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A Research on Influence of Fluid Viscous Damper on The Behaviour of Multi-storey Building Under Different Seismic Zones

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Abstract - *With advancements in urban design software and significant improvements in the fields of engineering and technology, high-rise structures are increasingly common. As the height of buildings increases, their response to seismic and wind loads also intensifies. According to Indian standard codes, the displacements and forces experienced by a structure are directly proportional to its height. Ongoing research focuses on mitigating these responses during extreme horizontal loading due to seismic activity and wind forces. One effective solution involves the use of passive control devices, such as various types of dampers, to manage and reduce the impact of these loads.*

***Key Words*: Fluid viscous dampers, Displacement, Storey Drift and Storey shear, ETABS**.

1. INTRODUCTION

1.1 General

➢ **Which different kind of load is acting on RC building?**

Various types of loads act on reinforced concrete (RC) buildings. In India, the major loads considered are dead load, live load, seismic load, and wind load (for buildings taller than 10 meters, as per IS 875 Part 3). However, according to IS 456 Table 18, when considering the effect of earthquakes, the wind load is substituted by the earthquake load in the specified load combinations. This substitution reflects the prioritization of seismic effects over wind effects in structural design under earthquake conditions.

- **Dead Load:**

Dead load is mainly caused by the individual weight of the structure and the completion of the structure. Dead loads are carried out only in the vertical direction. We can only assume that no tipping occurred due to static properties.

- **Live Load:**

Live load in a building is due to occupants, furniture, vehicles, and other movable objects. The value of live load varies depending on the type of building, as specified in IS 875 Part 2. This standard provides guidelines for determining the appropriate live load values for different building categories to ensure safety and structural integrity.

- **Earthquake Load (Seismic load):**

Seismic load is the horizontal force exerted on a building due to ground shaking during an earthquake. These loads are classified as "dynamic loads." Unlike other types of loads, which generally act slowly on a structure, seismic loads act rapidly and cause the structure to vibrate intensely.

➢ **What is earthquake resistant building?**

An earthquake-resistant building is designed to withstand various levels of seismic activity without significant damage. In a weak earthquake, no damage is allowed in structural members, and no major damage is permitted in non-structural members. During a moderate or moderately strong earthquake, some structural damage is allowed, but it should be repairable, and no major damage should occur. In a strong earthquake, major damage is allowed, but the structure must not collapse. This type of design ensures the building maintains its integrity and provides safety for occupants during and after an earthquake.

➢ **What is damper?**

"Dampers are energy dissipation system".

Dampers are devices used to dissipate or absorb vibrations resulting from an earthquake, thereby increasing the damping and stiffness of a structure. These devices help to control and reduce the seismic response, enhancing the overall stability and safety of the building during seismic events.

➢ **Different type of damper majorly used in building.**

1] Fluid Viscous Dampers (FVD)
2] Viscoelastic Dampers
3] Friction Dampers
4] Tuned Mass Damper (TMD)
5] Yielding Dampers
6] Magnetic Damper

1.2 Fluid viscous dampers:

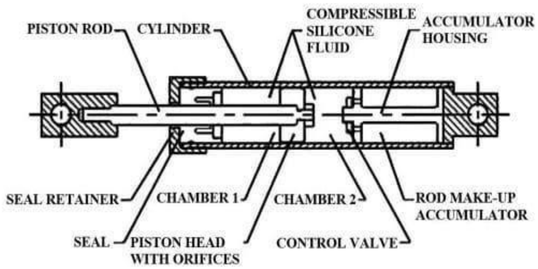

Figure 1: Schematic Detailing of Fluid Viscous Damper Components

In fluid viscous dampers, seismic energy is absorbed by a silicon-based fluid passing through a piston-cylinder arrangement. These dampers are commonly used in buildings located in higher earthquake zones. They effectively operate within a temperature range of 40°C to 70°C, significantly reducing vibrations caused by earthquakes and enhancing the building's seismic resilience.

➢ **Component of Fluid viscous dampers.**

1] Piston Rod
2] Cylinder
3] Silicone Fluid
4] Accumulator Housing
5] Seal and Seal Retainer
6] Chamber-1 and Chamber-2
7] Piston Head with Orifices
8] Control Valve
9] Rod Make-up Accumulator

➢ **Types of connection of Fluid viscous dampers.**

There are three ways to connect dampers,

1] In floor or foundation
2] In stern pericardial braces
3] In diagonal braces

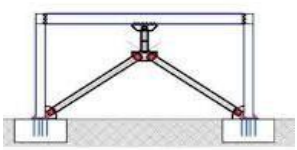

Figure 2: stern pericardial braces

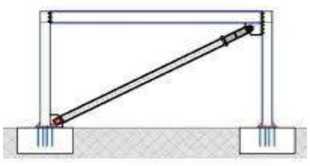

Figure 3: Diagonal Braces

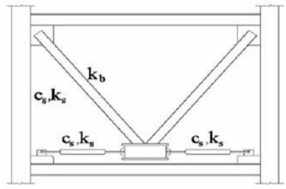

Figure 4: Floor or Foundation

1.3 Terminologies:

Displacement:

"The displacement of a structure is defined as the distance from the original position of a sample point on the structure to its final location after deformation."

Story Drift:

"The lateral displacement between consecutive floors is known as storey drift."

"The ratio of storey drift to the floor height is known as the storey drift ratio."

Story Shear force:

"The lateral force acting on a storey due to forces such as wind load or seismic load is known as storey shear force."

"A building with less stiffness attracts less storey shear, while a building with more stiffness attracts more storey shear."

1.4 Objective

The main objective of this study is to check the kind of performance a building can give when designed as per Indian Standards.

The Analysis of the building frame is carried out by using structural analysis and design software ETABS (version 21).

- To analyse Storey displacement of building.
- To analyse Storey drift of building.
- To analyse Storey shear of building.

We use ETABS (version 21) to analyse the model of an RCC building, considering various parameters for columns, beams, and other structural components. Our analysis accounts for different seismic zones and varying types of soil conditions to ensure comprehensive evaluation and design of the structure's seismic resilience.

2. NUMERICAL STUDY

Here we consider G+7 and G+9 storey RCC frame building for study.

Following different case to be studied.

1] Building without any dampers.
2] Building with fluid viscous damper at base corner
3] Building with fluid viscous damper at base middle
4] Building with FVD at corner in 1st two storey
5] building with FVD at middle in 1st two storey

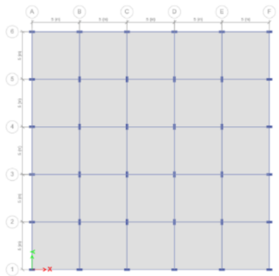

Figure 5: Plan view of building

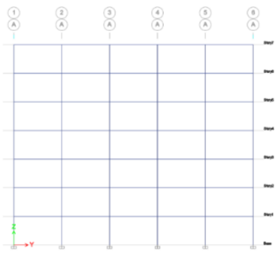

Figure 6: Elevation of building

Table 1: Detail of Building

Type of Building	Residencial
Plan Dimension	25 m x 25 m
Storey Height	3 m
Numbers of Storey	G + 7

Table 2: Material properties

Grade of Concrete	M30
Density of Concrete	25 kN/m^3
Grade of Steel	Fe 415
Density of Steel	76.9729 kN/m^3
Modulus of elasticity of Con.	27386.13 MPa
Modulus of elasticity of Steel	2 x 10^5 MPa

Table 3: Section Properties

Beam	230 x 575 mm
Column	230 x 600 mm
Slab Thickness	150 mm
Damper	FVD250
Wall Thickness	115 mm

Table 4: Gravity Load

Self-Weight	Taken by ETABS
Floor Finish for Typical	1.5 kN/m^2
Floor Finish for Terrace	2.3 kN/m^2
Wall Load	5.57 kN/m^2
Live Load	2 kN/m^2

Table 5: Seismic Properties

Importance Factor	1
Response Reduction Factor	5
Zone	III, IV, V
Zone Factor	0.16, 0.24, 0.36
Soil Type	II (Medium)

Table 6: Damper Properties

Dampers Type	FVD 250
Mass of Damper (kg)	44
Weight of Damper (kN)	250

3. RESULT AND DISCUSSION

Comparison of maximum displacement in X and Y direction in all five cases of building which we got from ETABS while analysed model is shown in figure 7 and figure 8.

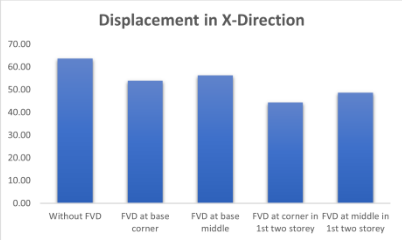

Figure 7: Maximum displacement in X-Direction

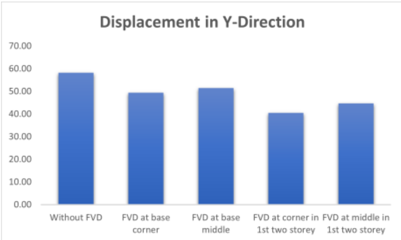

Figure 8: Maximum displacement in Y-Direction

Comparison of maximum storey drift of building is shown in figure 9 and figure 10.

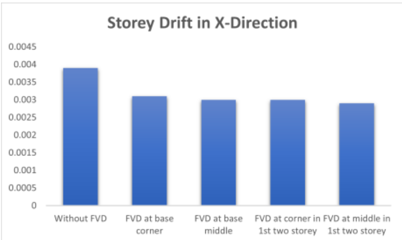

Figure 9: Maximum Storey drift in X-Direction

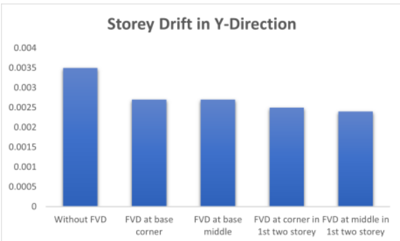

Figure 10: Maximum Storey drift in Y-Direction

Comparison of maximum storey shear in X and Y direction in all five cases of building which we got from ETABS while analysed model is shown in figure 11 and figure 12.

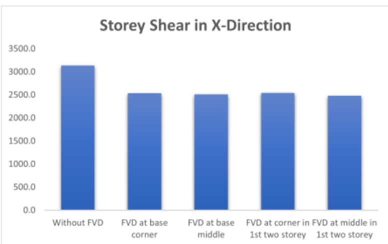

Figure 11: Maximum Storey shear in X-Direction

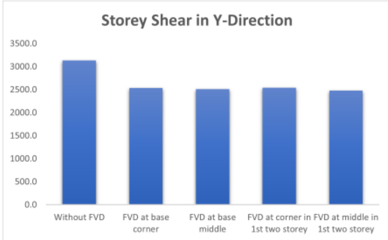

Figure 12: Maximum Storey shear in Y-Direction

Comparison of maximum Natural Time Period in all five cases of building which we got from ETABS while analysed model is shown in figure 13.

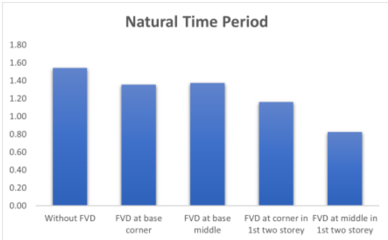

Figure 13: Maximum Natural Time Period

4. CONCLUSION

From all above study we can conclude that,

- Displacement of Building without FVD is more than Displacement of building with FVD.
- Storey drift and storey shear also decrease with Inclusion of Fluid viscous dampers.
- Storey Shear and Storey Drift is more less at storey where dampers are provided. Very next storey to the damper huge deflection noticed in graph of storey shear and storey drift.
- Decrement is higher when fluid viscous dampers add at corner of building as compared to fluid viscous dampers at middle.
- There is no huge difference in result when we change position of dampers corner to middle.
- Only base damping and 1st two storey damping has no huge difference like building without dampers and building with base damping.
- Time period is decrease with FVD, so natural frequency of building is increased.
- Time period is stiffness-based property of building so we can decrease it by increase size of column or by adding Dampers.
- With change of zone factor there is no change in Time period of building.

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