iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 Issue: XI Month of publication: November 2024

DOI: https://doi.org/10.22214/ijraset.2024.65298

Seismic Analysis of Multi-Storied Reinforced Concrete Building with Fluid Viscous Dampers

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Abstract: Frequent earthquakes around the world and the large number of buildings at risk have made it essential to focus on controlling how structures respond to these events. This demand has driven the increased use of structural response control methods globally. This study investigates the seismic performance of multi-storied Reinforced Concrete (RC) Buildings, distinguishing between Regular and Irregular Plan , with a focus on the role of Fluid Viscous Dampers (FVDs). The study aims to quantify the improvements in seismic resilience provided by these damping devices in mitigating the adverse effects of seismic events. Buildings having Regular and Irregular Plans are analyzed, with and without FVD using ETABS2018. The story responses in terms of Pseudo Spectral Accelerations, Maximum Displacement, Story Drift and Story Shear have been compared. The results of the Time History Analysis represent the effectiveness of dampers in improving the structural response and the damping demand on structural systems.
Keywords: Fluid Viscous Dampers (FVDs), Regular and Irregular Plans, Pseudo Spectral Accelerations, Maximum Displacement, Story Drift, Story Shear, Time History Analysis.

I. INTRODUCTION

Over the past few years, earthquakes have been happening more often and with greater intensity, highlighting the need for buildings capable to endure these forces. This challenge is made more difficult by the size and complexity of multi-story reinforced concrete (RC) buildings that are particularly at risk during earthquakes. Ever since, improvements to these buildings were made traditionally by improving materials and modifying their design for better resistance. But today, we have a variety of the most sophisticated dampings which can help absorb energy and prevent further damage**.** There are two main methods for analyzing how buildings might respond to earthquakes: i)Response Spectrum Analysis ii)Time History Here in these study Time History method has been used for analysis of the structure.

Time History Analysis: This approach uses real data collected from actual earthquakes. By studying how buildings behave during real seismic events, engineers can design future structures to better withstand similar conditions.

In this analysis, a G+14 story building is considered, and Time History data of the Bhuj (Gujarat, INDIA) earthquake has been utilized. This data is useful for predicting the story responses in terms of Pseudo Spectral Accelerations, Maximum Displacement, Story Drift, and Story Shear using ETABS2018.Building with Regular and Irregular plan are analyzed with or without Fluid Viscous. By conducting a detailed investigation into the dynamic behavior of such structures, this research aims to evaluate the effectiveness of FVDs in enhancing the seismic performance of RC buildings.

II. DAMPING

In Structural Engineering, Damping is the process of dissipating the energy of vibrations in a structure It is an essential aspect how buildings and other structures respond to dynamic forces. There are different types of damping mechanisms uses in structures, and fluid viscous damping is one of them, which employs a Fluid Viscous Damper as an Energy dissipation device.

A Fluid Viscous Damper (FVD) is a mechanical device used in structural engineering to reduce vibrations by dissipating kinetic energy through the movement of a viscous fluid. These dampers consist of a piston that moves within a cylinder filled with a highly viscous fluid, such as silicone oil. As the structure experiences dynamic motion, the piston forces the fluid within the cylinder, converting mechanical energy into heat and, thereby reducing the amplitude of vibrations and enhancing the overall stability of the building. The incorporation of FVDs into the structural design of multi-storied RC buildings offers a promising approach to improving their seismic resilience.

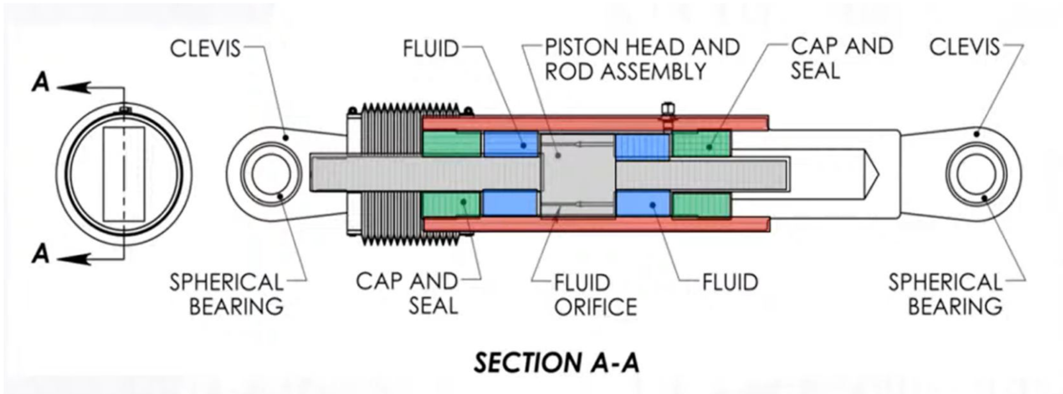


Fig a. Fluid Viscous Dampers

The fluid viscous damper is mathematically modeled by the equation:

$$F = C \times u$$

Where,
- F denotes damping force,
- C denotes damping coefficient,
- u is the relative velocity across the damper.

This equation implies that the damping force is directly proportional to the velocity of movement. The proportionality constant is the damping coefficient C, which dictates how much resistance the damper provides.

III. OBJECTIVE

1) To compare seismic response of Building with Regular and Irregular plan, both with and without Fluid Viscous Damper.
2) Analyze how Fluid Viscous Damper affects Displacement in the structure.
3) To study how FVD impacts the time period of different structure with and without fluid viscous dampers.
4) To compare variations in Base Shear when FVD is used in building.
5) To assess the overall impact of Dampers on all building model studied.

IV. METHODOLOGY

In the present study G+14 story RCC building is considered with four different models:
1) Regular Building with Fluid Viscous Damper.
2) Regular Building without Fluid Viscous Damper.
3) Irregular Building with Fluid Viscous Damper
4) Irregular Building without Fluid Viscous Damper.

The work proceeds as follow:
- Regular and Irregular building were analyzed using Time History Data (Bhuj,Gujarat) in Etabs2018.
- The response of each Irregular building was compared with that of Regular building.

V. MODELLING AND ANALYSIS

Table 1: Detailed data of models

S,No.	Design Data for the models	
	Details of Building	
i.	No, of Story	G+14
ii.	Story Height	3 meters
iii.	Seismis Zone	IV
	Material Properties	
i.	Grade of Concrete	HYSD 500

ii.	Grade of Steel	M30
iii.	Density of Steel	78.5 kN/m³
iv.	Density of Cement Concrete	25 kN/m³
	Member Properties	
i.	Beam	
	Grade	M30
	Size(same for all story)	0.4x0.35 m
ii.	Column	
	Grade	M30
	Size	0.6x0.6 m and 0.5x0.5 m
iii.	Slab	
	Grade	M30
	Size	0.15m
	Type of Load	
i.	Dead Load	1.5 kN/m²
ii.	Live Load	3.5 kN/m²
	Seismic Properties	
i.	Zone Factor	0.24
ii.	Importance Factor	1
iii.	Response Reduction Factor	3
	Link Proprties (FVD)	
	Mass	44kg
	Weight	250kN

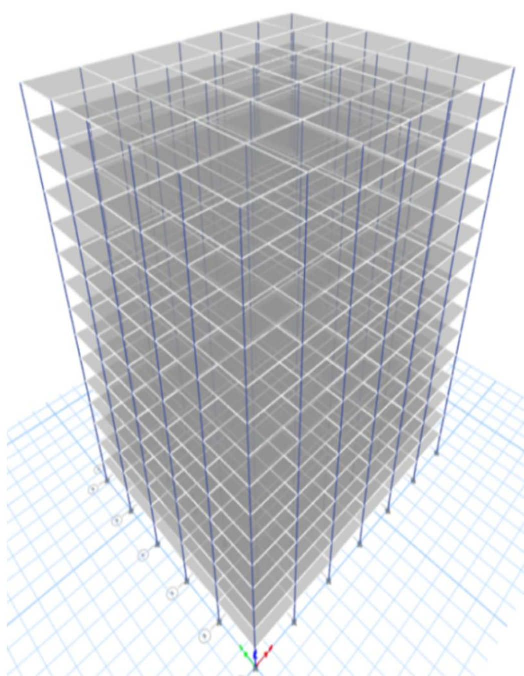


fig b. 3D model of Regular Building without FVD

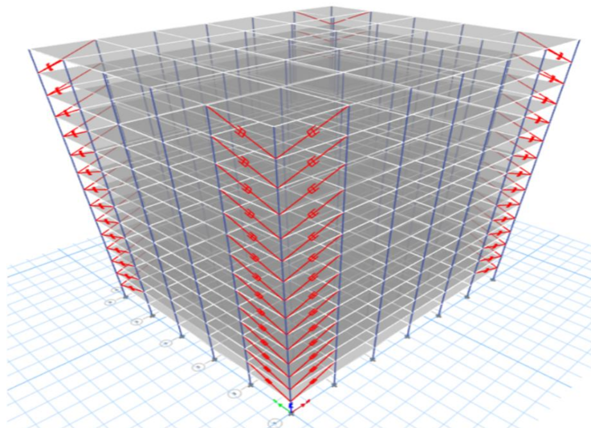


fig c. 3D model of Regular Building with FVD

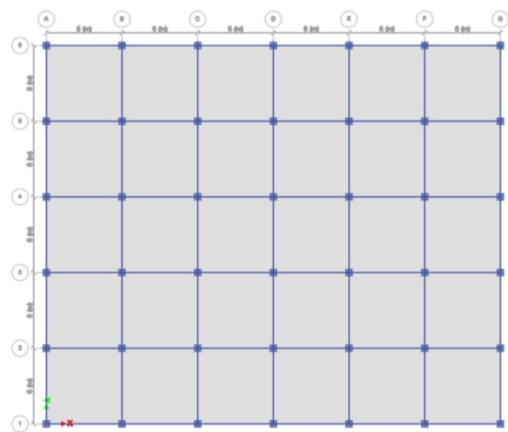


fig d. Regular Building Plan

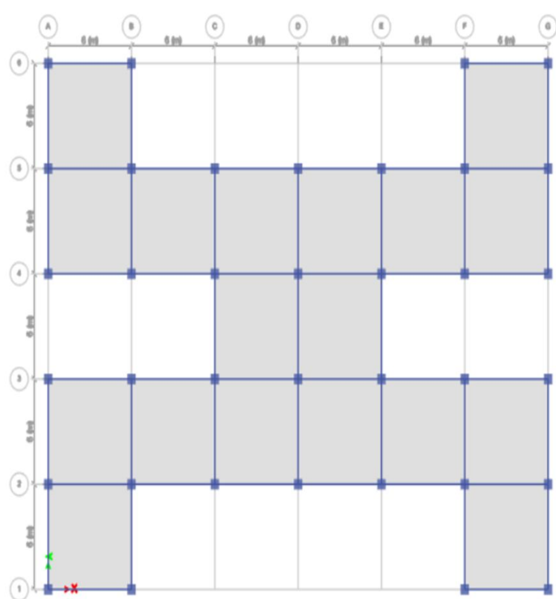


fig e. Irregular Building Plan

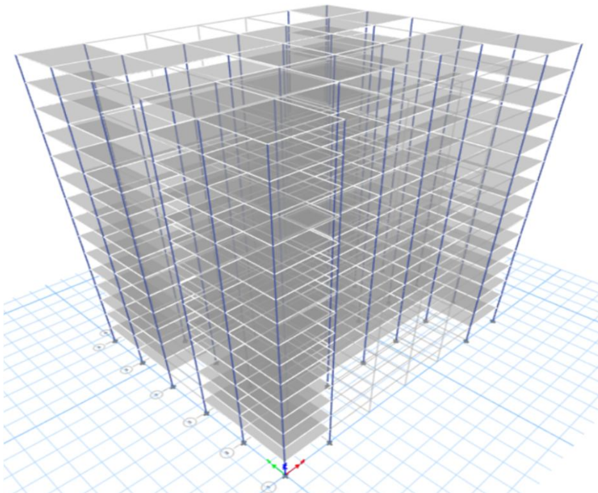


Fig f. 3D model of Irregular Building without FVD

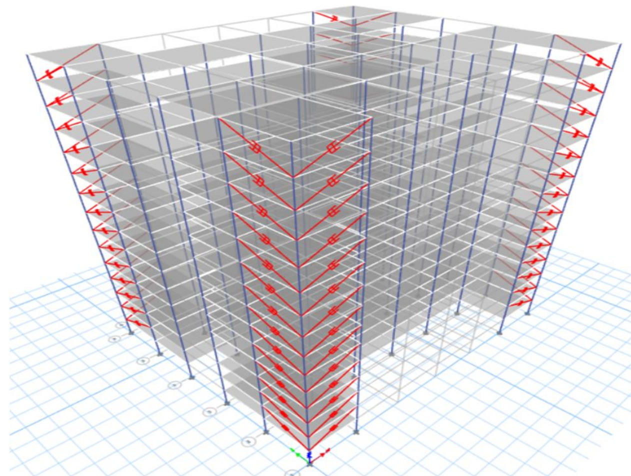


Fig g. 3D model of Irregular Building with FVD

- STORY DISPLACEMENT

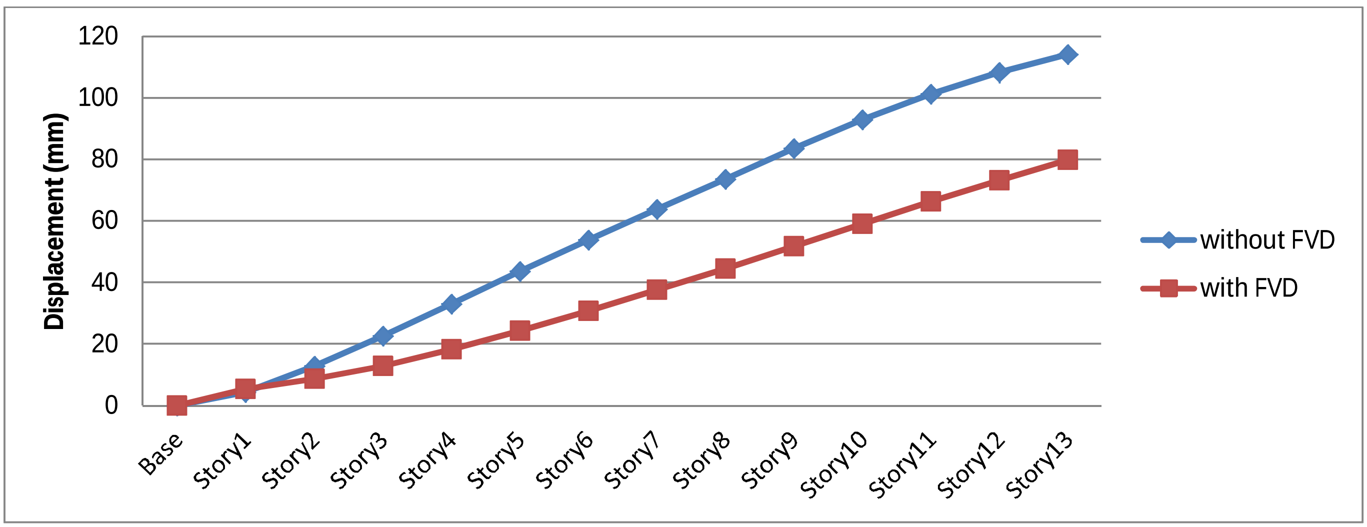


Fig h. Maximum Displacement Graph for Regular Building

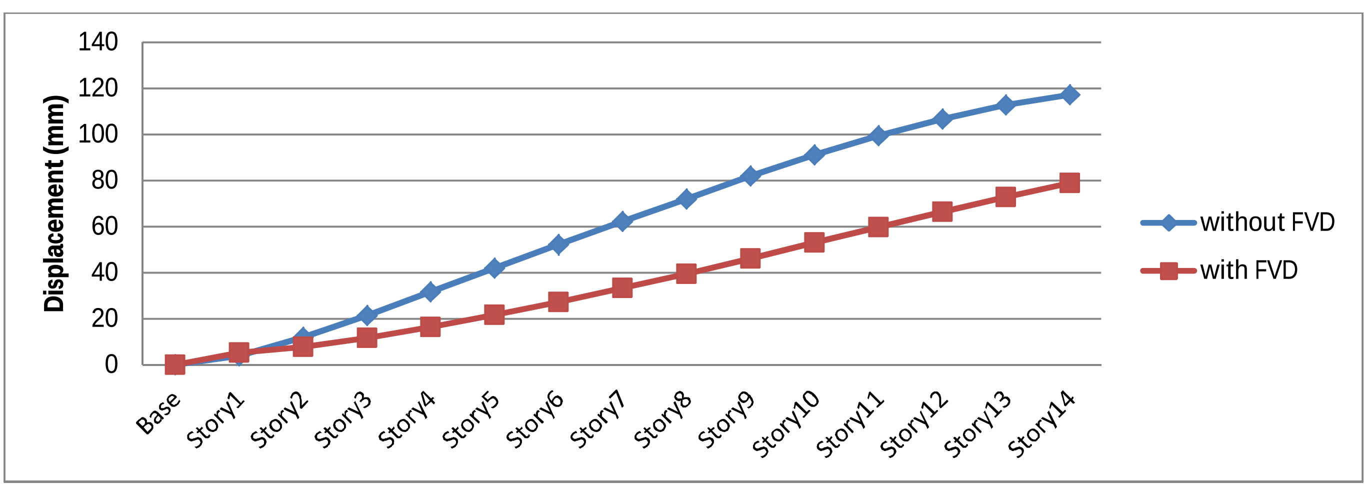


Fig i. Maximum Displacement Graph for Irregular Building

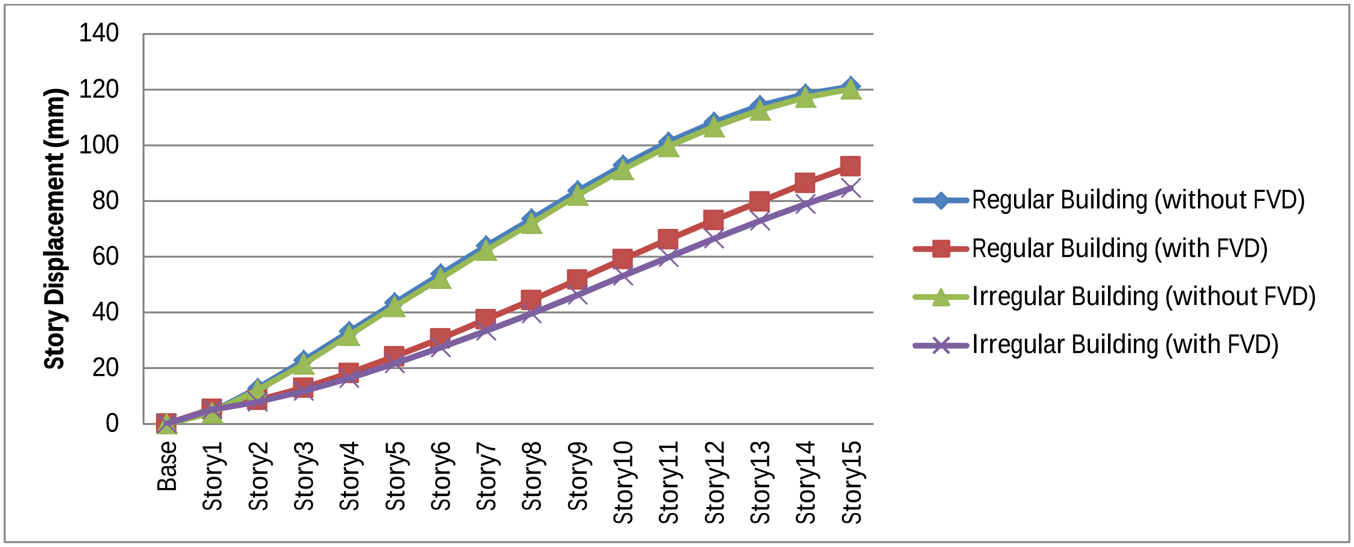


Fig j. Comparison of Story Displacement for all Buildings

- PSUEDO SPECTRAL ACCELERATION (PSA)

MODAL TYPES	LOAD CASES DIRECTION			
	MAXIMUM VALUES			
	TH X DIRECTION		TH Y DIRECTION	
	TIME PERIOD (sec)	PSA (mm/sec2)	TIME PERIOD (sec)	PSA (mm/sec2)
REGULAR BUILDING [WITHOUT DAMPERS]	0.394308	2615.065	0.269578	5.553
REGULAR BUILDING [WITH DAMPERS]	0.393441	5947.429	0.198188	134.544
IRREGULAR BUILDING [WITHOUT DAMPERS]	0.555556	2329.206	0.25	46.437
IRREGULAR BUILDING [WITH DAMPERS]	0.384615	4624.38	0.212766	619.93

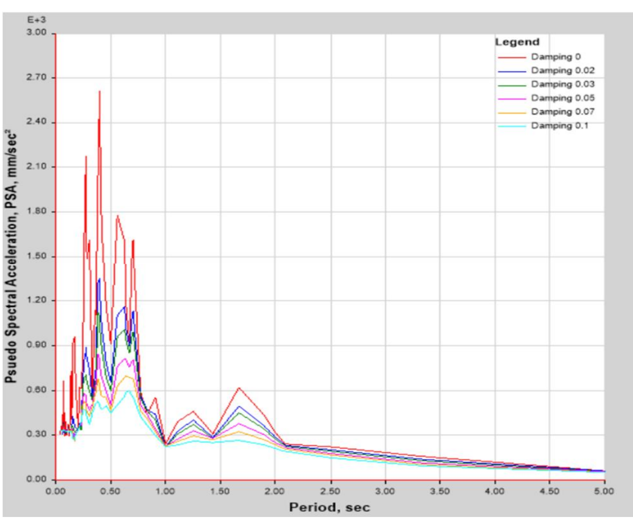


fig k. PSA vs Time graph (for regular building without FVD)

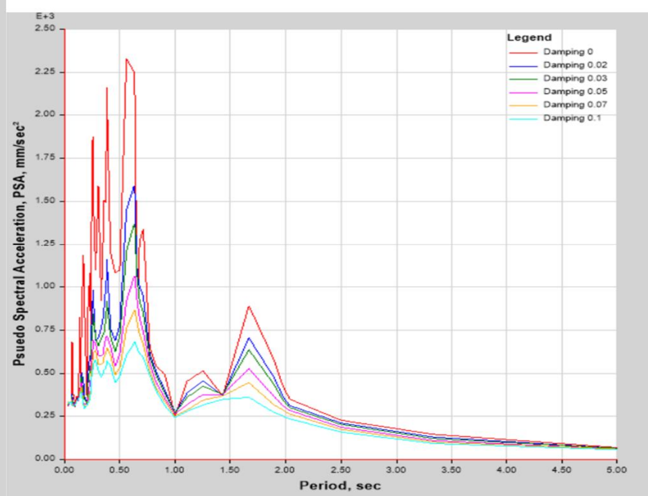


fig l. PSA vs Time graph (for irregular building without FVD)

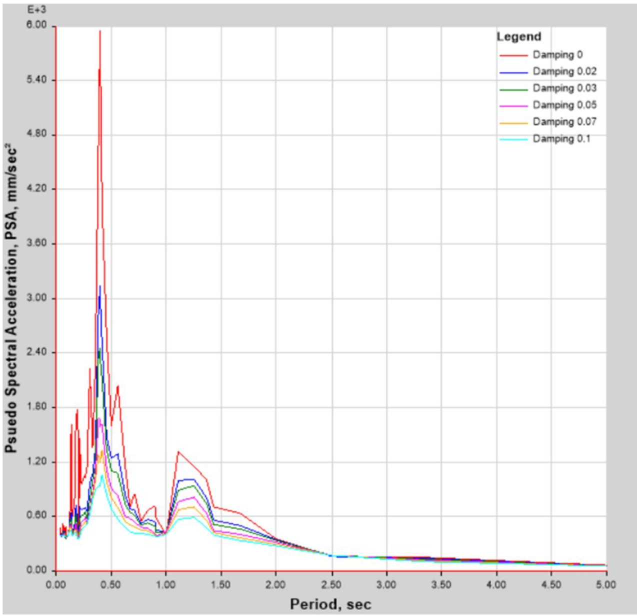


Fig m. PSA vs Time graph (for regular building with FVD)

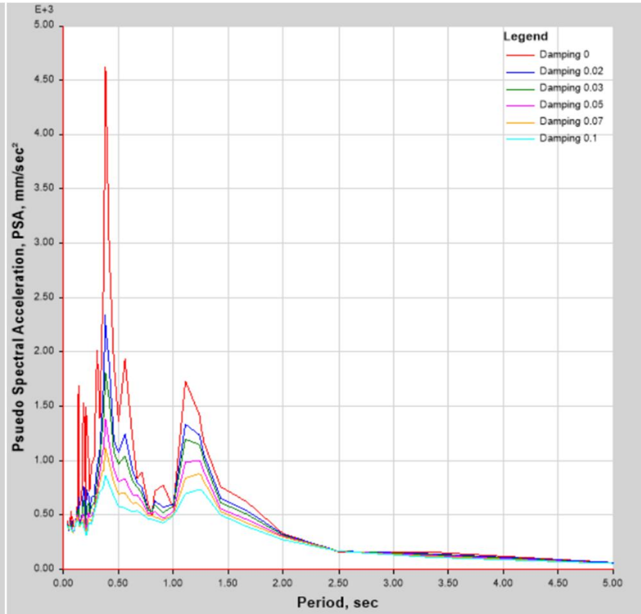


fig n. PSA vs Time graph (for irregular building with FVD)

- STORY DRIFT

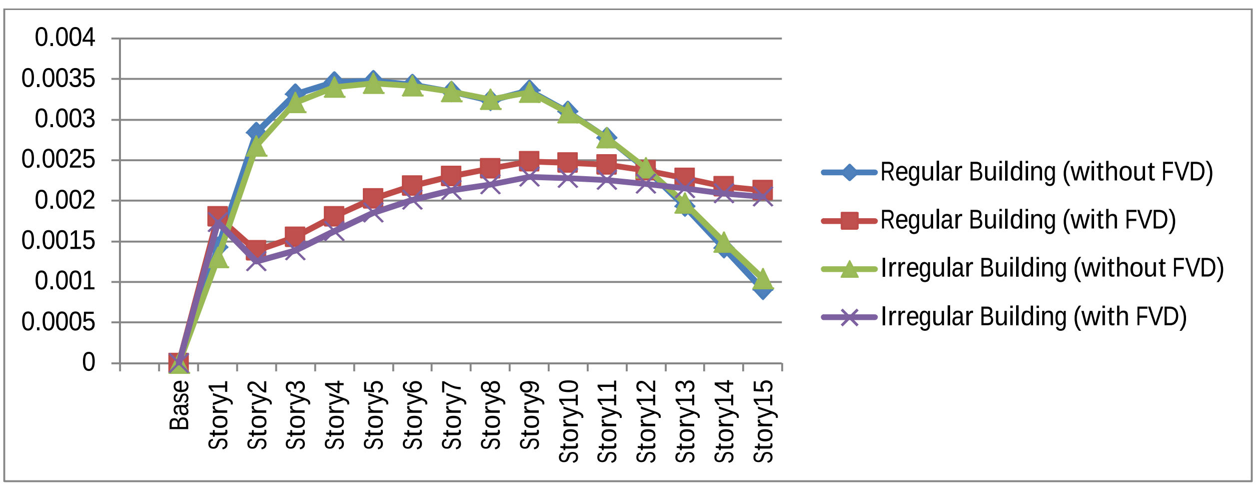
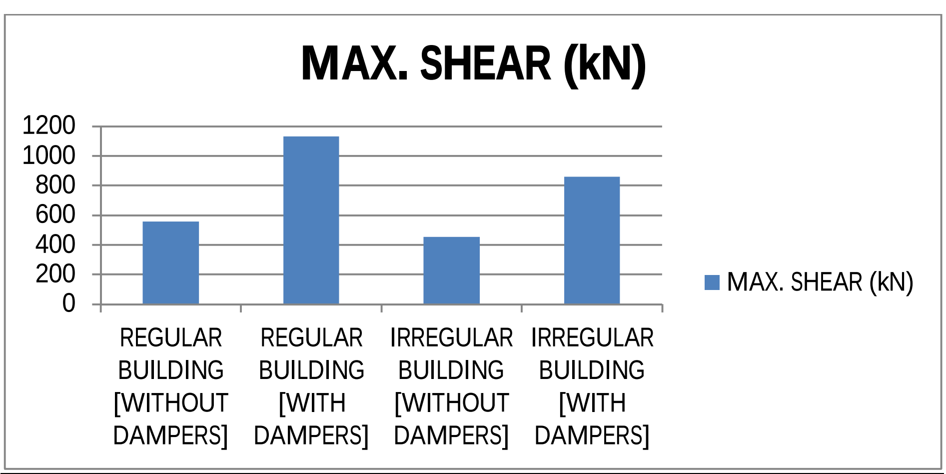


Fig o. Comparison of Story Drift for all Buildings

- BASE SHEAR



VI. CONCLUSION

1) At Higher Periods, response spectrum values are highly sensitive to both source and site conditions. Hence, it can be observed that buildings equipped with Fluid Viscous Damper (FVD) have low Periodic values while buildings without Fluid Viscous Damper exhibit high periodic values for maximum PSA at zero damping which is quite sensitive.
2) By observing the above results, it can be concluded that building with FVDs displace less compared to building without FVD. Hence FVDs effectively reduce the Lateral displacement of building with dampers by 25% -30% compared to building without dampers
3) The Base Shear of the building increases when FVDs are provided, compared to a building without dampers.
4) Compared to a building without dampers, the building with damper reduces the maximum Drift value.

The above results clearly show that using Dampers in the building provides an effective response under seismic conditions.

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