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Comparative Study of Various Types of Dampers used for Multi-Story R.C.C. Building

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Abstract: dampers are used to resist lateral forces coming on the structure. Dampers are the energy dissipating devices which also resist displacement of rc building during earthquake. These dampers help the structure to reduce the buckling of columns and beams and the stiffness of the structure is increased. At the time of earthquake multi-storey building is damaged and large deformation occurred in multi-storey building. Dampers reduce vibration and deformation of rc building during earthquake. There is lot of various types are used in rc building. This study .deals with selection of suitable type of damper which will be more resistant to earthquake for the selected building.
The dissertation work is concerned with the comparative study of various types of dampers used for multi-storey r.c.c. Building. Response spectrum method is used to analyse seismic behavior of g+7 storey building with and without dampers. 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. The structure is analyzed with and without various types of dampers. Results of these analyses are discussed in terms of various parameters such as maximum absolute displacement, absolute acceleration, 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 dampers.
Keywords: viscous dampers, visco-elastic damper, friction damper, tuned mass damper.

I. INTRODUCTION

Earthquake in the simplest terms can be defined as Shaking and vibration at the surface of the earth resulting from underground movement along a fault plane. The vibrations produced by the earthquakes are due to seismic waves. Seismic waves are the most disastrous one. However, modern high rise buildings and tall structures cannot conveniently be geared up with these techniques. The safety and serviceability of any structure is thus endangered with the increasing elevation. As per the standard codes, a structure that can resist the highest earthquake that could possibly occur in that particular area can be called as an earthquake resistant structure. However, the most efficient way of designing earthquake resistant structure would be to minimize the deaths as well as minimize the destruction of functionality of the structural element. The most disastrous thing about earthquake is its unpredictability of time and place of occurrence. These possess a great challenge to the economy and safety of structure. 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.

The Various types of damper are summarized below

A. Viscous Damper

In this type of damper by using viscous fluid inside cylinder energy dissipated. Viscous dampers are used in high-rise building in seismic areas. Viscous damper reduces the vibrations induced by both strong wind and earthquake.

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Fig: 1 Viscous Damper

B. Visco-Elastic Dampers

Another type of damper is visco-elastic dampers which stretch an elastomer in combination with metal parts. In visco-elastic dampers, the energy is absorbed by utilising controlled shearing of solids.

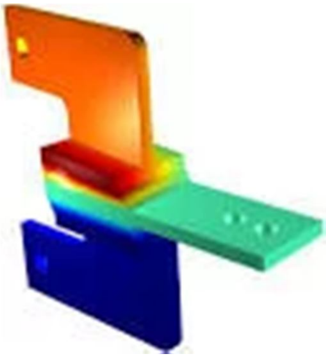

Fig: 2 Visco-elastic Damper

C. Friction Damper

Friction dampers use metal or other surfaces in friction; and energy is absorbed by surfaces with fiction between them rubbing against each other. Typically a friction damper device consists of several steel plates sliding against each other in opposite directions. The steel plates are separated by shims of friction pad material. The damper dissipates energy by means of friction between the sliding surfaces.

Fig: 3 Friction Damper

D. Tuned Mass Damper

Tuned Mass Damper (TMD) is a passive control device which absorbs energy & reduces response of vibration. It is attached to vibratory system. TMD is considered to have same damping ratio as that of main structure. Tuned mass dampers consists of spring attached to the structure and are used for vibration control of structures when subjected to earthquake excitations. It is a frequency dependent device. Recently, much research has been carried out such as analytical, numerical, experimental and optimum solutions

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of structures to study the effectiveness of TMDs in reduction of seismic response of structures.

Fig: 4 Tuned mass Damper

II. OBJECTIVE OF PRESENT STUDY

A. To study seismic behavior of selected G+7 R.C.C. building with various types of dampers by using ETABS 2015 software.
B. Compare various parameters namely base shear, storey drift, absolute displacement, and the absolute acceleration.
C. Selection of suitable type of damper which will be more resistant to earthquake for the selected building.

III. PROBLEM STATEMENT

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	
Link type – Damper bilinear	

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Mass	1700 Kg.
Weight	0.173 KN
Effective Stiffness	20,000 KN/M
Effective Damping	10,000 KN-S/M
Link (visco-elastic) properties	
Link type – Damper exponential	
Mass	2000 Kg.
Weight	0.203 KN
Effective Stiffness	30,000 KN/M
Effective Damping	10,000 KN-S/M
Link (friction damper) properties	
Link type – Damper exponential	
Mass	2200 Kg.
Weight	0.225 KN
Effective Stiffness	20,000 KN/M
Effective Damping	4,000 KN-S/M
Link (tuned mass damper) properties	
Link type – Damper bilinear	
Mass	2500 Kg.
Weight	0.25 KN
Effective Stiffness	5,000 KN/M
Effective Damping	4,000 KN-S/M

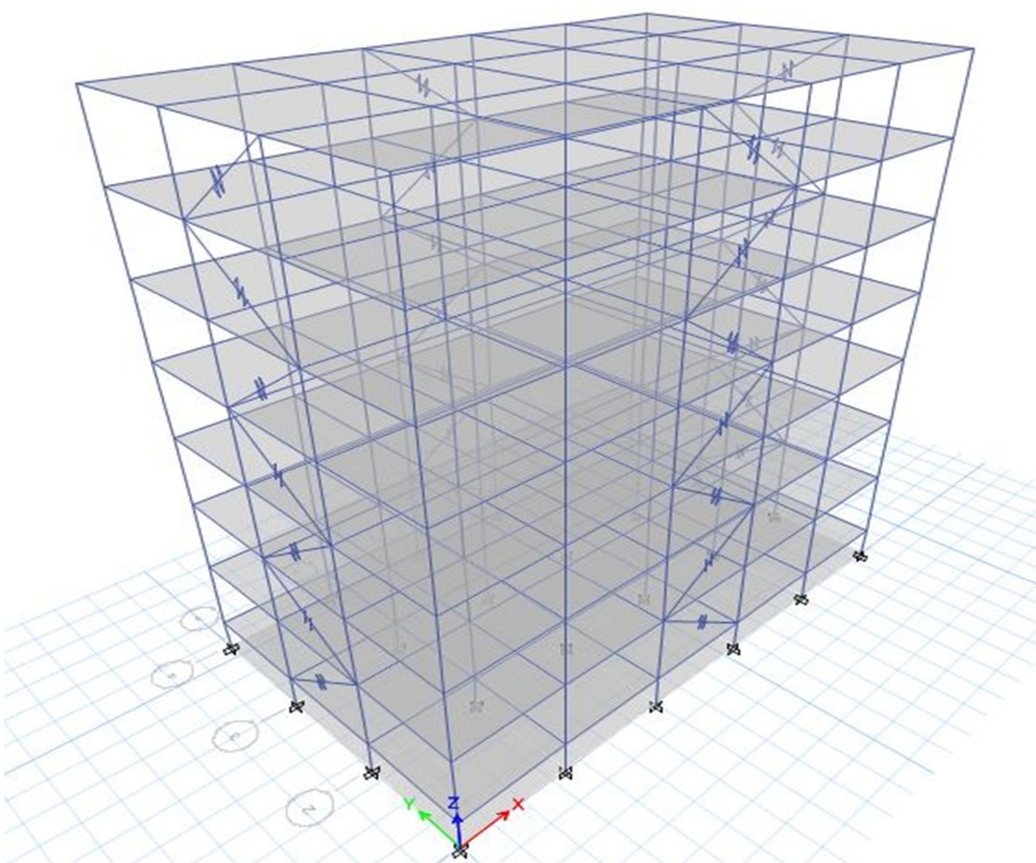

Fig: 5 Dampers are provided in central bay all along periphery.

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IV. RESULT AND DISCUSSIONS

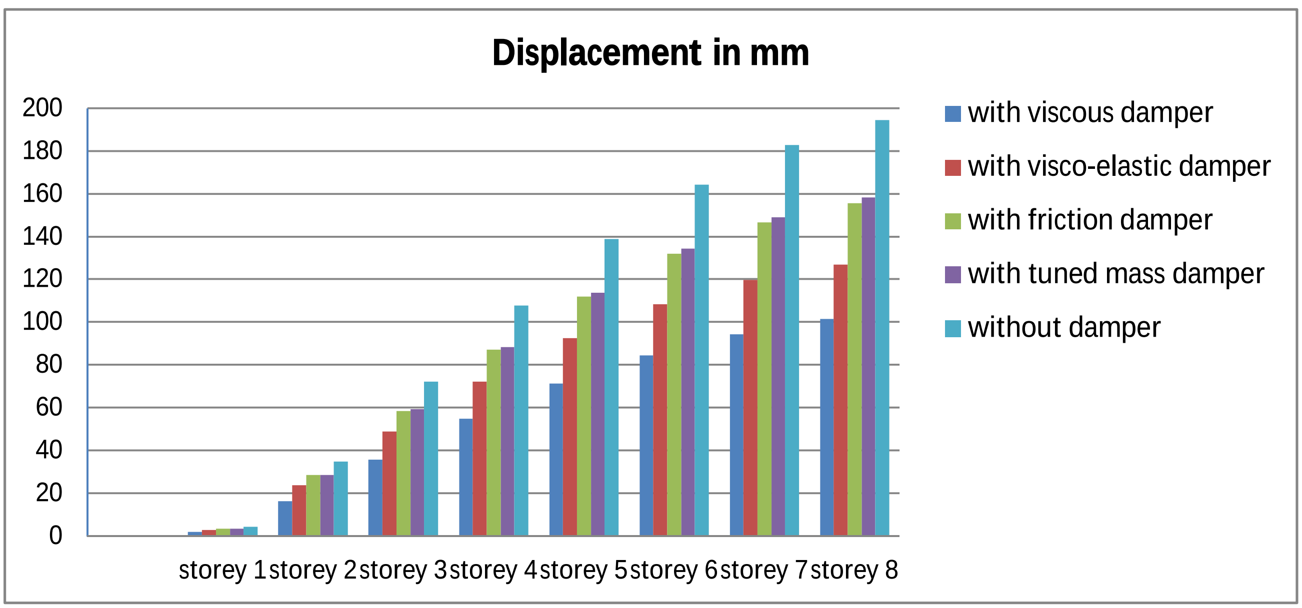
Dampers are used to reduce the seismic effect of the structure which is subjected to the earthquake load. The frames (with and without damper) is modeled according to the properties of the structure which are explained in the work. The models are subjected to analysis for gravity load (i.e., dead and 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 absolute displacement, acceleration, story drift and story shear.

A. Absolute 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 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				
		Without damper	With viscous damper	With Visco-elastic damper	With friction damper	With tuned mass damper
8	24.8	194.6	101.5	126.9	155.7	158.4
7	21.7	182.9	94.4	119.9	146.7	149.2
6	18.6	164.4	84.6	108.5	132.1	134.4
5	15.5	139.1	71.4	92.5	112	113.9
4	12.4	107.9	54.9	72.4	87.1	88.5
3	9.3	72.2	35.9	48.9	58.6	59.4
2	6.2	34.8	16.4	23.7	28.5	28.7
1	3.1	4.4	2	3	3.6	3.6



Graph 1: Comparison of displacement in x direction

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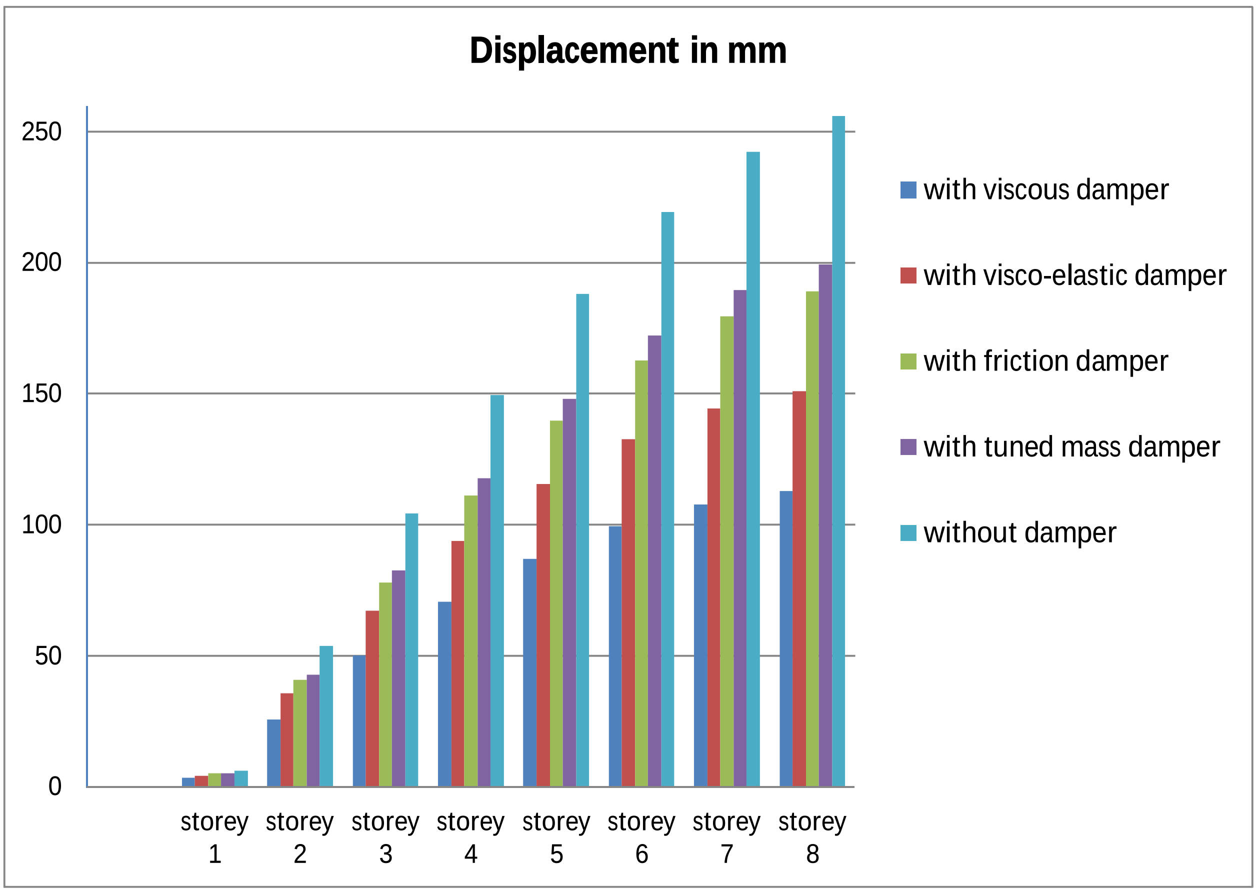
TABLE 3: Displacement in y direction

Storey No.	Elevation in m	Displacement in mm				
		Without damper	With viscous damper	With Visco-elastic damper	With friction damper	With tuned mass damper
8	24.8	256	112.9	151.1	189.1	199.5
7	21.7	242.4	107.9	144.5	179.6	189.7
6	18.6	219.4	99.5	132.7	162.9	172.4
5	15.5	188.1	87.2	115.7	139.9	148.2
4	12.4	149.6	70.8	93.9	111.4	118
3	9.3	104.4	50.2	67.3	78.1	82.7
2	6.2	54	25.9	35.9	41	43
1	3.1	6.3	3.5	4.3	5.2	5.3



Graph 2: Comparison of displacement in y direction

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.

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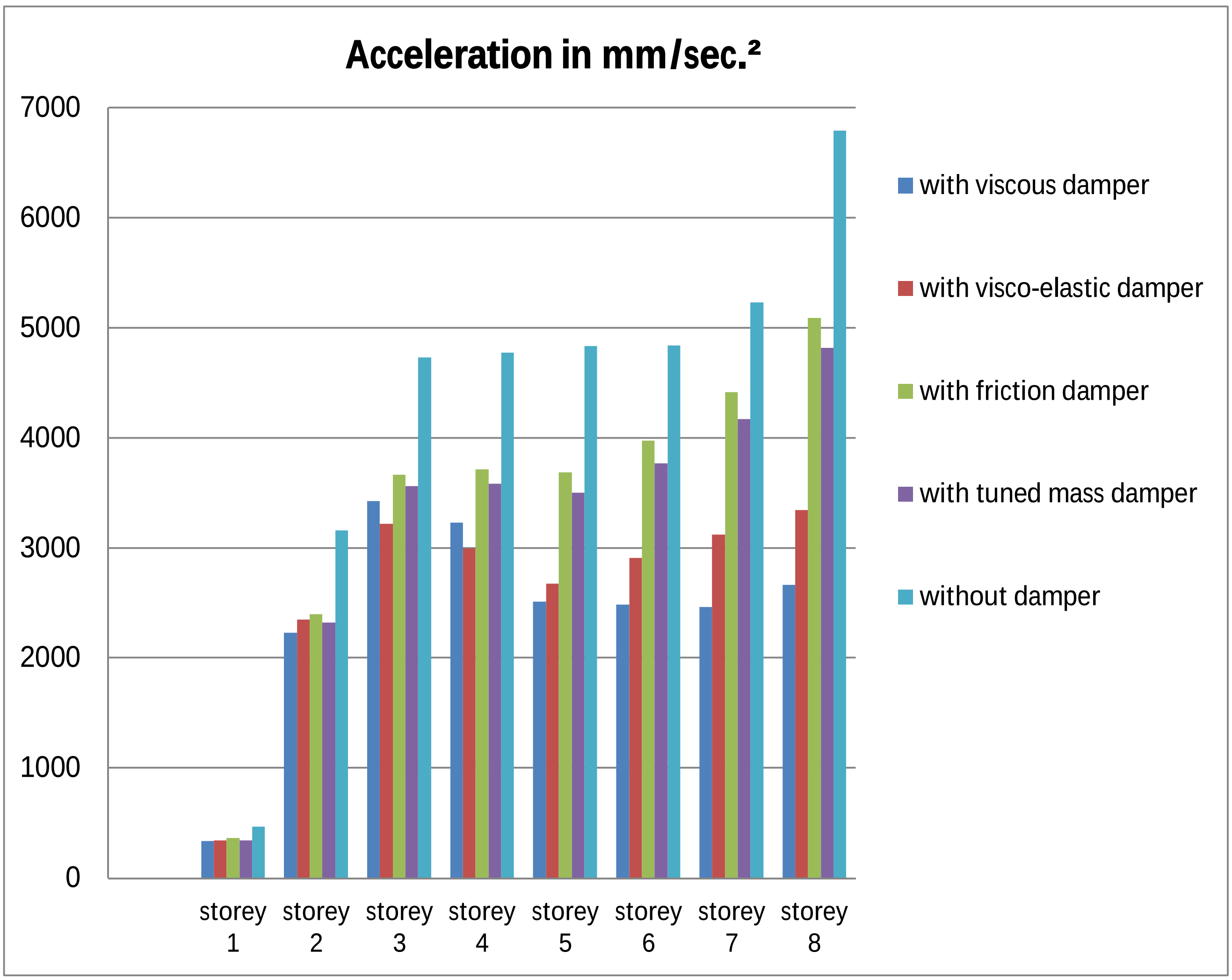
TABLE 4: Acceleration in x direction

Storey No.	Elevation in m	Acceleration in mm/sec.^{2}				
		Without damper	With viscous damper	With Visco-elastic damper	With friction damper	With tuned mass damper
8	24.8	6794.96	2664.08	3345.73	5094.24	4817.75
7	21.7	5233.8	2562.13	3123.62	4419.45	4172
6	18.6	4840.62	2487.63	2909.4	3976.68	3768.88
5	15.5	4835.41	2514.91	2674.54	3686.62	3503.62
4	12.4	4774.18	3231.77	2999.26	3716.86	3584.91
3	9.3	4730.18	3425.73	3223.2	3664.18	3561.37
2	6.2	3162.61	2228.4	2351	2397.98	2324.56
1	3.1	468.08	338.14	345.17	362.78	343.1



Graph 3: Comparison of acceleration in x direction

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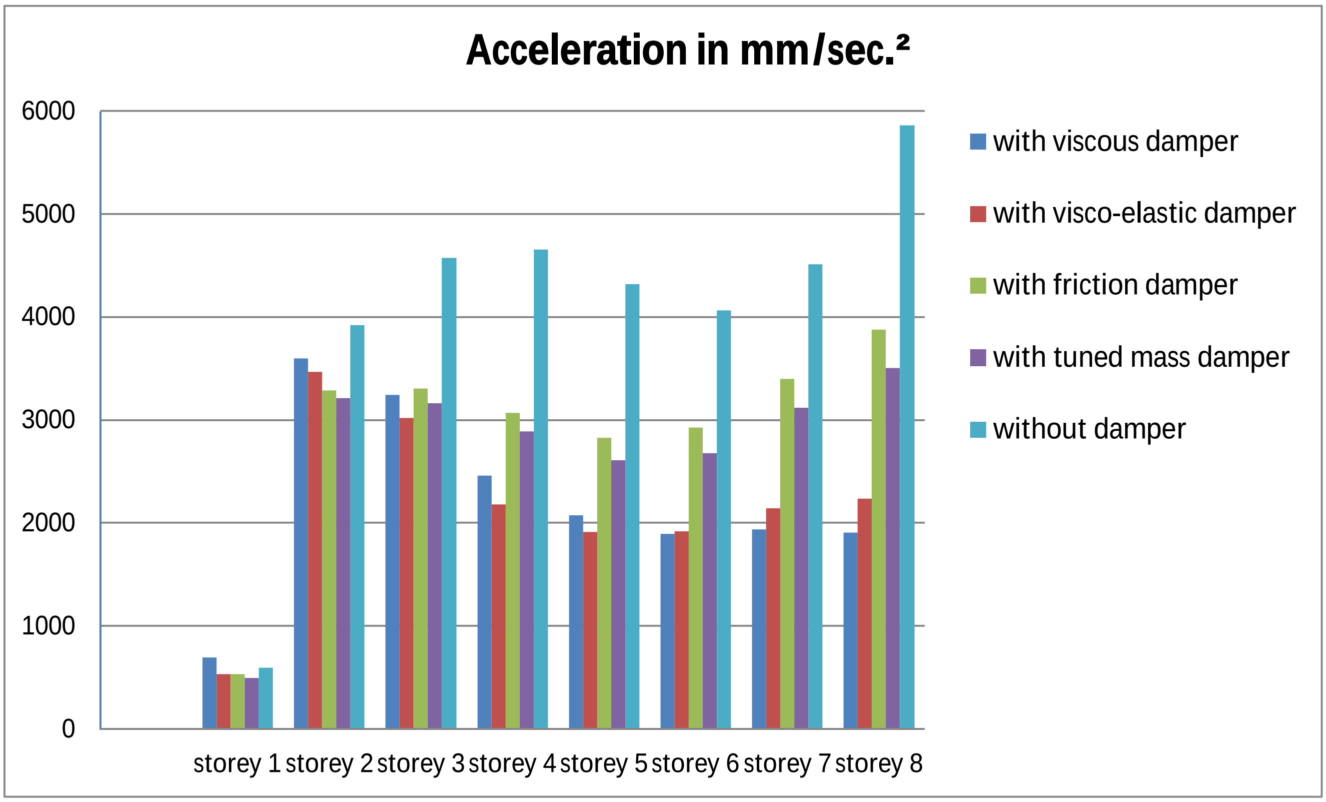
TABLE 5: Acceleration in y direction

Storey No.	Elevation in m	Acceleration in mm/sec.^{2}				
		Without damper	With viscous damper	With Visco-elastic damper	With friction damper	With tuned mass damper
8	24.8	5865.08	1911.61	2238.16	3877.61	3505.31
7	21.7	4515.41	1939.9	2143.43	3402.46	3120.57
6	18.6	4063.8	1896.57	1923.76	2930.69	2682.62
5	15.5	4323.43	2079.22	1914.34	2827.96	2611
4	12.4	4655.33	2463.94	2183.79	3070.69	2888.91
3	9.3	4578.91	3247.7	3023.85	3306.1	3164.68
2	6.2	3926.83	3602.76	3467.87	3286.87	3212.38
1	3.1	595.61	697.76	532.41	534.46	497.92



Graph 4: Comparison of acceleration in y direction

C. Storey 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.

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TABLE 6: Storey drift in x direction

Storey No.	Elevation in m	Storey drift in mm				
		Without damper	With viscous damper	With Visco-elastic damper	With friction damper	With tuned mass damper
8	24.8	0.004484	0.002525	0.002452	0.003246	0.00331
7	21.7	0.00691	0.003543	0.003993	0.005178	0.005289
6	18.6	0.00903	0.004702	0.005543	0.006996	0.00716
5	15.5	0.010757	0.005765	0.006881	0.008489	0.008705
4	12.4	0.012055	0.006546	0.00793	0.009609	0.009854
3	9.3	0.012505	0.006625	0.008408	0.010041	0.010275
2	6.2	0.01016	0.004922	0.006923	0.008291	0.008392
1	3.1	0.003354	0.001622	0.002298	0.00280	0.00285

Graph 5: Comparison of storey drift in x direction

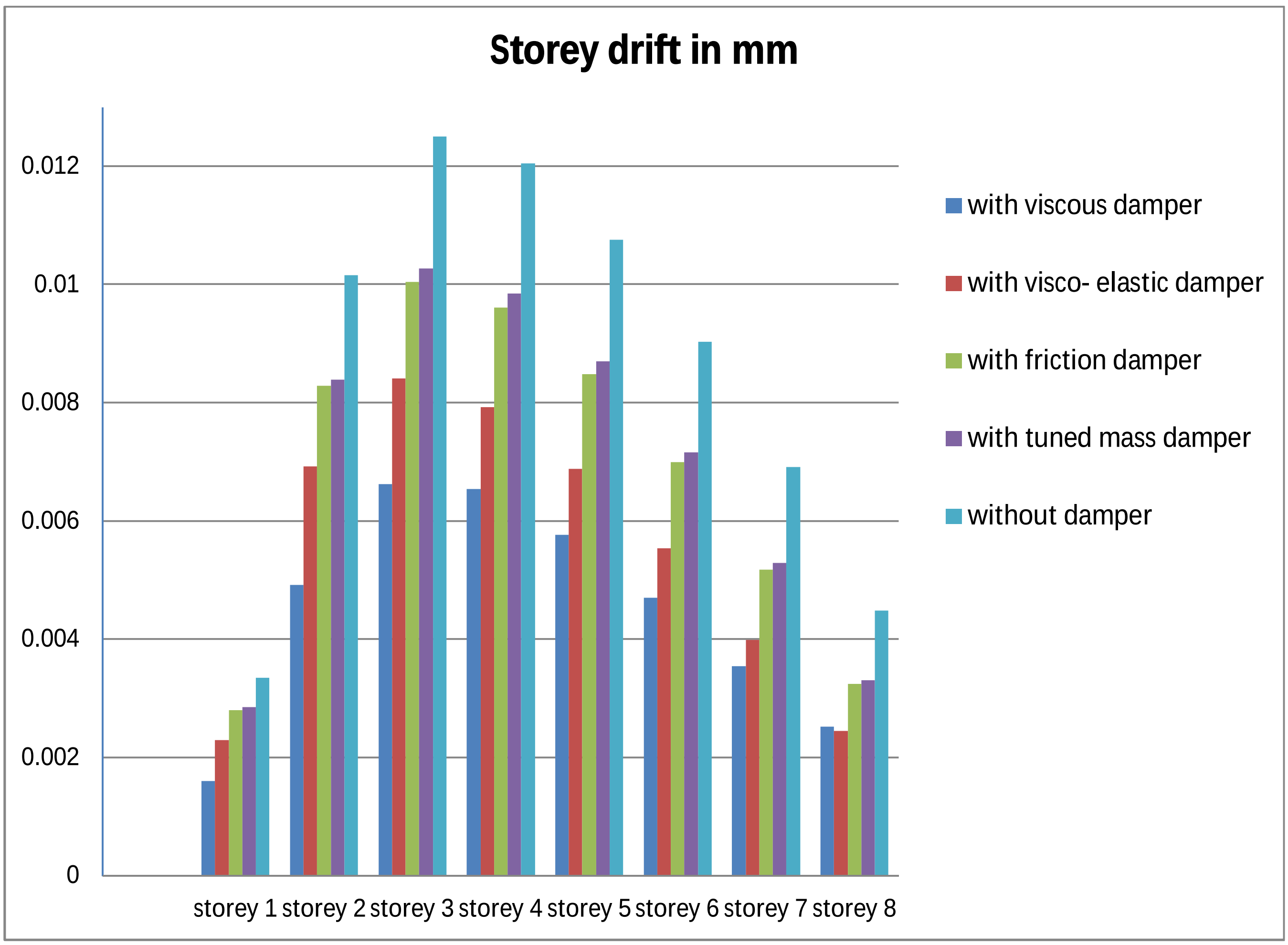

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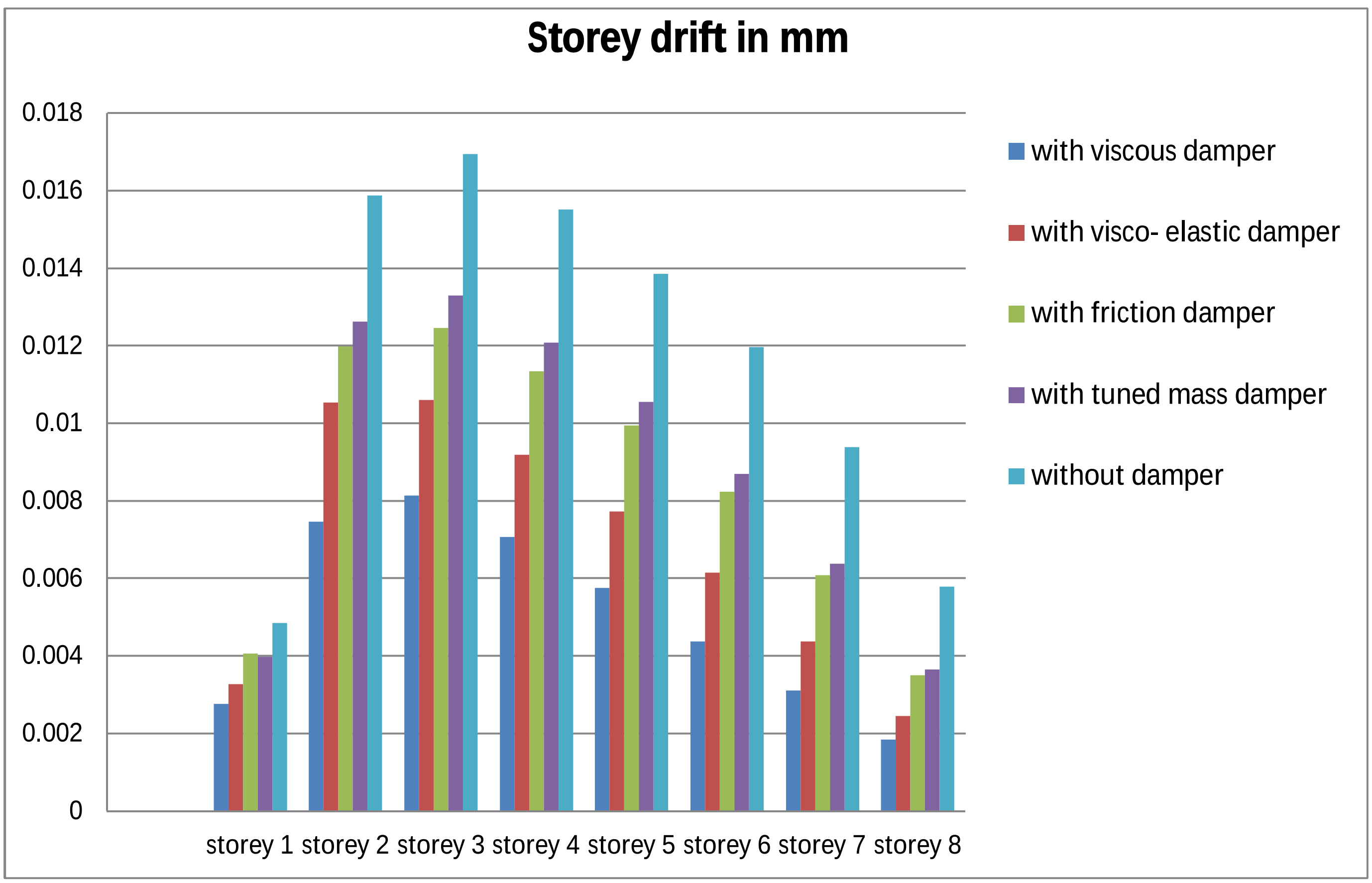
TABLE 7: Storey drift in y direction

Storey No.	Elevation in m	Storey drift in mm				
		Without damper	With viscous damper	With Visco-elastic damper	With friction damper	With tuned mass damper
8	24.8	0.005793	0.001855	0.002463	0.003517	0.003658
7	21.7	0.009391	0.003111	0.0043840	0.006086	0.006386
6	18.6	0.01197	0.00438	0.006154	0.00824	0.008707
5	15.5	0.013855	0.005764	0.007726	0.009952	0.010557
4	12.4	0.015517	0.007072	0.009193	0.011351	0.012095
3	9.3	0.016948	0.008141	0.010604	0.01246	0.013307
2	6.2	0.015887	0.007476	0.010543	0.011981	0.012628
1	3.1	0.004862	0.002771	0.00328	0.004074	0.003984

Graph 6: Comparison of storey drift in y direction



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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				
		Without damper	With viscous damper	With Visco-elastic damper	With friction damper	With tuned mass damper
8	24.8	2371.54	383.45	1168.24	1775.37	1677.33
7	21.7	4177.78	787.0	2290.82	3348.5	3158.006
6	18.6	5476.69	1168.94	3299.69	4644.22	4377.87
5	15.5	6542.53	1510.18	4151.18	5698.78	5369.89
4	12.4	7445.72	1848.35	4880.35	6558.076	6180.44
3	9.3	8241.81	2203.14	5561.63	7280.31	6875.48
2	6.2	8787.07	2443.26	6028.52	7744.84	7329.73
1	3.1	8867.06	2477.06	6096.33	7812.20	7395.066

Graph 7 : Comparison of storey shear in x direction

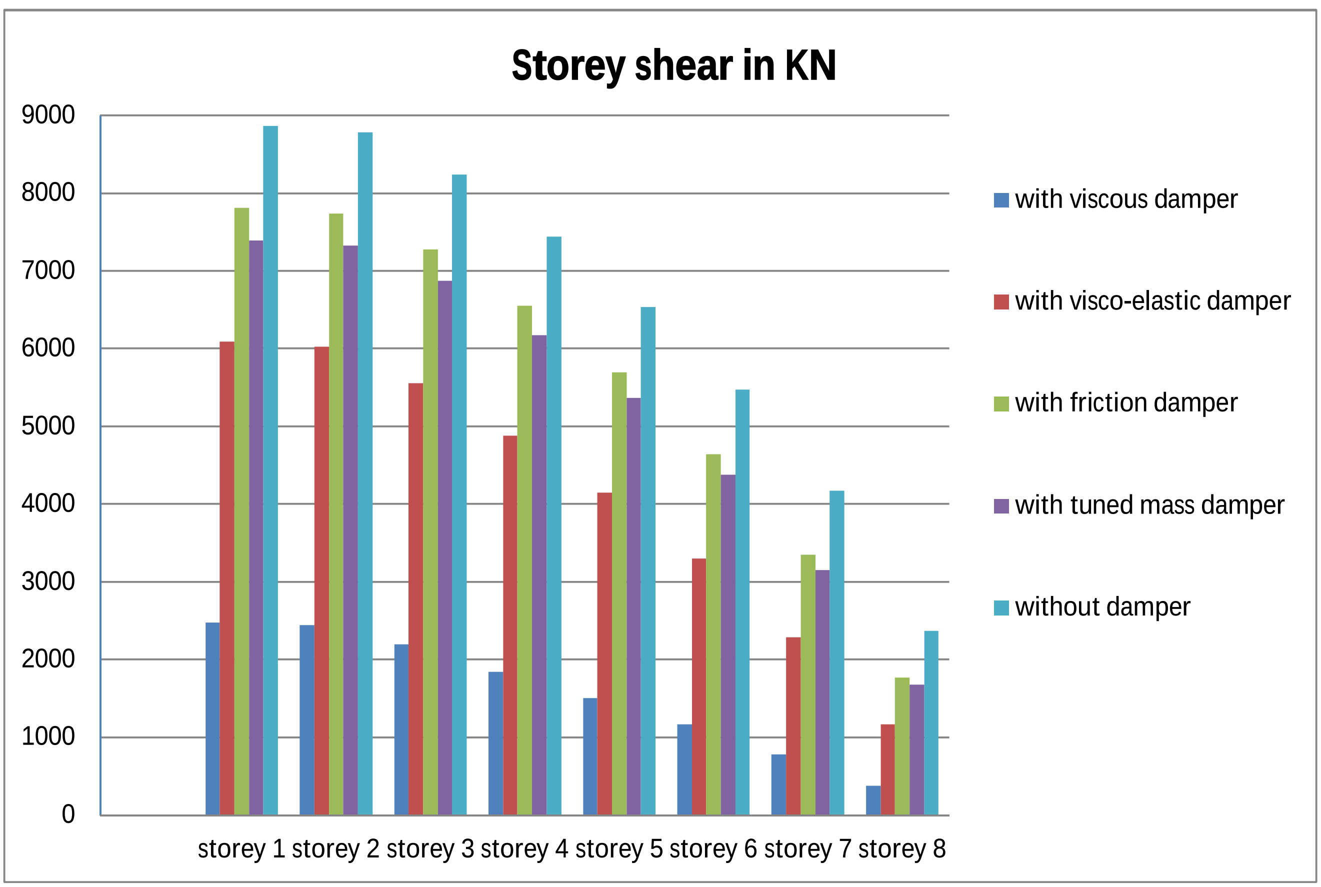

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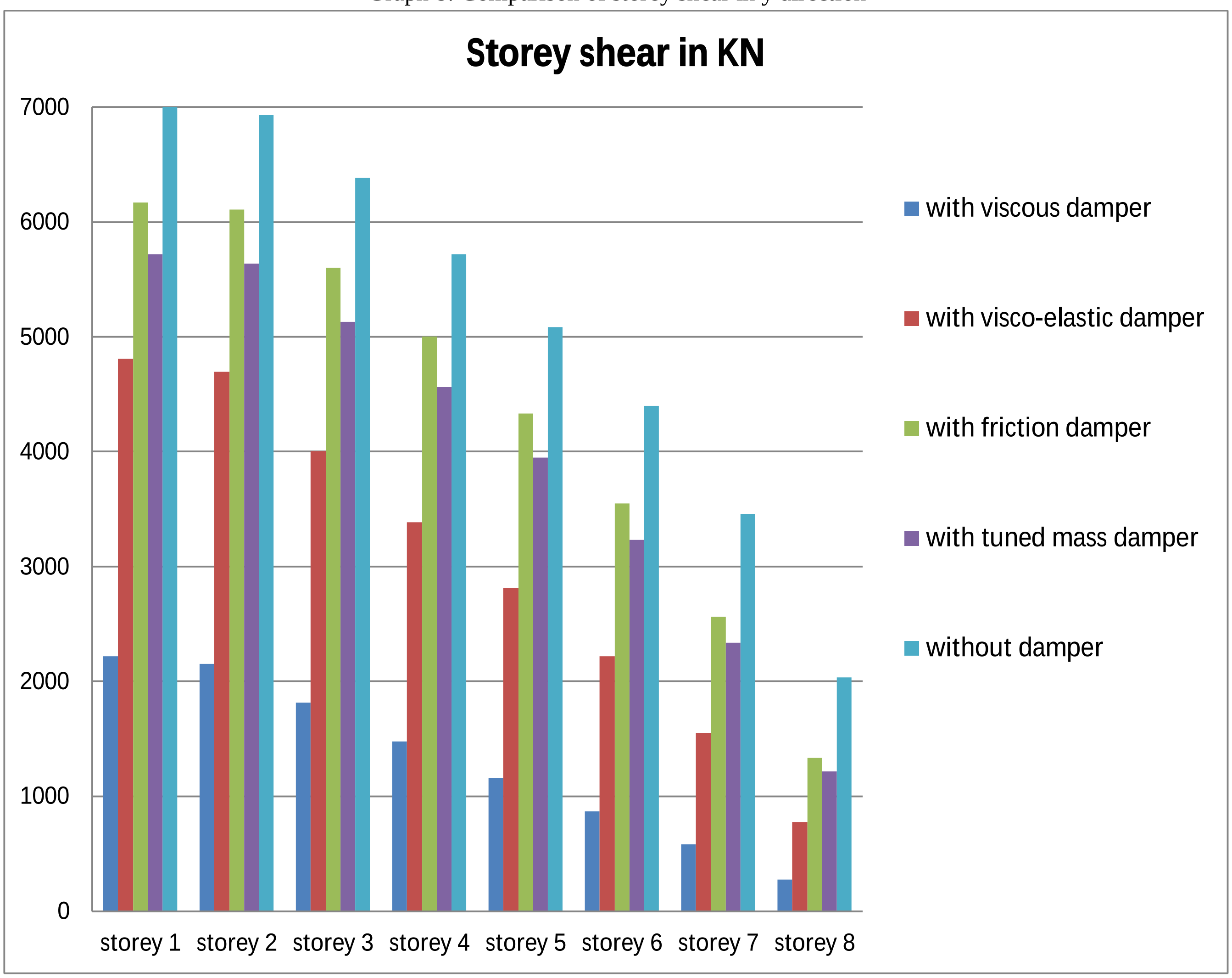
TABLE 9: Storey shear in y direction

Storey No.	Elevation in m	Storey shear in KN				
		Without damper	With viscous damper	With Visco-elastic damper	With friction damper	With tuned mass damper
8	24.8	2037.81	276.46	779.85	1335.93	1217.1
7	21.7	3460.28	583.76	1552.78	2564.01	2337.5
6	18.6	4401.27	871.59	2220.47	3551.23	3236.27
5	15.5	5087.48	1164.40	2814.56	4336.78	3951.60
4	12.4	5723.27	1477	3385.98	5005.18	4567.28
3	9.3	6384.26	1815.4	4004.85	5601.26	5131.24
2	6.2	6933.65	2157.38	4695.78	6111.22	5638.515
1	3.1	7020.43	2221.92	4810.88	6169.9	5722

Graph 8: Comparison of storey shear in y direction



V. CONCLUSION

After carrying out results by using ETABS 2015 software for multi-storey building, various parameters like absolute displacement, acceleration, storey drift, base shear are compared. Following conclusions are made.

A. By comparing the results (Graph no.1 and 2) it is concluded that lateral deflection for RC building with viscous damper as compared to other dampers is minimum.

B. By comparing the results (Graph no.3 and 4) it is concluded that absolute acceleration values for RC building with viscous damper are less

C. By comparing the results (Graph no.5 and 6) it is also concluded that storey drift values for RC building with viscous damper as compared to other dampers are minimum.

D. Base shear is maximum at the base and by comparing results (Graph no.7 and 8) It is observed that base shear values for RC building with viscous damper as compared to other damper are minimum.

E. From above it can be concluded that the viscous damper devices perform a vital role in reducing and controlling the seismic response of the structure as compared other types of dampers.

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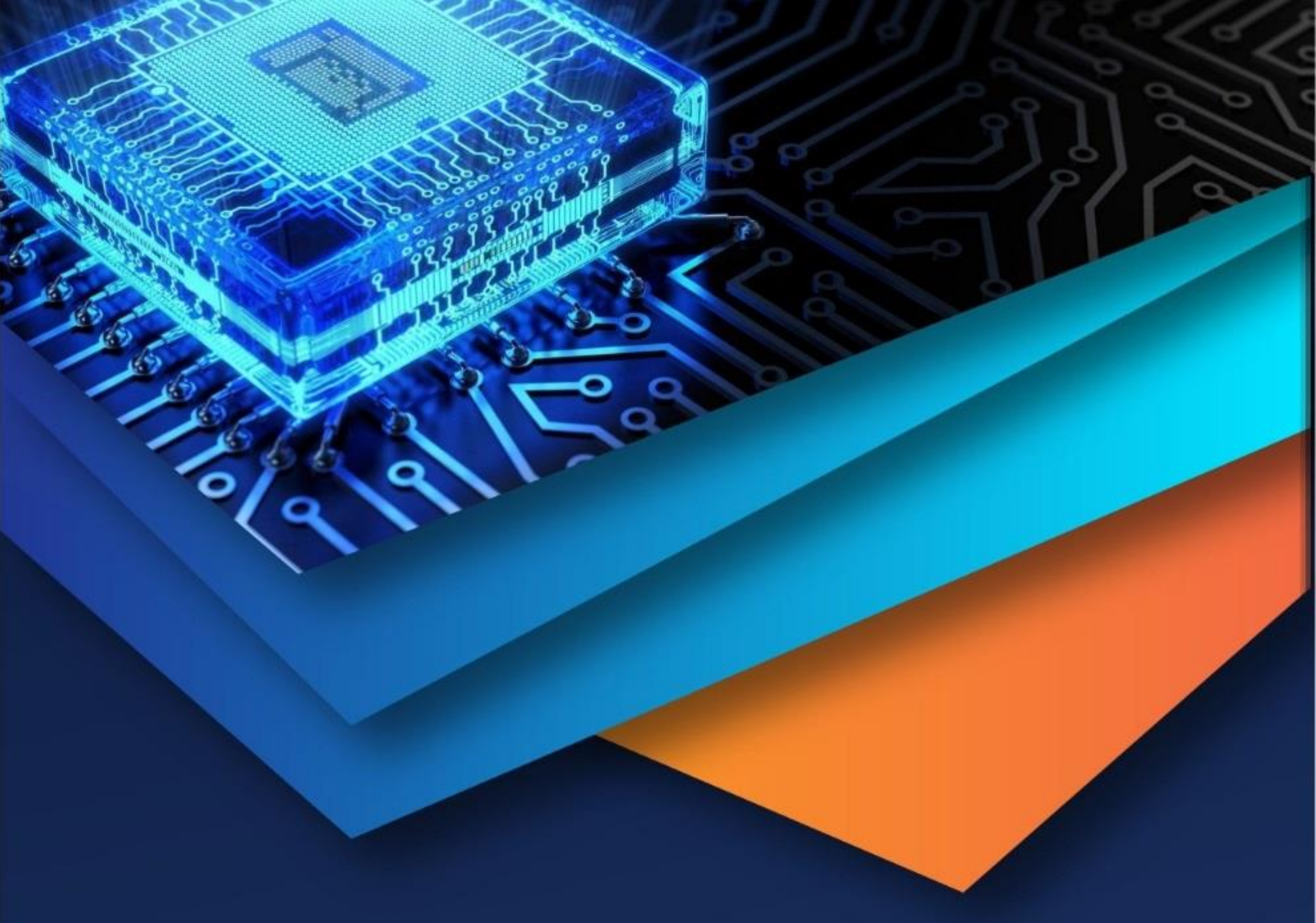

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