mode of the primary structure, so that a large amount of the structural vibrating energy is transferred to the TMD and dissipated via its out-of-phase motion with the primary structure (Soong and Constantinou, 1994). Consequently, the safety of the structure is enhanced. In other words, a TMD is a kind of dynamic secondary system implemented on a primary structure whereas its natural frequency is tuned to be very close to the dominant frequency of the primary structure. In such a situation a large reduction in the dynamic responses of the primary system can be achieved.

Single or Multiple TMDs may be designed in different kinds including Tuned Liquid Column Dampers (TLCD), Liquid Column Vibration Absorbers (LCVA), etc (Chang, 1999). However, one common type of such devices is the pendulum type TMD such as what we have on the Taipei101. The natural period of a pendulum depends only on its oscillating radius. For example, a pendulum with a natural period of 5 seconds requires a rod length of almost 6 meters. This simply means that the application of pendulum type tuned mass dampers needs occupying a large space inside the primary structure. This can be seen in Taipei101 as an example where the tuned mass damper system has occupied almost 5 stories in the top portion of the building.

This paper introduces a newly developed semi pendulum TMD system. The proposed device is composed of a specific configuration of rolling parts which provide a long natural period for the device along with providing the appropriate force transmission or energy dissipation capacity for the system. Since the natural period of this device is longer than a natural pendulum with the same rod length, the total size of the proposed device can be considerably smaller than the similar pendulum type ones. Figure 1 shows a simple shape of the device. The details would be further explored through the next parts of this paper.

The effectiveness of the device has been shown by a simple experimental prototype of the device. Figure 2 shows the velocity and acceleration time history responses of a single degree of freedom oscillator during a free vibration. For this, the SDOF oscillator is freely released from a specific initial displacement while it is once equipped with the proposed TMD and the other time oscillates without the application of the new TMD. It can be seen that the responses with TMD have both lower amplitude as well as shorter duration than those without the TMD. The numerical approach to the problem has also been performed in order to determine the optimal TMD parameters and attain the best control performance.

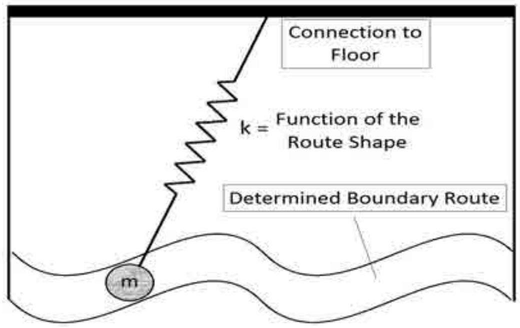
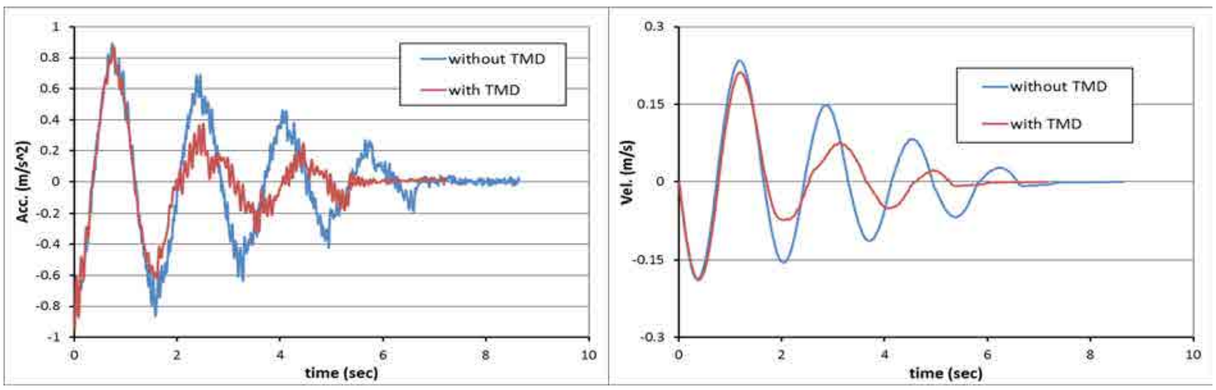


Figure 1. A simple schematic shape of the device



(a) Acceleration Response (b) Velocity Response

Figure 2. Experimental results showing the effectiveness of the new TMD according to the (a) acceleration and (b) velocity SDOF responses

The proposed system can be utilized for various structural bodies such as buildings, bridges, etc. It can also be used for both new and existing systems to improve their seismic performance for retrofitting purposes. It can be concluded that the proposed device is a proper substitute for the conventional TMD systems in long-period as well as shorter-period structures to mitigate the seismic/wind induces vibrations in a more efficient way in terms of the overall size and/or energy dissipation capacity.

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