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PERFORMANCE ANALYSIS OF HIGH RISE BUILDING WITH VISCOUS DAMPER

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Abstract

The present study is focused on effectiveness of energy dissipation device and lateral stiffness system. Numerical investigation is carried out, considering the seismic response of fifteen storey concrete moment resisting frame with regular and irregular in plan. Viscous damper, bracing and combination of viscous damper and bracing are connected to building frame at different locations and arrangements. Study is conducted to reduce the response of building effectively and optimum number of dampers by using bracing with dampers. Dynamic analysis and static nonlinear analysis are carried out using ETABS software. Results of various arrangements are studied to compare the structural response and performance.
Keywords: Viscous Damper, Bracing, Response Spectrum Analysis, Pushover Analysis, High rise building.

Introduction

In the modern trend, construction of multistory and high rise building is rapidly increasing. These buildings are dynamically sensitive and get affected by lateral loads due to earthquake and wind actions to an extent that they play an important role in the structural design. There is a need construct a structure, which is safe and economical against the lateral forces, originating from earthquakes. Structural design is changing from convention design, not to collapse to dissipate the energy due to natural hazards. Structural control systems are thus evolved, which reduces the response of the structure by absorbing or by controlling the vibrations. This structural control system can be mainly classified into two systems namely, Passive control system and Active Control system; the combination of these two evolves Semi-Active system and hybrid system Passive control system does not require external power source and works on structural motion. Whereas active system requires external power source and works on feedback of response of structures through sensors. Semi-Active requires power source and works on motion of structure. In this study a promising control device is passive control system, is considered as the energy dissipation devices for a structure. Such systems are referred as supplemental energy dissipation devices. They have ability to transmit forces according to the structural response. They are increasingly used in bracing in high rise buildings. The Figure 1 shows the flow chart of passive control system. The various passive energy devices are Viscous, Viscoelastic, Friction, Metallic, Tuned mass and Tuned liquid dampers. Viscous damper is considered for present study.

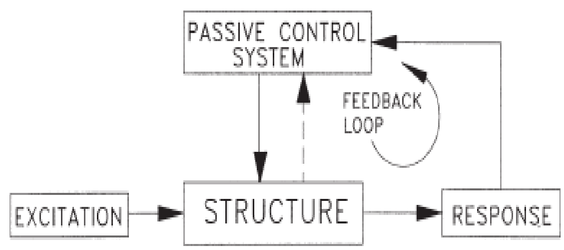

Figure 1 passive control system

Bracing systems are type of lateral stiffness system used to resist horizontal force. . Bracing members are arranged in many forms at outrigger, which add extra stiffness to structure by supporting tension and compression forces. Bracings make the structure stable by transferring the lateral loads sideways (wind or earthquake loads) down to the ground, thereby preventing sway of the structure. Diagonal braces are most commonly used and are efficient for developing stiffness and resistance to lateral loads.

Objectives

The main objectives of the study include. To study the response of the structure connected with;

1. Viscous Damper at different locations and arrangements
2. Bracing at different locations and arrangements
3. Combination of viscous damper and bracing at different locations and arrangements.

Viscous Damper

Viscous dampers or viscous fluid dampers are most commonly used passive energy dissipation devices for reduction in response of structures and to protect from seismic action. Damper consists of viscous fluid, usually silicone gel. Viscous damper consist of cylinder filled with viscous fluid and this fluid is incompressible, as shown in Figure 2. When piston rod and head stroked, fluid is forced to flow in orifice. The undesirable restoring force is prevent from accumulator, and collects the volume of fluid replaced by piston rod. When piston rod is back to its position, vacuum created is filled by fluid. Hence difference of pressure on each of piston head results in damping force that resist the relative motion of the damper. The fluid flows at high velocity resulting in development of friction between fluid particles and piston head. Friction force dissipates the energy in the form of heat

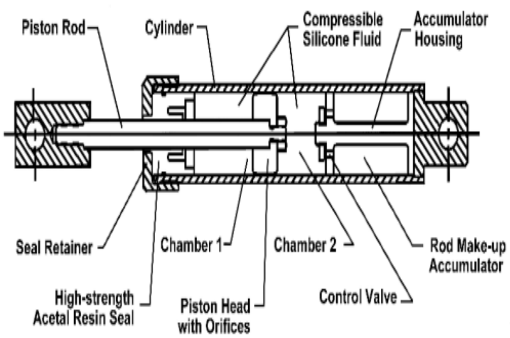

Figure 2 Viscous Damper

The ideal force output for a viscous damper is given by,

$$F = Cp.V\alpha.sgn(V) \quad (1)$$

Were F is the resistance force, Cp is the damping constant, V is the velocity and α is the exponent, which depends on the viscosity properties of fluid and piston.

Case Study

A fifteen storey concrete moment resisting frame is considered for analysis using ETABS software. Regular and irregular buildings are considered, Figure (3 and 4) shows the selected building plan.

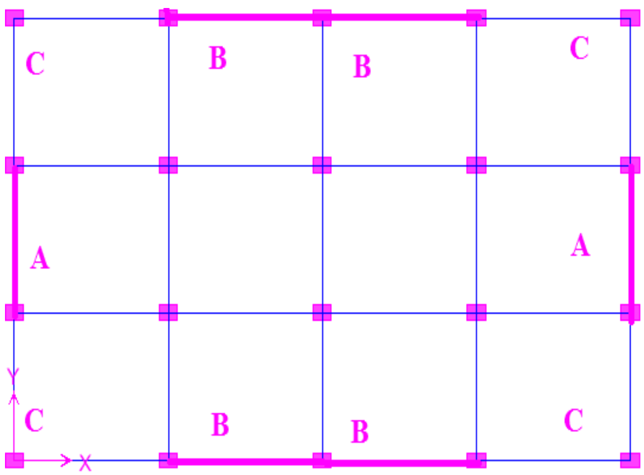

Figure 3 Selected Plan.

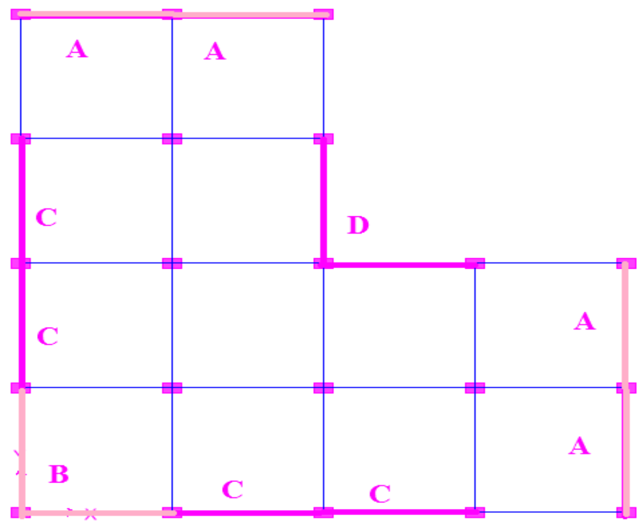

Figure 4 Selected Plan.

Description of Models

The fifteen storey building is modeled with different lateral stiffness system like viscous damper, bracing and combination of both. The building has five bays in X direction and four bays in y direction. The plan dimension of selected building is (20m x 12m). parameters considered for study are beam size (0.30m x 0.45m),column size (.40m x .60m), thickness of slab is 0.120m, bracing of (0.23m x 0.23m) and storey height of 3.0m each, same for all floors. The building considered is symmetric and asymmetric in plan. The size and orientation of column is kept same throughout the height of the building. The building considered is located to be in seismic zone III and to be on medium strength soil. As per code, Response reduction factor for the special moment resisting frame has been taken as 5.The unit weight of concrete taken as 25.0KN/m3. The floor and roof finishes are taken as 1.5KN/m2. The live load on floor is taken as 4KN/m2.50% of floor live loads are considered in seismic weight calculations

Models Considered for Analysis

1. Type I
Model (a): Building modeled as bare frame

2. Type II Models
Model (a): Viscous damper at locations A and B, located at exterior of frame along the height.
Model (b): Bracing locations A and B, located at exterior of frame along the height.
Model (c): Viscous damper at location A and bracing at location B, located at exterior of frame along height.

3. Type III Models

Model (d): Viscous damper at locations C and D, located at exterior of frame along height.
Model (e): Bracing at locations A and B, located at exterior of frame along height.
Model (f): Viscous damper at location C and bracing at location D, located at exterior of frame along height.

4. Type IV Models
Model (a): Viscous damper at alternative floor levels, located at exterior of frame along height.
Model (b): Bracing at alternative floor levels, located at exterior of frame along height.
Model (c): Viscous damper and bracing at alternative floor levels, located at exterior of frame along the height.

Results and Conclusions

The analysis for the above selected models is carried out using Response Spectrum Method. The results are shown in Figure 5 to Figure 20.

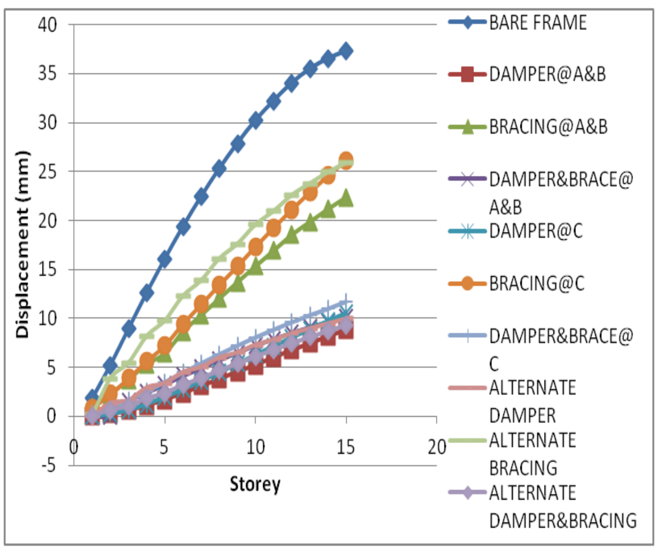

Figure 5 Comparison of Displacement of all types of models (symmetric building) in x direction.

Figure 5 gives the comparison of displacement of all types symmetric building models and from graph it can be concluded that models connected with viscous damper and combination of damper and bracing reduces the displacement about 60-70% compared to bare frame. Brace models reduces the displacement about 30-40% compared to Bare frame.

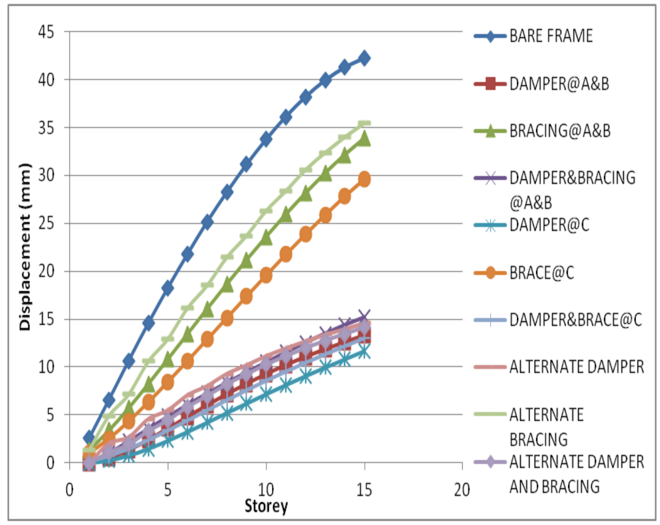

Figure 6 Comparison of Displacement of all types of Models (symmetric building) in y direction.

Figure 6 gives the comparison of displacement of all types symmetric building models and from graph it can be concluded that models connected with viscous damper and combination of damper and bracing reduces the displacement about 60-70% compared to bare frame. Brace models reduces the displacement about 30-40% compared to Bare frame.

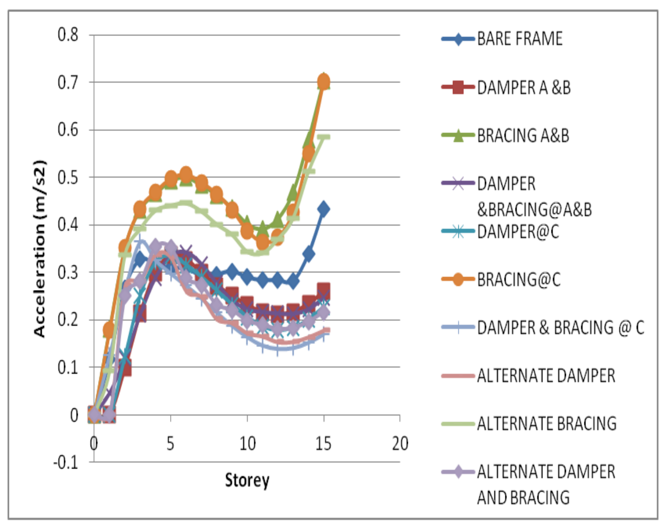

Figure 7 Comparison of Storey Acceleration of all type models (symmetric building) in X direction.

Figure 7 gives the comparison of storey Acceleration of all types symmetric building models and from graph it can be concluded that viscous damper and combination of damper and bracing dissipates the acceleration effectively, whereas the braced models shows the increased acceleration.

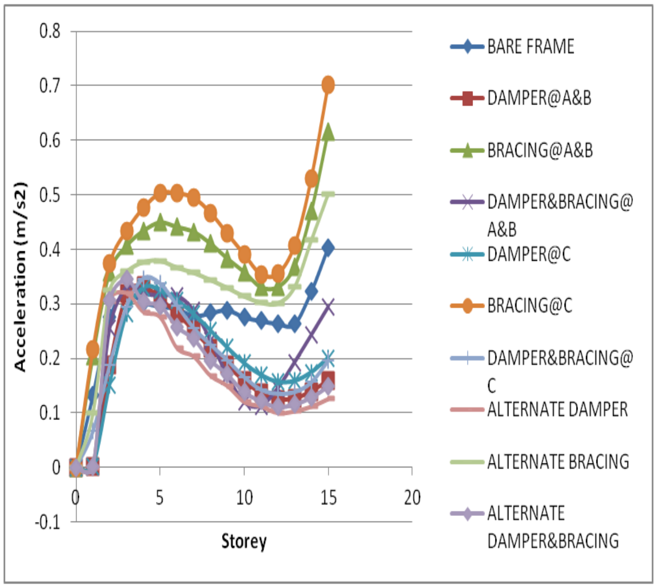

Figure 8 Comparison of Storey Acceleration of all type models (symmetric building) in Y direction.

Figure 8 gives the comparison of storey Acceleration of all types symmetric building models and from graph it can be concluded that viscous damper and combination of damper and bracing dissipates the acceleration effectively, whereas the braced models shows the increased acceleration.

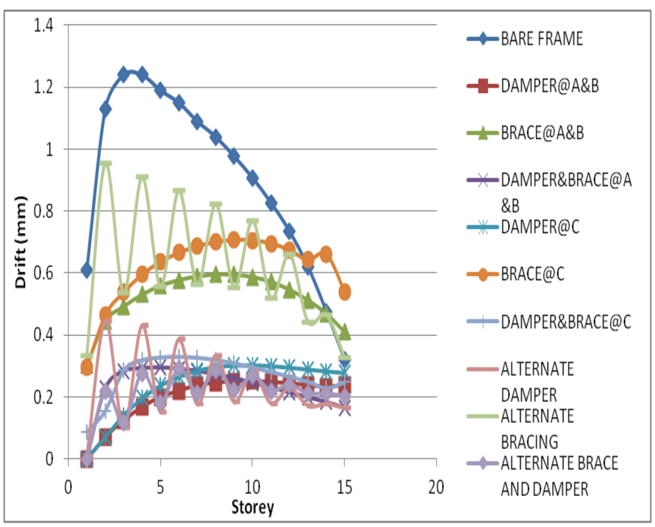

Figure 9 Comparison of storey drift of all types of models (symmetric building) in x direction

Figure 9 gives the story drift of all types of Symmetric building models, and it can be concluded that building connected with Viscous Damper and combination of Damper and Bracing reduces the inter storey drift effectively compared to bare frame. Braced frame also reduces the drift lesser than Viscous Damper and Combination.

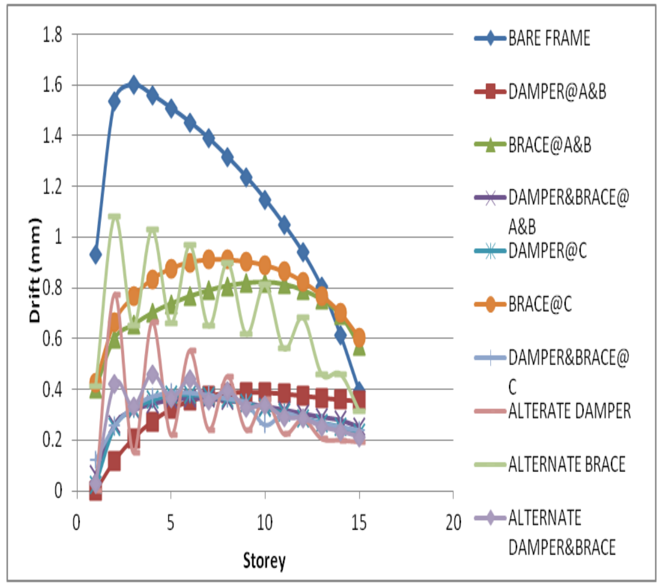

Figure 10 Comparison graph of storey drift of all types of models (symmetric building) in y direction

Figure 10 gives the story drift of all types of Symmetric building models, and it can be concluded that building connected with Viscous Damper and combination of Damper and Bracing reduces the inter storey drift effectively compared to bare frame. Braced frame also reduces the drift lesser than Viscous Damper and Combination.

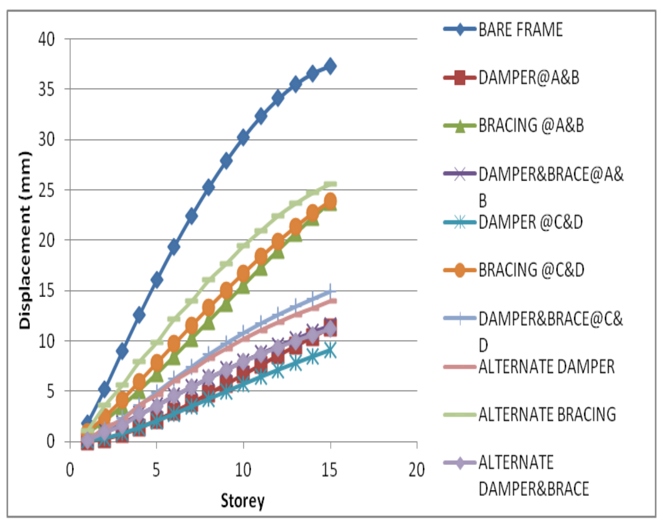

Figure 11 Comparison of displacement of all types of models (asymmetric building) in x direction

Figure 11 gives the comparison of displacement of all types asymmetric building models and from graph it can be concluded that models connected with viscous damper and combination of damper and bracing reduces the displacement about 60-70% compared to bare frame. Brace models reduces the displacement about 30-40% compared to bare frame.

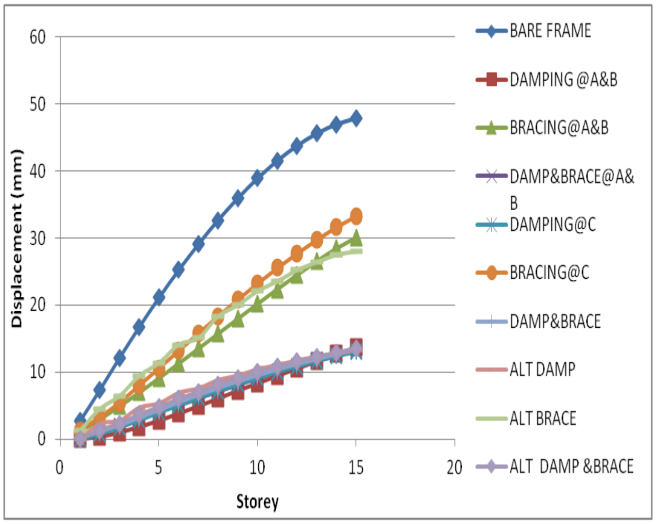

Figure 12 Comparison of displacement of all types of models (asymmetric building) in y direction

Figure 12 gives the comparison of displacement of all types asymmetric building models and from graph it can be concluded that models connected with viscous damper and combination of damper and bracing reduces the displacement about 60-70% compared to bare frame. Brace models reduces the displacement about 30-40% compared to bare frame.

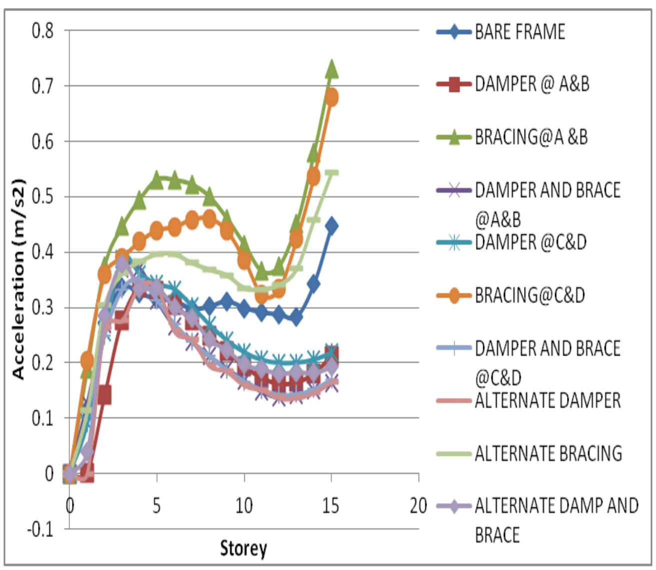

Figure 13 Comparison of Acceleration of all type models (asymmetric building) in X direction

Figure 13 gives the comparison of storey Acceleration of all types asymmetric building models and from graph it can be concluded that viscous damper and combination of damper and bracing dissipates the acceleration effectively, whereas the braced models shows the increased acceleration.

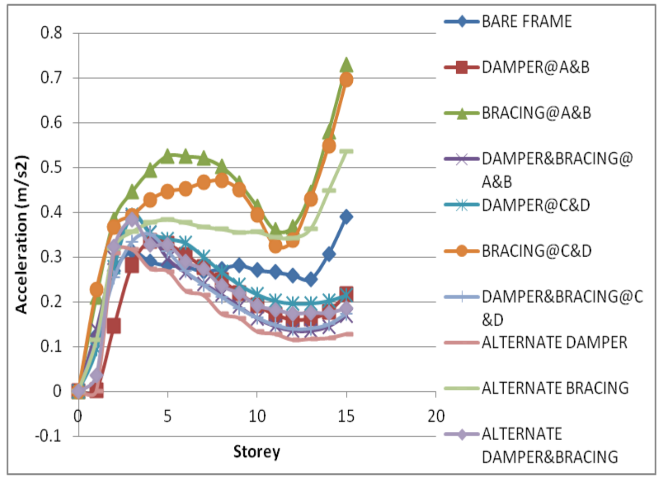

Figure 14 Comparison of Acceleration of all type models (asymmetric building) in Y direction

Figure 14 gives the comparison of storey Acceleration of all types asymmetric building models and from graph it can be concluded that viscous damper and combination of damper and bracing dissipates the acceleration effectively, whereas the braced models shows the increased acceleration.

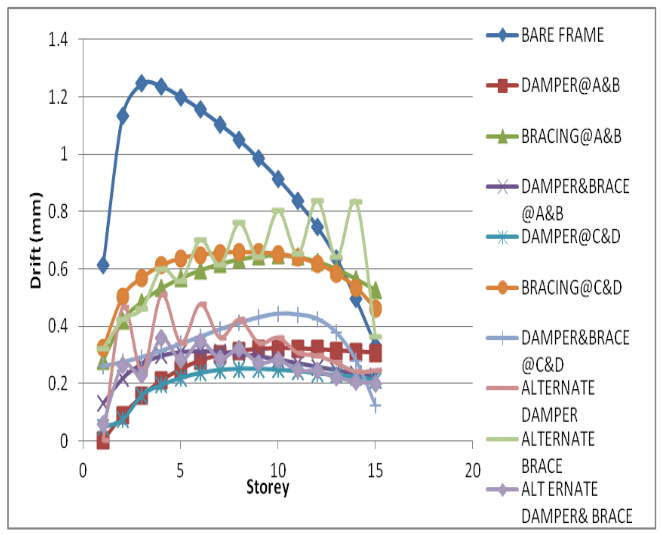

Figure 15 Comparison of storey drift of all types of models (asymmetric building) in x direction

Figure15 gives the story drift of all types of asymmetric building models, and it can be concluded that building connected with Viscous Damper and combination of Damper and Bracing reduces the inter storey drift effectively compared to bare frame. Braced frame also reduces the drift lesser than Viscous Damper and Combination.

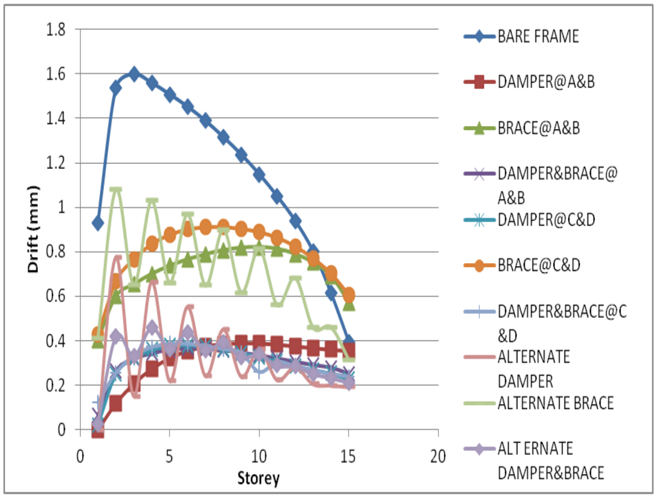

Figure 16 Comparison of storey drift of all types of models (asymmetric building) in y direction

Figure 16 the story drift of all types of asymmetric building models, and it can be concluded that building connected with Viscous Damper and combination of Damper and Bracing reduces the inter storey drift effectively compared to bare frame. Braced frame also reduces the drift lesser than Viscous Damper and Combination.

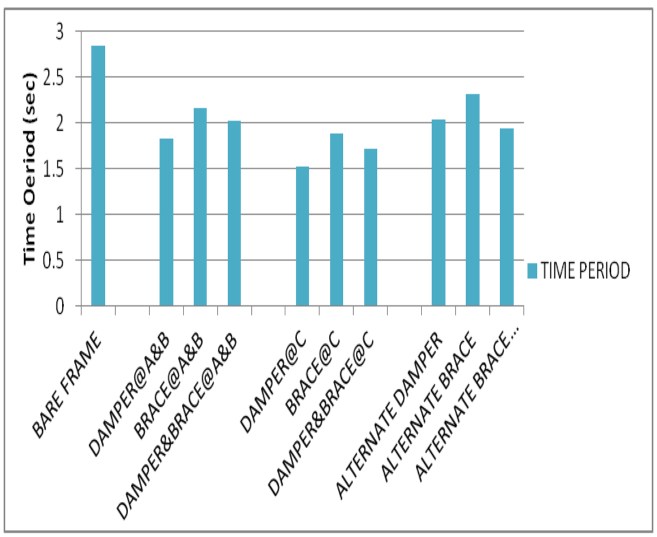

Figure 17 Time Period of all types of models (symmetrical building)

Figure 17 gives the Time period of all types of models, and it can be concluded that building connected with viscous damper and combination of damper and bracing has short time period compared to bare frame. Braced models also shows reduced time period.

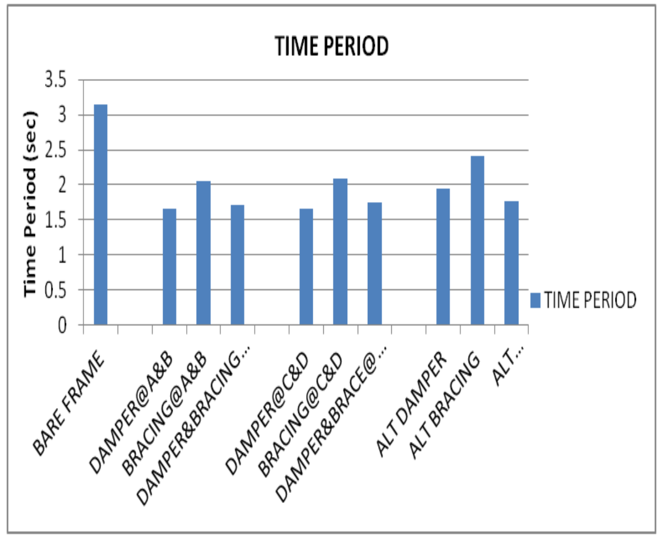

Figure 18 Time Period of all types of models (asymmetrical)

Figure 18 gives the Time period of all types of models, and it can be concluded that building connected with viscous damper and combination of damper and bracing has short time period compared to bare frame. . Braced models also shows reduced time period.

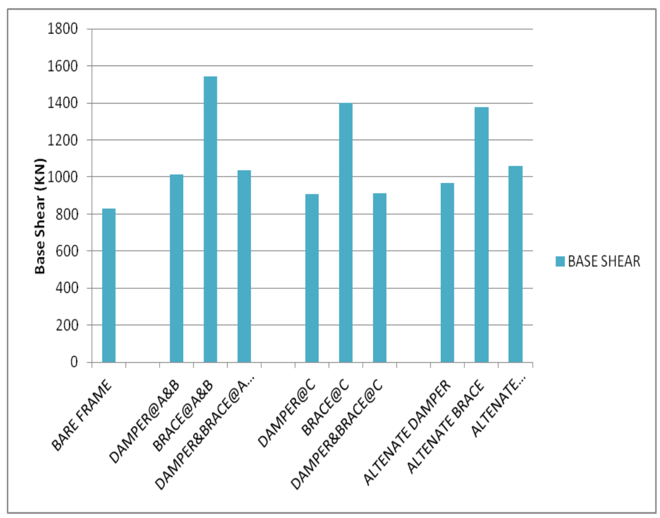

Figure 19 Comparison of Base Shear of all type models (symmetric building).

Figure 19 gives the base shear of all types of models, and it can be concluded that, Braced models has higher base shear followed by Viscous Damper and combination of Viscous Damper and Bracing compare to bare frame.

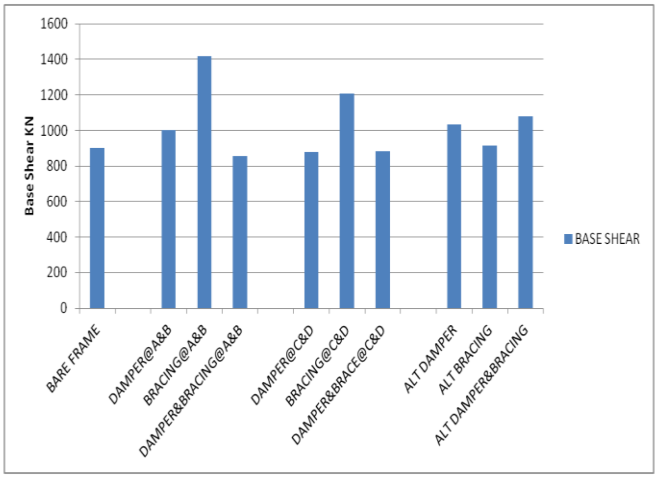

Figure 20 Comparison of Base Shear of all type models (asymmetric building)

Figure 20 gives the base shear of all types of models, and it can be concluded that, Braced models has higher base shear followed by Viscous Damper and combination of Viscous Damper and Bracing compare to bare frame. Whereas in alternative arrangement braced models has lesser base shear than Viscous Damper and combination of both.

The analysis for the all the selected models also Carried out by using pushover analysis. The results are as shown in Figure 21 and Figure 22.

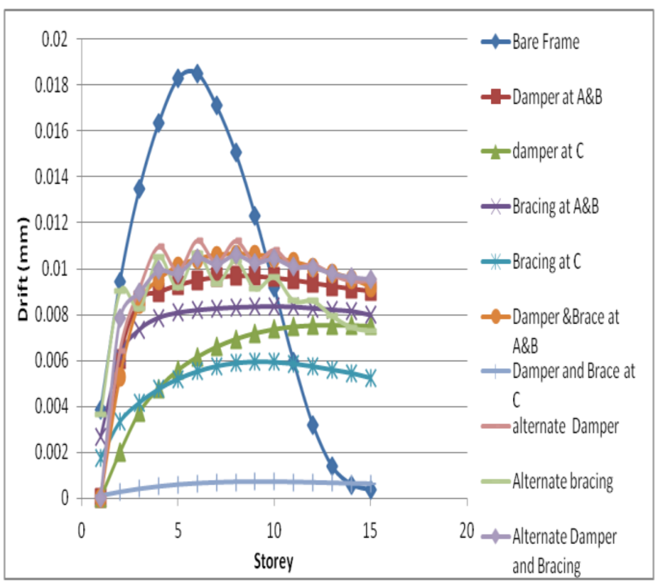

Figure 21 Comparison of story drift of pushover analysis of all types of symmetric building models.

Figure 21 gives the story drift of all types of models, and it can be concluded that building connected with Viscous Damper and combination of Damper and Bracing reduces the drift followed by braced models.

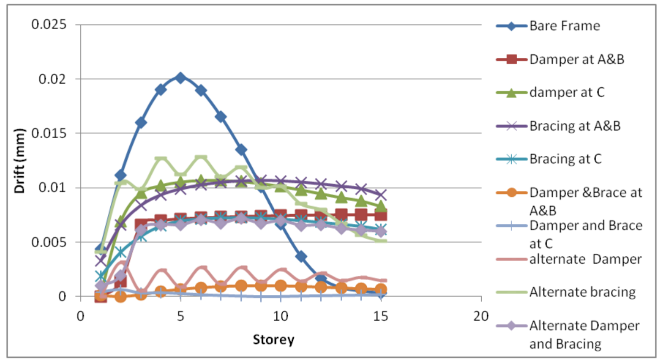

Figure 22 Comparison of story drift of pushover analysis of all types of asymmetric building models

Figure 22 gives the story drift of all types of models, and it can be concluded that building connected with viscous damper and combination of damper and bracing reduces the drift compared to bare frame.

CONCLUSIONS

From the above studies conducted for symmetrical and unsymmetrical building, connected with Viscous Damper, Bracing and combination of Damper and Bracing, can be concluded that

i). Viscous damper effectively reduces response of the building like displacement and story drift up to 70%.

ii). In most cases building connected with viscous damper and bracing also reduces the response of the structure about 65%.

iii). Bracing reduces the response of the structure about 35-40%.

iv). Time period reduces about 45-55% of building connected with viscous damper and damper and bracing compared to bare frame.

v). Hence bracing the structure along with energy dissipation device can effectively reduce the response due to natural hazards and also reducing the cost of dampers.

Acknowledgments

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