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Review Paper on "Tuned Mass Damper"

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Abstract – Now a days, structures are continuously increasing in the construction industries which are having a very low damping value. The structures can easily fail under structural vibrations induced by earthquake and wind, some several techniques are available today to control the vibration of the structure, TMD is one of these techniques are use today. Some investigations are carried out to identify the importance and performance of tuned mass damper in different structures. In this thesis, a one-storey and a two-storey building frame models are developed for shake table experiment under sinusoidal excitation to observe the response of the structure with and without TMD. The TMD is tuned to the structural frequency of the structure keeping the stiffness and damping constant. Various parameters such as frequency ratio, mass ratio, tuning ratio etc. are considered to observe the effectiveness and robustness of the TMD in terms of percentage reduction in amplitude of the structure. Then the responses obtained are validated numerically using finite element method. From the study it is observed that, TMD can be effectively used for vibration control of structures.

Keywords: Tuned Mass Damper, MTMD.

- X -

I. INTRODUCTION

Earthquake is a compartment of structural analysis which involves the computation of the response of a structure subjected to earthquake excitation. This is required for carrying out the structural design, structural assessment and retrofitting of the structures in the regions where earthquakes are prevalent.

Now a day number of tall buildings are going on increasing which are quite flexible and having very low damping value to minimize increasing space problems in urban areas. These structures should be designed to oppose dynamic forces through a combination of strength, flexibility and energy absorption such that it may deform beyond elastic limit when subjected to severe earthquake motion.

During earthquake structural performance of Reinforced Concrete (RC) buildings always plays crucial roles in losing of life, injuries,

economic losses etc. But to a certain extend structures already built are vulnerable to future earthquakes. Earthquake risk is associated with seismic hazard and vulnerability of building. Therefore, to protect such civil structures from significant damage one of the way is to increase flexibility of structures. But will affect the comfort ability of people inside the building. so the response reduction of civil structures during dynamic loads such as severe earthquakes and strong winds has become an important topic in structural engineering.

1.1. Future Study

A linear model is considered in the experimental study.This can be studied by considering a non-linear model.

In current study the damper mass is placed at the top of the frame model and reduction in response is observed. A further study can be carried outby placing the damper mass at different floors of the frame structure.

The study can be extended by using multiple tuned mass damper (MTMD) tuned with various modal frequencies at different levels.

II. LITERATURE REVIEW

Brief information of the research work done by researchers about topic which will help us to decide about the subject, is as given below. A number of researchers have made important contributions to the development of our understanding of the experimental studies on Tuned Mass Damper.

Kenny C. S. et al. (1984)[1]) Spectral density functions of wind-induced acceleration responses of Sydney Tower identify natural frequencies of vibration of 0.10 Hz and 0.50 Hz for the first mode and second mode respectively was analysed. For natural frequencies and damping measurements. Two accelerometers were installed in the Tower, one at Turret Level 8 to monitor the first mode vibrations and one near the Intermediate Anchorage Ring to monitor the second mode vibrations

GendaChen et. al. (2001)[2].The proposed procedure is applied to place the dampers on the floors of the six-story building for maximum reduction of the accelerations under a stochastic seismic load and 13 earthquake records. Numerical results show that the multiple dampers can effectively reduce the acceleration of the uncontrolled structure by 10–25% more than a single damper. It is found that time-history analyses indicate that the multiple dampers weighing 3% of total structural weight can reduce the floor acceleration up to 40%. The multiple dampers can even suppress the peak of acceleration responses due to impulsive excitations, which a single damper of equal mass cannot achieve

Roberto Villaverdeet. al. (2002)3 The investigation includes a comparison of the building's response under severe ground motion when it is considered with and without the isolation system, as well as determination of the properties and size of the isolation system components required. It is found that the proposed isolation system is effective, is able to be constructed, and has the potential to become an attractive way by which to reduce structural and nonstructural earthquake damage in low- and medium-rise buildings.

Haruna Ibrahim et. al. (2015)[4] Preliminary results on the passive control of the structural response of single degree of freedom (SDOF) and two dimensional multi-storeyed frames using Tuned Mass Damper (TMD) are presented here. At first a numerical analysis was developed to investigate the response of a shear building fitted with a tune mass damper. Then another numerical was developed to investigate the response of a 2D frame model fitted and without Tuned Mass Damper (TDM).

III. METHODOLOGY

3.1. Experimental Work

Tuned mass damper is a low cost seismic protection technique which is implemented in many tall building and tower in the world without interrupting the use of the building. Thus till now various research works have been conducted to discover the effect of TMD to reduce the seismic shaking of the structure numerically. But experimental works under this field is quite limited.

The motive of this study is to reduce the response by attaching a tuned mass damper to the structure under sinusoidal loading and also to obtain the effect of various parameters such as mass ratio, frequency ratio, tuning ratio etc. on response of the structure. Ratio of damper mass to the mass of the structure is known as mass ratio, ratio of excitation frequency to the fundamental frequency of the structure is known as frequency ratio and the ratio of damper tuning frequency to structural frequency is known as tuning ratio.

For this experiment, shaking table test is conducted to study the dynamic behavior of a single and a double frame structure with and without TMD where it is subjected to sinusoidal ground motion. The structure is rigidly attached to the shaking table platform. The weight of the structure may be regarded as concentrated at the roof level. Since a sinusoidal motion consists of a single frequency, it will provide a better understanding of the behavior of TMD-structure system. The fundamental frequency of the structure is determined from free vibration analysis.

Force vibration analysis is carried out by exciting the frame at various frequencies and the response is recorded. Signal study is usually divided into time and frequency domains; each domain gives a different outlook and insight into the nature of the vibration. Time domain analysis starts by analysing the signal as a function of time. A signal analyser can be used to develop the signal. The time history analysis plots give information that helps describe the behavior of the structure. Its behavior can be characterized by measuring the maximum vibration level. Frequency analysis also provides valuable information about structural vibration. Any time history signal can be transformed into the frequency domain. The most common mathematical technique for transforming time signals into the frequency domain is called the Fourier Transform. Fourier Transform theory says that any periodic signal can be represented by a series of pure sine tones. In structural analysis, usually time waveforms are measured and their Fourier Transforms are computed. The Fast Fourier Transform (FFT) is a computationally optimized version of the Fourier Transform. With test experience, one can gain the ability to understand structural vibration by studying frequency data.

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Single storey frame without TMD

Single storey frame with TMD

TMD structure model:

A one-storey and a two-storey building frame are developed for this experiment. The frame is supported by four columns of circular cross section of diameter 7.7 mm. The height of the column is 70 cm for single storey and 50 cm each for double storey. The roof of the frame is a rectangular iron plate of size 50 cm x 40 cm weighting 15.44 kg which is connected to the columns by nuts. An accelerometer is attached to the model to record the storey acceleration and displacement. The TMD is made up of various square iron plates of size 12.6 x 12.6 cm each having a weight of 0.707 kg, attached at the centre of roof plate by a circular rod. The frame is subjected to free vibration analysis to know the fundamental frequency of the structure. Then the damper is designed by tuning it to that frequency to obtain maximum response reduction at various mass ratios.

During the experiments, the frameasshown in figure (a) is subjected to lateral harmonic

Excitation defined by the expression, $x=x_0\omega 2$ $\sin(2\pi ft)$where,$x_0$andfaretheamplitudeand

frequency of excitation respectively which are the two varying parameters.

3.2. Test Methods:-

Weight of the plate=15.44 Kg

Height of column (l)= 70cm

Diameter of column (D)= 0.77 cm

Fundamental frequency of frame (f) = 1.75 Hz (obtained from free vibration analysis)

Displacement Amplitude(x_0) =0.5 cm

Stiffness of frame (k)=1864.84 N/m (*w* □ 2□*f*)

Stiffness of each column=k/4=466.62N/m

Moment of inertia of column (I)= □*D* /64= 1.7

IV. ADVANTAGES OF STUDY

1. They do not depend upon external power sources
2. They do not depend on an external power source for their operation.
3. They can respond to small level of excitation.
4. Their properties can be adjusted in the field.
5. They can also be introduced in upgrading structure.
6. They require low maintenance.
7. They can be cost effective.

V. APPLICATIONS

1. Tall and slender free-standing structures (bridges, pylons of bridges, chimneys, TV towers) which tend to be excited dangerously in one of their mode shapes by wind

2. Stairs, spectator stands, pedestrian bridges excited by marching or jumping people. These vibrations are usually not dangerous for the structure itself, but may become very unpleasant for the people

3. Rural energy applications: Biogas holders, biogas digesters, incinerators and panels for solar energy collectors.

4. Steel structures like factory floors excited in one of their natural frequencies by machines, such as screens, centrifuges, fans etc.

5. Ships exited in one of their natural frequencies by the main engines or even by ship motion.

Tuned Mass Dampers may be already part of the structure’s original design or may be designed and installed later.

VI. CONCLUSION

A brief review of several literatures presented shows the application of a passive energy dissipating device Tuned Mass Damper. It is found that a single TMD is not much effective than series of multiple tuned mass dampened arrangement. Because heaver mass dampers reaches its full potential slowly than lighter. A mitigation of 10-25% in seismic acceleration can be done by MTMD than single TMD. But from best of knowledge it seems that no work has been reported on a systematic approach to place the multiple dampers of various frequencies in a multi-storey building structure for optimal performance.

If TMDs are providing on a building as a retrofitting element, it the seismic acceleration response for most cases although it is not tuned to accommodate the specific structure's dynamic behavior and localized soil condition. And this arrangement will be effective not only in high rise buildings but also in low and medium rise buildings. This will helps to reduce displacement, storage drift, and base shear. And also it have best control in first mode. From all the researches, it is found that the proper implementation of TMD in any high-rise buildings in earthquake prone area is necessary.

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