Performance Analysis of High-Rise Building with and without Damper

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Abstract: *The growing population, particularly in third-world nations, demands higher, more flexible, and lighter structures. The majority of these nations face a high risk of earthquakes, demanding more construction seismic response regulation. However, there are a number of measures that may be used to reduce the vibrations caused by an earthquake. The usefulness of employing fluid viscous dampers as a passive dissipative device will be discussed in this study, as well as some design optimization of the number and location of dampers in the building. Fluid viscous dampers provide additional damping in combination with adequate stiffness, providing a unique and appealing approach for controlling seismic response of tall structures in high-risk locations. According to IS 1893-2016, the building was analysed using FEA software,using seismic zones and medium soil (Type II). Storey displacement and Base Shear are used to evaluate the storey's performance. The objectives of this paper is to evaluate static and dynamic analysis results in both longitudinal and transverse directions, with and without damper installation.*

Keywords**: *Equivalent static method, Fluid viscous damper, Response spectrum method, Seismic analysis, Time history analysis.***

1.Introduction

Earthquakes are widely recognized as significant natural hazards, with a significant impact on structures. Energy dissipation and seismic isolation have been widely documented as active safety measures for attaining the performance objectives of modern codes. Many codes, on the other hand, provide design rules for seismically separated structures, but stronger energy dissipation protection recommendations are still needed. The most extensively used tools for controlling structural reactions and dispersing energy are fluid viscous dampers (FVD). In order to minimize structural responses to seismic excitation, these tools are used along with a range of construction techniques.

Dampers are earthquake-controlling devices. When a structure is subjected to high-magnitude ground motion, it develops forces; if the structure is free of damping, its stiffness is lower and vibration is higher; if the structure is dampened, its stiffness is higher and vibration is lower; if the structure is damped, its stiffness is higher and vibration is lower; if the structure is damped, its stiffness is higher and vibration is lower. Passive energy dissipation devices come in a range of shapes and sizes. Fluid viscous dampers are more widespread in structures. The performance of the building is improved with fluid viscous dampers.

1.1 Fluid Viscous Damper

Fluid viscous dampers are a form of passive energy vanishing device used in mechanical and structural systems to control vibration. For many years, these kinds of dampers have been widely utilized in the military and aerospace sectors, and they are now being used in structures to minimize vibrations caused by wind and earthquakes. One of the dampers most unusual features is its ability to minimize both stress and deflection in structures that have been subjected to transients. Because the dampers only vary their force in response to velocity, and the structure bends, the reaction is always out of phase with the loads.

These dampers are used to disperse energy in the structure since they are velocity dependent. These sorts of dampers should be utilised to reduce the building's reactivity. FVDs are stiffness-free devices that are frequency-independent.

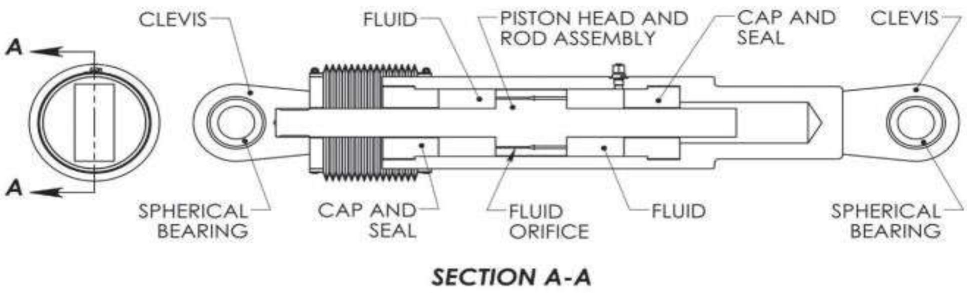

Fig. 1 . Logitudinal section of FVD

The Fig. 1 represents the longitudinal section of FVD.The primary pressure chamber is known as the cylinder, and it is filled with fluid. It takes into account the volume on both sides of the piston. The piston rod is attached to the piston head. The structure is attached to the piston rod via a clevis on the left side. During the dynamic phase, the piston rod, piston head, and clevis all move as a single unit, while the other components stay static. The fluid in the cylinder is a viscous compressible silicone oil that is heat stable, toxic free, inflammable, and environmentally friendly. When a structure moves, FVD activate and impart a resistive force to the structure. They don't add to the structure's rigidity and don't carry any weight. If you want it, we can make the dampers stiffer. Pressure is produced when a piston in an FVD travels back and forth. The orifice, which is designed to work in combination with the piston, establishes an optimized interaction that causes the pressure to fluctuate with velocity.

2.Objectives

1. To evaluate the seismic behaviour of G+15 storey structure with FVD and without FVD using static and dynamic method.
2. Analysis and comparison of structure with and without FVD by using FEA software in terms of storey displacement and base shear.

3.Methodology

Learn about the behavior of the structure with and without dampers under seismic loads using the finite element method. Create a mathematical prototype model of a G+15 storey structure using the provided beams and slabs. Loads are also available. Following the modelling, the structure of the building was analyzed for seismic loads. The results, such as base shear and storey displacement, are examined and compared to with FVD and without FVD structures.

4.Model Description

In this study two types of building models are studied, structure with FVD and structure without FVD for all the seismic zones. These are G+15 storey structures with 3.2m storey to storey height in type II soil. Geometric details of the structure shown in Table1,plan without FVD shown in Fig. 2 and isometric view of the structure shown in Fig. 3.

Table.1

Geometric details	
Dimension of building	17mx12m
Type of building	Residential
Storey height	3.2m
Column size	300x900mm
Beam size	200x600mm
Slab thickness	125mm
Grade of concrete	M40 & M20
Grade of steel	Fe500
Primary load cases	
Typical live	2 kN/m^2
Floor finish	1.5 kN/m^2
Roof and floor finish	1.5 kN/m^2
Seismic properties	
Zone factor Z Zone II Zone III Zone IV Zone V	 0.1 0.16 0.24 0.36
Response reduction factor R	3 (for zone 2) & 5 (for zone 3,4 &5)
Importance factor I	1
Soil type	Type II
Damping ratio	5%

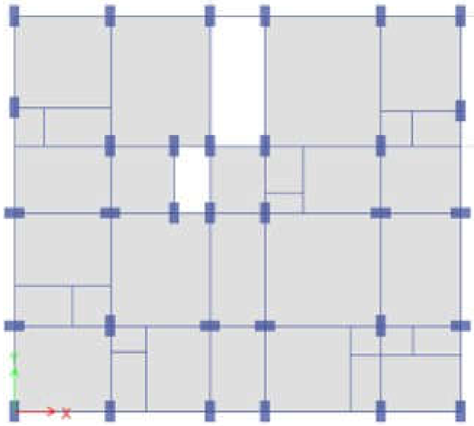

Fig. 2 :Without FVD structure plan

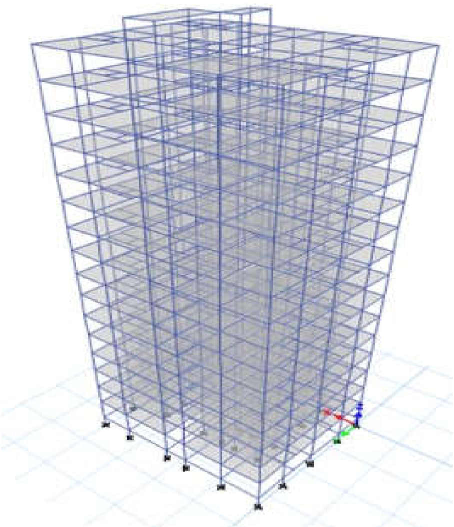

Fig. 3 :Isometric view

4.1 Damper data

The dampers placed with a single diagonal bracing in axial direction. After describing the Link properties, FVD is introduced to the structure by adding a new Damper-Exponential in Link Property Data, as shown in Table2.FVD installed diagonally for the exterior corner of the structure, plan view of the structure shown in Fig. 4, elevation and the isometric view of the structure shown in Fig.. 5 and Fig.. 6 below.

FORCE	TAYLOR DEVICES MODEL NUMBER	STROKE (mm)	BEARING THICKNESS (mm)	MAXIMUM CYLINDER DIAMETER (mm)	WEIGHT (kg)
250	17120	±75	33	114	44
500	17130	±100	44	150	98
750	17140	±100	50	184	168
1000	17150	±100	61	210	254
1500	17160	±100	67	241	306
2000	17170	±125	78	286	500
3000	17180	±125	89	350	800
4000	17190	±125	111	425	1088
6500	17200	±125	121	515	1930
8000	17210	±125	135	565	2625

Table.2

1. FVD mass = 98 kg.
2. FVD force = 500kN

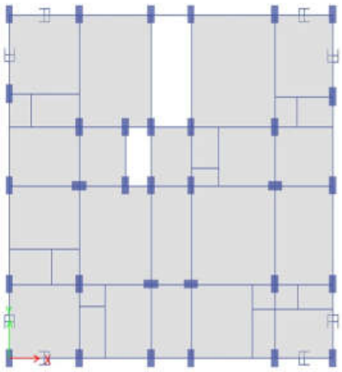

Fig. 4: Plan of FVD exterior corner at corner

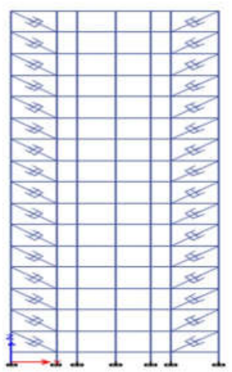

Fig. 5 : FVD at exterior corner Elevation

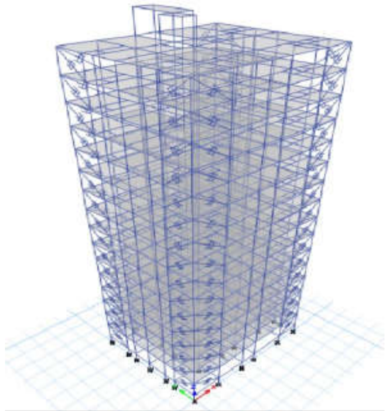

Fig. 6 : FVD at exterior Isometric view

5.Methods of analysis

A seismic study of a specific building may be done in a variety of methods to identify the forces created in the structure as a consequence of seismic activity. Mainly analysis is done on the basis of model of structure selected, materials used in the structure, and external inputs.

5.1 Equivalent Static analysis

Equivalent lateral force method is another name for equivalent static method. A building's seismic analysis is based on the assumption that the horizontal force is equivalent to the dynamic loading. Except for the basic period, the approach does not require durations or shapes of higher modes of vibration, hence the analytical work is reduced.

5.2 Response spectrum analysis

It is a linear dynamic research approach that analyses the effect of each natural mode of vibration to determine a structure's potential outstanding seismic performance. Response Spectrum Analysis according to IS 1893:2002 The graphical representation of response spectra shown in Fig. 7.

5.3 Time History Analysis

It is an important procedure for structural seismic analysis, especially when the structural response under consideration is non-linear. Time History Analysis is a stage-by-stage examination of a building's dynamic reaction to a known stimulus that may change over time. Earthquake recordings from Elcentro are obtained and used as input for our supplied structure. The outcome of analyzing the structure is a graphical depiction of Psuedo Acceleration with regard to time, as shown in Fig. 8.

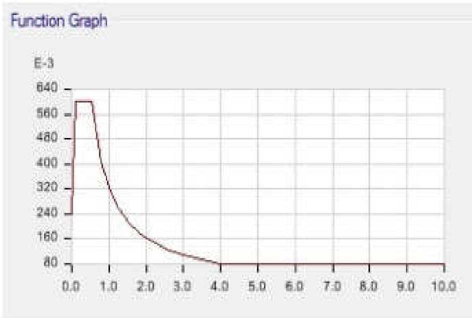

Fig. 7 : Response spectra

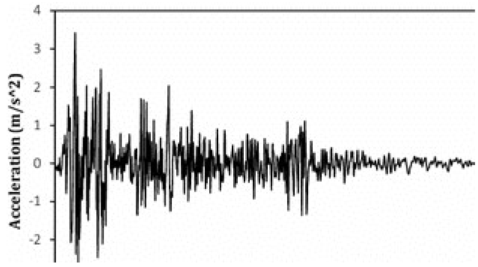

Fig.. 8 Elcentro -Time History

6.Results and Discussion

After the analysis various storey response includes storey displacement and base shear are considered and compared below.

6.1 Storey displacement

The lateral displacement of a storey in relative to its base is called storey displacement. The displacement value obtained for a G+15 storey building with and without FVD using both the static method and dynamic method in both the x and y directions for all the seismic zones.

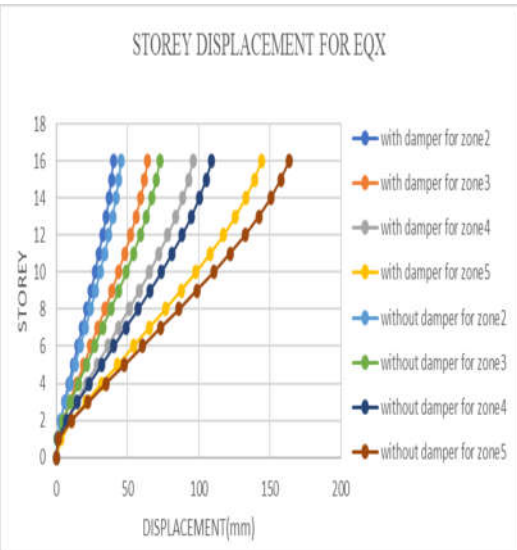

Fig. 9 : Storey displacement in x direction for static method

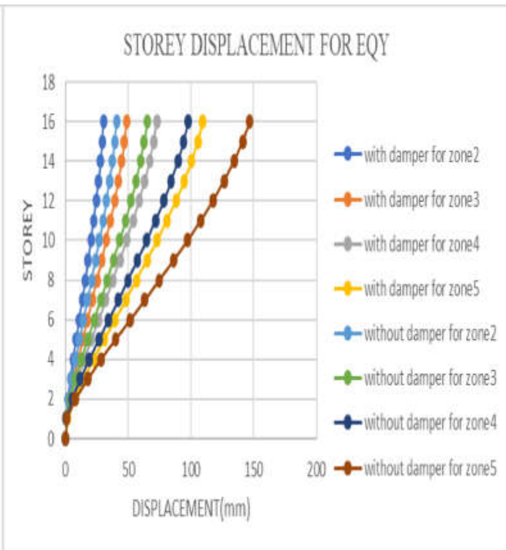

Fig. 10 : Storey displacement in y direction for static method

Fig. 9 and Fig. 10 shows storey displacement of structure with FVD and without FVD for static method in x and y direction for all the seismic zones.When compared to zone2, zone3, zone4 and zone5, zone 2 has least displacement whereas zone 5 has maximum displacement in x direction.Based on results a structure with an FVD has minimum displacement compared to the structure without an FVD for all the seismic zones in x direction.Same results is observed in y direction also.After installation of FVD to the structure it succesfully minimises the displacement.

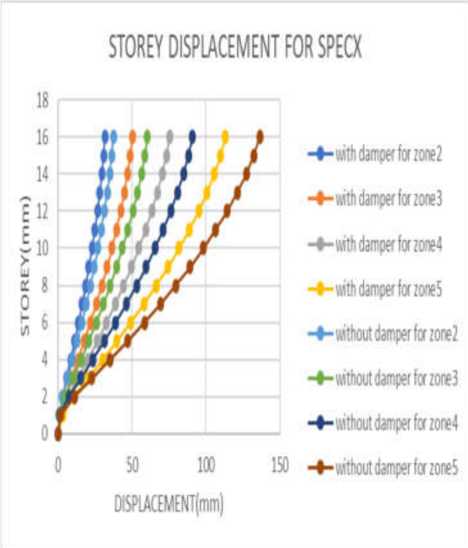

Fig. 11 : Storey displacement in x direction for response spectrum method

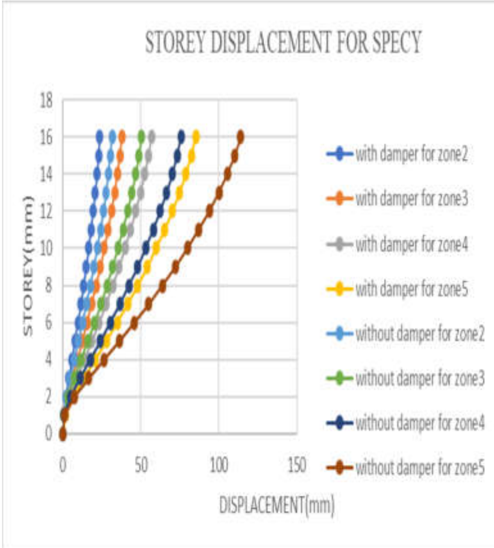

Fig. 12 : Storey displacement in y direction for response spectrum method

Fig.11 and Fig.12 represents storey displacement in x and y direction for all the seismic zones for the structure with and without FVD. Zone 2 has the least displacement and Zone 5 has the maximum displacement in the x direction when compared to Zones 2, 3, 4, and 5. Based on the results,a structure with FVD has least displacement in the x direction for all seismic zones than a structure without FVD. Same results is observed in y direction also. FVD successfully reduces displacement after being installed in the structure.

Fig.13 : Storey displacement in x direction for time history method

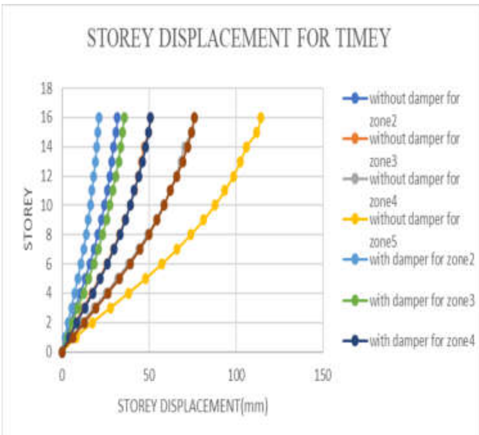

Fig. 14 : Storey displacement in y direction for time history method

Storey displacement of the structure using the time history method for all seismic zones is shown in Fig.. 13 and 14,for the structure with and without FVD. Zone 2 has the least displacement in the x direction compared to zones 2, 3, 4, and 5, whereas zone 5 has the maximum displacement. From the results, for all seismic zones in the x direction, a structure with an FVD has least displacement than a structure without FVD. In the y direction, the same results were observed.When FVD installed to the structure storey displacment succesfully reduced.

Further comparing both equivalent static method and dynamic method the structure with and without FVD in both x and y direction, equivalent static method shows the maximum displacement of 150.973mm and 171.638mm respectively.Dynamic method shows the minimum displacement of 117.78mm and 142.35mm in both x and y direction,this may be because of trasient loads acting on the structure in both x and y direction.

6.2.Base Shear

It is the total lateral energy acting on the building at its base, which is equal to the bottom storey's storey shear. Table 3 compares the base shear of buildings with and without FVD.

	With damper	Without damper
Zone2	2375.895	2186.465
Zone3	3652.315	3498.344
Zone4	5378.947	5247.515
Zone5	7968.421	7871.273

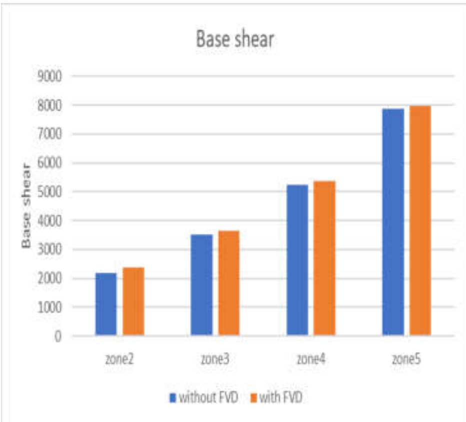

Table 3 : Base shear of building

Fig..15 Base shear comparison

Fig.. 15 shows that base shear for structure with and without FVD for different seismic zones. It is observed that maximum base shear is observed in zone5 and least base shear in zone2. Further,structure with FVD has maximum base shear when compared to structure without FVD,this may be because of structure weight increases after installation of FVD.

7.CONCLUSION

Based on the results and discussion the following conclusions are drawn:

- Displacement in the structure reduced when the FVD is installed.
- Structure without FVD shows the maximum displacement of 13.8% in x direction and 33.90% in y direction under static analysis compared with structure having FVD.

- When compared to structures with FVD,structures without FVD shows maximum displacement of 20.86 % in the x direction and 34.17% in the y direction.
- The results shows that 14.1% and 49.97% of displacement decreases in the structure with FVD when compared to the structure without FVD in x and y direction respectively.
- Base shear of the structure with FVD shows maximum base shear as compared to structure without FVD.

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