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Seismic Performance Evaluation of RC Building Connected with and without Viscous Damper

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Abstract: Structures are mainly subjected to various types of loading conditions such as earthquake, wind loads etc. For earthquake zone areas, the structures are designed considering seismic forces. The structure which are present in higher earthquake zone area are liable to get damaged or collapsed, hence to increase the safety of these structure few retrofitting techniques or addition of materials to stabilize the structures against the earthquake forces are done. And if the retrofitting techniques are adopted then cost plays an important role and possibly few spaces will be compromised depend upon the type of methods adopted. Later the structure may be strengthened by adding materials externally to transfer the lateral loads i.e. some protective devices have been developed. In modern seismic design, damping devices are used to reduce the seismic energy and enable the control of the structural response of the structure to that earthquake excitation.

The dissertation work is concerned with the comparison of the seismic evaluation of RC buildings connected with and without viscous damper. Response spectrum method is used to analyse seismic behavior of G+7 storey building with and without viscous damper. In response spectrum method, earthquake load is applied in both x and y direction. For the analysis purpose ETABS 2015 software is used by considering seismic zone IV as per IS 1893:2002(part 1) code. Results of these analyses are discussed in terms of various parameters such as maximum absolute displacement, absolute acceleration, absolute velocity, storey shear, storey drift. The comparison of these various parameters is done. From these comparison it is concluded that maximum absolute displacement, absolute acceleration, storey shear, storey drift values are more in case of RC building without damper as compared to RC building with damper.

Keywords: viscous dampers; maximum absolute displacement, absolute velocity, absolute acceleration, storey shear and Storey drift.

I. INTRODUCTION

From the past and few present records, the world has experienced number of destroying earthquakes, causing in number of increase the loss of human being due to structural collapse and severe damages to structure. Because of such type of structural damages, during seismic (earthquake) hazards clearly explains that the buildings / structures like residential buildings, public life-line structures, historical structures and industrial structures should be designed to seismic force design and very carefully to overcome from the earthquake hazards. The approach in structural design using seismic response control device is now widely accepted for structure and frequently used in civil engineering field. Structural control concept into a workable technology and such devices are installed in structures.

As a part of Strategic China-Japan Cooperative Program on Science and Technology organized by the National Nature Science Foundation of China (NSFC) and Japan Science and Technology Agency (JST), the joint research on the seismic evaluation and mitigation technologies is being conducted by the researchers at Tingyi University and Dalian University of Technology, China and at Tokyo Institute of Technology (Tokyo Tech.) and Hokkaido University, Japan. The first stage of the research focuses on the use of energy dissipation devices, hereby called as "damper", for seismic repair or upgrade of existing reinforced concrete (RC) buildings. Damper is one of the important device by which the seismic performance of a building can be improved. Damper is energy dissipating device which absorbs the input energy during earthquake and reduces seismic effect. The damper devices are easy to manufacture and implement in structures. The dampers are economical to manufacture due to the selection of material and its availability. In the unlikely situation of damage to a damper, it can easily be replaced or readjusted.

II. VISCOUS DAMPER

In this type of damper by using viscous fluid inside cylinder energy dissipated. The viscous damper works on the principle of flow of fluid through the orifice in the chamber. The silicone-based fluid is used in the chamber. The piston which is made up of stainless steel travels in the chamber which is filled by the silicone oil. The characteristic of the silicone oil is inert, non-flammable, nontoxic

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and extremely stable for a period of long time. The pressure or force developed by the earthquake will be of different. This difference in pressure between two chambers will force the oil to flow through orifice in piston head. The inside energy is transferred into heat which will dissipate into the atmosphere. Due to easy n installation, adaptable and having variety in their sizes, these dampers have more application in designing and retrofitting of the structure. Viscous dampers are used in high-rise building in seismic areas. Viscous damper reduces the vibrations induced by both strong wind and earthquake.

Fig: Viscous Damper

III. PROBLEM MODELLING

TABLE 1: Problem statement for analysis

Geometric details	
Plan dimension	20×12 m
Structure	SMRF
Type of building	Regular in plan
Each story height	3.1 m
Type of building	Residential
Seismic zone	V
Material properties	
Grade of concrete	M20
Grade of steel	Fe 415
Section properties	
Column	300×600mm
Beam	230×450mm
Slab thickness	125mm
Primary load cases	
Dead load	13.5 KN/M
Live load	2 KN/M^2
Floor finish	0.5 KN/M^2
Earthquake load in X and Y	IS 1893:2002
Seismic properties	
Zone factor (Z)	0.36
Response reduction factor (R)	5
Importance factor (I)	1
Soil type	II
Damping ratio	0.05
Link (viscous damper) properties	
Mass	1700 Kg.
weight	0.173 KN
Effective Stiffness	20,000 KN/M
Effective Damping	10,000 KN-S/M

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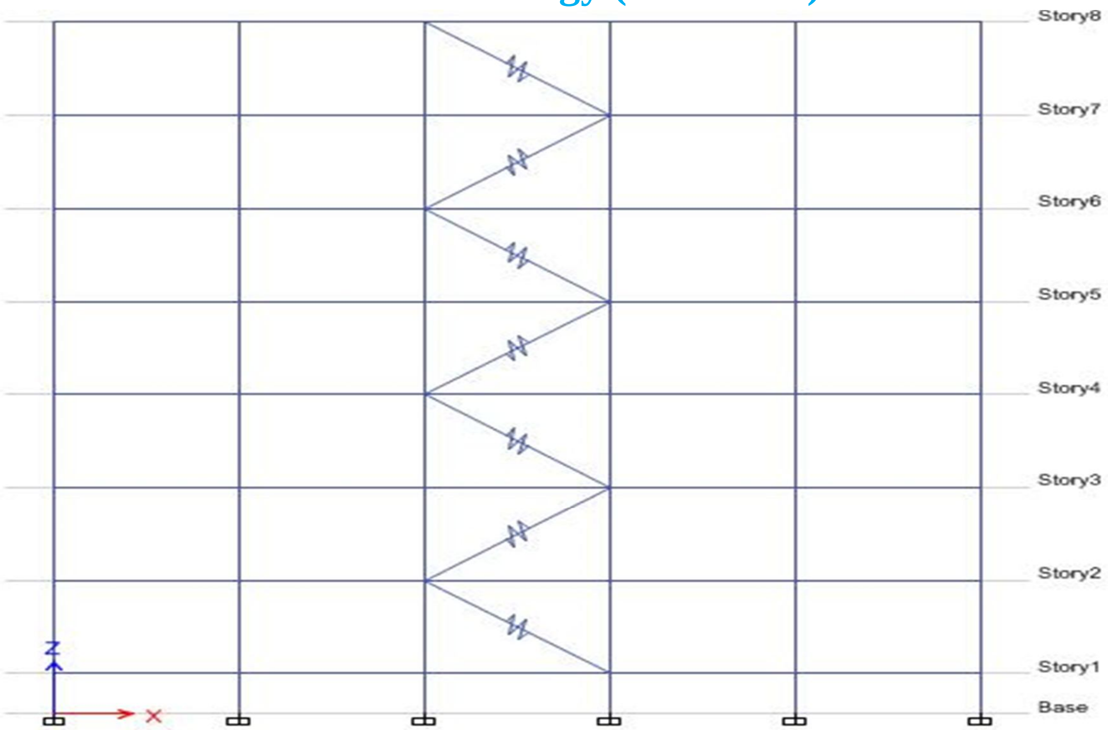

Fig.2 with viscous damper

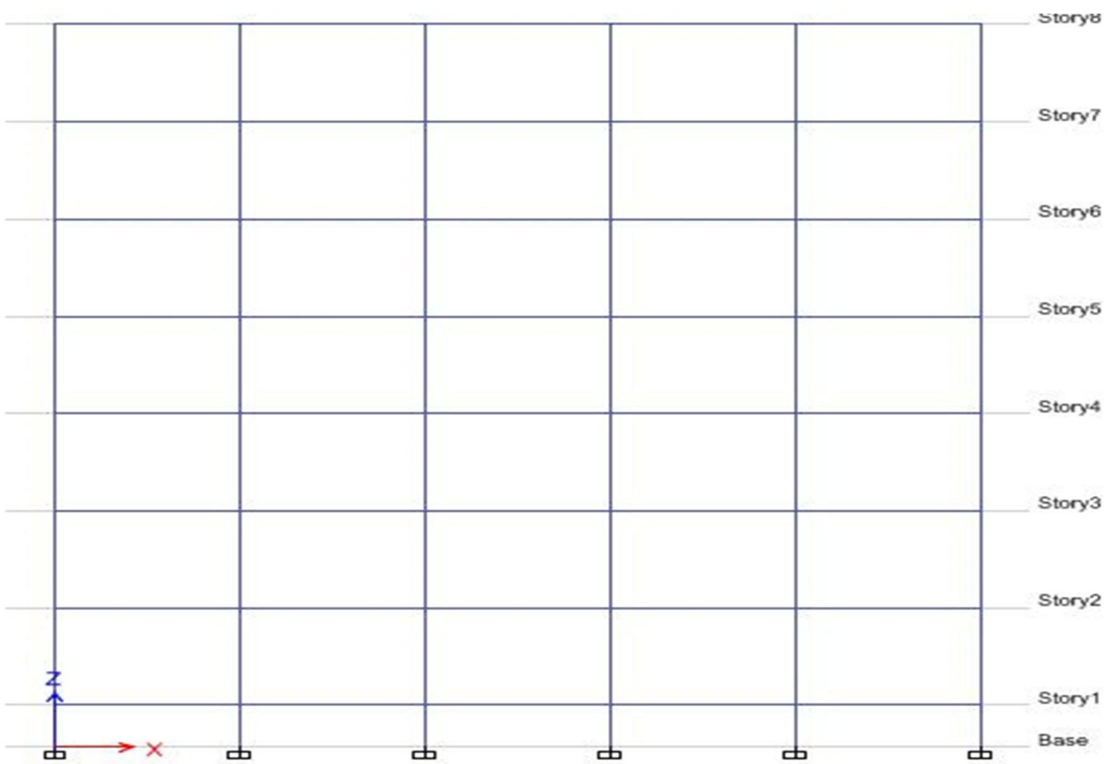

Fig.3 without viscous damper

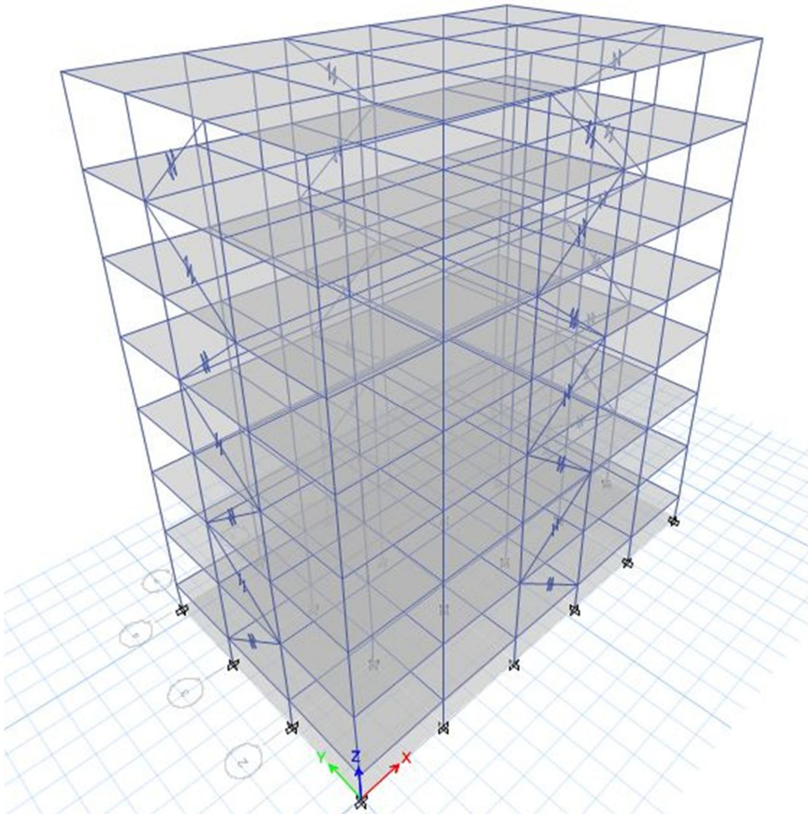

Fig.4 Dampers are provided in central bay all along periphery

IV. RESULT AND DISCUSSIONS

In the present study, viscous dampers are used to reduce the seismic effect of the structure which is subjected to the earthquake load. The frames (with and without viscous damper) is modeled according to the properties of the structure which are explained in the work. The models are subjected to analysis for gravity load (i.e., dead and live load) and seismic loads. Dynamic analysis is carried out by response spectrum method according to the Indian Standards codes by using ETABs 2015 software. The seismic behavior of the Reinforced Concrete structure is judged by observing the parameters such as displacement, acceleration, story drift and story shear.

A. Displacement

Displacement is the parameter of maximum importance as it governs the failure pattern of the structure. From this present study, the displacement of the model with and without viscous damper is observed. By providing the damper to the structure we observe that the displacement of the structure is reduced.

Table 2: Displacement in x direction

Storey No.	Elevation in m	Displacement in mm	
		With damper	Without damper
8	24.8	101.5	194.6
7	21.7	94.4	182.9
6	18.6	84.6	164.4
5	15.5	71.4	139.1
4	12.4	54.9	107.9
3	9.3	35.9	72.2
2	6.2	16.4	34.8
1	3.1	2	4.4

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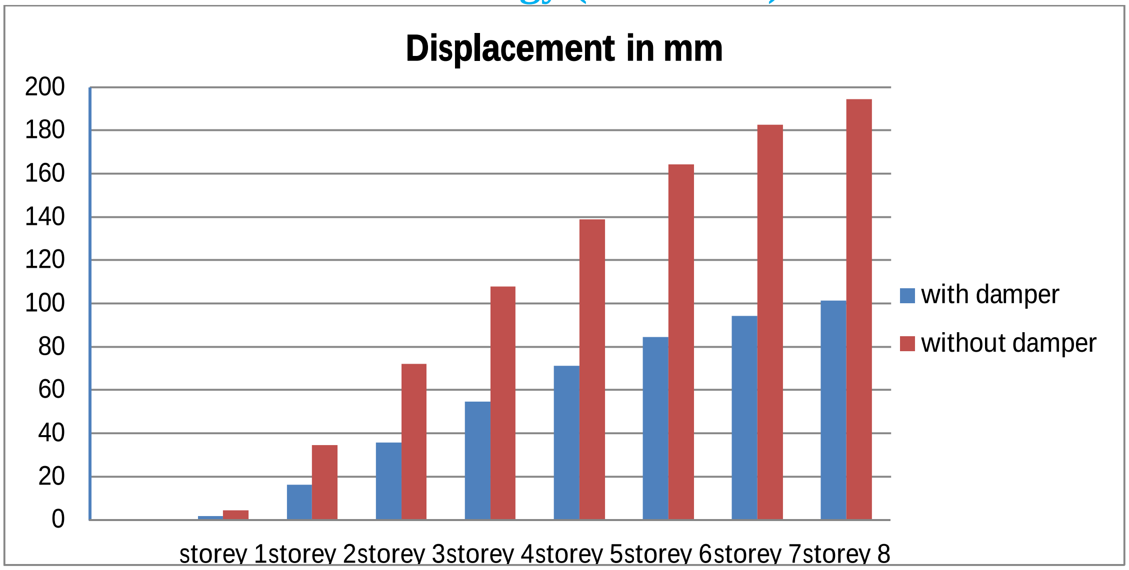

Fig.3 Comparison of displacement in x direction

Table3 : Displacement In Y Direction

Storey No.	Elevation in m	Displacement in mm	
		With damper	Without damper
8	24.8	112.9	256
7	21.7	107.9	242.4
6	18.6	99.5	219.4
5	15.5	87.2	188.1
4	12.4	70.8	149.6
3	9.3	50.2	104.4
2	6.2	25.9	54
1	3.1	3.5	6.3

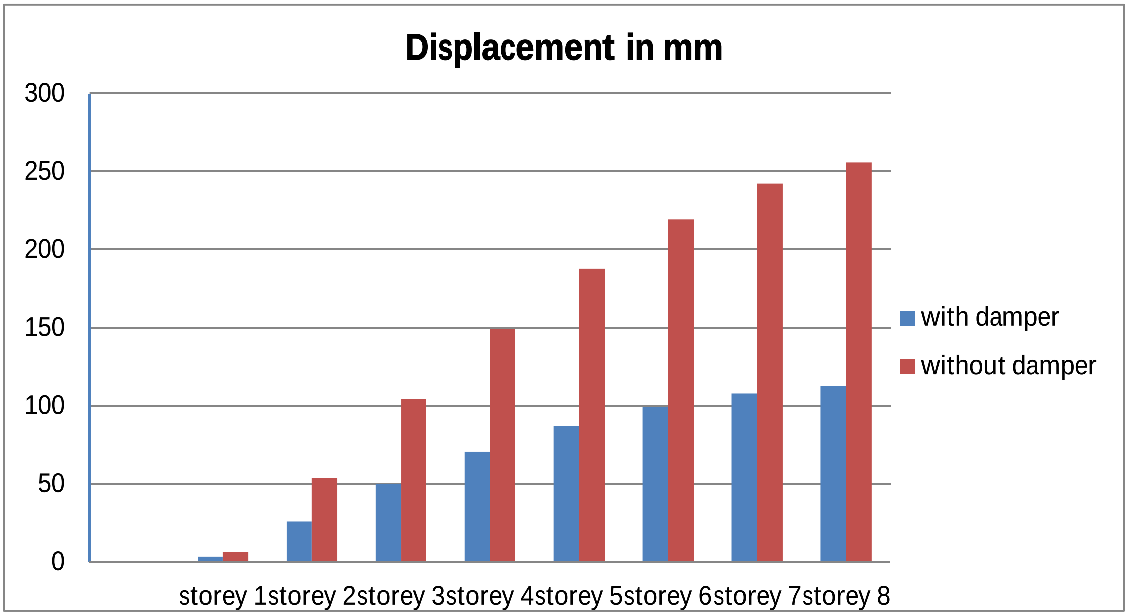

Fig.4 Comparison of displacement in y direction

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B. Acceleration

Storey acceleration is maximum at top floor when RC building analyses without damper. But when RC building analyses with damper acceleration values changes at each storey.

Table 4: Acceleration In X Direction

Storey No.	Elevation in m	Acceleration in mm/sec.^{2}	
		With damper	Without damper
8	24.8	2664.08	6794.96
7	21.7	2562.13	5233.8
6	18.6	2487.63	4840.62
5	15.5	2514.91	4835.41
4	12.4	3231.77	4774.18
3	9.3	3425.73	4730.18
2	6.2	2228.4	3162.61
1	3.1	338.14	468.08

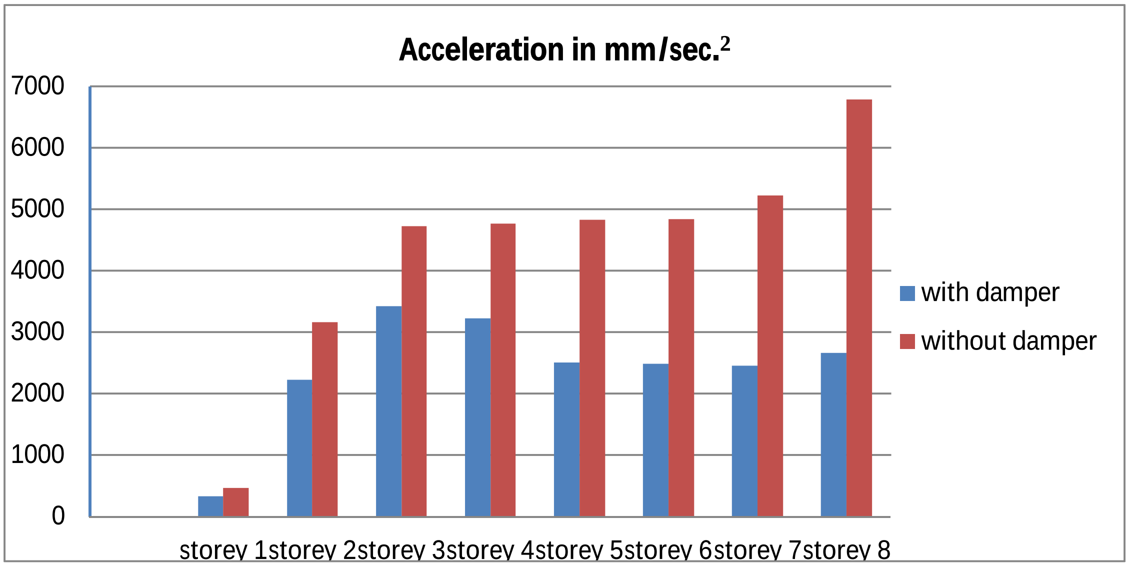

Fig.4 Comparison of acceleration in x direction

Table 5: Acceleration In Y Direction

Storey No.	Elevation in m	Acceleration in mm/sec.^{2}	
		With damper	Without damper
8	24.8	1911.61	5865.08
7	21.7	1939.9	4515.41
6	18.6	1896.57	4063.8
5	15.5	2079.22	4323.43
4	12.4	2463.94	4655.33
3	9.3	3247.7	4578.91
2	6.2	3602.76	3926.83
1	3.1	697.76	595.61

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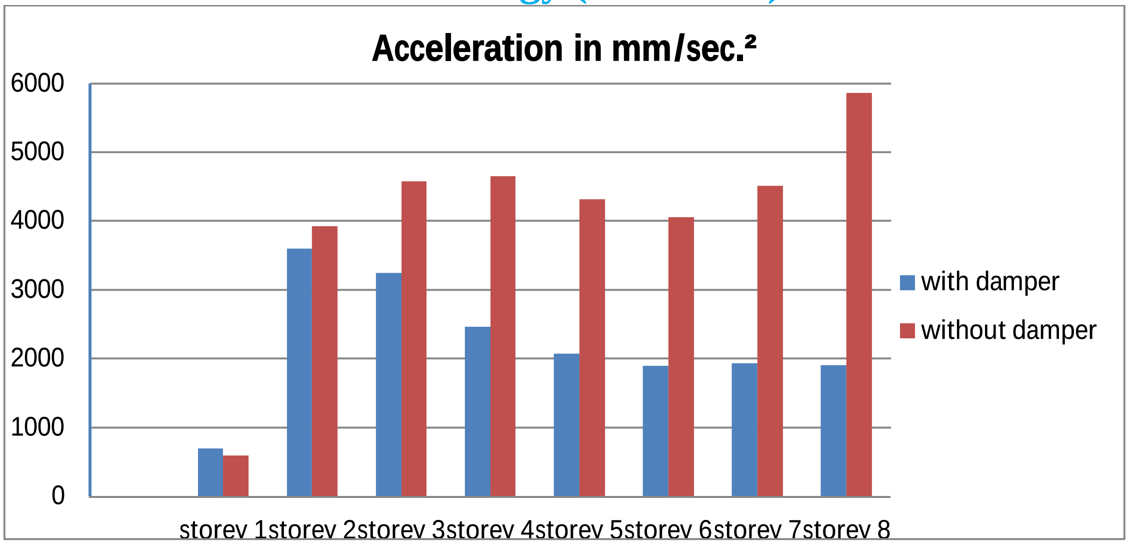

Fig.5 Comparison of acceleration in y direcion

C. Story Drift

As the number of story increases in the structure, the drift is the common factor for multi-storey building. The variance between the lateral displacements of two adjacent floors of the structure is defined as the story drift. The structure which is modeled and analyzed by dynamic analysis i.e., response spectrum method. The values of the storey drift of the structure are noted According to IS 1893(Part 1):2002 clause 7.11.1 Storey drifts limitations are explained that the Storey drifts in any storey due to the minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times the storey height.

Table 6: Storey Drift In X Direction

Storey No.	Elevation in m	Storey drift in mm	
		With damper	Without damper
8	24.8	0.002525	0.004484
7	21.7	0.003543	0.00691
6	18.6	0.004702	0.00903
5	15.5	0.005765	0.010757
4	12.4	0.006546	0.012055
3	9.3	0.006625	0.012505
2	6.2	0.004922	0.01016
1	3.1	0.001622	0.003354

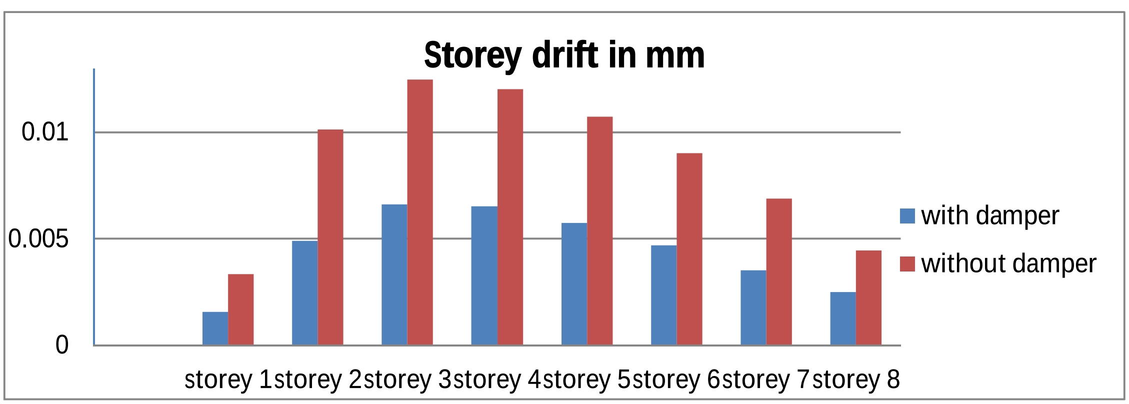

Fig.6 Comparison of storey drift in x direction

Table 7: Storey Drift In Y Direction

Storey No.	Elevation in m	Storey drift in mm	
		With damper	Without damper
8	24.8	0.001855	0.005793
7	21.7	0.003111	0.009391
6	18.6	0.00438	0.01197
5	15.5	0.005764	0.013855
4	12.4	0.007072	0.015517
3	9.3	0.008141	0.016948
2	6.2	0.007476	0.015887
1	3.1	0.002771	0.004862

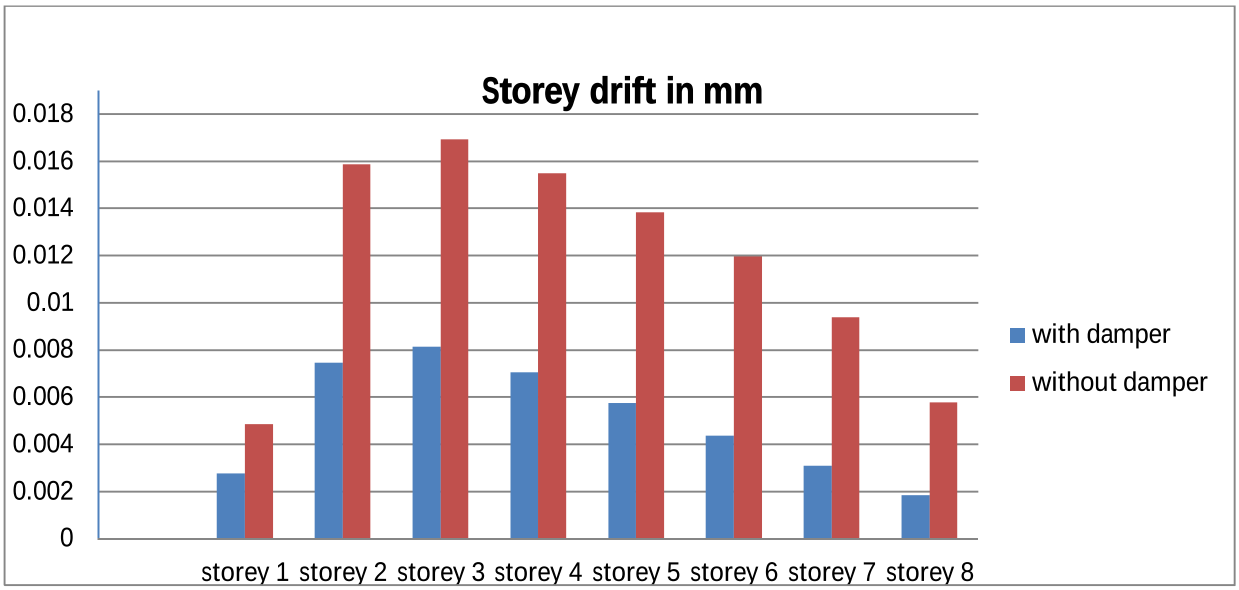

Fig.7 Comparison of storey drift in x direction

D. Storey Shear

The story shear is the shear value obtained from the sum of design lateral forces at the levels above the story consideration of the structure. The story shear at bottom stories will be maximum and will be minimum at the top stories. The shear values of the both models are below in the table.

Table 8: Storey Shear In X Direction

Storey No.	Elevation in m	Storey shear in KN	
		With damper	Without damper
8	24.8	383.45	2371.54
7	21.7	787.0	4177.78
6	18.6	1168.94	5476.69
5	15.5	1510.18	6542.53
4	12.4	1848.35	7445.72
3	9.3	2203.14	8241.81
2	6.2	2443.26	8787.07
1	3.1	2477.06	8867.06

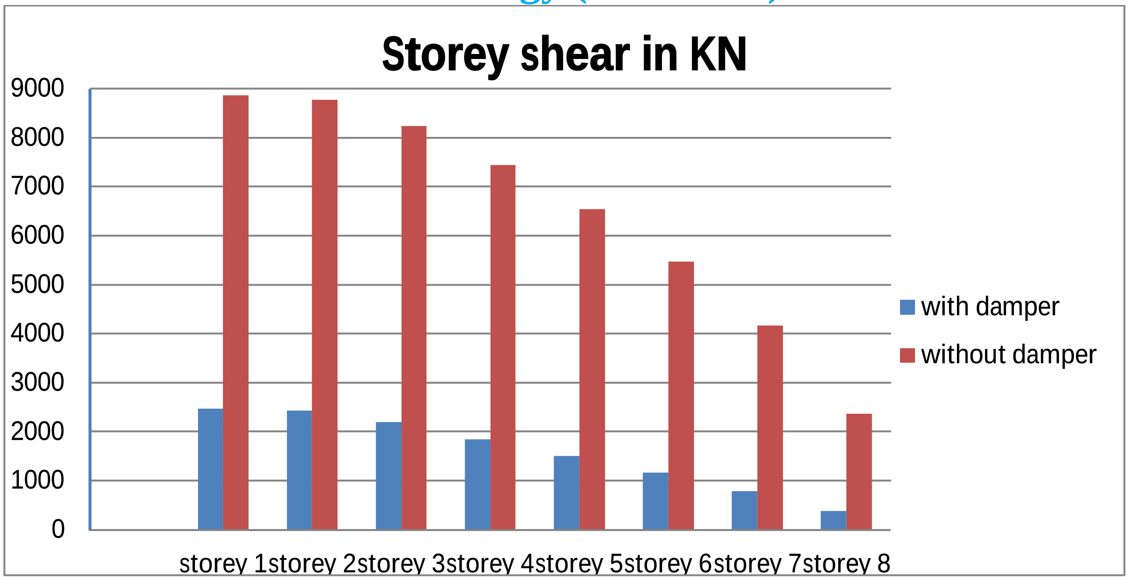

Fig.8 Comparison of storey shear in x direction

Table 9: Storey Shear In Y Direction

Storey No.	Elevation in m	Storey shear in KN	
		With damper	Without damper
8	24.8	276.46	2037.81
7	21.7	583.76	3460.28
6	18.6	871.59	4401.27
5	15.5	1164.40	5087.48
4	12.4	1477	5723.27
3	9.3	1815.4	6384.26
2	6.2	2257.38	6933.65
1	3.1	2221.92	7020.43

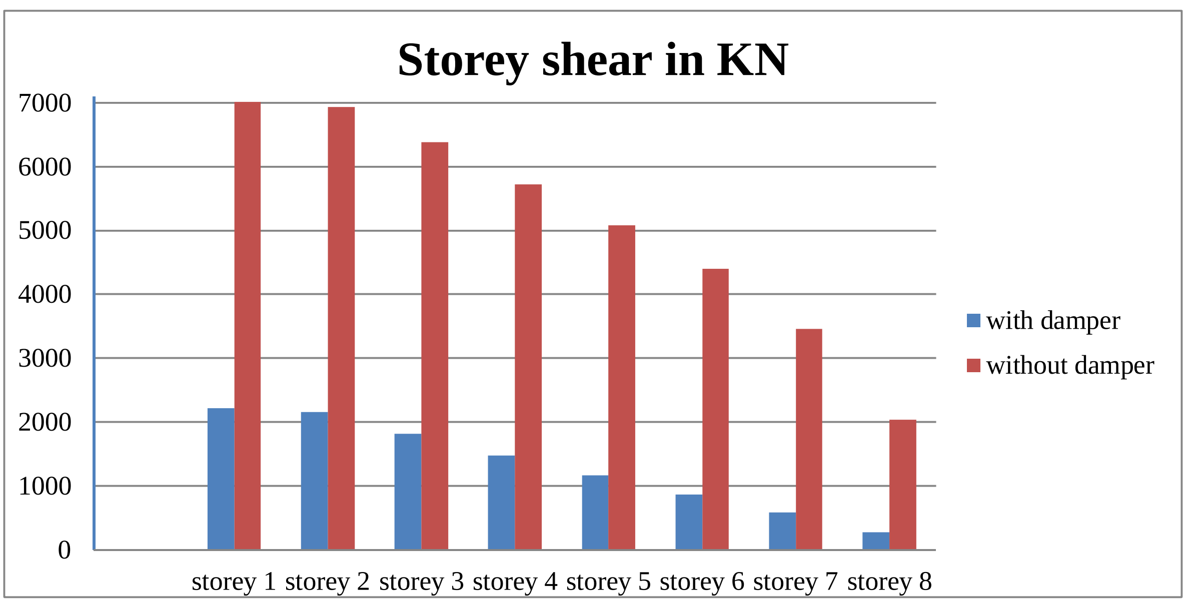

Fig.9 Comparison of storey shear in y direction

V. CONCLUSION

In this study, viscous damper is used to control the seismic response of the structure which is subjected to the earthquake load. The symmetrical plan of 8-stories is modeled and subjected to the class of gravity load using ETABs 2015. As per IS 1893-2002 code, the structure is subjected to the earthquake load. The response spectrum method is used for dynamic analysis. After analysis the structure and considering the static and dynamic values the scale factor is fixed. After the analysis of structure the results obtained and compared. And the conclusions are as follows.

A. The bare frame model which is without damper is analysed and obtained the results of maximum displacement as 194.6 mm and 256 mm in both x and y direction as well as story drift as 0.012505 mm, 0.016948 mm.

B. The results obtained from the model with addition of viscous damper are maximum displacement as 101.5 mm and 112.9 mm in both x and y direction as well as story drift as 0.006625 mm, 0.008141 mm.

C. From the comparison, the displacement value of the structure is reduced about 70% to 75% when viscous dampers are applied to the structure.

D. By applying viscous damper to the structure there is reduction of about 60% to 80% in drift value at top and bottom stories.

E. The base shear value of bare frame model is 8867.06 KN and that to model with viscous damper is 2477.04 kN in x direction. Also base shear of bare model is 7020.43 KN and that to model with viscous damper 2221.92 KN. From these values it is concluded that base shear value goes on decreasing after installation of viscous damper.

F. Base shear reduction one can make the structure cost effective.

G. Due to absolute acceleration reduction the inertial forces also reduced.

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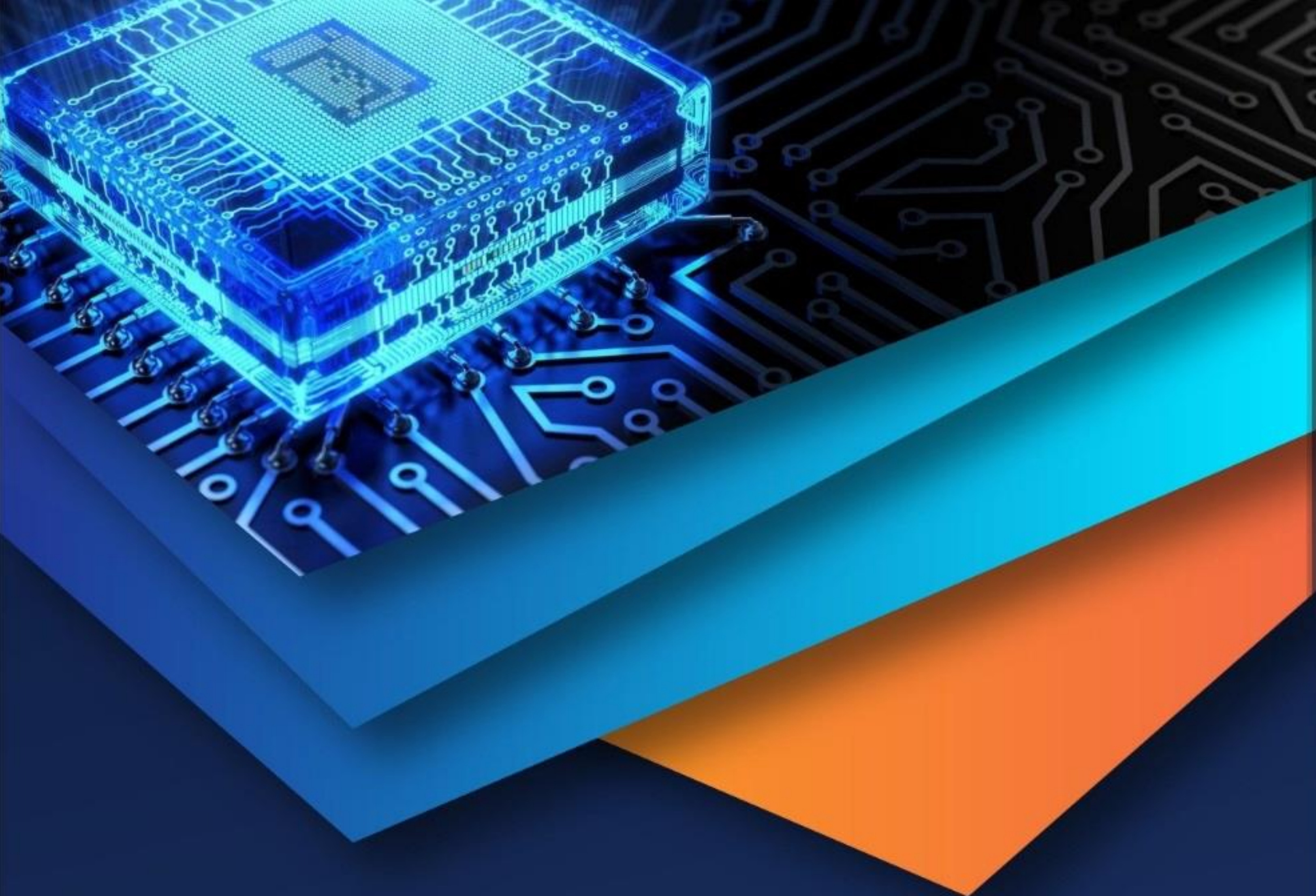

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