International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-12, October 2019

Performance of Fluid Viscous Dampers on Seismic Response of RCC Structures

Md Mujeeb, J S R Prasad, Venu Malagavelli

Abstract: Structures are mainly subjected to various types of loading conditions such as dead loads, live loads and dynamic loads such as earthquake and wind loads etc. The earthquake creates vibration at the base of the structure. In modern seismic design, the damping devices are used to reduce the seismic energy and enable the control of the structural response of the structure. In the present study, the seismic behavior of a structure connected with and without Fluid Viscous Dampers (FVD) has been describes. The software ETABS 2016 is used to perform the modeling and analysis of G +10 storey building by considering seismic zone IV. For analysis IS codes have been referred. The response of the RCC building is evaluated using Push-over and Time history analyses. Fluid Viscous Dampers are suggested to the structure, to control the seismic response and increase the stiffness of the structure.

Keywords: Fluid Viscous Dampers, Push-over and Time history analyses, storey displacement and storey shear.

I. INTRODUCTION

An Earthquake cause critical death toll and annihilation to property consistently. In recent years, substantial expenses have been paid for exact acknowledgment of seismic earthquake in the exploration establishments the motivation behind diminishing its damage, the expanding requirement for more research thinks about on the impacts came about because of the earthquake is felt in the hypothetical and laboratorial scales. Afterward, this definition adjusted and different factors likewise impacted this arrangement. Over the ongoing years, the exploration concentrates focused on the investigation of the effects of ground movement in the close field seismic earthquake on the basic execution. The devastative impacts of the ongoing seismic earthquakes, for example, Northridge earthquake (1994), Kobe seismic earthquake (1995), and Taiwan earthquake (1999) on the structures of the urban communities neighboring shortcoming, and concerning the nearby area of a large number of the urban communities of India to the dynamic deficiencies show the importance of the exploration. Structural damage brings about a decrease in structure stiffness and in the model parameters of structures.

Revised Manuscript Received on October 30, 2019.
* Correspondence Author
Venu Malagavelli*, Professor in the Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad, India.
J S R Prasad, Professor in the Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad , India.
MD Mujeeb, Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad , India.

Approximately 5% change in natural frequency is viewed as basic for harm location. Fluid Viscous Dampers are placed as diagonal to improve seismic response. Energy dispersal limit relies on its damping coefficient and non-linearity is characterized by the damping exponent.

II. DAMPERS

Dampers are defined as the response loss energy over the time period. Energy dissipation includes factors, for example, materials, soil radiation etc. Clear understanding of damping is required for incorporating its impact to the structure. The response curve shape doesn't change by damping but the magnitudes are reduced.

The Fluid Viscous Dampers (FVD) are the more connected devices for controlling the seismic reactions and to increase the stiffness of the structures. These apparatuses are connected dependent on various development advancements so as to avoid the structural damage for the reactions to the seismic excitation.

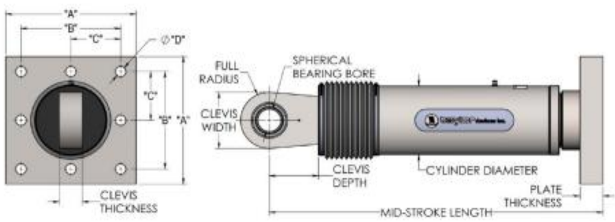

Figure 1: Fluid viscous dampers & lock-up devices clevis – base plate configuration [taylor devices inc.]

III. OBJECTIVES OF THE STUDY

Following are the objectives considered in this study

1. To carry out modeling and analysis of RCC building with and without Fluid Viscous Dampers by using ETABS 16.2.0 version software and study the effect forces on these models.
2. To study the effect of placement of fluid viscous damper to building at different locations.
3. To carry out comparison study on response of considered RCC building with and without Fluid Viscous Dampers by using Push over and Time history analyses.

IV. METHODOLOGY

In the present study G + 10 RCC building is considered.

Five different models are considered. They are as follows

1. RCC building without fluid viscous dampers.
2. RCC building with corner fluid viscous damping for all storey's.
3. RCC building with central fluid viscous damping for all storey's.
4. RCC building with corner fluid viscous damping for alternate storey's.
5. RCC building with corner fluid viscous damping for bottom 3 storey's.

The RCC building is assumed to be located in seismic zone IV of India having medium stiff soil.

Table 1: Detail data of building studied

S. No.	DESIGN DATA FOR THE BUILDING		
1	**Details of building**		
a)	Structure		OMRF
b)	Number of storey		G + 10
c)	Storey height	Ground storey	4.00 m
		Upper storey	3.50 m
d)	Type of building		Commercial
e)	Seismic zone		IV
2	**Material properties**		
a)	Grade of concrete		M25 and M30
b)	Grade of steel		Fe 500
c)	Density of reinforcement concrete		25 kN/m³
d)	Density of steel		78.5 kN/m³
3	**Member properties**		
a)	**Beam**		
i)	Grade		M25
ii)	Size (for all stories)		0.3 m x 0.45 m
b)	**Column**		
i)	Grade		M30
ii)	Sizes		0.45 m x 0.45 m and 0.72 m x 0.72 m
c)	**Slab**		
i)	Grade		M25
ii)	Thickness		125 mm
4	**Types of loads**		
i)	Dead		1.5 kN/m²
ii)	Live		3.5 kN/m²
5	**Seismic properties**		
i)	Zone factor (Z)		0.24
ii)	Importance factor (I)		1
iii)	Response reduction factor I		5
iv)	Soil type		II
v)	Damping ratio		0.005
6	**Link (FVD) properties**		
i)	Mass		44 kg
ii)	Weight		250 kN

The work started with modelling and analysis of RCC building for two case

1. Analyzing of building with corner damping, central damping, alternate damping and bottom 3 storey's damping that effectiveness of placement of Fluid Viscous Dampers.
2. Then comparing the results of the original building with effective damping building.

V. MODELLING AND ANALYSIS

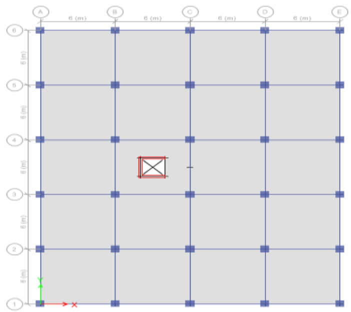

Figure 2: **RCC building without dampers plan view.**

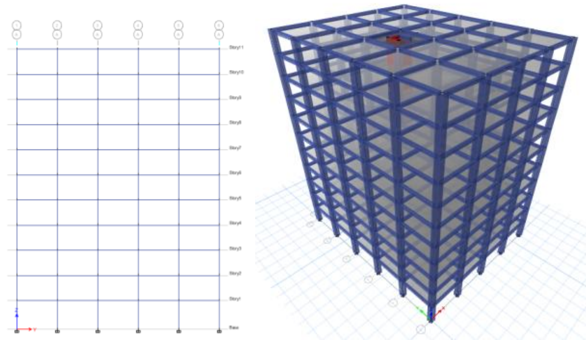

Figure 3: **RCC building without dampers.**

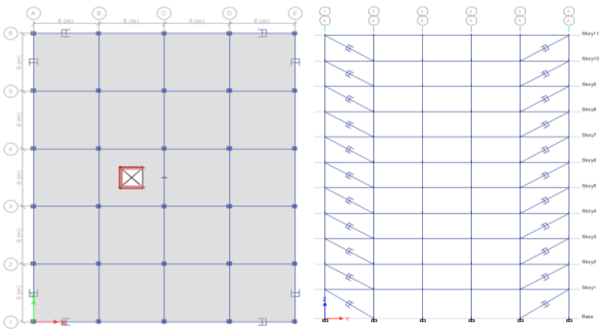

Figure 4: **RCC building with corner Fluid Viscous Dampers for all storey's.**

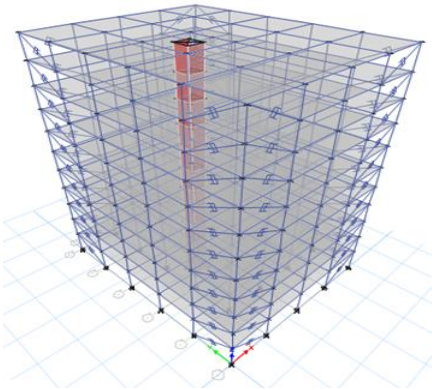

Figure 5: RCC building with corner Fluid Viscous Dampers 3D view.

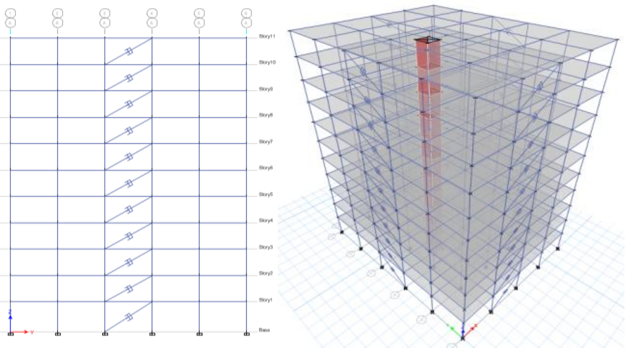

Figure 6: RCC building with central Fluid Viscous Dampers for all storey's.

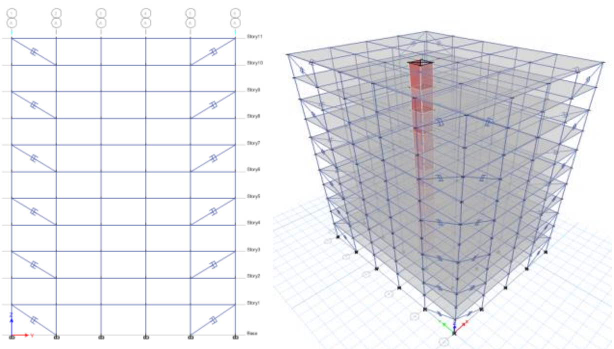

Figure 7: RCC building with corner Fluid Viscous Dampers for alternate storey's.

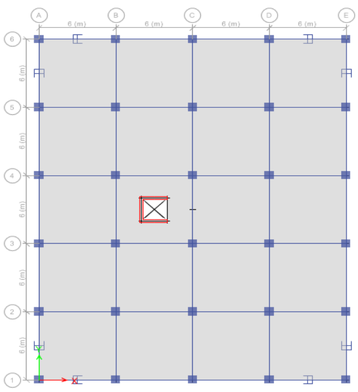

Figure 8: RCC building with corner Fluid Viscous Dampers for bottom 3 storey's plan view.

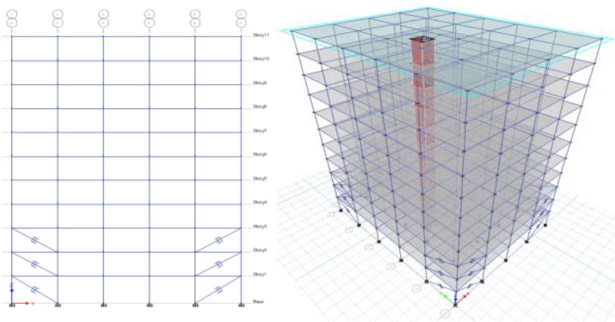

Figure 9: RCC building with corner FVD damping for bottom 3 storey's.

These are rectangular shaped buildings with 5 rows of Slab panels in X and 4 column of slab panels in Y directions and square shaped 30 Columns with 6m spanning connected beams as shown in figures (2-9). It is elevated for ten floors with height of 3.5m between adjacent floors as shown in figure. The 3D view with all connecting structural members is also shown in the figure. Gridlines A-E are parallel to the Y axis and gridlines 1-6 are parallel to the X axis.

VI. RESULTS AND DISCUSSIONS

A. Response Spectrum Curves from Time History

Response spectrum plots obtained from time history results at a specified point for a specified time history load case.

Table 2: Input Data

Name	RS from TH1		
Load case	THX	Coordinate system	Model
storey	Storey11	Response direction	X
point	1	Spectrum widening	0 %

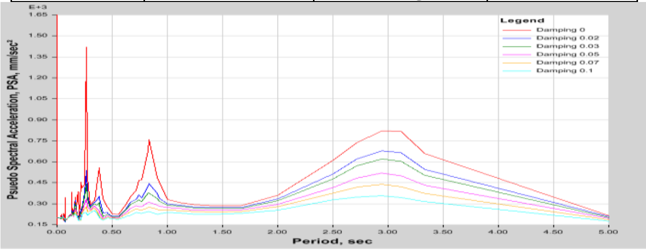

Figure 10 : without dampers RS curves.

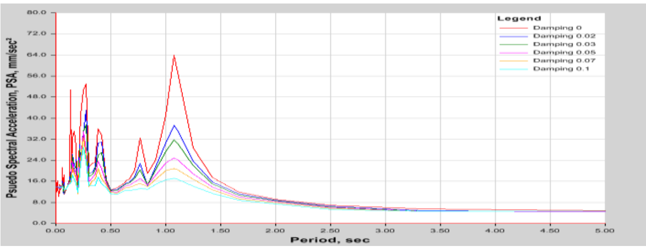

Figure 11 : Corner with dampers RS curves.

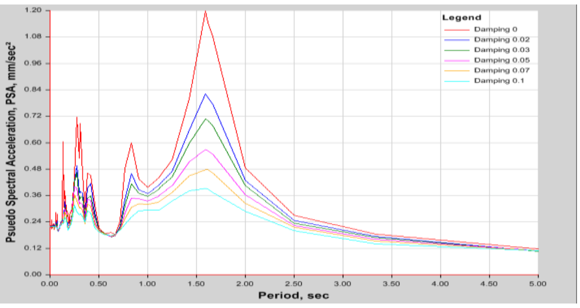

Figure 12: **Central with dampers RS curves.**

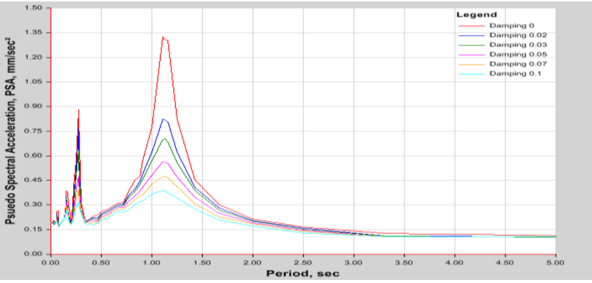

Figure 13: **Alternate with dampers RS curves.**

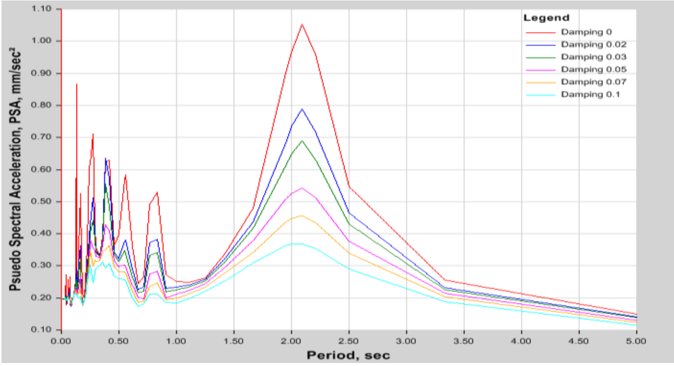

Figure 14 : Bottom 3 storey's dampers RS curves.

Table 3 : Maximum PSA at Zero Damping

Max Value	**LOAD CASE/DIRECTION**							
Building model	**THX/X**		**THX/Y**		**THY/X**		**THY/Y**	
	Period (sec)	PSA (mm/sec^2)	Period (sec)	PSA (mm/sec^2)	Period (sec)	PSA (mm/sec^2)	Period (sec)	PSA (mm/sec^2)
Without damp	0.269	1420.472	2.71	0.00001	0269	2323	0.269	3288.310
Corner with damp	1.0723	64.015	1.077	0	0.642	0.0026	1.077	63.97
Central with damp	1.593	1197.33	0.203	0.2068	0.203	0.2068	1.593	1815.31
Alternate with damp	1.111	1326.10	0.909	0.000001	0.274	1130	0.274	1891.81
Bottom 3 With damp	2.090	1052.13	0.133	0.001542	0.277	1334	0.133	1886.81

Table 4: Max. Disp. of Modals at different storey's due to Push X

Storey Level	**No damping**	**Corner damping**	**Central damping**	**Alternate damping**	**Bottom 3 storey's Damping**
Storey11	137.04	13.835	15.805	17.41	91.818
Storey10	129.645	12.128	14.069	15.596	83.348
Storey9	121	10.417	12.313	13.644	73.54
Storey8	110.68	8.714	10.542	11.834	62.088
Storey7	98.493	7.039	8.769	9.728	49.089
Storey6	84.463	5.423	7.02	8.012	35.078
Storey5	68.832	3.905	5.332	5.875	21.114
Storey4	52.103	2.538	3.755	4.425	8.969
Storey3	35.121	1.381	2.352	2.469	1.448
Storey 2	19.227	0.507	1.198	1.542	0.534
Storey 1	6.489	0	0.383	0	0.007
Base	0	0	0	0	0

C. Story Max/Avg. Displacements

From the ETABS obtained a simple table in the summary output with “Storey Maximum and Average Lateral Displacements”. This provides an indication of maximum to average ratio to check torsional irregularity. The Maximum Displacements due to Push-X in X-direction shown in above table4.

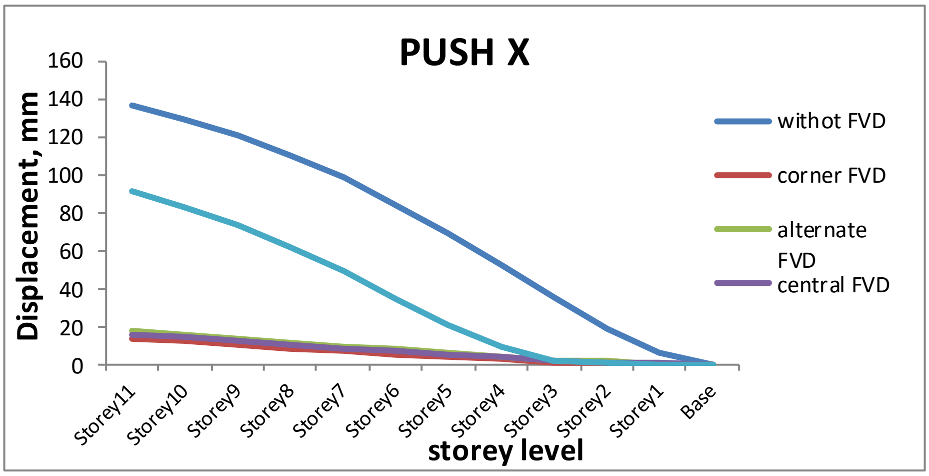

Figure 15 : Comparison Maximum storey displacements due to PUSH X

From the interrelation curves in Figure 15, it is obtained that due to insertion of Fluid Viscous Dampers (FVD) in the structures the displacements have been reduced by 89.90% for corner damping, 87.29% for alternate damping, 88.46% for central damping and 33% for bottom 3 storey’s damping.

.

For storey 2 the displacements have been reduced by 97.36% for corner damping, 91.90% for alternate damping, 93.76% for central damping and 97.22% for bottom 3 storey’s damping.

Table 5 : Max. Disp. of Modals at different stories due to Push Y

Storey Level	No damping	Corner damping	Central damping	Alternate damping	Bottom 3 storey’s
Storey11	136.206	13.74	15.871	18.382	94.669
Storey10	129.477	12.046	14.125	16.614	86.751
Storey9	121.388	10.348	12.36	14.64	77.264
Storey8	111.568	8.658	10.581	12.877	65.905
Storey7	99.841	6.996	8.8	10.66	52.737
Storey6	86.221	5.391	7.043	8.988	38.233
Storey5	70.91	3.885	5.348	6.642	23.396
Storey4	54.337	2.526	3.765	5.23	10.005
Storey3	37.253	1.377	2.357	2.963	1.407
Storey2	20.911	0.507	1.199	2.061	0.531
Storey 1	7.351	0	0.383	0	0.039
Base	0	0	0	0	0

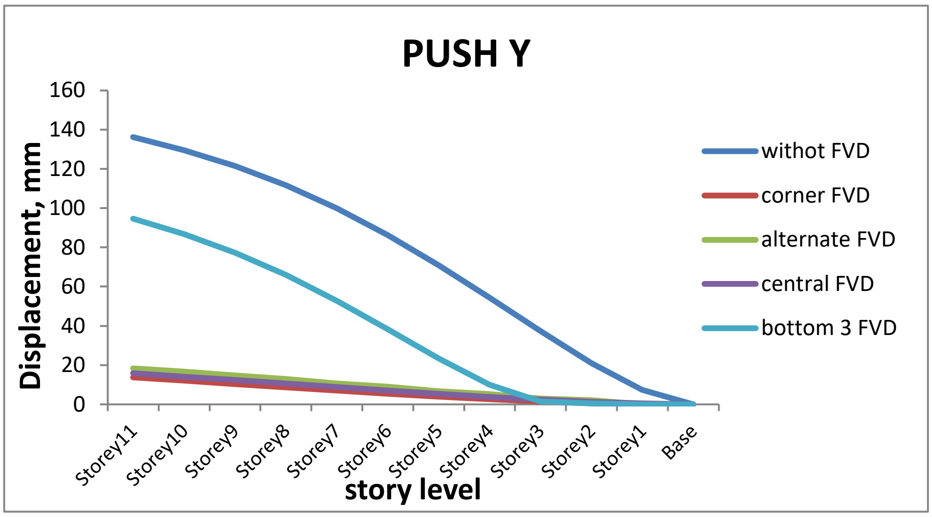

Figure 16 : Comparison Maximum story displacements due to PUSH Y

From the correlation curves in figure 16, it can be clearly predicted that due to inoculation of Fluid Viscous Dampers (FVD) in the structures the displacements have been reduced by 89.91% for corner damping, 86.50% for alternate damping, 88.34% for central damping and 30.49% for bottom 3 storey's damping.

For storey 2 the displacements have been reduced by 97.57% for corner damping, 90.14% for alternate damping, 94.26% for central damping and 97.46% for bottom 3 storey's damping.

D. Base Shear

The base shear obtained from Time history and Pushover analyses are as mentioned below are the compared bar-charts:

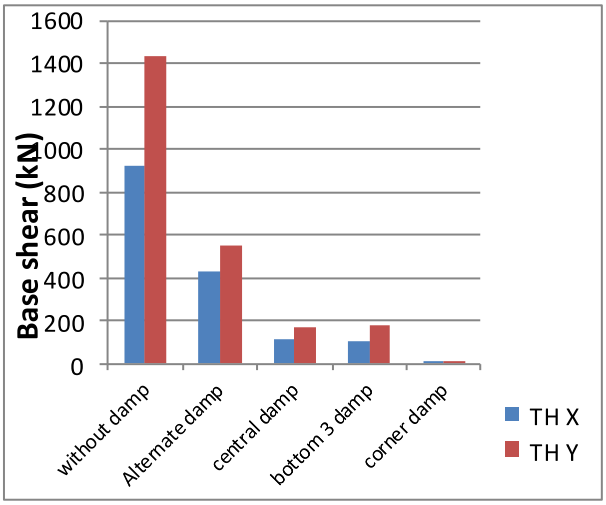

Figure 17: Comparison of Base shears for Time history.

From the correlation values in figure 17, it can be clearly found that due to the introduction of Fluid Viscous Dampers (FVD) in the structures the base shears of storey1 have been diminished by 53.53% for alternate damper, 87.17% for central damper, 88.34% for bottom 3 storey's damper and 99.26% corner damper in TH-X/ X-direction. Similarly, the base shears have been reduced by 61.29% for alternate damper, 88.08% for central damper, 87.35% for bottom 3 storey's damper and 99.63% corner damper in TH-Y/ Y-direction.

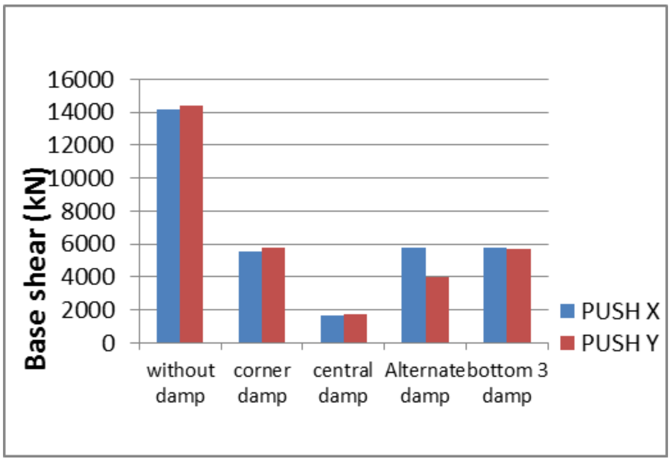

Figure 18 : Comparison Base shears for Pushover.

From the correlation values in figure 18, it can be precisely found that due to installation of Fluid Viscous Dampers (FVD) in the structures the base shears have been miniaturized by 59.44% for alternate damper, 88.39% for central damper, 59.37% for bottom 3 storey's damper and 60.74% corner damper PUSH-X/ X-direction. Correspondingly the base shears have been reduced by 72.17% for alternate damper, 88.16% for central damper, 60.42% for bottom 3 storey's damper and 59.71% corner damper in PUSH-Y/ Y-direction.

E. Comparing Pushover and Time History Analyses

Pushover analysis shows high base shear values than that of ELCENTRO time history analysis. Hence for dynamic analysis in structures with MDOF time history analysis fetches much realistic results under required seismic effect. Otherwise pushover curves, proves to have a better accuracy in assessing the target displacements. The result shows that prediction of damage in structures are difficult to estimate by means of the pushover analysis.

Retrieval Number L25551081219/2019©BEIESP
DOI: 10.35940/ijitee.L2555.1081219
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

F. Eigenvalues

Modal Periods and Frequencies" heading, the Eigenvalues are increasing with number of modes. Where w^2 is the eigenvalue and is directly proportional to stiffness, then increase in Eigenvalues will in turn increases the stiffness. It is found that Eigen values increases by 50 to 90% when Fluid Viscous Dampers (FVD) is applied to the same structure.

VII. CONCLUSIONS

The following conclusions are drawn from the above results

- From the dynamic response of the buildings, it can be concluded that, placing of FVD250 at the external corner on all four sides is effective when compared to central damping and alternate damping.
- When dampers are provided at corner throughout the building, storey displacement has been reduced 89.90% and 89.91% in X and Y direction respectively compared to without damper.
- When dampers are provided at central throughout the building, storey displacement has been reduced 33% and 30.49% in X and Y direction respectively compared to without damper.
- When dampers are provided at alternate throughout the building, storey displacement has been reduced 87.29% and 88.34% in X and Y direction respectively compared to without damper.
- Up to 90% decrease in Time period of maximum PSA in Response spectrum curves when used bottom 3 storey's damping for center damping.
- FVD250 decreasing the Base Shear of the structures by 80% in Time history analysis. The top storey Displacements are minimized by 90% with the use of Fluid Viscous Dampers.
- The increase of 50% to 90% are observed in Eigenvalues shows the effective increment in the stiffness of the structure when FVD250 used for exterior corners.
- In evaluating the seismic performance of structures the prediction of damage in structures are difficult to estimate by using the pushover analysis when compared with the Time history analysis.

REFERENCES

1. M. R. Arefi, "A study on the damping ratio of the viscous fluid dampers in the braced frames," Vol. 3, No. 4, pp. 1223–1235, 2014.
2. M. K. Muthukumar G, "Analytical modeling of damping," *indian Concr. J.*, Vol. 88, No. 4, 2014.
3. López, J. M. Busturia, and H. Nijmeijer, "Energy dissipation of a friction damper," *J. Sound Vib.*, Vol. 278, No. 3, pp. 539–561, 2004.
4. W. J. William H. Robinson, "Lead Damper for base isolution.pdf." Proceedings of 9th world conference on Earthquake, 1998.
5. S. Infanti, J. Robinson, and R. Smith, "Viscous Dampers For High-Rise Buildings," *14th World Conf. Earthq. Eng.*, 2008.
6. V. S. Balkanlou, M. R. Bagerzadeh, B. B. Azar, and A. Behravesh, "Evaluating Effects of Viscous Dampers on optimizing Seismic Behavior of Structures," No. 2007, 2013.
7. M. Paz, "Structural Dynamics.pdf." Van Nostrand Reinhold Comapany, NYC., pp. 574, 1985.
8. S. Amir and H. Jiaxin, "Optimum Parameter of a Viscous Damper for Seismic and Wind Vibration," Vol. 8, No. 2, pp. 192–196, 2014.

AUTHORS PROFILE

MD Mujeeb is a student of M.Tech (Structural Engineering) in the Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad. He has an interest in research in Earthquake Resistant Design of Building, Structural Dynamics and Concrete Technology. He has done his B.Tech in Civil Engineering from Siddhartha Institute of Engineering & technology, Ibrahimpatnam, Hyderabad.

J S R Prasad is a Professor in the Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad and has 15 years of experience in industry, research and academics. He obtained B.Tech from Andhra University, Vishakhapatnam; M.Tech from Indian Institute of Technology, Roorkee and was conferred doctorate by Indian Institute of Technology, Roorkee in 2009. He has published 15 research papers in national and international journals. He was a FELLOW of The Institute of Engineering (India), Life member of Indian Society of Earthquake Technology (ISET), Indian Concrete Institute (ICI), and Indian Society of Technical Education.

Venu Malagavelli, working as Professor in the Department of Civil Engineering, Institute of Aeronautical Engineering, Dundigal, Hyderabad. He obtained PhD and ME from BITS Pilani and B.Tech from JNTUCEH, Hyderabad. He published more than 30 papers in International and national Journals and conferences. His area of research is development of new concrete using industrial waste materials. He is a life member of IEI, ICI, IIBE, ISTE etc. He received travel grants from DST and CICS.