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Seismic Parametric Analysis of RC Multi-Storied Buildings with and Without Fluid Viscous Dampers

Kamal Kumar[1], Ajay Vikram[2,]
Rayat-Bahra University, Department of civil Engineering

Abstract: Earthquakes are enormous natural disasters that increase the energy within the structural system, causing catastrophic destruction. Various control systems, such as passive, active, hybrid, and semi active control systems, can be used to dissipate this unwanted energy.

The fluid viscous damper is one such dissipation device used in this study. The goal of this project is to use a fluid viscous damper to lessen the seismic response of the Symmetrical and unsymmetrical G+9 structure in ETABS2017. To obtain the seismic response with and without a fluid viscous damper, ETABS2017 was used to analyse symmetrical and unsymmetrical structures with and without a fluid viscous damper. The analysis takes into account nonlinear temporal history, which is derived using fast nonlinear analysis of Electro data. The position and function of dampers are discussed in this study. For seismic evaluation of buildings with and without fluid viscous dampers, the equivalent static approach and response spectrum method are utilized. The building was analyzed using ETABs 2017 software, with seismic zone IV and medium soil (Type II) as per IS 1893-2016. The building's performance is evaluated using storey displacement, storey shear, storey drift, and modal periods and frequencies. The goal of this study is to compare the results of static and response spectrum analysis in both longitudinal and transverse directions for damper construction with and without damper building.

Keywords: Energy dissipation, Fluid viscous damper, Non-linear time history analysis, Passive control system, Seismic response control.

I. INTRODUCTION

Seismic control devices known as dampers can be used to lessen the lateral force caused by earthquakes in seismic constructions. A tremendous quantity of energy is applied to the structure during seismic events. When a structure is free of damping, its stiffness is lower and its vibration is higher; however, when the structure is dampened by fluid viscous damping, its stiffness increases and vibration is reduced.

Fluid viscous dampers (FVD) are the most often used devices for modulating structure reactions. These devices are used to decrease structural responses to seismic stimulation using a variety of building approaches. The viscous fluid dampers (VFD) are the more applied tools for controlling responses of the structures. These tools are applied based on different construction technologies in order to decrease the structural responses to the seismic excitation. Though over the recent years heavy costs have been paid for accurate recognition of force of an earthquake in the research institutes of the world with the purpose of decreasing its damage, the increasing need for more research studies on the effects resulted from the earthquake is felt in the theoretical and laboratorial scales damping its stiffness is less and vibration in the structure is more, or else the structure is damped it increases the stiffness of the building as of the vibration reduces. Among various passive energy dissipating devices Fluid viscous dampers are more widely used in buildings.

A. Fluid viscous Damper

Fluid viscous dampers are a type of passive energy vanishing device used to regulate vibration in mechanical and structural systems. These types of dampers have been used widely in the military and aerospace industries for many years, and they are now being employed in structures to control vibrations generated by wind and earthquakes. One of the dampers' most distinctive capabilities is that it can reduce both stress and deflection within a structure that has been subjected to a transient. This is because the dampers only alter their force with velocity, and because the structure flexes, the response is always out of phase with the stresses. Because these dampers are velocity dependant, they are employed to dissipate energy in the building. FVDs are frequency independent devices without a stiffness component

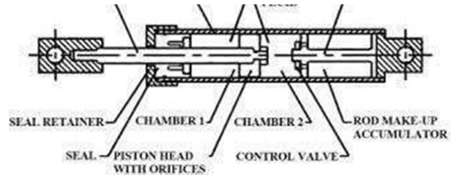

Fig 1-Details of Fluid viscous Damper

The figure shows in which dampers is in mid stroke position. The main pressure chamber is called cylinder, it consists full of fluid inside .It including the volume on both sides of piston. Piston head is connected with the piston rod. The fluid present in the cylinder is compress able viscous fluid silicone oil which is stable for heat, toxic free, inflammable and also environmental friendly.

B. Damping characteristics

An equation is used FVDs operate when a structure moves and add a resisting force to the structure. They do not add stiffness to the structure and do not carry any load. We can add stiffness to the dampers if you desire it. When a piston moves back and forth in an FVD, pressure is created. The orifice, which is specifically constructed in conjunction with the piston, develops an optimal interaction that results in the pressure varying with velocity. The greater the velocity, the greater the resistive to illustrate this relationship.

Damping force = Damping constant x velocity α

F D= C x Vα

Where α is the damping exponent. The value of α a very important role in magnitude of damping force. t. The value of α a very important role in magnitude of damping force. The damper with α value 1 then its is a linear damper in this case as per above equation the damper force is proportional to the velocity. As per practical application the value of α greater than 1 not still in practice.

C. Objectives

- To compare the seismic Response of symmetrical with and without FVD.
- To compare the seismic Response of unsymmetrical building with and without FVD.
- To check the reduction in the various storey responses (Displacement, Base shear, storey drift).
- To study the variations in time period for different structures with and without FVD.
- To compare Pushover when using FVD in structures.
- To conduct Response Spectrum Analysis.

II. METHODOLOGY

Multi-story buildings are classified as multi-degrees-of-freedom systems. In multi-degrees-of-freedom systems, the deformation of the entire structure cannot be described by a single displacement; many displacement co-ordinates are required to identify the displaced structures completely. MDOF is best exemplified by multi-story buildings. The overall mass of buildings is centered at the floor level in multi-story structures. This assumption demonstrates that these structures have an unlimited number of degrees of freedom; structures with numerous degrees of freedom have a lumped mass at the floor levels.

A. Methods of analysis

There are a variety of methods for performing a seismic analysis on a specific building to determine the forces created in the structure as a result of seismic activity. The study is mostly based on the structure's chosen model, the materials utilised in the structure, and external inputs.

1) Equivalent static method is also known as lateral force method. Except for the fundamental period, seismic analysis on a building is based on the assumption that the horizontal force is identical to dynamic loading. Because periods and shapes of higher modes of vibration are not required in this method, the effort for the analysis is reduced. The base shear is calculated using the structure's mass, fundamental vibration periods, and forms. The base shear for an entire structure is computed first, followed by distribution throughout the height of the building. The lateral force is distributed to each structural element at each floor level. This approach is typically used for low to medium-rise structures.

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2) Response spectrum method is also called as a modal method or mode superposition method This method is utilised in a structure where modes other than the fundamental one affect the response of the structure. It is mostly used in the dynamic analysis of buildings that are asymmetrical in plan or irregular in regions. This method is used to analyse multi-story buildings to determine the forces and displacements induced by medium-range seismic activity.

III. MODELLING AND ANALYSIS

G+9 storey building is considered for the analysis and modelling is done in ETABs 17 software.

Description of building model

Geometric details	
No of grid in X direction	7
No. of grid in Y direction	7
Storey height	3 m
Size of Beam	(300x450) mm
Size of column	(600x750/600x600)mm
Slab thickness	150mm& 200mm
Grade of concrete	M 30
Grade of steel	FE 500
Each Bay width	6 m
Primary load cases	
Live load	3 Kn/m^2
Floor finish load	1.25 Kn/m^2
Seismic load in X and Y	IS 1893:2016
Wall load	10.55 Kn/m
Seismic properties	
Zone factor Z	0.24
Importance factor (i)	1.2
Damping Ratio	0.05
Response reduction factor (R)	5

Table 1: Building model Details

A. *Damper data*

In the axial direction, the dampers with a single diagonal bracing are active. Because damper behaviour is non linear, the U1 directional characteristic is chosen and the others are maintained fixed. The non linear option is selected when specifying the damper property, and the stiffness, damping constant, and damping exponent values are entered. Because there is no provision for damper rotation, the rotating attributes R1, R2, and R3 are all set to zero. The damper data utilised in this study is listed below; these values are placed into the ETABs when defining dampers. Taylor Devices Inc. in the United States provided the data for the dampers. All storeys have dampers at the exterior corner of the structure.

Damper Type	FVD 250
Mass in kg	44 KG
Damping constant KN-s/m	460
Damping exponent α	0.3

Table 2: Damper input Data

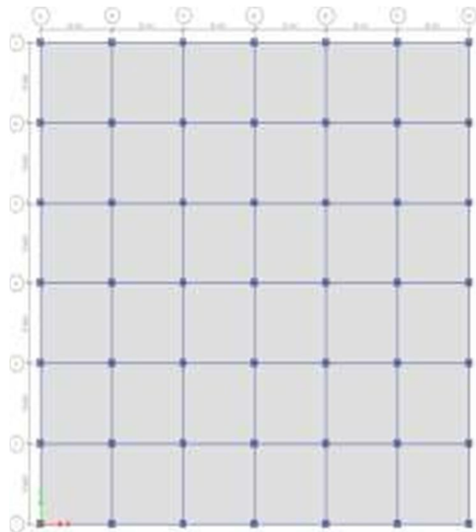


Figure 2: Symmetrical Building plan without Damper

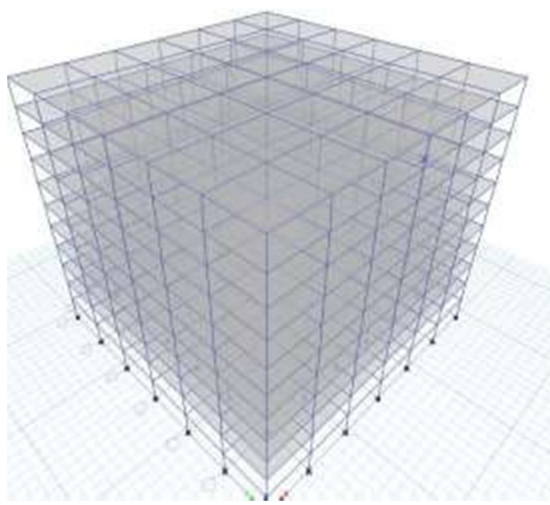


Figure 3 : Isometric view

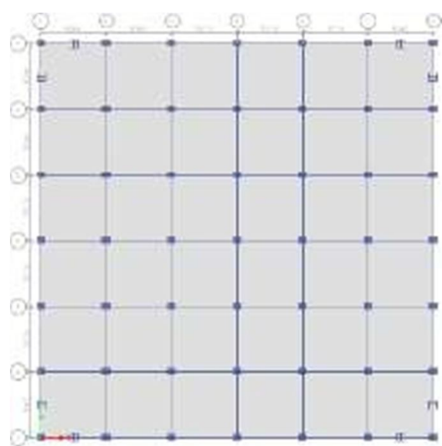


Figure 4: Symmetrical Building plan with Damper

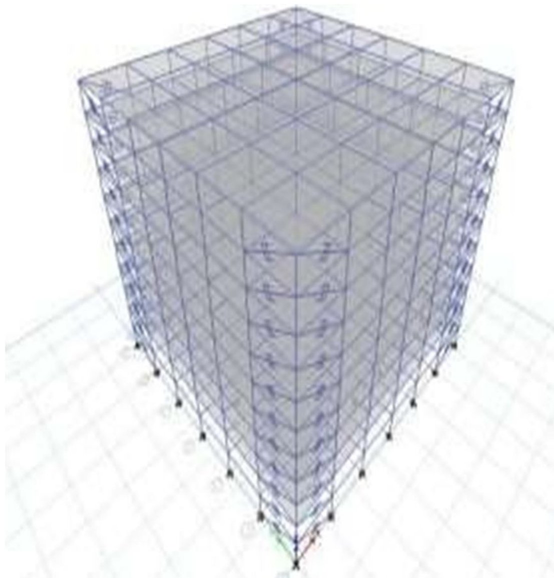


Figure 5: FVD at Exterior corner Isometric view

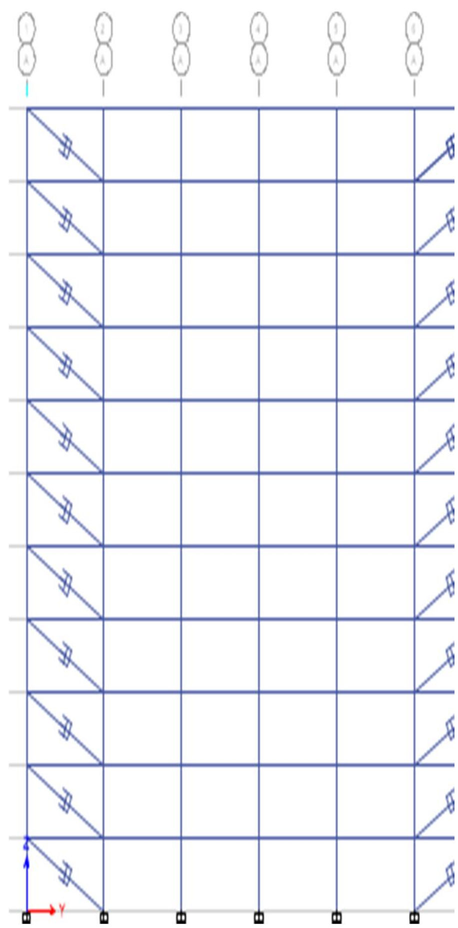
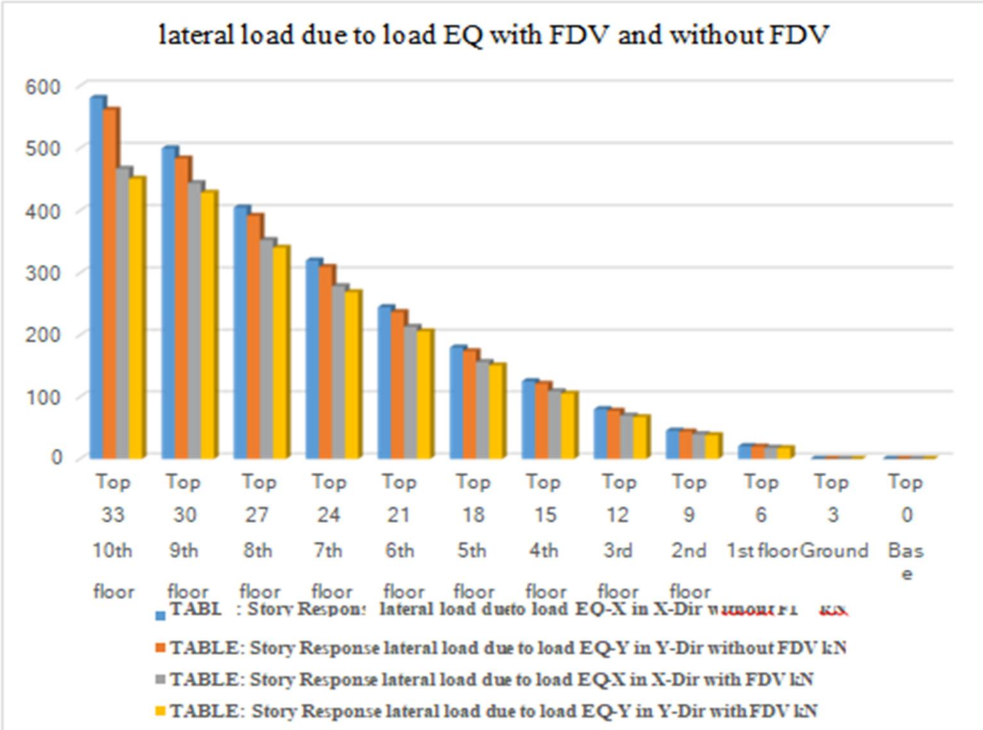
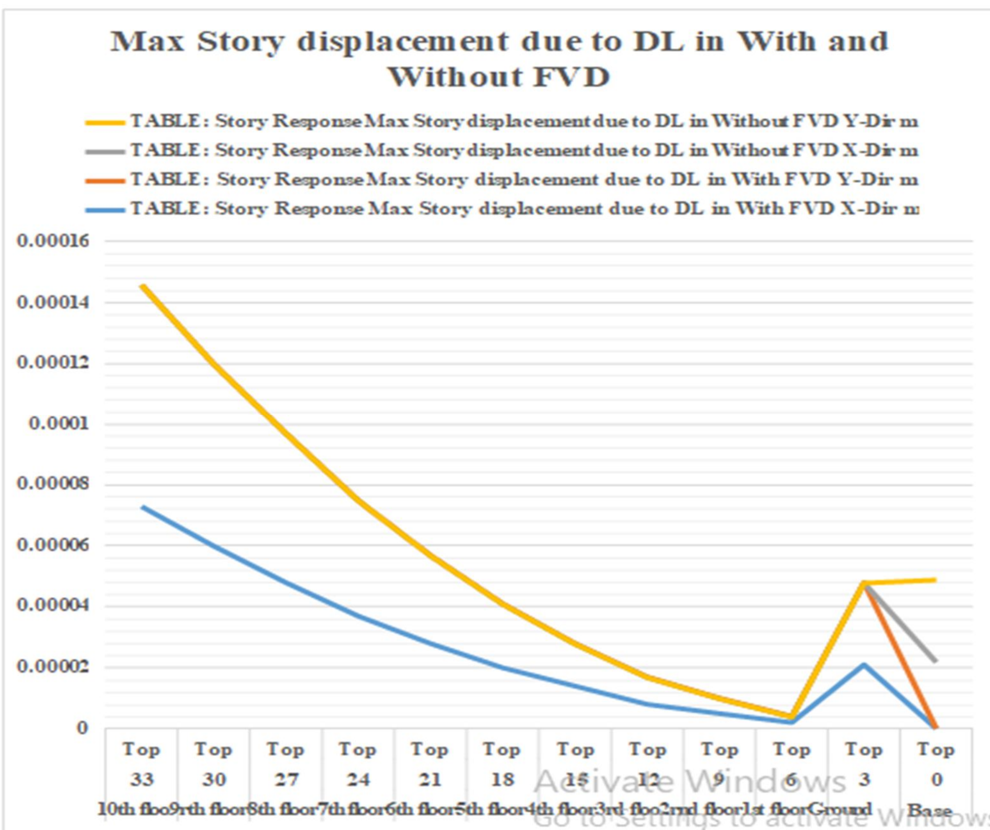


Figure 6: FVD at exterior corner Elevation in YZ plane

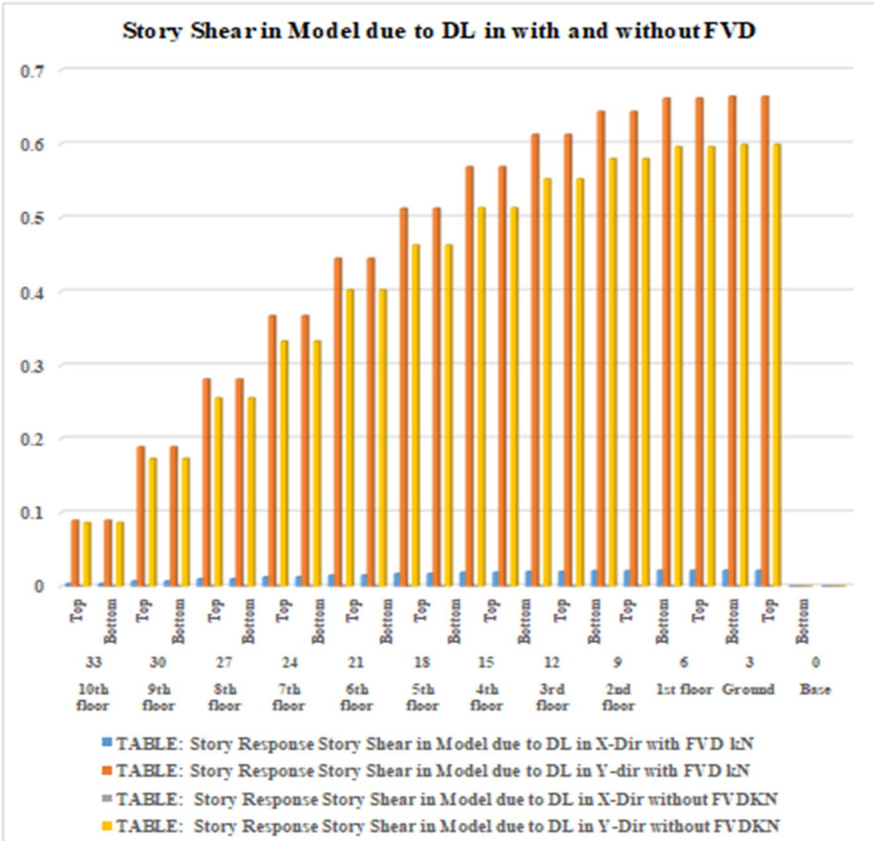
IV. ANALYSIS AND RESULT



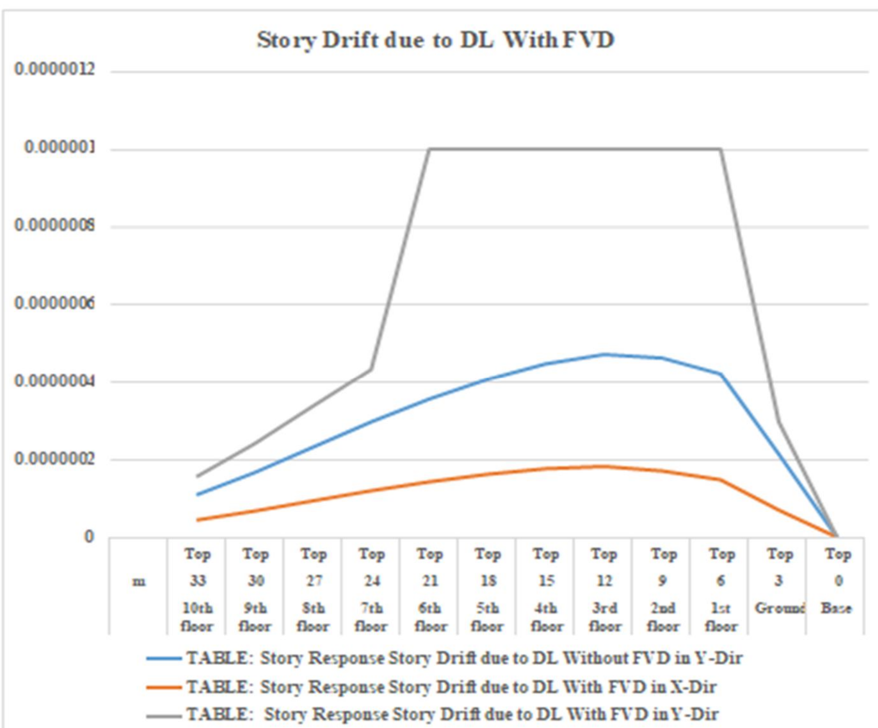
V. STORY DISPLACEMENT



A. Story Shear in Model due to DL in with and without FVD



B. Story Drift due to DL With FVD



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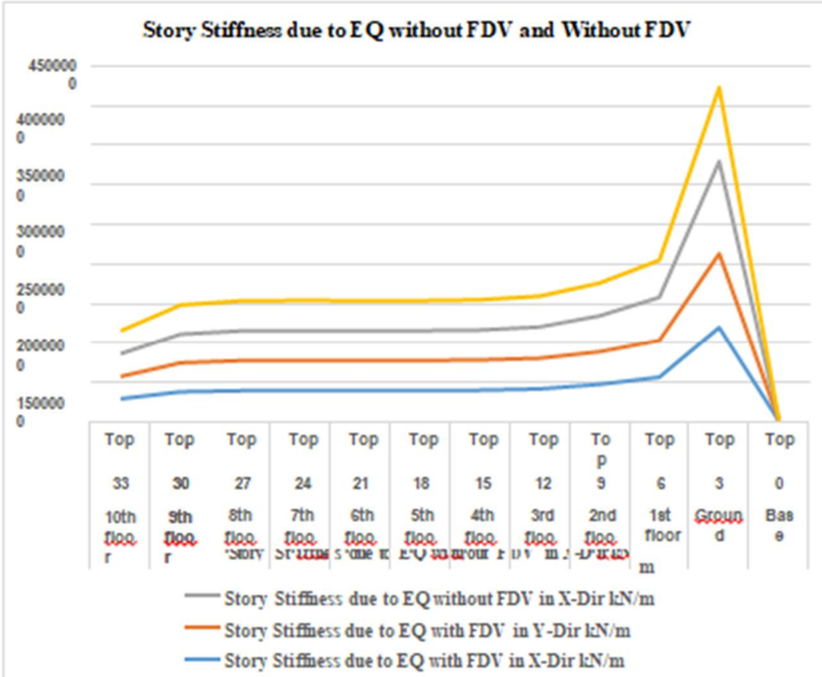
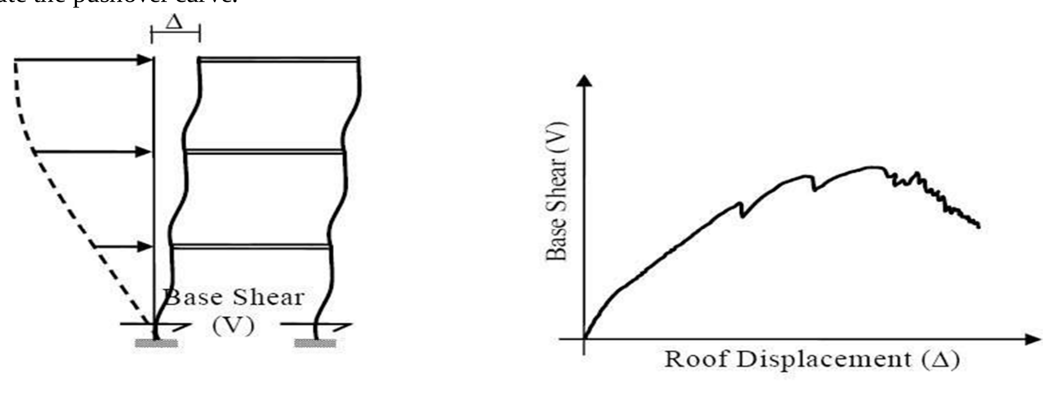
C. Story Stiffness due to EQ without FDV and Without FDV



D. Push Over Analysis

Pushover analysis is a static, nonlinear system where the greatness of the parallel burdens is gradually expanded, keeping a predefined dissemination design along the tallness of the structure. Pushover analysis can decide the conduct of a structure, including a definitive burden and the most extreme inelastic redirection. Neighborhood nonlinear impacts are demonstrated and the construction is pushed until a breakdown component is created. At each progression, the base shear and the rooftop dislodging can be plotted to create the pushover curve.



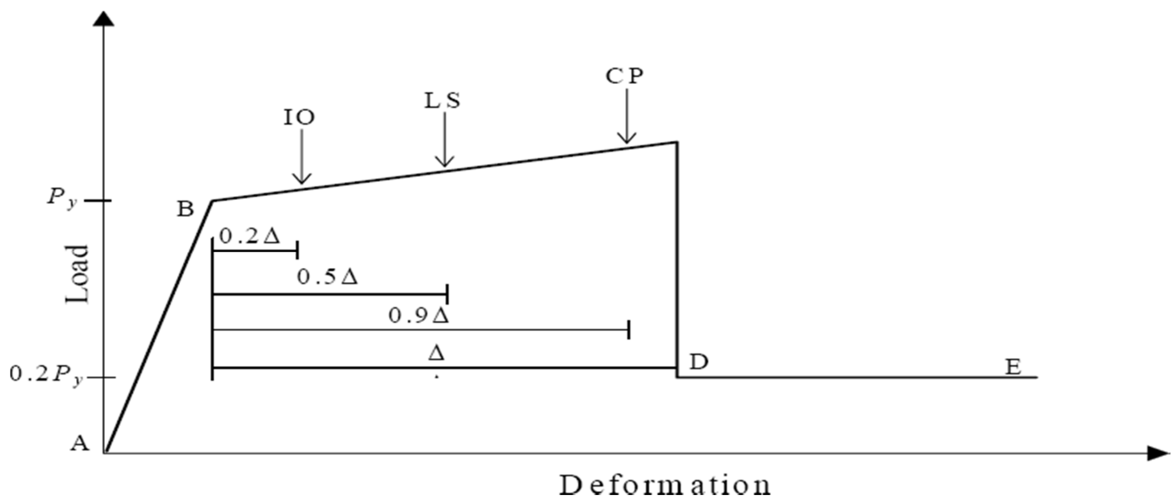
a) Building model b) Pushover curve

E. Seismic Load Distribution

Pushover analysis requires the seismic burden appropriation with which the construction will be uprooted gradually. The heap appropriation depends on the initial three mode shapes

- Point 'A' corresponds to the unloaded condition
- Point 'B' corresponds to the onset of yielding.
- Point 'C' corresponds to the ultimate strength.
- Point 'D' corresponds to the residual strength

A glorified burden distortion curve is displayed in Fig (09). It is a piece-wise straight curve characterized by five as clarified beneath For the computational soundness, it is prescribed to determine non-zero remaining strength. Without the displaying of the slipping part of a heap distortion curve, the remaining strength can be thought to be 20% of the yield strength.
Point 'E' compares to the most extreme misshapening limit with the remaining strength. To keep up with computational strength, a high worth of distortion limit equivalent to 15δy can be expected, where Δy is the deformation at the beginning of yielding.



F. Hinge Properties in Pushover Analysis

There are three sorts of pivot properties in E-Tabs. They are

- Default hinge properties,
- User-defined hinge properties and
- Generated hinge properties.

Just default pivot properties and client characterized pivot properties can be appointed to outline components. At the point when these pivot properties are appointed to a casing component, the program naturally makes an alternate produced pivot property for every single pivot. The inherent default pivot properties are normally founded on FEMA-273 as well as ATC-40 measures.
we have Default-M3, Default-P, Default-P-M-M and Default-V2. Typically second pivot properties (Default-M3) are appointed to radiates and interfacing pivot properties (Default-P-M-M) are alloted to segments.

VI. CONCLUSION

The Present study is focused on the study of Seismic demands of different R.C buildings high rise buildings using numerous analytical techniques for the buildings located in seismic zone V of India medium soil. The achievement of the building is studied in terms of time period, base shear, lateral displacements, storey drifts in linear static and linear dynamic analysis for with and without fluid viscous dampers building G+9 storey models. The seismic analysis is carried out by equivalent static method and response spectrum method for G+9 storey building with unsymmetrical in plan. The below are the conclusions that can be concluded from the present study, which are as follows.

1) The fundamental natural period of the structure rises due to the lesser stiffness of the bare frame buildings compared to buildings having fluid viscous dampers.
2) The base shears due to seismic forces for the building with fluid viscous dampers are greater than the base shear obtained for without fluid viscous dampers.
3) Compared to the regular building the storey displacement reduces for the buildings having fluid viscous dampers. Addition of fluid viscous dampers in the building will result in drastic depletion of lateral displacement of the building there by in turn assures the safety of the structure.
4) The storey drift rises in regular building as compared to building having fluid viscous dampers. T h e addition of fluid viscous dampers in the building drastically reduces the inter storey drift as compared to that of building without fluid viscous dampers. R

5) The story floats saw of the design are found inside the breaking point as indicated by code (IS: 1893-2002, section 1) in Linear Analysis.
6) Storey Stiffness of frame model at bottom storey is within the limit as clause no 4.20 of IS- 1893 (Part-1):2002.
7) Story drift value is more in the open story as compared to the soft storey at different levels of building.

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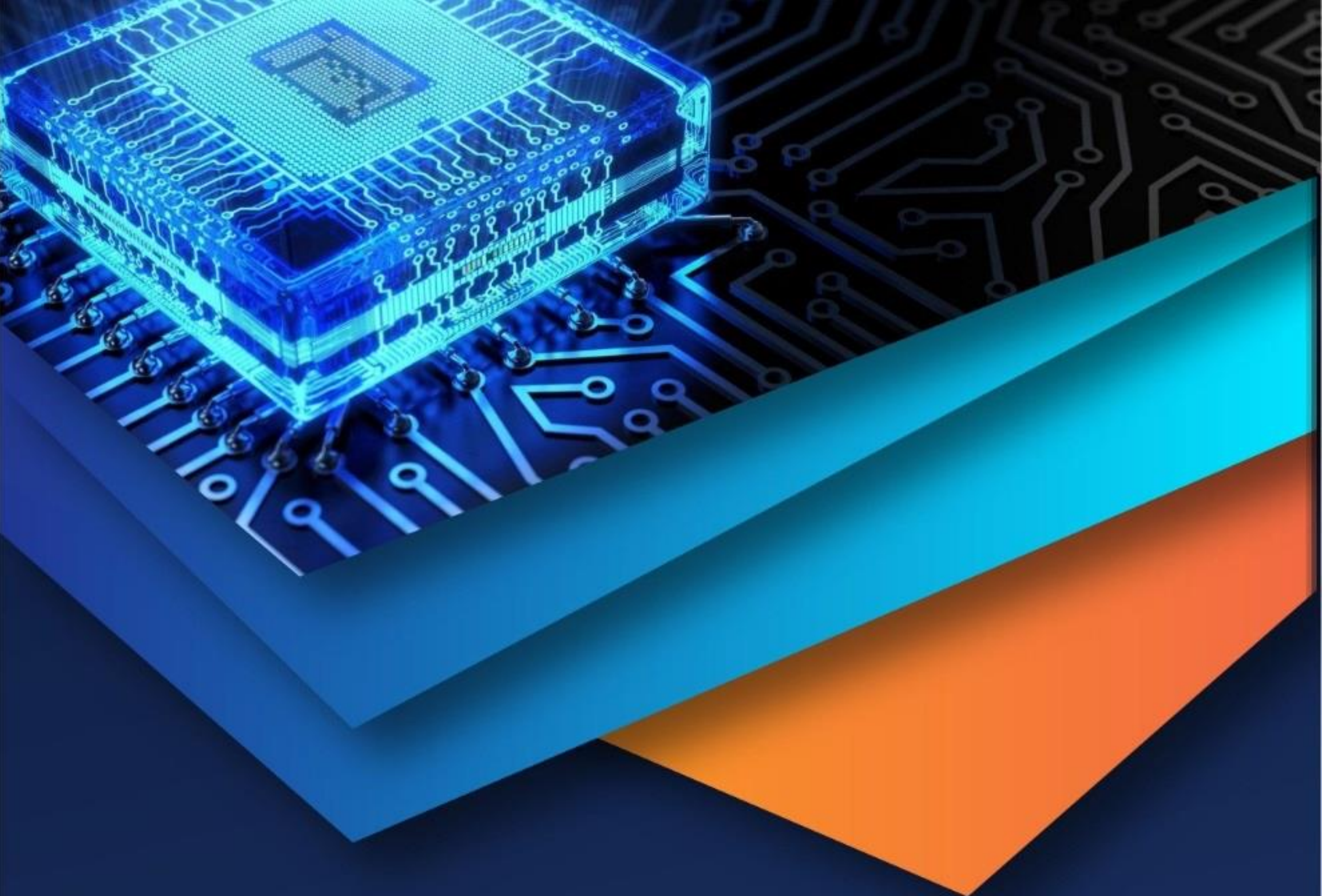

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