Seismic Performance Evaluation of RC Building Frame using Energy Dissipating Device at Different Locations

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Abstract— The vibrations produced by the earthquakes are due to seismic waves. Seismic waves are the most disastrous for multistoried building. The safety and serviceability of any structure is thus endangered with the increasing elevation. Energy dissipating devices has the capacity to absorb significant efforts without damaging the structure and ensuring the protection of human lives and property. The fluid viscous dampers 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. The objective of this study is to evaluate the performance of RC building frame using viscous dampers as energy dissipating device with and without dampers at different location by considering the floor displacement, story shear and story drift as seismic parameters by Response spectrum method. The building will be analyzed for different Model of RC G+8 building frame without Damper and with dampers near top and bottom at side face and corners. This study reveals that when number of damper is less, then effective location for placing the dampers is near base of the structure. This study also shows performance of RC multistoried building increases when the dampers are placed at faces rather than dampers placed at corners in terms of floor displacement, story shear and story drift.

Keywords: Siesmic waves, RC building frame, Fluid viscous dampers, Response spectrum method, Floor displacement, Story shear, Story drift

I. INTRODUCTION

However, the most efficient way of designing earthquake resistant structure would be to minimize the deaths as well as minimize the destruction of functionality of the structural element. The most disastrous thing about earthquake is its unpredictability of time and place of occurrence. These possess a great challenge to the economy and safety of structure. From the past and few present records, the world has experienced number of destroying earthquakes, causing in number of increase the loss of human being due to structural collapse and severe damages to structure. Because of such type of structural damages, during seismic (earthquake) hazards clearly explains that the buildings / structures like residential buildings, public life-line structures, historical structures and industrial structures should be designed to seismic force design and very carefully to overcome from the earthquake hazards.

To do this, the field of the earthquake engineering has made significant inroads catalysed by the development of computational techniques on computer and the use of powerful testing facilities. This has favoured the emergence of several innovative technologies such as the introduction of special damping devices in the structures, which have the immediate effect of increasing the critical damping ratio right up 20–30% (against 5% value usually used for RCC structures) and at the same time reducing the stresses and strains generated by earthquakes. This approach, is commonly known as the ‘‘energy dissipation”, and has the capacity to absorb significant efforts without damaging the structure and ensuring the protection of human lives and property.

The fluid viscous dampers (FVD) 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.

A. Objectives of study

The objective of this study is to evaluate the performance of RC building frame using viscous dampers as energy dissipating device at different location by RSA method by considering the following parameters given below:

1) To compare the seismic response of building with and without viscous damper at different location.
2) To compute Floor Displacement, Story Shear and Story Drift in building with and without dampers at different location.
3) To find the effective location of viscous dampers in building structure.

II. LITERATURE REVIEW

Several investigators performed the various type of studies considering the various type of dampers which broadly falls in the area of seismic response of structure. Timothy Paul Jester et al. (1992) has stated that there are two types of Visco-elastic (VE) seismic dampers for building structures, the VE diagonal damper and the VE passive mass damper which are studied in this thesis. It presents analytical equations for determining the damping added for each system. Finite element modelling of each system is used to determine the effectiveness of the dampers at reducing the seismic response of a prototype frame structure. Xi Lin. et al. (2000) study the equivalent SDOF system it can be seen that when the strength levels of the dampers increase, the effective period of the structure with the supplemental dampers will decrease and the equivalent viscous damping due to the dampers will increase. This will lead to a reduction of the spectral displacement. The acceleration response of the structure reflects the response level of the base shear of the structure. Mohsen Kargahi et al. (2004) presents an optimization technique for selecting damper properties that incorporates the nonlinear behaviour of a building. The optimization ensures that the dampers are highly effective, even at relatively small displacements, by selecting properties for dampers at different stories that result in overall minimum cost. An existing building is used as an illustration, and the impact of dampers is evaluated for

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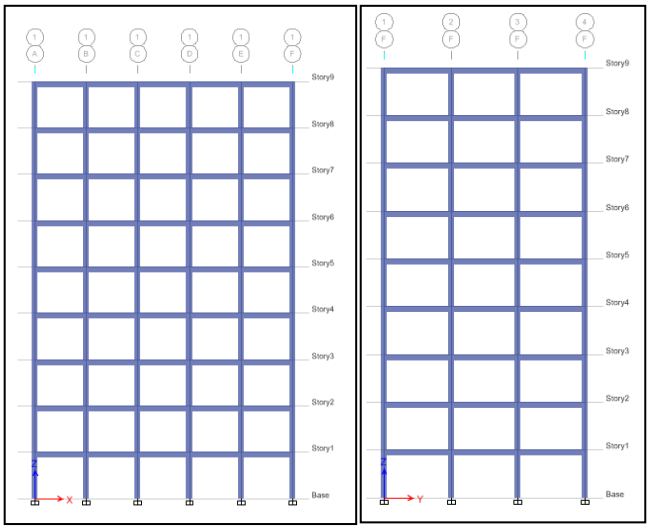
several building performance levels and ground motion levels.

Carolina Tovar et al. (2004) assed how the variation of placement and number of dampers affect the seismic response of frame structure and also evaluate a simplified method to analyse frame structures. They conclude the large number of damper do not always leads to the best benefit in terms of drift reduction for all stories. Shrimali M.K. et al. (2008) studied the Seismic response of two adjacent buildings, namely ten and eight storeys inter-connected through semi-active VF damper in which ten storeys building being isolated is investigated under unidirectional excitation due to Imperial Valley earthquake. Jae-Do Kang et at. (2017) proposed a simplified evaluation method to evaluate the inelastic seismic parameters of buildings with a seesaw energy dissipation system (SEDS) by utilising fluid viscous dampers (FVDs). Nonlinear time history analysis (NTHA) conducted on series of three and Six story steel moment resisting frames by utilising an SEDS with FVDs and a corresponding equivalent SDOF system model. Comparing the result of story drift ratio evaluated by the proposed method with nonlinear time history analysis resulting the proposed method has more precise in estimation of seismic demands. R. Purasinghe et al. (2016) reports the results of a parametric study performed using the finite element method for multi-story building frames with a range of viscous damping values and the results are compared with a simplified analytical model developed for a single degree of freedom system for a bridge model. The results obtained from the approximation agreed very well with the finite element results. This method may be useful for designers of buildings for earthquake applications. Anju Krishna et al. (2017) carried out investigations to identify the importance and performance of tuned mass damper in different structures. The study went on different paths such as alignment, placement, types; it's kind of applications etc. In every study, each aims on the optimization of parameters of the dampers to bet maximum results and thereby reducing the displacement of the structure under seismic forces.

III. MODELLING

A G+8 story RCC building is taken for the analysis using ETABS v16 software. The building has five bays in the X direction and three bays in the Y direction. In present study five models are proposed for seismic response of building. All are similar changing the location of placement of damper. In present study there are five models are developed for the analysis in which one is without Damper, two model are having twenty dampers, placement of damper from top and from bottom, other are thirty six damper at side facing and seventy two damper at corner of building.
Building is considered as reinforced concrete building. For this material is used concrete and steel. M20 grade of concrete is used for beam, column and slab. Fe500 grade of HYSD steel is considered for rebar. For dead load calculation of brick wall the density of brick is 18.85 kN/m^3 (IS:875-part 1). Technical specification of damper are used Taylor Devices Inc, USA



Elevation in x-direction Elevationin y-direction

Fig. 1: Elevation: Model-1: Building without Damper (WO)

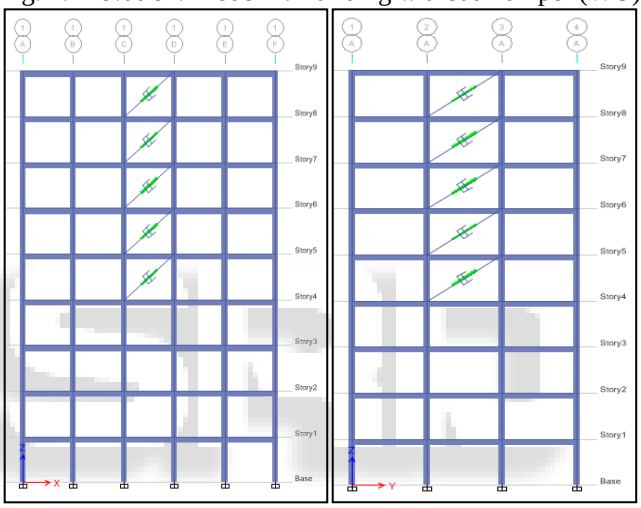


Fig. 2: Elevation of Model-2: Building with 20 Damper placed near top at side face (WDT)

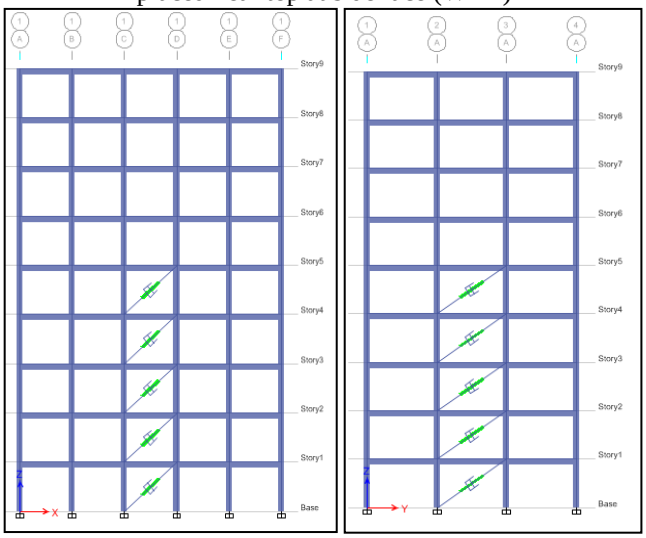


Fig. 3: Elevation of Model-3: Building with 20 Damper placed near bottom at side face (WDB)

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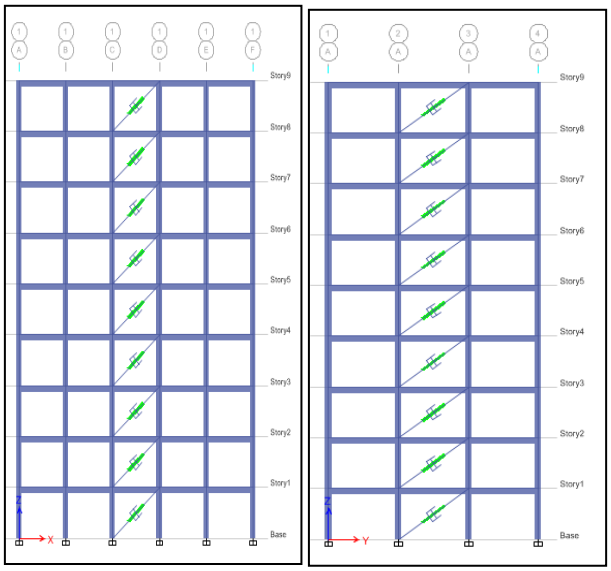

Fig. 4: Elevation of Model-4: Building with 36 Damper placed top to bottom at side face (WDF)

The building frame is considered as residential building and the live load taken for analysis is given below:

- Live load on floor = 2 kN/m
- Wall load = 0.23x3.5x18.85 = 15.17 kN/m
- Floor finish = 1.5 kN/m^2

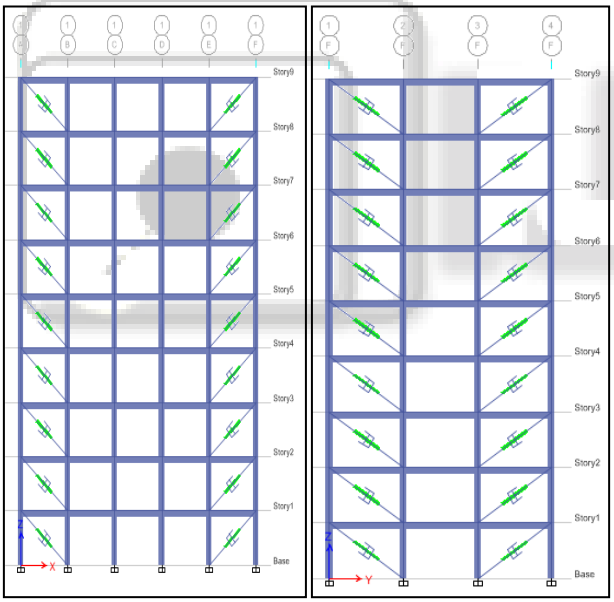

Fig. 5: Elevation of Model-5: Building with 72 Damper placed top to bottom at corners (WDC)

IV. Results and Discussion

There are several load combination are form for static as well as dynamic analysis of structure which discussed in previous chapter. From these load combination a critical load combination is considered for various result which is represent the seismic response of structure. These are floor displacement, story drift, story shear and acceleration.

A. Results from response spectrum analysis of Model-1, Model-2 and Model-3

In first case there are first three models are consider for comparison of various parameters Floor displacement, Story drift and Story shear. There is no damper is provided in Model-1 and Model-2 and Model-3 have twenty dampers are used. In which five dampers are placed on each face near top and bottom respectively.

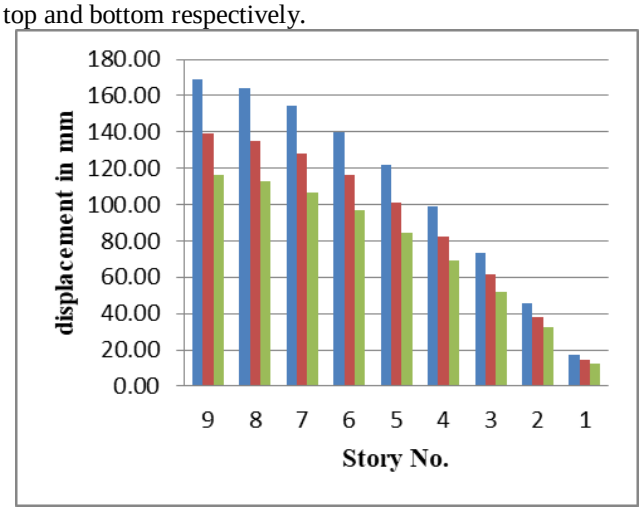

Fig. 6: Floor displacements in x-direction at different story in model 1, 2 and 3

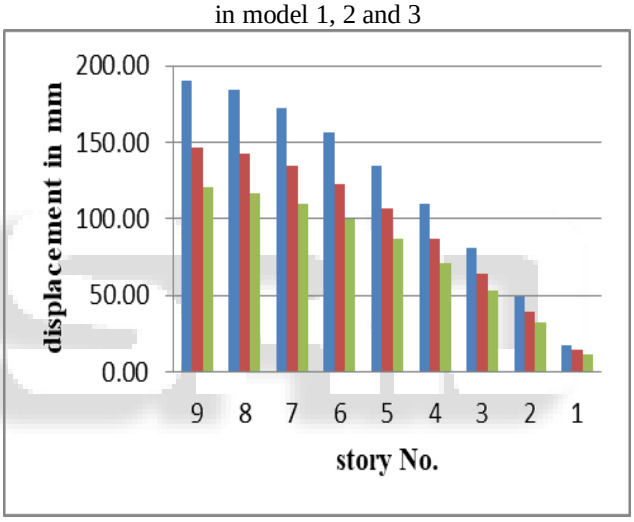

Fig. 7: Floor displacements in y-direction at different story in model 1, 2 and 3

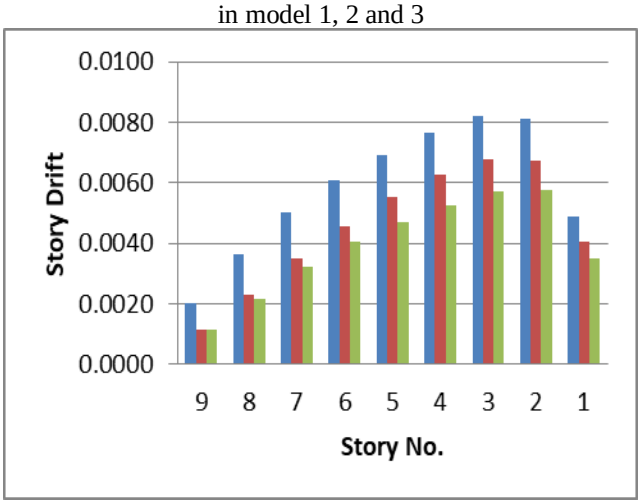

Fig. 8: Story Drift in x-direction at different stories of the models

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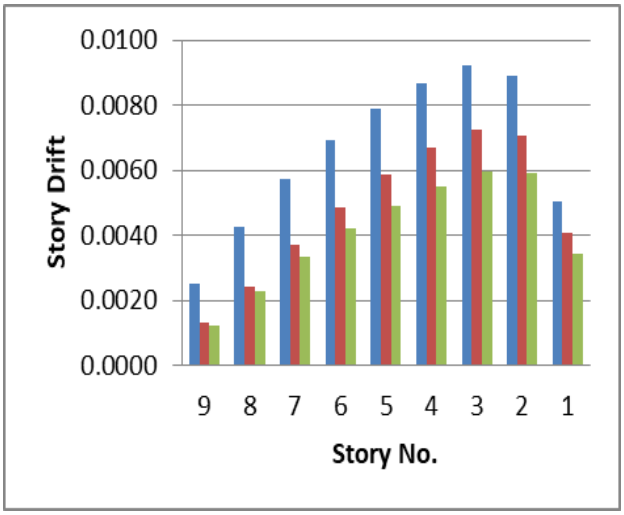

Fig. 9: Story Drift in y-direction at different stories of the models

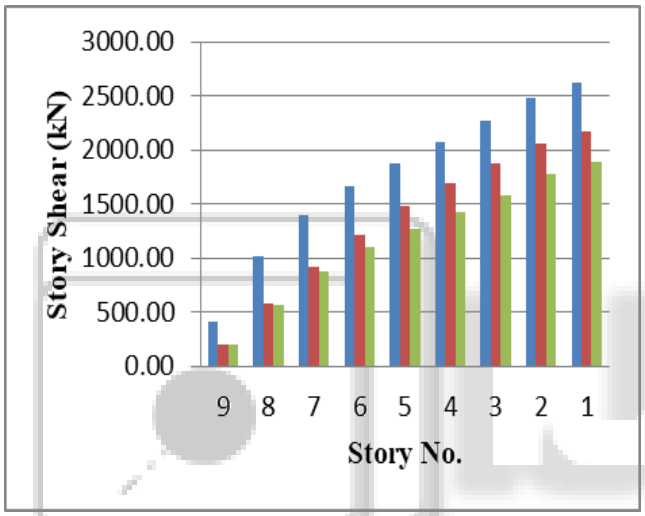

Fig. 10: Story Shear in x-direction at different stories of the models

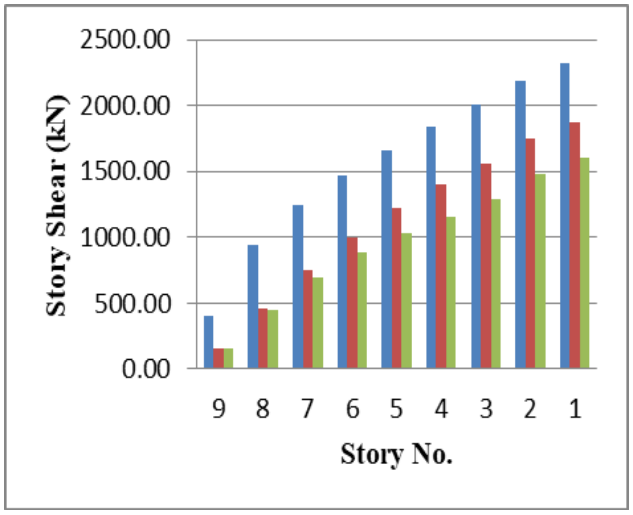

Fig. 11: Story Shear in y-direction at different stories of the models

B. Results from response spectrum analysis of Model-1, Model-4 and Model-5

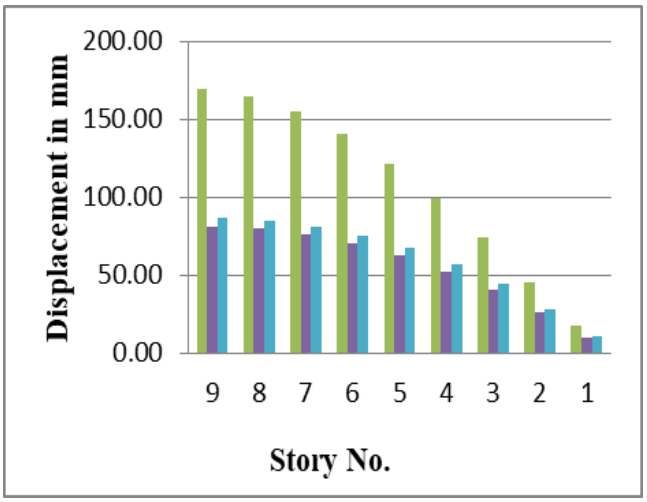

Fig. 12: Floor displacements in x-direction at different story of model-1, model-4 and model-5

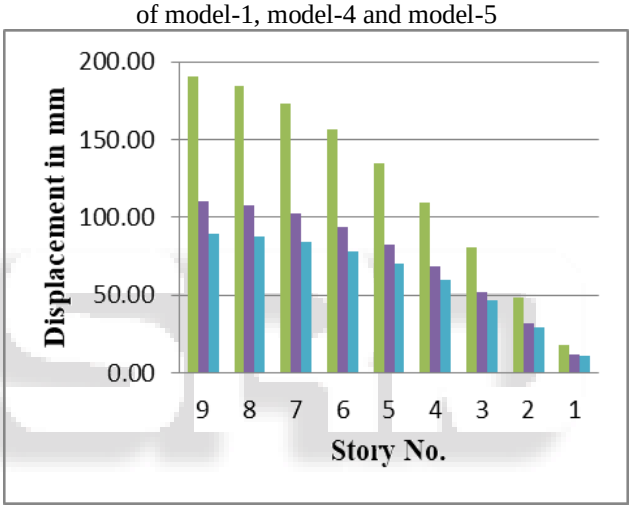

Fig. 13: Floor displacements in y-direction at different story of model-1, model-4 and model-5

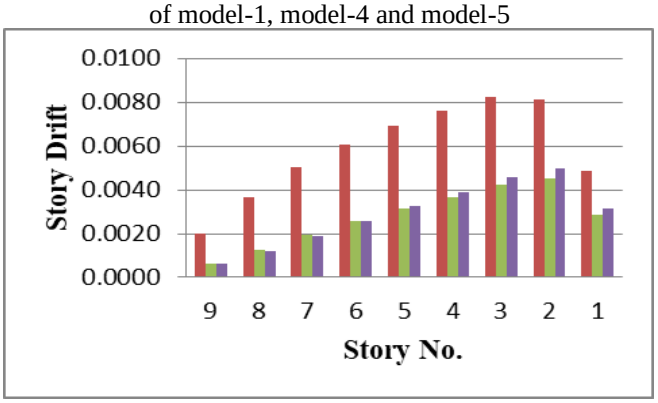

Fig. 14: Story Drift in x-direction at different story of model-1, model-4 and model-5

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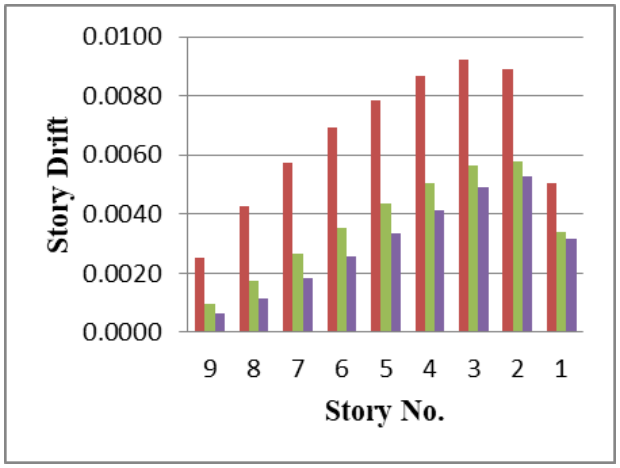

Fig. 15: Story Drift in x-direction at different story of model-1, model-4 and model-5

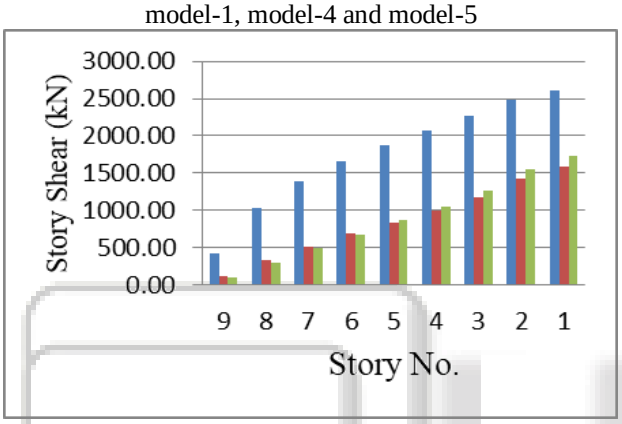

Fig. 16: Story Shear in x-direction at different story of model-1, model-4 and model-5

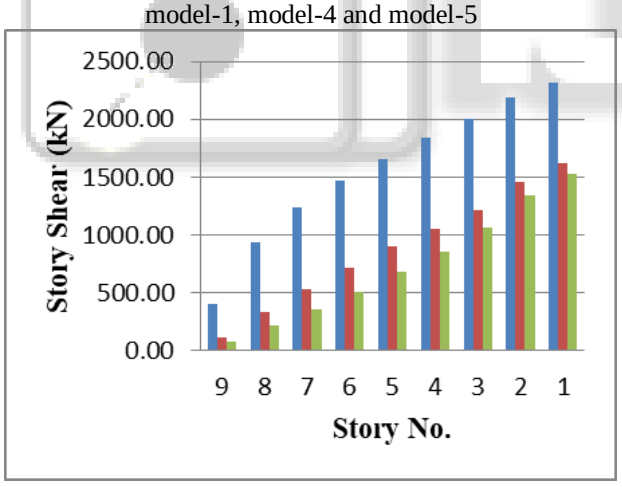

Fig. 17: Story Shear in y-direction at different story of model-1, model-4 and model-5

V. Conclusion

The results of the Response Spectrum Analysis conducted on G+8 story RC frame structure with and without FVD at various locations. Seismic response parameter, Story displacement, Story drift and Story Shear, are compared in the models.

- It can be concluded that when number of damper is less, then effective location for placing the dampers is near base of the structure. It has been also observed that percentage reduction in floor displacement in case of model-4 is 8.14% more as compared to model-5 while the number of dampers in model 5 is twice of model 4. This indicates that dampers at faces are more effective than dampers at corners.
- It can also concluded that when number of damper is less, then effective location for placing the dampers is near base of the structure. It has been also observed that percentage reduction in floor displacement in case of model-4 is 8.53% more as compared to model-5 while the number of dampers in model 5 is twice of model 4. This indicates that dampers at faces are more effective than dampers at corners.
- It can also concluded that when number of damper is less, then effective location for placing the dampers is near base of the structure. It has been also observed that percentage reduction in floor displacement in case of model-4 is 5.44% more as compared to model-5 while the number of dampers in model 5 is twice of model 4. This indicates that dampers at faces are more effective than dampers at corners.

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