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# SEISMIC ANALYSIS OF BUILDINGS USING FLUID VISCOUS DAMPER

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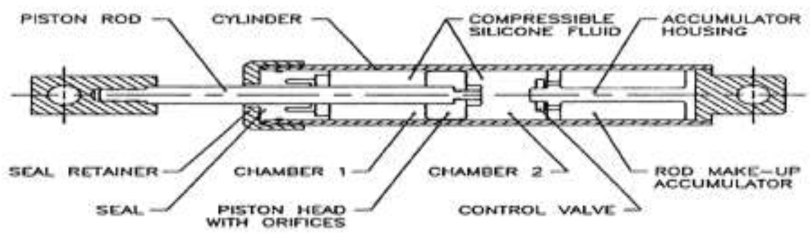
## ABSTRACT
Now a day's Earthquakes are happening in various parts of the earth. So buildings should be designed and constructed in such a manner that they will withstand the earthquakes. Non linear seismic assessment is a good tool in helping us to predict the seismic capacity. Many devices are used to improve the seismic capacity of the buildings. In order to reduce the negative impacts of earthquakes, different kinds of protective system have been adopted in the structures worldwide. Placement of fluid viscous damper is one of the techniques in which it absorbs the shock vibrations of the building which causes damage. The effect of damper on the seismic response of the RC structures is studied in this. Little attention has been paid to evaluating the influence of the number and placement of dampers on the dynamic response Three dimensional models are created using SAP2000. Time History analysis is carried out to study the effect of damper on the time period, base shear and acceleration in RC structures.

**KEYWORDS**: Fluid viscous dapmer, SAP2000, Time history analysis

## INTRODUCTION
During earthquake most structures are subjected to vibration. These vibrations may arise from wind forces, earthquake excitation, machine vibrations, or many other sources. In some cases, especially under strong earthquake excitations, these vibrations can cause structural damage or even structural collapse. By using dampers severe damages can be prevented. The concept of the fluid viscous damper is to absorb the shocks and vibrations from the structure. However provide little attention in the correct placement and number of dampers is very important. Fluid viscous dapmer is considered as the passive control of structure during earthquake extations. It has the ability to dissipate energy, cannot increase it. The main advantage is that it return back the structure in its same position. This device and its effect on the seismic structure response are the subject of the study.

**Figure: 1**




***Fluid viscous dapmer***

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Fluid viscous dampers consist of a piston head with orifices contained in a cylinder filled with a highly viscous fluid, usually a compound of silicone or a similar type of oil. Energy is dissipated in the damper when the piston head moves through the fluid. The fluid in the cylinder is nearly incompressible, and when the damper is subjected to a compressive force, the fluid volume inside the cylinder is decreased as a result of the piston rod area movement. A decrease in volume results in a restoring force. Thus the device works.

## TYPES OF ANALYSIS

Modal Analysis: It is the study of the dynamic behaviour of structures under free vibration. In structural engineering, modal analysis uses the overall mass and stiffness of a structure to find the various periods at which it will naturally resonate. A normal mode of an oscillating system is a pattern of motion in which all parts of the system move sinusoidal with the same frequency and with a fixed phase relation.

Time History Analysis: Time history analysis was carried out to determine the response of the frame under a given dynamic loading. Time history analysis is the most natural approach. The response history is divided into time increments and the structure is subjected to a sequence of individual time independent forces/acceleration. The nonlinear response is thus approximated by series of piecewise linear systems.

Landi et al. [1] compared the performance of symmetric and asymmetric buildings. Time-history analyses were also conducted. Whittle et al. [2] presented a paper in which the comparison of viscous damper placement methods for improving seismic building design. The building structure is modeled by finite elements, an anti-vibration mechanism is placed at the building with special finite element, and an artificial earthquake equivalent to El Centro is generated and applied at the building. The behaviour of the frame, with and without anti-vibration mechanisms, is compared.

In the present study modal and nonlinear time history analysis is performed to evaluate the effect of base isolation on the response of a 8 story 4 bay x 4 bay structure indented for commercial purpose.

## MATHEMATICAL MODELLING OF STRUCTURES

An eight-story building modelled as 3D RC frame is analyzed with and without viscous dampers in SAP2000. The structure analysed is as four bay eight storied reinforced concrete framed structure. The plan dimension is 22m x 22m and the height of top storey is 4 m and other stories are 3.5m. All the columns at bottom floors are of 450mm X 450mm size and other columns are 300 x 300mm. The entire beam at outer periphery is of size 6000 mm x 300 mm. And other beams are 450 x 300mm. The slab thickness is 120 mm. The unit weight of concrete is assumed to be 23.5kN/m and Modulus of elasticity is $25x10^6$ kN/m$^2$. Both the without damper and with damper models were created in SAP2000. The mechanical behaviour in 6 directions is governed by the directional properties $U_1$, $U_2$, $U_3$, R1, $R_2$, and $R_3$.

## VISCOUS FLUID DAMPER (VFD) PARAMETERS

The important factors affecting the performance of any damper applied to a building are the damping coefficient (*C*), damping exponent (*n*) and the stiffness of the damper (*kd*). By knowing the mass of the building (*m*) and the first natural frequency (*f*) of the building, the stiffness of the building (*k*) can be calculated as shown below:

**First natural frequency,** $f = \frac{1}{2\Pi}\sqrt{k/m}$

The output force *FD* of the fluid viscous damper may be expressed as; FD = $CV^n$

where: *C* is damping coefficient, *n* is damping exponent, *V* is relative velocity between ends of the device. Generally for tall buildings the n values are taken in the range of 0.5 to 0.8. In present study the values of *n* are taken as 0.5 and 0.75 respectively. Also the critical damping *Cc* of the structure can then be calculated as:

**Critical damping**, $C_c = 2\sqrt{mk}$

**Damping ratio,** $\tau = \frac{C}{C_c}$

where: *Cc* is the critical damping of the structure, *m* is the mass of the building, *k* is the stiffness of the building, is the damping ratio (usually taken as 0.5 for experiments with building models) For X and Y directions based on the trail analysis, the stiffness *kd* values were found out for the damper in order to satisfy the storey drift limitation criterion of values below 0.004times the storey height as given in *IS 1893 (Part I): 2002*[5]

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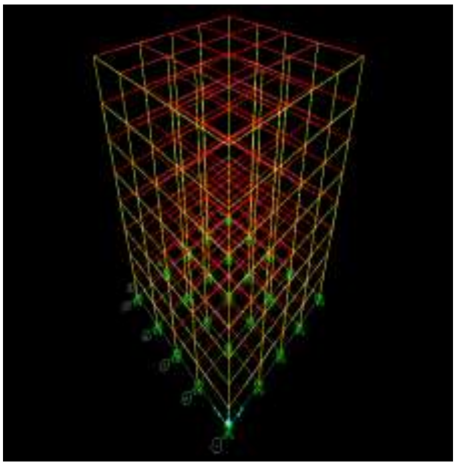
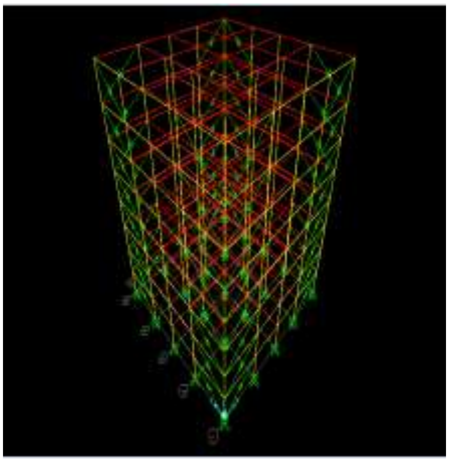
**Figure: 2**





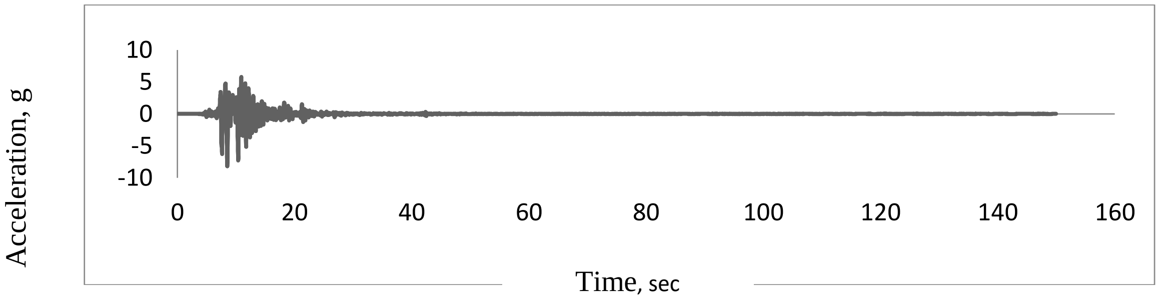
***Model without damper and model with damper***

A nonlinear modal time history analysis using load dependent ritz vectors is known as Fast Nonlinear Analysis (FNA), an automated technique suggested by Wilson has been considered for solution of equilibrium equations. The method is extremely efficient as it is designed for structural systems which are primarily linear elastic, but have limited number of predefined nonlinear elements. The program considers that the analysis results vary during a time step. The iterations are carried out until the solution converges.
Damper placed on different positions and obtained the result.

- FVD are placed in all the exterior middle bays
- FVD are placed in all the exterior corner
- FVD are placed in all the interior middle bays.

Seismic time history function is selected as the ground excitation data of Kobe earthquake having magnitude 5.79 in year 1940 is used. Total duration of this time history function is 149.98 seconds. It is applied at X direction. The graph of the functions is illustrated in Fig. 3.

**Figure: 3**




***Time history function Kobe***

## ANALYSIS AND RESULTS

After modal analysis modal time periods are obtained. The modal time periods are shown in the table below.
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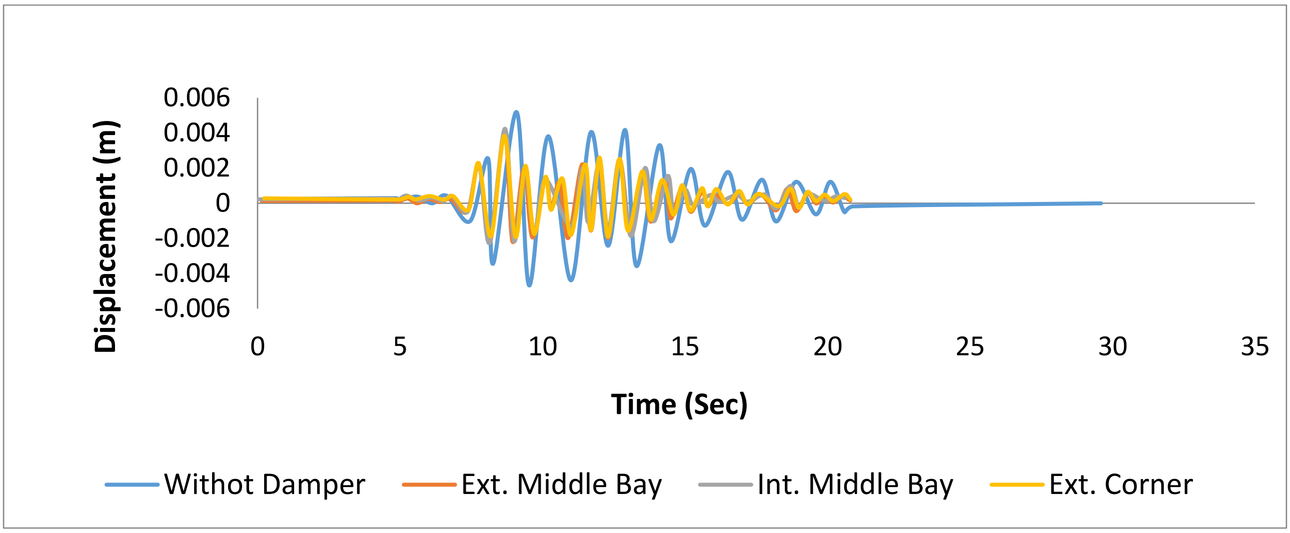
*Table 1. Modal Time Periods*

| Mode | Time Period without damper, sec |
|---|---|
| 1 | 1.213 |
| 2 | 1.033 |
| 3 | 0.400 |
| 4 | 0.234 |
| 5 | 0.161 |

The modal time periods of the structure with damper and without damper are same. Because the damper have no effect on the time periods. But it absorbs the energy and keeps the structure elastic

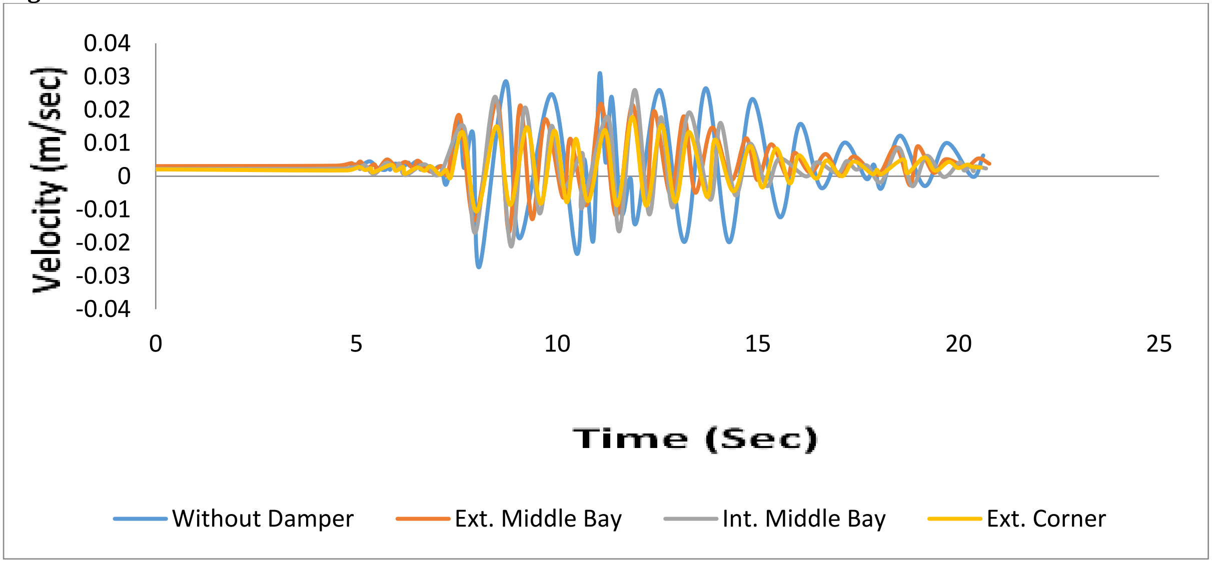
## TIME HISTORY CURVES

**Figure: 4**




***Displacement Vs Time***

**Figure: 5**




***Velocity Vs Time***

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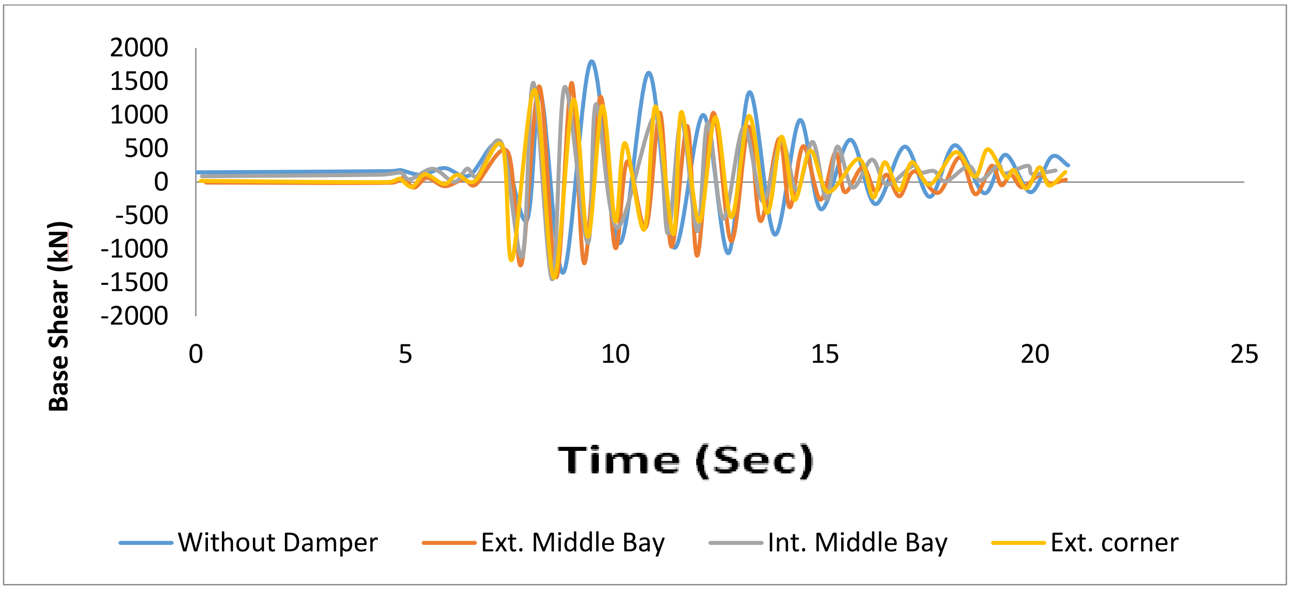
**Figure: 6**




***Base shear Vs Time***

***Table 2. Results obtained***

| | Displacement(mm) | Acceleration(mm/sec$^2$) | Base shear(kN) |
|---|---|---|---|
| **Without Damper** | 0.00519 | 0.484 | 1800 |
| **External Middle Bay** | 0.00484 | 0.326 | 1420 |
| **Internal Middle Bay** | 0.00424 | 0.297 | 1480 |
| **External corners** | 0.00384 | 0.259 | 1370 |

The results shows that the base shear, displacement, acceleration of the building with damper reduces when compared to the buildings without damper. The time history curves for each of them are shown above. It can be seen from fig. the building with damper, magnitude of each value is considerably lower than building without damper which indicates the effectiveness of placement of damper. Seismic performance of building can be improved by providing damper, which absorbs the input energy during earthquake. By the addition of damper at all the exterior corners ie, four dampers per each story has greater role in the vibration control. The displacement reduces from 0.00519 to 0.00384mm ie, 26% displacement is reduced. Acceleration reduces from 0.484 to 0.259 mm/sec$^2$ ie, 46% reduction is happened by the addition of dampers at all the exterior corners. Base shear reduces from 1800 to 1370kN ie, 23% reduction.

## CONCLUSION

A comparative study on the effect of fluid viscous damper on the seismic response of a reinforced concrete structure is presented in this paper. The buildings and dampers were modelled using SAP2000 software. Modal and Nonlinear time history analysis were carried out and the results are compared. The conclusions are listed below.

1. The responses such as displacement, acceleration, base shear are minimized when the viscous dampers are added to the structure.
2. The placement of the damper plays an important role in the vibration control of the structure. Effectiveness is more when dampers are placed in corners instead of middle.
3. When the damper is placed on all the floors, there is much larger reduction in the displacement, velocity and acceleration. But it obstructs the placement of doors and movement of people.
5. Hence, from the present analysis, the placement of damper is very effective and recommended.

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