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# Seismic Analysis of Tuned Mass Damper in Vertically Irregular Structure

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***Abstract:****Seismic analysis is one of the most important tasks to understand the behavior of structure under action of earthquake loading. Different system are generate to reduce the effect of earthquake loading TMD (tuned mass damper) system is one which is used to reduce the vibration of the building. In this review paper studied the behavior of TMD on a steel frame structure under the action of dynamic loading with irregularity in vertical direction. The TMD performance is assessed by means of response reduction coefficient. Which are generated from the ratio of the structure response with or without tuned mass damper attached?*

***Keywords: tuned*** *mass damper, structure response, earthquake, reduction coefficient, assessed etc.*

## 1. Introduction

The concept of providing tuned mass damper in structure to increase the time period of seismic force. A tuned mass damper is a system for damping the amplitude in one oscillator by coupling it to a second oscillator. If tuned properly the maximum amplitude of the first oscillator in response to a periodic driver lowered and much of the vibration will be 'transferred' to the second oscillator. This used, for example in tall buildings to limit the swaying of the building in the wind. People are sensitive to this swaying, so by adding, a tuned mass damper the building sways less and the damper, which no one can feel, vibrates instead. In the figure, the spring system $m_1$; $k_1$; $c_1$ is the oscillator to be damped (say a building) and $m_2$; $k_2$; $c_2$ is the damping oscillator. (Say a reasonably large mass attached to the building).

Note: $x_2$ is the absolute position of $m_2$. This is often replaced by the relative position of $m_2$ with respect to $m_1$, i.e., with what we would call $x_2$, $x_1$.

Assuming that the damping force is proportional to velocity and there is a periodic force $p_0$ cos($_\beta$t) on $m_1$ it is easy to work out the differential equations governing the motion of the system. We simplify slightly by letting $c_1 = 0$ and get the following equations. ($x_{01}$ is the time derivative of $x_1$.)

Dynamic Vibration Absorbers (DVA) are based on the concept of attaching a secondary mass to a primary vibrating system such that the secondary mass dissipates the energy and thus reduce the amplitude of vibration of the primary system. There are many application of DVA, A few are noted below: vibration control of transmission cables control of torsional oscillation of crankshaft control of rolling motion of ships chatter control of cutting tools control of noise in aircraft cabin vibration control of hand held devices

DVAs are generally of three types

**Vibration Neutralizer**: Here, a secondary mass connected to the primary using a spring element.

**Auxiliary Mass Damper**: Here the secondary mass connected to the primary by a damper/dashpot.

**Dynamic Vibration Absorber**: A general case where both spring and damper used to connect the secondary mass, with the primary system.

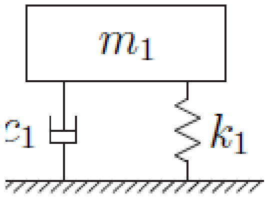

**Figure1.1**. Basic DOF equivalent

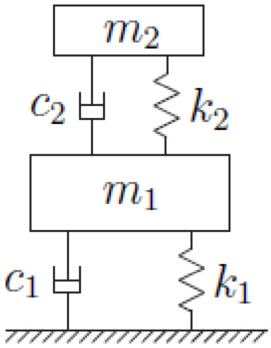

**Figure1.2**. SDOF system + tuned mass damper

## 2. Literature review

This literature review includes previous studies on different application of vibration of tuned mass damper.

**Jos´e L. Almaz´an**,in his research paper he studied the behavior of Passive tuned-mass dampers (TMDs) are a very efficient solution for the control of vibrations in structures subjected to long-duration, narrowband excitations. In this study, a Bidirectional and Homogeneous Tuned Mass Damper (BH-TMD) is proposed. The pendulum mass is supported by cables and linked to a unidirectional friction damper with its axis perpendicular to the direction of motion. Some advantages of the proposed BH-TMD are: (1) its bidirectional nature that allows control of vibrations in both principal directions; (2) the capacity to tune the device in each principal direction independently; (3) its energy dissipation capacity that is proportional to the square of the displacement amplitude, (4) its low maintenance cost. Numerical results show that, under either unidirectional or bidirectional seismic excitations, the level of response reduction achieved by the proposed BH-TMD is similar to that obtained from an “ideal” linear viscous device.

**Alex Y. Tuan and G. Q. Shang** (2014) in his analysis investigate the mitigating effects of a TMD on the structural dynamic responses of Taipei 101 Tower, under the action of winds and remote (long-distance) seismic excitation. To begin with, the optimal parameters of the TMD in Taipei 101 Tower are first determined. Then a finite element model of this high-rise building, equipped with a TMD system, is established. A detailed dynamic analysis conducted accordingly, to evaluate the behavior of the structure-TMD system. The simulation results obtained compared with the wind tunnel test data and the recorded field measurements. The accuracy of the established computational frameworks is then verifies. Findings of this study demonstrate that the use of theTMD in this building is materially effective in reducing the wind-induced vibrations. However, it is not as effective in mitigating remote seismic vibrations responses.

**Dr. Mohan M. Murudi** in his research paper Tuned Mass Damper (TMD) have been found to be most effective for controlling the structural responses for harmonic and wind excitations. In the present paper, the effectiveness of TMD in controlling the seismic response of structures and the influence of various ground motion parameters on the seismic effectiveness of TMD have been investigated. The structure considered is an idealized single-degree-of-freedom (SDOF) structure characterized by its natural period of vibration and damping ratio. Various structures subjected to different actual recorded earthquake ground motions and artificially generated ground motions are considered. It is observed that TMD is effective in controlling earthquake response of lightly damped structures, both for actual recorded and artificially generated earthquake ground motions. The effectiveness of TMD for a given structure depends on the frequency content, bandwidth and duration of strong motion; however, the seismic effectiveness of TMD is not affected by the intensity of ground motion.

**Christoph Adam and Thomas Furtmuller** in his fundamental parametric study the seismic performance ofTuned Mass Dampers (TMDs) are investigated. Earthquake excited vibration prone structures modeled as elastic single-degree-of-freedom oscillators and they are equipped with a single TMD. The TMD performance assessed by means of response reduction coefficients, which are generated from the ratio of the structural response with and without TMD attached. It is found that TMDs are effective in reducing the dynamic response of seismic excited structures with light structural damping. The results of the presented study are based on a set of 40 recorded ordinary ground motions.

**Kourosh Talebi Jouneghaniin his studythe** application of tuned mass damper in improving the response of structures is considered. At first, three frames of 3, 9 and 20 stories are evaluated in which time history analysis is done according to El – Straw earthquake. The maximum reduction of among the three mentioned frames belongs to a 20-stories structure in which the rate of story displacement reduction is between 25 to 45%, and this indicates that by increasing the height of the structure, the performance of tuned mass damper improved. In the second part, the effect of semi-active tuned mass damper is studied on a 10-stories frame. Studies showed that using a tuned mass damper system with viscous damper with controller force decreases the average of maximum displacement of roof story down to 39.9 % and this amount of reduction is 22.8% for semi-active tuned mass damper. Finally, the performance of tuned Single and multiple mass Damper is evaluated on a 20-stories frame, and the results show that single and multiple dampers decrease structures ‘responses and the performance of tuned multiple dampers depends on the mass and frequency ratio and also concluded that the performance of tuned multiple mass dampers is reduced by transition to middle of the structure stories.

**Min Ho Chey** in his research This thesis explores next generation passive and semi-active tuned mass damper (PTMD and SATMD) building systems for reducing the seismic response of tall structures and mitigating damage. The proposed structural configuration separates the upper storey(s) of a structure to act as the ‘tuned’ mass, either passively or semi actively. In the view point of traditional TMD system theory, this alternative approach avoids adding excessive redundant mass that is rarely used. In particular, it is proposed to replace the passive spring damper system with a semi active resettable device based system (SATMD). This semi-active approach uses feedback control to alter or manipulate the reaction forces, effectively re-tuning the system depending on the structural response. In this trade-off parametric study, the efficacy of spreading stiffness between resettable devices and rubber bearings is illustrated. Spectral analysis of simplified 2-DOF model explores the efficacy of these modified structural control systems and the general validity of the optimal derived parameters is demonstrated. The end result of the spectral analysis is an optimally-based initial design approach that fits into accepted design methods.

**Anthony C. Webster and Rimas Vaicaitis** in his research both analysis floor vibration problems appears to be on the rise,1.2 the use of mechanical damping devices to control vibrations is limited. In a recent survey of vibration control methods, Murray3 reports that passive-mechanical damping methods, including viscous damping, viscous-elastic damping, and tuned-mass dampers, have often gone untried outside the laboratory or have had marginal impact in actual buildings. This is particularly unfortunate because mechanical dampers can sometimes control floor vibrations more cheaply than structural stiffening, and are often the only viable means of vibration control in existing structures. This paper details the successful implementation of a tuned-mass damping system to reduce the steady-state vibrations of the long span, cantilevered, composite floor system at the Terrace on the Park Building in New York City. The experience with this implementation suggests that tuned mass dampers (TMDs) can be successfully employed to control steady-state vibration problems of other composite floor systems. The potential for general application of TMDs in composite floor systems is discussed, and areas for further research are suggested.

## 3. Methodology

It is very important to perform the dynamic analysis for the structure subjected torandom/dynamic loadings. The dynamic analysis of structures mainly involves the responsespectrum analysis and time history analysis. In some of the structures having very largespans, the effects of ground motion at different supports may be different and in such cases, itis necessary to perform the time history analysis considering the effects of time delay of Earthquake ground motions.It is very important to perform dynamic analysis for the structures subjected to earthquakeinduced ground motions. The support induced vibrations cause deformations and stresses inthe structural systems. The support excitations can be divided into two types:

(i) Single-support excitation
(ii) Multi-support excitation

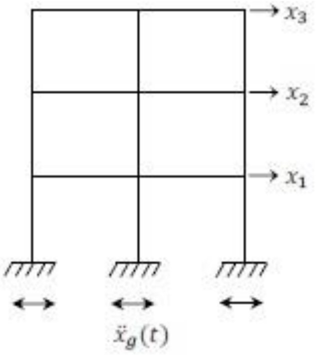

**Figure 3.1** A system subjected to single support excitation.

In single-support excitation, it is assumed that all the supports undergo an identical (uniform)ground motion. In other words, due to the same ground motion at all supports, the supportsmove as one rigid base as shown in Figure 3.1. Hence, the masses attached to dynamicsdegrees of freedom are excited by the ground motion. For example, tall buildings, towers,chimneys etc. for which the distances between the supports are not very large compared withthe predominant wave length of the ground motionIn multi-support excitations, the ground/support motions or excitations are different atdifference supports. For the same travelling wave of an earthquake,the time histories of ground motion at two supports could be different if the two supports areseparated by a large distance. This is the case because the travel time of the wave betweenany two supports is not sufficiently negligible to make the assumption that the groundmotions are the same at the two supports. For examples, big network of pipe lines, very longtunnels, long dams, bridges etc. Although the piping may not be especially long, its ends areconnected to different locations of the main structure and would therefore experience different motions during as earthquake

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