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Performance of RCC Structure with Viscous Damper

Mayur B Prajapati[1], Arjun M Butala[2], Nirmal S Mehta[3]
[1]*PG Student, Department of Civil Engineering UVPCE, Ganpat University at Kherva, India*
[2]*Professor, Department of Civil Engineering UVPCE, Ganpat University at Kherva, India*
[3]*Professor, Department of Civil Engineering UVPCE, Ganpat University at Kherva, India*

Abstract
Although structures are built to resist earthquakes, these pressures can produce considerable changes in displacement, story drift, and base reaction, potentially resulting in damage or collapse. To counteract these seismic forces, various systems are available for structural resistance. One such system is the passive system, which utilizes mechanical devices like viscous dampers to mitigate earthquake effects. In this research study, the focus was on analysing an RCC structure equipped with viscous dampers. The objective was to assess the behaviour of the structure under seismic loads by applying earthquake time history analysis using Bhuj and El Centro earthquake records within the ETABS software. A comparison was made between the results obtained for displacement, story drift, and base reactions. Through this analysis, the study aimed to provide insights into the performance of the RCC structure with viscous dampers, specifically in terms of displacement, story drift, and base reactions.

Keywords*: Viscous Damper, Time history Analysis, Displacement, Story drift, Base reaction*

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I. INTRODUCTION

When designing a structure in an earthquake-prone area, the seismic load must be taken into account in addition to the gravity-related loads. Seismic design is based on the tenet that a structure must be able to withstand earthquake loads. The design of a structure aims to withstand earthquake forces by utilizing strength, deformability, and energy absorption. To mitigate the hazardous effects of seismic activity, it is important to distribute the energy throughout the structure. When lateral forces are applied, the structure absorbs this energy, converting it into kinetic and potential energy, which needs to be dissipated, typically in the form of heat. By incorporating supplemental damping devices that absorb the input energy from earthquake forces, the structure's performance can be enhanced. The utilization of structural control response systems aims to minimize structural damage and regulate the structural response. These systems, also known as earthquake protective systems, have evolved to encompass active, passive, and semi-active systems. The purpose of these systems is to provide protection and enhance the structural behaviour during seismic events.

Viscous damper: While originally used in military and aerospace applications, dampers have increasingly been employed in structural work in recent years. Typically composed of a piston and silicone oil, these dampers consume energy by facilitating the movement of the piston within the fluid.

$F= CV^{\alpha}$

F= Damping forced
C= Damping Constant
V= Velocity
α = Velocity exponent


Figure 1: Viscous damper

II. LITERATURE REVIEW

In a 2020 study by Kirtikumar K. Prajapati and Prof. Arjun M. Butala, reinforced concrete structures with viscous dampers were analyzed using Elcentro Earthquake Time History and ETABS software. Five building models were examined, each with different numbers of viscous dampers on various floors. The results showed that buildings with dampers installed at all floors had reduced displacement, story drift, base shear, and column forces compared to the other buildings.

In a 2017 study by M. Landge and P. Joshi, a G+7 floor R.C.C. building was examined using different types of dampers. ETABS 2015 software was employed, and earthquake loads were applied based on IS 1893-2002 Part 1 for Zone-4. The study aimed to identify the most suitable damper type for effective earthquake resistance. The results showed that viscous dampers resulted in the lowest lateral deflection, storey drift, and storey shear among the tested damper types.

III. OBJECTIVES

- To study the behaviour of building with different arrangement of dampers with Bhuj and Elcentro earthquake time history.
- Study of results in terms of displacement, story drift and base reaction.
- To study how dampers affect the seismic response of a frame structure.

IV. DATA OF THE BUILDING

- Analysis of G+11 building with damper and without damper
- The Bhuj Earthquake data have taken

Table 1: Data of the building

Building	G+11
Height of the building	36 Meter
Number of bay	5 x 4
Spacing of bay	5 meter
All storey height	3 meter
Ground floor Column size	700 mm x 700 mm
Column size	600mm x 600mm
Beam size	230mm x 600mm
Slab thickness	150mm
Live load	3 kN/m^2
Glass load periphery	7.3 kN/m

Glass load parapet	2.5 kN/m

- Damper property taken from the Taylor device guide line.

Table 2: Damper property

Force	500 kN
Weight	98 g

4.1 Model 1 – Bhuj building analysis without dampers

- Building without damper

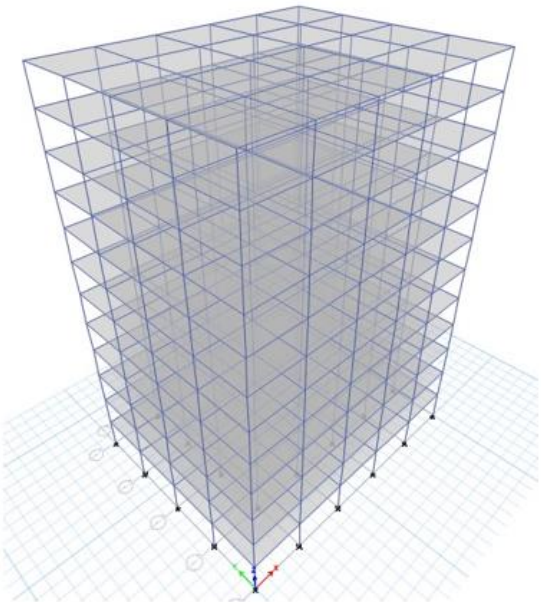


Figure 2 : 3D view of model 1

4.2 Model 2 – Bhuj building analysis with dampers

- Number of damper use – 30

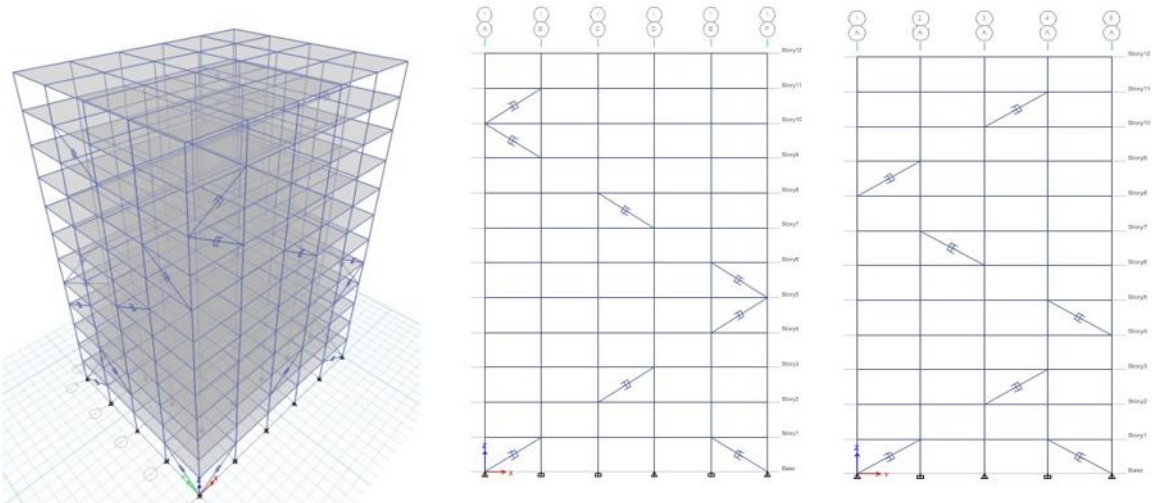


Figure 3 : 3D & elevation view of model 2

4.3 Model 3 – Bhuj building analysis with dampers

- Number of damper use – 30

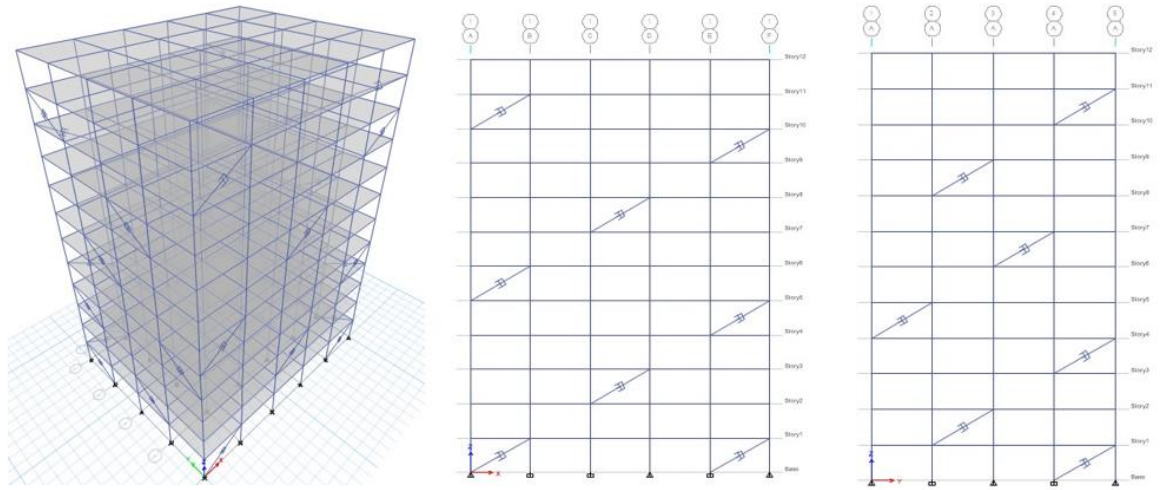


Figure 4 : 3D & elevation view of model 3

4.4 Model 4 – Bhuj building analysis with dampers

- Number of damper use – 30

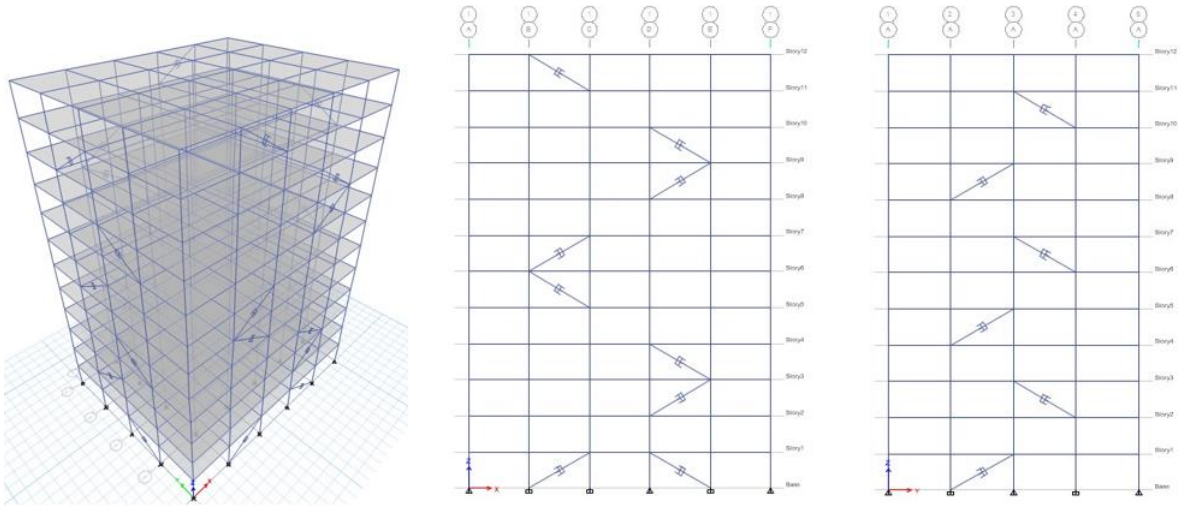


Figure 5 : 3D & elevation view of model 4

4.5 Model 5 – Bhuj building analysis with dampers

- Number of damper use – 30

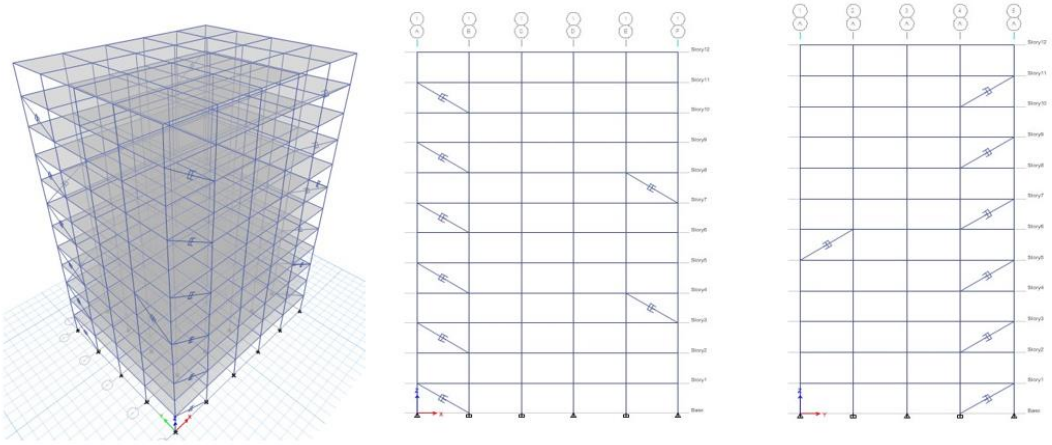


Figure 6 : 3D & elevation view of model 5

4.6 Model 6 – Bhuj building analysis with dampers

- Number of damper use – 30

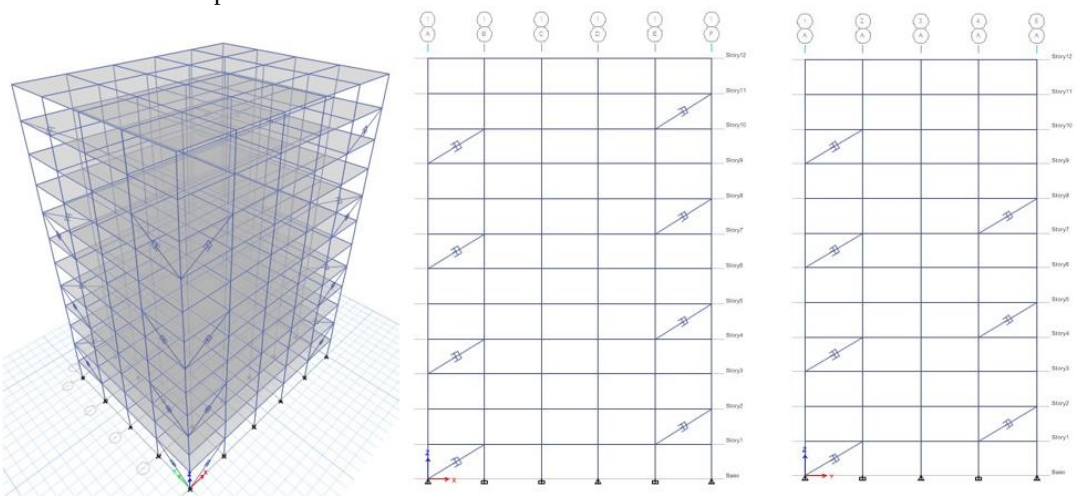


Figure 7 : 3D & Elevation view of model 6

4.7 Model 7 – Bhuj building analysis with dampers

- Number of damper use – 30

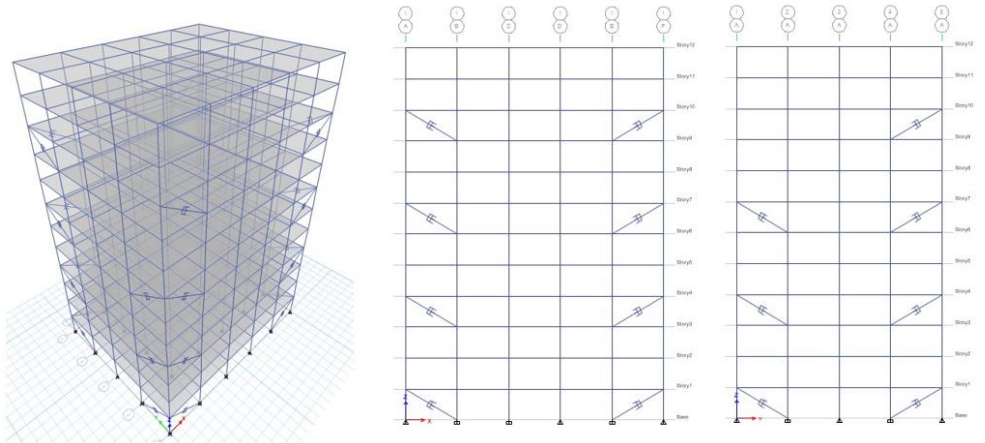


Figure 7 : 3D & elevation view of model 7

V. RESULT AND DISCUSSION

The research study aimed to analyze the behavior of an RCC structure with and without viscous dampers under seismic loads. Bhuj earthquake records were used for the analysis using the ETABS software. The study compared the results of displacement, story drift, and base reactions between the structure with and without dampers.

5.1 Result comparing in term of displacement

- X –direction

Table 3 : Bhuj displacement data of all models in X - direction

Bhuj displacement in X - direction									
Story	Elevation	Location	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	m		mm	mm	mm	mm	mm	mm	mm
12	36	Top	52.857	33.04	32.65	36.893	38.159	38.516	38.529
11	33	Top	51.192	31.025	30.831	34.611	35.84	35.897	36.412
10	30	Top	48.614	29.111	28.866	31.586	32.562	32.404	33.741
9	27	Top	45.138	26.908	25.936	27.89	28.454	28.675	31.18
8	24	Top	40.898	23.017	21.786	24.43	24.936	24.032	26.779
7	21	Top	36.047	20.081	18.719	20.132	22.271	20.592	22.403
6	18	Top	30.73	15.904	14.406	17.409	18.613	17.006	20.087
5	15	Top	25.078	13.305	12.232	14.006	13.574	11.886	15.102
4	12	Top	19.214	10.251	9.713	9.059	10.186	8.958	10.339
3	9	Top	13.276	5.69	5.732	6.631	8.018	6.281	8.798
2	6	Top	7.497	3.614	3.978	4.016	5.314	1.873	4.152
1	3	Top	2.537	0.282	0.31	0.62	1.197	0.527	0
0	0	Top	0	0	0	0	0	0	0

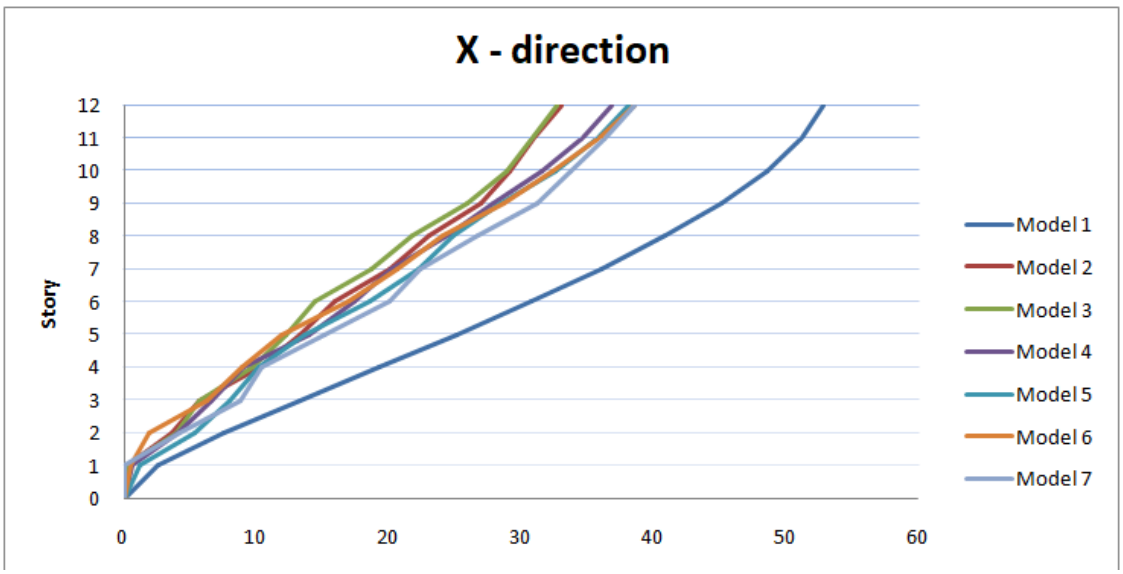


Figure 8 : Comparison of story displacement of all models in X - direction

- Y – direction

Table 4 : Bhuj displacement data of all models in Y - direction

Bhuj displacement in Y - direction									
Story	Elevation	Location	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	m		mm	mm	mm	mm	mm	mm	mm
12	36	Top	56.097	27.132	26.908	34.144	40.527	37.742	40.629
11	33	Top	54.28	25.407	25.252	32.237	38.127	35.002	38.326
10	30	Top	51.51	24.576	24.112	29.854	34.771	31.355	35.414
9	27	Top	47.797	21.801	20.669	25.87	30.713	27.717	32.547
8	24	Top	43.281	19.79	18.511	23.035	27.051	23.209	27.839
7	21	Top	38.124	16.185	14.709	18.979	22.292	19.951	23.246
6	18	Top	32.478	14.996	13.248	16.734	18.631	16.472	20.889
5	15	Top	26.484	11.466	9.218	11.963	16.601	11.475	15.696
4	12	Top	20.273	9.474	7.523	9.293	13.101	8.682	10.731
3	9	Top	13.993	4.965	5.997	5.749	8.308	6.091	9.161
2	6	Top	7.898	3.767	1.725	3.766	5.39	1.8	4.328
1	3	Top	2.684	0.069	0.323	0.475	1.333	0.522	0
0	0	Top	0	0	0	0	0	0	0

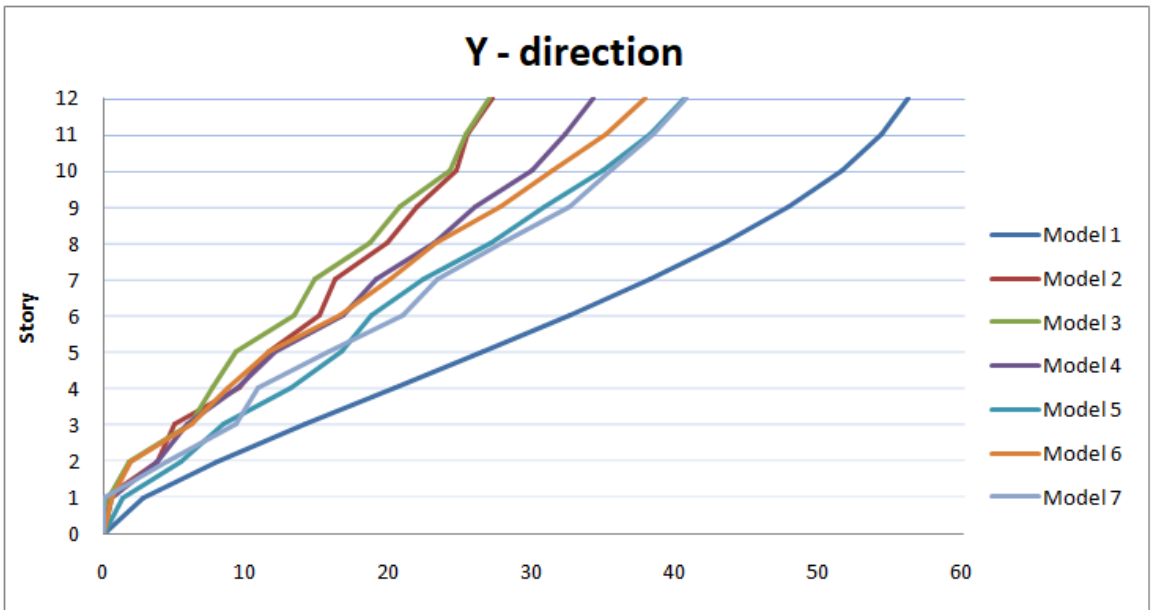


Figure 9 : Comparison of story displacement of all models in Y - direction

5.2 Result comparing in term of drift

- X – direction

Table 5 : Bhuj story drift data of all models in X - direction

Bhuj drift in X - direction									
Story	Elevation	Location	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	m								
12	36	Top	0.000555	0.000722	0.000739	0.000786	0.00091	0.000873	0.000706
11	33	Top	0.000859	0.000853	0.000884	0.001057	0.001322	0.001164	0.00089
10	30	Top	0.001159	0.000766	0.000977	0.001232	0.001532	0.001243	0.000854
9	27	Top	0.001413	0.001297	0.001383	0.001154	0.001326	0.001547	0.001467
8	24	Top	0.001617	0.001107	0.001022	0.001516	0.000942	0.001147	0.001459
7	21	Top	0.001772	0.001519	0.001438	0.0011	0.001256	0.001195	0.000772
6	18	Top	0.001884	0.001084	0.000791	0.001134	0.00168	0.001707	0.001662
5	15	Top	0.001955	0.001018	0.00084	0.001649	0.00113	0.000976	0.001588
4	12	Top	0.00198	0.00152	0.001413	0.001092	0.000723	0.000893	0.000514
3	9	Top	0.001926	0.000692	0.000776	0.000932	0.000901	0.001469	0.001549
2	6	Top	0.001653	0.001113	0.001223	0.001224	0.001373	0.000449	0.001384
1	3	Top	0.000846	0.000094	0.000103	0.000207	0.000399	0.000176	0.0013
0	0	Top	0	0	0	0	0	0	0

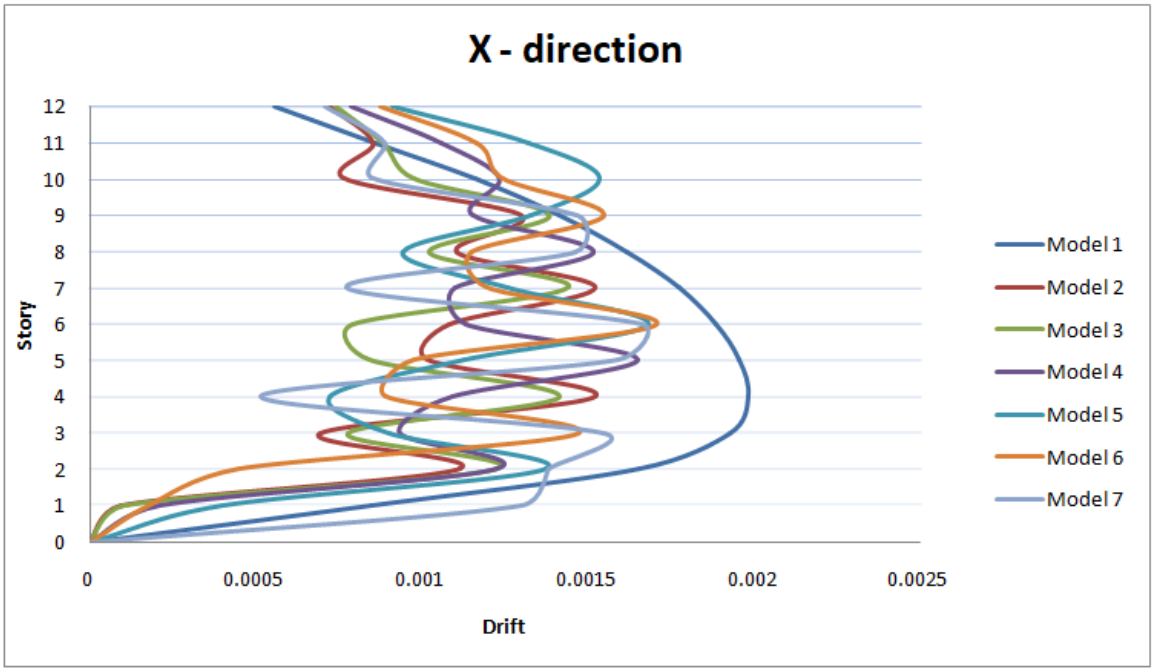


Figure 10 : Comparison of story drift of all models in X - direction

- Y – direction

Table 6 : Bhuj story drift data of all models in Y - direction

Bhuj drift in Y - direction									
Story	Elevation	Location	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	m								
12	36	Top	0.000606	0.000637	0.000718	0.000668	0.00097	0.000913	0.000768
11	33	Top	0.000923	0.000546	0.000666	0.000855	0.001404	0.001216	0.000971
10	30	Top	0.001238	0.000964	0.001148	0.001328	0.001556	0.001213	0.000956
9	27	Top	0.001505	0.00067	0.000719	0.000945	0.00141	0.001503	0.001569
8	24	Top	0.001719	0.001362	0.001267	0.001457	0.001654	0.001086	0.001531
7	21	Top	0.001882	0.000555	0.000487	0.000988	0.001264	0.00116	0.000786
6	18	Top	0.001998	0.001449	0.001427	0.00159	0.000677	0.001666	0.001731
5	15	Top	0.00207	0.000664	0.000565	0.00089	0.001166	0.000931	0.001655
4	12	Top	0.002093	0.001503	0.000616	0.001535	0.001598	0.000864	0.000523
3	9	Top	0.002032	0.000399	0.001663	0.000736	0.000973	0.00143	0.001611
2	6	Top	0.001738	0.001235	0.000467	0.001212	0.001352	0.000426	0.001443
1	3	Top	0.000895	0.000023	0.000108	0.000158	0.000444	0.000174	0.00135
0	0	Top	0	0	0	0	0	0	0

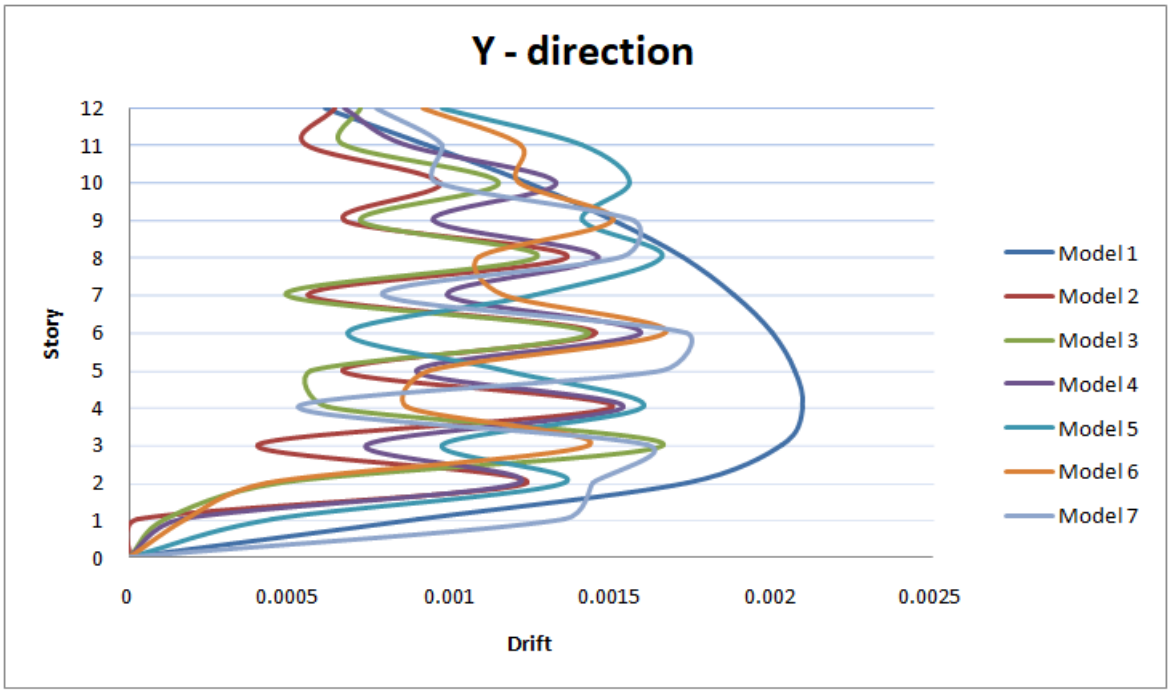


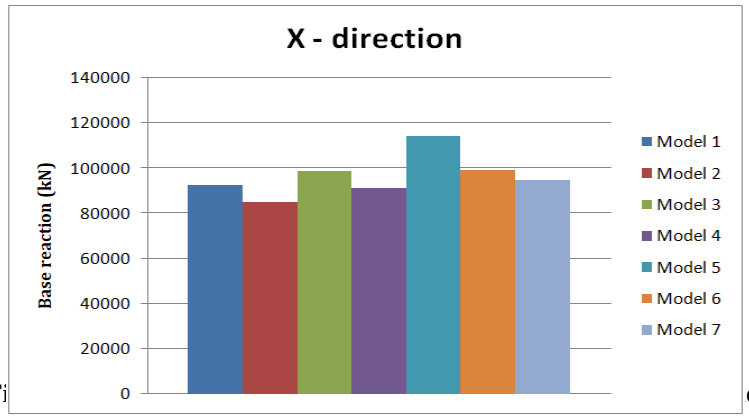
Figure 11 : Comparison of story drift of all models in Y - direction

5.3 Result comparing in term of base reaction

- X – direction

Table 7 : Bhuj base reaction data of all models in X - direction

Bhuj base reaction in X - direction						
Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
kN	kN	kN	kN	kN	kN	kN
92657.1	84897.91	98613.96	91135.371	114477.8	99224.15	94676.04



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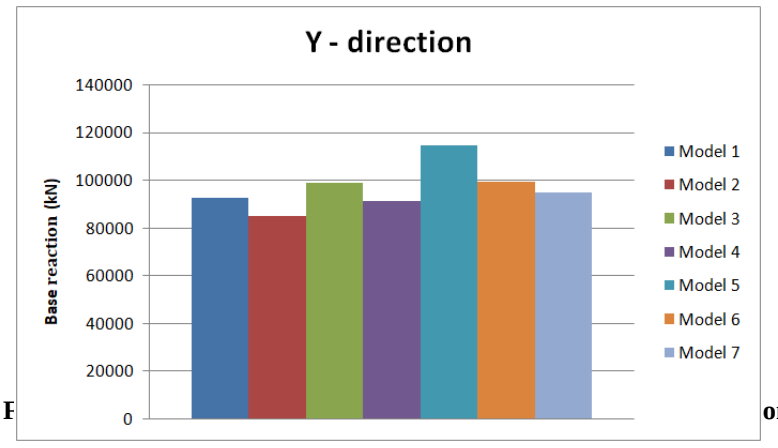
- Y – direction

Table 8 : Bhuj base reaction data of all models in Y - direction

Bhuj base reaction in Y- direction						
Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
kN	kN	kN	kN	kN	kN	kN
92657.1	84994.39	98635.955	91249.72	114554.6	99238.08	94677.21



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VI. CONCLUSION

From the comparison of current study, following conclusion considered:

1. From the different orientation of damper in different floors and different places in building as compare to building without damper there is decreasing in displacement but in model 2, model 3 almost received the same and less displacement as compare to model 1, 4, 5, 6, 7 from the analysis of Bhuj earthquake time history data.
2. In buildings where dampers are installed with various orientations on different floors and locations, there is a noticeable reduction in story drift compared to buildings without dampers. However, when analyzing the effects of Bhuj earthquake using different models (model 2, model 3), it is observed that these models consistently exhibited similar and minor story drift compared to model 1, 4, 5, 6, 7.
3. It is observed that the model 2 has received minimum base reaction and in model 5 received maximum base reaction as compare to model 1, 3, 4, 6, 7, from the analysis of Bhuj earthquake time history data.
4. In overall study, the installation of dampers with different orientations in various locations within a building leads to decrease in displacement and story drift. The analysis of Bhuj earthquake using different models (model 2, model 3) consistently showed similar and reduced displacements and story drift compared to other models (model 1, 4, 5, 6, 7).

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