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A Comparative Study of RC Framed Structures using Passive Control Devices as Soft Storey

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***Abstract*—The present pattern toward structures of perpetually expanding statures and the utilization of light weight, high quality materials and propelled development strategies have prompted progressively adaptable and delicately damped structures. Presently a days a few strategies are accessible to minimize the vibration of the structure, out of the alternatives accessible for vibration control of which tuned mass dampers (TMD) is a never one.This study must be made to decide the viability of utilizing TMD for controlling vibration structure.**

The present study uncovers the impact of TMD with ideal parameters (frequency proportion and mass proportion). Here TMD is utilized as weak story which is thought to be comprised of RCC developed up to top of the building. A multi-story RC outlined structure with and without TMDs has been considered for the analysis.3D models and examination will be done by utilizing a FE package SAP2000 by utilizing direct combination technique. TMDs with mass proportionis considered. The models were utilized to speak to structures situated in zone 4 of India. The systemic parameters examined are frequency, base shear, roof displacement, lateral displacement, storey drift and Time history investigation has been considered out the structures must be subjected to a ground movement Dharmashala for the working with, without TMD and TMD as soft-storey and the outcomes are deciphered.

Keywords— Tuned Mass Damper; Soft Storey; SAP 2000

I. INTRODUCTION

Vibration control is a set of technical means aimed to reduce the undesired vibrations in a structure. 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. Vibration control of structures like tall buildings subjected to earthquake and wind excitations are important for human comfort and structural safety. Generally tall structures do not have sufficient damping; therefore control of the vibration response of the structures is very essential. Passive control devices like Tuned Mass Dampers (TMD) are elegant solutions for increasing damping in a structure, thereby, reducing the response due to external loading.

SOFT STOREY is a multistoried building which having more opening space. These floors especially dangerous against the earthquake forces, because of they cannot resist the lateral forces caused by swaying. soft storey structures, having first stories a great deal less inflexible than the stories above are especially powerless to seismic tremor harm in view of extensive, unreinforced openings on their ground floors

"A soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storeys above."

II. OBJECTIVES AND METHODOLOGY

A. Objectives

- To understand the concept of tuned mass damper (passive) in controlling vibration of a framed structures.
- To evaluate the response of multi-degree of freedom system
- (MDOF) frames structures with and without tuned mass damper using SAP2000 Software.
- To understand the dynamics of the frames structures subjected to earth quake load.
- To investigate the effect of the damping ratio of soft storeyat top and TMD on the response of the structure subjectedto a dynamic load excitation.

B. Methodology

- Collection of detailed information about earthquake ground motion.
- Tuned mass damper with mass ratio 1% as been used for dynamic analysis.
- Softstorey will be made up of concrete and its column, beam and slab sizes will be smaller than the columns beams and slab sizes other storey of the building the height and member sizes of soft storey will be device based on principle of TMD.

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- A set of recorded time verses acceleration curve and displacement curve is obtained for systematic parameter like roof top displacement and base acceleration.
- The ground motion used in the study to generate a single record time verses acceleration curve is DHARMASHALA EARTHQUAKE RECORD.
  - Interpretation of results.

III. PRESENT STUDY

A. Parameters considered for the study

TABLE-1

Type of building	Multi storey
Grades of concrete(f_{ck})	M25
Bay length	5m
Number of bay	
Along X direction	6
Along Y direction	5
Modulus of elasticity	25000 KN/m^2
Poissons ratio	0.3
Loads	
Total dead load Dead load Wall load Parapet load	IS 875 Part 1
Floor loads Live load Floor finish	IS 875 part 2 2KN/m 1.5 KN/m
Earth quake load	IS 1893-2002
Importance factor,I	1
Zone	IV - (DHARMASHALA)
Zone facor, Z	0.24
Response factor	5

DETAILS OF THE BUILDING WITHOUT SOFT STOREY

TABLE-2

Number of stories	Column size	Beam size	Slab thickness
G+5	G+5		150mm
	0.23X 0.45	0.23X 0.45	
G+10			
Upto 5 floors	0.45 X 0.6	0.23 X 0.45	100 mm
6th to 10 th floors	0.23 X 0.45	0.23 X 0.45	
G+15			
Upto 5 floors	0.6 X 0.9	0.23 X 0.45	100mm
6th to 10 th floors	0.45 X 0.6	0.23 X 0.45	
11th to 15 th floors	0.23 X 0.45	0.23 X 0.45	

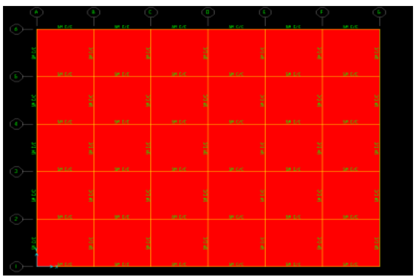

Fig -1 Plan of the models considered

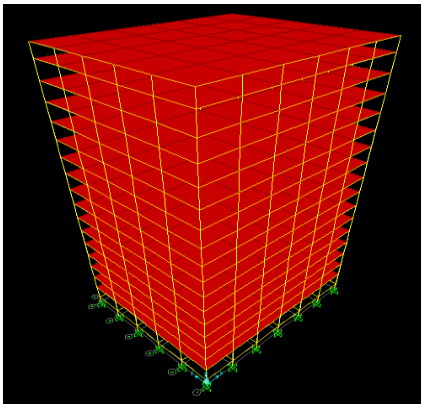

Fig -2 Elevation of G+15 building

TABLE-3

Mass percentage	Storey	Column size(m)	Beam size(m)	Slab thickness (mm)
	G+5			
1%	Upto 5 floors	0.23X 0.45	0.23X 0.45	150
	Soft storey	0.23X 0.23	0.15 X 0.15	75
2%	Upto 5 floors	0.23X 0.45	0.23X 0.45	150
	Soft storey	0.23X 0.3	0.23X 0.23	75
3%	Upto 5 floors	0.23X 0.45	0.23X 0.45	150
	Soft storey	0.3X 0.45	0.3X 0.45	75
	G+10			
1%	Upto 5 floors	0.45 X 0.6	0.23 X 0.45	100
	6th to 10 thfloors	0.23 X 0.45	0.23 X 0.45	
	Soft storey	0.15 X 0.3	0.15 X 0.3	
2%	Upto 5 floors	0.45 X 0.6	0.23 X 0.45	100
	6th to 10 thfloors	0.23 X 0.45	0.23 X 0.45	
	Soft storey	0.3 X 0.3	0.3 X 0.3	
3%	Upto 5 floors	0.45 X 0.6	0.23 X 0.45	100
	6th to 10 thfloors	0.23 X 0.45	0.23 X 0.45	
	Soft storey	0.3 X 0.45	0.3 X 0.45	
	G+15			
1%	Upto 5 floors	0.6 X 0.9	0.23 X 0.45	100
	6th to 10 thfloors	0.45 X 0.6	0.23 X 0.45	
	11th to 15 thfloors	0.23 X 0.45	0.23 X 0.45	
	Soft storey	0.23 X 0.45	0.23 X 0.3	
2%	Upto 5 floors	0.6 X 0.9	0.23 X 0.45	100
	6th to 10 thfloors	0.45 X 0.6	0.23 X 0.45	
	11th to 15 thfloors	0.23 X 0.45	0.23 X 0.45	
	Soft storey	0.45 X 0.3	0.45 X 0.3	
3%	Upto 5 floors	0.6 X 0.9	0.23 X 0.45	100
	6th to 10 thfloors	0.45 X 0.6	0.23 X 0.45	
	11th to 15 thfloors	0.23 X 0.45	0.23 X 0.45	
	Soft storey	0.45 X 0.45	0.45 X 0. 45	

IV. RESULTS AND DISCUSSION

In the present study a three dimensional 6 bay 5m centre to centre in x direction and 5 bay 5m centre to centre in y direction. A conventional RC frame structure and soft storey at the top of the building has been modelled for G+5, G+10 and G+15 structures respectively with fixed base. The structure is assumed to be located in zone IV of India and is subjected to time history analysis. The variation in systematic parameters like frequency, base shear, roof top displacement and storey drift had been studied. The model has been subjected to Dharmashala earthquake ground motions and the responses are interpreted.

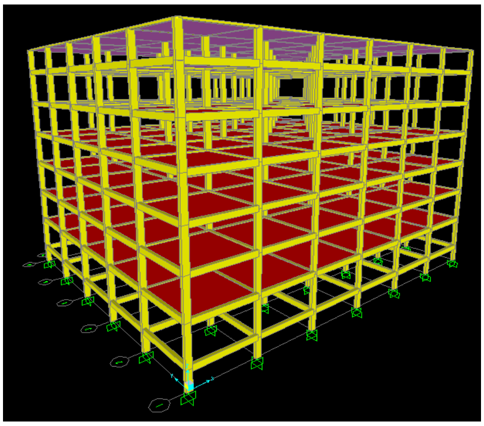

Fig -3 Elevation of G+5 building with soft storey

A. Variation in frequency.

Considering buildings with TMD, without TMD, 1%, 2% and 3% mass ratio of G+5, G+10 and G+15 building, maximum decrease in the frequency is observed in the building with soft storey of 2% mass ratio compared to the other G+5 building models. Maximum decrease in the frequency is observed in the building with soft storey of 1% mass ratio compared to the other building models of G+10 building and maximum decrease in the frequency is observed in the building with TMD compared to the other G+15 building models.

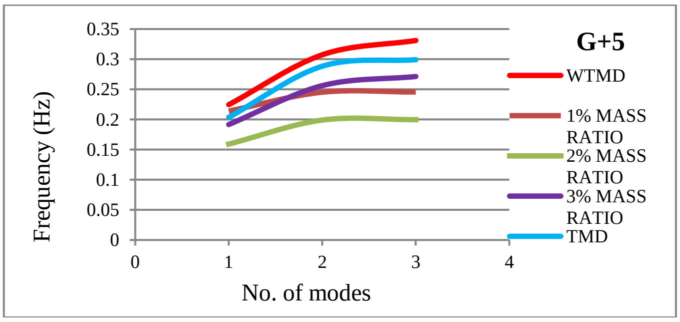

Fig-4 Variation in frequency.

B. Variation in lateral displacement

Considering the G+5, G+10 and G+15 buildings without TMD, with TMD and buildings with 1%, 2% and 3% mass ratios, it is observed that the building with TMD in G+5, G+10 and G+15 shows maximum decrease in lateral displacement and 1%, 2% and 3% mass ratios shows decrease in lateral displacements compared to the building without TMD.

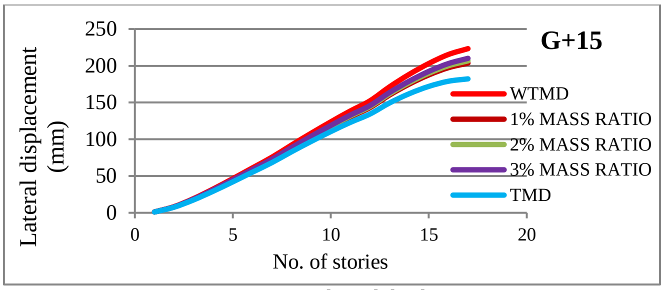

Fig-5 Variation in lateral displacement

C. Varaition in Storey drift

Considering the G+5, G+10 and G+15 buildings without TMD, with TMD and buildings with 1%, 2% and 3% mass ratios, it is observed that the building with TMD in G+5, G+10 and G+15 shows maximum decrease in storey drift and 1%, 2% and 3% mass ratios shows decrease in storey drift compared to the building without TMD.

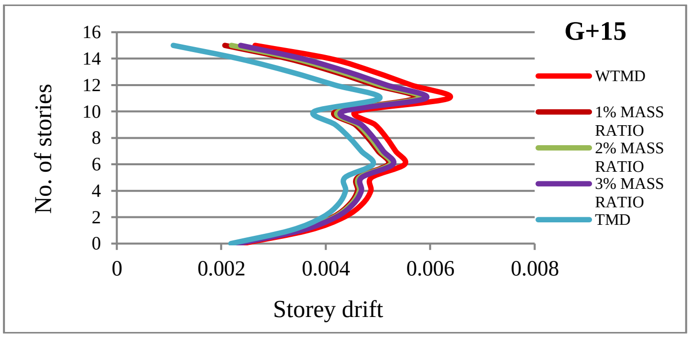

Fig-6 Variation in Storey drift

D. Variation In base shear

Considering the G+5, G+10 and G+15 buildings without TMD, with TMD and buildings with 1%, 2% and 3% mass ratios, maximum decrease in the base shear is observed in the building with soft storey of 1% mass ratio compared to the other models of the G+5 building, maximum decrease in the base shear is observed in the building with TMD compared to the other models of the G+10 building and maximum decrease in the base shear is observed in the building with soft storey of 1% mass ratio compared to the other models of the G+15 building.

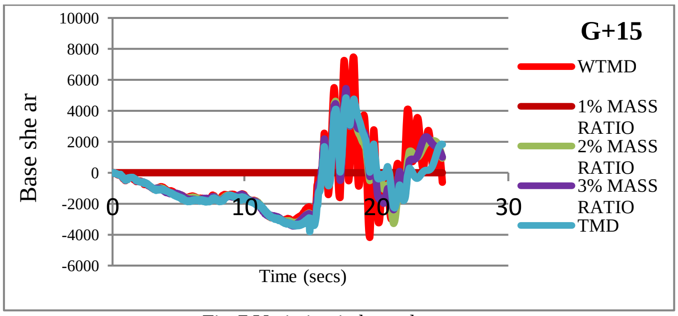

Fig-7 Variation in base shear

E. Variation In Roof Top Displacement

Considering the G+5, G+10 and G+15 buildings without TMD, with TMD and buildings with 1%, 2% and 3% mass ratios, maximum decrease in the Roof Top Displacement is observed in the building with soft storey of 1% mass ratio compared to the other models of the G+5 building, there is no decrease in the Roof Top Displacement due to incorporation of soft storey at the top of the structure for a G+10 storey building modelled with mass ratio 1%, 2% and 3% respectively, but there is minor reduction in the roof top displacement in the building with TMD compared to the models of the other G+10 buildings and there is no decrease in the Roof Top Displacement due to incorporation of soft storey at the top of the structure for a G+15 storey building modelled with mass ratio 1%, 2% and 3% and the building with TMD respectively.

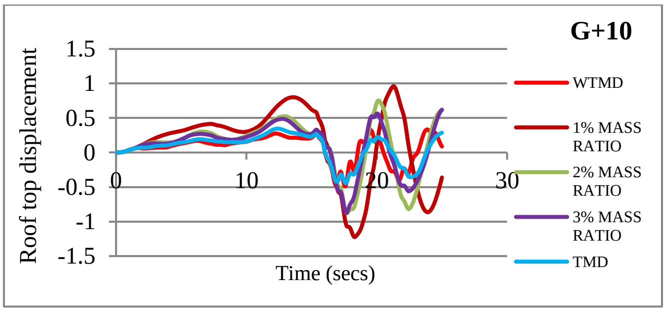

Fig-8 Variation in roof top displacement

V. CONCLUSIONS

This study presents summary of the project work for conventional RC framed structures with, without tuned mass damper and soft storey with mass ratio 1%, 2% and 3% at top of building for different height of the buildings (G+5, G+10, G+15) storey situated in the seismic zone IV, the effect of lateral load and time history analysis (Dharmashala earthquake) has been studied. On the basis these results obtained, some of the important conclusions are presented here.

1. The natural frequency decreases with the installation of TMD and soft storey at top of building when compared to conventional RC framed structures. Hence the structure will response less against lateral load (resonance effect will become least) in case of building with TMDs.
2. In comparison to the RC framed structures, the structure with soft storey at top of the buildings natural frequency decreases from 5 to 27%.
3. Base shear decreases with increase in mass and stiffness building hence structure with TMD has more base shear and soft storey at top of building has less base shear when compared with conventional RC framed structures.
4. The lateral displacement is more in case convention RC framed structures and it reduces up to 9 to 18% for structure with soft storey at top of the building and decreases up to 11to 18% in building with TMD.but least decrease is observed in case of structure with TMD (mass ratio 1%) i.e., 11.11 % in G+5, 14% in G+10 and 18% in G+15.
5. The storey drift decreases with increase in mass and stiffness building.
6. The storey drift decreases up to 5 to 21% in soft storey at top of building and 10 to 59% decreases in TMD 1% is observed when compared to conventional RC framed structures.
7. Tuned mass damper in form of soft storey at top of the building is found to be effective reducing seismic response of a building.
8. Soft storey presence also reduces seismic forces so it is found to be economical than installing a TMD which is uneconomical (price wise).

VI. SCOPE

1. Future work can be done by using multiple tuned mass dampers.
2. Optimum frequency ratio and optimum damping ratio can be found by using multiple tuned mass damper.
3. A tuned mass damper for irregular shape building can be studied.
4. A tuned mass damper for industrial building can be studied.

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