



# **iJRASET**

International Journal For Research in  
Applied Science and Engineering Technology



---

# **INTERNATIONAL JOURNAL FOR RESEARCH**

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

---

**Volume: 7      Issue: II      Month of publication: February**

**DOI: <http://doi.org/10.22214/ijraset.2019.2079>**

**[www.ijraset.com](http://www.ijraset.com)**

**Call: ☎ 08813907089**

**E-mail ID: [ijraset@gmail.com](mailto:ijraset@gmail.com)**

# Seismic Response of Structure with Fluid Viscous Damper (FVD)

Abhijeet Koshti<sup>1</sup>, Shridhar Shinde<sup>2</sup>, Kartikey Yamagar<sup>3</sup>, Sagar Shegunshi<sup>4</sup>

<sup>1</sup>Assistant Professor, Civil Engineering Department, Sanjay Ghodawat Institutions, Kolhapur

<sup>1</sup>B.E. Student, Civil Engineering Department, Sanjay Ghodawat Institutions, Kolhapur

<sup>2</sup>B.E. Student, Civil Engineering Department, Sanjay Ghodawat Institutions, Kolhapur

<sup>3</sup>B.E. Student, Civil Engineering Department, Sanjay Ghodawat Institutions, Kolhapur

**Abstract:** The seismic waves caused by an earthquake will make buildings sway and oscillate in various ways depending on the frequency and direction of ground motion, and the height and construction of the building. Seismic activity can cause excessive oscillations of the building which may lead to structural failure. The main task of a structure is to bear the lateral loads and transfer them to the foundation. Since the lateral loads imposed on a structure are dynamic in nature, they cause vibrations in the structure. To enhance the building's seismic performance, a proper building design is performed engaging various seismic vibration control technologies. Damping devices had been used in the aeronautics and automobile industries long before they were standard in mitigating seismic damage to buildings. In order to have earthquake resistant structures, fluid viscous dampers have been used. In present study software Etabs 2015 have been used. In this building is analysed and compare with and without FVD on the basis of base shear and story displacement.

**Keywords:** Fluid Viscous Damper, Etabs 2015, Damping, Base Shear, Story Displacement

## I. INTRODUCTION

### A. General

The dampers are huge concrete blocks or Steel bodies mounted in skyscraper or other structures, and moved in opposition to the resonance frequency oscillations of the structure by means of springs, fluid or pendulums. Sources of vibration and resonance. Unwanted vibration may be caused by environmental forces acting on a structure, such as wind or earthquake, or by a seemingly innocuous vibration source causing resonance that may be destructive, unpleasant or simply inconvenient. The Fluid Viscous Damper (FVD) is 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. Over the last fifty years, the earthquakes are categorized into two groups of near-field earthquakes and far-field earthquakes based on the distance of the place of recording the earthquake from the fault. Later, this definition was modified and other factors also influenced this categorization. Over the recent years, the research studies concentrated on the study of impacts of ground motion in the near-field earthquake on the structural performance. The devastative effects of the recent earthquakes such as Northridge earthquake (1994), Kobe earthquake (1995), and Taiwan earthquake (1999) on the buildings of the cities adjacent to fault, and with regard to the close location of many of the cities of India to the active faults indicate the significance of the research. In last few years, many essential developments in seismic codes are turned up. Due to the renewed knowledge of the existing buildings behavior, retrofit of buildings is a paramount task in reducing seismic risk. New techniques for protecting buildings against earthquake have been developed with the aim of improving their capacity. Seismic isolation and energy dissipation are widely recognized as effective protection techniques for reaching the performance objectives of modern codes.

### B. Objective

- 1) To compare seismic response of structure with and without FVD
- 2) To determine displacements variations in the structure due to introduction of FVD.
- 3) To find the reduction in base shear by using FVD in RC buildings.

### C. Overview of Software

Etabs is an engineering software product that caters to multi-story building analysis and design. Modelling tools and templates, code-based load prescriptions, analysis methods and solution techniques, all coordinate with the grid-like geometry unique to this class of structure. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. For a sophisticated assessment of seismic performance, modal and direct-integration time-history analyses may couple with P-Delta and

Large Displacement effects. Nonlinear links and concentrated PMM or fibre hinges may capture material nonlinearity under monotonic or hysteretic behaviour. Intuitive and integrated features make applications of any complexity practical to implement. Interoperability with a series of design and documentation platforms makes ETABS a coordinated and productive tool for designs which range from simple 2D frames to elaborate modern high-rises.

#### D. Fluid Viscous Damper

In the FVD, by using viscous fluid inside a cylinder, energy is dissipated. Due to ease of installation, adaptability and coordination with other members also diversity in their sizes, viscous dampers have many applications in designing and retrofitting. Fig 1 shows the components of FVD.

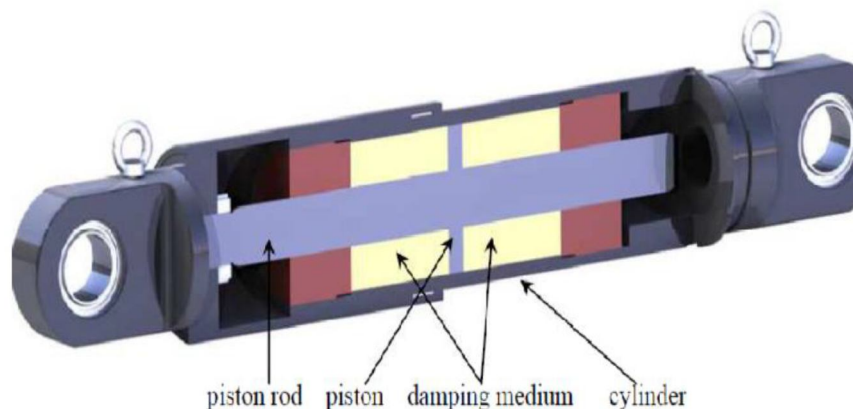


Fig. 1 Components of FVD

## II. LITERATURE REVIEW

Y. G. Zhao and T. Ono in 2001<sup>[1]</sup> mentioned about “Moment methods for structural reliability” in which they said, to perform an accurate analysis a structural engineer must determine such information as structural loads, geometry, support conditions, and materials properties. The results of such an analysis typically include support reactions, stresses and displacements. This information is then compared to criteria that indicate the conditions of failure. Advanced structural analysis may examine dynamic response, stability and non-linear behaviour.

V. Umachagi, K. Venkataramana,<sup>[2]</sup> G. R. Reddy, and R. Verma in “Applications of Dampers for Vibration Control of Structures: An overview” has briefly explained that Viscous dampers works based on fluid flow through orifices. Viscous damper is as shown in Fig.4 (Feng Qian et al., 2012) consisted viscous wall, piston with a number of small orifices, cover filled with a silicon or some liquid material like oil, through which the fluid pass from one side of the piston to the other. Stefano et al., 2010 have manufactured the viscous damper and it was implemented in 3 storey building structure for seismic control of structure with additional viscous damper. Attar et al., 2007 have proposed optimal viscous damper to reduce the interstory displacement of steel building.

S. Amir and H. Jiaxin<sup>[3]</sup> in “Optimum Parameter of a Viscous Damper for Seismic and Wind Vibration” found that in most structures, even a relative low damping can also provide a significant energy dissipation which considerably decreases the vibration of a structure. The description in that explains how a nonlinear characteristic is required for a damping system to optimize the vibration of a simple moment frame.

B. S. Taranath<sup>[4]</sup> in “Reinforced Concrete Design of Tall Buildings” explains that sophisticated nonlinear time history analysis is required for each of the earthquake ground motions, and the results of the simulations are compared against the performance criteria to ensure the design meets the desired level of safety. The analysis tools used to conduct these simulations have become commercially viable only in the last several years. It is believed that result of this sophisticated and rigorous approach yields a safe and reliable design.

Liya Mathew & C. Prabha<sup>[5]</sup> in 2014 published “Effect of Fluid Viscous Dampers in Multi-Storeyed Buildings” in which they mentioned that Special protective systems have been developed to enhance safety and reduce damage of structures during earthquakes. Fluid viscous damper (FVD) comes into prominence here. That paper also deals with the study of reinforced concrete buildings with and without fluid viscous dampers. A parametric study for finding optimum damper properties for the reinforced concrete frames was conducted. Nonlinear time history analysis is done on a symmetrical square building. Pushover Analysis has been carried out using software and comparisons are presented in graphical format



### III.METHODOLOGY

#### A. General

The study in this thesis is based on linear and nonlinear analysis of RC structures with different areas of building and variable cross section of column. This chapter presents a summary of various parameters defining the computational models, the basic assumptions and the RCC frames geometry considered for this study. Accurate modelling of the nonlinear properties of various structural elements is very important in nonlinear analysis.

#### B. Material Properties

M25 grade of concrete and Fe 500 grade of Steel are used for all slabs and beams and columns. Elastic material properties of these materials are taken as per IS 456-2000.

#### C. Structural Elements

For this we consider the G+11 building. The different structural elements considered are columns, beams and slabs with variable sections are mentioned below.

- 1) Column Sizes – 350 mm x 600 mm
- a) Beam Size – 230 mm x 450 mm
- b) Slab Sizes – 1. Panel Area – 6 m x 6 m
2. Thickness – 150 mm

#### D. Loads

While applying the loads to the structure we consider only the external loads which are actually acting on the members neglecting its self-weight because ETABS 2015 automatically takes the members self-weight. Other loads are listed below.

- 1) Live Load on Floor = 3 KN/m<sup>2</sup>
- 2) Live Load on Terrace = 1.5 KN/m<sup>2</sup>
- 3) Dead load = 1.5kN/m<sup>2</sup>
- 4) The Frame loads applied uniformly on the beams as Dead=5.25kN/m<sup>2</sup>
- 5) The Seismic loads EQ-x and EQ-y are given in Load patterns directly using Code IS1893:2002.
- 6) The Wind loads wind-x and wind-y are given using Code IS875:1987.

Fig. 2 and Fig. 3 shows the load patterns and seismic loads in etabs 2015.

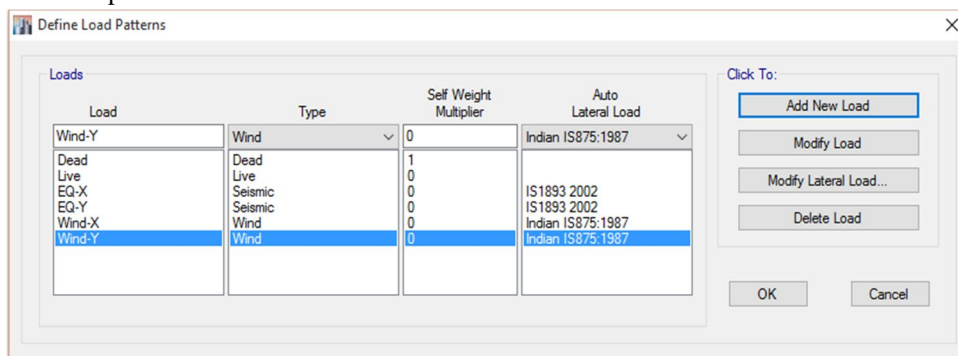


Fig. 2 Load Patterns

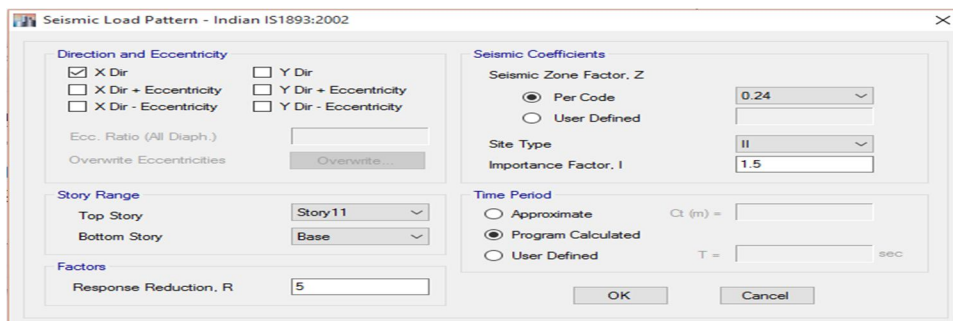


Fig. 3 Seismic Load Patterns

#### E. Modelling of structure on Etabs 2015

The analysis of the structure is held in etabs ia as follows,

- 1) Modelling
- 2) Static analysis
- 3) Design
- 4) Time History analysis

Fig. 4 shows the geometry of the G+11 Structure without FVD.

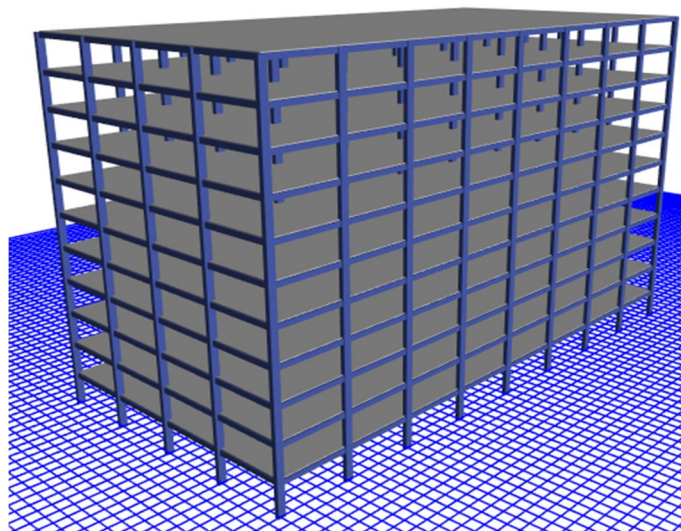
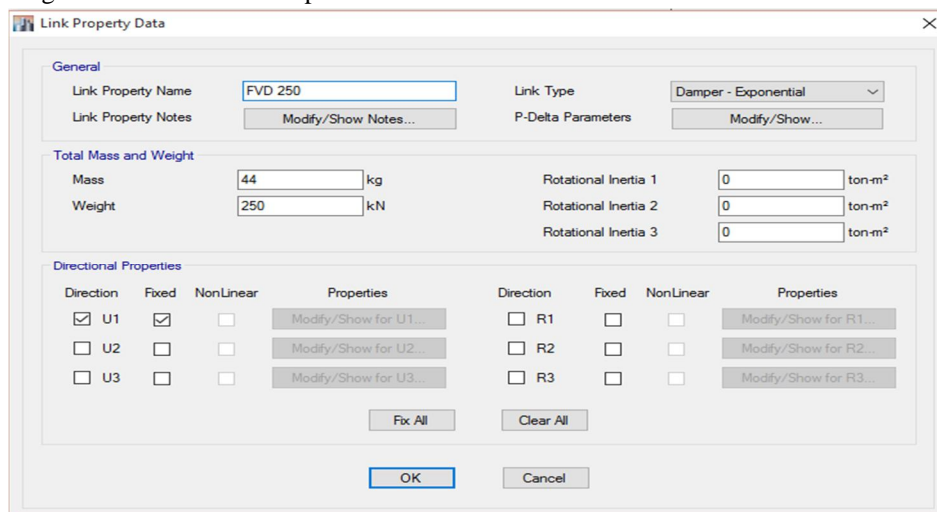


Fig. 4 Modell of G+11 building without damper

#### F. Modelling of Fluid Viscous Damper on Etabs 2015

Fluid viscous dampers with different forces can be used for different types of buildings, since structure modelled is of low height; smaller devices were used to start analysis. FVD is added to structure after defining in Link properties by adding a new Damper-Exponential in Link Property Data. ETABS MENU=> Define=> Link Properties=> Add new Link=> Link Property Data. Since FVD 250 is linear it is used for direction U1 with fixed end properties. The Mass is 44kg and Weight is 250kN to be mentioned in Total Mass and Weight. Then press OK to add and OK once more to close the tab. Now this damper can be added by draw link option and selecting the FVD 250 damper property across the floor beams ends diagonally; starting from top end to bottom end; Keeping the structure in elevation view for more accuracy. Fig. 5 shows the link property data given in the Etabs and fig. 6 shows the model of G+11 building with fluid viscous damper.



General			
Link Property Name		FVD 250	
Link Property Notes		Modify/Show Notes...	
Link Type		Damper - Exponential	
P-Delta Parameters		Modify/Show...	
Total Mass and Weight			
Mass	44	kg	
Weight	250	kN	
Rotational Inertia 1		0	ton-m <sup>2</sup>
Rotational Inertia 2		0	ton-m <sup>2</sup>
Rotational Inertia 3		0	ton-m <sup>2</sup>
Directional Properties			
Direction	Fixed	NonLinear	Properties
<input checked="" type="checkbox"/> U1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Modify/Show for U1...
<input type="checkbox"/> U2	<input type="checkbox"/>	<input type="checkbox"/>	Modify/Show for U2...
<input type="checkbox"/> U3	<input type="checkbox"/>	<input type="checkbox"/>	Modify/Show for U3...
Fix All		Clear All	
OK		Cancel	

Fig. 4 Link Property data for Fluid viscous damper

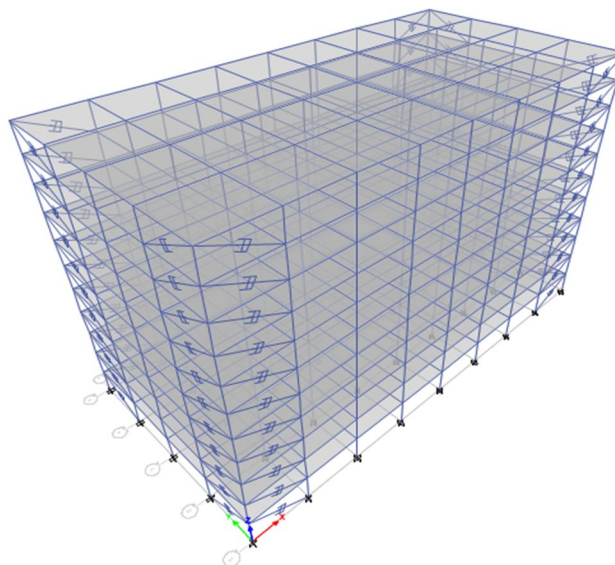


Fig. 5 model of G+11 building with fluid viscous damper

#### IV.RESULTS

##### A. Displacement

Etabs provides a simple table in the summary output with "Story Maximum and Average Lateral Displacements". The Maximum Displacements due to TH-X in X-direction are in table 1.

Table 1 Max. Disp. of Modals at different stories due to TH-X

Story	Displacement in X-direction	
	Without Damper	With FVD
Story 11	89.231	35.686
Story 10	85.428	31.116
Story 9	80.095	26.533
Story 8	73.138	21.985
Story 7	64.738	17.547
Story 6	55.176	13.319
Story 5	44.768	9.419
Story 4	33.857	5.984
Story 3	22.876	3.162
Story 2	12.49	1.111
Story 1	3.965	0
Base	0	0

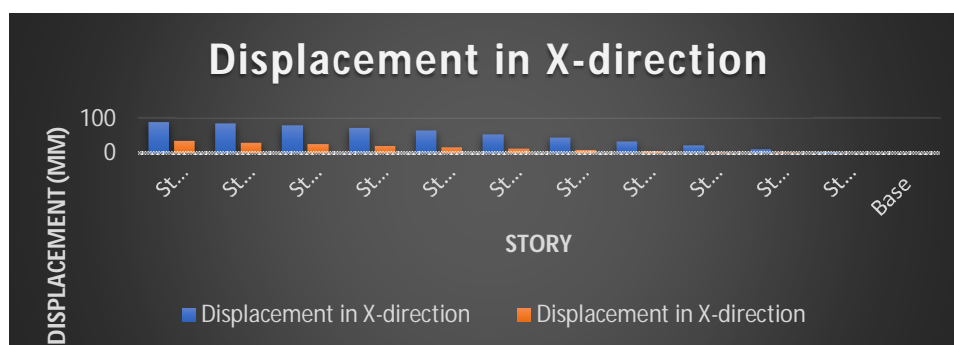


Fig 6 Graph for displacement in X-dir. With and without FVD

The Maximum Displacements due to TH-Y in Y-direction are in table 2 as follows

Table 2 Max. Disp. of Modals at different stories due to TH-Y

Story	Displacement in Y-direction	
	Without Damper	With FVD
Story 11	112.481	36.644
Story 10	108.64	31.916
Story 9	102.493	27.184
Story 8	94.132	22.497
Story 7	83.929	17.934
Story 6	72.288	13.595
Story 5	59.586	9.603
Story 4	46.166	6.094
Story 3	32.375	3.216
Story 2	18.733	1.129
Story 1	6.525	0
Base	0	0

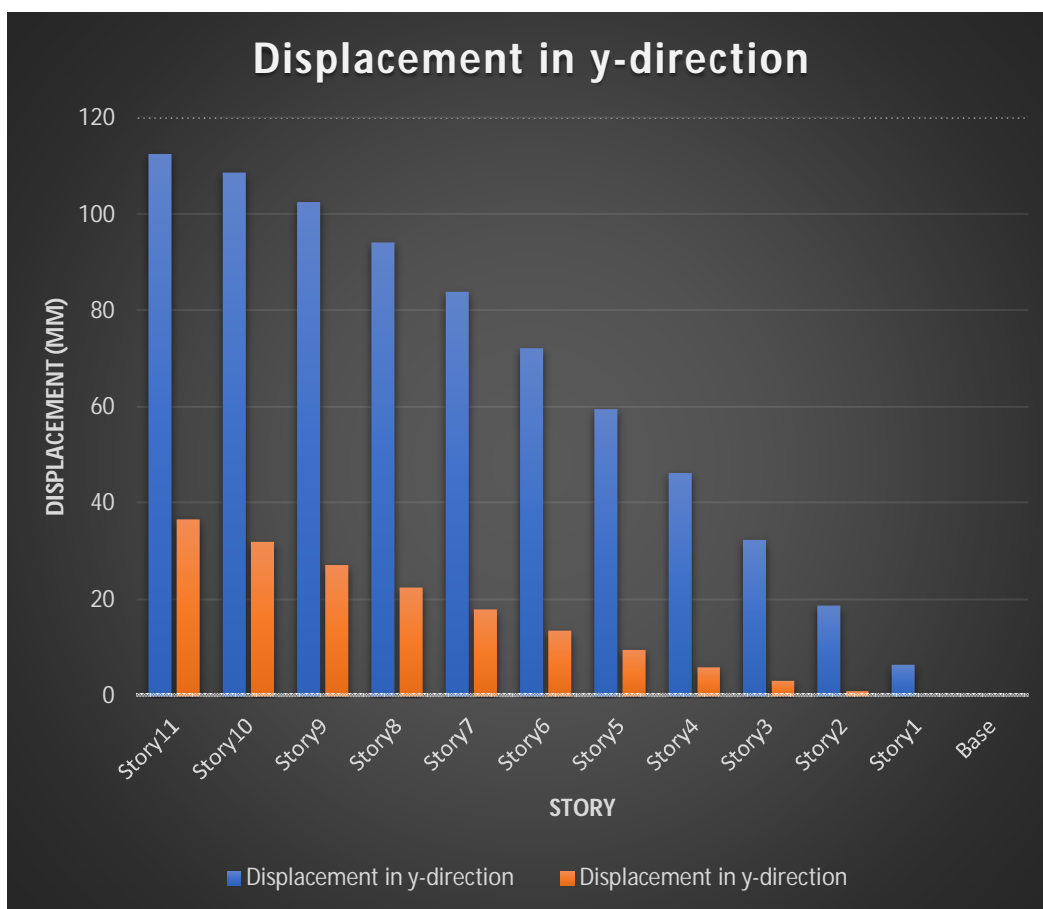


Fig 7 Graph for displacement in Y-dir. With and without FVD

Load Cases/Combo	FX (KN)	FY (KN)	FZ (KN)	MX (KN-m)	MY (KN-m)	MZ (KN-m)
Dead	0	0	119897.0762	1438765	-2877530	0
Live	0	0	34296.6342	411559.6101	-823119	0
EQ X	425.4336	0	0	0	52237.7394	-5105.2034
EQ Y	0	146.6225	0	10474.5688	0	3518.9397
Wind X 1	133.6514	0	0	0	16646.9761	-1603.8163
Wind X 2	-133.6514	0	0	0	-16646.9761	1603.8163
Wind Y 1	0	93.9346	0	5817.5937	0	2254.4312
Wind Y 2	0	-93.9346	0	-5817.5937	0	-2254.4312
TH X Max	361.4948	0	0.1944	2.1651	0	507522.1779
TH X Min	-42293.516	-0.0003	0	0	-5571113	-4337.9372
TH Y Max	0	401.8972	0.0364	665.2813	0.2378	9645.5332
TH Y Min	-0.0023	-14968.6579	0	-1013976	-2.9509	-359248

### B. Base Shear

Following are the results of base shear shown in table 3 and table 4 for building without and with FVD respectively.

Table 3 Base reaction of building without damper

Load Cases/Combo	FX (KN)	FY (KN)	FZ (KN)	MX (KN-m)	MY (KN-m)	MZ (KN-m)
Dead	0	0	112575.563	1350907	-2701814	0
Live	0	0	36288	435456	-870912	0
EQ X	-1544.3394	0	0	0	-39693.3116	18532.0722
EQ Y	0	-1484.6299	0	38158.6322	0	-35631.1176
Wind X 1	-1578.7366	0	0	0	-28527.1945	18944.8391
Wind X 2	1578.7366	0	0	0	28527.1945	-18944.8391
Wind Y 1	0	-3157.4732	0	57054.389	0	-75779.3564
Wind Y 2	0	3157.4732	0	-57054.389	0	75779.3564
TH X Max	1312.6221	0.0002	0.0006	0.0042	23495.4939	-3.2786
TH X Min	0.2732	-0.00002366	-0.0009	-0.0126	0	-15751.4651
TH Y Max	0.0001	1345.6639	0.0001	0	0.007	32295.9337
TH Y Min	0	0.2732	-0.0008	-23748.1385	-0.0288	6.5573

Table 4 Base Reaction of building with Fluid Viscous damper

Fig. 8 shows the graph of story shear of building with and without fluid viscous damper obtained from time history analysis.

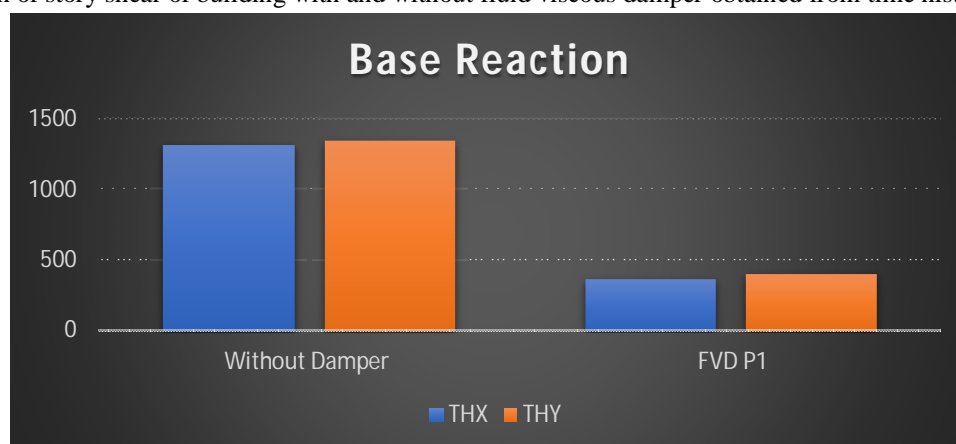


Fig 8 Graph for Base Reaction With and without FVD



## V. CONCLUSION

- A. From above research work it is observed that the top story has maximum displacement of 89.23 mm and 112.48 mm in X and Y directions respectively when we not use fluid viscous damper, but after the introduction of damper in building there is decrease in story displacement by 35.68 mm and 36.64 mm in X and Y directions respectively. When FVD applied to structure the story displacement minimized by 75%-80%.
- B. Fluid viscous damper reduces the base shear by 65%-70% from that of building without damper.
- C. Overall when we applied the fluid viscous damper to structure there is reduction in base shear and displacement which makes structure earthquake resistance.

## REFERENCES

- [1] Y. G. Zhao and T. Ono, "Moment methods for structural reliability," *Struct. Saf.*, vol. 23, no. 1, pp. 47–75, 2001.
- [2] V. Umachagi, K. Venkataramana, G. R. Reddy, and R. Verma, "Applications of Dampers for Vibration Control of Structures : an Overview," *Int. J. Res. Eng. Technol.*, pp. 6–11, 2013.
- [3] S. Amir and H. Jiaxin, "Optimum Parameter of a Viscous Damper for Seismic and Wind Vibration," vol. 8, no. 2, pp. 192–196, 2014.
- [4] B. S. Taranath, *Reinforced Concrete Design of Tall Buildings*.
- [5] Liya Mathew & C. Prabha, "Effect of Fluid Viscous Dampers in Multi-Storeyed Buildings," *IMPACT Int. J. Res. Eng. Technol. (IMPACT IJRET)*, vol. 2, no. 9, pp. 59–64, 2014.
- [6] IS 1893:2002 (Part 1): Criteria for Earthquake Resistant Design of Structures, Part 1: General Provisions and Buildings (Fifth Revision).
- [7] IS: 875-1987 (part-1) for Dead Loads, code of practice of Design loads (other than earthquake) for buildings and structures.
- [8] IS: 875-1987 (part-2) for Live Loads or Imposed Loads, code of practice of Design loads (other than earthquake) for buildings and structures.
- [9] IS: 875-1987 (part-3) for Wind Loads, code of practice of Design loads (other than earthquake) for buildings and structures



10.22214/IJRASET



45.98



IMPACT FACTOR:  
7.129



IMPACT FACTOR:  
7.429



# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089  (24\*7 Support on Whatsapp)