



## REDUCE EARTHQUAKE EFFECTS BY USING DAMPERS AND COMPARING DISPLACEMENT, SHEAR DRIFT RESULTS FOR VARIOUS ZONES

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### ABSTRACT

*The current trend toward buildings of ever increasing heights and the use of lightweight, high strength materials, and advanced construction techniques have led to increasingly flexible and lightly damped structures. Damper as a new effective system is one which is used in structural engineering. Damper is a passive system that absorbs energy and reduces response of vibration. Dampers are found to be a straight forward effective, cheap and reliable means that for decreasing undesirable vibration of structure caused by seismic or wind excitation. This analysis explores further high structure as tuned mass damper in building system for reducing the seismic response of tall structure. The structural configuration consists of RCC frame and Damper (composite frame). This extra structure is additionally of RCC buildings and its beam and column sizes are smaller than that of building. The effects dampers for seismic vibration management are investigated. The proposed dampers on the floors are placed at the top floor on both the buildings. The behaviour of flexible-base structures with connected TMD, subjected to earthquake arises has been investigated. The impact of Dampers on the seismic response of structure is studied. The response spectrum analysis is carried out to access the parameters such as storey displacement, storey drift. It's seen that Dampers within the style of weak structure at the highest of building reduces the displacement and reduce damage.*

**KEYWORDS:** Damper, Storey displacement, storey shear.

### INTRODUCTION

Earthquake is natural hazards under which disasters are mainly caused by damage or collapse of buildings and other man-made structures. Experience has shown that for new constructions, establishing earthquake resistant regulations and their implementation is the critical safeguard against earthquake induced damage. As regards existing structures, it is necessary to evaluate and strengthen them based on evaluation criteria before an earthquake. Earthquake damage depends on many parameters, including intensity, duration and frequency, content of ground motion, geologic and soil condition, quality of construction.

[O. R. Jaiswal et al]1 A simplest form of TMD is introduced in the form of a weak story at the top of the structure. The mass of the top story is kept around 3 to 5 % of the total weight of the structure. To satisfy this condition the sizes of column, beam and slab are reduced. Also walls are not provided to this story. [Fahim

Sadek et al]2 The optimum parameters of tuned mass dampers (TMD) that result in considerable reduction in the response of structures to seismic loading are presented. The parameters are used to compute the response of several single and multi-degree of-freedom structures with TMDs to different earthquake excitations. The results indicate that the use of the proposed parameters reduces the displacement and acceleration responses significantly. The result obtained by response spectrum analysis of structure with TMD showed that the forces in column reduce by 20% to 40%.

[Thakur V.M. et al]3 In this paper TMD is used as soft storey which is considered to be made up of RCC, constructed at the top of the building. A six storied building with rectangular shape is considered for analysis. Analysis is done by FE software SAP 2000 by using direct integration approach. TMDs with percentage masses 2% & 3% are considered. Their result shows that a soft storey at the top of building reduces top building deflection by about 10 to 50%. In these study a straightforward style of Tuned Mass Damper (TMD) has been projected.

[G.S. Balakrishna et al]4 here a 6 storeyed regular building is proposed to be analyzed using SAP2000 v14 with viscous damper (VFD), with Tuned Mass Dampers (TMD) and without any damping device. Tuned Mass Dampers with varying mass ratios of 2%, 3% and 5% was applied. Various tall structures were constructed by using dampers such as Bhuj (2001) intensity of earthquake. A comparative study was done after the analysis of regular building with Tuned Mass Dampers and without damping device. For the regular building frame, 3% TMD is found to effectively reduce base shear by about 10-35% and top storey displacement by up to 10-30% (amongst 2%, 3% and 5% TMD's). TMDs are easy to construct and implement on top of buildings compared to implementation.

## THEOROTICAL BACKGROUND

Dampers consists of a secondary mass with properly tuned spring and damping components, providing a frequency-dependent physical phenomenon that will increase damping within the primary structure. The frequency of the damper is tuned to a specific structural frequency so once that frequency is worked up; the damper can resonate out of part with the structural motion. Then the surplus energy that's designed up within the structure are often transferred to a secondary mass and is dissipated by the dashpot to relative motion between them at a later time. Mass of the secondary system varies from 1-5% of the structural mass. Also for various Zones what effects occur due to earthquake that studied

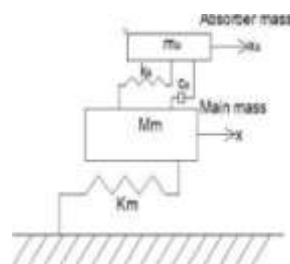


Figure I: A schematic representation of damped vibration absorber suggested by Den Hartog [3]

TMD as A Soft Storey-

The soft structure are going to be created from concrete and its columns, beams, and block sizes are going to be smaller than columns, beams, and block sizes alternative stories of the building. The height, member sizes of sentimental structure are going to be devised supported the principle of TMD i.e. the natural frequency of TMD (soft storey) ought to have same natural frequency as that of main building.

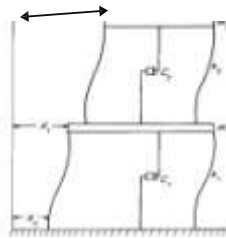


Figure II: SDOF Structure with Soft-Storey at top

Optimum parameter of TMD

[Fahim Sadek et al] formulated optimum parameters of TMD for SDOF and MDOF system, which are given below. For undamped structure the tuning ratio ‘f’ is found to be equal to  $1/(1+\mu)$  and the damping ratio ‘ $\xi$ ’ is equal to  $\mu$ . Also for damped structure the following equations were obtained, Where, f = Tuning ratio,  $\xi$  =Damping ratio, K = Stiffness of structure, k=Stiffness of TMD, C = damping of damper, M = mass of structure, m = mass of TMD,  $\mu$  =mass ratio,  $\omega_0$  = Natural frequency

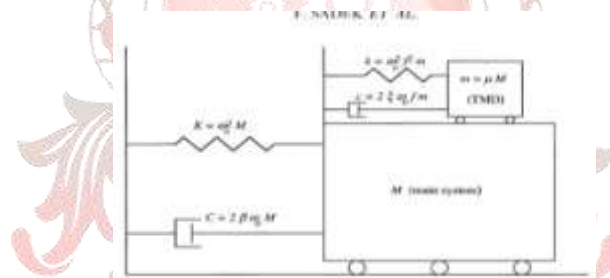


Figure III: Tuned Mass Damper mounted on a main Structure

### 3. PRESENT WORK

The model of building is G+10 storey RCC structure considered for the analysis. The building is symmetric in plan as shown in figure 4. The building has bay width of 5m in X and Y direction with 3.1 m storey height. Slab is modelled as rigid diaphragm. Damper is installed at top of building with 2.68% mass of structure. Response Spectrum analysis is carried out in ETABS2016 software.

Column = 380mm X 600mm	Beam = 300mm X 530mm
Slab thickness = 120mm	Live Load = 3.5 kN/m <sup>2</sup>
Dead Load = 5 kN/m <sup>2</sup>	Grade of Concrete/Steel = M20/Fe415
Imposed load on floor = 1.5 kN/ m <sup>2</sup>	Floor finish on all floor = 3 kN/m <sup>2</sup>
Unit weight of RCC = 25KN/m <sup>3</sup>	

<u>Seismic Properties (IS 1893:2002):-</u> Seismic zone: All (II to V)	
Response reduction factor: 5	Size of Column = 150mmX150mm
Importance factor: 1	Size of Beam = 150mmX150mm
Zone factor: 0.1	Flange Thickness = 5mm (Fe250)
Outer material = Fe250	Slab Thickness = 120mm
Fill Material = M20 concrete	Height of Weak storey at top = 6m

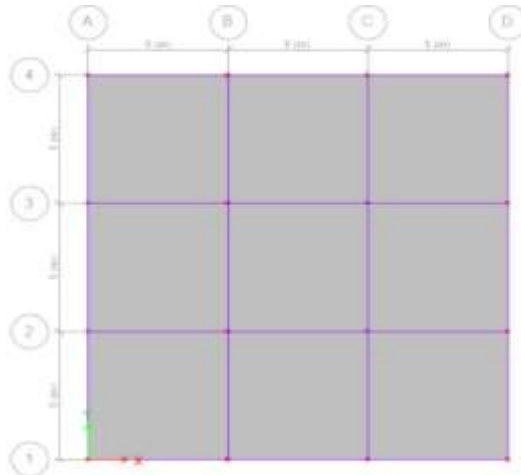


Figure IV: Plan view of Symmetrical Building

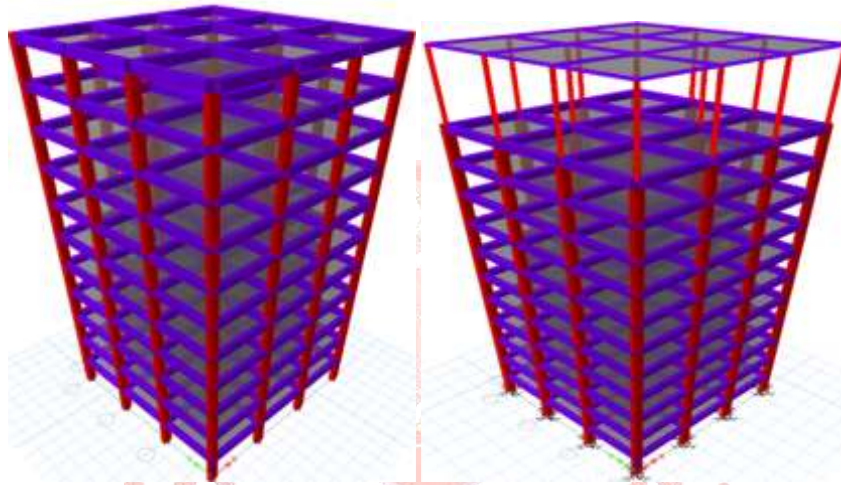


Figure V: (a) Building without Damper (b) Building with Damper

#### 4. RESULT AND DISCUSSIONS

The response of symmetric building with damper as soft storey is investigated in terms of displacement, storey drift.

##### A) Storey displacement

Figs. VI, VII, VIII, and IX show the variation in the displacement of building without and with TMD by considering effect of different earthquake zones. From the analysis it can be seen that buildings having TMD which is 2.58 % of mass of building, reduce the structural response significantly. Reduction of displacement as per results is 19-20% for G + 11 building. In zone II, III, IV, V reduction of displacement with dampers is 19%, 19%, 18.5%, 18.2% respectively.

ZONE 1		ZONE 2		ZONE 3		ZONE 4	
W/TMD	WOT/TMD	W/TMD	WOT/TMD	W/TMD	WOT/TMD	W/TMD	WOT/TMD
5.39	6.59	8.93	12.06	13.885	16.54	18.27	22.631
13.5	16.8	20.657	25.512	32.475	39.754	48.712	59.631
21.2	27.03	34.686	42.565	52.012	63.826	78.017	95.739

29.8	37.022	45.781	58.35	70.147	86.424	106.22	130.36
37.105	45.88	57.767	71.5	86.622	107.214	129.932	160.82
42.33	52.572	67.729	84.115	101.558	126.13	152.337	189.194
47.991	59.638	76.785	95.42	115.138	143.082	172.707	214.623
53.046	65.757	84.874	105.212	127.268	157.764	190.902	236.646
57.43	70.857	91.888	113.372	137.785	170	206.677	254.999
61	74.814	97.6	119.703	146.35	179.493	219.525	269.24

Table No 1

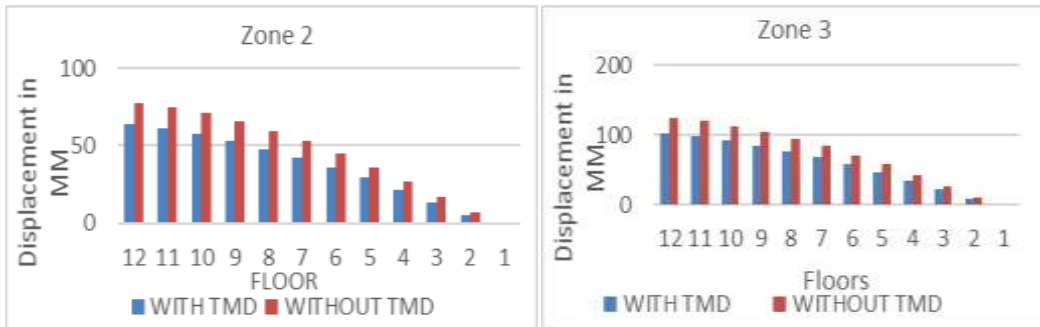


Fig VI

Fig VII

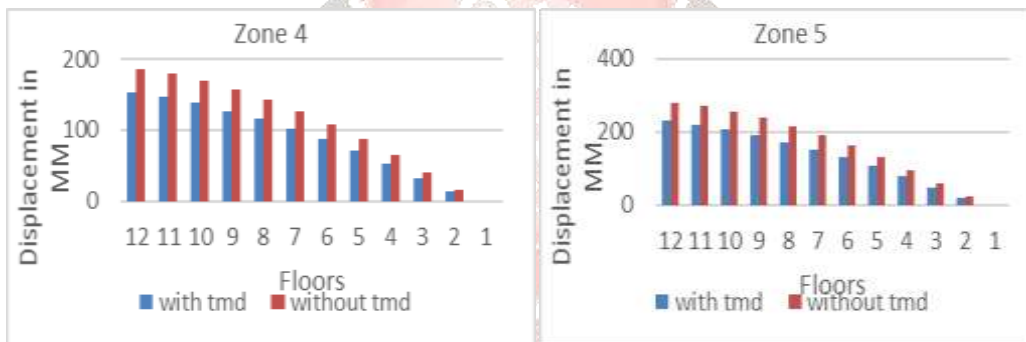


Fig VIII

Fig IX

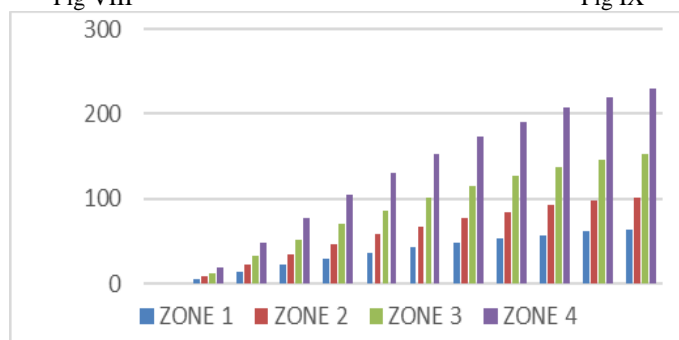


Fig X

B) Storey Drift

In zone II, III, IV, V results by comparing figure no XI, reduction of Storey Drift with dampers is 19.5%, 19.4%, 19.3%, 18.9% respectively.

ZONE 1		ZONE 2		ZONE 3		ZONE 4	
W/TMD	WOT/TMD	W/TMD	WOT/TMD	W/TMD	WOT/TMD	W/TMD	WOT/TMD
0.001085	0.00109	0.001836	0.001827	0.0027	0.00269	0.00391	0.00389
0.00148	0.00162	0.002368	0.002589	0.00355	0.003882	0.00533	0.00582
0.00179	0.00319	0.003864	0.003502	0.0043	0.005251	0.00644	0.00788
0.001841	0.00206	0.002946	0.003293	0.00442	0.004938	0.00663	0.00741
0.002092	0.00239	0.003348	0.003824	0.00502	0.005735	0.00753	0.0086
0.002248	0.00266	0.003597	0.004251	0.00539	0.006374	0.00809	0.00956
0.002329	0.00285	0.003726	0.004567	0.00559	0.006848	0.00838	0.01027
0.002425	0.00303	0.00388	0.004847	0.00582	0.007267	0.00873	0.0109
0.002572	0.0032	0.004116	0.005127	0.00617	0.007688	0.00926	0.01153
0.002723	0.00334	0.004357	0.005338	0.00653	0.008005	0.0098	0.01201

Table No II

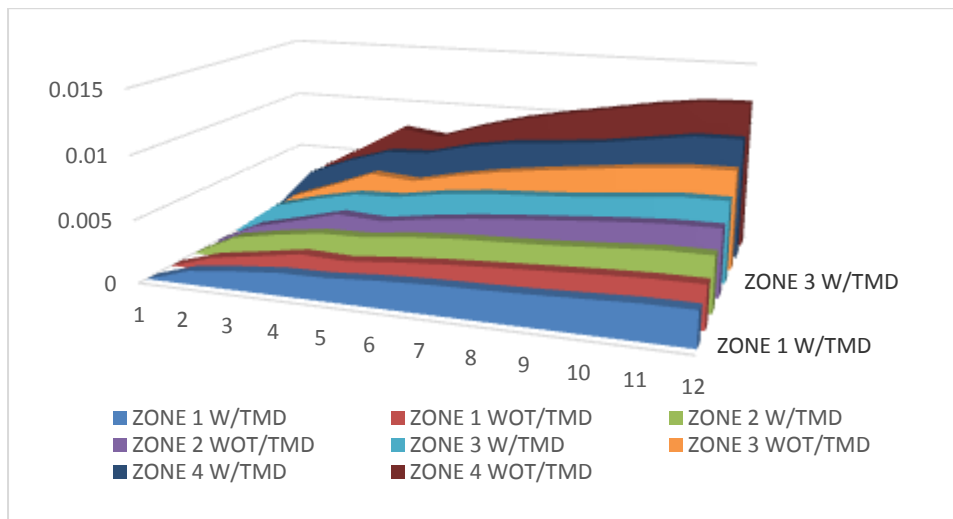


Fig XI

By using E tabs and analysis of G+10 Building with dampers reduction in displacement, storey drift. Displacement results also decreases and also reduction in Florey to Florey drift. It is economical as material of Dampers easily available i. e composite structure made from steel and concrete. This gives results as per literature review, by viewing results it is beneficial for small to midrise buildings.

2. The model of building is G+6 storey RCC structure considered for the analysis. The building is symmetric in plan as shown in figure XIII. The building has bay width of 5m in X and Y direction with 3.2m storey height. Slab is modelled as rigid diaphragm. Damper is installed at top of building with 2.48% mass of structure. Response Spectrum analysis is carried out in ETABS software

- Column = 300mm X 530mm
- Beam = 300mm X 500mm
- Slab thickness = 120mm
- Live Load = 2.5 kN/m<sup>2</sup>
- Dead Load = 5 kN/m<sup>2</sup>
- Grade of Concrete/Steel = M20/Fe415
- Imposed load on floor = 1.5 kN/ m<sup>2</sup>
- Floor finish on all floor = 3 kN/m<sup>2</sup>
- Unit weight of RCC = 25KN/m<sup>3</sup>
- Seismic Properties (IS 1893:2002):- Seismic zone: All (II to V)
- Response reduction factor: 5
- Size of Column = 150mmX150mm
- Importance factor: 1
- Size of Beam = 150mmX150mm
- Zone factor: 0.1
- Flange Thickness = 5mm (Fe250)
- Outer material = Fe250
- Slab Thickness = 120mm

Fill Material = M20 concrete

Height of Weak storey at top = 4.5



Figure XII: Plan view of Symmetrical Building

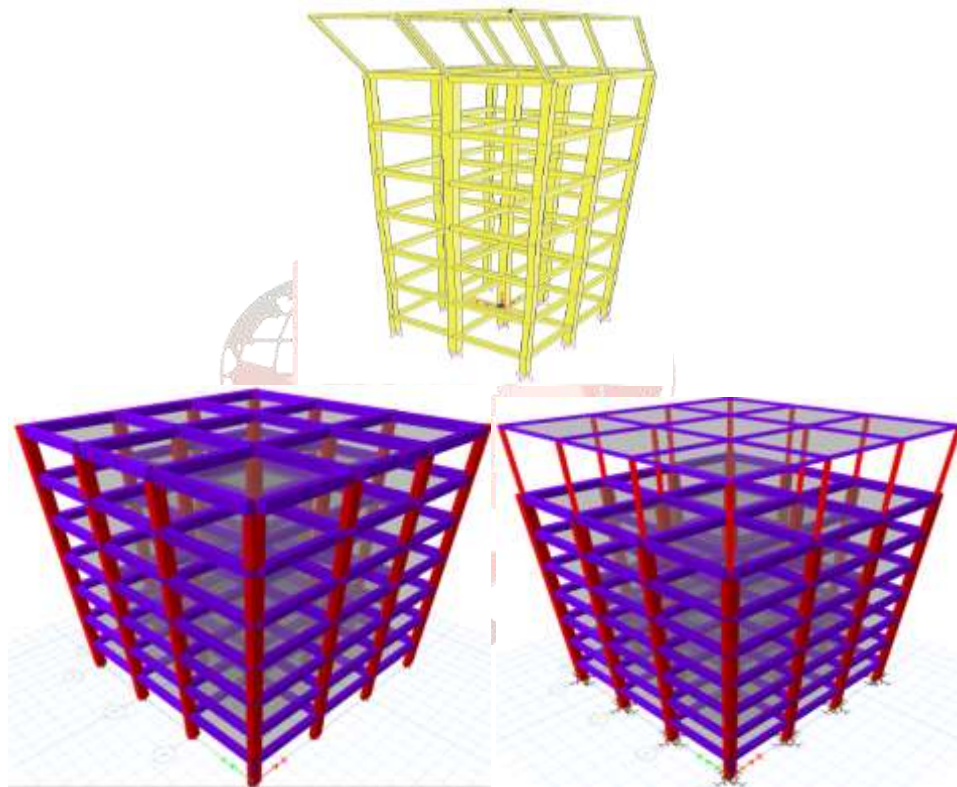


Figure XIII: (a) Building without Damper

(b) Building with Damper

The response of symmetric building with damper as soft storey is investigated in terms of displacement, storey drift.

A) Storey displacement

Figs. XVI shows the variation in the displacement of building without and with TMD by considering effect of earthquake zones. From the analysis it can be seen that buildings having TMD which is 2.58 % of mass of building, reduce the structural response significantly. Reduction of displacement as per results is 20-24%.

In zone II, III, IV, V reduction of displacement with dampers is 24%, 23.5%, 22%, 21% respectively.

Zone 1		Zone 2		Zone 3		Zone 4	
W/TMD	WOT/TMD	W/TMD	WOT/TMD	W/TMD	WOT/TMD	W/TMD	WOT/TMD
8.95	11.299	7.51	9.2	12.757	15.293	18.155	21.94
18.74	24.39	22.153	26.399	30.719	37.08	45.579	55.12
30.935	40.024	33.168	40.024	49.735	60.015	74.602	90.023
42.6	54.845	42.518	51.845	66.254	80.26	97.881	118.86
48.46	63.318	51.838	63.318	77.73	94.944	116.595	142.417
54.26	71.01	57.813	71.01	86.689	106.479	130.034	159.718

Table no III

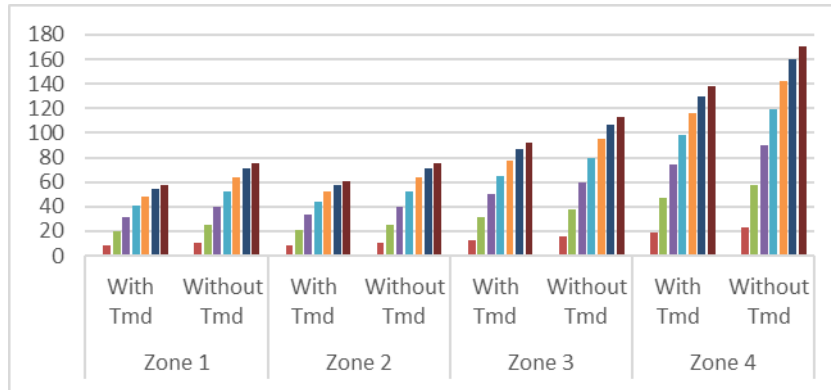


Fig XIV

B. Storey Drift

Figs XVII shows the variation in the storey drift of building without and with dampers by considering the effect of earthquake zones. From the analysis it can be seen that buildings having damper which is 2.48% of mass of building, reduce the structural response significantly

In zone II, III, IV, V reduction of Storey Drift with dampers is 23.8%, 22.75%, 22.05%, 21.05% respectively.

ZONE 1		ZONE 2		ZONE 3		ZONE 4	
W/TMD	WOT/TMD	W/TMD	WOT/TMD	W/TMD	WOT/TMD	W/TMD	WOT/TMD
0.003151	0.003902	0.001401	0.001735	0.002101	0.002601	0.001491	0.001735
0.00512	0.00767	0.002277	0.002793	0.003415	0.004188	0.002238	0.002793
0.0067	0.008274	0.002839	0.0034	0.004257	0.005098	0.002651	0.0034
0.00803	0.00986	0.003005	0.003678	0.004506	0.005515	0.002869	0.003678
0.009087	0.01106	0.003572	0.004387	0.005355	0.006578	0.003354	0.004387
0.009483	0.01141	0.00404	0.004918	0.006058	0.007375	0.003769	0.004918

Table No IV

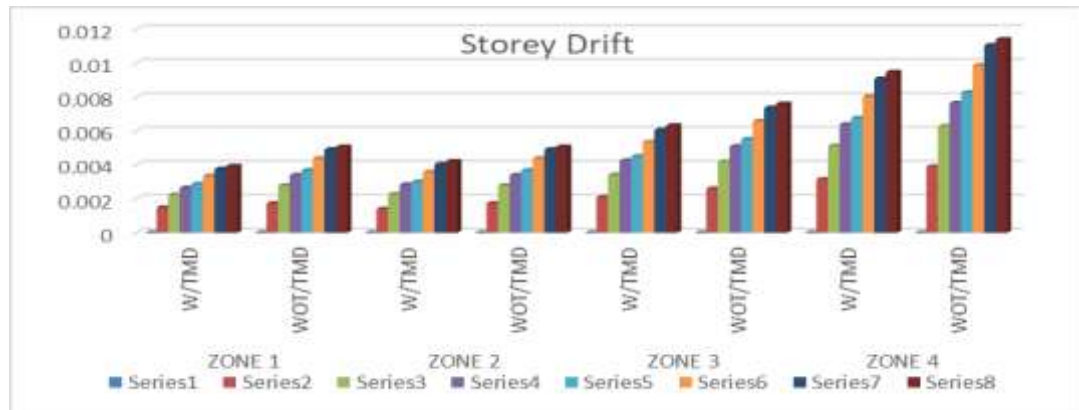


Fig XV

On the basis of present study and reviewed literature the following conclusions can be drawn: From the above results we can observe that, as the intensity of earthquakes or frequency of the building differs, the effectiveness of the mass ratio of Tuned Mass Damper changes. So in order to find out the effective mass ratio which gives the least displacement of the building, the responses of the building having different magnitude, frequency content and magnitude is compared and results are discussed. Also frequency of Rigid Structure and dampers material (i. e flexible) should match according to these results arises.

## 5. CONCLUSIONS

From the Response Spectrum analysis on multi-storey building, it can be concluded that

- It has been found that the TMDs can be successfully used to control vibration of the structure.
- Seismic performance of building can be improved by providing energy dissipating device (damper), which absorb the input energy during earthquake.
- Damper at the top of building reduces deflection by about 10 to 26%.
- The application of Dampers in the form of soft storey at the top of high rise building is the simplest, economical and feasible method for reducing structural response of the building.
- By using 2.68% TMD for G + 10 building, maximum displacement of building can be reduce from 18.2- 19% with medium soil for various Zones & for G + 6 building, maximum displacement of building can be reduce up to 25% with medium soil for various Zones.
- Storey drift of the building with Dampers as a soft storey can reduce up to 19.3% on medium soil.

## 6. REFERENCES

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