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MITIGATION OF SEISMIC BEHAVIOUR OF MULTISTORIED & UNSYMETRICAL BUILDING BY USING PASSIVE TUNED MASS DAMPER

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ABSTRACT:
Most of the buildings are often constructed with irregularities such as soft storey, torsional irregularity, vertical and plan irregularity. Past earthquake studies shows that the most of the RC buildings having such irregularities were severely damaged under the seismic ground motion. The concept of structural control is now widely accepted and has been frequently applied in construction These effects occur due to different reasons, such as non uniform distribution of the mass, stiffness and strength and torsional components of the ground movement. Among the numerous passive control methods available, tuned mass damper (TMD) is one of the simplest. The mechanism involved in mitigating the vibration consists in the transfer of the vibration energy to the TMD, which dissipates it by damping. In order to increase the efficiency of a TMD, it is necessary to define its optimum parameters. The response of asymmetric building with tuned mass damper to the selected ground motion is investigated with respect to the following parameters; eccentricity ratio of the superstructure (ex/d), ratio of uncoupled torsional to lateral frequencies of the superstructure (ω θ /ωx), uncoupled time period of the superstructure (T x) and mass ratio (m d /ms). In the present work, study the performance of tuned mass damper system in multi-storeyed RCC building. Two models of building G+10 storey and G+8 storey are considered. Nonlinear time history analysis is carried out in SAP2000 software using El Centro earthquake record. Building is analysing with and without TMD for different mass ratio varying from 0.01 to 0.05. Compared different parameter such as displacement, drift, max bending moment, max base shear for building with and without TMD.

Keywords- Asymmetric building, Eccentricity ratio, Mass ratio, Non-linear Time History Analysis, Optimum Parameter of TMD, Passive tuned mass damper.

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1. INTRODUCTION

With the rapid seismic response of asymmetric buildings subjected to ground motions may be modified due to the occurrence of torsional effects. The floors of the building not only translate laterally but also rotate along a vertical axis. This effect produces distribution of the lateral displacements at the same level, and a modification of the internal actions. The main reasons for the occurrence of torsional effects . Lack of symmetry of the structural system due to a non-uniform distribution in plan of the stiffness, mass or strength and asynchronic movement of the foundation of building due to characteristics of the seismic excitation. An ideal multi-storey building designed to resist lateral loads due to earthquake would consist of only symmetric distribution of mass and stiffness in plan at every storey and a uniform distribution along height of the building. Such a building would respond only laterally and is considered as torsionally balanced building. But it is very difficult to achieve such a condition because of restrictions such as architectural requirements and functional needs. The issue of mitigating the response of structures due to seismic loads has drawn the interest of many researchers in recent years. Tuned mass dampers (TMD) have been widely used for the vibration control in civil engineering structures. The concept of vibration control, using a mass damper, dates back to the year 1909, when Frahm invented a vibration control device called a dynamic vibration absorber. Since 1971, through intensive research and development in recent years, the TMD has been accepted as an effective vibration control device for both new and existing structures. The TMD is found to be a simple, effective, inexpensive and reliable means for suppressing undesirable vibrations of structures caused by seismic excitations. TMD is attached to a structure in order to reduce the dynamic response of the structure. The frequency of the damper is tuned to a particular structural frequency so that when that frequency is excited, the damper will resonate out of phase with the structural motion. Therefore, these flexible structures are susceptible to be exposed to excessive levels of vibration under the actions of a strong wind or earthquake. Earthquake loads are to be carefully modelled so as to assess the real behavior of structure with a clear understanding that damage is expected but it should be regulated.

Mass of the secondary system varies from 1-10% of the structural mass [1] illustrated the practical considerations and vibration control effectiveness of passive tuned mass dampers for irregular buildings, modelled as multi-storey torsionally coupled shear buildings, under bi-directional horizontal earthquake excitations. Zaharai and Ghannadi [2] presented the effectiveness of TMD in controlling building under earthquake excitation and investigated the practical consideration and vibration control efficiency of TMD for moment resisting

frames. Mane and Murudi [3] investigated the influence of various ground motion parameter on seismic effectiveness of TMD. Den Hortog [4] derived closed form expression for optimum damper parameter assuming

2. LITERATURE REVIEW

- Zahrai and Ghannadi [1] presented the effectiveness of Tuned Mass Dampers (TMDs) in controlling building structures under earthquake.
- It was observed that TMD effective in reducing maximum displacement in MRF buildings by as much as 32.2% in the Tabas earthquake an 45.3% in the El Centro earthquake.
  - The maximum displacement results of a respon Sespectrum analysis for the uncontrolled and controlled case in the El Centro earthquake, in an 8-story structure, were 25.70cm and 14.59cm.

2. **Mane And Murudi**

- Mane and Murudi presented 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.

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3. BASIC PRINCIPLE

Tuned Mass Damper:- A tuned mass damper (TMD) is a device consisting of a mass, a spring, and a damper that is attached to a structure in order to reduce the dynamic response of the structure. The frequency of the damper is tuned to a particular structural frequency so that frequency is excited, the damper will resonate out of phase with the structural motion.

TMD system subjected to a vibratory force, f (t), as shown in figure 1. Referring to figure 2, the equations of motion are given as follows [2].

$m.\ddot{u}(t) + c.\dot{u}(t) + k.u(t) = cd.\dot{z}(t)$ R+ $k_d.z(t) + f(t)$ (1) $m_d.\ddot{z}(t) + c_d.\dot{z}(t)$ R+ $k_d.z(t) = - m_d.u(t) + g(t)$
(2)

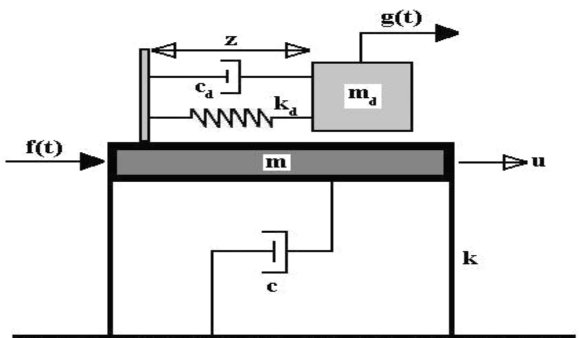

Fig. 1 Model of SDOF structure and TMD

where u is the displacement of the SDOF system, z is the relative displacement between the SDOF system and the mass damper, m is the main mass, md is the damper mass, k is main spring stiffness, kd is the absorber spring stiffness, cd is the absorber damping, f (t) is the force acting on the main mass and g (t) is the force acting on the damper mass. Force acting on damper mass equals to zero for wind excitation and equals to µ.f (t) for earthquake loading. Summation of equation (1) and (2) leads to:

$$(m+m_d).\ddot{u}(t)\mathrm{R}+ c.\dot{u}(t) +k.u\ (t) = f\ (t) + g\ (t) - m_d.\ddot{z}(t) \quad (3)$$

values with and without TMD as well as the top stories displacement reductions were obtained after analysis. By the damper inertia force acting on the structure. The Tuned Mass Damper (TMD) concept was first applied by Frahm in 1909 (Frahm, 1909) to reduce the rolling motion of ships as well as ship hull vibrations. A theory for the TMD was presented later in the paper by Ormondroyd and Den Hartog (1928), followed by a detailed discussion of optimal tuning and damping parameters in Den Hartog's book on mechanical vibrations (1940). The natural frequency of the TMD is tuned in resonance with the fundamental mode of the primary structure, so that a large amount of the structural vibrating energy is transferred to the TMD and then dissipated by the damping as the primary structure is subjected to external disturbances. Consequently, the safety and habitability of the structure are greatly 2enhanced. From the field vibration measurements, it has been proved that a TMD is an effective and feasible system to use in structural vibration control against high earthquake loads, as shown in Figure 2

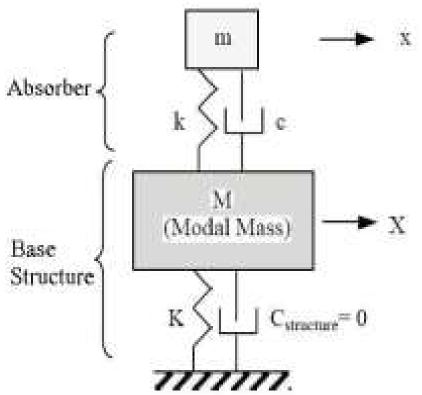

Figure-2 A schematic representation of damped vibration absorber suggested by Den Hartog

The model of building is G+8 storeys RCC structure considered for the analysis. The building is asymmetric in plan. The building has bay width of 3m in X and Y direction with 3m storey height. Slab is modelled as rigid diaphragm. Building is eccentric with respect to mass and stiffness. Tuned mass damper is installed at top of building. Non-linear time history analysis is carried out in SAP2000 software using El Centro Earthquake records. CM (Centre of mass) is location where all mass of the system can be considered to be located. CR (Centre of rigidity) is the stiffness centroid within a floor diaphragm plan. When CM not coinciding with CR then eccentricity is created in structure i.e. distances between CM and CR. CM and CR are calculated by using ETABS software. Since building is eccentric with respect to mass and stiffness, the structure exhibits a torsional effect when excited in lateral X-direction.

4 RESULTS AND DISCUSSION

the maximum displacement time histories of structures with and without TMD under the Bhuj earthquake. It demonstrates that the maximum displacement of the top storey without TMD is 35.4 mm and that of with TMD is 21.9 mm in an 10th storey structure. In comparison with an 10th storey structure, in a 12th storey structure, the The maximum displacement of the top storey without TMD is 42.9 mm and that of with TMD is 27.3 mm. Whereas, in a 21 storey structure the maximum displacement of the top storey without TMD 76.8 mm and that of with TMD is 53.4 mm.

3.1**Storey Displacement**

Figure 4.1 shows the maximum displacement time histories of structures with and without TMD under the Bhuj earthquake. It demonstrates that the maximum displacement of the top storey without TMD is 35.4 mm and that of with TMD is 21.9 mm in an 10th storey structure. In comparison with an 10th storey structure, in a 12th storey structure, the maximum displacement of the top storey without TMD is 42.9 mm and that of with TMD is 27.3 mm. Whereas, in a 21 storey structure the maximum displacement of the top storey without TMD 76.8 mm and that of with TMD is 53.4 mm. Also the Top storey displacement values with and without TMD as well as the top stories displacement reductions were obtained after analysis.

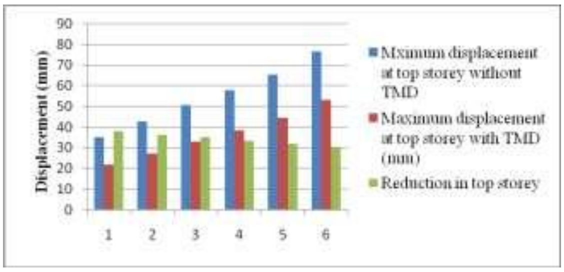

Fig. 3: Maximum storey displacement reduction with TMD structure.

5. CONCLUSION

The seismic behaviour of 10th , 12th , 14th , 16th , 18th , and 21st storey building with tuned mass damper and without tuned mass damper was investigated. TMD is effective in reducing displacement and acceleration and, thereby, can be used for structures under earthquake. This study is aimed as tuned mass dampers in reducing structural (storey drift, storey displacement and base shear) of seismically excited 10th,18th , and 21th storey building.

1. It has been found that the TMDs can be successfully used to control vibration of the structure.
2. For the regular building frame, 5% TMD is found to effectively reduce top storey displacement. The reduction of 10th storey building is 38.13, reduction of 12th top storey building is 36.36, reduction of14th top storey building is 35.16, reduction of 16th , 12th top storey building is 33.34, reduction of 18th topstorey building is 31.96, and reduction of 21st top storey building is 30.46. And base shear by about2%.
3. Therefore, the TMD should be placed at top floor for best control of the first mode.
4. For the regular building, TMD with damping exponent (n) value 0.2 is found to be better than TMD with damping exponent value 0.5.
5. From analysis it can be seen that it is necessary to properly implement and construct a damper in any high rise building situated in earthquake prone areas.

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