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Seismic Effect of RCC Building Control by Viscous Damper

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Abstract

Structures are particularly outlined to resist the strengths produced by seismic tremors, depending on a combination of quality, deformability, and vitality assimilation. These powers can cause noteworthy changes in displacement, story drift, and base responses, possibly coming about in harm or indeed collapse of the building. To neutralize these seismic powers, different frameworks are accessible for basic resistance. In this inquire about ponder, the center was on examining an RCC structure prepared with thick dampers One such system is the passive system, which utilizes mechanical devices like dampers to mitigate earthquake effects. In this research study, the focus was on analyzing an RCC structure equipped with dampers. The objective was to assess the behaviour of the structure under seismic loads by applying earthquake time history analysis using Ahmedabad and E1Centro earthquake records within the ETABS software. Through this analysis, the think about pointed to supply experiences into the execution of the RCC structure with thick dampers, particularly in terms of relocation, story float, and base responses.

Keywords: *Fluid Viscous Damper, E-tab, Seismic Effect*

1. Introduction

When designing structures in earthquake-prone areas, it is crucial to consider seismic loads alongside gravity-related loads. Seismic design principles emphasize that structures must withstand the forces generated by earthquakes. The objective of structural design in earthquake-prone regions is to ensure resilience against seismic forces by leveraging strength, deformability, and energy absorption. An effective strategy involves distributing seismic energy throughout the structure. When lateral forces act upon the building, the structure absorbs this energy, converting it into kinetic and potential energy that must be dissipated, often in the form of heat. To enhance a structure's performance and mitigate the detrimental effects of seismic activity, engineers incorporate supplemental damping devices. These devices absorb energy from earthquake forces, thereby improving the overall seismic resilience of the structure. The gridline spacing is 4 m on both sides, and each story has a height of 3 m.

1.1. Structural Control Response System

The adoption of structural control response systems is intended to mitigate structural damage and manage the response of buildings. These systems, alternatively referred to as earthquake protective systems, have progressed to encompass active, passive, and semi-active systems. Their primary objective is to safeguard structures and improve their performance during seismic events. Active systems typically employ sensors and actuators to actively counteract seismic forces in real-time. Passive systems, on the other hand, utilize devices like base isolators or dampers to dissipate energy and reduce the seismic response of structures. Semi-active systems combine aspects of both active and passive systems, adjusting their characteristics based on real-time feedback. Overall, these earthquake protective systems play a crucial role in enhancing structural safety and resilience, ensuring that buildings can withstand seismic forces and minimize potential damage. [1]

1.2. Passive system

The advantage of this system is that it operates without the need for external power and transfers forces generated in response to building motion. The system's functioning involves sending signals to the control device, which measures the response.

1.3. Active System

The operation of this system relies on an external power source to control the actuator, which is used to both dissipate and add energy to the structure. The system's functioning involves sending signals to the control device, which measures the response of the system through physical sensors.

1.4. Semi-Active System

The system integrates both active and passive elements and operates with a minimal external power source. In certain scenarios, battery power alone can be sufficient. In the event of a power failure in the building during an earthquake, the system can continue operating using battery power. [2]

1.5. Hybrid System

The hybrid control system combines features from both active and passive control systems. During an earthquake, if there is a loss of electric power, the hybrid control system can function as a control system. [3]

1.6. Viscous Damper

Initially developed for military and aerospace applications, dampers have gained traction in structural engineering in recent times. These devices typically consist of a piston mechanism immersed in silicone oil, designed to absorb energy by allowing controlled movement of the piston through the fluid.

2. Objective of Work

To study the behaviour of building with different arrangement of dampers with 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. Using this system for controlling displacement and reducing the effect of lateral forces in buildings.

3. Need for Study

- The installation of viscous dampers in structures reduces the vibrations caused by earthquakes.
- Using this system for controlling displacement and reducing the effect of lateral forces in buildings. and operates with a minimal external power source. Figure 1 shows the Viscous Damper.

Figure 1 Viscous Damper

4. Data of the Building

The subject of analysis is a 6-story reinforced concrete structure with a rectangular plan measuring 32 m x 32 m. The gridline spacing is 4 m on both sides, and each story has a height of 3 m. The total height of the structure is 18 m. Furthermore, the structure is analyzed using the time history data in ETABS software. Passive systems, on the other hand, utilize devices like base isolators or dampers to dissipate energy and reduce the seismic response of structures. [3] Semi-active systems combine aspects of both active and passive systems, adjusting their characteristics based on real-time feedback., converting it into kinetic and potential energy that must be dissipated, often in the form of heat. To enhance a structure's performance and mitigate the detrimental effects of seismic activity, engineers incorporate supplemental damping devices. These devices absorb energy from earthquake forces, thereby improving the overall seismic resilience of the structure. [4]

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4.1. Analysis of G+5 Building with Damper and Without Damper

Table 1 shows the Building Data

Table 1 Building Data

Floors	G+5
Total Height of the building	18 Meter
Grid layout	8 x 8
Spacing of layout	4 meters
Typical height of All story	3 meters
Ground floor Column size	300mm x 600mm
Column size	230mm x 600mm
Beam size	230mm x 600mm
Thickness of Slab	125mm
Live load (all floor)	3 kN/m^2
Glass load periphery	7.3 kN/m
Glass load parapet	2.5 kN/m

4.2. Damper Property

Table 2 Damper Property Data

Force	250kN
weight	44kg

- **Model 1 –** Ahmedabad building analysis without dampers
- **Model 2 –** Ahmedabad building Non-linear time history analysis with dampers in elevation A&E
- Number of damper use – 24

Figure 2 shows the model analysis without dampers. Figure 3 shows the model analysis with dampers in elevation A&E. This analysis was conducted using data from Ahmedabad and El centro earthquake time history, highlighting the effectiveness of strategically placed dampers in minimizing structural displacement during seismic events. In buildings equipped with dampers placed at various orientations across different floors and locations, there is a notable reduction in story drift compared to structures lacking dampers. When analyzing the impact of Ahmedabad and El centro earthquakes across different models (model 2, model 3, model 4, model B, model C Model D), it was consistently observed that these configurations exhibited minimal story drift. The gridline spacing is 4 m on both sides, and each story has a height of 3 m. The total height of the structure is 18 m. Furthermore, the structure is analyzed.

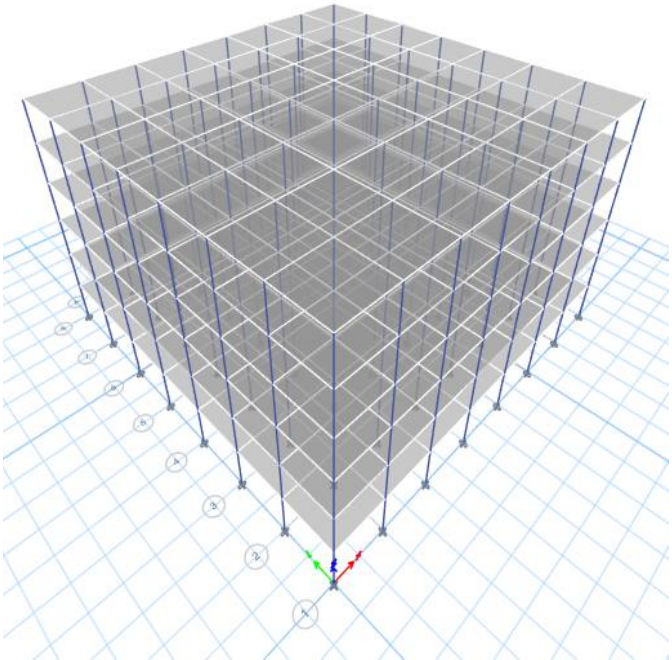

Figure 2 Model Analysis Without Dampers

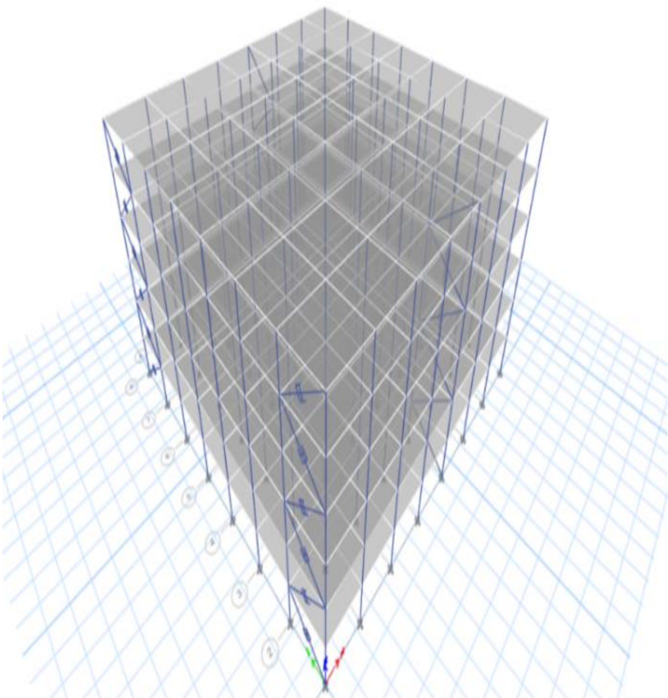

Figure 3 Model Analysis with Dampers in Elevation A&E

Model 3– Ahmedabad building Non-linear time history analysis with dampersin elevation A&H

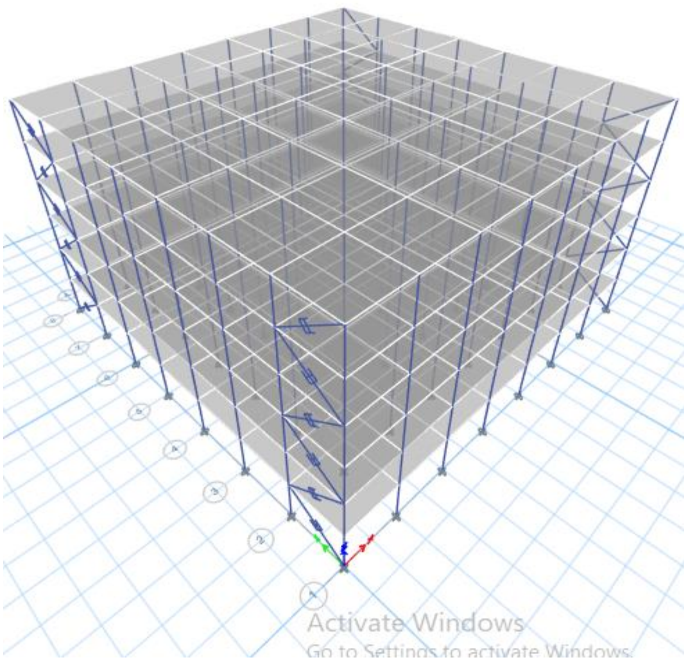

Figure 4 **Model Analysis with Dampers in Elevation A& H**

Number of dampers uses – 24. Figure 4 shows the model analysis with dampers in elevation A&E.

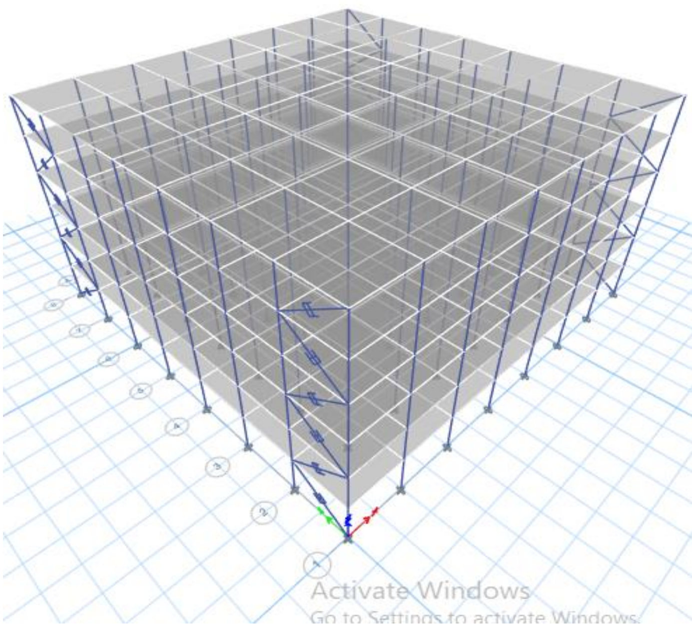

Figure 5 **Model Analysis with Dampers in Elevation A, E& H**

Model 4– Ahmedabad building Non-linear time history analysis with dampers in elevation A, E&H. Figure 5 shows the model analysis with dampers in elevation A, E& Number of dampers uses – 36

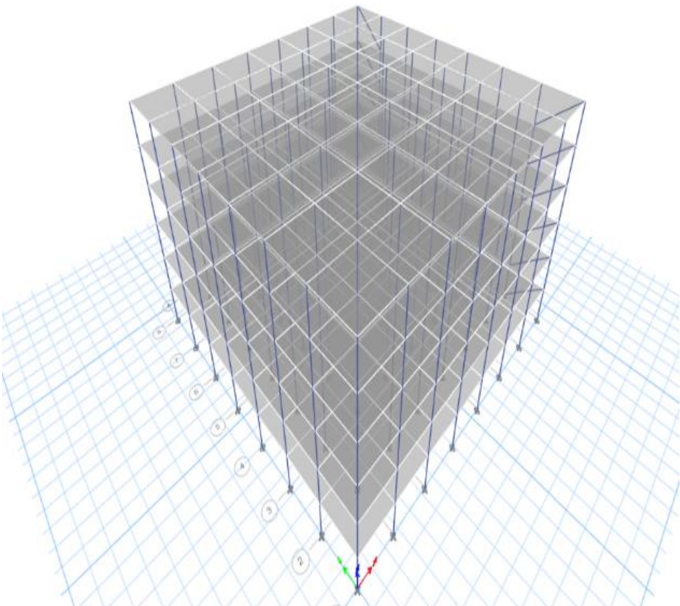

Figure 6 **Model Analysis with Dampers in Elevation A**

Model 6– Ahmedabad building Non-linear time history analysis with dampers in elevation. Figure 6 Shows the model analysis with damper elevation A Number of dampers uses – 12

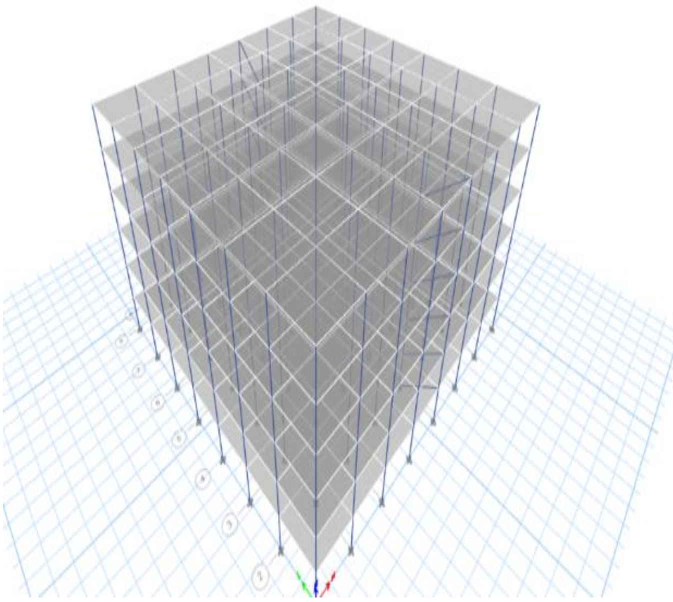

Figure 7 **Model Analysis with Dampers in Elevation E**

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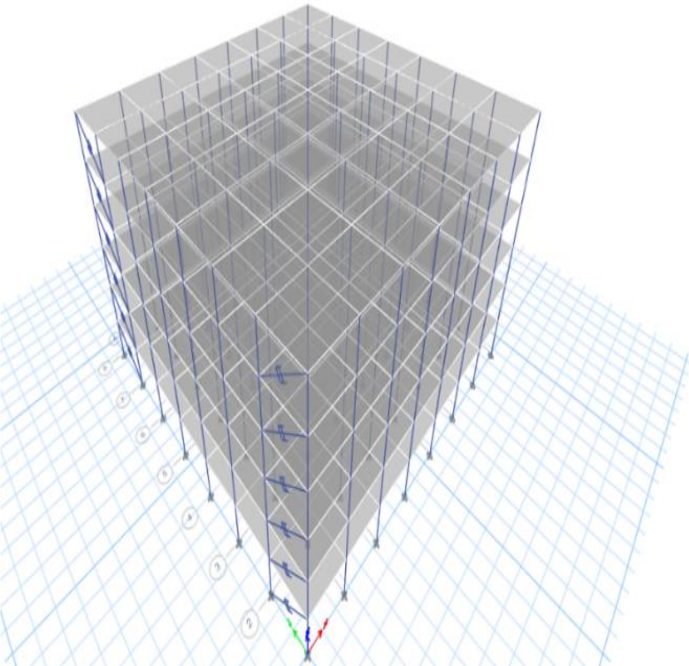

Figure 8 Model Analysis with Dampers in Elevation H

- **Model 7–** Ahmedabad building Non-linear time history analysis with dampers in elevation E
- **Model 8–** Ahmedabad building Non-linear time history analysis with dampers in elevation H
- Number of dampers uses – 12. Figure 7 shows the Model analysis with dampers in elevation E. Figure 8 shoes the Model analysis with dampers in elevation H. [5]

5. Results 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. [6]

6.Result Comparison of Ahmedabad and El Centro Models

6.1. Result Comparing in Term of Displacement

6.1.1. X – Direction

Table 3 Story Displacement Data of all Ahmedabad Model in X Direction

Ahmedabad 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
6	18	Top	15.365	7.952	7.203	8.704	9.306	8.503	10.043
5	15	Top	12.539	6.652	6.116	7.003	6.787	5.943	7.551
4	12	Top	9.607	5.125	4.856	4.529	5.093	4.479	5.169
3	9	Top	6.638	2.845	2.866	3.315	4.009	3.14	4.399
2	6	Top	3.748	1.807	1.989	2.008	2.657	0.936	2.076
1	3	Top	1.268	0.141	0.155	0.31	0.598	0.263	0
0	0	Top	0	0	0	0	0	0	0

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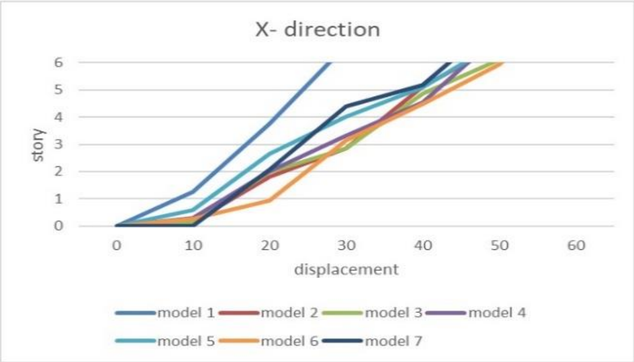

Figure 9 Story Displacement of Model 1 to 7 in X Direction

Table 3 shows the story displacement data of all Ahmedabad model in X direction. Figure 9 shows the story displacement of model 1 to 7 in X direction.

6.1.2. Y – Direction

Table 4 Story Displacement Data of all Ahmedabad Model in X direction

Ahmedabad 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
6	18	Top	16.239	7.498	6.624	8.367	9.315	8.236	10.444
5	15	Top	13.242	5.733	4.609	5.981	8.30	5.737	7.848
4	12	Top	10.136	4.737	3.761	4.646	6.55	4.341	5.365
3	9	Top	6.996	2.482	2.998	2.874	4.154	3.045	4.58
2	6	Top	3.949	1.883	0.862	1.883	2.695	0.9	2.164
1	3	Top	1.342	0.0345	0.161	0.2375	0.666	0.261	0
0	0	Top	0	0	0	0	0	0	0

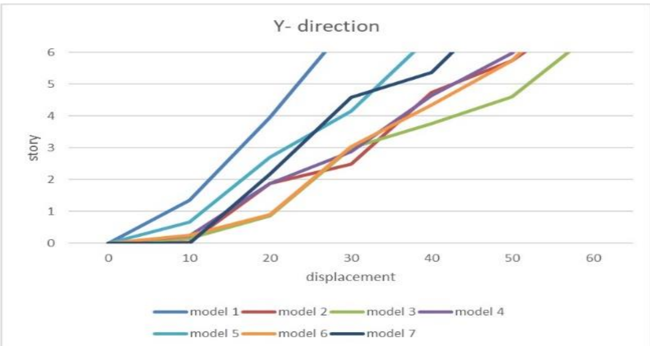

Figure 10 Story Displacement of Model 1 to 7 in Y Direction

Table 4 shows the story displacement data of all Ahmedabad in X direction. Figure 10 shows the story displacement of model 1 to 7 in Y direction. [7]

6.2. Result comparing in term of drift

6.2.1. X –Direction

Table 5 Story Drift Data of all Ahmedabad Model in X direction

Ahmedabad drift in X - direction									
Story	Elevation	Location	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	m								
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

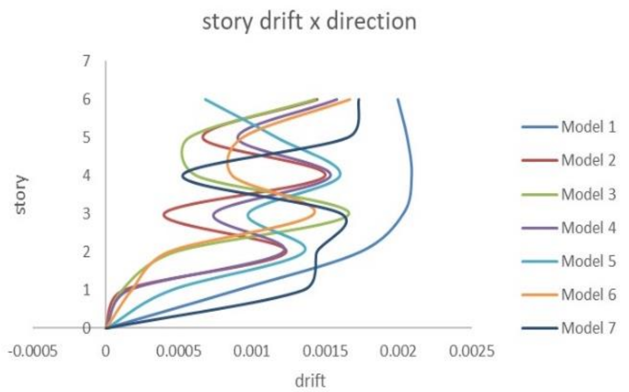

Figure 11 Story Drift of Model 1 to 7 in X Direction

Figure 11 shows the story drift of Model 1 to 7 in X direction. Table 5 shows the story drift of all Ahmedabad model in X direction

6.2.2. Y–Direction

Table 6 Story Drift Data of all Ahmedabad Model in Y direction

Ahmedabad drift in Y - direction									
Story	Elevation	Location	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	m								
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

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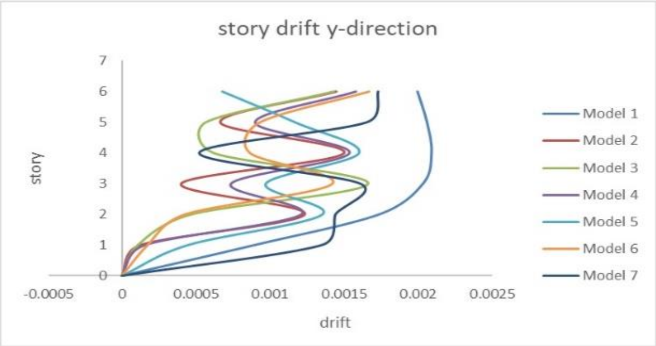

Figure 12 Story Drift of Model 1 to 7 in Y Direction

Table 6 shows the story drift data of all Ahmedabad model in Y direction. Story drift of model 1 to 7 in Y direction.

6.3. Result comparing in term of base reaction

6.3.1. X –Direction

Table 7 Base reaction Data of all Ahmedabad Model in X Direction

Ahmedabad 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
46328.5	42448.9	49307	45567.6	57239	49612	47338

Table 7 shows the Base reaction data of all Ahmedabad model in X direction. Figure 13 shows the base reaction of Model 1 to 7 in X direction.

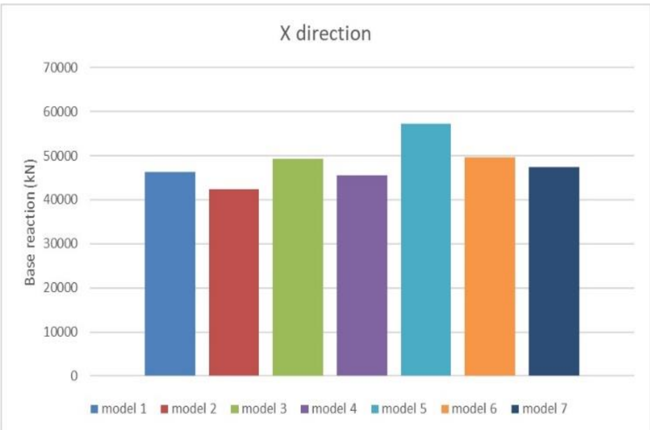

Figure 13 Base Reaction of Model 1 To 7 In X Direction

6.3.2. Y–direction

Table 8 Base Reaction Data of all Ahmedabad Model in Y Direction

Ahmedabad 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
46328.5	42497.2	49317.9	45624.8	57277.5	49619	47338.6

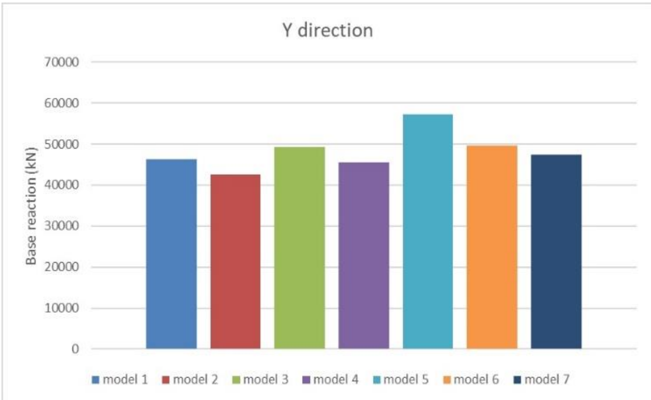

Figure 14 Base Reaction of Model 1 To 7 In Y Direction

Table 8 shows the base reaction data of all Ahmedabad Model in Y direction. Figure 14 shows the base reaction of model 1 to 7 in Y direction.

7. Discussion

Comparative study of building without damper, with damper in different orientation with Ahmedabad and Elcentro earthquake acceleration data & comparing the result in terms of displacement, story drift and base reaction. [8]

Conclusion

From the comparison of current study, following conclusion considered: In comparing building models equipped with dampers in various orientations across different floors and locations to those without dampers, it was observed that models 2, 3, 4 and B exhibited significantly reduced displacement. Specifically, these models showed comparable and generally lower displacement compared to models 1, 5, 6, and 7, as well as models

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A, D, E, F, and G. This analysis was conducted using data from Ahmedabad and El centro earthquake time history, highlighting the effectiveness of strategically placed dampers in minimizing structural displacement during seismic events. In buildings equipped with dampers placed at various orientations across different floors and locations, there is a notable reduction in story drift compared to structures lacking dampers. When analyzing the impact of Ahmedabad and El centro earthquakes across different models (model 2, model 3, model 4, model B, model C Model D), it was consistently observed that these configurations exhibited minimal story drift. In contrast, models 1, 5, 6, and 7, as well as models A, E, F, and G, showed higher levels of story drift. This assessment underscores the effectiveness of strategically positioned dampers in mitigating structural displacement during seismic events, thereby enhancing building resilience and safety. In the analysis of El centro earthquake time history data, it was observed that in model 2, 4 model B, D exhibited the lowest base reaction among the various models studied. Conversely, in model 5, model E showed the highest base reaction compared to model 1, 3,6, and 7, as well as models A, C, F, and G. This comparison highlights the variability in base reactions across different structural models equipped with dampers, underscoring the influence of damper placement and orientation on mitigating seismic forces and stabilizing building foundations. [9]

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