Seismic Analysis of Rcc Structure with Different Types of Dampers

Waseemuddin Asad, Aravind Kumar Harwalkar

ABSTRACT: In the present Era escalation of multi-storey high rise building is very common because of rapid urbanization in the entire world also innovation in the field of Engineering, science and Technology. Also Engineers have sophisticated designing software. As height of the building increases building response to the wind and seismic load increases. It means that forces and displacement of the structure is directly proportional to the height of the structure. Many research studiesare going on to reduce the structural instability due to high speed winds and earthquakes. During the earthquake the multi-storey high rise structures are failed to resist the seismic loads and it become the catastrophic disaster for human life's and for the country. It is most important that structure should be able to withstand against external excitation forces. This can be achieved by building structure more flexible.During the time of earthquake multi-storey structures are swing and large deformation is occurred and vibrations are transferred in the structure through the ground which causes instability in structure. Thus the use of damper is resists lateral forces (wind load, earthquake load) and providing stability to the structure. Dampers are the mechanical devices which dissipate energy which is facilitate in multi-storey structure to reduce the displacement, buckling of beams and columns and increases the structural stiffness. There is lot of various types of dampers are used in RC multi-storey building. This study deals with performance and selection of suitable type of damper which will be more resistant to earthquake for the selected multi-storey building and different seismic parameters like time period, story stiffness, story displacement, story drift and base shear are checked out. In this study seismic behavior of multi-story RCC building with various types of dampers like fluid viscous damper, friction damper and tuned mass damper is carried out.

Keywords: fluid viscous damper, friction damper, tuned mass damper.

I. INTRODUCTION

Seismic dampers are the special devices which are built in such a way that they absorb seismic energy during the time of earthquake. They reduce the structural displacement and maintain the structural stability during the action of lateral forces also provided the stiffness to the structure. Generally seismic dampers are classified into three types according to their controlling system.

A. Active control system

An active control system is an energy dissipating or adding system in which an outsource power aid required to manage actuators, which apply forces in a prescribe manner to the structure. These forces are helpful to add or dissipate energy within the structure. In this active response control system, the signals sent to the actuator which is measured with physical sensors. Below Fig.1 shows the working chart of active control system.

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Waseemuddin Asad, PG Student, Department of Civil Engineering, PDA College of Engineering Kalaburagi Karnataka, India. Email: waseemuddinasad@gmail.com

Dr. Aravind Kumar Harwalkar, Associate professor, Department of Civil Engineering, PDA College of Engineering Kalaburagi Karnataka, India.

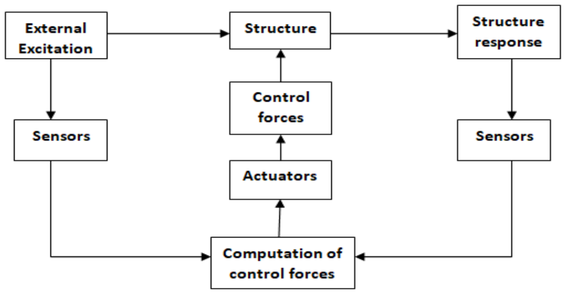

Fig. 1.Flow chart of active control system

B. Semi-active control system

Semi active control system as the name itself indicates it is similar as active control system but outsource power magnitude required is less compared with typical active system and they do not insert energy to the structural system. Semi-active control systems recently adopted as seismic damping in structural engineering. This type of system is generally develops from passive system by modifying its mechanical properties. In semi active control system they required less amount of external energy to operate. Fig.2 shows the working chart of semi active control system.

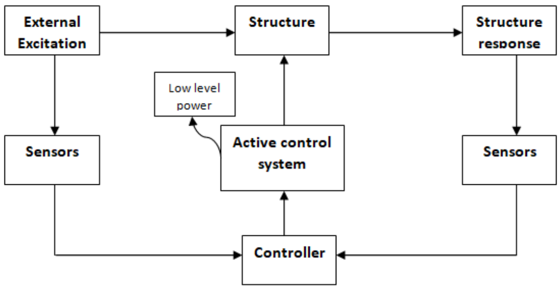

Fig. 2.Flow chart of semi active control system

C. Passive control system

A passive system is one in which any external source of power is not required to operate the system. They are self activate during the time of dynamic excitation and they absorb part of energy and damped the motion of the structure and reduces the structure response. Below Fig.3 shows the working chart of passive control system.

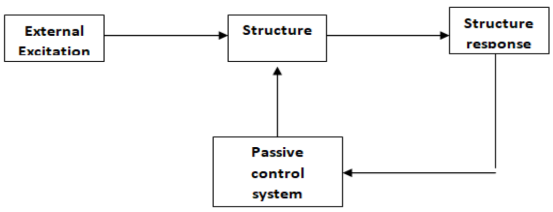

Fig. 3.Flow chart of passive control system

D. Reasons for selecting passive controlling devices

Passive control damping devices are popular in engineering solutions due to their simplicity, having less installation cost & less maintenance. A common characteristic of all passive control devices are they reduces the structural response by dissipating energy also enhances the stiffness of the structure. Following are the silent features of passive control devices.

- Passive damping device does not need any external power source to activate.
- Passive damping devices are comparatively inexpensive.
- It is intrinsically stable.
- These are effective during minor as well as major earthquakes.
- They can install during new construction or rehabilitation of the building.

E. Types of passive damping devices

a) Tuned mass damper
b) Friction damper
c) Fluid viscous damper

a) Tuned mass damper

A tuned mass damper (TMD) comes under passive control system have a secondary mass attach to the primary structure.During the action of seismic forces TMD is acts like a pendulum and helps to reduce lateral response of the structure. Fig.4 shows the TMD.

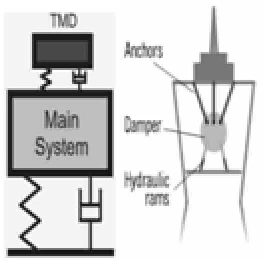

Fig.4.Tuned mass damper

b) Friction damper

A friction damper is a passive damping device consisting of several sliding plates which may be of steel, graphite or bronze and separated by the shims of friction pad materials. During the action of lateral forces these plates sliding against each other and energy is absorbs by means of friction. Fig.5 shows the friction damper.

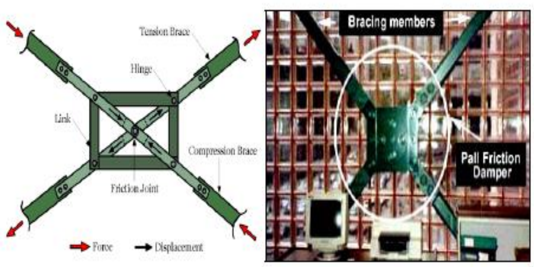

Fig. 5.Friction damper

c) Fluid viscous damper

Fluid viscous damper comes under passive damping system in which any external source of power is not needed to activate it, they are self activated during the action of lateral forces. A fluid viscous damper is similar to the mechanical piston. The cylindrical part of this piston is filled with compressible silicon oil as damping fluid which is helpful to dissipate energy. Below Fig.6 shows the cross-section of FVD.

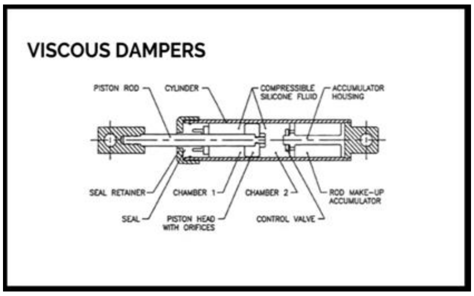

Fig. 6.Fluid viscous damper

II. OBJECTIVES OF THE STUDY

This study aimed to determine the behavior of multi-storey RCC structure under the seismic loading with and without dampers. Following are the objectives.

1. To perform response spectrum and time history analysis of multi-story building with and without dampers.
2. To study the seismic performance of multi storey structure in terms of base shear, storey drift, displacement etc.
3. To study the effectiveness and performance of the RCC structure with different dampers like Fluid viscous damper, Friction damper and Tuned mass damper.
4. To find out the suitable and effective damper for the selected structure.

III. METHODOLOGY

In this thesis an attempt to investigate the RCC structure modal with various types of dampers i.e. fluid viscous damper-250, friction damper and tuned mass damper under the seismic loading. This project mainly emphasizes comparison of models having dampers with the bare frame model by means of displacement, storey drift, time period and base shear using E-tabs 2016 software for analysis. In this study response spectrum method and time history method are used for seismic analysis, after the analysis results are carried out and these results are compared and discussed by plotting the graphs.

In this study following models considered for the analysis

1. G+20 RCC multi-storey building without damper
2. G+20 RCC multi-storey building with Fluid viscous damper
3. G+20 RCC multi-storey building with Friction damper
4. G+20 RCC multi-storey building with Tuned mass damper

IV. ANALYTICAL MODELLING

A. RCC Structure details

The detail properties of RCC structure and seismic properties (as per IS-1893:2016) listed in table-I

Table-I: RCC Structure details

Type of building	Commercial building (regular)

Type of frame	Moment resisting frame
No. Of storeys	G+20 storeys
Total height of building	69.2 m
Height of each storey	3.2
Bays in x-direction	5
Bays in y-direction	5
Floor finish load	1KN/m2
Thickness of the wall	230mm
Live load	4 KN/m2
Grade of concrete	M30
Grade of steel	HYSD500
Density of brick masonry	20KN/m3
Dimension of columns	400mmX850mm
Dimension of beams	230mmX450mm
Thickness of slab	125mm
Seismic zone	V
Soil type	III
I	1.5
R	5
Z factor	0.36

B. Description of models

Below Table-II shows the descriptions of models for analysis using E-tabs software.

Table-II: Description of models

Model No.	Description
1	G+20 RCC multi-storey building without damper
2	G+20 RCC multi-storey building with Fluid viscous damper
3	G+20 RCC multi-storey building with Friction damper
4	G+20 RCC multi-storey building with Tuned mass damper

C. Modeling of different models in E-tabs software

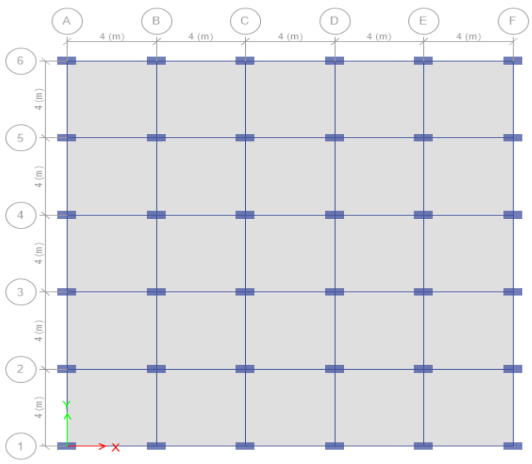

Fig. 7.Plan of the structure

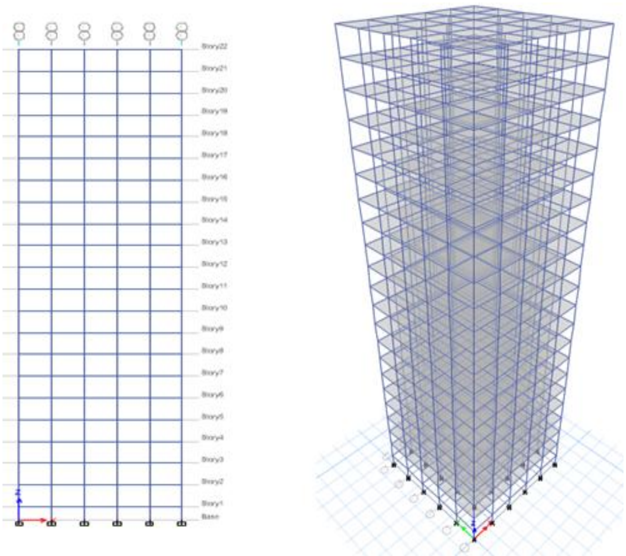

Fig. 8.Model-1

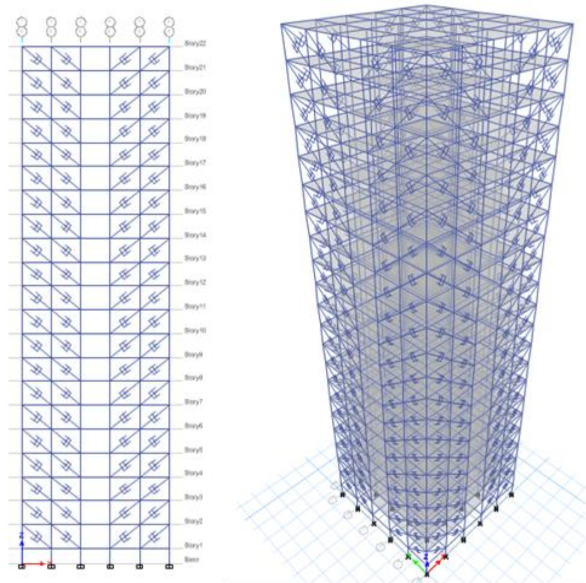

Fig. 9.Model-2

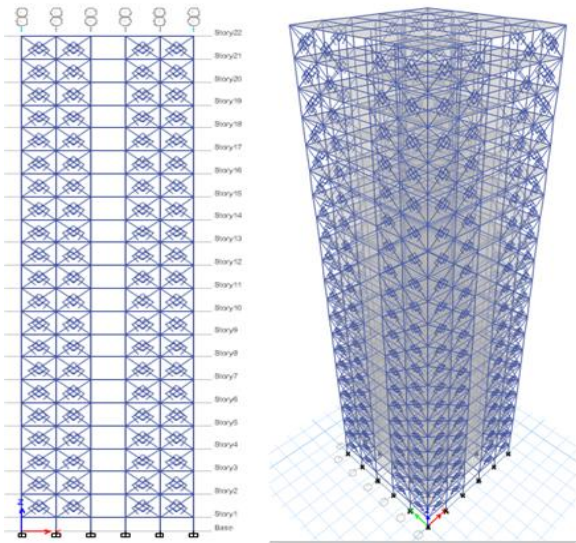

Fig. 10.Model-3

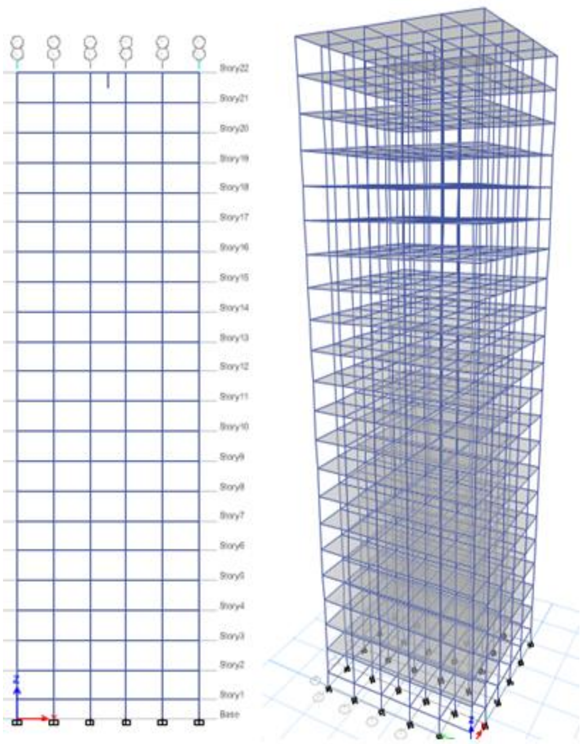

Fig. 11.Model-4

V. RESULTS AND DISCUSSION

A. Time period

Below table-III shows the time period of models and Fig.12 represent the graphical variation of time period of each models.

Table-III: Time period of different models

Model no.	1	2	3	4
Time period (sec)	4.12	2.3	3.2	3.9

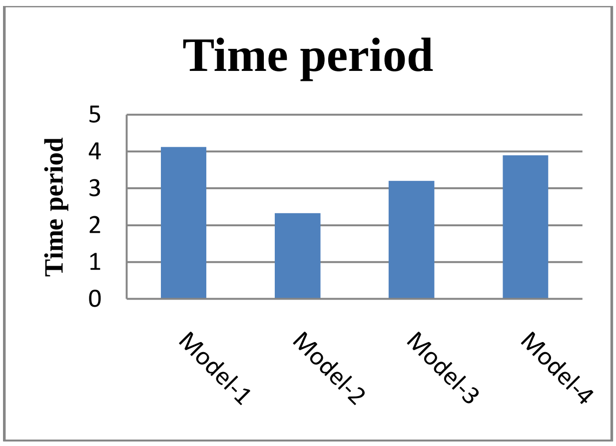

Fig. 12.Time period of different models

The time period is least in model-2 i.e. structure with fluid viscous damper. When we compared the model-1 i.e. RCC structure bare frame model with remaining models having dampers it is found that 43.4%, 22.3% and 5.3% reduction in time period in model2, model3 and model4 respectively.

B. Storey displacement

The storey displacement with different models in X and Y-direction by response spectrum analysis and time history analytical method are shown below in Table-IV and Table-V respectively.

Table-IV: Storey displacement of different models from RSA

Model no.	1	2	3	4
X-dir (mm)	126.13	76.17	103.44	121.8
Y-dir (mm)	143.64	73.19	111.75	133.62

Table-V: Storey displacement of different models from THA

Model no.	1	2	3	4
X-dir (mm)	102.90	61.78	91.53	97.0
Y-dir (mm)	123.06	69.78	89.80	112.70

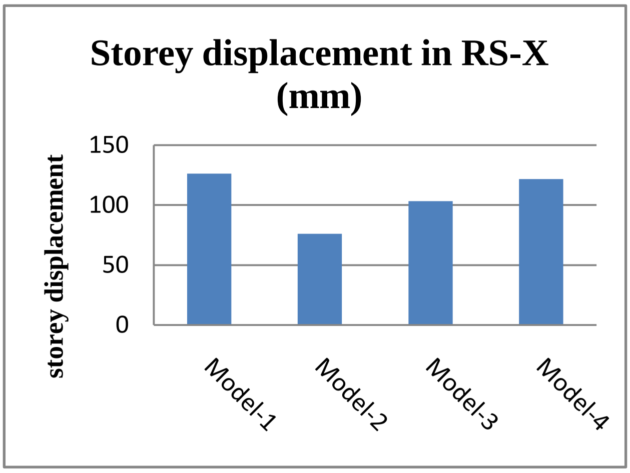

Fig. 13.Storey displacement along X-direction form RSA

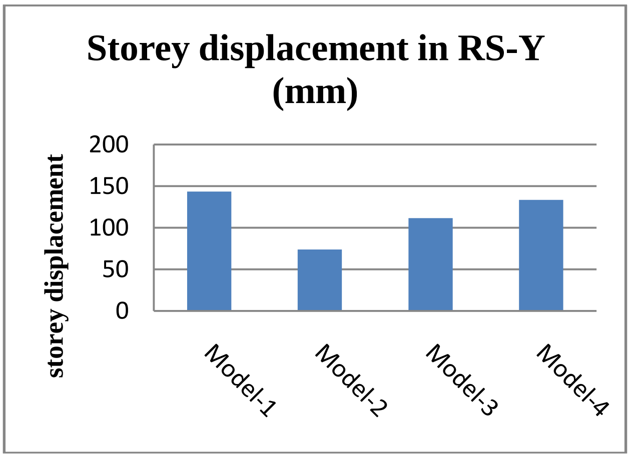

Fig. 14.Storey displacement along Y-direction form RSA

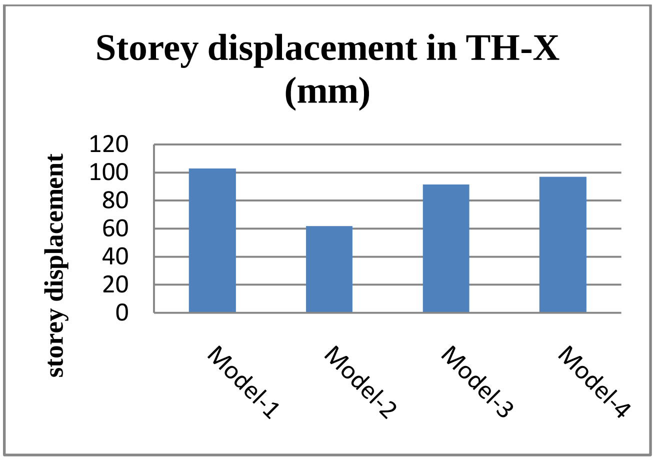

Fig.15.Storey displacement along X-direction form THA

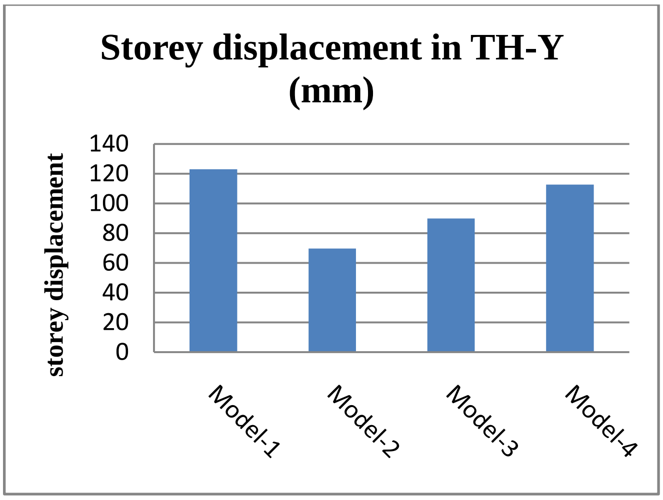

Fig.16.Storey displacement along Y-direction form THA

When model-1 is compared with respect to model 2, 3 and 4 it is found that storey displacement is reduced by 39.6%, 17.98% and 3.43% in x-direction and 49%, 22.2% and 6.9% in y-direction by response spectrum analysis. Similarly through time history analysis the percentage reduction of storey displacement in model 2, 3 and 4 when compared with model 1 is 39.95%, 11% and 5.7% in X-direction and 43.29%, 27% and 8.42% in Y-direction respectively.

C. Storey drift

Below Table-VI and Table-VII shows thestorey drift in X and Y-directions by response spectrum and time history analysis.

Table-VI: Storey drift of different models from RSA

Model no.	1	2	3	4
X-dir	0.002694	0.001427	0.002071	0.00258
Y-dir	0.003106	0.001358	0.002195	0.00292

Table-VII: Storey drift of different models from THA

Model no.	1	2	3	4
X-dir	0.002482	0.001139	0.002067	0.00232
Y-dir	0.003084	0.0012	0.002139	0.002798

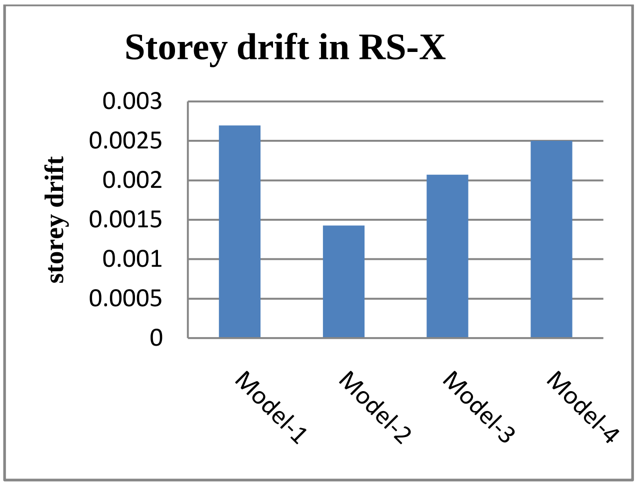

Fig.17.Storey drift along X-direction form RSA

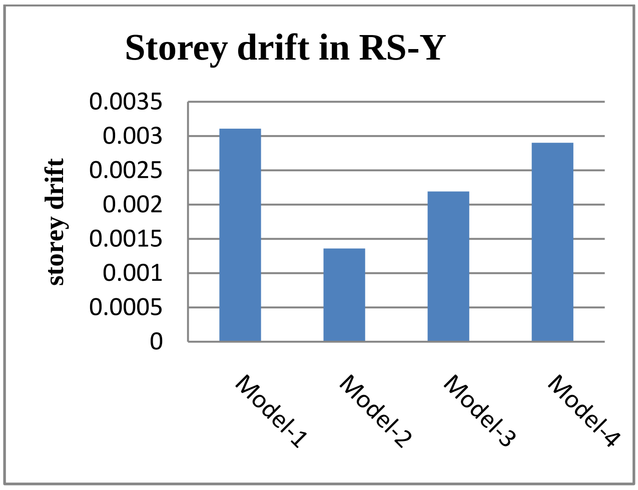

Fig.18.Storey drift along Y-direction form RSA

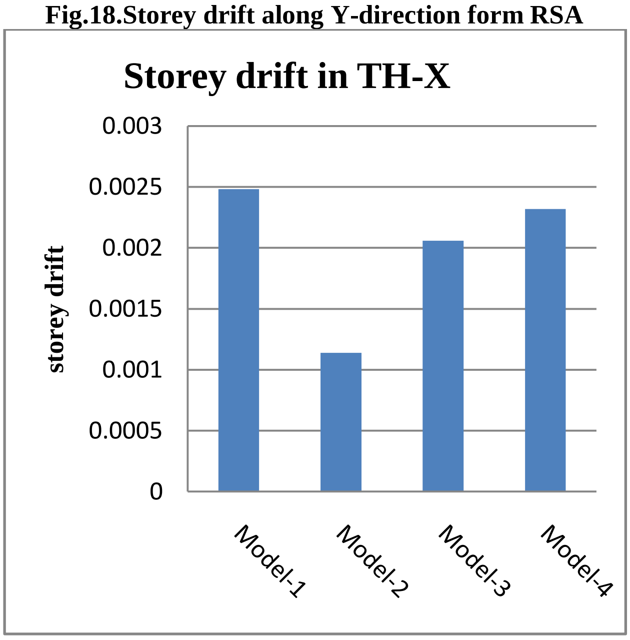

Fig. 19.Storey drift along X-direction form THA

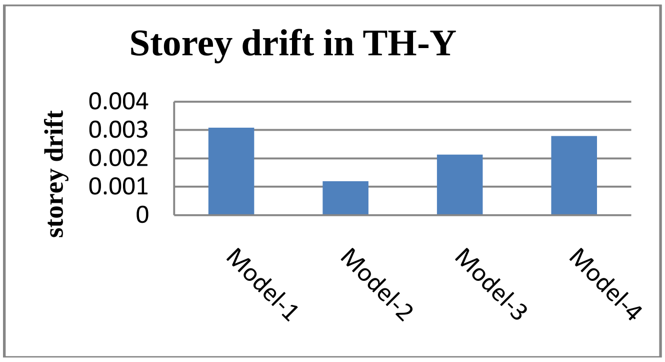

Fig.20.Storey drift along Y-direction form THA

In comparison of model-1 with model2, model3 and model4 by response spectrum analysis storey drift is reduces by 47%, 23% and 4.23% in x-direction and 56%, 29% and 5.98% in y-direction respectively. Similarly by time history analysis storey drift is reduces by 54%, 16.7% and 6.5% in x-direction and 61%, 30.6% and 9.27% in y-direction in model2, model3 and model4 respectively.

D. Base shear

The base shears in all models along X-direction are shown in Table-VIII.

Table-VIII: Base shear of different models

Model no.	1	2	3	4
Base shear (Kn)	3615.45	8666.9	4053.3	3452.2

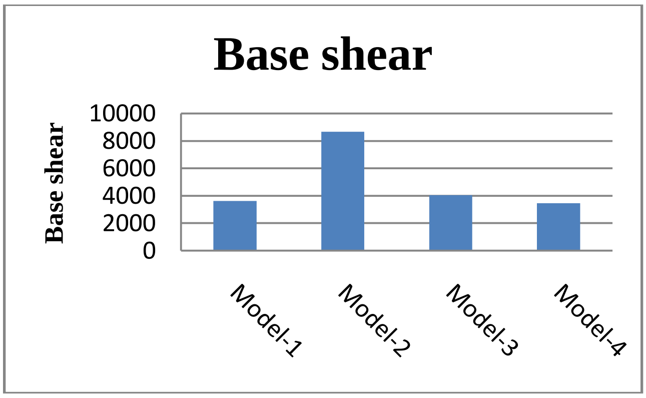

Fig.21.Base shear of different models

The base shear is found to be least in model-4 i.e. with tuned mass damper and highest in model-2 i.e. with fluid viscous damper. When we compared the base shear of RCC structure without damper (model-1) with RCC structure with tuned mass damper (model-4) 4.5% of base shear is reduced and base shear is increases by 58% when model-1 is compared with model-2.

VI. CONCLUSIONS

Following conclusions are carried out through the analytical study.

1. From the results it is notice that storey displacement is reduces significantly by the application of dampers in the structure. Analytical results shows that the utmost reduction of storey displacement with fluid viscous damper.
2. Among fluid viscous damper, friction damper and tuned mass damper maximum reduction of storey drift is found with the application of fluid viscous damper because of its visco-elastic property.
3. Structure with fluid viscous damper poses high base shear because of viscous damper may add stiffness in the structure to resist lateral forces during seismic action.
4. The use of dampers in the structure provides elastic movement to the building and dissipates seismic energy.
5. The time period of RCC structure with fluid viscous damper is least compared to all other models. The percentage reduction in the time period is 43% when compared with bare frame model.
6. From the overall study it is found that among FVD, friction damper and TMD, FVD is effective to dissipate seismic energy. The addition of FVD in the structure provides damping up to 30% of critical and some times more.

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AUTHORS PROFILE

WASEEMUDDIN ASAD, PG Student, Department of Civil Engineering, PDA College of Engineering Kalaburagi Karnataka, India. 585104 Email: waseemuddinasad@gmail.com

Dr. Aravind Kumar Harwalkar, Associate professor, Department of Civil Engineering, PDA College of Engineering Kalaburagi Karnataka, India. 585102