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Investigation on Seismic Analysis of Framed Structure

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***Abstract*- Earthquake is a natural disaster which can cause severe damage to human lives and properties. Recent earthquakes which occurred during last decade have indicated that major damage occurred was not directly due to actions of earthquakes but due to poor performance of structure during earthquake. It is said that the earthquake will not kill the human life, But the structures which are constructed by not considering the earthquake forces do. There are many methods to reduce the damage caused by the earthquake. The most advanced methods are Base isolation and Energy dissipation devices. Energy dissipation devices is also known as dampers. There are many types of dampers such as viscoelastic dampers, friction dampers, tuned mass damper, fluid viscous damper, magnetic damper, yielding damper etc., Among all dampers fluid viscous dampers has been used in various structural and mechanical systems. The main objective of the study is to model and analyze the structure against the seismic loads. In this study, fluid viscous dampers are used in the G+5 L-shaped framed structure and the seismic analysis is carried out by using ETABS (version 19) software. The data required are taken from IS1893 2016 code. The method used for seismic analysis is Response spectrum method. The structure is assumed to be in zone II. The response of the structure before and after the application of the dampers is studied. The results are discussed based on parameters such as maximum storey displacement, maximum storey drift, storey stiffness, overturning moment, storey shear.**

Key Words: Seismic analysis, Fluid Viscous Damper, Response Spectrum Analysis, ETABS 19.

INTRODUCTION

An earthquake is the sudden and rapid shaking of the Earth's surface which is caused by the movement of tectonic plates. Earthquakes can range in intensity from barely noticeable tremors to violent shocks that cause buildings to collapse and cause massive destruction. In recent years, occurrence of earthquake has increased rapidly which leads to lot of destruction in human lives and properties. Earthquake can happen at any time and in any part of the world, so it is important to be prepared for the natural disaster like this. It is observed that medium to high rise buildings are suffered more compared to low-rise buildings.

Seismic analysis is the process of studying the behavior of the structures, such as buildings, bridges, dams and other infrastructure under seismic forces, which are generated by earthquake. The primary goal of seismic analysis is to ensure that structures can withstand the shaking and ground motion caused by earthquake and remain functional after seismic events. This analysis considers factors such as type of soil, importance factor, terrain category, zone factor, response reduction factor.

There are different types of seismic analysis methods such as

- Equivalent static method
- Pushover analysis
- Response spectrum method
- Time history analysis

In this project response spectrum method of analysis is considered as it provides maximum seismic response of the structure.

Energy Dissipating Devices:

Energy dissipating devices are used to reduce the amount of energy or force in a system. The main purpose of energy dissipating devices is to absorb, disperse or dissipate energy from an object, process, or system in a controlled manner. One of the energy dissipating device is seismic dampers.

Seismic Damper: Seismic dampers are mechanical devices that are installed in buildings and other structures to absorb and dissipate seismic energy during earthquakes. They are designed to help reduce the damaging effects of earthquakes on the structures and Energy dissipation devices can be used in both new construction and retrofitting of existing structures. They can help to reduce the risk of structural damage during earthquakes and provide safety to the occupants.

Classification of Dampers:
There are several types of seismic dampers, each with its own mechanism of energy absorption and dissipation. Some common types include are

- Fluid viscous damper
- Viscoelastic damper
- Friction damper
- Tuned mass damper
- Yielding damper
- Magnetic dampers

Fluid Viscous Damper:
Fluid viscous dampers (FVD) are devices used to reduce the effects of vibrations caused by earthquakes, wind, or other external forces. They work by dissipating the energy of the vibrations as heat by passing the fluid through a constriction, which generates a resistance force. FVDs consist of a piston that moves through a cylinder filled with a viscous fluid, typically oil. The piston is attached to the structure being protected from vibrations, while the cylinder is attached to a fixed point in the building. As the structure moves during an earthquake or other disturbance, the piston moves through the fluid, generating a force proportional to the velocity of the motion. The force generated by the FVD opposes the motion of the structure and dissipates the energy of vibration and duration of motion. It is used in high rise buildings.

Modelling details:

Type of the building	Irregular building (L- shaped)
No of bays	10
Spacing of bay	3m x 3m
Height of base storey	4m
Height of remaining storey	3m
Grade of concrete	M30
Grade of steel	Fe500
Size of beam	300mm x 400mm
Size of column	450mm x 450mm
Thickness of slab	150mm
Number of floors	6

TABLE 1: Geometric details

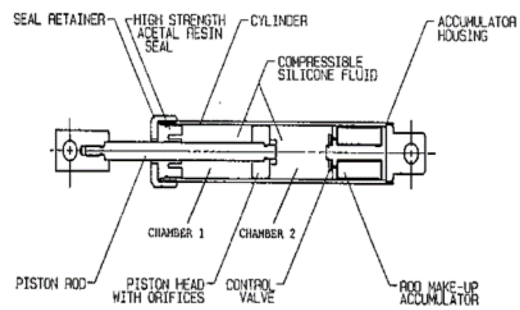


FIGURE 1: Components of fluid viscous damper


FIGURE 2: Incorporation of dampers

MODELLING AND ANALYSIS:
The modelling and analysis is carried out on ETABS-19 software for G+5 building. Response spectrum method of analysis used. The analysis is done by incorporating fluid viscous dampers at

- Corner panel at outer surface
- Center panel at outer surface
- Centers and corners panel at outer surface
- Alternate panel at outer surface

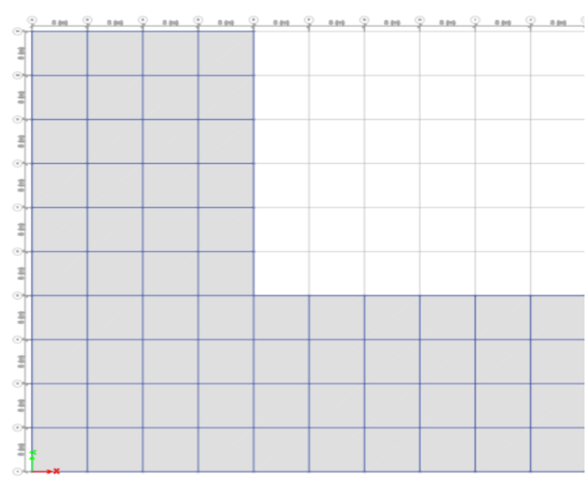


FIGURE 3: Plan View

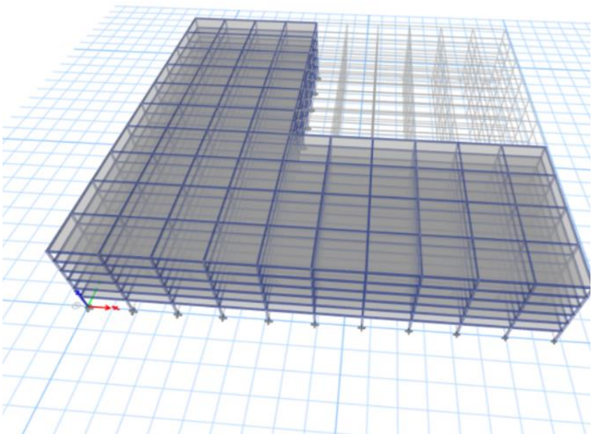


FIGURE 4: 3D View

Loading details:

The loads considered are dead load, live load, earthquake load in x-direction, earthquake load in y-direction, wind load in x-direction, wind load in y-direction. Wind load values are taken based on IS 875 2015. Earthquake loads are taken based on IS code provisions such as IS 1893 2016

Zone	II
Damping ratio	5%
Importance factor (I)	1
Type of soil	I
Response reduction factor (R)	3
Zone factor (Z)	0.10

TABLE 2: Loading details

DAMPER DETAILS:

Name	Type	Mass kg	Weight kN
FVD 500	Damper-exponential	98	500

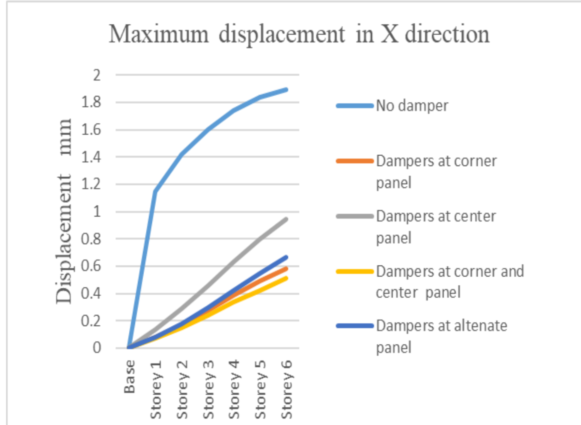
TABLE 3: Damper details

RESULTS AND DISCUSSION:

In the present study all 4 models have been analyzed by ETABS 19. Linear dynamic method (Response spectrum method) of analysis used for analytical purpose and all 3 models which has dampers and a model with no damper is also analyzed. The results of the analysis are discussed below.

1. Storey displacement:

Storey displacement is used to describe the horizontal displacement (movement) of a building's floor at a given level during a seismic event. The maximum storey displacement is an important factor in the design of buildings in earthquake prone areas, as excessive movement can cause structural damage or collapse.



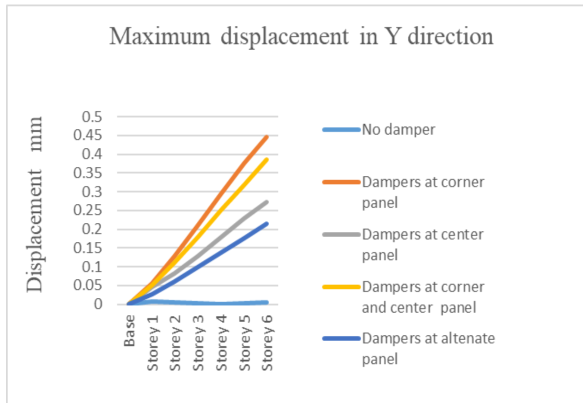
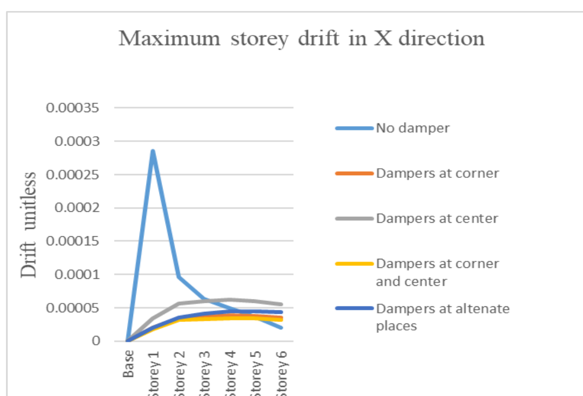


FIGURE 5: Maximum storey displacement

2. Storey drift:

Storey drift is used to describe the lateral displacement or movement of the building's floor at a given level relative to the floor above or below it. It is caused by the external forces acting on the building such as wind, seismic activity or other lateral loads. Excessive storey drift can cause structural damage or failure and effect the safety of the building components.



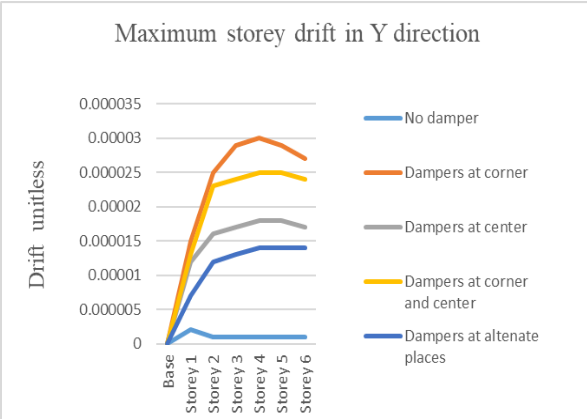


FIGURE 6: Maximum storey drift

3.Storey Stiffness:

Storey stiffness refers to the ability of the building storey to resist the lateral displacement or movement caused by external loads, such as wind or seismic activity. Storey stiffness is influenced by several factors which includes the building's structural system, the materials used in the construction, the floor and wall configurations, and the overall geometry of the building.

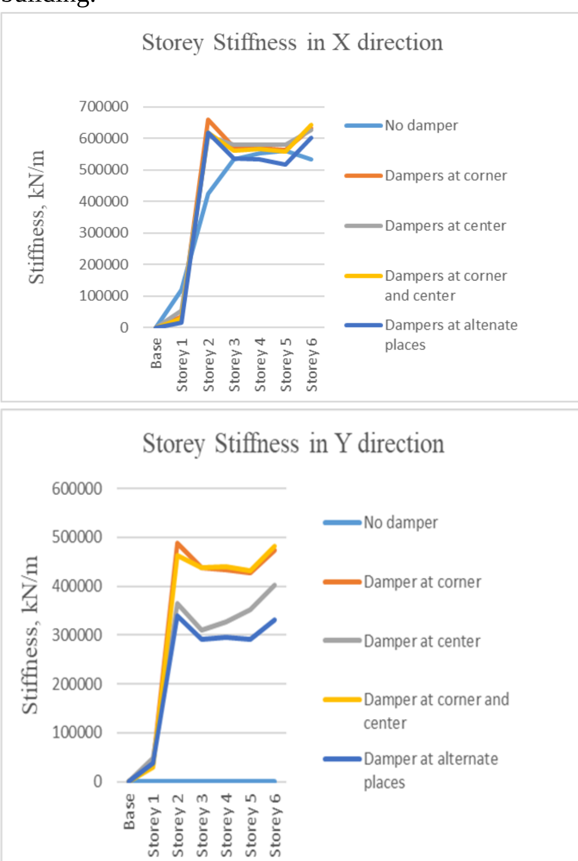


FIGURE 7: Storey stiffness

4. Storey overturning moment:

Overturning moment refers to the tendency of a force to rotate or overturn a structure or object. It is a measure of the moment, or turning effect, created by the force about a particular point. When a force is applied to an object, it can cause a rotation or tipping motion depending on the position and direction of the force relative to a reference point. The overturning moment is a measure of the force's ability to cause this rotation or tipping.

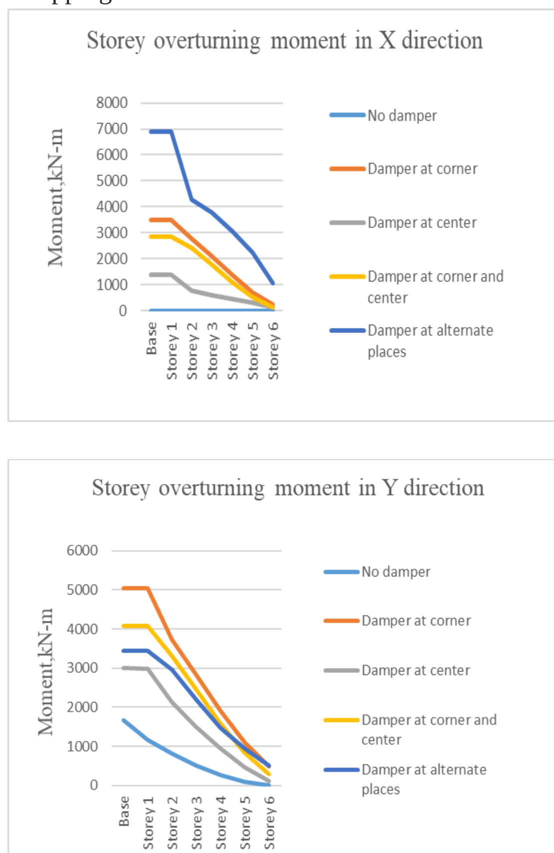


FIGURE 8: Storey overturning moment

5. Storey shear:

It represents the distribution of shear forces along the height of a building due to external loads such as wind or seismic forces. Storey shear is typically expressed as the total lateral force acting on a particular storey divided by the building's total weight. It is commonly represented by the symbol "V." The storey shear values are usually calculated in two orthogonal directions (e.g., X-direction and Y-direction) to account for different loading scenarios.

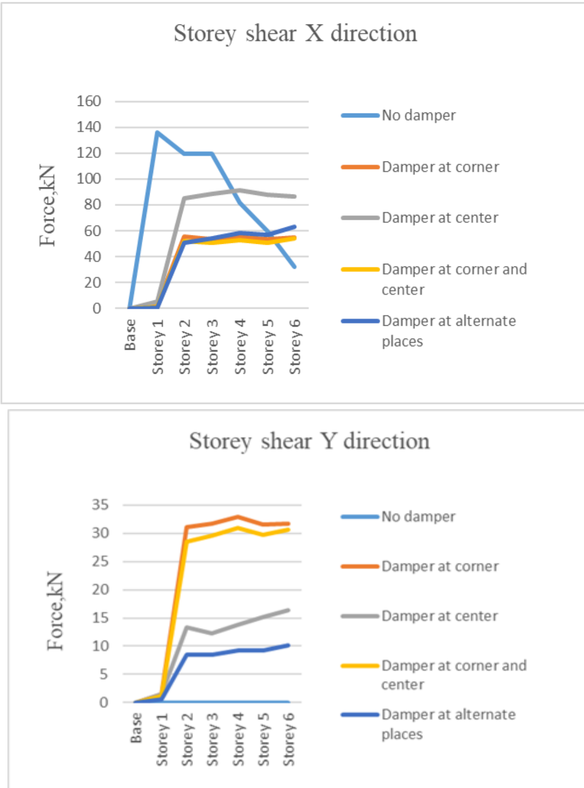


FIGURE 9: Storey shear

CONCLUSION

The main goal of this study is to analyze the L-shaped building equipped with fluid viscous dampers. Parameters such as maximum storey displacement, maximum storey drift, storey stiffness are studied and the results are as follows.

1. The performance of the structure with damper is more effective than the structure with no damper.
2. The amount of maximum storey displacement and maximum storey drift is decreases by using fluid viscous dampers.
3. The value of maximum storey displacement decreases. Maximum storey displacement is an important parameter because excessive storey displacement can cause the structural damage or failure, while insufficient displacement can lead to discomfort or unsafe conditions for the occupants.
4. Storey drifts value is decreasing when dampers is placed which reduces the probability of collapse of building.
5. The value of storey stiffness increases which ensures that the building has better seismic resistance compared to the building with no damper. Good seismic resistive building will have high lateral stiffness, low stiffness results to deformation and damage.
6. The performance of buildings with fluid viscous damper at corners and center is more effective compared to other position of dampers
7. According to Response Spectrum Analysis storey Overturning moment was found to be maximum at base and it decreased to minimum in top storey in all cases.
8. Response Spectrum Analysis using ETABS proved to be successful in predicting the response of the structure more accurately than the conventional methods.

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