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Dynamic Analysis of Vertical Irregular RCC Framed Structures with and without Fluid Viscous Dampers using Response Spectrum Analysis

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ABSTRACT: The dynamic behavior of reinforced cement concrete (RCC) structures, particularly those with irregular geometries, is significantly influenced by seismic forces. This project analyzes and compares the seismic performance of irregular RCC framed structures with and without fluid viscous dampers using response spectrum analysis. The study evaluates the structural response under earthquake loading conditions and quantifies the impact of fluid viscous dampers on energy dissipation, displacement and drift reduction. The results demonstrate that structures equipped with fluid viscous dampers exhibit enhanced resilience, with notable reductions in displacement and drift. These findings provide practical insights into the effectiveness of dampers in minimizing seismic risks, offering valuable guidelines for designing safer building in earthquake prone regions.

KEYWORDS: Response spectrum analysis, Fluid viscous dampers, Vertical Irregularity, ETABS V20.

I. INTRODUCTION

One of the most frightening and destructive phenomena of nature is a severe earthquake and its terrible aftereffects. An earthquake is a sudden movement of the Earth, caused by the abrupt release of strain that has accumulated over a long time. For hundreds of millions of years, the forces of plate tectonics have shaped the Earth as the huge plates that form the Earth's surface slowly move over, under, and past each other. Sometimes the movement is gradual. Today we are challenging the assumption that earthquakes must present an uncontrollable and unpredictable hazard to life and property. Scientists have begun to estimate the locations and likelihoods of future damaging earthquakes. Seismic analysis of structures is required for the design of high-rise building as these are hazards that threaten the built environment and human life. However, it was observed that most of the high-rise structures show irregularities in form of mass, stiffness, strength, plan, etc.

Technique to resist Earthquake

- 1) Base isolation technique
- 2) Energy dissipation devices (Damper)

Base Isolation Technique - A base isolation system is a method of seismic protection where the structure (superstructure) is separated from the base (foundation or substructure). By separating the structure from its base the amount of energy that is transferred to the superstructure during an earthquake is reduced significantly.

1. Elastomeric Rubber Bearings
2. Elastomeric Lead-rubber Bearings
3. Friction Based Isolators
4. Friction Pendulum System

Energy dissipation devices (Damper) - The second of the most important new techniques for improving the earthquake resistance of buildings also depends upon damping and energy dissipation. Structural control systems can be classified as passive, active, semi-active and hybrid.

1. **Passive Control Devices** - Passive control systems are devices or elements that do not require external power or input to operate. They rely on the inherent properties of the materials or the geometry of the structure to reduce seismic response.
2. **Active Control Devices** - This system provides seismic protection by imposing forces on a structure that counterbalance the earthquake induced forces. Examples among active control devices include active tuned mass damper, active tuned liquid column damper and active variable stiffness damper.
3. **Semi Active Control Devices** - Semi-active control devices combine the positive aspects of passive and active control devices. Examples of semi-active devices include variable orifice dampers, variable friction dampers, variable stiffness damper, and controllable fluid dampers.
4. **Hybrid Control Devices** - An HMD is a combination of a passive tuned mass damper (TMD) and an active control actuator. The ability of this device to reduce structural responses relies mainly on the natural motion of the TMD. Examples of hybrid control devices include hybrid mass damper and hybrid base isolation.

II. LITERATURE REVIEW

Summary

1. Provision of Fluid Viscous Damper in all frames gives good result but also provision in corner frames gives satisfactory results. (economically good)
2. The result of base shear in RCC building with damper shows lower than in case of without damper.
3. Adding Viscous Damper to the structure reduces not only the deformation but also the overturning moment.
4. On comparing Visco-elastic Damper with Fluid Viscous Damper, FVD gives good result while considering same location of placing damper.
5. When dampers are provided in building, the reduction in story drift decreases with increase in number of floor.
6. On comparing Tuned Mass Damper with Fluid Viscous Damper, FVD gives maximum reduction in response (Base Shear, Displacement, Velocity, Acceleration) for same damping coefficient.
7. Maximum storey displacements and storey stiffness has found to be more in metallic dampers which are placed in middle of structure than fluid viscous damper.

III. OBJECTIVE AND SCOPE

Objective

1. To understand the behaviour of R.C.C. structures analytically with and without Fluid Viscous Damper.
2. To find out the change in the values of various structural parameters like Time period, Storey Displacement, Storey Drift and Acceleration using Response Spectrum Analysis.
3. To find out the optimised location for the dampers in the structure. So, it gives maximum reduction in the structure response.

Scope of Work

1. Detailed analytical study on Fluid Viscous Damper using ETABS version 20.
2. The study is limited to analysis of 20 story, 30 story and 40 story of R.C.C. Buildings.
3. Total Nine different structures are modelled for three different height and three vertical irregular structures.
4. Fluid Viscous Dampers are provided on different locations in every structure.

IV. METHODOLOGY

Steps for design and analysis

1. Determine structural properties of building and perform structural analysis under the earthquake load.
2. Study the response of the structure after analysis like storey displacement, storey drift, and Time period.
3. Determine the appropriate locations of the damper in the model.
4. Again analysis is carried out for model with no damper and also model with different damper locations.
5. Carried out the response of the structure like storey displacement, storey drift, and Time period for individual model.
6. Compare the result of storey displacement, storey drift, and time period for with and without Damper.

Problem Statement

The present work involves the study of structure with and without Fluid Viscous Damper. The various height will be consider for this study are 20 floors, 30 floors and 40 floors. The aim of study is to find out the differences in various parameters of structure by using ETABS software by performing Response Spectrum Analysis.

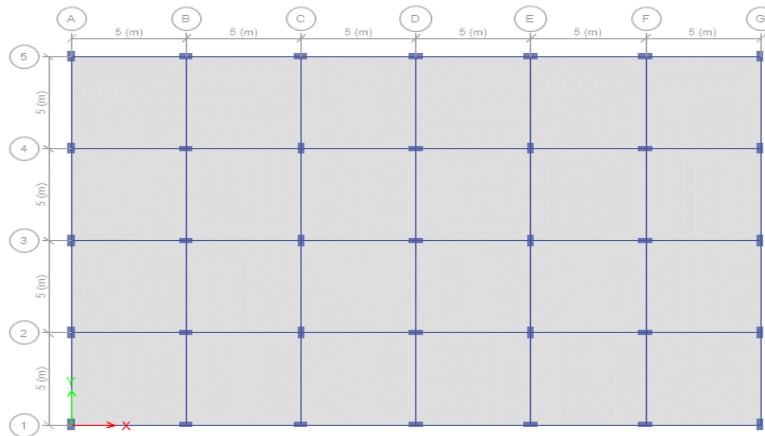


Fig 1: Plan for Model

Structural Details

Table 1 - General Detail of Structure

Particulars	Model - A	Model - B	Model - C	Units
Max. Length in X-direction	30	30	30	m
Max. Length in Y-direction	20	20	20	m
Nos. of Floors	20	30	40	
Typical Floor Height	3.1	3.1	3.1	m
Ground Floor Height	3.1	3.1	3.1	m
Total Height of Structure	62	93	124	m

- Without damper – Case - 1
- With diagonal damper at corner – Case - 2
- With zig-zag diagonal damper – Case – 3

Table 2 - Material Properties

Name	Type	E (MPa)	V (Poissons Ratio)	Unit Weight (KN/M3)	Design Strength
Fe 415	Rebar	200000	0.3	76.97	Fy = 415 Mpa
Fe 500	Rebar	200000	0.3	76.9	Fy = 500 Mpa
M-40	Concrete	31622.78	0.2	25	Fck = 40 Mpa

Types of Loads and Their Intensities

Details of building load configurations as per IS 875 Part 2:2015

- Self-Weight – As per ETABS

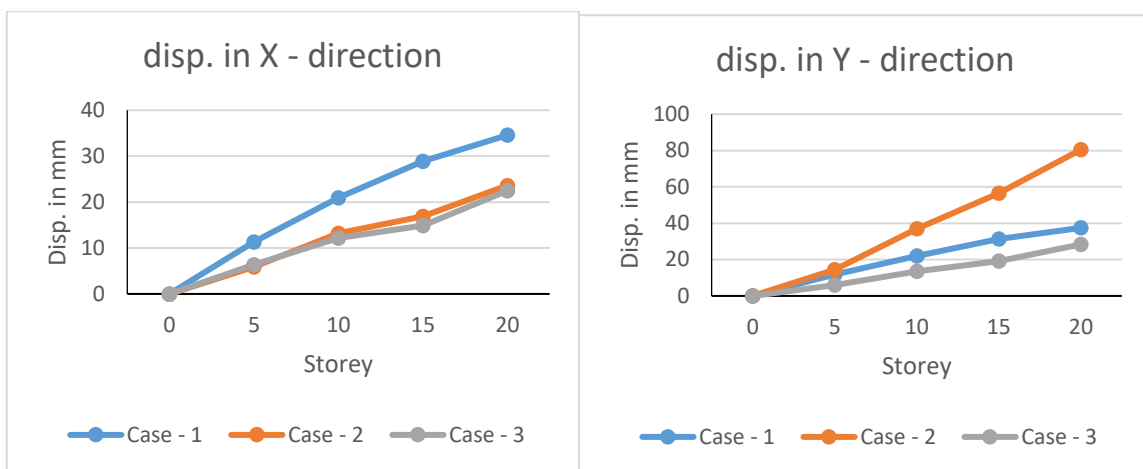
- Live Load – 0.5 KN/SqM
- Floor Finish – 2KN/SqM

Properties of Viscous Damper to be used

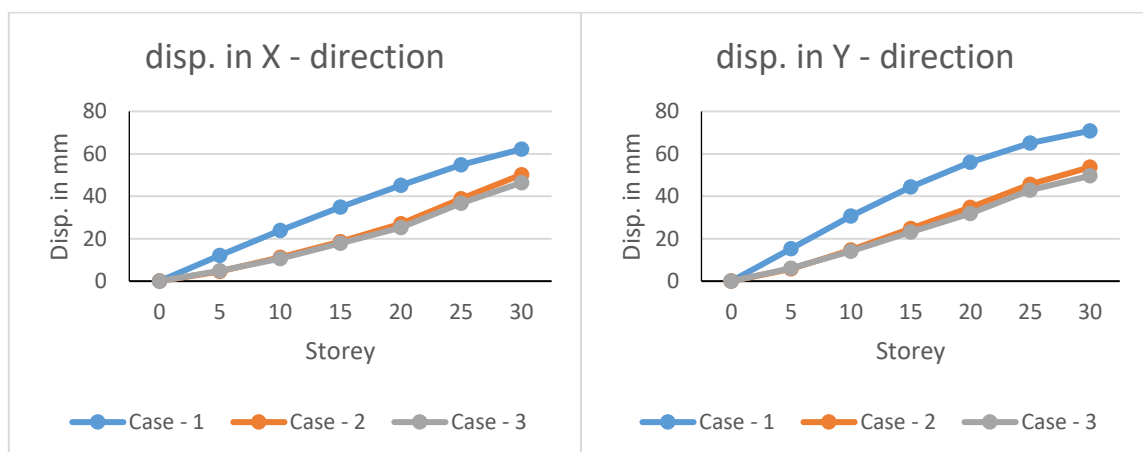
Linear Fluid Viscous Damper:-

- Model No.17130 (From Taylor Devices)
- Force: 500 KN
- Weight: 98 Kg

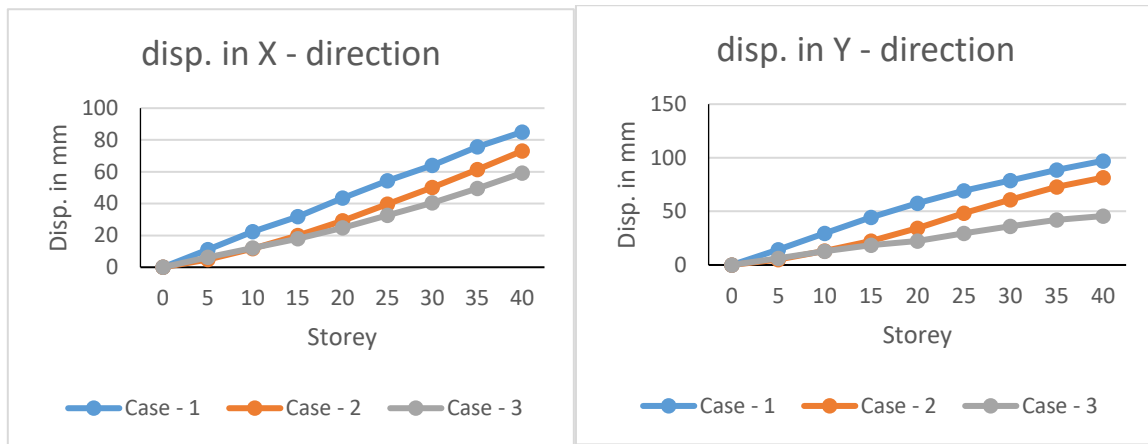
V. RESULT



(a)

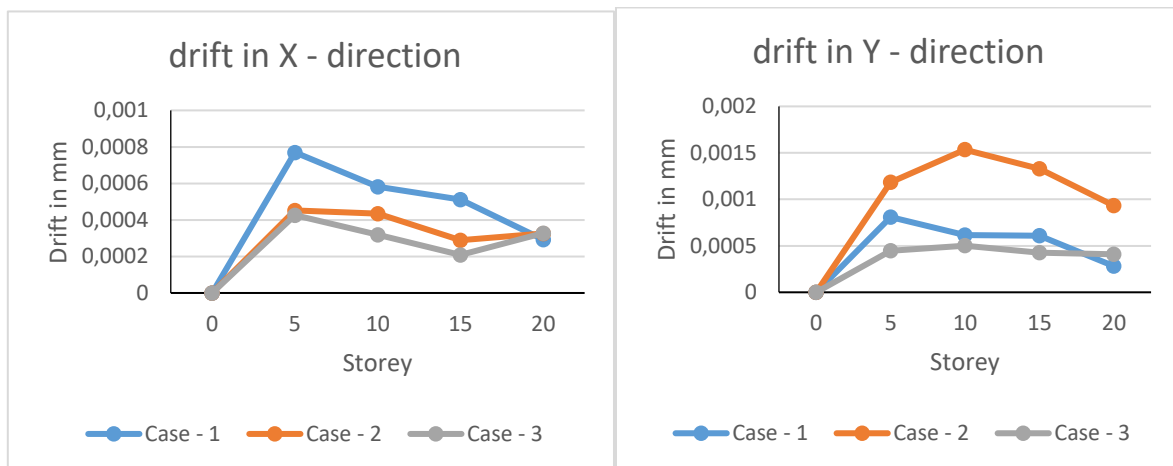


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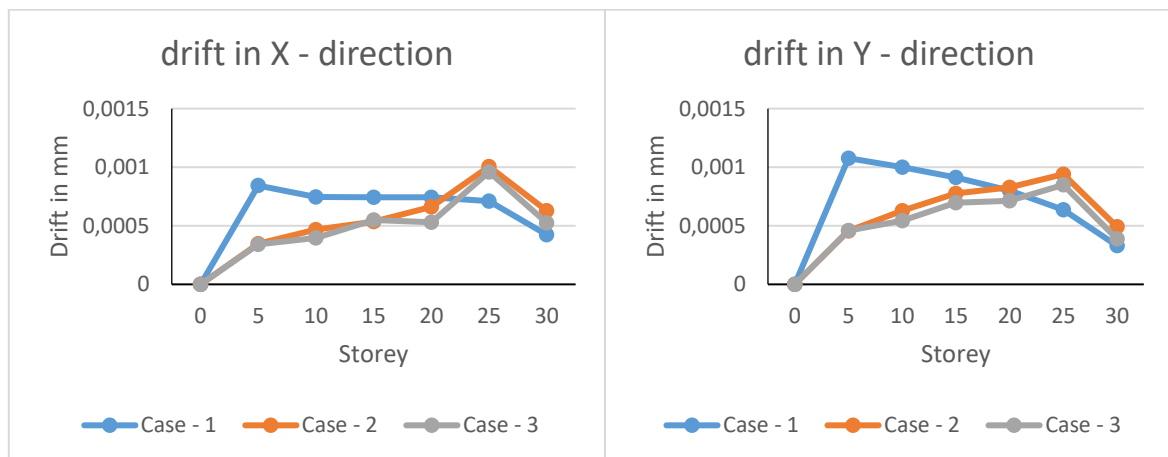


(c)

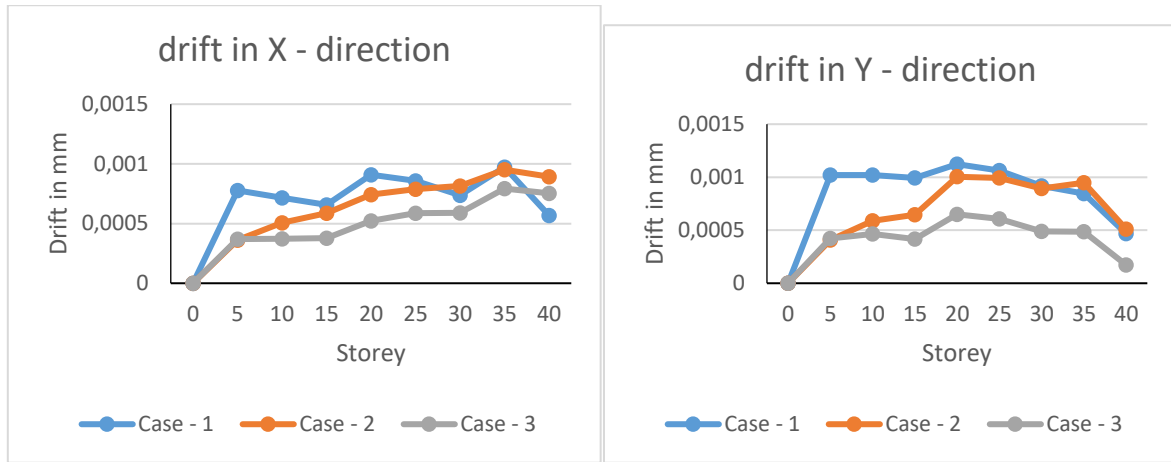
Fig 2: Storey Displacement for Model A (a), Model B (b) and Model C (c) when earthquake force applied in X and Y direction



(a)

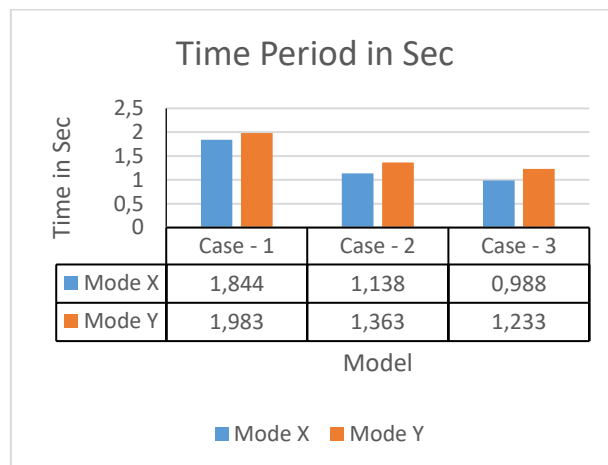


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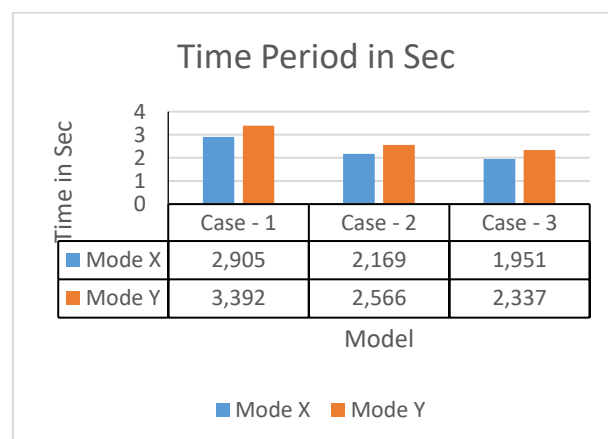


(c)

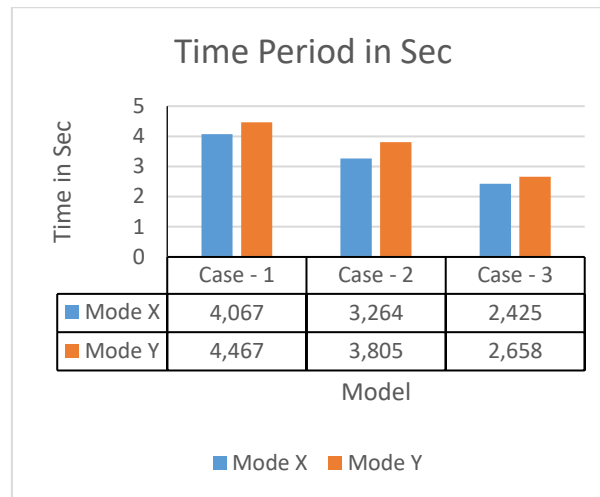
Fig 3: Story Drift for Model A (a), Model B (b) and Model C (c) when earthquake force applied in X and Y direction



(a)



(b)



(c)

Fig 4: Time Period for Model A (a), Model B (b) and Model C (c) when earthquake force applied in X direction and Y direction

VI. CONCLUSION

1. For displacement it is observed that the FV dampers provided in zig-zag position gives better results (i.e. decreased the storey displacement) when compared to FV damper provided in diagonal position and without damper model.
2. For drift it is observed that the FV dampers provided in zig-zag position gives better results (i.e. decreased the storey drift) when compared to FV damper provided in diagonal position and without damper model.
3. Around 35% - 40% reduction in time period has been observed when FVD are used.
4. It is observed that FVD provided in zig-zag position gives better result and more resistance to earthquake forces as compared to other models.

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