VIBRATION CONTROL OF MULTISTORY BUILDING WITH TOP STORY AS TUNED MASS DAMPER

Anupama sanan[1], Kiran jacob[2]

[1]PG Student, Department of Civil Engineering, Ilahiya College of engineering, Muvattupuzha, Kerala, India
[2]Assistant Professor, Department of civil Engineering, Ilahiya College of engineering, Muvattupuzha, Kerala, India

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Abstract – *Rapid urbanization has led to construction of an oversized number of high-rise buildings. Seismic safety of those building is also important. To reduce the seismic damages, there are some techniques like base isolation, active control and passive control devices has developed. A tuned mass damper (TMD) is a passive energy dissipation device which absorbs energy and reduce vibration effects. In this project a story is constructed on top of the building which is treated as a TMD. The top story will be made up of concrete. The height, member sizes of story going to be devised supported on the principle of TMD i.e. the natural frequency of TMD should have same natural frequency as that of main building. In this paper, a non-linear time history analysis was administrated and effectiveness of top story as TMD with different mass ratio2%,3%, and 4%were studied. Buildings with different configuration was also studied. Comparison was done between bare frame model and building with top story as TMD. Finally results of story shear, displacement and drift were compared using all models using with and without TMD.*

Key Words: **Non-linear time history analysis, TMD**

1. INTRODUCTION

In the past few decades high rise buildings have received interest in many cities where the land is scarce that the taller buildings are in built everywhere in the world even in seismic areas, so seismic safety of those building important. Efforts have led to the development of techniques like base isolation, active control and passive control devices. Base isolation is one of the most powerful techniques, which is employed to forestall or reduce the damage to the building during earthquake. Base isolation is an expensive technique and required continuous maintenance. Active control systems are accustomed counteract the hazardous excitations during earthquake and providing structural service and safety to the building but this method end up to be quite costly for buildings, as they need a continuous power supply. In these studies, an easy kind 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 so as to cut back the dynamic vibrations induced by wind or earthquake loads. There are some disadvantages on tuned mass damper an oversized space is needed for its installation. The effectiveness of TMD is constrained by the maximum weight that may be practically placed on the top of the building. Their effectiveness depends on the accuracy of their tuning, but the natural frequencies of a structure can't be predicted with great accuracy. So as to beat these difficulties a story is constructed on the top the building. In this present study rather than mass and spring, beam and column will act as mass and spring therefore the top story itself become a tuned mass damper. The story is made 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 story are going to be devised supported the principle of TMD i.e. the natural frequency of TMD should have same natural frequency as that of main building. In the present paper, a story constructed at the top of a building is treated as a TMD and its usefulness in response reduction is evaluated.

1.1 Case study

A G+12 story RCC framed structure was modelled in the base journal which has published in springer. Sayed Mahmoud has published his work on "Time history analysis of RC frame building with soft story "in this journal. The considered building includes a width of 16 m divided into four bays and length of 36 m divided into six bays as well. The associated storey height considered is of 3 m. The beam and column size are 300× 600 mm and 300×900 mm and slab thickness are 150 mm. In this study M_{30} grade concrete and $HYSD_{415}$ steel are chosen as material properties and applied loads are self-weight, live load and seismic loads as per Indian standard.

1.2 Non-linear time history analysis

In this paper dynamic response time history of reinforced concrete moment resisting frame building to near fault records of EL Centro are considered. The seismic loads produced by the structural package ETABS correspond to the data records of the El Centro with peak ground accelerations of 0.34. A damping ratio of 5% has been associated for all the models during the analysis.

2. METHODOLOGY

A systematic study is carried out regarding the vibration control of high rise building with use of top story as TMD. Mainly symmetrical and asymmetrical structural configuration plan are adopted for this study like rectangular, I, Land T SHAPES. All these models are considered with different mass percentage like building without TMD,2%TMD,3%TMD AND 4%TMD.All these models are analyzed using ETABSv.16. For the presence of TMD add a top story so, became 14 storey which is designed with suitable mass percentage. Story height of building is 3 m, height of top story is 2 m. The grade of concrete is M30.The beam and columns in top story is considered as steel. The beam and column in top story are designed as per the mass percentages. All columns in the building models are assumed to be fixed at the base. Building with TMD are compared with building without TMD. Building with various plan configurations and with TMD are shown in figure 1,2,3 and 4.

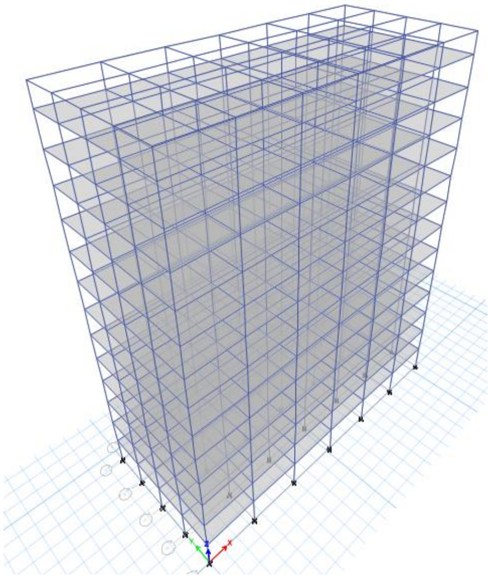

Fig -1: Rectangular building with TMD

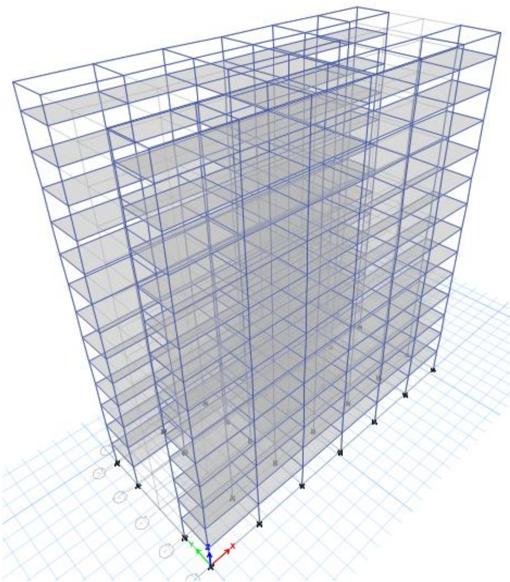

Fig -2: I shaped building with TMD

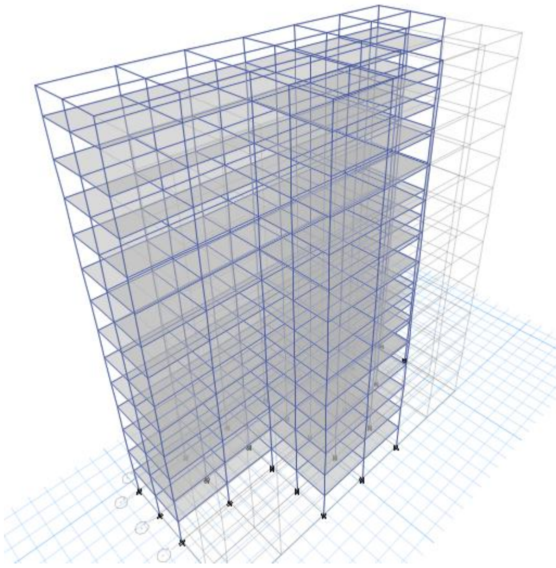

Fig -3: T shaped building with TMD

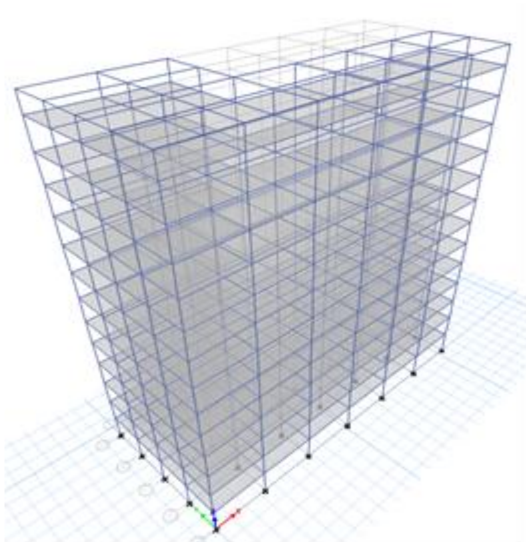

Fig-4: L shaped building with TMD

3. RESULTS AND DISCUSSION

The analysis results of RCC models of G+12 building with and without TMD and also with various plan configuration and different mass percentages. Displacement comparison of these models in X and Y direction has done and comparing the values in both direction and analyzing the results. Drift and story shear of the building with and without TMD as top story is also analyzed.

3.1 Displacement

Considering the G+12 story rectangular buildings without TMD, with TMD and buildings with 2%,3% and 4%mass ratios, it is observed that the building with TMD shows decrease in displacement. For bare frame R. C. C model shows 89.20mm displacement and building with 2%TMD shows 78.99mm so 11.46% reduction in displacement has shown in building with 2%TMD.

Table-1: Displacement comparison of rectangular building with and without TMD

		DISPLACEMENT (mm)
NO	MODELS	EQY
1	BARE FRAME	89.20
2	2% TMD	78.99
3	3% TMD	128.22
4	4% TMD	133.98

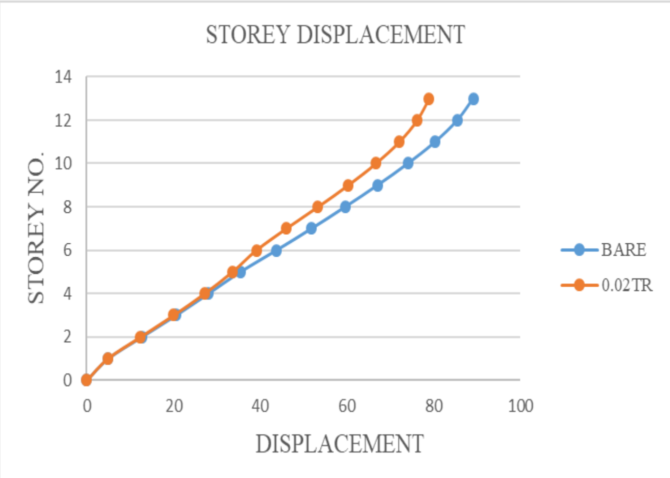

Chart -1: Displacement Comparison of bare frame model and building with 2% TMD

3.2 Drift

Drift is also reduced by the presence of building with TMD.Bare frame model results with the drift of 0.00913 and building with 2% TMD shows 0.00705. 2% and 3% mass ratios show decrease in story drift compared to the building without TMD, so the effective mass percentage is 2.

Table-2: drift comparison of rectangular building with and without TMD

		DRIFT
NO	MODELS	EQX
1	BARE FRAME	0.00913
2	2%TMD	0.000705
3	3% TMD	0.000729
4	4% TMD	0.000847

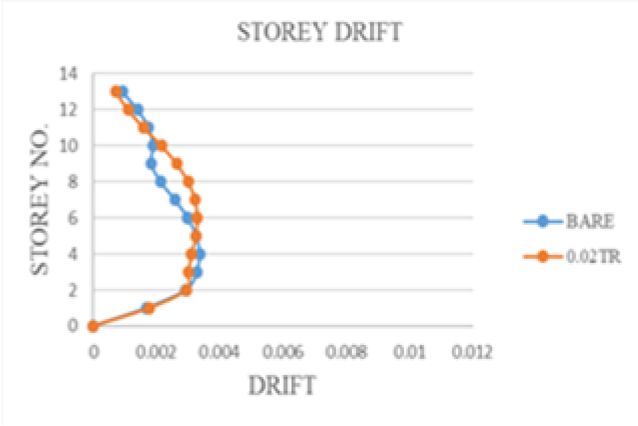

Chart -2: Drift Comparison of bare frame model and building with 2% TMD

3.3 Story shear

Story shear in bare model results 3911.302kN and building with 2%TMD results 2702.11kN maximum decrease in the base shear is observed in the building with TMD compared with building without TMD.

3.4 DISPLACEMENT RESULT OF VARIOUS PLAN CONFIGURATION

Table-3: Displacement comparison of various shape building with and without TMD

BUILDING MODEL	EFFECTIVE MASS PERCENTAGE	DISPLACEMENT (mm)
I -SHAPE	NO TMD	95.708
	3%	81.128
T -SHAPE	NO TMD	117.561
	3%	103.308
L -SHAPE	NO TMD	90.194
	2%	70.453

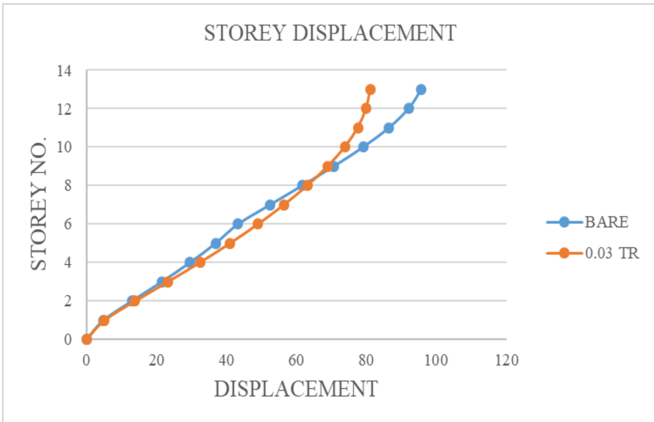

Chart -3: Displacement Comparison of I shaped bare model and building with 3% TMD

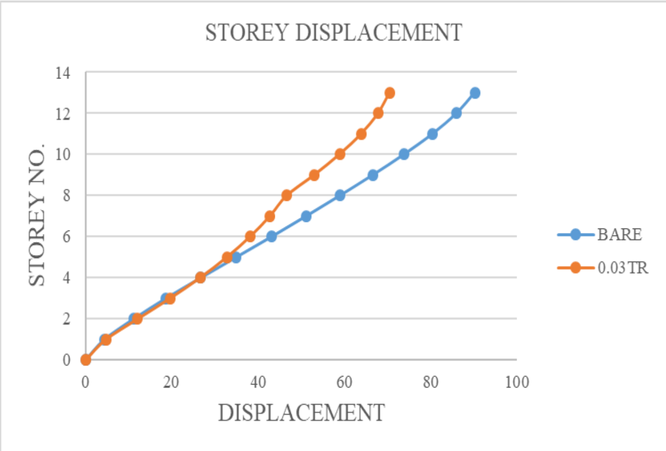

Chart -4: Displacement Comparison of T shaped bare model and building with 3% TMD

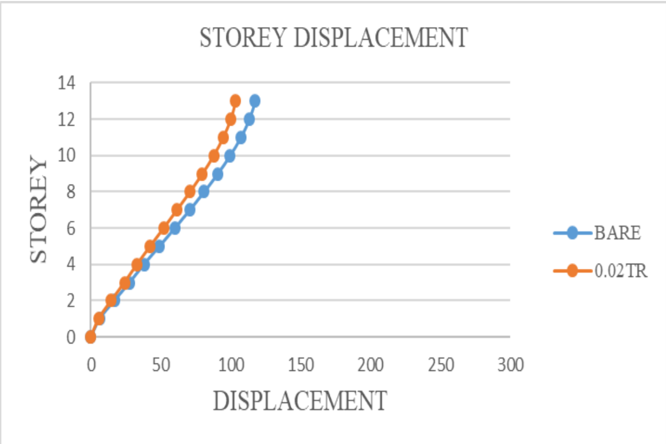

Chart -5: Displacement Comparison of L shaped bare model and building with 2% TMD

3.5 DRIFT RESULTS OF VARIOUS PLAN CONFIGURATION

Table-4: Drift comparison of various shape building with and without TMD

BUILDING MODEL	EFFECTIVE MASS PERCENTAGE	DRIFT
I -SHAPE	NO TMD	0.00122
	3%	0.000552
L-SHAPE	NO TMD	0.000948
	2%	0.000768
T -SHAPE	NO TMD	0.000927
	3%	0.000768

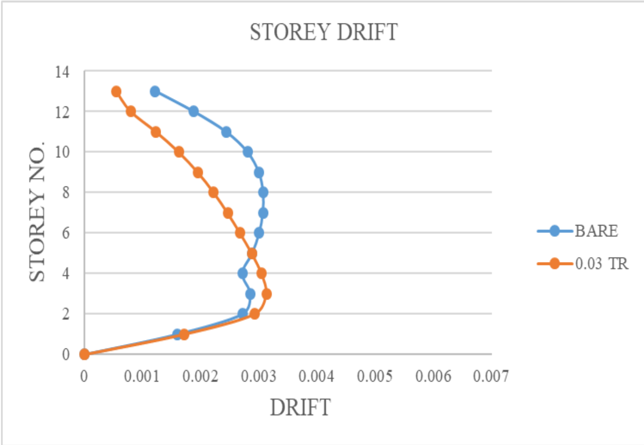

Chart -6: Drift Comparison of I shaped bare model and building with 3% TMD

- In I shaped symmetrical building drift is also reduced by the presence of building with TMD.I shaped bare frame model results with the drift of 0.00122 and building with 3% TMD shows 0.000552 in X direction.

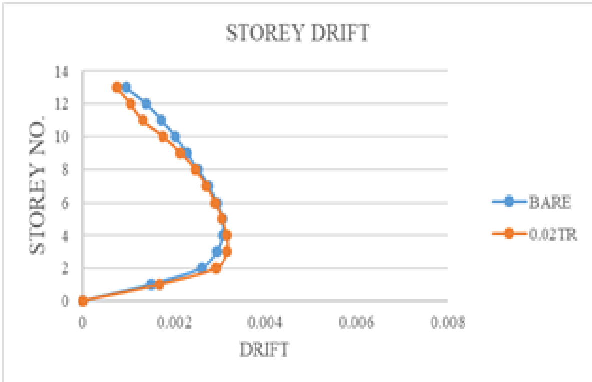

Chart -7: Drift Comparison of L shaped bare model and building with 2% TMD

- In L shaped building drift is reduced by the presence of building with TMD.L shaped bare frame model results with the drift of 0.000948 and building with 2% TMD shows 0.000746.

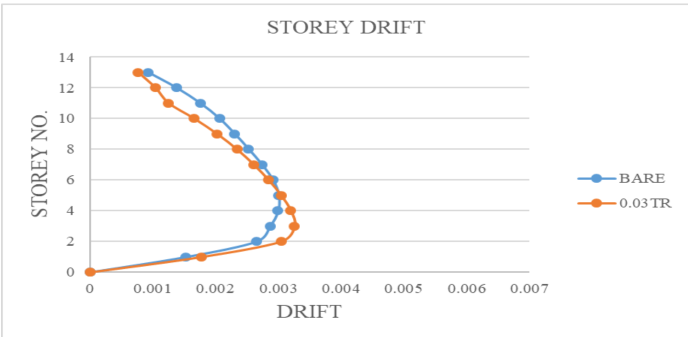

Chart -8: Drift Comparison of T shaped bare model and building with 3% TMD

- Drift is also reduced by the presence of building with TMD.Drift in T shaped bare model results 0.000927 which is reduced by 0.000768 in T shaped building with 3%mass ratio.

3.6 Story shear

- Story shear in I shaped bare model results 5438.35kN and building with 3%TMD results 3116.67kN maximum decrease in the base shear is observed in the building with TMD compared with building without TMD.

- For T shaped building story shear in bare model results 33446.963kN and building with 3%TMD results 2575.84kN maximum decrease in the base shear is observed in the building with TMD compared with building without TMD.

- Story shear in bare model results 3300.17kN and building with 2%TMD results 2380.56kN maximum decrease in the base shear is observed in the building with TMD compared with building without TMD.

4. CONCLUSIONS

Tuned mass damper (TMD) is a passive control device which absorbs energy and reduces vibration response of structures. This paper addresses the usefulness of incorporating a top storey to function as TMD in controlling the structural response. The displacement variation, storey shear and drift ratios parameters were studied.

- Implementation of static analysis using ETABS software was done successfully, thereby achieving the objective of the study.

- It has been found that the TMDs can be successfully used to control vibration of the structure.

- In general, a top story as TMD can reduces deflection at top building by about 10 to 25%.

- For I and T shaped building 3% TMD is found to be the most effective among all on a statistical basis. Displacement, drift and shear are controlled in 3% TMD compared with bare frame model.

- Displacement, drift and shear are controlled in 2% TMD compared with bare frame model so 2% TMD is most effective in L shaped building.

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