Comparison of seismic response of R.C. structures with and without exponential dampers.

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Abstract *In this study the effect of exponential dampers on the performance of reinforced concrete structures has been studied. Time history analysis has always been considered as a very important and useful tool for analysis especially when the response of the structure is non-linear. Hence Time history analysis was used for the analysis in this study. A G+10 storied building with exponential dampers was compared to similar bare framed building for its performance under seismic action.*

Key Words: Dampers, Earthquake, Response, Seismic activity, Time history analysis, ETABS.

1. INTRODUCTION

Natural hazards such as Earthquakes causes disastrous effects by damaging or collapsing of buildings and such other man-made structures. Due to such hazards expected during the life span of structures it has become necessary to design our structures to resist such hazards. The damage due to earthquake depends upon many factors such as, Intensity, duration and frequency, content of ground motion, geologic and soil condition, quality of construction.

Likewise dampers provided in cars and other such machines to resist or absorb the shocks and resulting vibrations, on the same track the damping system provided in the buildings uses friction to absorb the forces due vibrations caused by earthquake and other dynamic conditions.

A much larger damping system is required so as to resist the forces in case of an Earthquake resistant building.

In India the earthquakes like Bhuj (2002), Killari (1993), etc., has shown that all the structures which failed during these quakes were the result of neglecting the detailing of buildings which is expected so as to resist inertia forces during seismic activities. Post seismic studies has always indicated deficiencies in structures which may be exclusion of seismic resistant features seismic engineering practices. The earthquake forces can be resisted by the use of energy absorbing or dissipating devices such as dampers. From the wide study of high rise structures it can be concluded that dampers are very effective for resisting high lateral forces and reducing the vibration ultimately caused. Dampers too are subdivided under various types such as viscous dampers, friction dampers, yielding dampers, tuned mass dampers, etc. based upon their method of working, some of which has been shown below in fig. 1.

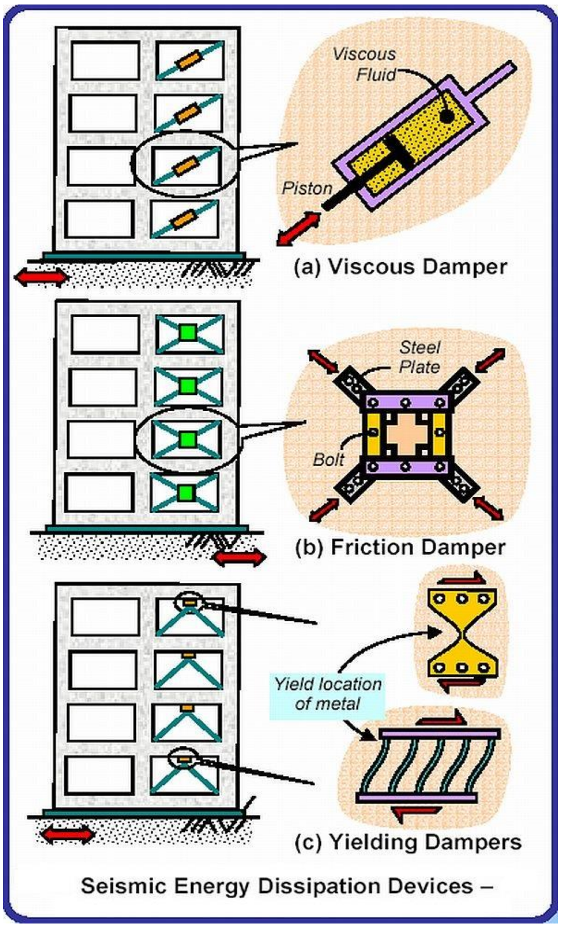


Fig. 1: Various Types of Dampers

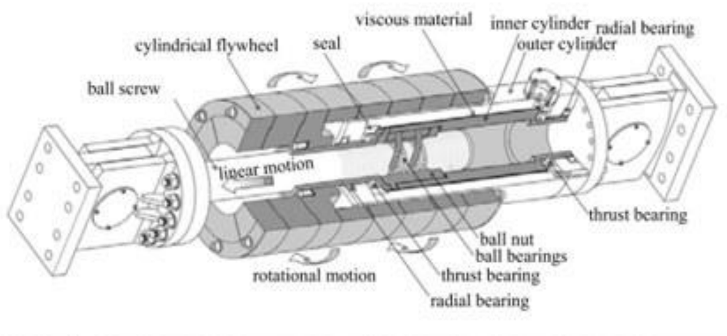


Fig 2: Components of a typical damper

The working of various dampers varies based upon their types. The working depends upon the components they include. Fig. 2 shows a typical viscous damper's components.

2. LITERATURE REVIEW

Taipei 101 has proved to be one of the biggest application of TMD (Tuned mass dampers) in the world. Shubham Mishra and Learin Mathew [1] investigated a study on gyroscopic dampers and made a validation of their previous study. A case study for Taipei 101 was taken where a huge gyroscopic damper, one of its kind has been used. In this case study it was shown that the Taipei 101 which stands only 660 ft. from a major fault has been designed for major seismic activities and major wind pressures. To compensate the huge vibrations of winds and earthquakes this gyroscopic damper has been used which was tuned mass damper with a heavy mass hanging from the roof of top floors by suspension cables to make a pendulum system. It was lastly concluded that when a gyroscopic damper is used in a structure during lateral activity due to the momentum conservation analogy the building reacts in a compensating manner resulting into stability of the structure.

Bandivadekar T.P, Jangid R.S [2]: In this study it was shown that the mass distribution is one of the most important factor for MTMD (multiple tuned mass damper) for reducing effectively the dynamic response of a main system. By controlling mass distribution with other parameters like damping ratio, frequency range, number of dampers etc. the response of structures can be controlled. The effect of various mass distribution like, bell shaped mass distribution and parabolic mass distribution were shown on the response of a system. Lastly it was shown that among all the mass distribution systems the modified bell shaped mass distribution is superior to all others. It was found in this study that reducing dynamic response of structure makes it more flat and increases bandwidth of the flat region. Also it was suggested that lower values of damper damping associated with MTMD makes it more workable.

Ashish Badave, Vijay Singh Deshmukh, and Sudhir Kulkarni [3]: Investigated on tuned mass vibration absorbers (TMVA). In this study it was shown that TMVA has been used for many sectors in mechanical, civil, aerospace but in this study TMVA was used in its most generic form as a secondary system the parameters of which were controlled to suppress the maximum vibration of a primary system. It was shown that secondary system may be of a common spring mass damper and the TMVA suppress vibrations of a primary system at its point of attachment. Some minor modifications were made and very accurate results were extracted from this setup. It was subsequently suggested that the design can be based on frequency tuning, which leads to equal damping ratio and an accurate explicit approximation was found for the optimal damping parameters. The approach for finding an optimal damping amount was suggested further in this study.

Shashank R. Bedekar, Prof. Rakesh Shinde [4]: Performed time history analysis of high rise structures using different accelerograms. In this work an attempt was made to analyse high rise structures with the help of E-tab software. For analysis purpose a high rise structure with G+25 stories was used. Time history data of Bhuj and Koyna earthquakes was used for analysis of selected high rise structure. Comparative study was made between two selected places without & with provision of visco- elastic dampers. Lastly it was concluded that in previous research papers we can see comparative study between any two types of dynamic analysis. Also we can find specific analysis for selected building plan with changes in various locations, type, shapes of shear wall. In this proposed work we will analyse high rise structure for two different Accelerograms (Bhuj & Koyna). Comparative study between two time histories can be made without application & with application of visco- elastic damper at various levels.

Hyun-Su Kim, Young-Jinn, Kim [5]: Evaluated the control performance of a shared tuned mass damper (STMD) for reduction of the seismic response of adjacent buildings. In this study they analyzed two structures each of which consisted of eight storied buildings for which the STMD was evaluated. Multi-objective genetic algorithm was employed for optimal design of the stiffness and damping parameters of the STMD. It was shown by numerical analysis that STMD can effectively control the dynamic response of RC structures and also it can reduce the pounding effect between adjacent buildings subjected to earthquake excitations in comparison to a traditional TMD.

3. SYSTEM DEVELOPMENT

The models which were analysed in this study were modelled on the FEM software ETABS. Three models were modelled in this study, which were of simple rectangular buildings having dimensions 50m X 70m and 10 storeys high. The material used were M30 grade of concrete and Fe-415 Grade of steel. The other material properties has been shown in the subsequent pages in table. The three models were having the variation as

- Structure-1: G+10 building without dampers
- Structure-2: G+10 building with exponential dampers of weight = 10kN
- Structure-3: G+10 building with exponential dampers of weight = 1kN

The height of the structures and height of each floor were kept constant. The effect of exponential dampers of 10 KN and 1 KN has been checked. The results of which has been stated in subsequent pages. The plans and extruded views has been shown below:

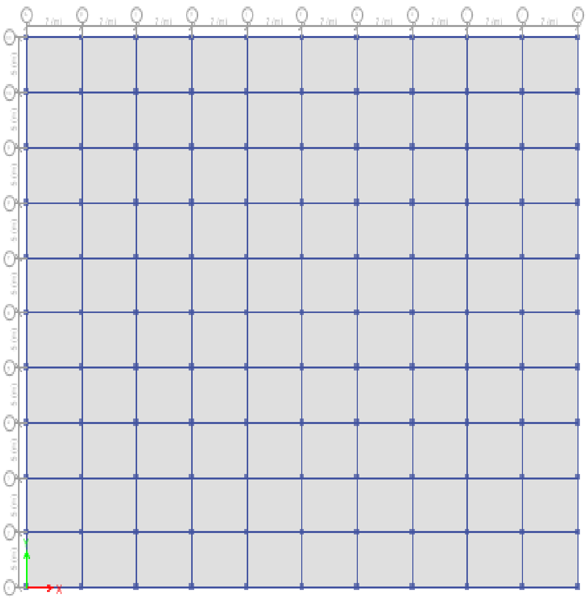


Figure 3: Plan of the Building Models

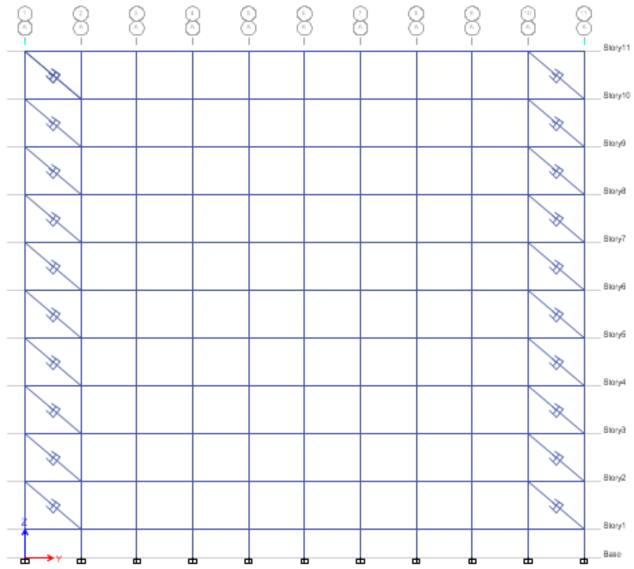


Figure 4: Elevation of Building Model with Exponential Dampers

The specifications of materials, structural elements, loading etc. has been described in the below given tables.

Table 1: Material Specifications

1.	Grade of concrete	M30
2.	Grade of reinforcing steel	Fe 415
3.	Density of concrete	25 KN/m^3
4.	Density of brick masonry	19 KN/m^3

Table 2: General Specifications of the buildings

1.	Type of Building	Residential RCC
2.	Plan Dimensions	70m X 50m
3.	Height of the structure	47 m
4.	Height of storeys	4.2m
5.	Thickness of Slabs	150 mm
6.	Internal Wall thickness	150 mm
7.	External wall thickness	150 mm
8.	Waist slab thickness	150 mm
9.	Depth of footings	2.5 m

Table 3: Structural Specifications

1.	Type of sections	R.C.C.
Sizes of Column sections		
2.	Columns (C1)	300 X 500
Sizes of beam sections		
3.	All Beams	600 X 600
Type of support considered		
4.	Support Conditions for all columns	Fixed

Table 4: Loading Specifications

1.	Live load	3.0 KN/m^2
2.	External Load	10 KN/m
3.	Code for RCC	IS 456 (2000)
4.	Code for Earthquake analysis	IS 1893 (1984)
5.	Code for Wind analysis	IS 875-III (1987)
5.	Zone	II, III, IV, V
6.	Zone factor (Z)	Accordingly
7.	Method used for Analysis	Non-Linear THA
10.	Importance factor	1.0
11.	Moment resisting frame type	SMRF
12.	Response reduction factor	5.0
13.	Site soil type	III

Table 5: Load Combinations

1.	DL
2.	LL
3.	ELX
4.	ELY
5.	1.5 (DL+LL)
6.	1.2 (DL+LL+ELY)
7.	1.2 (DL+LL+ELY)
8.	1.5 (DL+ELX)
9.	1.5 (DL+ELY)
10.	0.9DL+1.2ELX
11.	0.9DL+1.2ELY

4. RESULTS AND DISCUSSION:

The modelling and analysis of the all the RCC structures has been done finite element based software ETABS 2016. For comparative study of various parameters total three RCC structures were modelled. The parameters such as storey displacement, Storey Shear and overturning moments has been considered for this study. All the seismic parameters which were necessary for the analytical purpose were considered from IS 1893 (2002).

A. Storey Displacements:

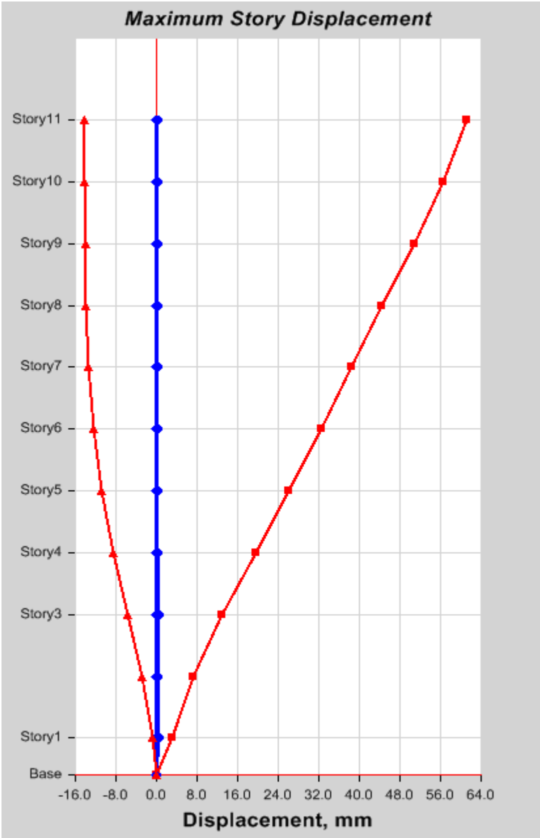


Figure 5: Storey Displacement for Structure-I

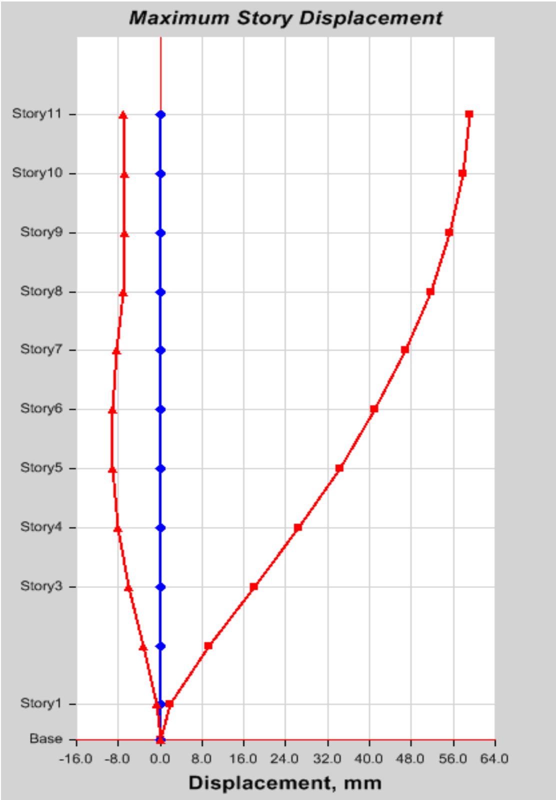


Figure 6: Story Displacement for Structure-II

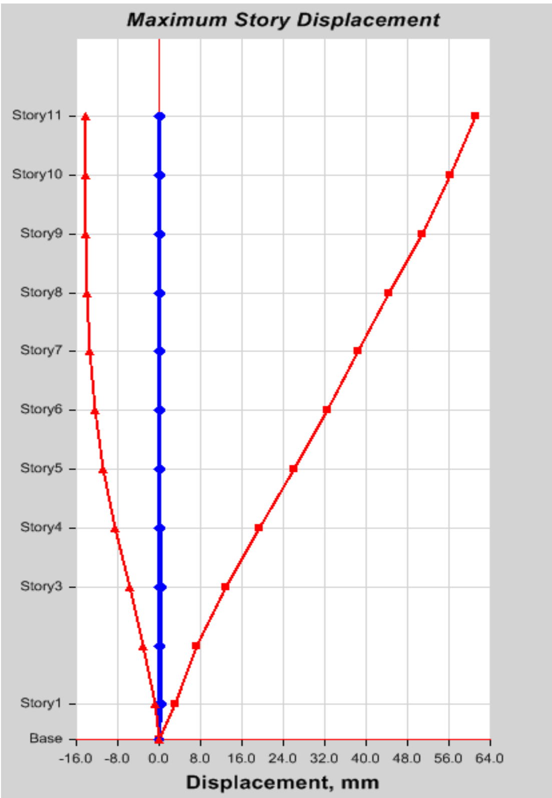


Figure 7: Storey Displacement for Structure-III

B. Story Shears

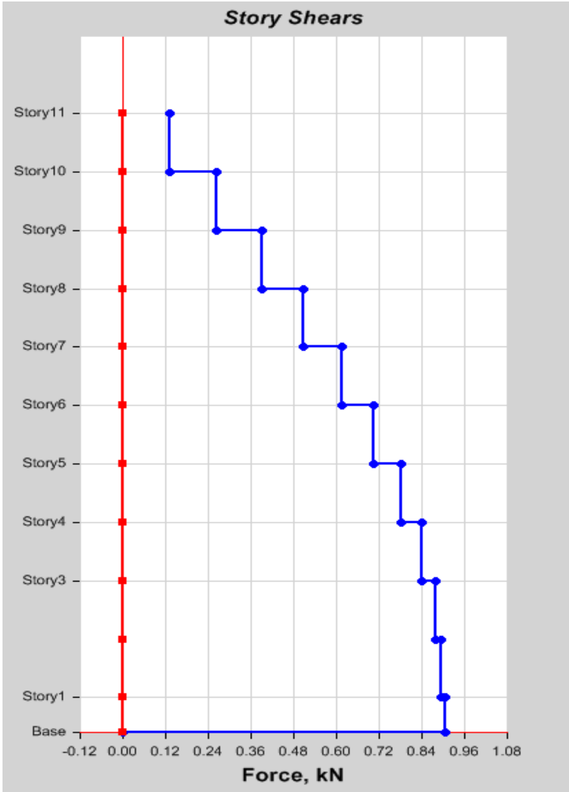


Figure 8: Storey Shear for Structure-I

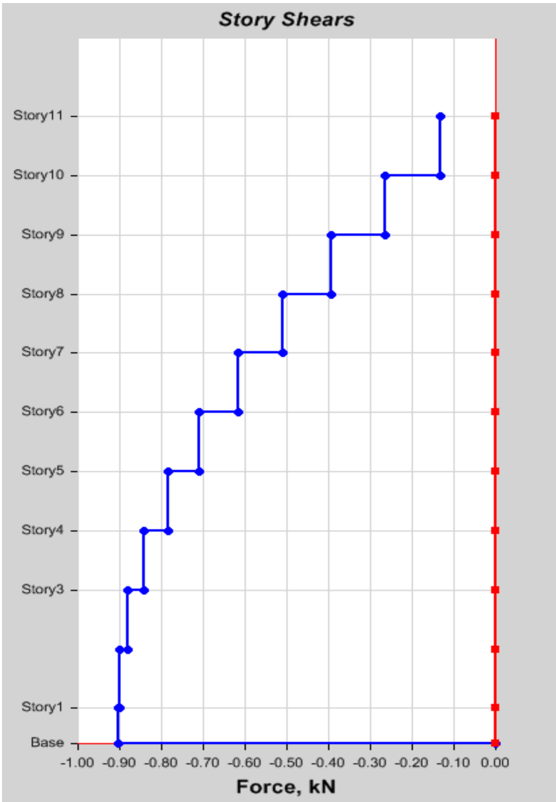


Figure 9: Storey Shear for Structure-II

C. Time History Curves

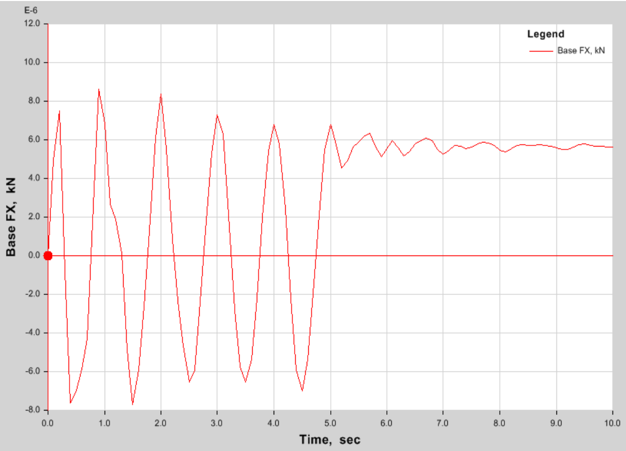


Figure 10: Time History Curve for Structure-I

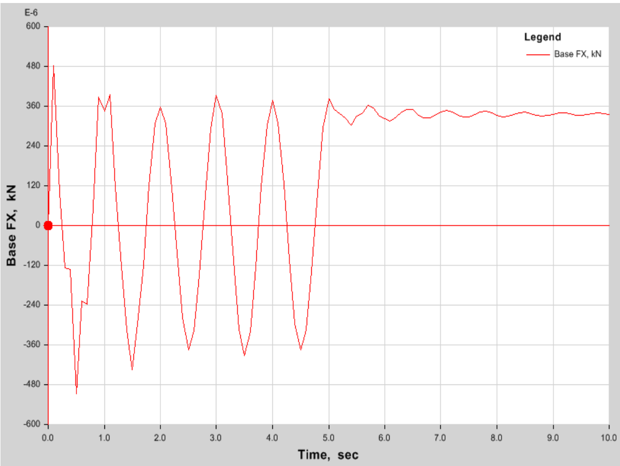


Figure 11: Time History Curve for Structure-II

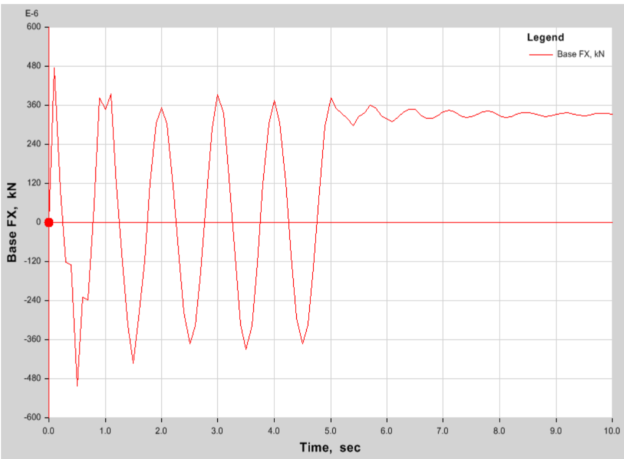


Figure 12: Time History Curve for Structure-III

D. Maximum Story Displacements

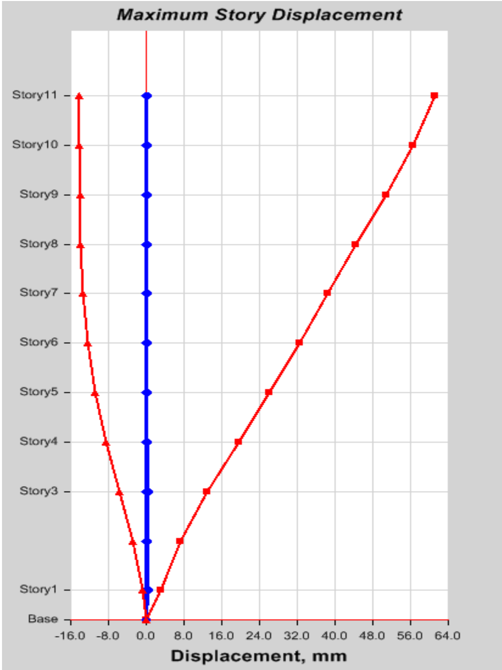


Figure 13: Story Displacements for Structure-I

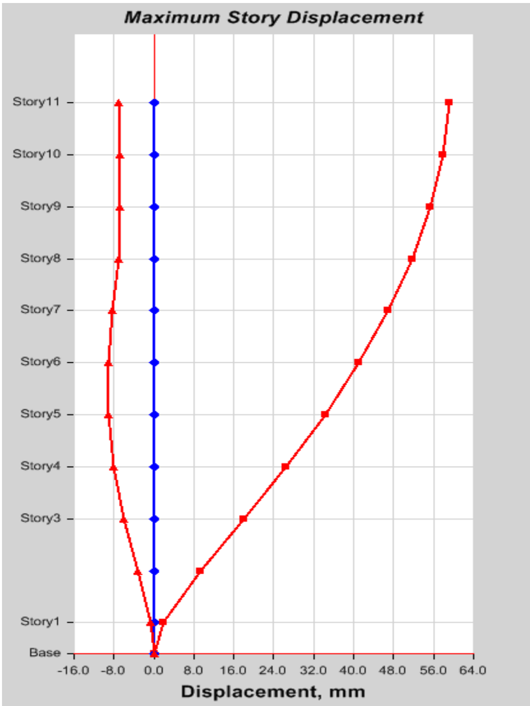


Figure 14: Story Displacements for Structure-II

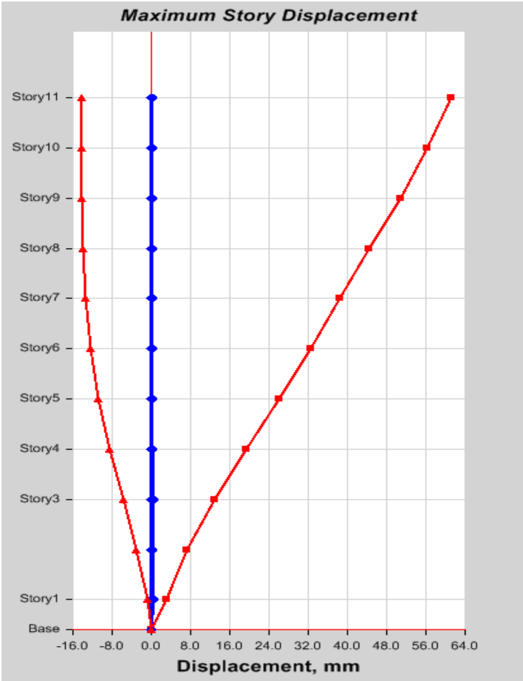


Figure 15: Story Displacements for Structure-III

E. Over Turning Moments

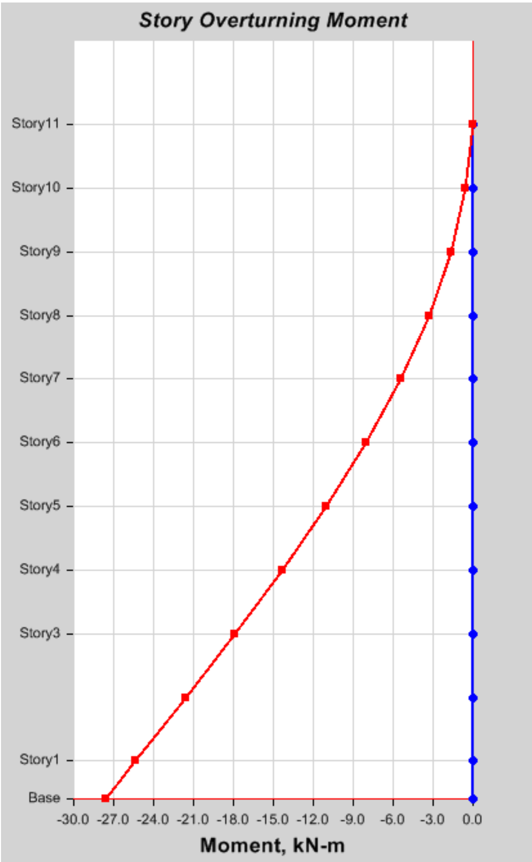


Figure 16: Over Turning Moments For Structure-I

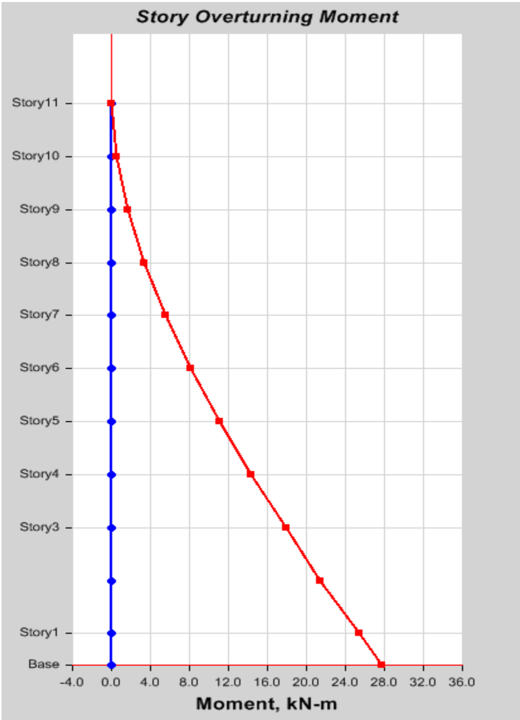


Figure 17: Over Turning Moments For Structure-II

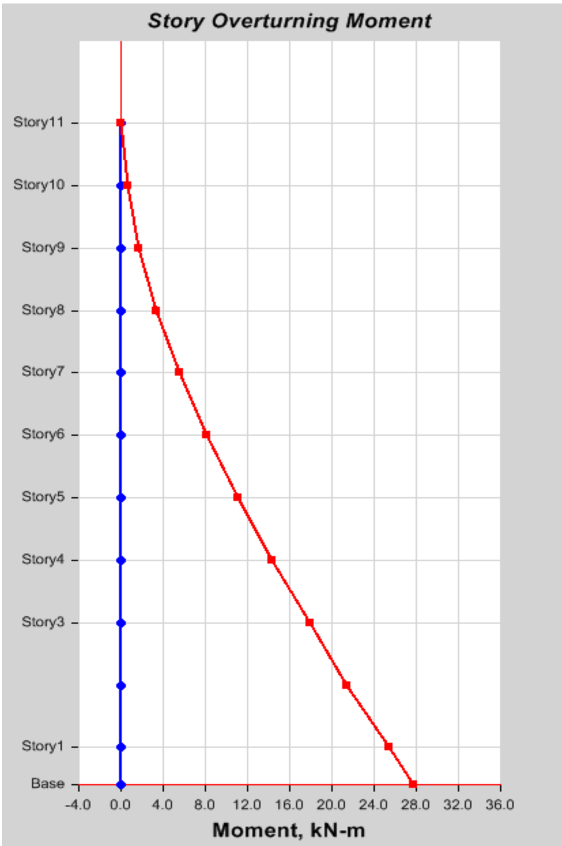
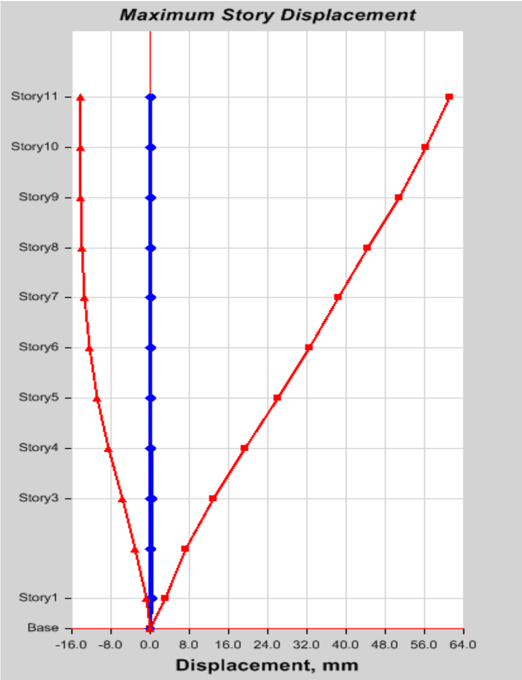


Figure 18: Over Turning Moments For Structure-III



5. CONCLUSIONS

From this comparative study following conclusions were drawn:

- Maximum Displacement was seen up to 16 mm in all three type of structures, with the use of mass dampers this displacement was reduced by around 57%.
- Provision of dampers in Type-II and III structures has shown increase in the time period of both the structures, the elongation being 40% in type-II and 88% in type-III structures.
- The Lateral Displacement of the top story was seen to be maximum for Type-II structures in zone-V with a magnitude of around 259 mm, which was reduced by about 1% due to use of dampers in the structure.
- The Maximum Story Drift was seen on the 3rd Story of Type-II and Type-III Structures which in zone-II and Zone-III are within the permissible limit, whereas it exceeds the permissible limit for Structures lying in zone-IV & zone-V.
- Addition of masses due to installation of mass dampers results in an increased column force for type-II and type-III structures, especially lying in zone-III and zone-V.
- The Maximum Base Shear was seen to be acting in type-I structures being 87411 KN which after the installation of dampers reduced by 12%.

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