Comparetive Study of 25 Storey RCC Building With Exponential (Viscous), Bilinear (Tuned Mass) And Friction Damper At Different Storey

Mohammad Ahmad[1], Tabish Izhar[2]
[1, 2] Department of Civil Engineering
[1, 2] Integral University Lucknow, Utter Pradesh, India

Abstract- *Energy induced by strong earthquakes affects the structure. The seismic performance as well as response of the structure will be substantially improved if this energy is dissipated in a manner independent of structural components. Time history analysis of 25 storey RCC building which will be used as commercial building; typical floor area 270 sq meters was performed. The structure is modelled using the finite element program ETABS and is analyzed by dynamic analysis.*

The building is situated in earthquake zone V. Use of passive dampers for improvement of seismic performance and enhancing design of new structures has increased in recent years. The main objective of the study is to assess the improvement in response of structure achieved through use of the Exponential (viscous), Bilinear (tuned mass) and Friction damper devices.

Keywords- Dynamic Analysis. Seismic performance, viscous damper, tuned mass damper and friction damper.

I. INTRODUCTION

With the rapid economic development and advanced technology, civil structures such as high- rise buildings, towers and long span bridges are designed with an additional flexibility, which lead to an increase in their susceptibility to external excitation. Therefore, these flexible structures are susceptible to be exposed to excessive levels of vibration under the actions of a strong wind or earthquake. To protect such civil structures from significant damage, the response reduction of civil structures during dynamic loads such as severe earthquakes and strong winds has become an important topic in structural engineering. An earthquake is a natural phenomenon associated with violent shaking of the ground.

Fluid viscous damping

This is a way to add energy dissipation to the lateral system of a building structure. A fluid viscous damper dissipates energy by pushing fluid through an orifice, producing a damping pressure which creates a force. These damping forces are 90 degrees out of phase with the displacement driven forces in the structure. This means that the damping force does not significantly increase the seismic loads for a comparable degree of structural deformation and deflection The addition of fluid viscous dampers to a structure can provide damping as high as 30% of critical, and sometimes even more. This provides a significant decrease in earthquake excitation. The addition of fluid dampers to a structure can reduce horizontal floor accelerations and lateral deformations by 50% and sometimes more. Using supplemental fluid viscous dampers to dissipate energy and reduce building response to dynamic inputs is gaining worldwide acceptance. The concept of supplemental dampers added to a structure is that they absorb much of the energy input to the structure from a transient, not by the structure itself, but rather by supplemental damping elements.

This paper presents an application of fluid viscous dampers in a high -rise structure to suppress the anticipated wind induced accelerations. The description of the damping system, the design criteria and cost data are discussed.

The viscous damper system proves to be a very cost-effective method to reduce wind motions and resist seismic lateral loads and deflections of structures. The Fluid Viscous Damper is an equipment protecting structure from damage in earthquake or strong wind.

Tuned Mass Damper (TMD)

This has been found to be most effective for controlling the structural responses for harmonic and wind excitations. In the present paper, the effectiveness of TMD in controlling the seismic response of structures and the influence of various ground motion parameters on the seismic effectiveness of TMD have been investigated. TMD is a viscous spring-mass unit, when attached to a vibrating main structure, provides a frequency dependant hystersis that increases the damping in the structure. The efficiency of TMD for controlling structural response is sensitive to its parameters i.e. mass, frequency, and damping ratio. TMD acts as a secondary vibrating system when

connected to primary vibrating system. When TMD is tuned to frequency close to natural frequency of structure, vibration of structure makes TMD to vibrate in resonance, dissipating maximum vibration energy through damping in damper and also due to relative movement of damper with respect to the structure. The main advantages of TMD are, they are inherently stable and guaranteed to work even during major earthquakes. In addition TMD is attractive as it dissipates a substantial amount of vibration energy of main structure without requiring any connection to ground.

Friction damper

Friction damper is functioned according to friction mechanism among rigid materials. In fact, friction is a great mechanism of energy dissipation, employed in car brake systems successfully and extensively. A base metal selection of friction damper is of high importance. Since, there are different materials employed for slippery surfaces. A new friction damper device was employed for the first time by Mualla. Full scale experiments for three stories structure equipped with such damper on shaking table was done in Taiwan. In order to increase the seismic capacity of existing structures, it is possible to use the friction damping system connected to high strength tendons

Seismic Protection Systems

There are several types of seismic protection that, when included in a structure, improve the seismic behaviour (Guerreiro, 2008), classified as active or passive protection systems depending on whether or not it is necessary to provide energy for its operation. The most commonly used are the passive protection systems, due to its simplicity and proven effectiveness (Guerreiro, 2008), such as base isolation and the use of devices for energy dissipation.

Energy Dissipation Systems

The energy dissipation systems are devices specially designed and tested to dissipate large quantities of energy. The most common energy dissipation systems are the viscous ones (force proportional to the velocity of deformation) and the hysteretic (force proportional to displacement), however there are also the visco-elastic.

II. OBJECTIVES

1. The main objective is to perform analytical analysis of R.C.C tall building with three different types of Damper of the structure using ETABS software.

a) Exponential (Viscous Damper)
b) Bilinear (Tuned Mass Damper)
c) Friction Damper

2. To determine the efficiency of each Damper at different floors by comparing following parameters at different storey.

a) Drift
b) Displacement
c) Shear Forces

III. EXISTING RESEARCH

Viscous dampers themselves are old technology, dating back to more than a century ago to full-scale usage on US large Caliber military cannons in the 1860s. This technology was not available for the public disclosure or usage until the Cold War ended. In 1990, Taylor Devices received the permission to sell this technology to the public. Despite the long history and well-established usage of viscous damper, it is still a relatively new building technology yet to be further developed and studied.

Studies have been published regarding viscous dampers design methodology. Constantinou and Symans proposed a simplified method for calculating the modal characteristics of structures with added fluid dampers. The method was used to obtain estimates of peak response of the tested structures by utilizing the response spectrum approach. Gluck et al. Suggested a design method for supplemental dampers in multi-story structures, adapting the optimal control theory by using a linear quadratic regulator (LQR) to design linear passive viscous (VS) or viscoelastic (VE) devices depending on their deformation and velocity. Fu and Kasai compared frames dynamic behavior using VE or pure VS dampers, where identical mathematical expressions were derived in terms of two fundamental non dimensional parameters.

IV. MODELLING OF STRUCTURE

Building analyzed is a twenty five story, 75 meter high commercial building made up of RCC structure with plan dimension as 18m X 15m meter located in Mumbai with a gross area of 270 sq. meters. The columns are placed on grid of 3 meters in X direction as well as in Y direction. The building was designed as per IS code.

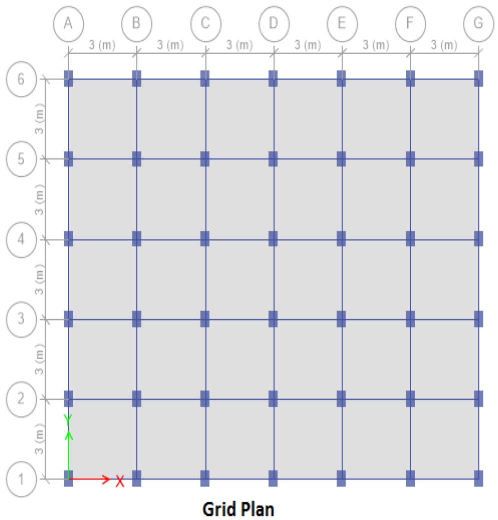

Figure 1. Plan view of building model ETABS

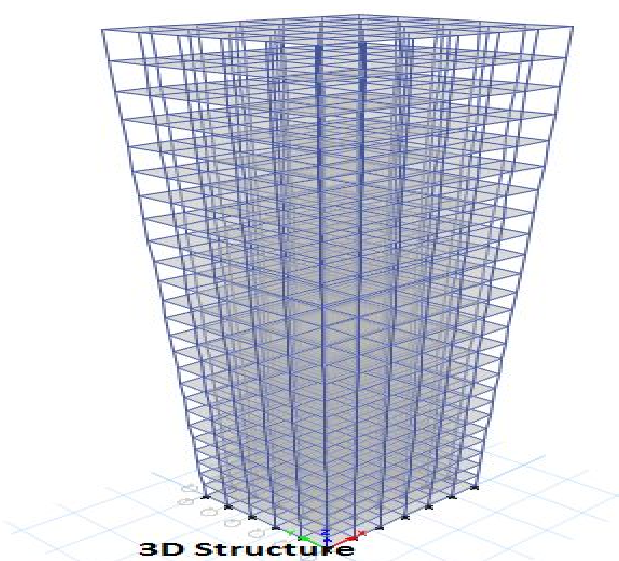

Figure 2. 3D view of building model in ETABS

ETABS (Non linear version)

ETABS is structural program for analysis and design of civil structures. It offers an intuitive yet powerful user interface with many tools to aid in the quick and accurate construction of models, along with the sophisticated analytical techniques needed to do the most complex projects, so in the present study three dimensional analyses with the help of ETABS 9.7 (Non-linear version) is used for modelling and analysis of the structure.

Table 1. BUILDING DETAILS

Dimension of beams Beam 1 Beam 2 Beam 3	 450*300 mm 300*250 mm 250*250 mm
Dimension of column	400*300 mm
Thickness of slab	125 mm
Load of wall	13.11 kn/m
Height of each storey	3 m
Live load On floor On roof	 4kn/m^2 1.5kn/m^2
Grade of reinforcing steel	Fe 415
Grade of concrete	M 30
Seismic Intensity	Very sever
Importance factor	1
Zone factor	0.36
Damping ratio	5%
Wind speed	50 m/s
Terrain category	2
Structure class	B

IV. RESULTS AND DISCUSSIONS

STOREY DISPLACEMENT WITHOUT DAMPERS

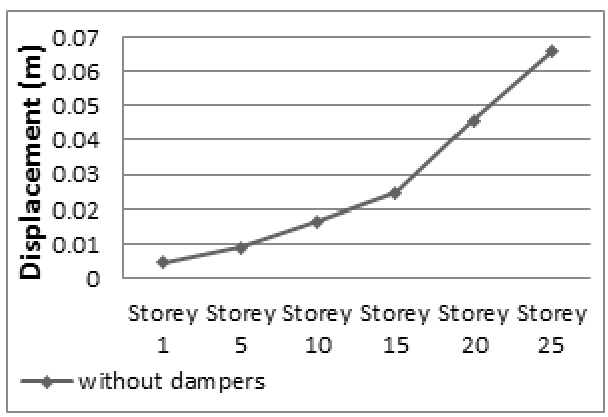

Figure 3. displacement of building by using without dampers

STOREY DISPLACENT WITH DAMPERS AT 25 STOREY

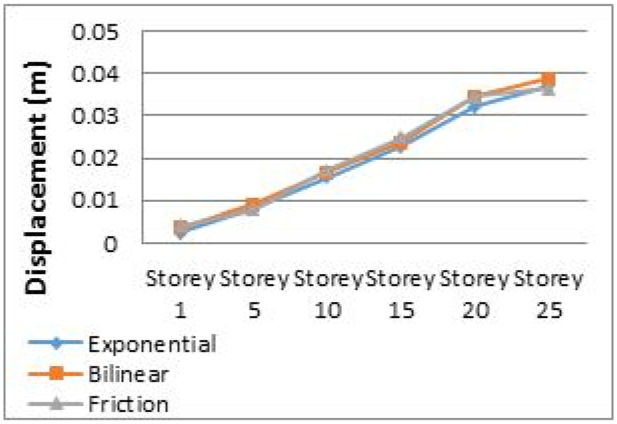

Figure 4. displacement of building by using dampers

This figure 4 shown that displacement value of Bilinear damper is more than other damper at storey 25 and approximately is same in remaining storeys.

STOREY DISPLACENT WITH DAMPERS AT 20 STOREY

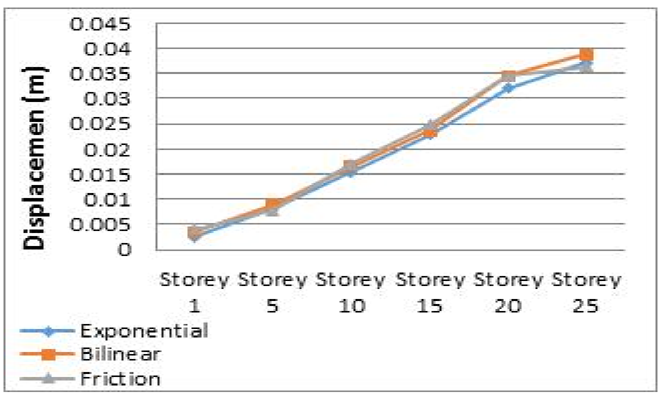

Figure 5 displacement of building by using dampers

The figure 5 shown that displacement at storey 25 is approximately same as others damper is placed at storey 20 .

STOREY DISPLACENT WITH DAMPERS AT 15 STOREY

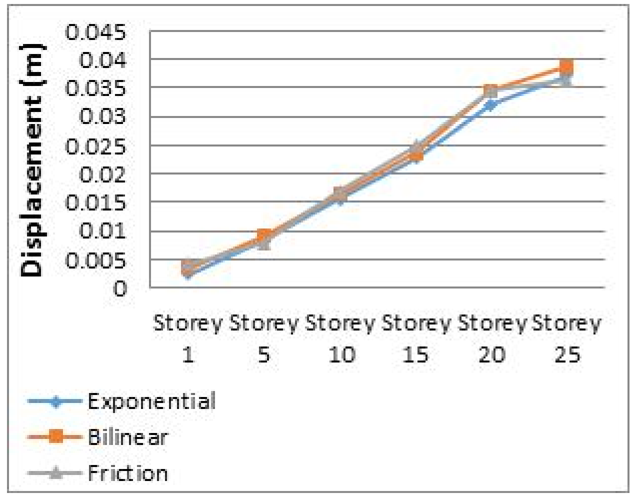

Figure 6. displacement of building by using dampers

The figure shown that displacement at storey 25 is approximately same as others damper is placed at storey 15. Displacement is less with exponential damper.

STOREY DISPLACENT WITH DAMPERS AT 10 STOREY

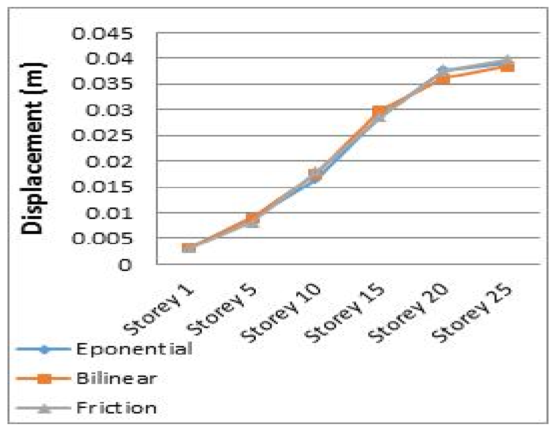

Figure 7. displacement of building by using dampers

The figure 7 shown that displacement at storey 10 with Friction damper is higher than bilinear damper and slightly down on going to bottom storey.

STOREY DISPLACENT WITH DAMPERS AT 5 STOREY

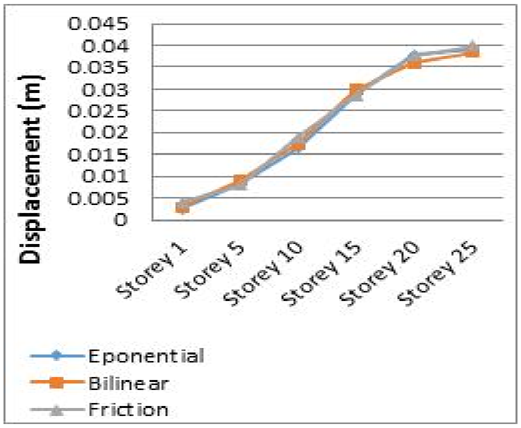

Figure 8. displacement of building by using dampers

The figure shown that displacement at storey 25 is approximately same as others damper is placed at 5 storey. Displacement is less with bilinear damper.

STOREY DISPLACENT WITH DAMPERS AT 1 STOREY

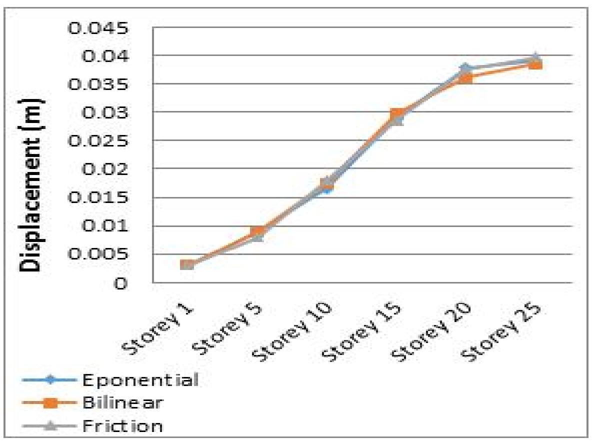

Figure 9. displacement of building by using dampers

The figure 9 shown that displacement at 25 storey is approximately same as others damper is placed at 1st storey. Displacement is less with Bilinear damper.

STOREY DRIFT WITHOUT DAMPERS

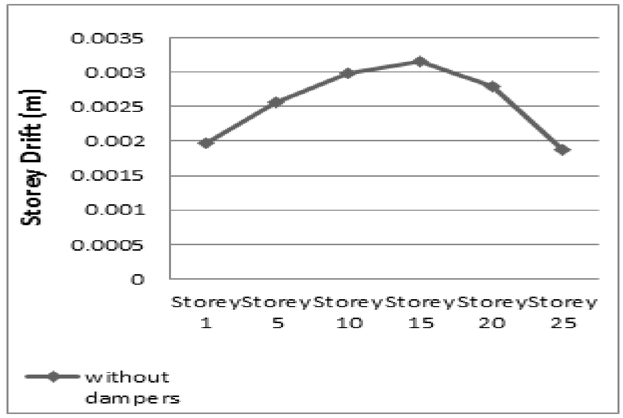

Figure 10. Storey Drift by using without dampers

STOREY DRIFT WITH DAMPERS AT 25 STOREY

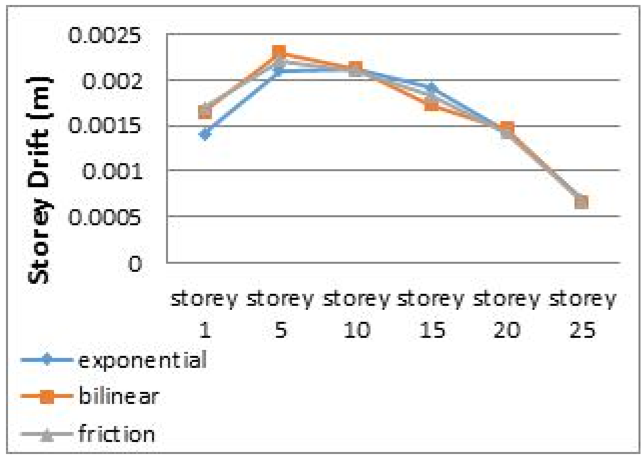

Figure 11. Storey Drift by using dampers

The figure 11 show that when damper is placed at storey 25 the storey drift is maximum at storey 5 in Bilinear damper in comparison of other damper.

STOREY DRIFT WITH DAMPERS AT 20 STOREY

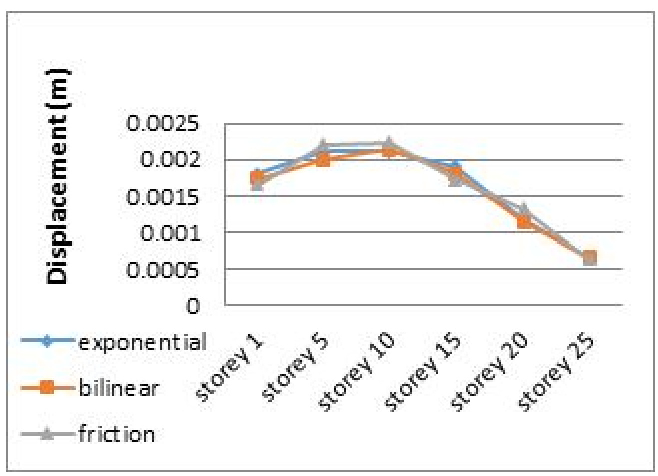

Figure 12. Storey Drift by using dampers

The figure 12 show that when damper is placed at storey 20 the storey drift is maximum at storey 10 in Friction damper and same as in remaining damper.

STOREY DRIFT WITH DAMPERS AT 15 STOREY

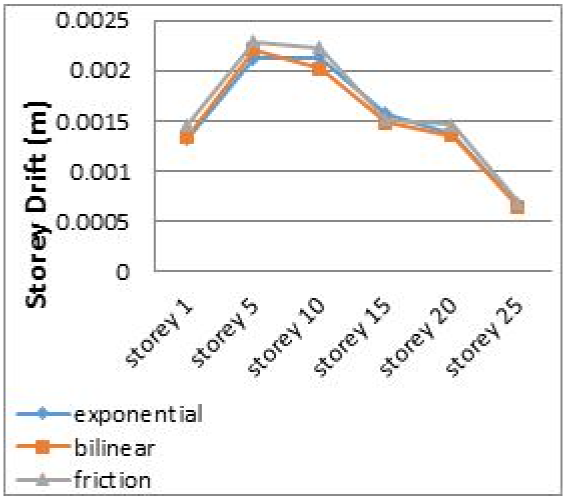

Figure 13. Storey Drift by using dampers

The figure shown that Drift is maximum at storey 5 with bilinear damper is approximately same as others damper is placed at storey 25.

STOREY DRIFT WITH DAMPERS AT 10 STOREY

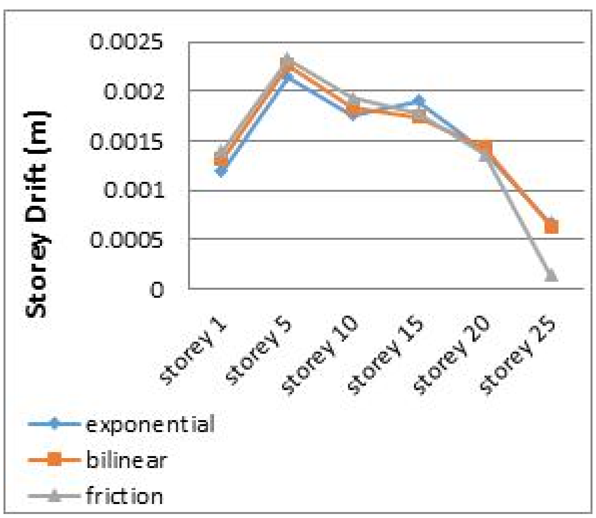

Figure 14. Storey Drift by using dampers

The figure shown that drift at storey 5 is approximately same as others damper is placed at storey 10.

STORY DRIFT WITH DAMPERS AT 5 STOREY

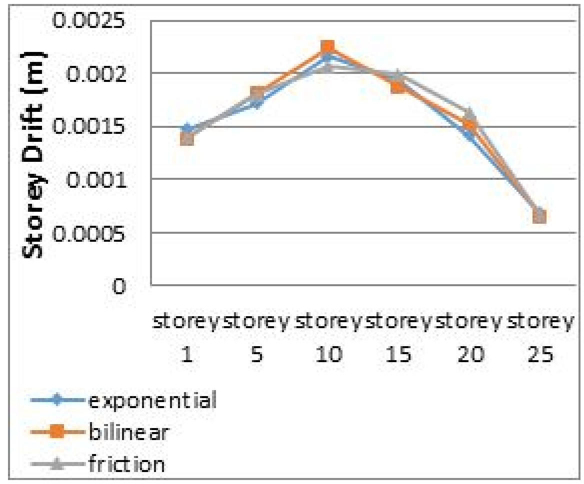

Figure 15. Storey Drift by using dampers

The figure shown that drift at storey 12 is maximum with bilinear damper and other damper gives the drift maximum at storey 12 when damper is placed at storey 5.

STOREY DRIFT WITH DAMPERS AT 1 STOREY

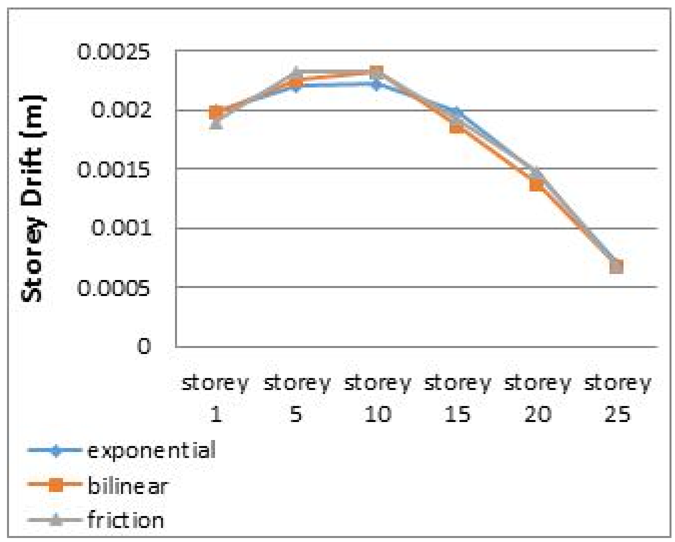

Figure16. Storey Drift by using dampers

The figure shown that drift at storey 10 is approximately same as others damper is placed at storey 1.

STOREY FORCES WITHOUT DAMPERS

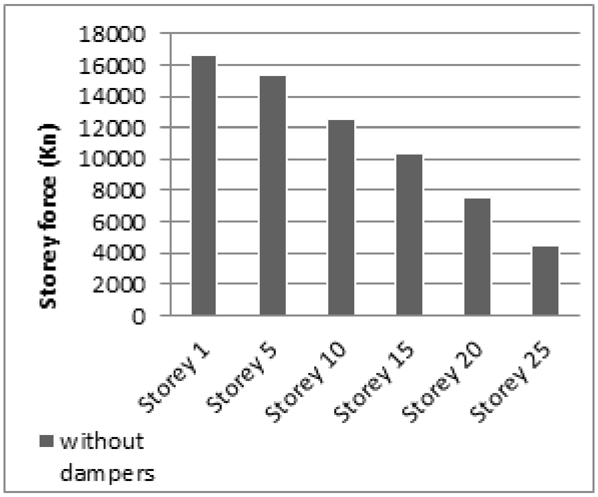

Figure17. Storey Drift by using without dampers

STOREY FORCES WITH DAMPERS AT 25 STOREY

Figure 18. Storey Forces by using dampers

In this figure shows that the storey forces is maximum in storey 1 and dampers is shown approximate same values but exponential damper have lower value than bilinear damper so we can say that exponential damper is quite good in storey forces.

STOREY FORCES WITH DAMPERS AT 20 STOREY

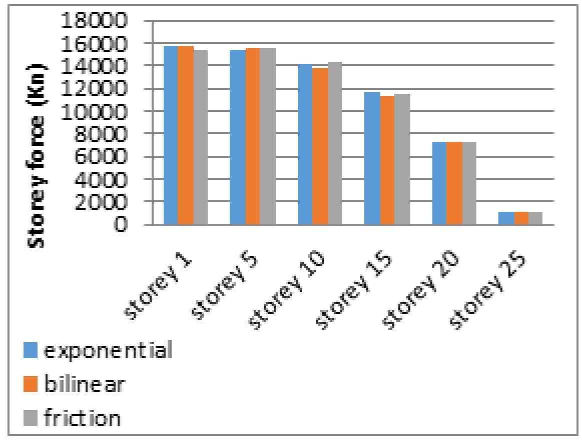

Figure 19. Storey Forces by using dampers

In this figure shows that the storey forces with friction damper is less as compared to other dampers.

STOREY FORCES WITH DAMPERS AT 15 STOREY

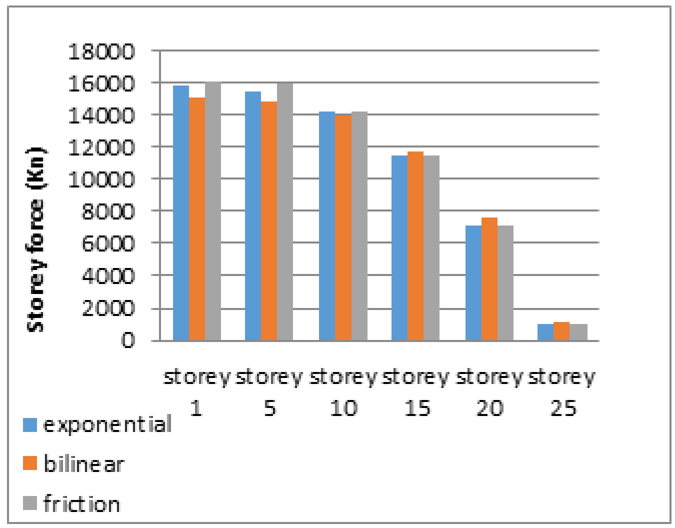

Figure 20. Storey Forces by using dampers

In this figure shows that the storey forces with bilinear damper at storey 1 is minimum as compared to other damper is placed.

STOREY FORCES WITH DAMPERS AT 10 STOREY

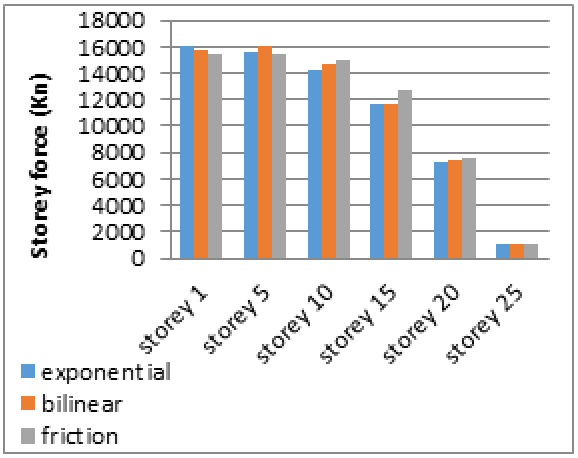

Figure 21. Storey Forces by using dampers

In this figure shows that the storey forces is maximum in storey 1 and dampers is shown approximate same values but exponential damper have lower value than bilinear damper so we can say that exponential damper is quite good in storey forces.

STOREY FORCES WITH DAMPERS AT 5 STOREY

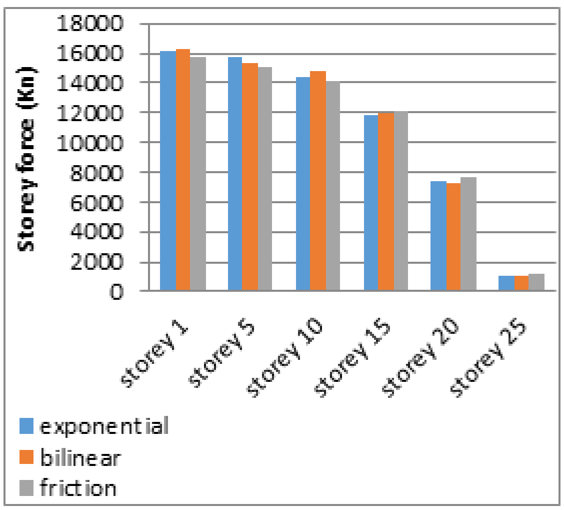

Figure 22. Storey Forces by using dampers

In this figure shows that the storey forces with friction damper is minimum at storey 1 as compared to other damper.

STOREY FORCES WITH DAMPERS AT 1 STOREY

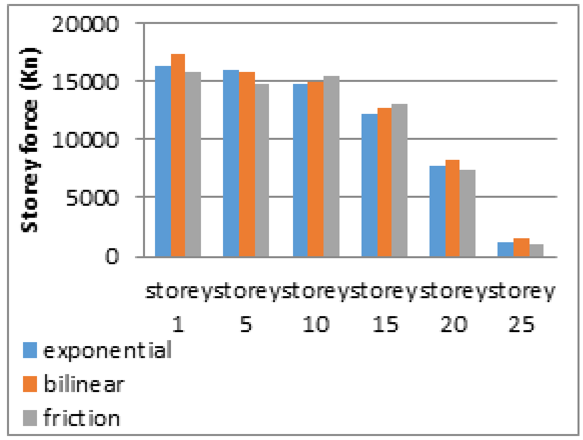

Figure 23. Storey Forces by using dampers

In this figure shows that the storey forces with friction damper is minimum at storey 1 as compared to other damper.

VI. CONCLUSION

According to results, the storey forces was found to be maximum for the first storey and it decreased to a minimum in the top storey in all cases and in comparison of three dampers the friction dampers attained the less storey forces. Large drift was observed in the middle of regular building and in comparison of three dampers the bilinear damper gives the minimum drift and slightly same as viscous damper. In comparison of three dampers the displacement is less with Bilinear damper and also a Friction damper. Hence we said Bilinear and Friction damper is suitable for the deflection of building. It is observed that the storey drift for all the stories are found to be within the permissible limits.

REFERENCES

[1] K.C. Chang, Y.Y. Lin and M.L. Lai, Seismic Analysis and Design of Structures with Viscoelastic Dampers Journal of Earthquake Technology(ISET) , Paper No.380, Vol. 35, No4, December 1988.

[2] Mohan M. Murudi and Sharadchandra M. Mane, Seismic Effectiveness of Tunned Mass Damper (TMD) For Different Ground Parameters, 13th World Conference on Earthquake Engineering, canada August1-6,2004 paper no. 2325.

[3] A.V. Bhaskararao and R.S. Jangid, Seismic analysis of structures connected with friction dampers, International Journal of Research in Engineering and Technology , 2319-1163, 2009

[4] Kambiz Esteki, Ashutosh Bagchi and Ramin Sedaghati,

Semi Active Tuned Mass Damper for Seismic Applications, International Research (IRJET) ISSN: 2395-0056, 2011

[5] Nitendra G. Mhajan and D B Raijiwala, Seismic Response Control of a Building installed with passive Dampers, International journal of Advanced Engineering Technology IJAET/vol..II/Issue III/ july- september, 2011/246-256, E-ISSN 0976-3945

[6] F. Khoshnoudian, A. Molavi-Tabrizi, Response of a isolated Buildings with MR Dampers, International journal of civil engineering ,vol. 10, No. 3, September 2012.

[7] K.Krishne Gowda and K.K Kiran, Earthquake resistance of structure using dampers, International jounal of Advanced Structure and Geotechnical Engineering ISSN 2319-5347, vol. 02, No. 01, January 2013.

[8] Prashanthi C. Sudula and B. Shivakumara Swamy, Comparative Study on Seismic Behavior of Multistoreyed Frames With Different Passive Dampers for Different Zones, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 3 Issue 7, July – 2014

[9] Sachin Kuckian, Mohammed Parvez, Avinash AR and Kiran Kamath, A Study on Seismic Response of Reinforced Structures Retrofitted with Fluid Viscous Dampers in Shear Walls, International Journal of Earth Sciences and Engineering ISSN 0974-5904, Volume 08, No. 02, April 2015

[10] Anita Tippanagoudar, J.G Kori and D.K Kulkarni, Performance Analysis of High Rise Building with Viscous Damper, International journal of Advanced Technology & Research (IJATER) ISSN No:2250-3536 Volume 5, Issue 4, July 2015

[11] Mahesh N. Patil and Yogesh N. Sonawane, Seismic Analysis of multi-storeyed building, International Journal of Engineering and Innovative Technology (IJEIT) volume 4, issue 9, march 2015

[12] U.P Vijay, P.R. Kannan Rajkumar and P.T. Ravichandran, Seismic Response control of RC Structure using Viscoelastic Dampers., Indian journal of Science and Technology, Vol 8(28), ISSN: 0974-5645, October 2015

[13] Aleksandra Bogdanovic, Zoran T. Rakicevic and Dejan Filipovski, Effectiveness of Viscous Dampers for Structure subjected to large Earthquake, International journal of Engineering Research and Technology (IJERT) ISSN:2278-0181 Vol. 5 Issue 07, July-2016.

[14] Alfonso Vulcano and Fabio Mazza, Comparision between viscous and Tmd Dampers International Journal of Research in Engineering and Technology ISSN: 2319-1163 | ISSN:

[15] Vineet G. Khotri and C.S. Sanghvi, Comparative study of Seismic Analysis of Structure with Viscoelastic Damper., International Journal for Scientific Research & Development| Vol. 3, Issue 03, 2015.

[16] Vida Tarassoly and James C. Anderson, A Fluid viscous dampers versus a Conventional Retrofit System International journal of Scientific Engineering and Technology Research, ISSN 2319-8885 Vol.05, Issue.41, November-2015.

[17] Shaik Khadervali andM. Mujahid Ahmed, Seismic Analysis of a High Rise Building with Viscous Dampers using Etabs, International journal of Scientific Engineering and Technology Research, ISSN 2319-8885 Vol.05, Issue.41, November-2016.

[18] Shaik Khadervali andM. Mujahid Ahmed, Seismic Analysis of a High Rise Building with Viscous Dampers using Etabs, International journal of Scientific Engineering and Technology Research, ISSN 2319-8885 Vol.05, Issue.41, November-2016.

[19] Ashkan Vafaei and Ashkan Khoda Bandesh Lou, Review and Assess the Optimal arrangement of Viscous Dampers in order to reduce the Seismic response of Tall Reinforced concrete Structure.

[20] Avinash A.R, Padigela, Abhinai, Karthik B. and Kiran Kamath, A Study on Seismic Performance of Adjacent Structures Connected with Fluid Viscous Dampers, Journal of Advances Mechanical and Civil Engineering, ISSN: 2394-2827, Volume-3 Issue-4, Aug-2016.

[21] Puneeth Sajjan and Prveen Biradar, Study on the effect of Viscous Damper for RCC Frame Structure., International Journal of Research in Engineering and Technology ISSN: 2319-1163 | ISSN: 2321-7308.

[22] Shaik Khadervali andM. Mujahid Ahmed, Seismic Analysis of a High Rise Building with Viscous Dampers using Etabs, International journal of Scientific

Engineering and Technology Research, ISSN 2319-8885 Vol.05, Issue.41, November-2016.

[23] Vida Tarassoly and James C. Anderson, A Fluid viscous dampers versus a Conventional Retrofit System International journal of Scientific Engineering and Technology Research, ISSN 2319-8885 Vol.05, Issue.41, November-2015