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EXPERIMENTAL STUDY ON TUNED MASS DAMPER IN SEISMIC CONTROLLING VIBRATION OF FRAME STRUCTURES

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ABSTRACT :- Day by day, the numbers of taller and lighter structures are continuously increasing in the construction industries which are flexible and having a very low damping value. Those structures can easily fail under structural vibrations induced by earthquake and wind. Therefore several techniques are available today to minimize the vibration of the structure, out of which concept of using TMD is a newer one. There are large numbers of studies on theoretical investigation of behaviour of buildings with tuned mass dampers under various impacts. However, the experimental studies in this area are quite limited. 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.

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. To make these structures free from earthquake and wind induced structural vibration, various techniques has been adopted which can be broadly classified into 4 categories.

(i) Active control, (ii) Passive control, (iii) Semi-active control and (iv) Hybrid control.

1. Active control devices:

These devices use an external power source which operates control actuators to apply forces to the structures. Some signals are sent to the actuators which are a function of responses of the structure. Requirement of equipments are more in active control strategies than passive control thereby increasing the cost and maintenance of such systems. Active tuned mass damper, active tuned liquid column damper and active variable stiffness damper are some of the examples of active control devices.

2. Passive control devices:

It is a device which imparts forces that are developed in response to the motion of the structures. By absorbing some of the input energy, it reduces the energy dissipation demand on the structure. Therefore no external power source is required to add energy to the structural system. Base isolation, tuned mass dampers (TMD), tuned liquid dampers (TLD), metallic yield dampers, viscous fluid dampers are some of the examples of passive control devices.

3. **Semi-active control devices**:

It is a controllable passive control system where the external energy requirement is less than that of active devices. It unites the optimistic aspects of passive and active control devices. These devices generate forces as a result of the motion of the structure and cannot add energy to the structural system. Variable orifice dampers, variable friction dampers, variable stiffness damper, and controllable fluid dampers are some of the examples of semi active control devices.

4. **Hybrid control Devices:**

These devices combine the passive, active or semi-active devices to achieve higher level of performance. Since a portion of the control objective is accomplished by the passive system, less active control effort, implying less power resource, is required. A side benefit of hybrid systems is that, in the case of a power failure, the passive components of the control still offer some degree of protection, unlike a fully active control system. Examples of hybrid control devices include hybrid mass damper and hybrid base isolation.

Tuned mass damper:

Tuned mass damper is a passive control device connected to the structure like a secondary mass to reduce the dynamic response of the structure and increases the damping capacity. It has been widely used for vibration control in many mechanical engineering systems. Recently many theories have been adopted to reduce vibration in civil engineering structures because of its easy and simple mechanism. To obtain optimum response the natural frequency of the secondary mass is always tuned to that of primary structure such that when that particular frequency of the structure get excited, the TMD will resonate out of phase with the structural motion. The excess amount of energy built up in the structure is transformed to the secondary mass and dissipated due to relative motion developed between them at a later stage.

II EXPERIMENTAL PROCEDURE

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

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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 behaviour 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 behaviour of the structure. Its behaviour 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

Time-domain analysis for single storey frame: The frame is excited under sinusoidal excitation at various exciting frequencies ranging from 0.18 Hz to 2.97 Hz and the signals obtained are studied both in time and frequency domain which gives two different outlooks to examine the nature of vibration. The maximum displacement and acceleration response for each excitation frequency is obtained from corresponding time domain plots. Displacement and acceleration time history signal of the frame at various mass ratios with and without TMD are plotted for a frequency ratio of 0.8 and 1.0 in figure 4.3 to 4.6.

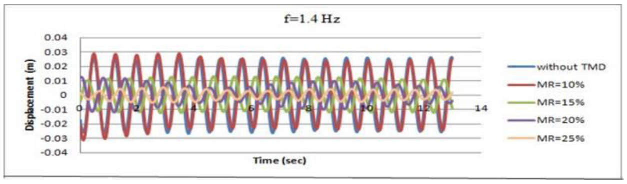
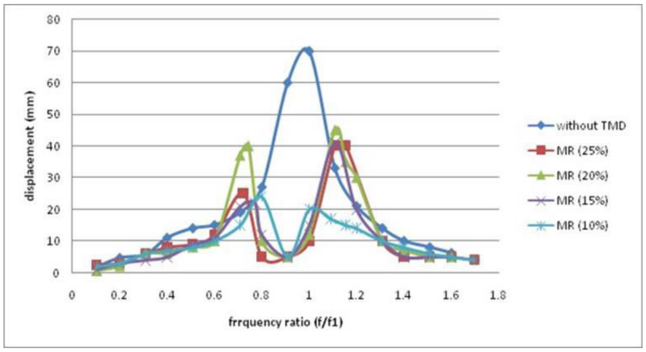


Figure 3.3 Time histories of structural displacement with and without TMD at frequency ratio = 0.8

Effect of mass ratio on structural response for single storey frame



Effect of tuning ratio on structural response for single storey frame:

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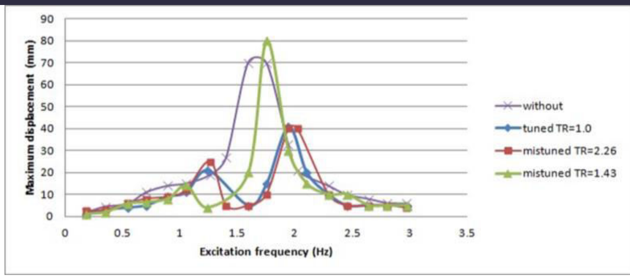
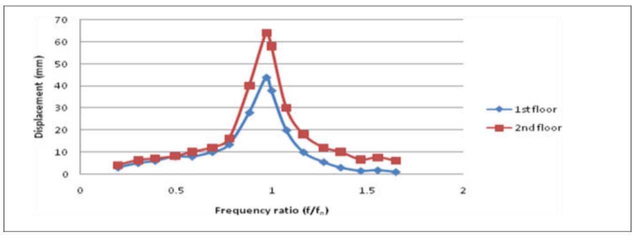


Frequency domain analysis for double storey frame:



III RESULTS & DISCUSSION

Comparison Study on the maximum displacement of the double storey building frame without and with TMD

Source	Displacement in mm		% reduction
	Without TMD	With TMD	
Present FEM	50.8	20.5	59.64%
Experiment	58	55	5.17%
STAAD Pro.	52.5	18.3	65.14%

Comparison of predicted frequency (Hz) obtained in FEM and STAAD Pro

Mode	FEM	STAAD Pro.	% Variation
1	1.439	1.373	4.8
2	4.0824	3.913	4.6
3	6.112	5.941	3.4
4	7.232	7.046	2.6

Comparison Study on the top storey displacement of the 4-storey frame without and with TMD:

Source	Displacement in mm		% Reduction
	Without TMD	With TMD	
FEM	30.9	22.8	26.2%
STAAD Pro.	34.2	27.8	20%

Comparison of predicted frequency (Hz) obtained in FEM and STAAD Pro

Source	Displacement in mm		% Reduction
	Without TMD	With TMD	
FEM	185.5	121.6	34.40%
STAAD Pro.	259	168	35.13%

Tuning of damper: To know the effect of tuning in reducing the structural response, the mass damper attached to the 10-storey frame is tuned to different modal frequencies obtained from analysis. Table 12 shows the storey displacement at various mass ratios when the damper is tuned to different modal frequencies.

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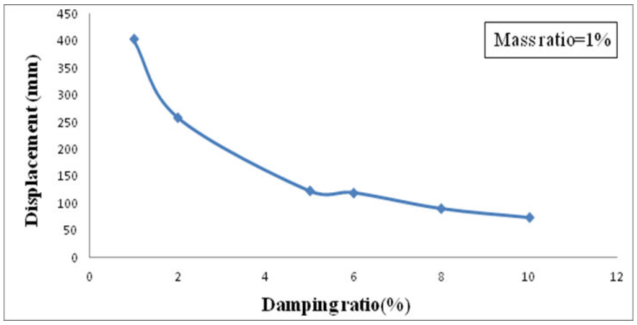
Effect of TMD on Displacement response with variation of damping ratio: The effect of variation of damping ratio of TMD is studied through the amplitude response of the frame at a constant mass ratio of 0.01 under sinusoidal acceleration. From the figure 5.28 it is found that the response of the frame decreases with increase in damping ratio and then it will remains constant after a certain point.



IV CONCLUSION

The present study focuses on the capability of TMD in reducing the structural vibration induced due to earthquake. A single and a double storey frame model are examined experimentally with and without TMD to determine the structural response and presented in graphical and tabular forms. Effect of various parameters such as frequency ratio, mass ratio, damping ratio on the amplitude response has been studied with TMD. The results obtained are validated numerically using finite method. Further a four storey and a ten storey RC frame models are studied using Finite element method and STAAD Pro considering various parameters. The experimental and numerical investigation of various frame models under sinusoidal ground motion confirms that the structural response can be considerably reduced to a large extent by a properly designed TMD.

The following conclusions are made from the study.

- When the frame is subjected to sinusoidal ground motion without TMD, amplitude becomes maximum at the point of resonance.
- From the experimental study, it is observed that, after using damper optimum reduction is occurring at a frequency ratio nearer to the point of resonance. That is when the frequency ratio becomes nearer to unity.
- With increase in mass ratio, the peak displacement is going on decreasing up to a particular mass ratio and again it is increasing on further increment of mass ratio.
- It is more effective in reducing the displacement responses of structures when tuned to fundamental (1st mode) frequency of the structure.
- It is more effective to use high damping ratio.
- At a higher beat frequency, beating effect is prominent which diminishes as the forcing frequency approaches to the fundamental frequency and no beating effect is observed at the state of resonance.
- From this study, it can be concluded that properly designed TMD with efficient design parameters such as tuning ratio, frequency ratio and mass ratio is considered to be a very effective device to reduce the structural response.

REFERENCES:-

1. Supradip Saha, Rama Debbarma, "An Experimental study on response control structures using multiple

tuned liquid dampers" (2017), Int J Adv Struct Eng 9:27-35.

2. Jitaditya Mondal, Harsha Nimmala, Shameel Abdulla, Reza Tafreshi, "Tuned Liquid Damper" (2014), International Conference on Mechanical Engg. And Mechantronics Prague, Czech Repulbic, August 14-15, paper no.68.
3. Roshni V. Kartha and Ritzy R., "Tuned liquid damper to control Earthquake response in a Multi-storied Building Frame" (2015), Int. Journal of Engineering Research and Applications, ISSN: 2248-9622, Vol.5, Issue 8, (Part-4) pp.49-56..
4. Pradipta Banerj, Avik Samanta and Sachin A. Chavan "Earthquake control of vibration using Tuned liquid Damper", International Journal of Advanced Structural Engineering, Vol. 2, No. 2 (2010), Pages 133-152,.
5. Haruna Ibrahim, Daha S. Aliyu and Hafizu Hamza "Vibration Control of a frames structure using Tuned Mass Damper"(2015), International Conference on Science, Technology and Management, 27 September 2015.
6. Saurabh Chalke and Prof. P. V., "Vibration Control of Frame Structure using Tuned Mass Damper" (2017), International journal of Engineering Development and Research, Volume 5, Issue 3, ISSN: 2321- 9939.
7. Emili Bhattacharjee, Lipika Halder and Richi Prasad Sharma, "An Experimental study on tuned liquid damper for mitigation of structural response", International Journal of Advanced Structural Engineering, (2013).
8. Muhammed Murad K. and Lavanya G., "Dynamic resistance of tall buildings by using Tuned mass dampers", International Conference on Current Research in Engineering Science and Technology, (2016).
9. Alexander Nicholas A, Schilder Frank. "Exploring to performance of a nonlinear tuned mass damper" Journal of Sound and Vibration 319 pp 445–462.
10. C. C. Lin, G. L. Lin and H. Y. Lung, "dynamic test of multiple tined mass dampers for vibration control of high rise buildings" (2014), National conference on earthquake engineering, July 21-25.