Seismic Analysis of Asymmetric RCC Buildings using Passive Energy Dissipating Devices

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Abstract - *This paper deals with the study of different passive energy dissipation devices. In the present study, the effectiveness of dampers in reducing the dynamic responses of a structure under seismic excitations is evaluated analytically using response spectrum method. Three different dampers viz., Visco Elastic dampers, Fluid Viscous dampers and Friction dampers are used to evaluate the response of asymmetric RCC buildings. G+10 storied four different buildings with asymmetric plans i.e., C shaped, T shaped, L shaped and U shaped are considered for the analysis. A parametric study for finding optimum damper properties for the reinforced concrete frames was conducted. In response spectrum method, earthquake load is applied in both x and y direction. For the analysis purpose Etabsv v.16 software is been used by considering seismic zone IV as per is 1893:2002(part 1) code. Results of these analyses are discussed in terms of various parameters such as storey displacement, storey drift, base shear, bending moment, axial forces. The analysis results confirmed that a significant reduction in the responses such as displacements and other forces is possible with the introduction of dampers and hence it can be used as an alternative to the conventional ductility based design method of earthquake resistant structures.*

***Key Words:** Passive dampers, fluid viscous dampers, viscoelastic dampers, friction dampers, response spectrum*

1. INTRODUCTION

Passive energy dissipation is a rising technology that enhances the performance of the building by adding damping (and in some cases stiffness) to the building. The principal use of energy dissipation devices is to reduce earthquake displacement of the structure. Energy dissipation devices will also decrease force in the structure provided the structure is responding elastically but would not be expected to reduce force in structures whose response is beyond yield. For many applications, energy dissipation provides an alternate approach to standard stiffening and strengthening schemes and would be expected to achieve comparable performance levels. Other objectives may additionally influence the choice to use energy dissipation devices, since these devices may also be helpful for control of building response due to minute earthquakes, wind, or mechanical hundreds.

2. BUILDING DESCRIPTION

This study consists G+10 storied building of C shaped, L shaped, U shaped and T shaped plans along with dampers are as shown in the Fig 1. Models consist of RCC building having 5 bays in each principal direction; each bay is having width of 4 m.

1. Grade of concrete: M25

2. Grade of steel for longitudinal bars: HYSD415

3. Grade of steel for confinement bars (Ties): Fe250

4. Floor to floor height: 3 m

5. Slab thickness: 120mm

6. Size of Column: 450mm×450mm

7. Size of Beam: 450mm×300mm

8. Seismic Zone: V

9. Soil condition: Medium

10. Importance Factor: I

11. Damping: 5%

12. Building Frame: Special moment resisting frame (SMRF)

13. Density of concrete: 25 kN/m³

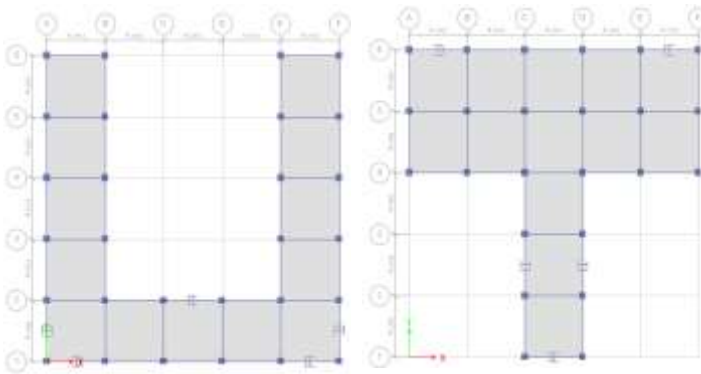14. Types of damper: Visco-elastic, Fluid viscous and Friction dampers.
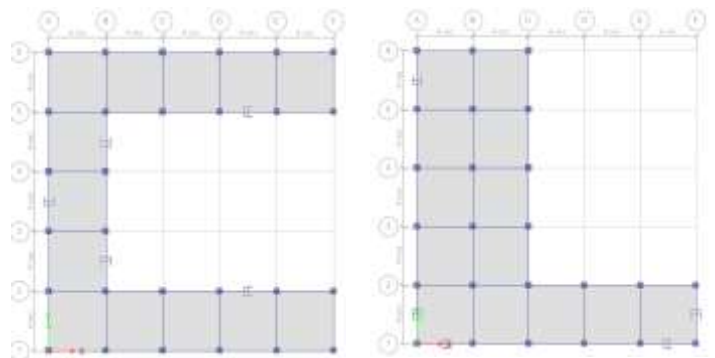
Fig -1: Plans of the buildings considered for the study

3. DAMPER PROPERTIES

3.1 Visco Elastic damper

Visco elastic damper of 3M Company is used for the analysis. The model considered is ISD110. Properties derived are as follows;

Table -1: Properties of VED

Stiffness of damper	12161.6 kN/m
Damping Coefficient	14593.92 kNs/m

3.2 Fluid Viscous Damper

Fluid Viscous Damper of Taylor Devices Inc. is used for the analysis. The model considered is 17190. Properties derived are as follows;

Table -2: Properties of FVD

Stiffness of damper	149883 kN/m
Damping Coefficient	10048 kNs/m
Damping exponent	0.45

3.3 Friction Damper

Friction damper of Pall Dynamics Limited is used for the analysis. Properties derived are as follows;

Table -3: Properties of FD

Stiffness of damper	54460.408 kN/m
Yield strength	700 kN
Post Yield Stiffness Ratio	0.0001
Yielding Exponent	10
Slip Load	500 kN
Brace section	ISMB 200

4. MODELING AND ANALYSIS

Modelling and analysis includes modelling of different building elements, different load cases considered for analysis and method used for analysis.

4.1 Modeling in ETABS

The building is modeled using finite element software ETABS. The following models are considered for C shaped, L shaped, U shaped and T shaped buildings for the analysis;

WD: Model without damper

VED: Model with visco elastic damper

FVD: Model with fluid viscous damper

FD: Model with friction damper

4.2 Method of analysis

The seismic analysis of all buildings is carried by Response Spectrum Method in accordance with IS: 1893 (Part I): 2002. Dynamic response of these buildings in terms of base shear, modal time period, storey displacement, storey drift, axial force in column, bending moment and torsional moment in beams.

5. RESULTS AND DISCUSSION

3D analysis has been carried out by using response spectrum method. Models are analysed to study the performance of structure by considering effect of three dampers in four different asymmetric RCC buildings. Dynamic response of these buildings is presented in terms of base shear, time period, storey displacement, storey drift, torsional moments, and axial forces in column.

5.1 Results for C shaped building

By observing the performance of C shaped building installed with visco-elastic damper, fluid viscous damper and friction damper, visco-elastic damper is found to be more effective in reducing displacement, drift, base shear, axial force and torsional moments as compared to other dampers installed in the building at the considered location. The results are shown using graphs shown in below charts;
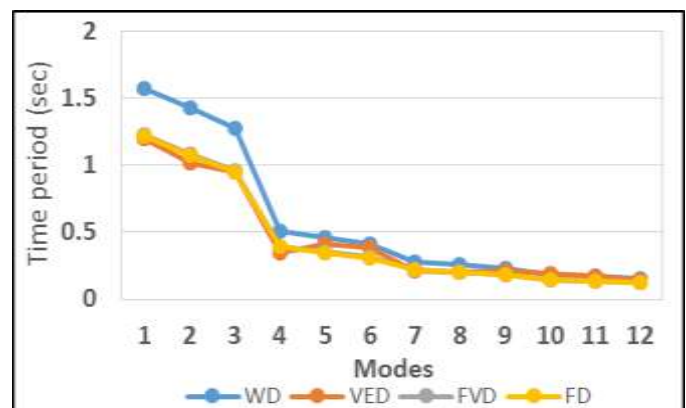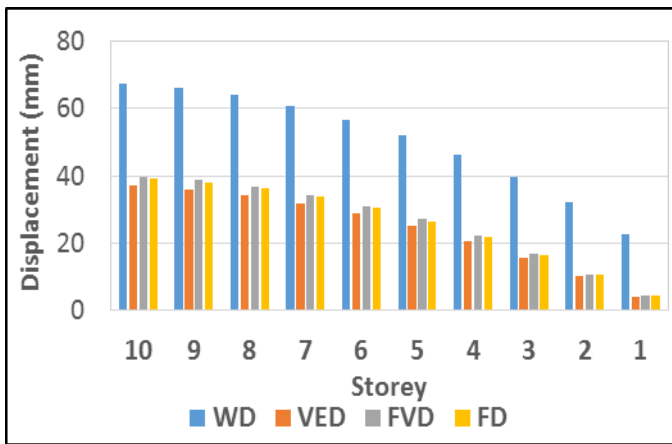

Chart -1: Variation of time period

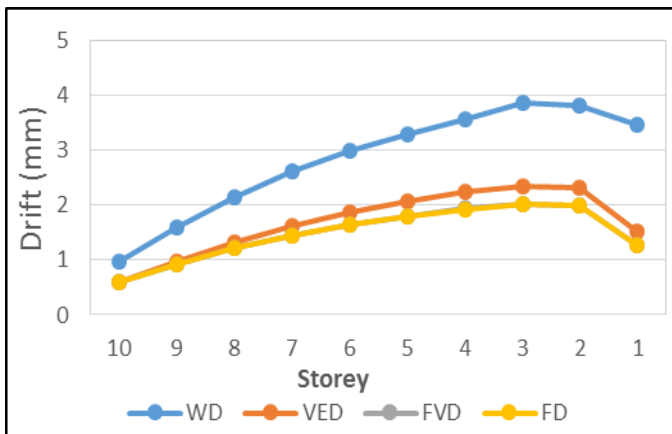**Chart -2**: Variation of storey displacement

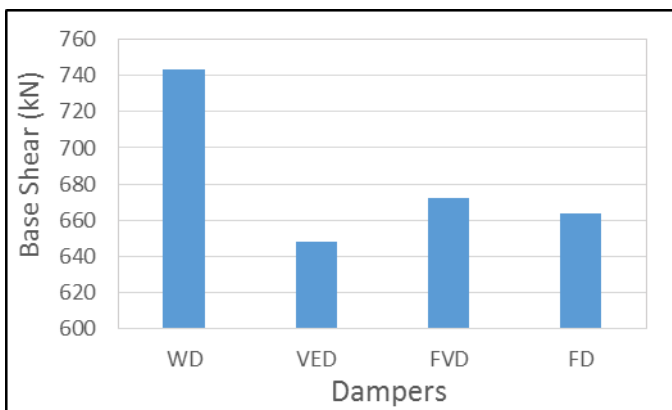**Chart -3**: Variation of storey drift

Chart -4: Variation of base shear

The results for axial force in column and torsional moment in beam are presented for the considered column and beam as shown in below fig 2.
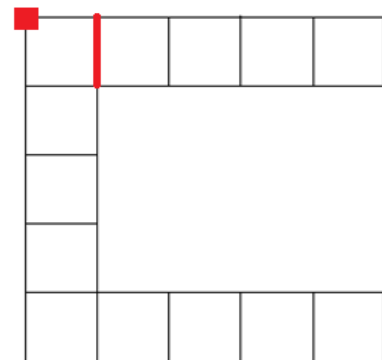

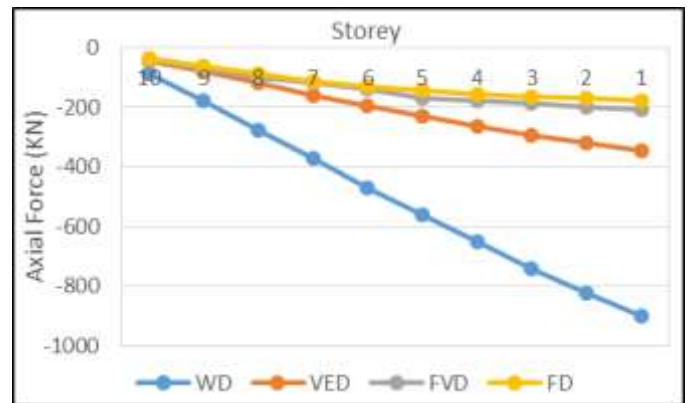**Fig -2**: Column and beam considered for results

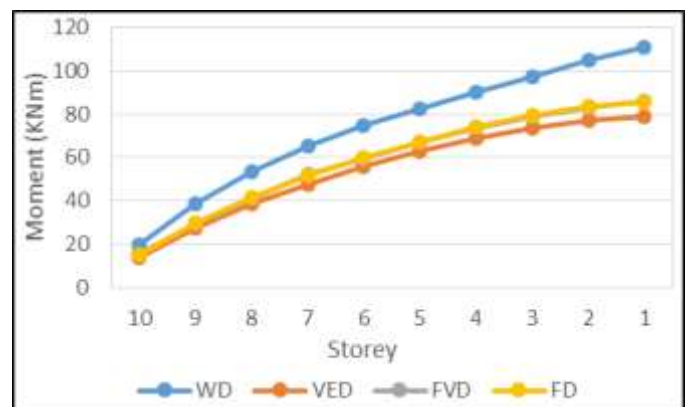**Chart -5**: Variation of axial force in column

Chart -6: Variation of torsional moment in beam

5.2 Results for L shaped building

From the analysis of L shaped building installed with visco-elastic damper, fluid viscous damper and friction damper, it is found that visco elastic damper gives less storey displacement, storey drift, base shear, axial force and torsional moments as compared to other dampers. The results for axial force in column and torsional moment in beam are presented for the same column and beam in L shaped building as shown in fig 2 for C shaped building. The results are shown using graphs shown in below charts;
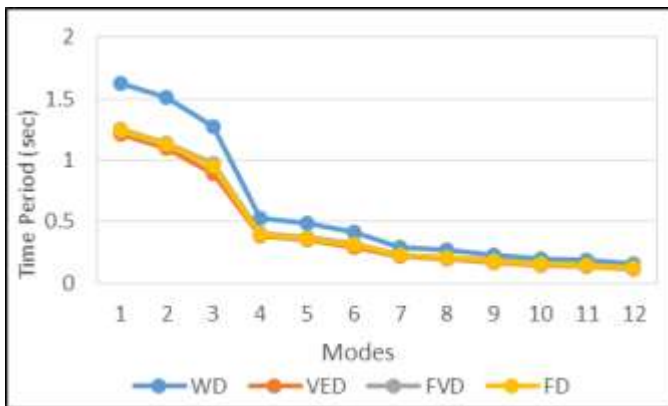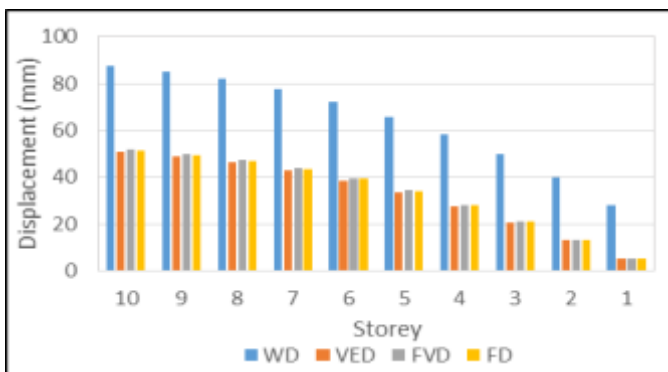
Chart -7: Variation of time period
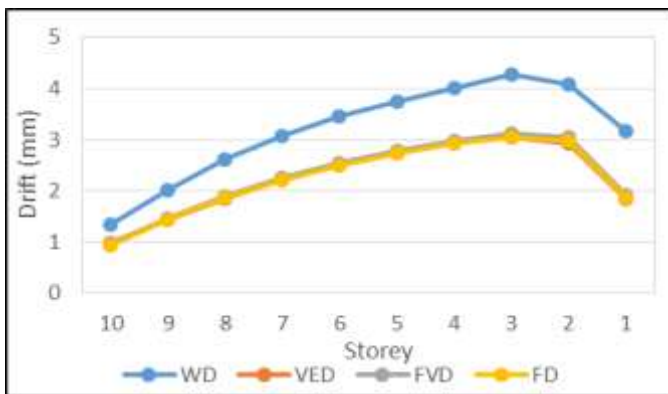

Chart -8: Variation of storey displacement

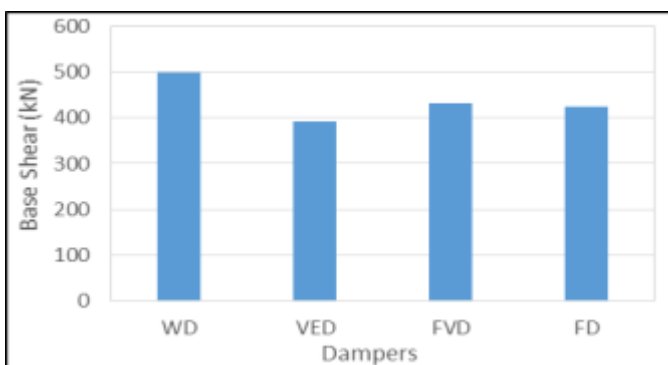**Chart -9**: Variation of storey drift

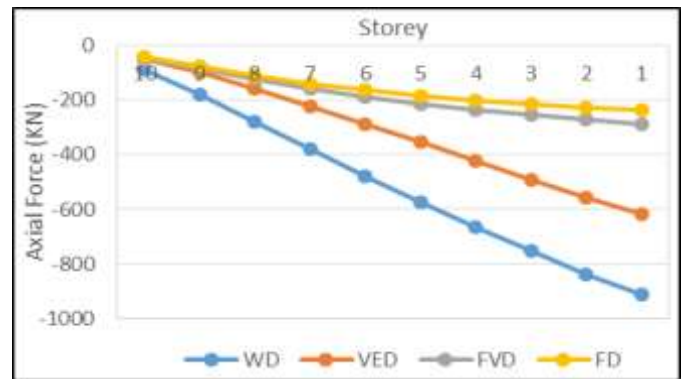**Chart -10**: Variation of base shear

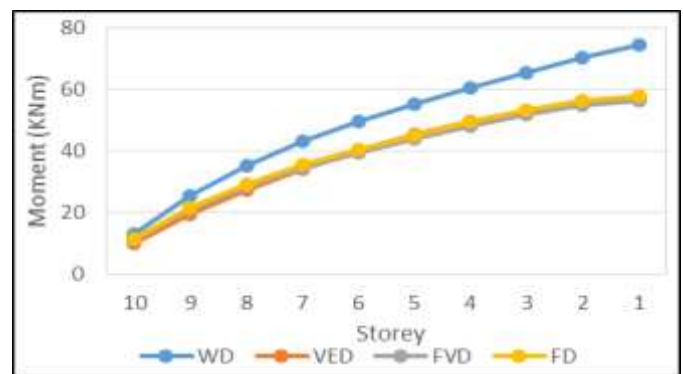**Chart -11**: Variation of axial force in column

Chart -12: Variation of torsional moment in beam

5.3 Results for U shaped building

For U shaped building after analysis, it is seen that the behaviour of friction damper is more effective as compared to visco-elastic damper and fluid viscous damper. The results obtained by installation of friction damper for the considered location of dampers has shown large reduction in displacement, drift, base shear, axial force, column moments, beam bending moments and torsional moments as compared to building without damper. The results for axial force in column and torsional moment in beam are presented for the same column and beam in U shaped building as shown in fig 2 for C shaped building. The results are shown using graphs shown in below charts;
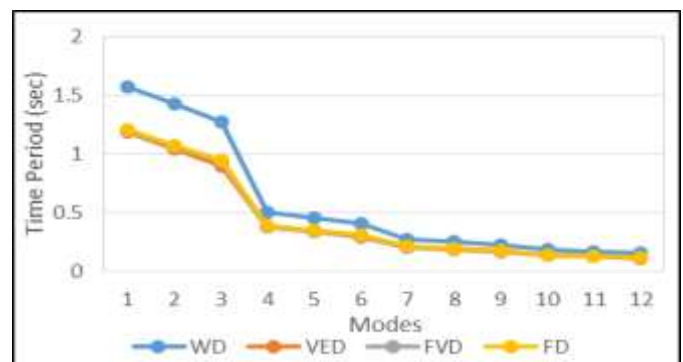

Chart -13: Variation of time period

Chart -14: Variation of storey displacement

Chart -15: Variation of storey drift

Chart -16: Variation of base shear

Chart -17: Variation of axial force in column

Chart -18: Variation of torsional moment in beam

5.4 Results for T shaped building

After carrying out the analysis of T shaped buildings, it is seen that visco-elatic damper show large reductions in the results as compared to fluid viscous damper and friction damper Visco-elatic damper prove better than the other two dampers. The results for axial force in column and torsional moment in beam are presented for the same column and beam in T shaped building as shown in fig 2 for C shaped building. The results are shown using graphs shown in below charts;
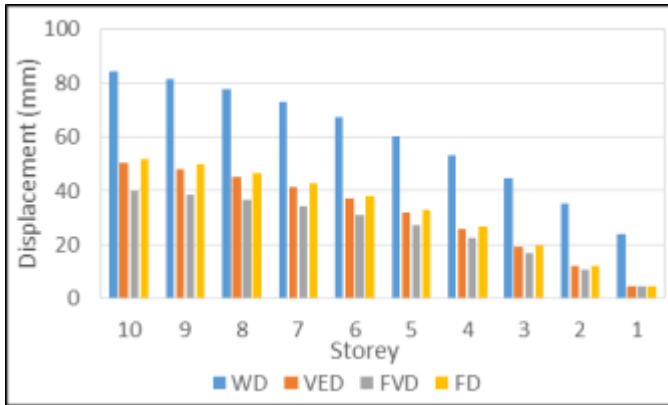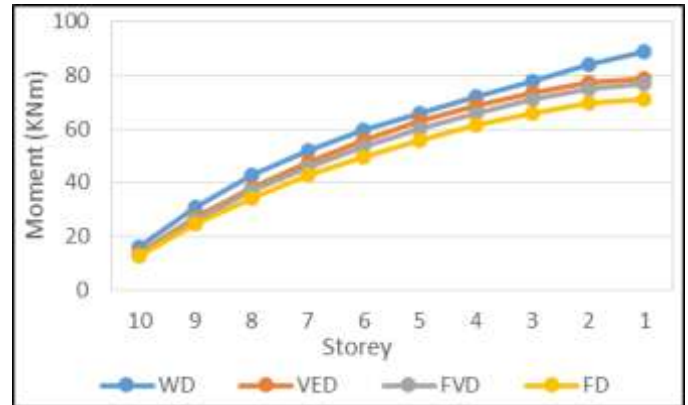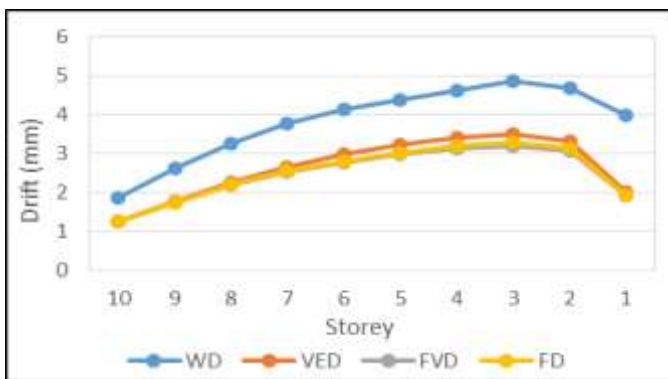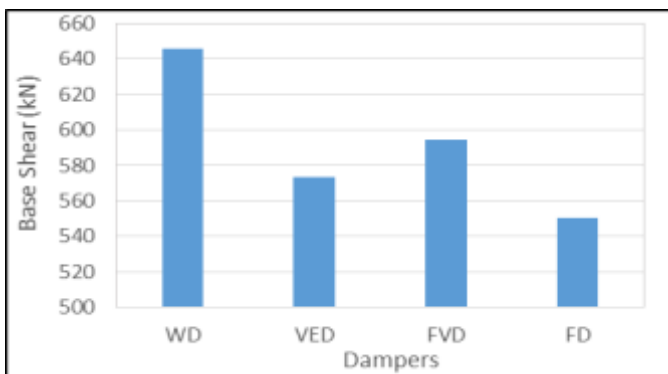

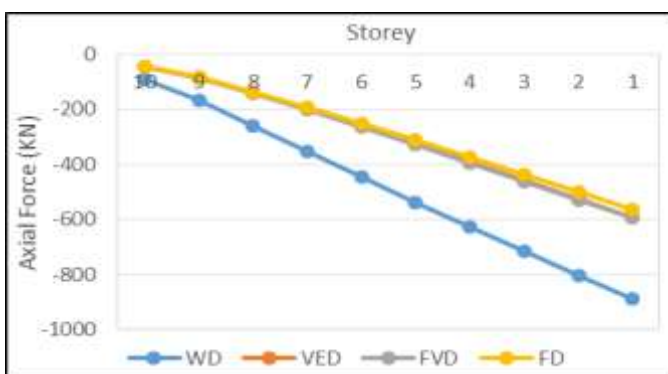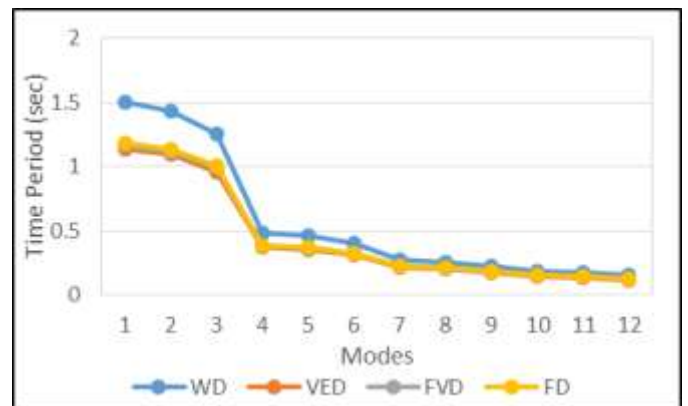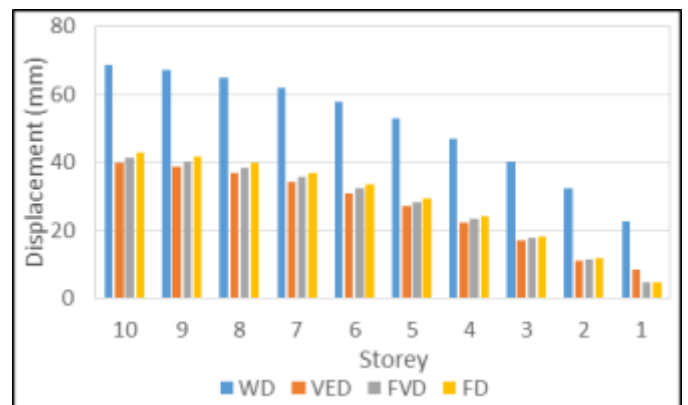**Chart -19**: Variation of time period

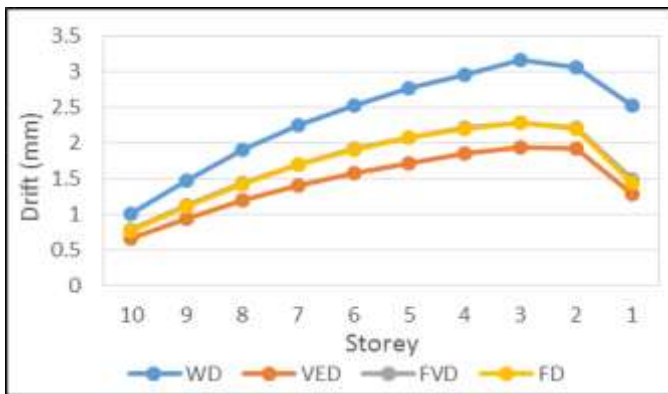**Chart -20**: Variation of storey displacement

Chart -21: Variation of storey drift
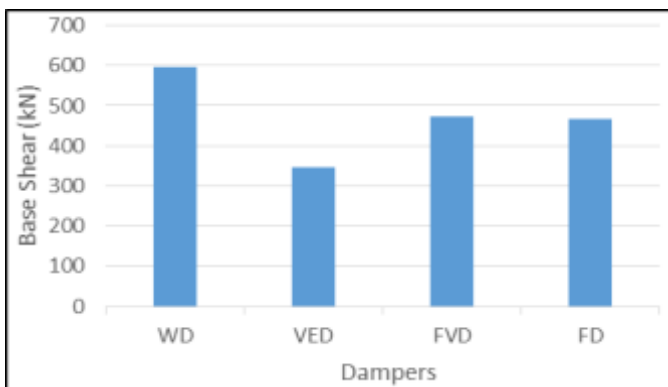

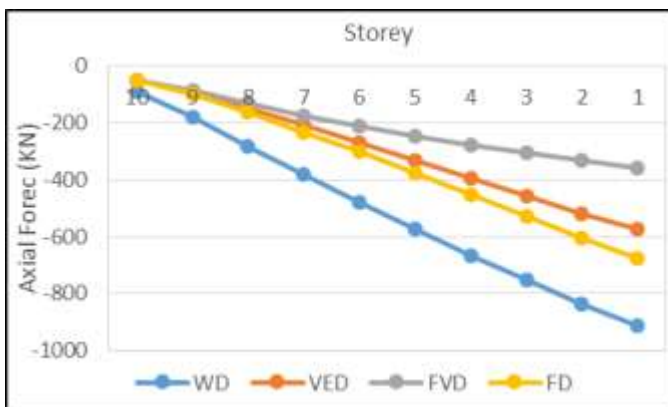
Chart -22: Variation of base shear

Chart -23: Variation of axial force in column
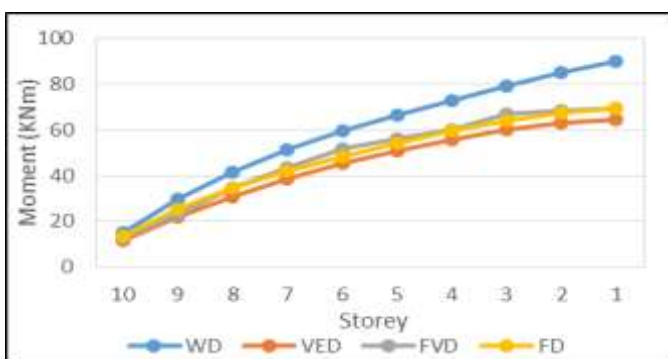

Chart -24: Variation of torsional moment in beam

6. CONCLUSIONS

After analysis the seismic performance of different models has been compared and effectiveness of passive energy dissipating devices is concluded. The conclusions of the present study are as follows:

1. After addition of the dampers to the building, a significant performance improvement is achieved. The responses of the storey displacement and inter-storey drifts decreased significantly as a result of added dampers.

2. It can be concluded that with the application of dampers in the structure maximum response, base shear reduces in structure. The time period is also found to be reduced as compared to that of bare frame with the addition of dampers. The bending moments in beams, axial forces in columns are greatly reduced with the addition of dampers.

3. It is found that the performance of the building structure in seismic loading is improved to great extent with the installation of dampers. From analysis it can be seen that it is necessary to properly implement and construct a damper in any high rise building situated in earthquake prone areas.

4. By the proper selection of location of dampers, the response of the structure can be minimized to great extent.

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