

Application of tuned mass damper (TMD) for vibration control of multistoried building under seismic excitation

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Abstract— current trends in construction industry demands taller and lighter structures, which are also more flexible and having quite low damping value. Now-a-days several techniques are available to minimize the vibration of the structure, out of the several techniques available for vibration control, concept of using TMD is a newer one. This study was made to study the effectiveness of using TMD for controlling vibration of structure. The numerical stimulation are performed to study the structure with and without TMD. The soft storey will be made up of steel and its columns, beams, and slab sizes will be smaller than columns, beams, and slab sizes other stories of the building. The height, member sizes of soft storey will be devised based on the principle of TMD i.e. the natural frequency of TMD (soft storey) should have same natural frequency as that of main building. A twelve storied building with rectangular shape is considered for analysis. Analysis is done by FE software SAP2000 by using direct integration approach. TMDs with percentage masses 2%, 3%, 4%, 5% are considered. Three different recorded time histories of past Earthquake are used for the analysis. Namely 1940 EL-Centro Earthquake, Northridge Earthquake, and Taft Earthquake. comparison is done between the buildings with TMD and without TMD.

IndexTerms—steel, concrete, time history, earthquake, soft storey, multistorey

I. INTRODUCTION

Fast urbanization has led to construction of a large number of multistoried buildings. Seismic safety of these building is of importance. Efforts have led to development of techniques like base isolation, active control and passive control devices. Base isolation technique is shown to be quite effective and it requires insertion of isolation device at the foundation level, which may require constant maintenance. Active control techniques turn out to be quite costly for buildings, as they need continuous power supply. In developing countries like India, such control devices can become popular only if they are easy to construct. Their design method is compatible with present practices and shall not require costly maintenance. With the aim of developing such a simple control device, some studies have been undertaken in last couple of years. In these studies a simple type of Tuned Mass Damper (TMD) has been proposed. A tuned mass damper (TMD) is a passive energy dissipation device, consists of a mass, spring, and a damper, connected to the structure in order to reduce the dynamic vibrations induced by wind or earthquake loads. The soft storey will be made up of concrete and its columns, beams, and slab sizes will be smaller than columns, beams, and slab sizes other stories of the building. The height, member sizes of soft storey will be devised based on the principle of TMD i.e. the natural frequency of TMD (soft storey) should have same natural frequency as that of main building. The number of tall buildings being built is increasing day by day. Today we cannot have a count of number of low-rise or medium rise and high rise buildings existing in the world. Mostly these structures are having low natural damping. So increasing damping capacity of a structural system, or considering the need for other mechanical means to increase the damping capacity of a building, has become increasingly common in the new generation of tall and super tall buildings. But, it should be made a routine design practice to design the damping capacity into a structural system while designing the structural system. The control of structural vibrations produced by earthquake or wind can be done by various means such as modifying rigidities, masses, damping, or shape, and by providing passive or active counter forces. To date, some methods of structural control have been used successfully and newly proposed methods offer the possibility of extending applications and improving efficiency. The selection of a particular type of vibration control device is governed by a number of factors which include efficiency, compactness and weight, capital cost, operating cost, maintenance requirements and safety. 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. The mass is usually attached to the building via a spring-dashpot system and energy is dissipated by the dashpot as relative motion develops between the mass and the structures.

II. DISCRPTION OF BUILDING

The model of building is G+12 storey RCC structure considered for the analysis. The building is symmetrical in plane and building has bay width of 5m in X and Y direction with 3.5m storey height. Base floor height is 4.5m. tuned mass damper is installed at the top of building. Linear time history analysis is carried out in SAP2000 software using three earthquake record such as EL Centro earthquake, Northridge earthquake and Taft earthquake. All details are given in table.

SR.NO.	CONTENT	DESCRIPTION
1.	Number of storey	G+12
2.	Floor height	3.5m
3.	Base floor height	4.5m
4.	Wall thickness	230mm
5.	Imposed load	3KN/m ²
6.	Size of column	450mm×450mm
7.	Size of beam	450mm×300mm
8.	Depth of slab	100mm
9.	Types of soil	Medium soil
10.	Seismic zone	V
11.	Zone factor	0.36
12.	Response of spectra	As per IS1893(Part 1):2002 for 5% damping
13.	L.L. On top	1.5 KN/m ²

III. RESULT

1. OPTIMUM PARAMETER OF TMD:

IV. Sizes of TMD are reduces to normal building sizes which are given in following table:

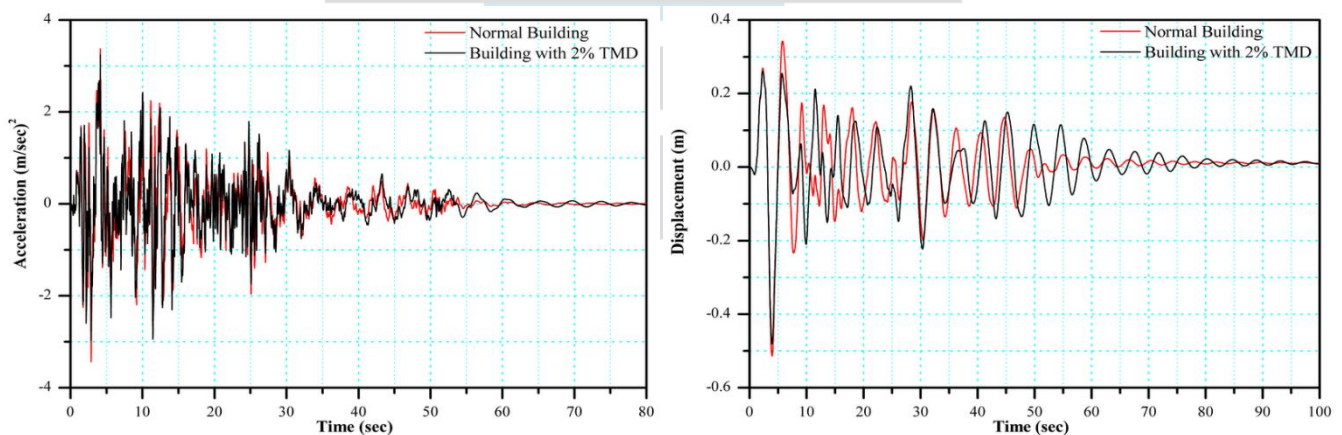
Sr. No.	Description	Mass Ratio of TMD with main building in %			
		2%	3%	4%	5%
1.	Column section	ISB113.5×113.5×5 .4	ISB113.5×113.5×5 .4	ISB113.5×113.5×5 .4	ISB113.5×113.5×5 .4
2.	Beam section	ISWB600	ISWB600	ISWB600	ISWB600
3.	Slab Thickness (M30) (m)	0.13	0.22	0.3	0.38
4.	Storey Height (m)	7	6	5.5	5.1

Different Mass Ratios of TMD With main Building

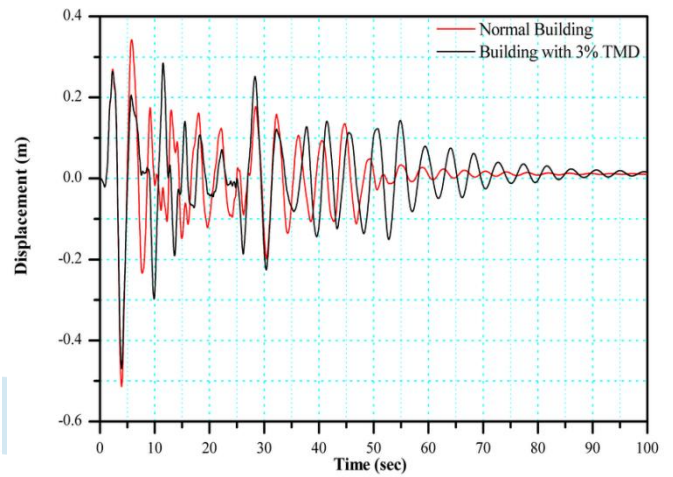
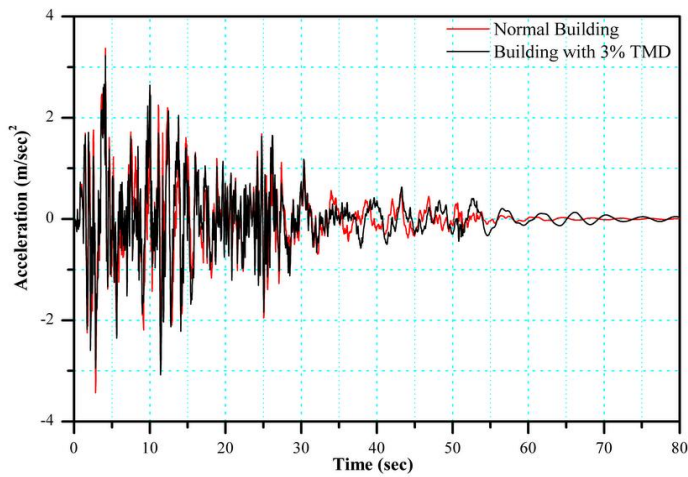
2. Time Histories of Random Ground Acceleration:-

A total of three random ground acceleration cases are considered for the analysis. The first is the compatible time history is the 1940 El Centro Earthquake record. Second is the compatible time history is the 1994 Northridge Earthquake record. Third is the compatible time history is the 1952 Taft Earthquake record.

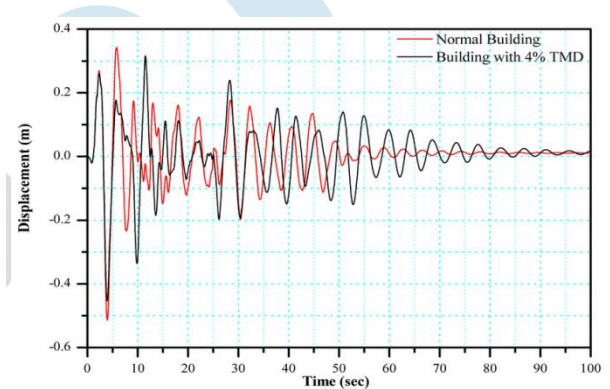
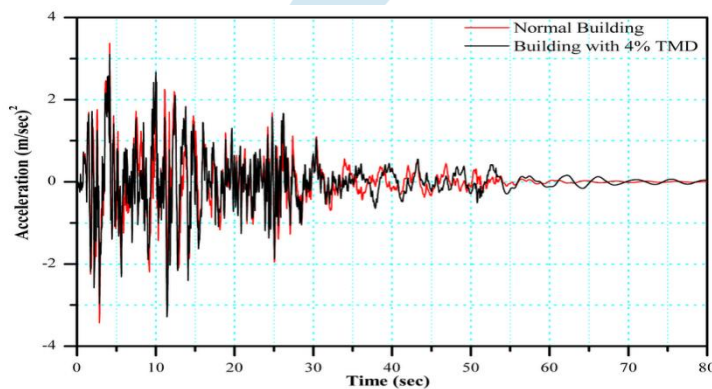
The response of symmetrical building with tuned mass damper for various ground motion is investigated in terms of displacement and acceleration.



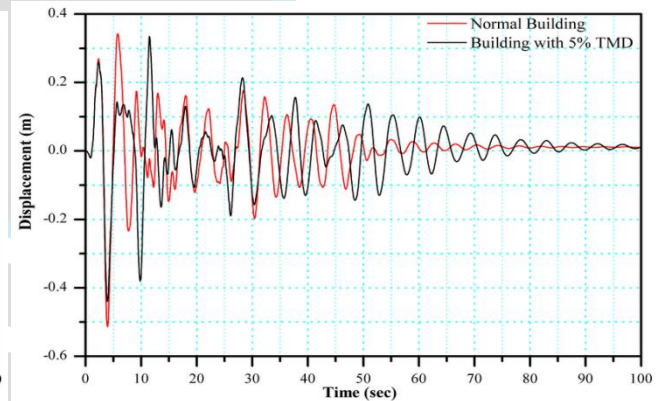
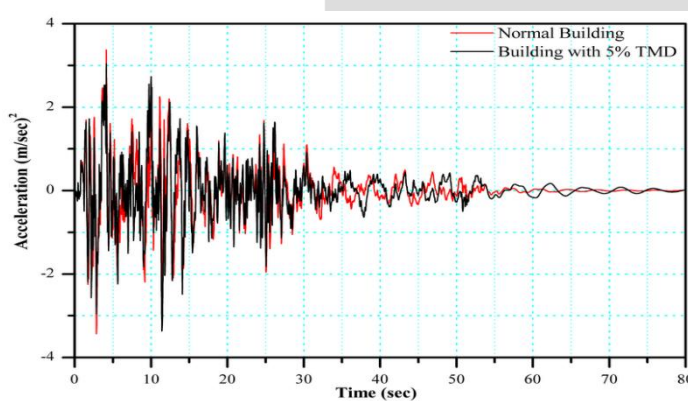
Response of the structure when mass ratio is 2% in the 1940 EL-Centro EQ



Response of the structure when mass ratio is 3% in the 1940 EL-Centro EQ



Response of the structure when mass ratio is 4% in the 1940 EL-Centro EQ



Response of the structure when mass ratio is 5% in the 1940 EL-Centro EQ

IV. CONCLUSION

Following conclusions can be made from this study:

1. It has been found that the TMD can be successfully used to control vibration of the structure.
2. Simple TMD with optimum frequency ratio, provided in the form of soft storey at building top is found to be effective in reducing seismic response of building.
3. Applying the three earthquake loadings, first is the corresponding to compatible time history in the EL-Centro earthquake. a soft storey at the top of building reduces top building deflection about 20%-61%
4. Second is the corresponding to compatible time history in the Northridge earthquake a soft storey at the top of building reduces top building deflection about 6%-15%

5. Third is the corresponding to compatible time history in the Taft earthquake a soft story at the top of building reduces top building deflection about 38%-67%
6. Among 2% to 5% TMDs 5% TMD is found better than 2%, 3%, 4% TMDs in reducing displacement.

V. REFERENCES

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