Performance of RCC Building With & Without Fluid Viscous Damper in High Seismicity Region

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Abstract— ***Structural reaction management has gained importance as a result of the large number of structures that are earthquake-prone and the numerous earthquakes that occur throughout the world. Structures are primarily affected by two types of loading situations: earthquakes and wind loads. In recent seismic design, damping devices are used to reduce seismic energy and give the structure's reaction to earthquake excitation control. The effectiveness of one such instrument, fluid viscous dampers, for regulating structural response and reducing damping demand, is examined in this work. The building is therefore able to resist earthquakes without suffering serious structural damage. In this work, four separate time history recordings of ground vibrations were compared to G+15 RCC frame building models with and without FVD using FVD at various sites. To determine the best position for FVD, the maximum displacements and storey drifts of the various models are evaluated. The analysis's findings demonstrated that maximum displacement and storey drift values are higher for RC-framed structures without dampers than for RC-framed structures with dampers.***

Indexed Terms— ***Damper Locations, Fast Non-linear Analysis (FNA), Fluid Viscous Damper, Time History Method.***

I. INTRODUCTION

The design of a structure is significantly influenced by the lateral forces produced by earthquake and wind loads. Building high-rise structures is one of the most challenging engineering tasks, and the design is fully based on analytical and scale modelling. The construction of high-rise buildings in seismically active places can vary widely from region to region based on the local seismic occurrences, even though these buildings are regarded to be safe during minor and moderate earthquakes because they are designed to resist wind loads.

Building regulation has become a scientific technology in recent years to protect structures from earthquake and wind loads. This approach of handling lateral loads can be classified into three major categories based on the amount of input energy needed: passive control, semi-active control, and active control. Due to the lack of input energy needs, simple setup, simple operation, and affordable repair and maintenance, using passive control tools is highly advised. Fluid viscous dampers are employed in a variety of construction techniques to reduce how structures react to seismic vibrations. Viscoelastic dampers, tuned mass dampers, steel dampers, friction dampers, and other forms of dampers are among the numerous available on the market, but FVD offers the greatest variety and application flexibility, making it the most suitable type of damper.

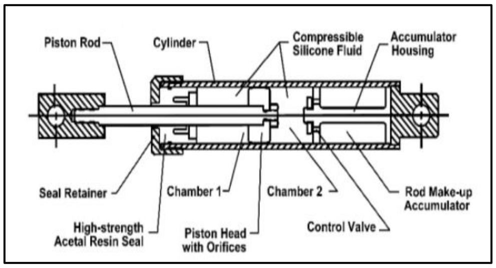


Fig. 1: Typical Fluid Viscous Damper

II. OBJECTIVE OF STUDY

1. To design high-rise RC Structure without Fluid Viscous Damper by using IS 456:2000.
2. To analyse high-rise RC Structure for selected ground motion data with and without Fluid Viscous Damper.
3. To compare performance of high-rise RC Structure with and without Fluid Viscous Damper for storey displacement and storey drift.
4. Optimization of Fluid Viscous Damper location in high-rise RC Structure for selected ground motion.

III. MODELLING AND MATERIAL PROPERTIES

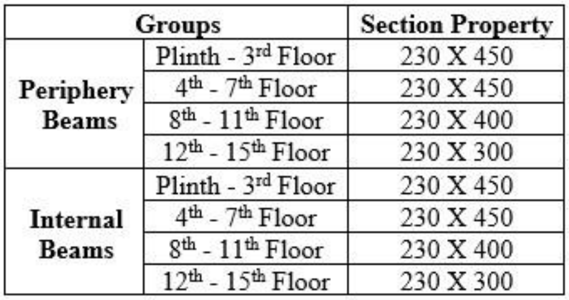
For the study, a G+15 storeyed building regular in plan is considered. The structure is modelled using SAP2000 software and analysed using four different time history (TH) records of ground motion. To reduce the dynamic response under lateral load, FVDs are applied to the structure in the form of diagonal bracing.

Table I: Design data for the building

Sr. No.	DESIGN DATA FOR THE BUILDING		
1.	Geometric Details of Building		
a)	No. of storeys		G + 15
b)	Plan dimensions		30 X 30 m
c)	Type of structure		SMRF
d)	Type of building		Regular in plan
e)	Typical storey height		3m
2.	Material properties		
a)	Grade of concrete		M30
b)	Grade of steel		Fe500
c)	Density of reinforced concrete		25 kN/m^3
d)	Density of steel		78.5 kN/m^3
3.	Load Details		
a)	Dead Load	Self-Weight	
		Wall Load External (230 mm) Internal (150 mm)	12 kN/m 7.8 kN/m
		Floor Finish	1.5 kN/m^2
b)	Live load	At floor	2 kN/m^2
		At terrace	1 kN/m^2
c)	Earthquake Load		As per IS 1893:2016 (Part 1)
d)	Wind Load		As per IS 875:2015 (Part 3)
4.	Seismic Properties		
a)	Seismic zone		V
b)	Zone factor (z)		0.36
c)	Response reduction factor (R)		5
d)	Importance factor (I)		1
e)	Soil type		II
f)	Damping ratio		0.05
5.	Wind Load Parameters		
a)	Wind Speed (V_b)		50 m/s
b)	Risk Coefficient (k_1)		1
c)	Terrain Category - 3 (k_2)		1.114
d)	Topography (k_3)		1
e)	Importance factor (k_4)		1
6.	Link (FVD) Properties (Manufactured by Taylor's Device Inc. USA)		
a)	Mass		82 Kg
b)	Force		500 kN
c)	Eff. Stiffness		28144.86 kN/m
d)	Eff. Damping		420 kN (s/m)

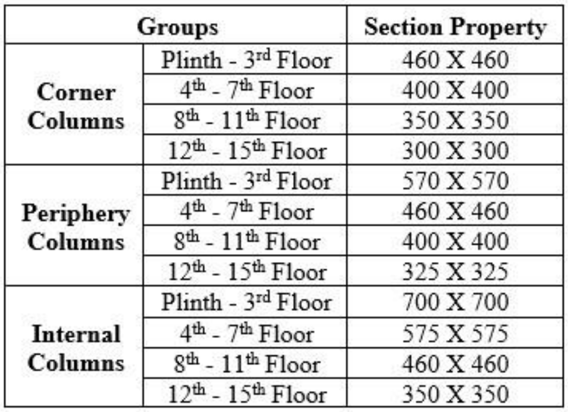
Member Properties as per Design:

Table II: Beam Section Properties



Groups		Section Property
Periphery Beams	Plinth - 3rd Floor	230 X 450
	4th - 7th Floor	230 X 450
	8th - 11th Floor	230 X 400
	12th - 15th Floor	230 X 300
Internal Beams	Plinth - 3rd Floor	230 X 450
	4th - 7th Floor	230 X 450
	8th - 11th Floor	230 X 400
	12th - 15th Floor	230 X 300

Table III: Column Section Properties



Groups		Section Property
Corner Columns	Plinth - 3rd Floor	460 X 460
	4th - 7th Floor	400 X 400
	8th - 11th Floor	350 X 350
	12th - 15th Floor	300 X 300
Periphery Columns	Plinth - 3rd Floor	570 X 570
	4th - 7th Floor	460 X 460
	8th - 11th Floor	400 X 400
	12th - 15th Floor	325 X 325
Internal Columns	Plinth - 3rd Floor	700 X 700
	4th - 7th Floor	575 X 575
	8th - 11th Floor	460 X 460
	12th - 15th Floor	350 X 350

Thickness of slab = 150 mm

Modelling of Fluid Viscous Dampers:

Various models have been prepared by placing viscous dampers at different location to check the efficiency on SAP2000.

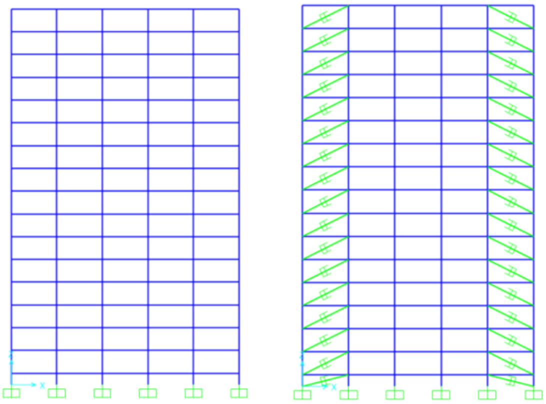
Model 1: RCC building without FVD

Model 2: RCC building with corner FVD for all storey's

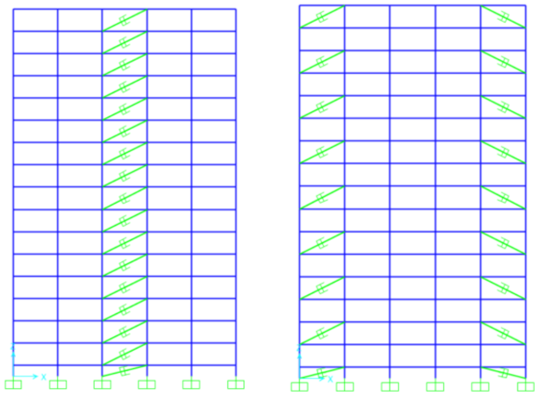
Model 3: RCC building with central FVD for all storey's
Model 4: RCC building with corner FVD for alternate storey's
Model 5: RCC building with corner FVD for two alternate storey's
Model 6: RCC building with corner FVD for bottom 3 storey's

Table IV: Damper Properties used in modelling

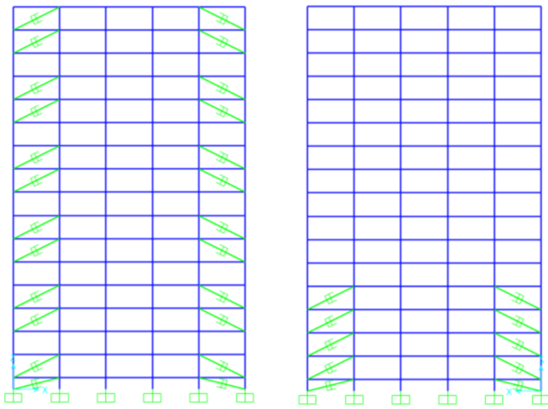
Mass	Force	Effective Stiffness	Effective Damping
(Kg)	(KN)	(KN/m)	(KN/(s/m)^{Cexp})
82	500	28144.86	420



Model 1 **Model 2**



Model 3 **Model 4**



Model 5 **Model 6**

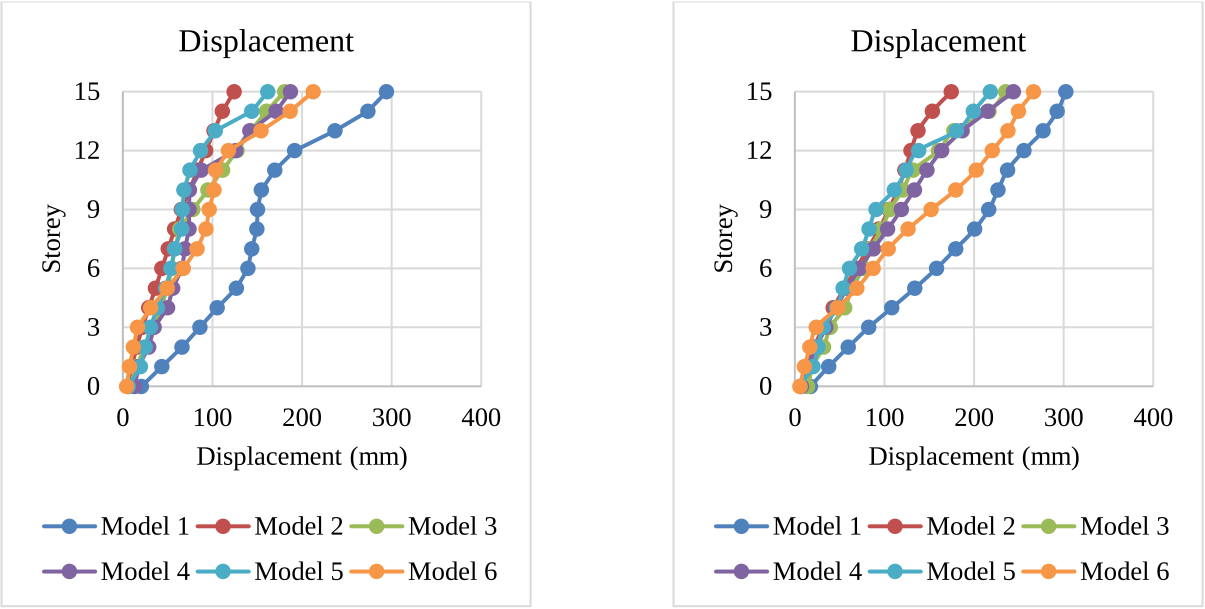
Fig. 2: Elevation of the RCC frame building models

IV. RESULTS AND DISCUSSION

In the current study, fluid viscous dampers are employed to minimize the seismic effects of the G+15 RCC building that is subjected to the earthquake load. Dynamic analysis is performed with SAP2000 software and the time history approach. The symmetric model ensures that the values in both directions are equal. To evaluate the seismic behaviour of a reinforced concrete structure, two observed variables are used as story drift and storey displacement.

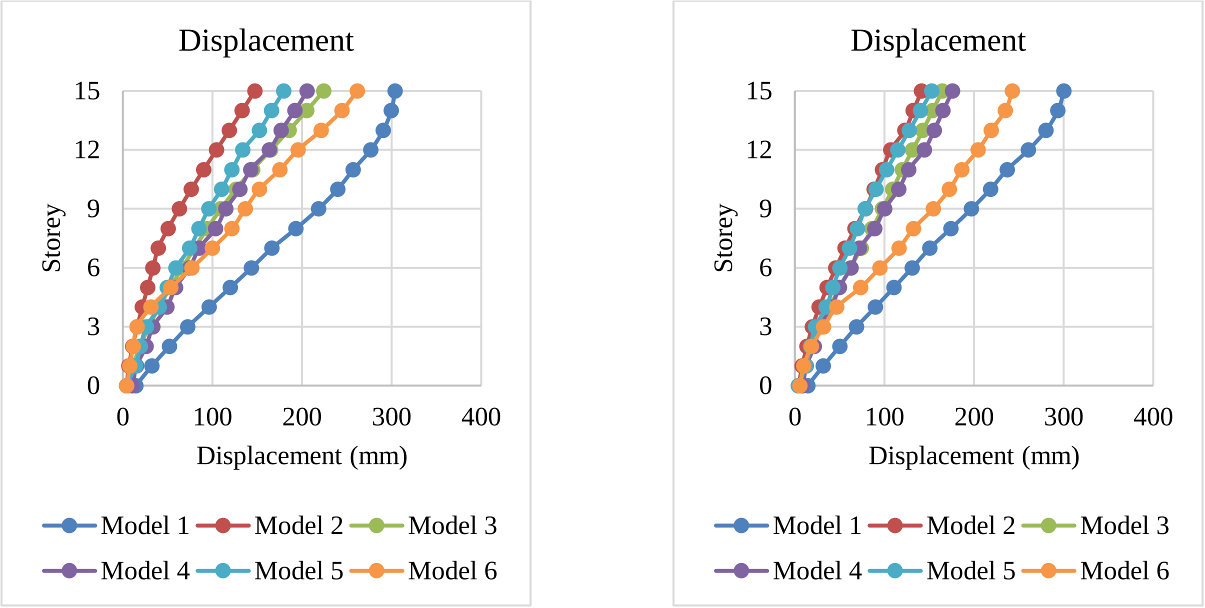
Storey Displacement:

The TH response of all six G+15 story building model cases is represented as in Fig. 3 in terms of storey displacements. The model without FVD undergo significantly greater displacement than models with FVD. In comparison to a bare frame, displacement was decreased by 60% to 28% by various damper models. Model 2 has a maximum displacement reduction of around 60%.



a) TH - Kobe Japan

c) TH – El Centro 1940



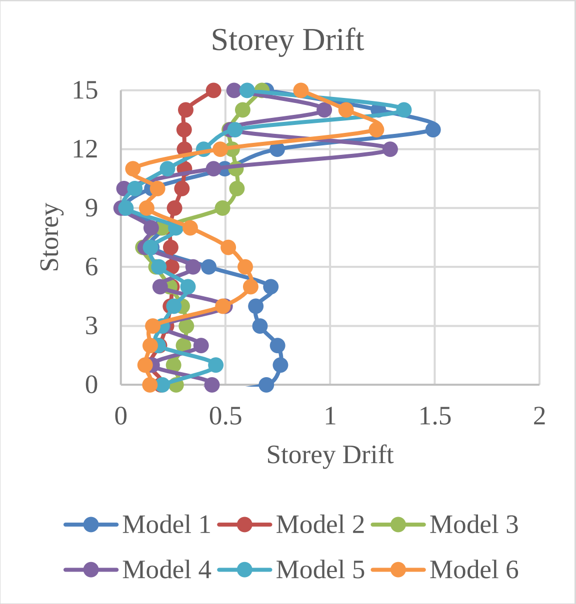
b) TH - Northridge

d) TH – Imperial Valley

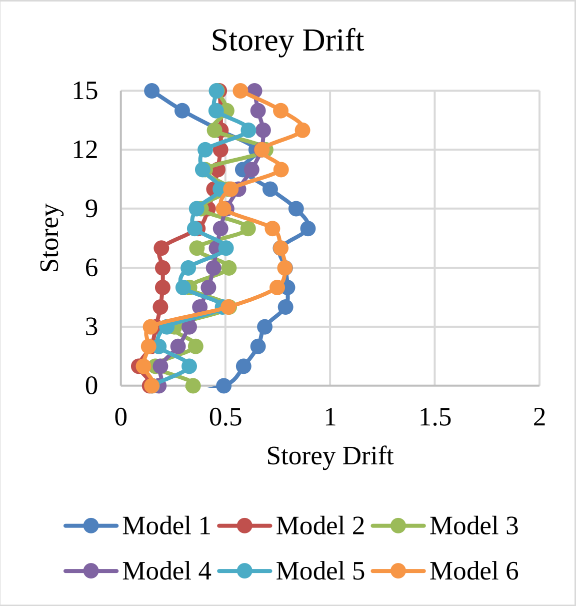
Fig. 3: Comparison of storey displacement for ground motions a) Kobe Japan b) Northridge c) El Centro 1940 d) Imperial Valley

Storey Drift:

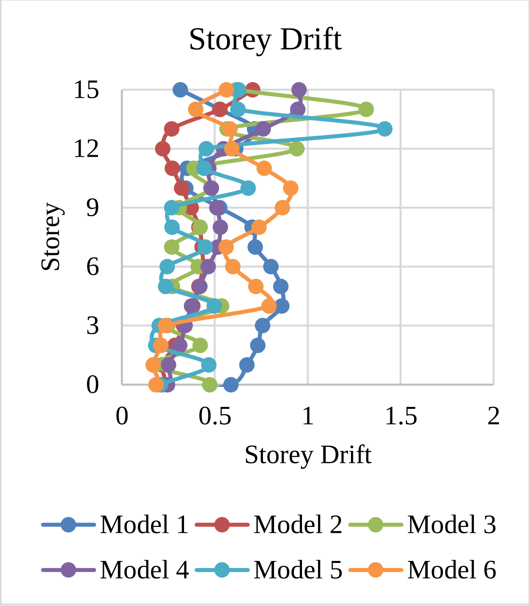
The TH response of all six G+15 story building model cases is represented as in Fig. 4 in terms of storey drift. Dampers are effective at reducing storey drift as indicated by the larger drift values for model without dampers as compared to other models. Dampers at every level uniformly distribute the forces that cause drifts and significantly lower drift values than other models.



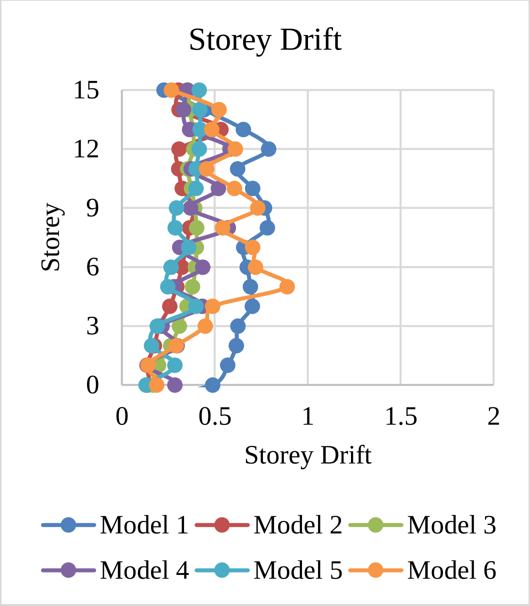
a) TH – Kobe Japan



b) TH – Northridge



c) TH – El Centro 1940



d) TH – Imperial Valley

Fig. 4: Comparison of storey drift for earthquakes a) Kobe Japan b) Northridge c) El Centro 1940 d) Imperial Valley

CONCLUSION

In this study, a fluid viscous damper controls the seismic response of the structure that is being subjected to the earthquake load. Using SAP2000, the symmetrical G+15 story plan is modelled. The time history approach is used while performing non-linear dynamic analysis. Four distinct ground motions are applied to the structure in order to investigate its behaviour both with and without FVD. Following the analysis of the structure, the results were compared.

The conclusion are as follows,

a. The max. displacements are dramatically decreased with use of FVD.
b. Models without fluid viscous damper are more susceptible to storey drifts compare to models with fluid viscous dampers.
c. The model which is without damper obtained the results of max. displacement as 294.483 mm and story drift as 44.769 mm for Kobe Ground Motion. For models with FVD, this displacement is reduced by 35% to 65%.
d. The model which is without damper obtained the results of max. displacement as 304.025 mm and story drift as 26.805 mm for Northridge Ground Motion. For models with FVD, this displacement is reduced by 25% to 60%.
e. The model which is without damper obtained the results of max. displacement as 302.428 mm and story drift as 25.853 mm for El-Centro 1940 Ground Motion. For models with FVD, this displacement is reduced by 15% to 50%.
f. The model which is without damper obtained the results of max. displacement as 300.547 mm and story drift as 23.719 mm for Imperial Valley Ground Motion. For models with FVD, this displacement is reduced by 20% to 50%.
g. From the comparison, the max. displacement value of the structure is reduced about 65% when FVDs are applied at exterior corners for all the stories to the structure.
h. FVD500 reduced the Base Shear of the structures in all models with Equivalent Static, Response Spectrum and Time history analysis.
i. It is noticed that buildings with FVD are performing well in terms of response of the structure.

REFFERENCES

[1] K. Sudheer Kumar, Y. Vinod, “Seismic Response Analysis of RC Framed Structure using Dampers”, *International Journal of Recent Technology and Engineering (IJRTE)*, Volume-7, Issue-6C2, 2019.

[2] Dr. R. B. Khadiranaikar, Dr. B. G. Naresh Kumar, Md. Aqeeb Hussain, Avinash Gornale, “Strengthening of RC Framed Structure Using Energy Dissipation Devices”, *Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, Volume 8, Issue 5, 2013.

[3] Samuele Infanti, Jamieson Robinson, Rob Smith, “Viscous Dampers for High-rise Buildings”, *The 14th World Conference on Earthquake Engineering*, Beijing, China, 2008.

[4] Puneeth Sajjan, Praveen Biradar, “Study on the Effect of Viscous Damper for RCC Frame Structure”, *International Journal of Research in Engineering and Technology*, Volume 5, Issue 9, 2016.

[5] Ying Zhou, Mohammed Samier Sebaq, Yi Xiao, “Energy dissipation demand and distribution for multi-story buildings with fluid viscous dampers”, *Engineering Structures*, Volume 253, 2021.

[6] Wesam Al Agha, Dr. Nambiappan Umamaheswari, “Comparative Study on Seismic Performance of Reinforced Concrete Building with and Without Fluid Viscous Dampers*”, International Journal of Engineering Research and Management (IJERM)*, Special Issue, 2020.

[7] Xiangxiang Wu, Dawei Zhou, Tianrong, Huang, “Structural analysis of a school building with viscous dampers applied”, *Journal of Physics: Conference Series*, Volume 2011, 2021 5th International Conference on Green Composite Materials and Nanotechnology (GCMN 2021), Nanjing, China, 2021.

[8] Kapil P. Gunjal, Prof. Sanket S. Sanghai, “Seismic Analysis of Building Using Dampers in Shear Walls”, *International Journal of Innovations in Engineering and Science*, Vol. 4, No.6, 2019.

[9] Rini Srivastava, Dr. Kailash Narayan, “Effect of location of fluid viscous dampers on the seismic performance of the multi-storey building”, *Journal of Emerging Technologies and Innovative Research (JETIR)*, Volume 6, Issue 5, 2019.

[10] Lingala Ajay, M. Anil Kumar, “Torsional Vibration Control of a Structure using Fluid Viscous Dampers”, *IOP Conference Series:*

Materials Science and Engineering, Volume 1197, International Conference on Advances in Civil Engineering (ICACE 2021), Guntur, India, 2021.

[11] Naziya Ghanchi, Shilpa Kewate, "Dynamic Analysis of 25 Storey RCC Building with and without Viscous Dampers", *International Journal of Scientific & Engineering Research*, Volume 6, Issue 12, 2015.

[12] Md Mujeeb, J S R Prasad, Venu Malagavelli, "Performance of Fluid Viscous Dampers on Seismic Response of RCC Structures", *International Journal of Innovative Technology and Exploring Engineering (IJITEE),* Volume-8, Issue-12, 2019.

[13] Sai Gowtham Dasari, K. Srinivasa Rao, "Seismic and Time History Performance of RCC Framed Buildings with and without Passive Energy Dissipaters", *International Journal of Engineering and Advanced Technology (IJEAT),* Volume-9, Issue-3, 2020.

[14] A.K. Sinha, Sharad Singh, "Structural Response Control of RCC Moment Resisting Frame using Fluid Viscous Dampers", *International Journal of Civil Engineering and Technology (IJCIET),* Volume 8, Issue 1, 2017.