Seismic Vibration Control of High Rise Building with Shear Wall Using ETABS

K A Krishnamurthy, S R Pruthviraj and T Maruthi

May 22, 2022

SEISMIC VIBRATION CONTROL OF HIGH RISE BUILDING WITH SHEAR WALL USING ETABS

Krishnamurthy K A
Lecturer, Department of Studies in Civil Engineering,
University B. D.T College of Engineering,
Davangere-577004, Karnataka, India.
krishnamurthyka432@gmail.com

Pruthviraj S R
Lecturer, Department of Studies in Civil Engineering,
University B. D.T College of Engineering,
Davangere-577004, Karnataka, India.
pruthvi960637@gmail.com

Maruthi T
Assistant Professor
Civil Engineering Department, Jain Institute of Technology,
Davanagere-577004, Karnataka, India.
maruthimanoj3@gmail.com

ABSTRACT

This work is concerned with the seismic vibration control of high rise building with shear wall. According to is 1893(part -1):2002 code is used to analyses the structures by time history method. To use the different load combinations by IS1893 (part-1):2002. In this study to prepare the U shapes of building in ETABS-2017 software. RCC model, shear wall, damper model and shear wall and damper may have varied seismic response performances. All the models are analysed for buildings located in zone Ⅲ of medium soil as per IS 1893-2002 (part 1). The results are tabulated In-terms of lateral displacement, story displacement, natural period time and base shear.

Key words: - Shear wall, Time history method and ETABS.

I. INTRODUCTION

RC Multi-Storey Buildings are adequate for resisting both the vertical and horizontal load. When such building is designed without shear wall, the beam and column sizes are quite heavy and there is lot of congestion at the joints and it is difficult to place and vibrate concrete at these places and displacement is quite heavy which induces heavy forces in member. Shear wall may become imperative from the point of view of economy and control of lateral deflection. Shear walls are vertical elements of the horizontal force resisting system. When shear walls are designed and constructed properly, they will have the strength and stiffness to the horizontal forces .In building construction, it is a rigid vertical diaphragm capable of transferring lateral forces rom exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes. Shear walls area especially important in high-rise buildings subjected to lateral wind and seismic forces .The most important property of shear wall for seismic design as different from design for wind is that it should have good ductility under reversible and repeated over loads.

LITERATURE REVIEW OF STRUCTURE WITH SHEAR WALL

Parmod Sharan, Balwan et al (2016):

In this paper to study the earthquake vibration control using modified framed shear wall. In earthquake regions major problem is rehabilitation of vulnerable buildings. In recent past a number of techniques have been developed to strengthened and rehabilitation the buildings in these regions. However, occupants are disturbed following these strengthening and rehabilitation techniques because vacation of buildings. In present study, a new strengthening technique for exterior shear walls has been discussed the under reversed cyclic loading.

D. Karishma and Asst. Prof. A. Satya Sunitha et al [10] (2019):

In this paper the earthquake vibration control using framed shear walls. The present work attempts to study the technique of shear wall. This study deals with the method of analysis and design ofa shear wall for G+5 buildings located in Zone-. The scope behind this work is to learn necessity of a shear wall in these modern days under the dead load, seismic load, live load (u.d.l) acting on the structure.

Kiran Tidke, Rahul G.R.Gandheet (2016):
In this paper to study the seismic analysis of building with and without shear wall. The scope of present work is to study the effect of seismic loading on placement of shear wall in building at different alternative location. Effectiveness of shear wall has been studied with the help of five different models. Model one is bare frame structural system and other four models have different arrangements of shear wall. Response spectrum and time history method are used for analysis in SAP2000 software and structure was assumed to be situated in zone II. From analysis some parameter are determine like base shear, storey drift and displacement of a structure.

Khushbo K. Soni, and Dr. Prakash S. Pajga et al (2015):
To study the design of multi-storeyed regular rcc buildings with and without shear walls. In the present study, an attempt has been made to model 12 storey, 15 storeys and 18 storey building with and without shear walls by static analysis method for earthquake zone III. E-TABv9.74 software is used for the analysis. The objective of this study is to assess the comparative seismic performance of buildings in terms of displacement, storey drift, base shear, and cost and carpet area. Buildings with shear wall are economical as compared to without shear wall.

II. OBJECTIVES

The aim of this to study on seismic vibration control of high rise building with shear wall using ETABS -2017 software and considered U shape of building and considered zone Ⅲ .The study is aimed at the following objectives,

- To perform time history analysis on irregular U shaped concrete framed structure using barkot earthquake data (1999) in ETABS software.
- To perform the seismic analysis of the multi-storeyed building and determining the time period, base shear, storey displacement and storey drift for considered zone Ⅲ building.
- To carryout seismic analysis by introducing both shears wall, as a combined effect in the considered structure and study the response parameters.
- To conduct comparative study on conventional RCC structures, conventional RCC structures with shear wall.

LOCATIONOFSHEARWALLSA BUILDING

a. Shear wall at center
b. Shear wall at core and parallel side
c. Shear wall at corner
d. Shear wall at periphery

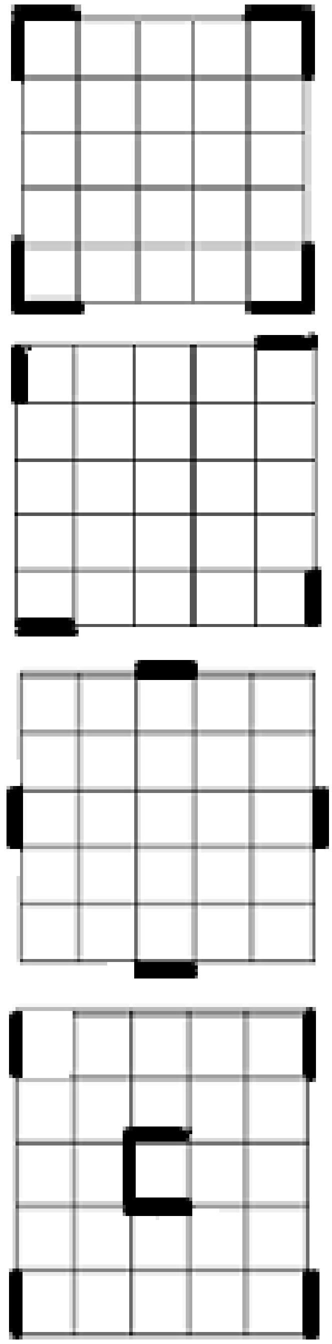

Figure-01: shows different location of shear wall in model

TYPES OF SHEAR WALL:

1. RC shear wall
2. Plywood shear wall
3. Midply shear wall
4. RC hollow concrete block masonry wall
5. Steel plate shear wall

ADVANTAGE OF SHEAR WALL

1. Shear wall are easy to construct, because reinforcement detailing of walls is relatively straight forward and therefore easily implemented at site.

2. Shear walls are efficient, both in terms of construction cost and effectiveness in minimizing the earthquake damage in structural and non-structural elements (like glass windows and building contents).

3. Architectural aspects of shear walls most RC building with shear walls also have columns; these columns primarily

carry gravity loads (i.e., those due to self-weight and contents of building).

FUNCTION OF SHEAR WALL

The two function of the shear wall are strength and stiffness.

- Shear wall must provide the necessary lateral strength to resist horizontal earthquake forces .When shear walls are strong enough, they will transfer these horizontal forces to the next element in the load path below them, such as other shear walls, floors, foundation walls, slab or footings.

- Shear walls also provide lateral stiffness to prevent the roof or floor above from excessive side's way. When shear wall are stiff enough, they will prevent floor and roof framing members from moving off their supports.

- The main function of shear wall is to resist the lateral load in the tall buildings which are induced due to earthquake or wind effects. Shear walls in addition to lateral loads they also carry gravity loads.

III. METHOD AND METHODLOGY

For this study four models of 10 storey RCC building was modelled with bare fame, conventional RCC building with shear wall, in ETABS. In this project work the shear wall is provided in middle position .Total height of building is 30m.Floor to floor height is 3m. Support base properties are fixed. Column size 450mmX450mm and beam size 350X450mm, Shear wall thickness is 230mm .Slab thickness is 200mm. Material properties for concrete M30 grade and Fe500 rebar are selected. Frame carries wall load of 12KN/m only. Loads on Slab in gravity direction are DL=1KN/m^{2}and LL=2KN/m^2.ETABS takes self-weight by ETABS default.

LOAD COMBINATION: The load combinations are defined as per the code is 1893-2002.The different load combinations are as follows.

1. 1.5(DL+LL)
2. 1.2(DL+LL+EQX)
3. 1.2(DL+LL+EQY)
4. 1.2(DL+LL-EQX)
5. 1.2(DL+LL-EQY)
6. 1.5(DL+EQX)
7. 1.5(DL+EQY)
8. 1.5(DL-EQX)
9. 1.5(DL-EQY)
10. 0.9DL+1.5EQX
11. 0.9DL+1.5EQY
12. 0.9DL-1.5EQX
13. 0.9DL-1.5EQY

TIME HISTORY ANALYSIS

Fast non-linear analysis (FNA) is adopted to get the seismic behaviour of the building with FVD at corner position. It is most accurate and fast method of analysis than direct integration method of time history analysis and mostly preferred for the ETABS software. FNA has been carried out to study the non-linear structural behaviour to get exact structural elements deformation beyond their yield limit. Each TH record, first defined as a time history (TH) function from file and then defined as a load case and applied to both models. After that TH records are applied to the models.

Procedure:

- An earthquake record representing the design earthquake is selected.In my workI have considered **Barkot** region in 1999 in east asia india from main website strong motion center
- A mathematical model of the building is set up, usually consisting of a lumped mass at each floor.
- The digitized record of the is applied to the model as acceleration at the base of structure.
- The complete record of acceleration, velocity and displacement of lumped mass at each interval.
- In the present study the desired model is analyzed using time history analysis

IV. MODELLING OF STRUCTURE AND ANALYSIS

BUILDING MODELLING:

In this modelling, the dimension of the building is 32.3088mx21.336m, the total height of the building is 30m .The modelling is considered as U shape of the building which is considered as zone and the ordinary RC moment resisting frame building is considered and type soil is considered, this modelling number of bays in X direction is and number of bays in Y direction is .The analysis is worked in ETABS-2017. In this modelling, the total number of storeys is 10 storeys is taken. The plan, 3D view, rendered view as shown in figure.

V. BUILDING DESCRIPTION

The building used in this study is 10 storied. All building models have same floor plan.

The data is taken for the analysis is as follows:

Grade of concrete : M30

Grade of steel : Fe500

Beam size up to 10 storey : 350×450 mm

Column size up to 10 storey : 450×450 mm.

Slab thickness : 200mm

Storey height : 3m

Shear wall thickness : 230mm

SEISMIC LOADS

Seismic design shall be done in accordance with IS: 1893:2002. The building is situated in earthquake zone Ⅲ. The parameters to be used for analysis and design are given below (As per IS: 11893:2002(Part I).

Zone	:	Ⅲ
Zone factor	:	0.16(Refer Table 2)
Importance factor	:	1.0 (Refer Table 6)
Response reduction Factor	:	3.0(Refer Table 7)
Soil1Type	:	Medium
Structure Type Structure	:	RC Frame

MODEL1.Conventional RCC Building:

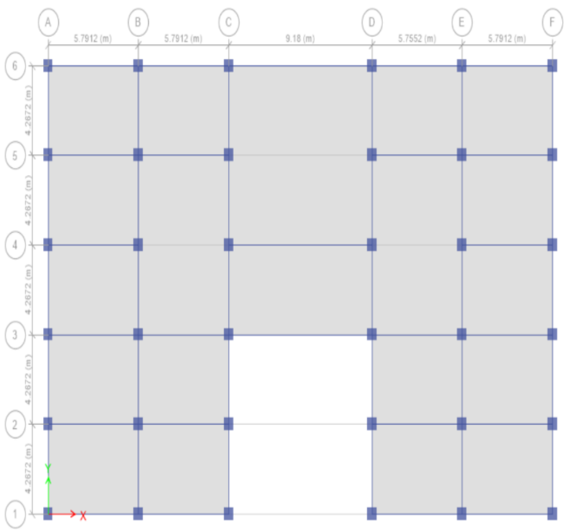

Figure-02: Plan for G+9 Storey conventional RCC building

MODEL2: Conventional RCC Building with shear wall

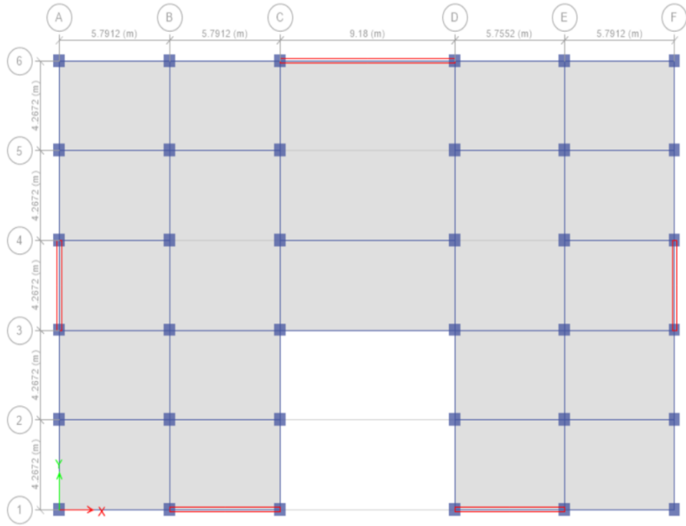

Figure-03: Plan for G+9 storey building with shear wall

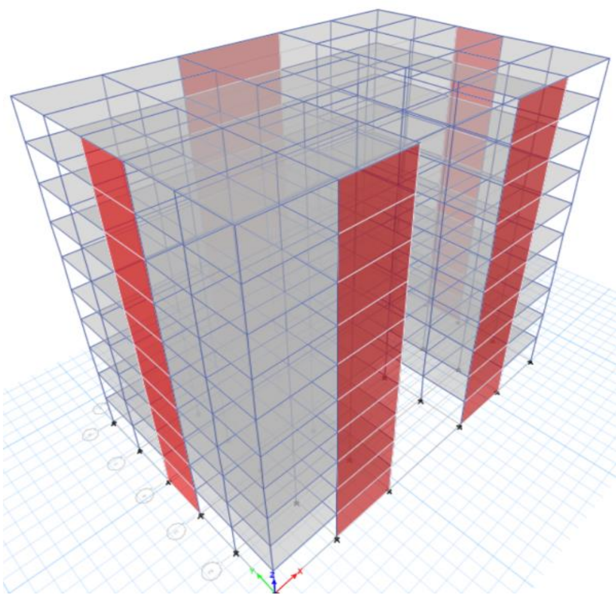

Figure-04: 3D view for building with shear wall

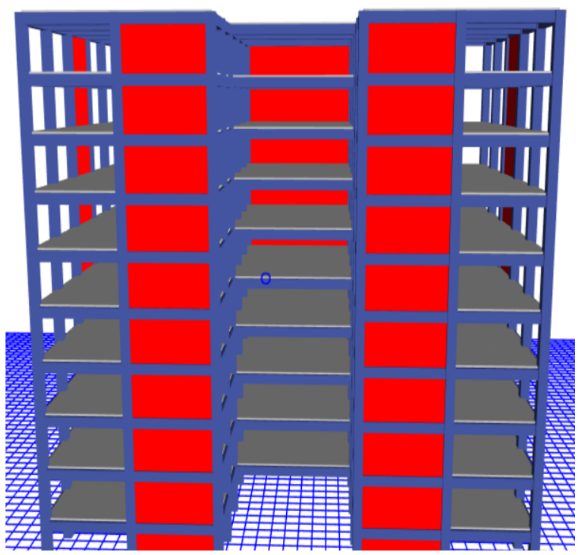

Figure-05: Rendered view for building with Shear wall

VI. RESULT AND DISCUSSION

In this chapter,we are going to discuss the results obtained for the analysis performed on the desired model.The analysis carried out is Time histroy analysis.

An attempt has been made to understand the behaviour of regular conventional RCC building comparision with building with shear wall.

In this study,the behaviour of each models are recorded and the results are tabulated in the form of natural time period,baseshear , storey displacement and storey drift.

NATURAL PERIOD TIME

Time taken by the wave to complete one cycle is called its time period. The naturl period periods obtained forthe different models using ETABS 2017 are given in the below tables.Time periods obtained in the time histroy analysis aredue to barkot earthquake.

Table-1: Time periods for different models for G+9 storey building

mode	Time Period in sec	
	Conventional RCC	Shear wall
1	1.85	0.924
2	1.557	0.644
3	1.47	0.553
4	0.589	0.245
5	0.5	0.145
6	0.47	0.13
7	0.324	0.118
8	0.279	0.079
9	0.263	0.079
10	0.213	0.073
11	0.187	0.065
12	0.176	0.063

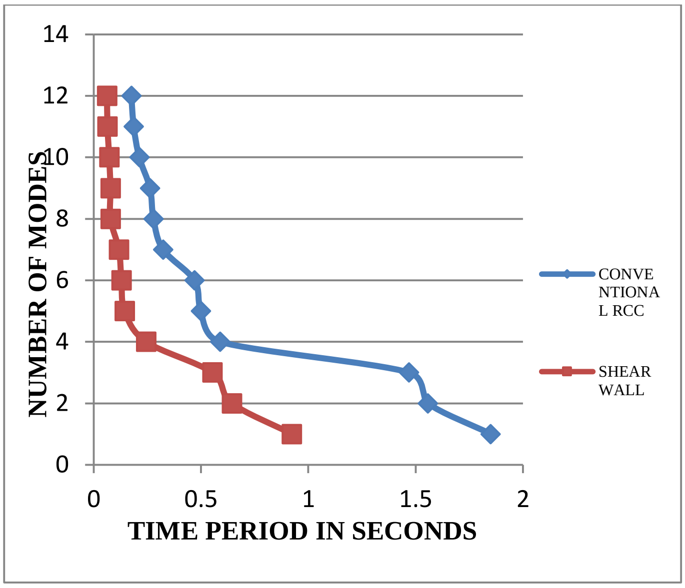

Figure-06: Time periods for different models for G+9 storey building

From fig 6.1 shows that the maximum time period of conventional RCC is 1.85sec, building with Shear wall is 0.924sec, building with damper is 0.86sec, and building with Shear wall and Damper is 0.718sec. The comparision of time periods for building with shear wall model shows lower value than compared to conventional RCC model.

BASE SHEAR

The base shear obtained from time histroy analysis for considered models are shown in below tables.The base shear are the functionof the mass,stiffness,height and the natural period of the building structure.

Table-2: Base shear for different models for G+9 storey building

TYPE OF MODEL	**X -direction**
	KN
Conventional RCC	1349.493
Shear wall	4284.1595

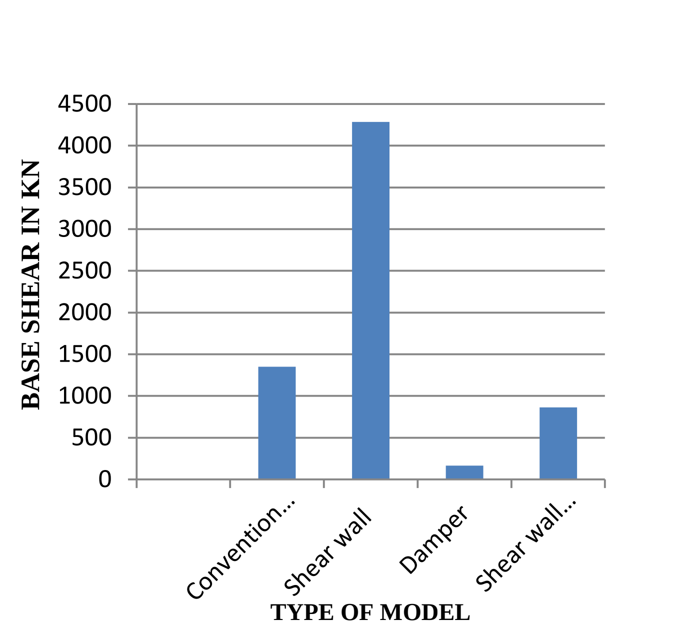

Figure-07: Base shear for different models for G+9 storey building

The time history response of 10 storey building models in terms of base shear is plotted in fig. 6.3 which shows that conventional RCC building has minimum base shear is 1349.493KN and maximum base shear is building with shear wall is 4284.1595KN. From the above table it is clear that the base shear of the building is directly proportional to the stiffness of the building.As the stiffness of the building increases the base shear of the building also increases. The building with shearwall having the more stiffness, that is the base shear of building with shear wall are more than compared to conventional RCC building.

STOREY DISPLACEMENT:

The storey displacement is obtained from the time history analysis for 10 storey building in X direction are listed in the table below. The tables to shows lateral displacements of G+9 storeyed conventional RCC building, building with shear wall, fig 6.3 to 6.9 indicates the plot of lateral displacements versus storey number.

Table-3: Storey displacement for different models for G+9 storey building

TYPE OF MODEL	X direction
	mm
CONVENTIONAL RCC	42.594
SHEAR WALL	21.143

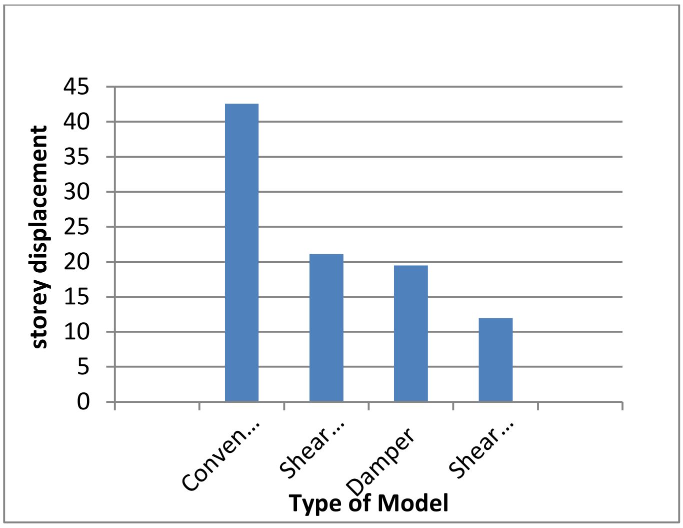

Figure-08: Maximum story displacement for all the models

Lateral displacement of the building at the top levels due to barKot earthquake for time history analysis. Top of the building shows the maximum displacement. From the figure it is observed that there is a reduction in lateral displacement at top of the building when the shear wall and fluid viscous dampers are connected in the building. The top roof level displacement is reducing from 42.594mm to 11.986mm at the top of the reduction. Hence we can provide the shear wall and viscous dampers in the building model.

STORY DRIFT:

Story drift is obtained from the time history analysis for 10 storey building in X direction. Storey drift for U shape of the building models obtained from analysis are shown in table. According to IS 1893 (part 1):2002 clause 27.11.1 storey drifts are explained. The storey drifts in any storey due to minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times the storey height for 3.0m storey height as got 12mm.

Table-4: Maximum storey drift on different models for G+9 storey building

TYPE OF MODEL	X -direction
	mm
Conventional RCC	2.975
Shear wall	0.215

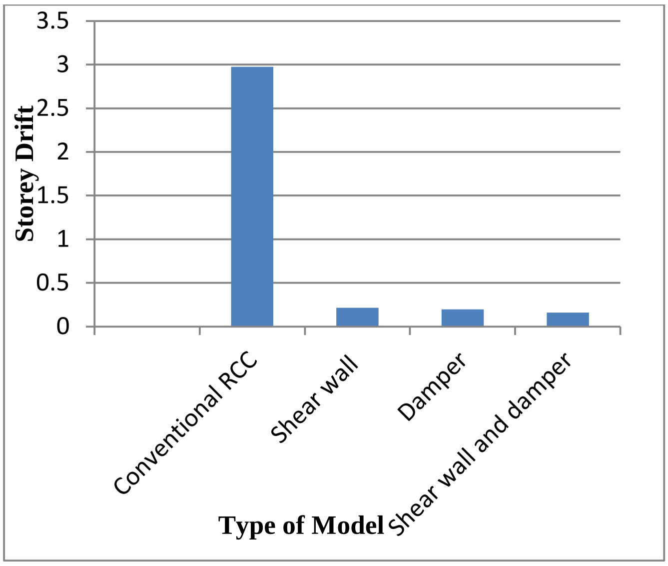

Figure-09: Maximum story drift for different models

For the loading combination 0.9DL-1.5EQX for time histroy method the storey drift is maximum for conventional RCC model compared to other model. Conventional RCC model has maximum value of 2.975mm where as for shear wall model at same storey drift is 0.215 that is the drift is reduced.

VII. CONCLUSION

The present work is focused on the seismic behaviour of building of ten storey situated in the seismic zone Ⅲ of Indian medium soil, associated with different damping materials. The time history analysis is performed for barkot earthquake data which was occurred in 1999.the performance of the building is studied for different seismic responses like time period, lateral displacement, shear wall and combination of both for ten storeys.

1. Considering the maximum modal period in RCC building is 1.85sec.The damper and shear wall model decreases the modal period to 0.924sec .Hence there is a reduction of 89.6%.

2. Base shear for the G+9 storey building with shear wall is increased up to 4284.16KN compared to the bare frame building the base shear is 1349.49KN.This increase in base shear is due to increase in the seismic weight of the building.

3. Considering the maximum displacement in RCC building is 42.594mm in X-direction. The damper and shear wall model decreases the displacement to 21.143mm.Hence there is a reduction of 78.54%.

4. Considering the maximum storey drift in RCC building is 2.975mm in X-direction. The shear wall model decreases the displacement to 0.215mm .Hence there is a reduction of 94.68%.

5. Finally seeing all the results of natural time period, base shear, storey displacement and storey drift values we can conclude that the shear wall model is better when compared with conventional RCC building other model. Hence in this project shear wall model is better and passes all the required criteria.

From the results of the study it can be concluded that the shear walls are effective in controlling the seismic response of the structure.

VIII. SCOPE OF FUTURE STUDY:

The further study can be undertaken in the following areas:

1. In the present study the work is carried out on zone Ⅲ for medium soil, further the study may also be undertaken by providing different zones and different oil conditions.

2. In the present study fixed base is considered for the structure; further study may also be undertaken by considering different kinds of supports.

3. The study may further carried out for different energy dissipation devices.

4. The study can be extended to various types of analysis such as response spectrum, push over analysis.

5. In the present work the fluid viscous dampers are located in corner and shear wall provided in centre of the building further study may be carried out to placing the dampers and shear wall in different location of the structures.

IX. REFERENCES

1. B. H. Maula, L. Zhang, "Assessment of embankment factor safety using two commercially available programs in slope stability analysis", Science Direct, 14(2011), pp. 559-566

2. Bharti, S. D. (2012). "Seismic Response Control of Asymmetric Plan Building with Semiactive MR Damper." 15th World Conference on Earthquake Engineering (15WCEE).

3. Chang, K. C., Lin, Y. Y., and Lai, M. L. (1998). "Seismic Design of Structures with Added Friction Dampers." Journal of Earthquake Technology.

4. Constantinou, M., Soong, T., and Dargush, G. (1998). Passive Energy Dissipation Systems for Structural Design and Retrofit. Multidisciplinary Center for Earthquake Engineering Research.

5. García, M., de la Llera, J. C., and Almazán, J. L. (2007). "Torsional balance of plan asymmetric structures with Friction dampers." Engineering Structures, 29

6. Goel, R. K. (1998). "Effects of Supplemental Viscous Damping on Seismic Response of Asymmetric-Plan Systems." Earthquake Engineering & Structural Dynamics, 27(August 1997), 125–141.

7. Hall, J. F., and Beck, J. L. (1986). "Hall and Damage in Mexico." Geophysical Research Letters, 13(6), 589–592.

8. Lin, W. H., and Chopra, A. K. (2001). "Understanding and predicting effects of supplemental viscous damping on seismic response of asymmetric one-storey systems." Earthquake Engineering and Structural Dynamics, 30(10), 1475–1494.

9. Lin, W. H., and Chopra, A. K. (2003a). "Asymmetric one-storey elastic systems with non-linear viscous and Friction dampers: Earthquake

response." Earthquake Engineering and Structural Dynamics, 32(4), 555–577.

10. Lin, W. H., and Chopra, A. K. (2003b). "Asymmetric one-storey elastic systems with non-linear viscous and Friction dampers: Earthquake response." Earthquake Engineering and Structural Dynamics, 32(4).