Seismic Analysis of Multi-Storey RCC Building with and without Viscous Dampers

[1]Jayadeep K S, [2]Pramod Kumar Mahato, [3]Dharmendra Kumar Sah, [4]Baiju Prasad Gupta, [5]Paon Thangjam
[1] Assistant Professor, Department of Civil Engineering, R R Institute of Technology, Bangalore, India.
[2,3,4,5]UG Students, Department of Civil Engineering, R R Institute of Technology, Bangalore, India.

Abstract - **Earthquake is the most important aspect to be considered in designing any building. During earthquake most structures are subjected to vibration. The vibrations may arise from wind forces, earthquake excitation, machine vibrations, or many other sources. In some cases, especially under strong earthquake excitations, these vibrations can cause structural damage or even structural collapse. By using dampers severe damages can be prevented. The concept of the viscous damper is to absorb the shocks and vibrations from the structure. However, the most important is the location of dampers which is the major consideration. Viscous damper is considered as the passive control systems used to dissipate and absorb energy induced during the earthquakes due to earthquake. The main purpose of application of dampers is to enhance the stiffness and stability of the structure and make the structure earthquake resistant. The present study is focused on the study of seismic behavior of building with the dampers and to evaluate seismic responses such as displacement, Storey drift and modal parameters. Three buildings (G+5), (G+10), (G+15) are analyzed by Dynamic Non-linear (Time-History method) using Cheerapunji earthquake acceleration data.**

Keywords - ***Viscous dampers, Storey response***

IINTRODUCTION

An earthquake is a powerful shaking of the earth's surface that can be fatal to thousands of people and cause serious damage. They are brought on by the unexpected release of energy from tectonic plate movements in the Earth's crust. Seismic waves are the means by which this power is discharged. The most severe and unanticipated natural calamities are earthquakes. In the worst situation, the large amount of energy produced during an earthquake may result in serious injury or the destruction of important structures. Civil constructions like high-rise buildings, skyscrapers, and long span bridges are designed with more flexibility as a result of the rapid economic development and modern technology, which increases their susceptibility to external excitation. Therefore, these flexible structures are susceptible to being exposed to extremely high levels of vibration in the event of a strong wind or earthquake. In order to keep such civil projects from suffering significant damage, the response reduction of civil structures during dynamic loads such large earthquakes and high winds has become a vital topic in structural engineering. The forces induced during the earthquakes should be resisted by the structures without suffering any major structural damage. All structures have to be designed to resist lateral loads in several ways. The most common lateral loads resisting systems are moment frames, shear wall and braced frame. Passive energy dissipating systems are also used as an alternative to seismic isolation which protects the structures against the earthquakes. The application of such systems enhances the energy absorbing capacity of structures. The most common types of these systems include fluid viscous dampers, friction dampers, tuned mass dampers and metallic dampers.in the present study one of the passive energy dissipating devices is used and the seismic behaviour of the building is studied.

A. *VISCOUS DAMPERS*

Viscous dampers, also referred to as seismic dampers, are hydraulic components that diffuse kinetic energy induced during earthquakes and soften structural collisions. They are adaptable devices that can be made to provide for both controlled and uncontrolled dampening of structures to shield them from earthquake.

Fig: 01 Viscous dampers

B. *Scope & Objectives:*

Scope of the study:

a) To perform the seismic analysis of multi storey RCC building with and without viscous dampers.

Objectives of the study:

a) To study the Seismic behavior of building with and without dampers.

b) To evaluate seismic responses such as Displacement, Storey drift and modal Parameters.

c) To study the performance of building incorporated with dampers.

d) To limit the parameters evaluated under permissible limits as per IS Provisions.

II. METHODOLOGY

a) To carry out the proposed work 3 building models are considered (G+5, G+10 & G+15).

b) The analysis is carried out considering the column supports fixed.

c) The analysis is carried out by Dynamic Non-linear (Time -History Analysis) using Cheerapunji earthquake acceleration.

d) The dampers are applied as Rigid links with required stiffness.

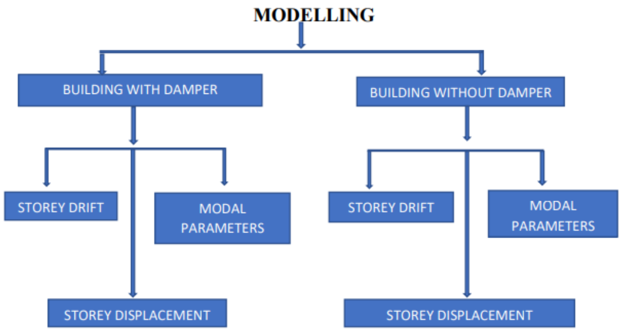

Fig: 02 Methodology flowchart

Table 01: Geometric details of the building

Number of storey	(G+5)	(G+10)	(G+15)
Storey height	3m	3m	3m
Height of the building	15m	30m	45m
Size of column	400* 400mm	500* 500mm	500* 500mm
No. of bays in X direction	6	6	6
No. of bays in Y direction	4	4	4
Spacing of bays in X direction	4m	4m	4m
Spacing of bays in Y direction	3m	3m	3m
Size of beam	200* 500mm	200* 500mm	200* 500mm
Thickness of slab	150mm	200mm	200mm
Grade of concrete	M25	M25	M25
Grade of steel	Fe 500	Fe 500	Fe 500
Live load (kN/m^2)	2	2	2
Floor finish (kN/m^2	1	1	1
Roof load (kN/m^2)	1.5	1.5	1.5
Damping ratio	5%	5%	5%

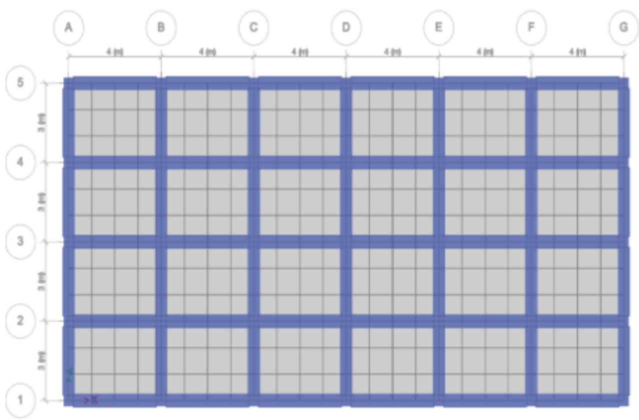

Fig: 03 Plan of building

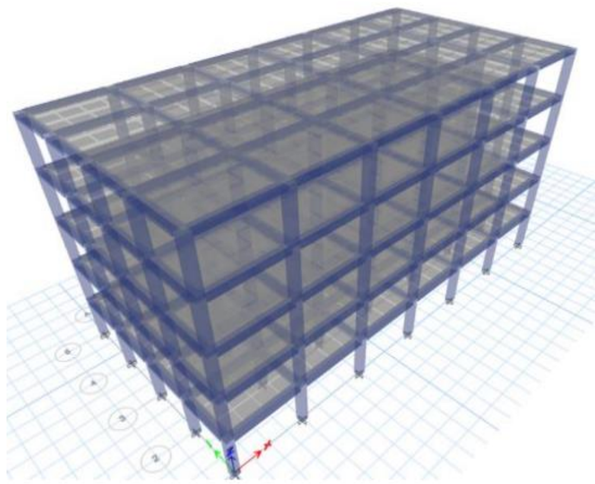

Fig: 04 3D view of G+5 building

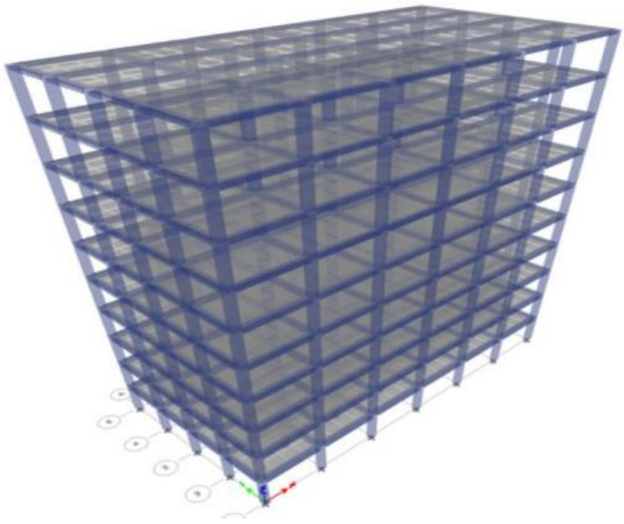

Fig: 05 3D view of G+10 building

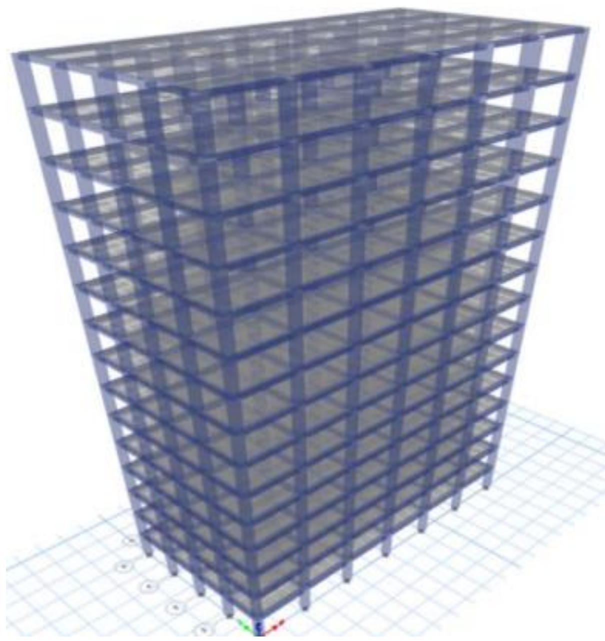

Fig: 06 3D view of G+15 building

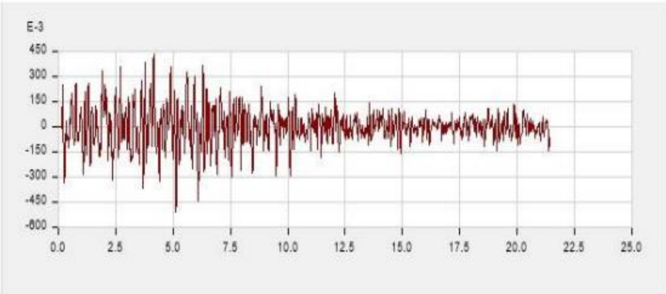

Fig: 07 Cheerapunji earthquake acceleration

a) Date: Aug 06 1988
b) Peak acceleration = -0.51100m/sec2 at 4.960sec
c) Duration of earthquake 22seconds
d) 1064 Acceleration data points at 0.020secs interval.

Table 02: Damper properties

Models	K (kN/m)	Mass(kN)
G+5	62426.070	48
G+10	72841.580	62
G+15	82692.895	79

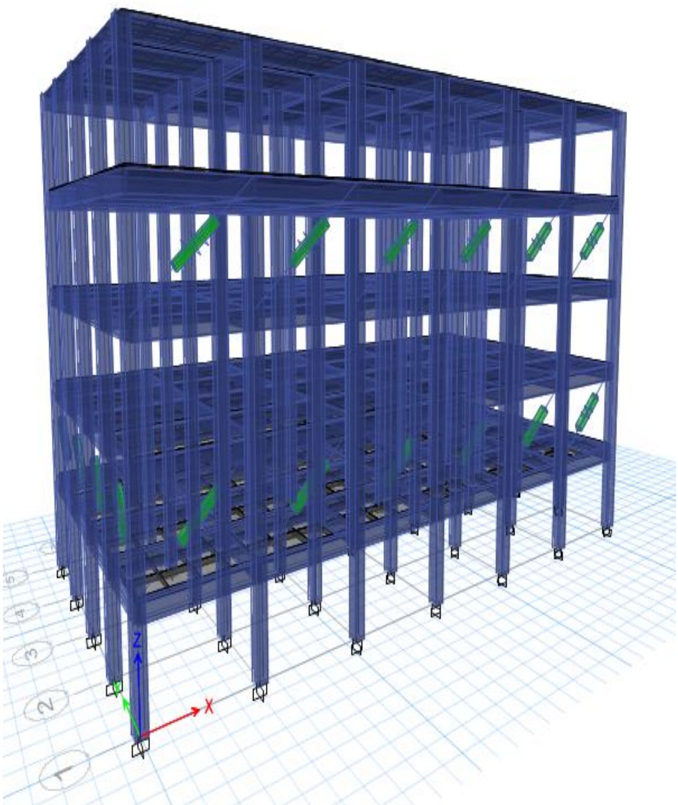

Fig: 08 G+5 Building with dampers applied at alternate storey

Table 03: Displacement of G+5 Building

Storey	Elevation (m)	Displacement (mm) without dampers		Displacement (mm) With dampers	
		X-Dir	Y-Dir	X-Dir	Y-Dir
5	15	44.17	39.97	25.62	23.58
4	12	39.71	35.34	23.03	20.85
3	9	31.95	27.47	18.53	16.21
2	6	22.04	19.99	12.78	11.79
1	3	10.03	9.24	5.82	5.45
0	0	0	0	0	0

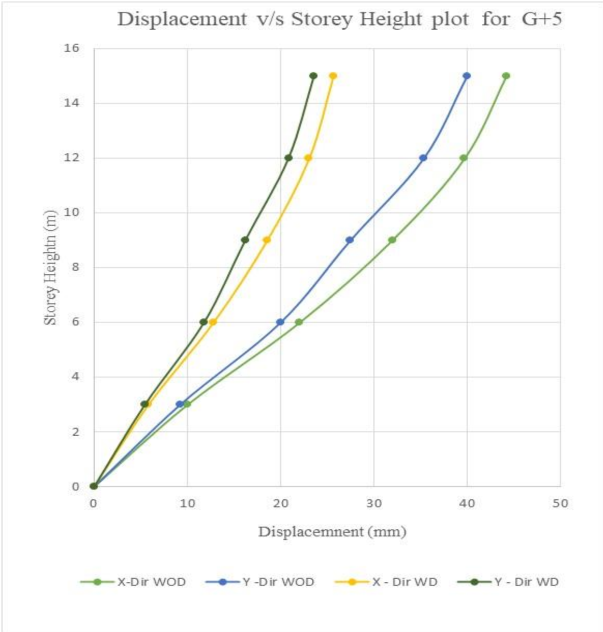

Fig: 09 Displacement v/s storey Height for G+5 building

a) The graph shows displacement v/s height of the building for G + 5 building with dampers applied at alternate storeys.
b) The permissible displacement as per IS code is (H/500) i.e, (15000/500) = 30mm
c) The maximum displacement obtained is 25.62mm in X-direction.
d) The displacement obtained was 44.17mm without dampers and with the application of dampers the displacement has been reduced to 25.62mm.
e) Application of viscous dampers have reduced the displacement by 42%

Table 04: Modal Parameters of G+5 building

CASE	Modes	Time period (secs)		Frequency (cycles/sec)	
		WOD	WD	WOD	WD
Modal	1	0.76	0.53	1.315	1.886
Modal	2	0.719	0.512	1.391	1.953
Modal	3	0.67	0.47	1.492	2.127

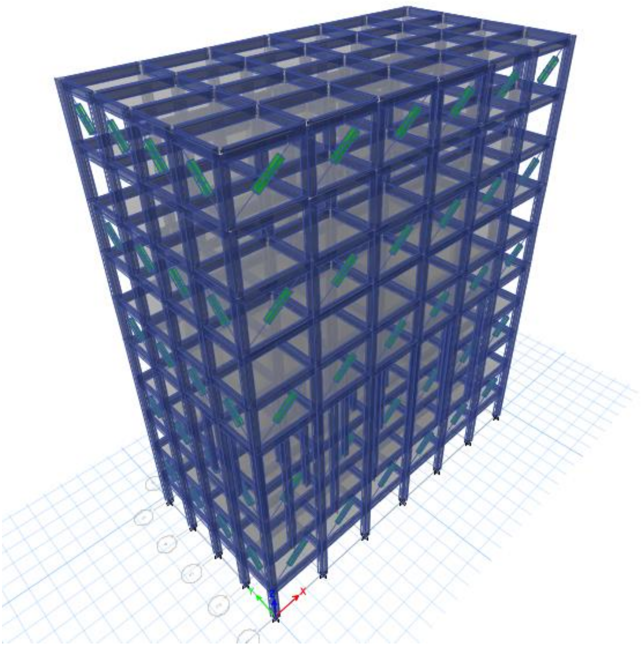

Fig: 10 G10 Building with dampers applied at alternate storey

Table 05: Displacement of G + 10 Building

Storey	Elevation (m)	Displacement (mm) without dampers		Displacement (mm) With dampers	
		X-Dir	Y-Dir	X-Dir	Y-Dir
10	30	94.15	78.34	52.72	43.87
9	27	92.53	76.45	51.81	42.81
8	24	89.51	73.63	50.13	41.23
7	21	85.01	69.62	47.61	38.99
6	18	78.66	64.23	44.05	35.97
5	15	70.76	57.72	39.62	32.32
4	12	61.73	50.16	34.57	28.09
3	9	51.68	41.72	28.94	23.36
2	6	40.30	32.64	22.57	18.28
1	3	26.34	21.60	14.57	12.09
0	0	0	0	0	0

Table 06: Modal Parameters of G + 10 building

CASE	Modes	Time period (secs)		Frequency (cycles/sec)	
		WOD	WD	WOD	WD
Modal	1	1.524	1.236	0.656	0.809
Modal	2	1.42	1.224	0.704	0.816
Modal	3	1.325	1.102	0.755	0.907

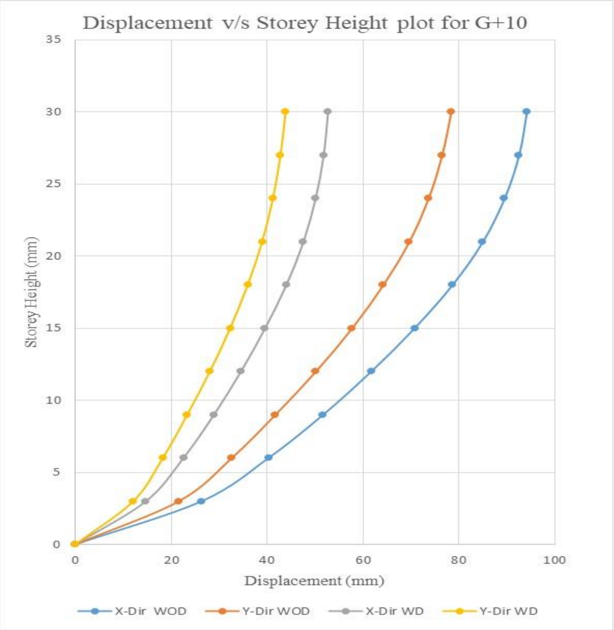

Fig: 11 Displacement v/s storey Height for G+10 building

a) The graph above shows displacement v/s height of the building for G + 10 building with dampers applied at alternate storeys.
b) The permissible displacement as per IS code is (H/500) i.e, (30000/500) = 60mm
c) The maximum displacement obtained is 52.72mm in X-direction.
d) The displacement obtained was 94.14mm without dampers and with the application of dampers the displacement has been reduced to 52.72mm.
e) Application of viscous dampers have reduced the displacement by 44.65%

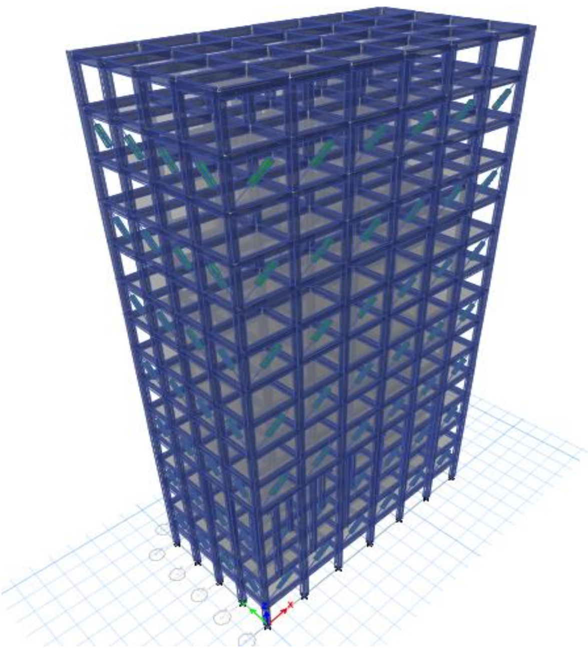

Fig: 12 G+15 Building with dampers applied at alternate storey

Table 07: Displacement of G + 15 Building

Storey	Elevation (m)	Displacement (mm) without dampers		Displacement (mm) With dampers	
		X-Dir	Y-Dir	X-Dir	Y-Dir
15	45	138.13	124.65	74.59	67.31
14	41	135.1	120.69	72.96	65.17
13	39	130.5	115.53	70.47	62.39
12	36	124.72	109.49	67.35	59.13
11	33	118.37	104.09	63.92	56.21
10	30	112.13	99.54	60.55	53.75
9	27	106.4	94.05	57.45	50.79
8	24	100.11	87.52	54.06	47.26
7	21	93.65	80.23	50.57	43.33
6	18	86.49	72.78	46.7	39.3
5	15	78.33	64.86	42.3	35.03
4	12	69	56.63	37.26	30.58
3	9	58.15	47.37	31.4	25.58
2	6	45.67	37.09	24.66	20.03
1	3	30.04	24.76	16.22	13.37
0	0	0	0	0	0

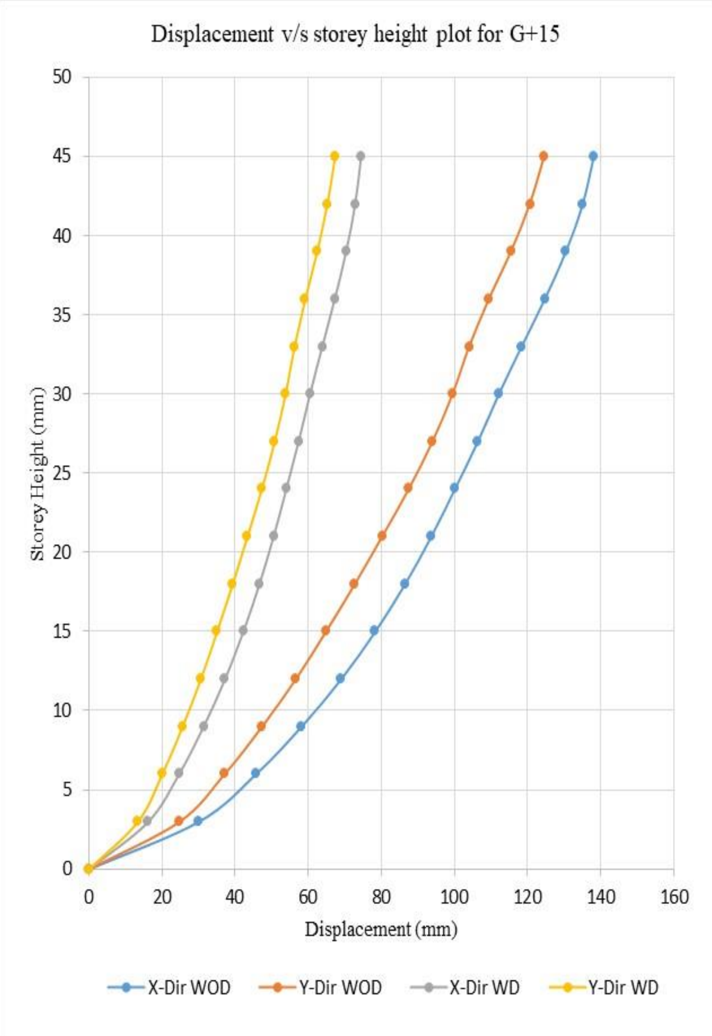

Fig: 13 Displacement v/s storey Height for G+15 building

Table 08: Modal Parameters of G + 15 building

CASE	Modes	Time period (secs)		Frequency (cycles/sec)	
		WOD	WD	WOD	WD
Modal	1	2.083	1.925	0.48	0.519
Modal	2	2.019	1.836	0.495	0.544
Modal	3	1.868	1.662	0.535	0.601

a) The graph above shows displacement v/s height of the building for G + 15 building with dampers applied at alternate storeys.
a) The permissible displacement as per IS code is (H/500) i.e., (45000/500) = 90mm
b) The maximum displacement obtained is 74.59mm in X-direction.
c) The displacement obtained was 138.12mm without dampers and with the application of dampers the displacement has been reduced to 74.59mm.
d) Application of viscous dampers have reduced the displacement by 46%

CONCLUSION:

a) The study shows that the structure evaluated with the application of dampers to be efficient and Viscous dampers can serve as better energy dissipating device.
b) It can be concluded that, with the application of viscous dampers the seismic performance of the structures can be improved against earthquakes.
c) The seismic responses such as Displacement, drift increases as the seismic zones changes for II to V.
d) Non-Linear dynamic analysis shows the actual response of the structure subjected to earthquakes.
e) The building models considered for the study shows higher responses during Non-Linear dynamic analysis and by application of dampers the responses have been reduced under permissible limit.
f) In G+5 building with the application of Viscous dampers we can see a reduction of displacement by 42%.
g) In G+10 building with the application of Viscous dampers we can see a reduction of displacement by 44.65%.
h) In G+15 building with the application of Viscous dampers we can see a reduction of displacement by 46%.
i) Storey drift of all the buildings is within the permissible limit of 0.004H.
j) Application of Viscous dampers significantly increases the stability and stiffness of the structures.

REFERENCES:

[1] “seismic design of multistorey RCC building with dampers using etabs.”b .naresh , j .omprakash p.g. student, department of civil engineering, dr. k. v .subba reddy institute of technology, duapdu, andhra pradesh, india (vol. 7, issue 1, January 2018).

[2] “seismic performance of steel moment-resisting frame retrofitted with linear and nonlinear viscous dampers” bryan chalarca, andré filiatrault, daniele perrone(2019), university school for advanced studies iuss pavia, pavia, Italy.

[3] “performance of fluid viscous dampers on seismic response of rcc structures md mujeeb, j s r prasad, venu malagavelli (international journal of innovative technology and exploring engineering (ijitee) issn: 2278-3075, volume-8 issue-12, october, 2019)

[4] “seismic analysis of multi storey rc building with and without fluid viscous damper” varun m, b s suresh chandra (international journal of trend in scientific research and development (ijtsrd) volume 4 issue 6, september-october 2020.

[5] “study on the effect of viscous damper for rcc frame structure” puneeth sajjan, praveen biradar student, department of civil engineering, blde cet, vijaypur, karnataka, india volume: 05 issue: 09 | sep-2016.

[6] “seismic response of rc structures using different types of dampers”, k. jaya gayathrri dhevi & dr. k rama mohana rao post graduate student, department of civil engineering, jawaharlal nehru technological university, kukatpally, hyderabad 2018

[7] “analysis of building using viscous dampers in seismic zone-v”abhishek kumar maurya, v.k. singh, international journal of advances in mechanical and civil engineering, issn: 2394-2827 volume-5, issue-3, jun.-2018.

[8] “seismic analysis of building using dampers in shear walls “. kapil p. gunjal , prof. sanket s. sangha, international journal of innovations in engineering and science, vol. 4, no.6, 2019.