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Comparison of Bracings and Fluid Viscous Dampers in 15-Storey Buildings across All Seismic Zones of India under Bi-Directional Excitation

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***Abstract:** An earthquake is a natural phenomenon i:e, sudden horizontal movement of earth's crust that causes sudden collapse of buildings and other structures such as large monuments, bridges etc. The damage of the building is based on the amount of magnitude and intensity of the earthquake. A building can withstand in lower intensity of earthquake. But higher intensity causes lots of damages on building or a building can suddenly collapse and causes increase in number of deaths. To mitigate these effects a control system is to be provided such as base isolations, dampers, bracings etc. The current topic is based on the behavior of linear and non linear fluid viscous damper provided at center and both side corners of 15 Storey RC building in diagonally bracing system. The building is modeled and analyzed by using ETABS software. Here IS 1983(part1): 2002 and medium soil type are to be considered for analysis with respect to all seismic zones (zone II - zone V) of India. Here linear static and response spectrum analysis are applied in each model. Results are to be drawn based on base shear, storey displacement and storey drift to understand how fluid viscous dampers helps to reduce the effects of earthquake.*
***Keywords:** Fluid viscous dampers (FVD), bracings, linear static, response spectrum, linear and non linear FVD*

I. INTRODUCTION

Fluid viscous dampers are the passive energy dissipation device which is provided in buildings to mitigate the effects caused by the earthquake. A fluid viscous damper consists of a cylinder filled with silicon oil, piston rod and orifice which is provided at piston head. When a building is subjected to seismic load, the piston rod which is provided in FVD moves against the fluid (silicon oil) and the fluid passes to another chamber of the cylinder through orifice. Since the silicon oil is thermal resistance, silicon oil reduces the effect of the heat due to the movement of the piston rod. Energy is dissipated by this mechanical function and this mechanical function creates resistance against the vibrations caused by the earthquake. The damping equation is given below.

$F = CV^{\alpha}$

Where:
F: damping force
C: coefficient of damping
V: velocity
α: Damping exponent

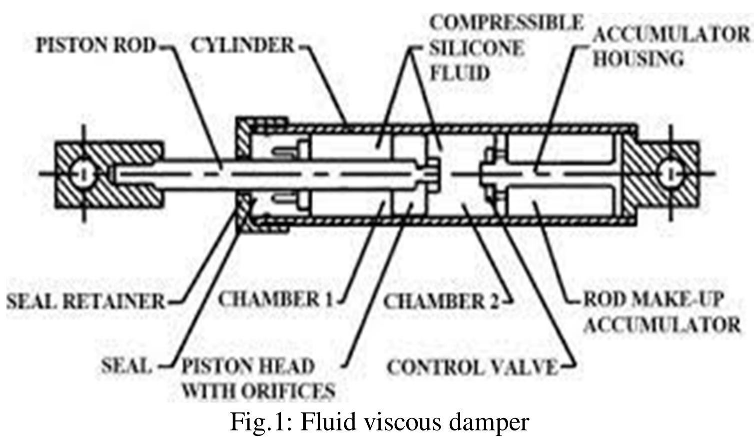

Fig.1: Fluid viscous damper

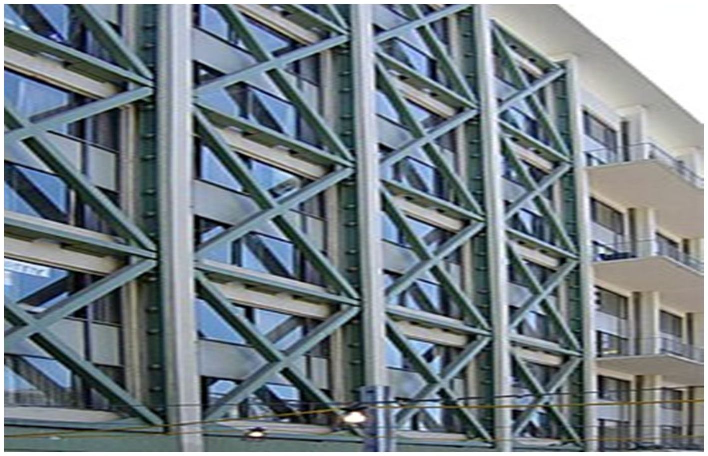

Fig.2: Multistory building provided with bracings

II. OBJECTIVES OF THE PROJECT:

1) To know about the performance of the building with and without conventional bracings and FVDs in all seismic zones (zone II – zone V) of India subjected to bi-directional excitation condition.
2) To understand the effectiveness of linear and non linear FVDs in resisting the seismic load on buildings during earthquake.

III. METHODOLOGY

1) Before starting the project various journals are referred and objectives are finalized and confirmed.
2) 4 No's 15 storey building models such as bare frame (building without any control systems), building with conventional bracings, building with linear FVDs (damper exponent = 0.3) and building with non linear FVD (damper exponent = 1.0) are carried out by using ETABS software.
3) Different loads such as dead load, live load, wind load and earthquake load as per Indian standards are adopted in analysis of the 15 storey models.
4) Linear static and response spectrum analysis are carried out in this project.
5) Results and conclusions are drawn with respect to displacement, base shear and storey drift.

IV. MODELING

A 15 storey reinforced cement concrete (RCC) building is analyzed by using ETABS software by applying linear static and response spectrum method. In this project all seismic zones of India are to be considered for analysis to determine the seismic response of building with bare frame, with bracings and with FVDs in all seismic zone condition.

Table 1: 15 storey model details:

Sl. No.	Description	Data
1.	Structure Length	36m
2.	Structure Width	36m
2.	Each Bay Width	6m
3.	Structure Height	52.5m
4.	Each Floor Height	3.5m
5.	Column Size used	For 15 storey model: 600x600mm - (1-5 Storey) 450x450mm - (6-10 Storey) 375x375mm - (11-15 Storey)

6.	Beam Size used	230x450mm
7.	Thickness of Roof	150mm
8.	Grade of Rebar (f_y)	HYSD500
9.	Bracing & Damper type	Single diagonal Bracing (Corner & Centre)
10.	Steel Brace Size used	RHS 525x375x9.2mm
11.	Grade of Steel (f_y) (for bracings)	Fe 250
12	Damper Model No	17140 (According to Taylor device company)

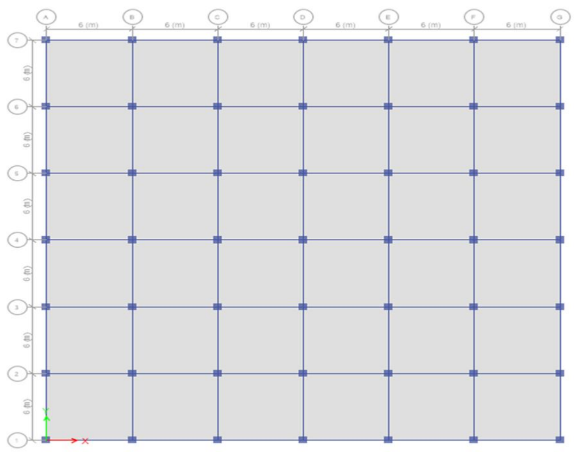

Fig.3: Plan view of 15 storey building

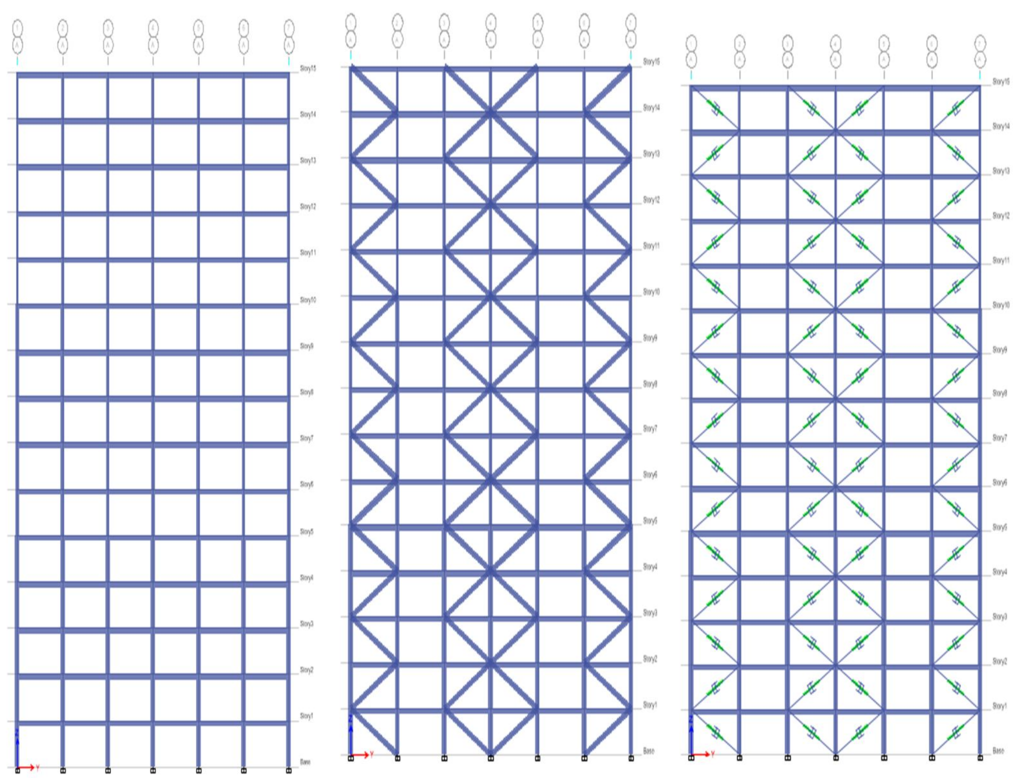

Fig.4: Elevation View of 15 Storey Building Models with Bare, Bracing & Damper

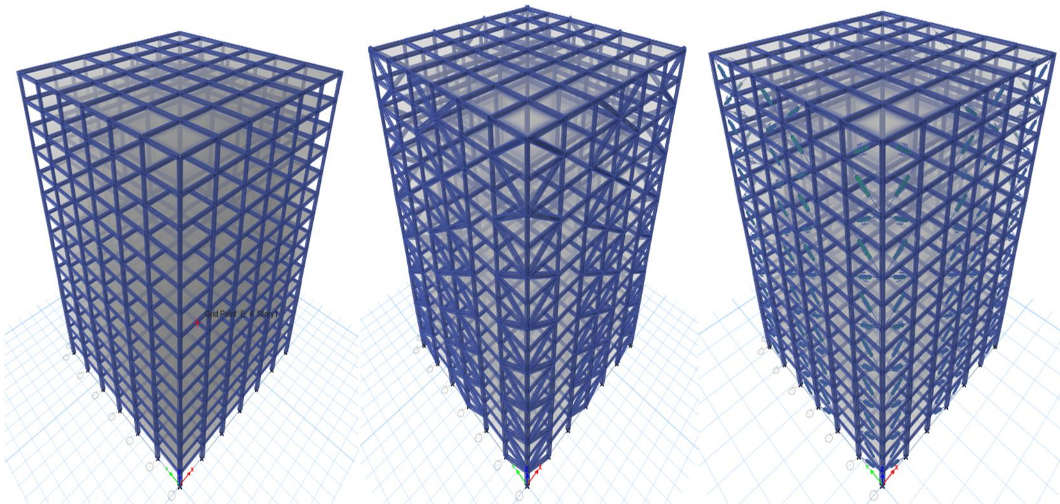

Fig.5: 3D View of 15 Storey Building Models with Bare, Bracing & Damper

V. RESULTS AND DISCUSSION

A. Displacement

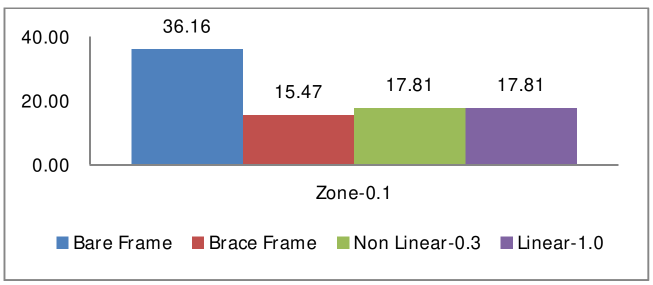

Fig.6: Effect of Equivalent Static Force (Zone-II) on Max Storey Displacement for Bare, Brace & Damper Frame15-Storey Model

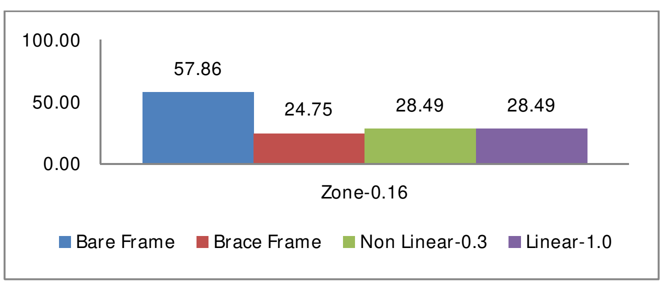

Fig.7: Effect of Equivalent Static Force (Zone-III) on Max Storey Displacement for Bare, Brace & Damper Frame15-Storey Model

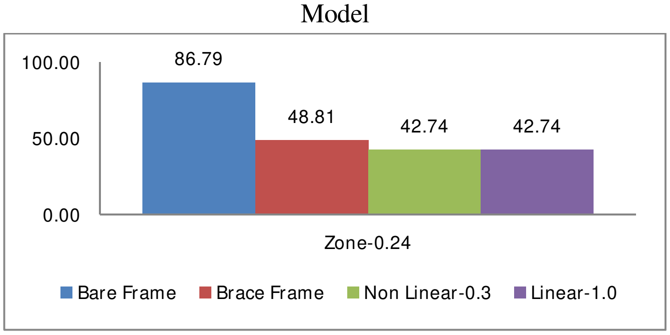

Fig.8: Effect of Equivalent Static Force (Zone-IV) on Max Storey Displacement for Bare, Brace & Damper Frame15-Storey Model

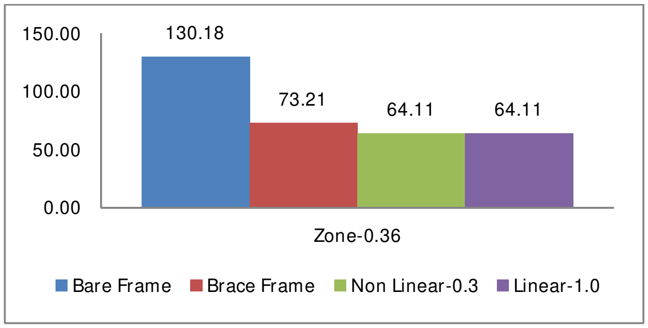

Fig.9: Effect of Equivalent Static Force (Zone-V) on Max Storey Displacement for Bare, Brace & Damper Frame15-Storey Model

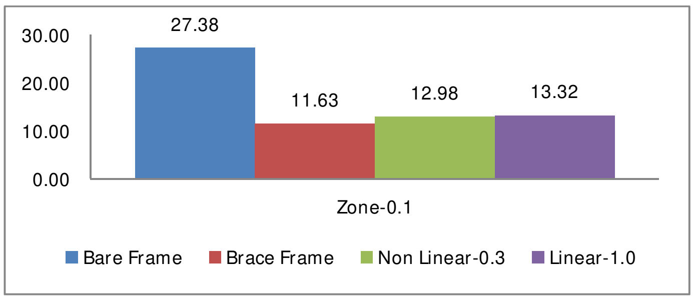

Fig.10: Effect of Response Spectrum Force (Zone-II) on Max Storey Displacement for Bare, Brace & Damper Frame 15-Storey Model

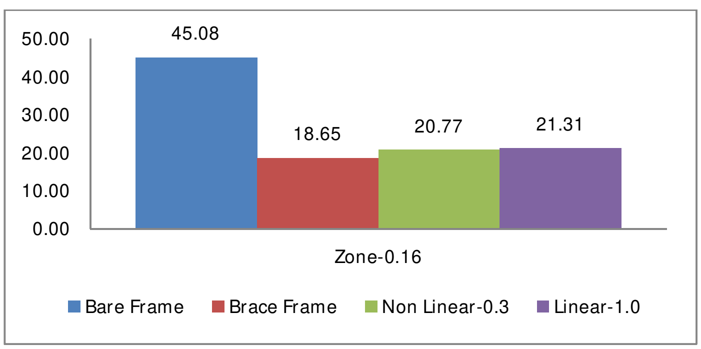

Fig.11: Effect of Response Spectrum Force (Zone-III) on Max Storey Displacement for Bare, Brace & Damper Frame 15-Storey Model

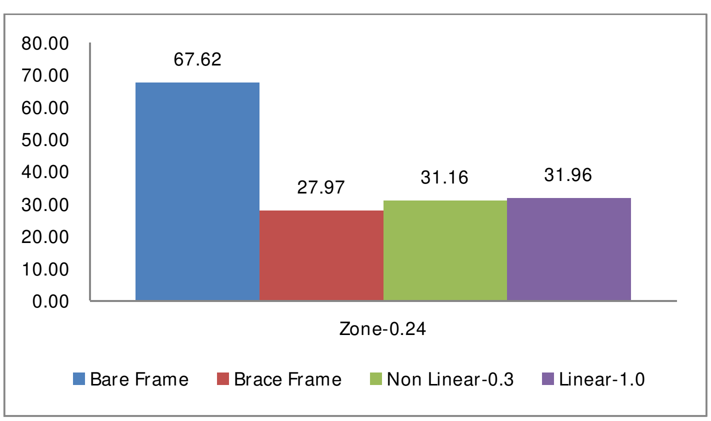

Fig.12: Effect of Response Spectrum Force (Zone-IV) on Max Storey Displacement for Bare, Brace & Damper Frame 15-Storey Model

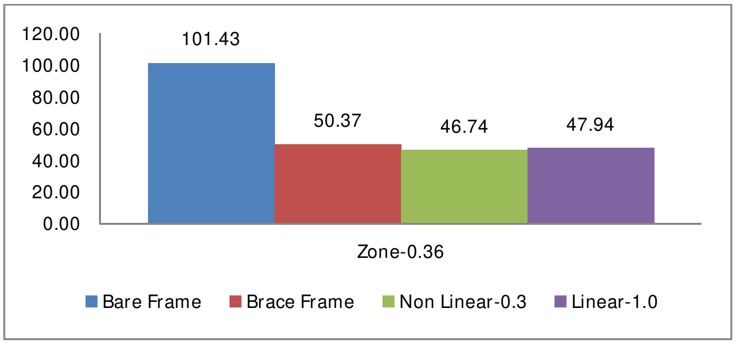

Fig.13: Effect of Response Spectrum Force (Zone-V) on Max Storey Displacement for Bare, Brace & Damper Frame 15-Storey Model

Table 2: Results of maximum displacement values of 15 storey model:

STOREY TYPE	STOREY DISPLACEMENT, mm								MODEL TYPE
	EQUIVALENT STATIC ANALYSIS				RESPONSE SPECTRUM ANALYSIS				
	SEISMIC ZONE				SEISMIC ZONE				
	0.1	0.16	0.24	0.36	0.1	0.16	0.24	0.36	
15-STOREY STRUCTURE	36.16	57.85	86.78	130.18	27.38	45.08	67.62	101.43	Model of Multi storey Structure With Bare Frame system
	15.47	24.74	48.80	73.20	11.62	18.64	27.96	50.37	Model of Multi storey Structure With Brace Frame system
	17.81	28.49	42.73	64.10	12.98	20.77	31.16	46.74	Model of Multi storey Structure With Non Linear Damper -0.3 Frame system
	17.81	28.49	42.73	64.10	13.31	21.30	31.95	47.93	Model of Multi storey Structure With Linear Damper -1.0 Frame system

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Comparing the Bare and Bracing frame configuration reveals a significant reduction in displacement, with a decrease of 53.92% compared to the bare framed structure. This implies that integrating bracing elements into the frame design stabilizes the structure, diminishing its overall movement. Conversely, in examining the Bare and Damper frame configuration, there's a decrease in displacement by 58.63% when compare to bare frame. This indicates that both bracings and dampers effectively control Storey displacement in this scenario, underscoring their role in mitigating structural movement and enhancing overall stability.

B. Base shear

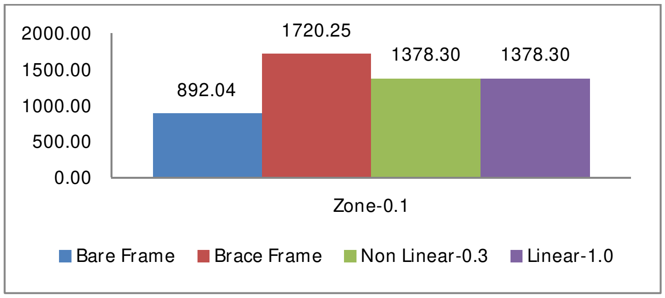

Fig.14: Effect of Equivalent Static Force (Zone-II) on Max Storey Shear for Bare, Brace & Damper Frame 15-Storey Model

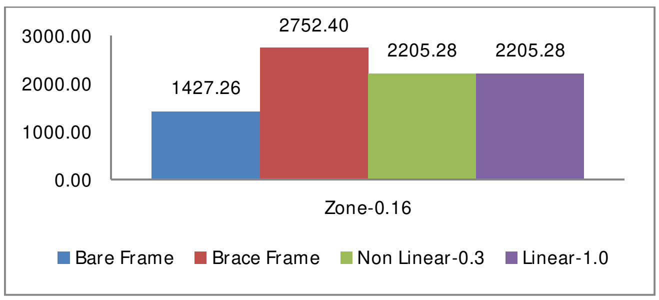

Fig.15: Effect of Equivalent Static Force (Zone-III) on Max Storey Shear for Bare, Brace & Damper Frame 15-Storey Model

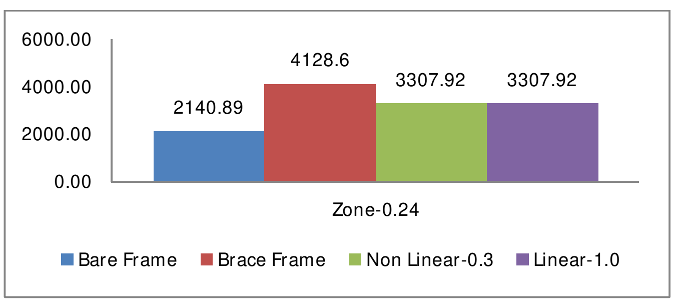

Fig.16: Effect of Equivalent Static Force (Zone-IV) on Max Storey Shear for Bare, Brace & Damper Frame 15-Storey Model

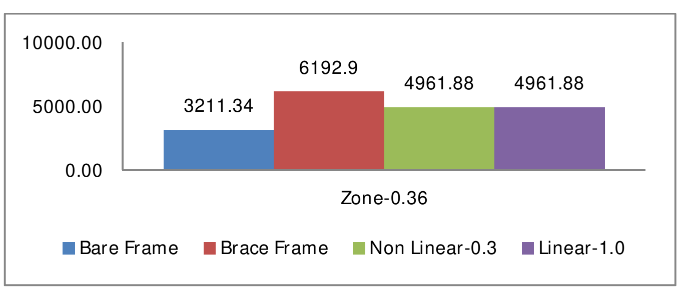

Fig.17: Effect of Equivalent Static Force (Zone-V) on Max Storey Shear for Bare, Brace & Damper Frame 15-Storey Model

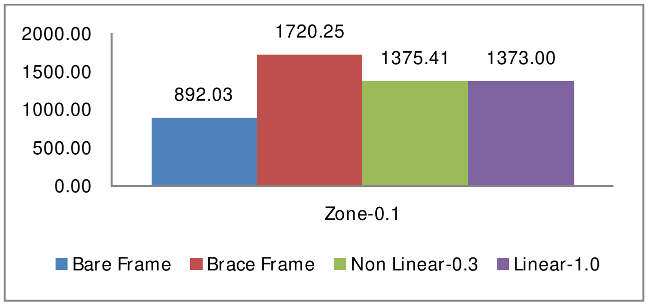

Fig.18: Effect of Response Spectrum Force (Zone-II) on Max Storey Shear for Bare, Brace & Damper Frame 15-Storey Model

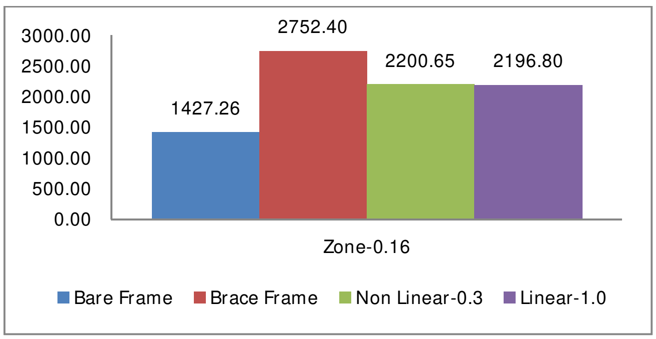

Fig.19: Effect of Response Spectrum Force (Zone-III) on Max Storey Shear for Bare, Brace & Damper Frame 15-Storey Model

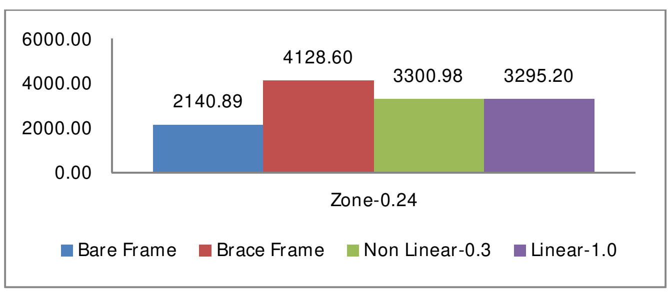

Fig.20: Effect of Response Spectrum Force (Zone-IV) on Max Storey Shear for Bare, Brace & Damper Frame 15-Storey Model

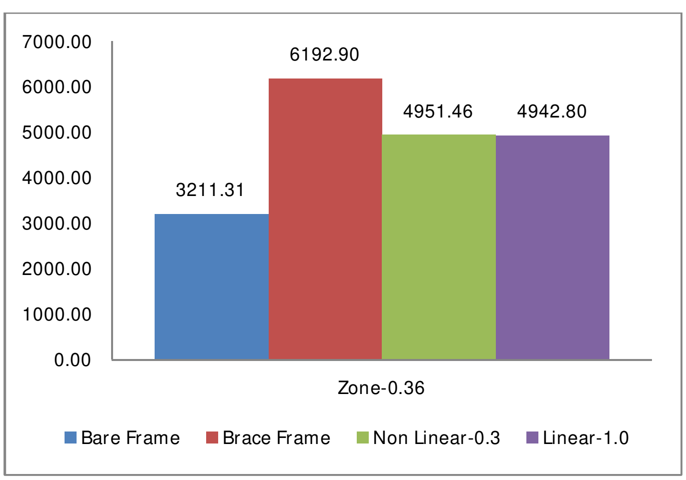

Fig.21: Effect of Response Spectrum Force (Zone-V) on Max Storey Shear for Bare, Brace & Damper Frame 15-Storey Model

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Table 3: Results of maximum base shear values of 15 storey model:

STOREY TYPE	BASE SHEAR (KN)								MODEL TYPE
	EQUIVALENT STATIC ANALYSIS				RESPONSE SPECTRUM ANALYSIS				
	SEISMIC ZONE				SEISMIC ZONE				
	0.10	0.16	0.24	0.36	0.10	0.16	0.24	0.36	
15-STOREY STRUCTURE	892.04	1427.26	2140.89	3211.34	892.03	1427.26	2140.89	3211.31	Model of Multi storey Structure With Bare Frame system
	1720.25	2752.40	4128.60	6192.90	1720.25	2752.40	4128.60	6192.90	Model of Multi storey Structure With Brace Frame system
	1378.30	2205.28	3307.92	4961.88	1375.41	2200.65	3300.98	4951.46	Model of Multi storey Structure With Non Linear Damper -0.3 Frame system
	1378.30	2205.28	3307.92	4961.88	1373.00	2196.80	3295.20	4942.80	Model of Multi storey Structure With Linear Damper -1.0 Frame system

In the case of the Bare and Bracing frame configuration, the results demonstrate a substantial increase of 48.14% in the base shear value compared to the bare frame alone, highlighting the impact of bracing on structural behavior. Similarly, in the scenario of the Bare and Damper frame, there's a significant rise of 35.28% in the base shear value compared to the bare frame, emphasizing the effectiveness of dampers in improving the structure's seismic performance. When comparing the results of the Bracing and Damper framed structures, it becomes evident that the Damper frame effectively controls the base shear, exhibiting a decrease of 24.81% compared to the Bracing frame alone. This underscores the crucial role dampers play in mitigating base shear forces during seismic events.

C. Storey drift

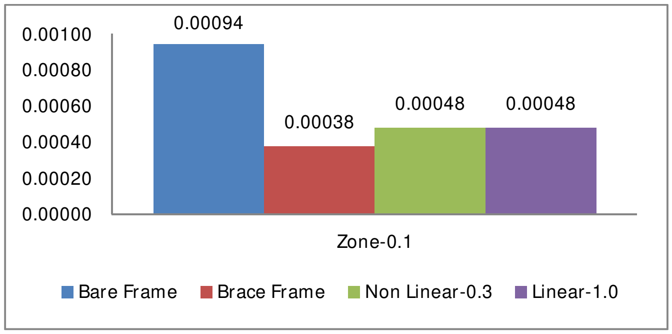


Fig.22: Effect of Equivalent Static Force (Zone-II) on Max Storey Drift for Bare, Brace & Damper Frame 15-Storey Model

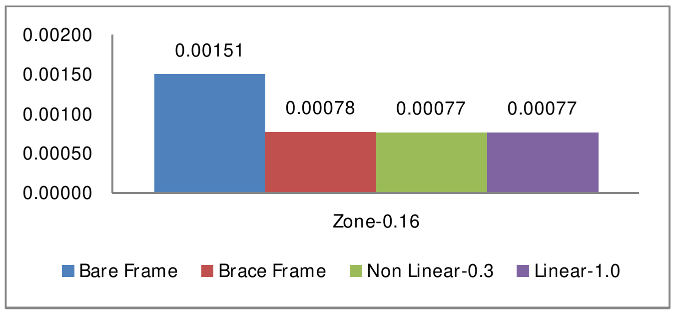


Fig.23: Effect of Equivalent Static Force (Zone-III) on Max Storey Drift for Bare, Brace & Damper Frame 15-Storey Model

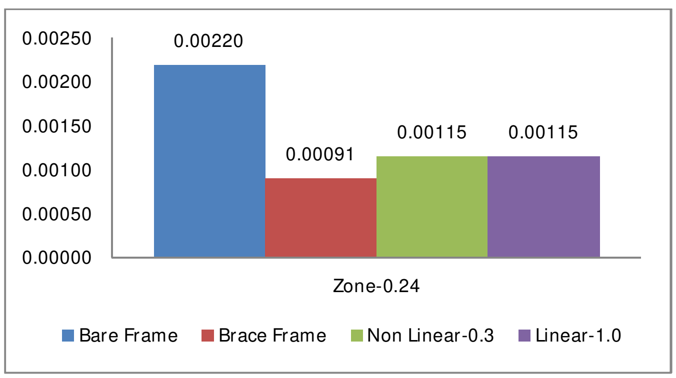


Fig.24: Effect of Equivalent Static Force (Zone-IV) on Max Storey Drift for Bare, Brace & Damper Frame 15-Storey Model

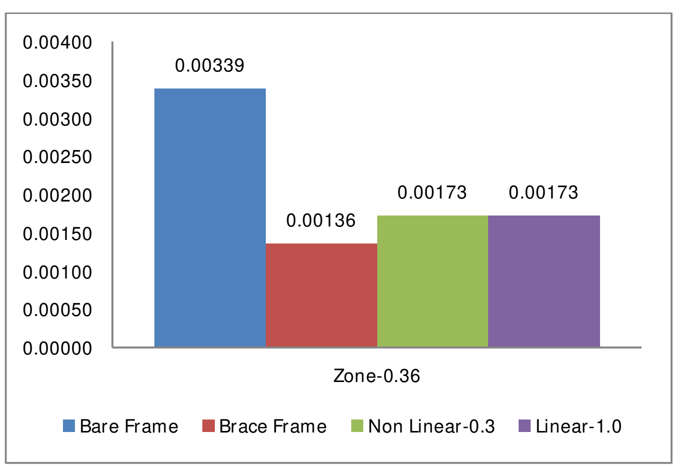


Fig.25: Effect of Equivalent Static Force (Zone-V) on Max Storey Drift for Bare, Brace & Damper Frame 15-Storey Model

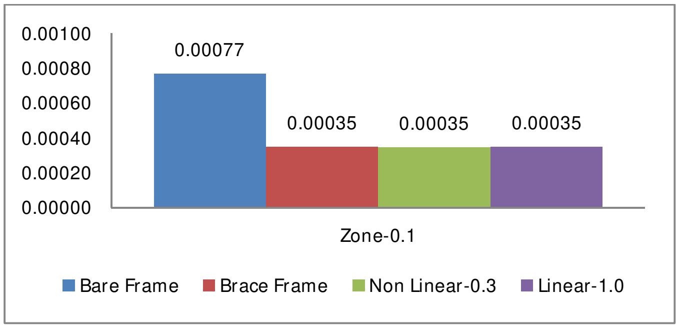


Fig.26: Effect of Response Spectrum Force (Zone-II) on Max Storey Drift for Bare, Brace & Damper Frame 15-Store Model

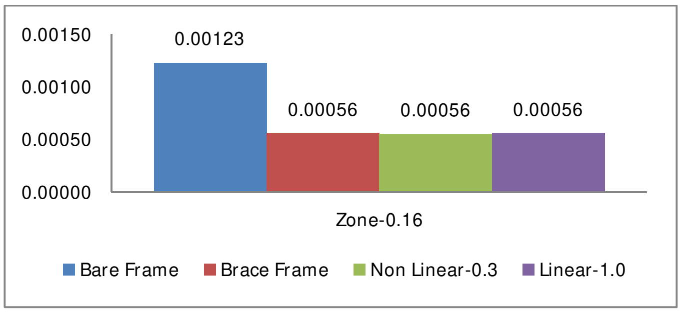


Fig.27: Effect of Response Spectrum Force (Zone-III) on Max Storey Drift for Bare, Brace & Damper Frame 15-Storey Model

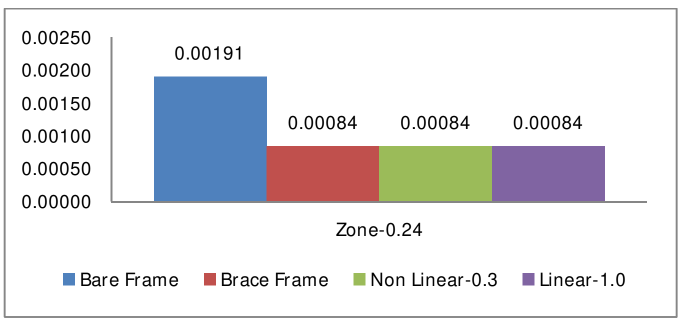


Fig.28: Effect of Response Spectrum Force (Zone-IV) on Max Storey Drift for Bare, Brace & Damper Frame 15-Storey Model

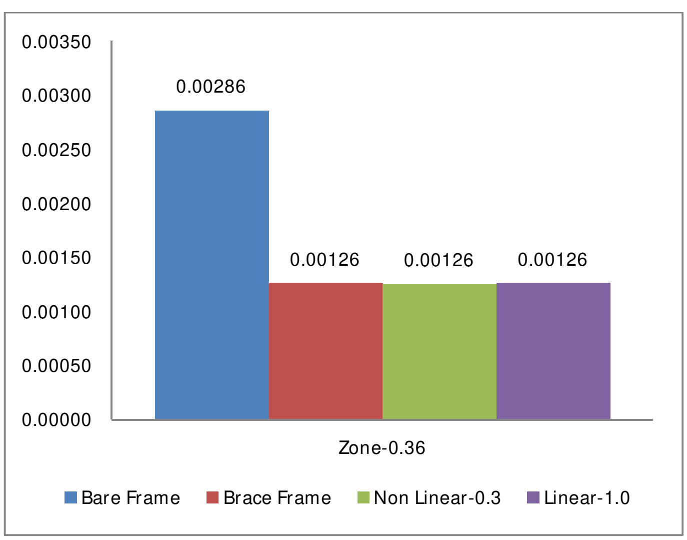


Fig.29: Effect of Response Spectrum Force (Zone-V) on Max Storey Drift for Bare, Brace & Damper Frame 15-Storey Model

Table 4: Result of maximum storey drift values of 15 storey model:

STOREY TYPE	STOREY DRIFT								MODEL TYPE
	EQUIVALENT STATIC ANALYSIS				RESPONSE SPECTRUM ANALYSIS				
	SEISMIC ZONE				SEISMIC ZONE				
	0.1	0.16	0.24	0.36	0.1	0.16	0.24	0.36	
15-STOREY STRUCTURE	0.00094	0.00151	0.00220	0.00339	0.00077	0.00123	0.00191	0.00286	Model of Multi storey Structure With Bare Frame system
	0.00038	0.00078	0.00091	0.00136	0.00035	0.00056	0.00084	0.00126	Model of Multi storey Structure With Brace Frame system
	0.00048	0.00077	0.00115	0.00173	0.00035	0.00056	0.00084	0.00126	Model of Multi storey Structure With Non Linear Damper -0.3 Frame system
	0.00048	0.00077	0.00115	0.00173	0.00035	0.00056	0.00084	0.00126	Model of Multi storey Structure With Linear Damper -1.0 Frame system

In the Bare and Bracing frame configuration, the data illustrates a drift value of 48.41%, indicating a reduction in drift when compared to the bare framed structure. The inclusion of bracing elements seems to enhance structural stiffness, resulting in decreased drift. Conversely, in the Bare and Damper frame configuration, the results reveal a drift value of 56.23%, surprisingly indicating a decrease in drift compared to the bare framed structure. The integration of dampers appears to contribute to improved structural performance in terms of drift reduction. When comparing the results of the bracing and damper a framed structure, a notable difference emerges. In equivalent static analysis, there's a 21.41% reduction in drift for the Damper framed structure compared to the Bracing framed structure. However, in response spectrum analysis, the difference is notably smaller, with a mere 0.53% reduction. This suggests that the effectiveness of dampers in controlling drift may vary depending on the analysis method employed.

VI. CONCLUSION

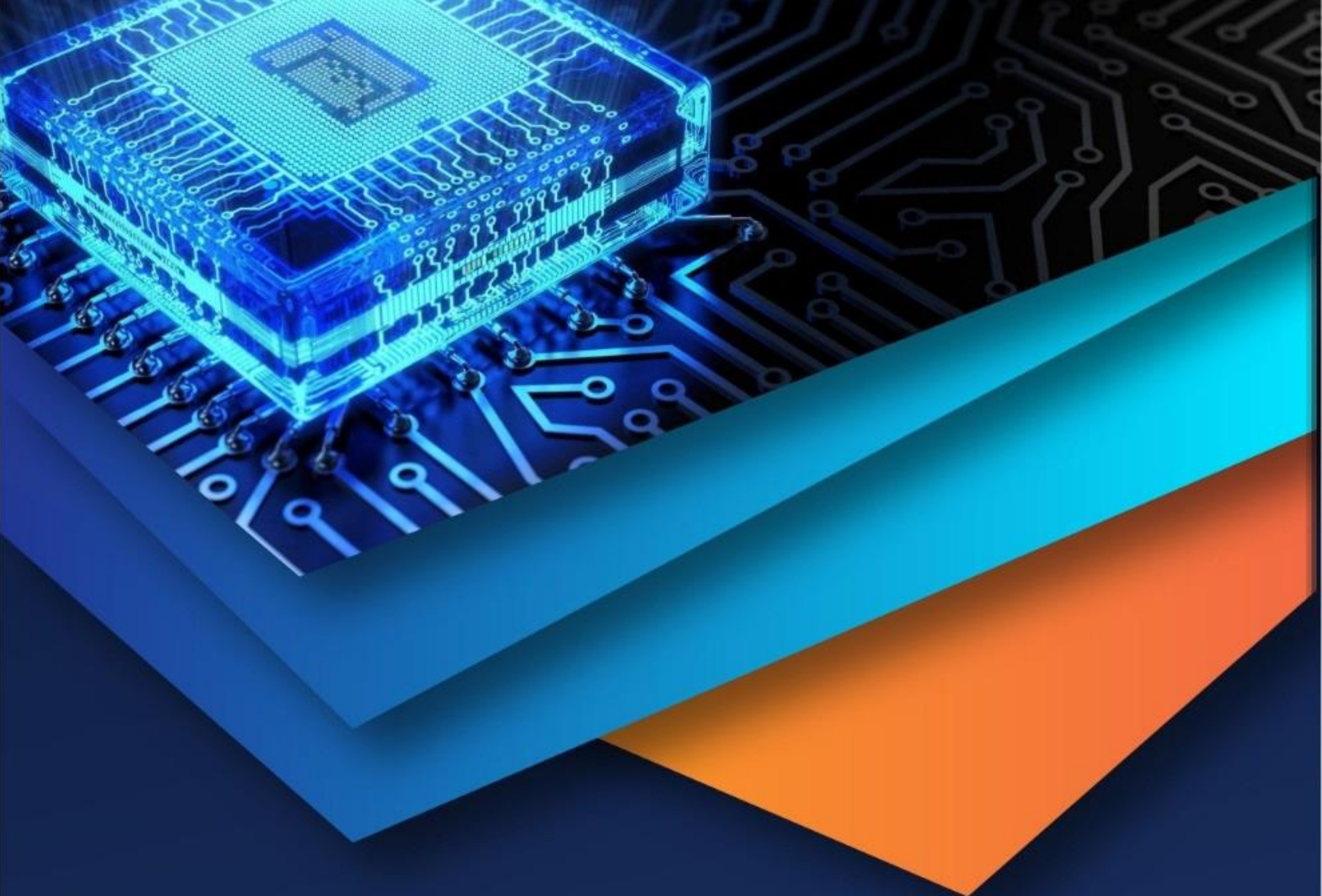
The following conclusions are drawn below:

1) Seismic response values containing displacement, base shear and storey drift increases with respect to the seismic zones.
2) The maximum displacement and storey drift occurs in bare frame model. Therefore bare frame model exhibits low seismic resistance and high vulnerability to seismic damage.
3) Displacement is reduced in bracings in zone II and zone III. Whereas in FVD displacement reduced in zone IV and zone V.
4) Base shear is decreased in FVD compared to bracings.
5) Storey drift is also reduced in both bracings and FVDs compared to bare frame.
6) Both linear and non linear FVDs exhibits similar values in all seismic response values such as displacement, base shear and storey drifts.

From the above conclusion, bracings are preferred for lower zones such as zone II and zone III. Whereas FVDs are preferred for higher zones such as zone IV and zone V. Therefore FVDs gives better performance compared to bracings during earthquake events.

VII. REFERENCES:

[1] Shmerling, A. and Gerdts, M., 2023. "Short-horizon acceleration-predictive control for reducing lateral seismic inertia forces of inelastic frame structures using semiactive fluid viscous dampers". Computers & Structures, 281, p.107032.
[2] Baikhan, S. and Karunakar, D., "Optimization of Fluid Viscous Damper Chevron Bracing ArrangementiIn G+ 9 RCC Structure".
[3] GS, A.K. and Kori, J.G., "Seismic Response Control of High-Rise Mass Varied Structures Using Linear Fluid Viscous Damper".
[4] Gupta, P.K. and Ghosh, G., 2021. "Effect of Bi-directional excitation on a curved bridge with lead rubber bearing". Materials Today: Proceedings, 44, pp.2239-2244.
[5] Scozzese, F., Gioiella, L., Dall'Asta, A., Ragni, L. and Tubaldi, E., 2021. "Influence of viscous dampers ultimate capacity on the seismic reliability of building structures". Structural Safety, 91, p.102096.
[6] Alehojjat, S.B., Bahar, O. and Yakhchalian, M., 2021, December. "Improvements in the direct displacement-based design procedure for mid-rise steel MRFs equipped with viscous dampers". In Structures(Vol. 34, pp. 1636-1650). Elsevier.
[7] Shen, D. and Kookalani, S., 2020. "Effect of Fluid Viscous Damper parameters on the seismic performance". Journal of Civil Engineering and Materials Application, 4(3), pp.141-153.
[8] Hu, G., Wang, Y., Huang, W., Li, B. and Luo, B., 2020. "Seismic mitigation performance of structures with viscous dampers under near-fault pulse-type earthquakes". Engineering Structures, 203, p.109878.
[9] Bakhshinezhad, S. and Mohebbi, M., 2020, April. "Multi-objective optimal design of semi-active fluid viscous dampers for nonlinear structures using NSGA-II". In Structures (Vol. 24, pp. 678-689). Elsevier.
[10] Kang, J.D. and Mori, Y., 2017. "Simplified estimation method of inelastic seismic demands of buildings with seesaw system using fluid viscous dampers". Engineering Structures, 138, pp.120-130.
[11] S.K. Jain et al; "Explanatory Example on Indian Seismic Code IS 1893 (Part – I)" – IIT Kanpur.
[12] "Limit State of Analysis" – IS 456: 2000 and IS 875:1987 part 1, 2, 3 for dead, live, wind loads.
[13] "Recommendations for Earthquake Resistant Design of Structures", Code of Practice – IS 1893 – 2002.



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