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Analysis and Design of Multi Storied Building for Vertical and Horizontal Loading with and Without Dampers

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ABSTRACT: Dampers are strategically placed in the building structure to control floor vibrations and building displacement, cater for occupancy comfort and mitigate against major seismic events. The energy generated by floor vibration and building displacement is absorbed by the dampers and dissipated though heat energy. The most crucial factor to take into account while designing any construction is earthquake. The majority of structures experience vibration during an earthquake.. 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. Using the acceleration data from the Cheerapunji earthquake, Dynamic Non-linear (Time-History technique) analysis is performed on three structures (G+5, G+10, and G+15).

KEYWORDS: Seismic Analysis, Earthquake, Dampers, Storey Drift, Displacement, Time History Method

I. INTRODUCTION

Natural disasters are inevitable and it is not possible to get full control over them. The history of human civilization reveals that man has been combating with natural disasters from its origin but natural disasters like floods, cyclones, earthquakes, volcanic eruptions have various times not only disturbed the normal life pattern but also caused huge losses to life and property and interrupted the process of development. With the technological advancement man tried to combat with these natural disasters through various ways like developing early warning systems for disasters, adopting new prevention measures, proper relief and rescue measures. But unfortunately, it is not true for all natural disasters. Earthquakes are one of such disaster that is related with ongoing tectonic process; it suddenly comes for seconds and causes great loss of life and property. So earthquake disaster prevention and reduction strategy is a global concern today. Hazard maps indicating seismic zones in seismic code are revised from time to time which leads to additional base shear demand on existing buildings. Retrofitting reduces the vulnerability of damage of an existing structure during future earthquakes. It aims to strengthen a structure to satisfy the requirements of the current codes for seismic design. In this thesis, a methodology has been proposed for retrofit of existing buildings for additional base shear demand and serviceability requirement using viscoelastic dampers. Seismic zone map in Indian standard IS 1893 Part 1 2002 is being revised from time to time which leads to increase in elastic demands on existing buildings. Base shears for a typical low rise (three storey) and high rise (twenty storey) buildings for zone 2, zone 3, zone 4 and zone 5 for hard soil condition are estimated using seismic coefficient method and time history analysis with spectrum compatible acceleration. Number of viscoelastic dampers and damping ratio required for different cases are worked out and the comparisons are made. The common practice to strengthen existing buildings is to strengthen members and joints with concrete or steel jacketing and to increase the size of the structural members so as to meet the new design requirements. However, it is a time-consuming process and requires demolition of plastering of members, further it may cause pollution to the environment.

II. LITERATURE REVIEW

[1] Seismic Design of Multistorey RCC-Building with Dampers Using ETABS (2018)- The basic principles of design for vertical and lateral loads (wind & seismic) are the same for low, medium or high-rise building. But a building gets high both vertical & lateral loads become controlling factors. The vertical loads increase in direct proportion to the floor area and number of floors. In contrast to this, the effect of lateral loads on a building is not linear and increase rapidly with increase in height. Due to these lateral loads, moments on steel components will be very high. By providing viscous dampers these moments can be reduced. In the present analysis, a residential building with 20 floors is analysed with columns, columns with viscous dampers at different locations were for all the 2 cases. The building is analysed in Zone 3 & Zone 5 with three soils in both static Analysis. Displacement was compared for all the cases. It is observed that the deflection was reduced by providing the Viscous dampers. Displacement is compared for two models i.e,, without dampers & with dampers at top storey of a high rise building in zone-2 & zone -5 in each soil it is observed that 50% displacement is reduced when the dampers are provided at each elevation. By providing the dampers the stiffness of the structure is increased and storey shear is decreased with increase in height of structure.

[2] Analysis and Design of Multi Storied Building For Vertical And Horizontal Loading With And Without Dampers (2018)- Damping plays important feature in format of Earthquake Resistant Structures, which reduces the response of the structure while they are subjected to lateral loads. There are many particular sorts of dampers in use. In the prevailing have a study Fluid Viscous dampers (FVD) are used to evaluate the reaction of RC buildings. The major task of a shape is to undergo the lateral loads and switch them to the foundation. Since the lateral loads imposed on a structure are dynamic in nature, they motive vibrations in the shape. In order to have earthquake resistant systems, fluid viscous dampers have been used. Buildings having square and rectangular plans, with rectangular and rectangular column pass- sections are analyzed, with and with out FVD. In the prevailing take a look at the software program ETABS 2015 had been used. Using Push over and Time facts analyses the reaction of the RC constructing taken into consideration in the present test is evaluated and as compared with and without FVD.

[3] Analysis and Design of Multi Storied Building for Vertical and Horizontal Loading with and Without Dampers using SAP2000 (2016)- The current trend toward buildings of ever-increasing heights and the use of lightweight, high strength materials, and advanced construction techniques have led to increasingly flexible and lightly damped structures. Understandably, these structures are very sensitive to environmental excitations such as wind, ocean waves and earthquakes. In this study a Tuned mass damper proposed as energy dissipation devices for buildings subjected to earthquake loads. The springs of the Tuned mass damper are placed between the structure and the mass of the damper to eliminate or minimize the damage due to earthquake loads. To reduce the response of displacement, The Tuned mass damper are introduced as energy dissipation devices. The Tuned mass damper (with spring and dashpot) is sufficiently flexible to reduce the response of acceleration. A TMD system using spring units and visco-elastic dampers can reduce vibration in a building, and it is become more safety during the earthquakes. For applying this system in India, it is necessary to confirm the seismic safety. At first static loading tests of the spring units and dynamic loading tests of a visco-elastic damper were carried out.

[4] Design and Analysis of Seismic Forces in Multi-Storey Building with Water Tank as Liquid Damper (2017)- The principle objective of this project is to analyse and design a multi-storeyed building G+10 (3 dimensional frame) using ETABS 2015. The design involves load calculations manually and analyzing the whole structure by ETABS 2015. The design methods used in ETABS 2015 analysis are Limit State Design conforming to Indian Standard Code of Practice. ETABS features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities.

[5] Dynamic Analysis of a Steel Structure for Horizontal and Vertical Loading with and Without Dampers (2018)- Earthquakes are the most capricious and destroying of every single catastrophic event, which are extremely hard to spare over building properties and life, against it. Thus so as to beat these issues we have to recognize the seismic execution of the fabricated condition through the improvement of different explanatory strategies, which guarantee the structures to withstand amid visit minor tremors and create enough alert at whatever point subjected to real quake occasions. So that can spare however many lives as could be expected under the circumstances. There are a few rules everywhere throughout the world which has been over and again refreshing on this subject.

III. AIM & OBJECTIVES

3.1 AIM

To analysis and design of multi storied building for vertical and horizontal loading with and without dampers.

3.2 OBJECTIVES

- The analytical models created by SAP 2000 program with and without damper to study the behaviour of the building and the responses of it after subjected to earthquake load.
- To study the Seismic behaviour of building with and without dampers.
- To evaluate seismic responses such as Displacement, Storey drift and modal Parameters.

IV. PROPOSED METHODOLOGY

4.1 BUILDING DETAILS

Table 4.1: Geometric details of the building (G+5)

Storey height	3 m
Height of the building	15 m
Size of column	400 mm× 400 mm
No. of bays in X direction	6
No. of bays in Y direction	4
Spacing of bays in X direction	4 m
Spacing of bays in Y direction	3 m
Size of beam	200 mm× 500 mm
Thickness of slab	150 mm
Grade of concrete	M 25
Grade of steel	Fe 500
Live load (kN/m^2)	2
Floor finish (kN/m^2)	1
Roof load (kN/m^2)	1.5
Damping ratio	5%

Table 4.2: Geometric details of the building (G+10)

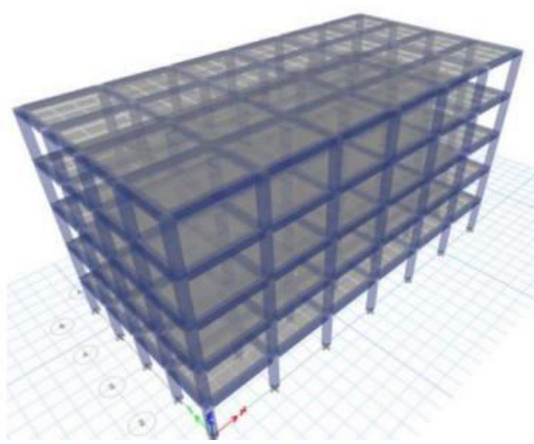
Storey height	3 m
Height of the building	30 m
Size of column	500 mm× 500 mm
No. of bays in X direction	6
No. of bays in Y direction	4
Spacing of bays in X direction	4 m
Spacing of bays in Y direction	3 m
Size of beam	200 mm× 500 mm
Thickness of slab	200 mm
Grade of concrete	M 25
Grade of steel	Fe 500

Live load (kN/m^2)	2
Floor finish (kN/m^2)	1
Roof load (kN/m^2)	1.5
Damping ratio	5%

Table 4.3: Geometric details of the building (G+15)

Storey height	**3 m**
Height of the building	45 m
Size of column	500 mm× 500 mm
No. of bays in X direction	6
No. of bays in Y direction	4
Spacing of bays in X direction	4 m
Spacing of bays in Y direction	3 m
Size of beam	200 mm× 500 mm
Thickness of slab	200 mm
Grade of concrete	M 25
Grade of steel	Fe 500
Live load (kN/m^2)	2
Floor finish (kN/m^2)	1
Roof load (kN/m^2)	1.5
Damping ratio	5%

4.2 STRUCTURAL MODELING



[Fig.4.1: 3D view of G+5 building]

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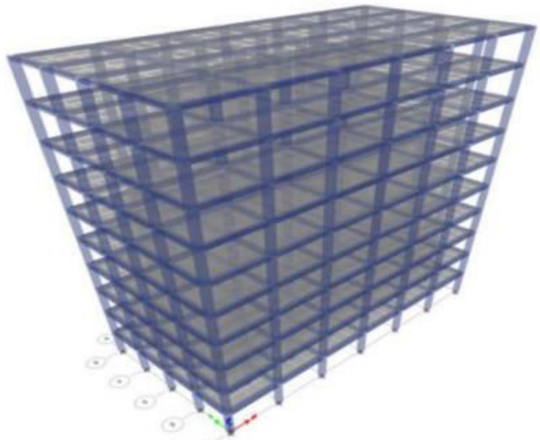
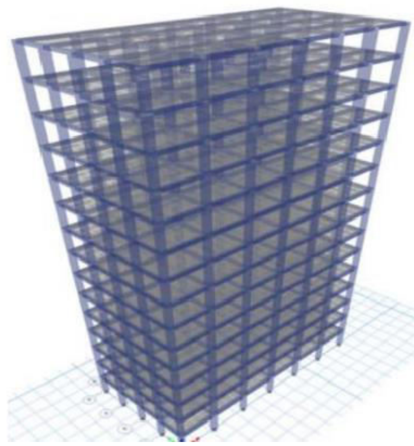


[Fig.4.2: 3D view of G+10 building]



[Fig.4.3: 3D view of G+15 building]

Table 4.4: Damper Properties

Models	K (kN/m)	Mass(kN)
G+5	62426.065	48
G+10	72841.590	62
G+15	82692.898	79

V. RESULTS& DISCUSSION

5.1 DISPLACEMENT CALCULATIONS

5.1.1 Displacement of G+5 Building

Table 5.1: Displacement of G+5 Building

Storey	Elevation (m)	Displacement (mm) without dampers X- Direction	Displacement (mm) without dampers Y- Direction	Displacement (mm) With dampers X- Direction	Displacement (mm) With dampers Y- Direction
5	15	44.15	39.98	26.63	23.59
4	12	39.70	35.36	23.04	20.84

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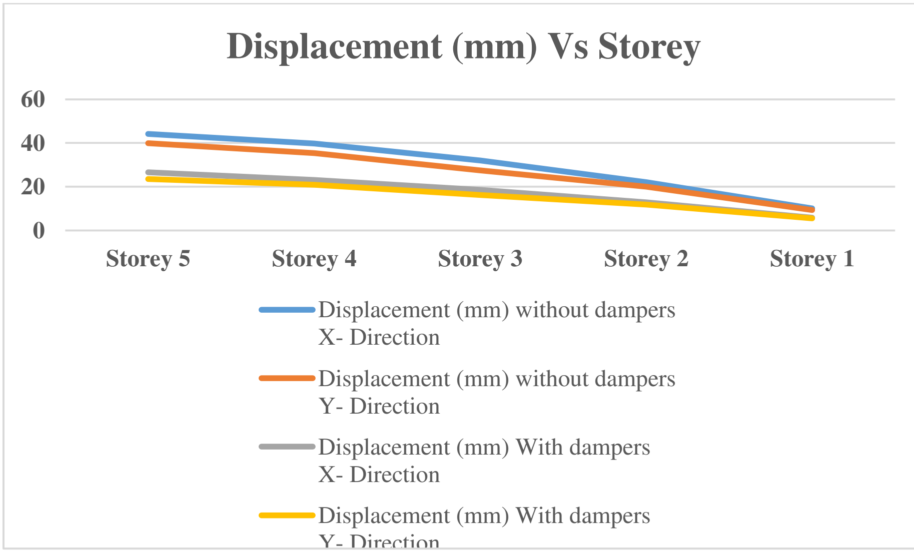
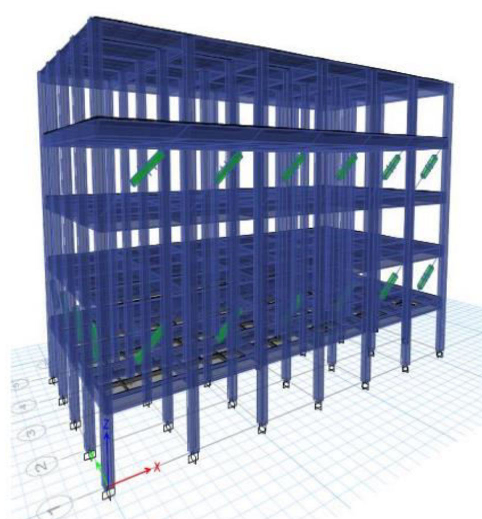
3	9	31.96	27.48	18.55	16.23
2	6	22.05	20.00	12.79	11.80
1	3	10.04	9.26	5.83	5.46
0	0	0	0	0	0



[Fig.5.1: Displacement v/s storey Height for G+5 building]



[Fig.5.2: G+5 Building with dampers applied at alternate storey]

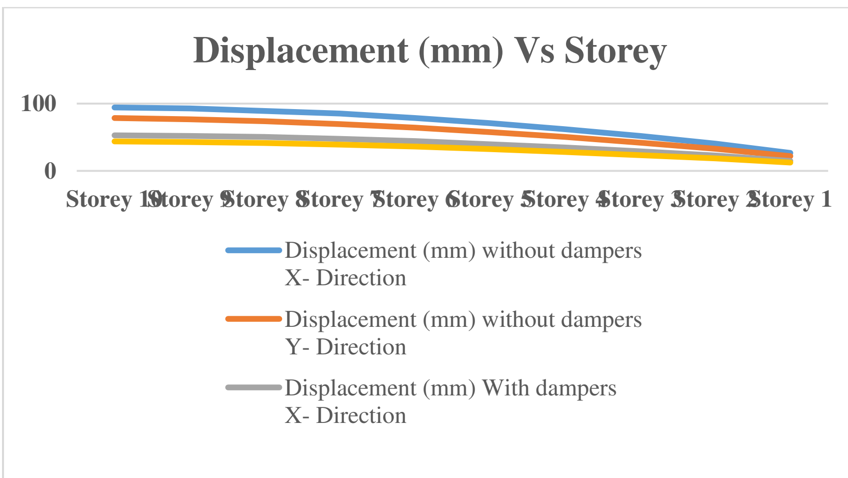
Table 5.2: Modal Parameters of G+5 building

CASE	Modes	Time period (secs) WOD	Time period (secs) WD	Frequency (cycles/sec) WOD	Frequency (cycles/sec) WD
Modal	1	0.75	0.54	1.315	1.887
Modal	2	0.716	0.512	1.392	1.954
Modal	3	0.68	0.47	1.492	2.126

5.1.2 Displacement of G+10 Building

Table 5.3: Displacement of G+10 Building

Storey	Elevation (m)	Displacement (mm) without dampers X- Direction	Displacement (mm) without dampers Y- Direction	Displacement (mm) With dampers X- Direction	Displacement (mm) With dampers Y- Direction
10	30	94.15	78.35	52.71	43.88
9	27	92.54	76.46	51.81	42.82
8	24	89.16	73.64	50.14	41.24
7	21	85.02	69.62	47.62	38.99
6	18	78.67	64.24	44.06	35.96
5	15	70.75	57.73	39.63	32.33
4	12	61.72	50.16	34.58	28.08
3	9	51.67	41.73	28.95	23.37
2	6	40.30	32.65	22.58	18.27
1	3	26.35	21.60	14.59	12.08
0	0	0	0	0	0



[Fig.5.3: Displacement v/s storey Height for G+10 building]

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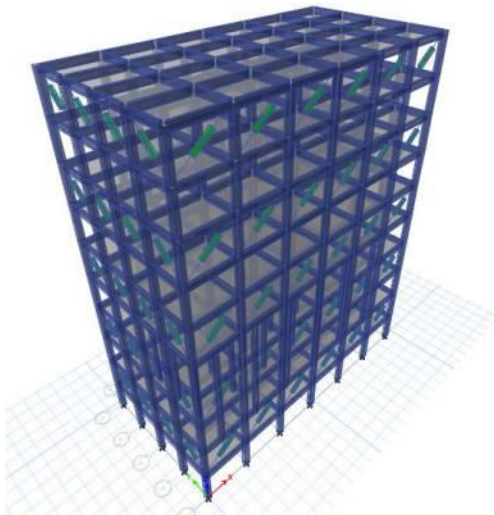

[Fig.5.4: G+10 Building with dampers applied at alternate storey]

Table 5.4: Modal Parameters of G+10 building

CASE	Modes	Time period (secs) WOD	Time period (secs) WD	Frequency (cycles/sec) WOD	Frequency (cycles/sec) WD
Modal	1	1.525	1.236	0.656	0.809
Modal	2	1.41	1.225	0.704	0.815
Modal	3	1.325	1.101	0.755	0.906

5.1.3 Displacement of G+15 Building

Table 5.5: Displacement of G+15 Building

Storey	Elevation (m)	Displacement (mm) without dampers X- Direction	Displacement (mm) without dampers Y- Direction	Displacement (mm) With dampers X- Direction	Displacement (mm) With dampers Y- Direction
15	45	138.12	124.66	74.59	67.32
14	41	135.10	120.70	72.96	65.16
13	39	130.50	115.54	70.46	62.39
12	36	124.73	109.50	67.35	59.13
11	33	118.36	104.09	63.92	56.22
10	30	112.14	99.55	60.56	53.76
9	27	106.45	94.05	57.46	50.78
8	24	100.12	87.53	54.05	47.25
7	21	93.65	80.23	50.07	43.32
6	18	86.49	72.79	46.70	39.30
5	15	78.32	64.85	42.30	35.03
4	12	69	56.64	37.26	30.59
3	9	58.14	47.38	31.45	25.59
2	6	45.66	37.08	24.65	20.04
1	3	30.04	24.75	16.23	13.36
0	0	0	0	0	0

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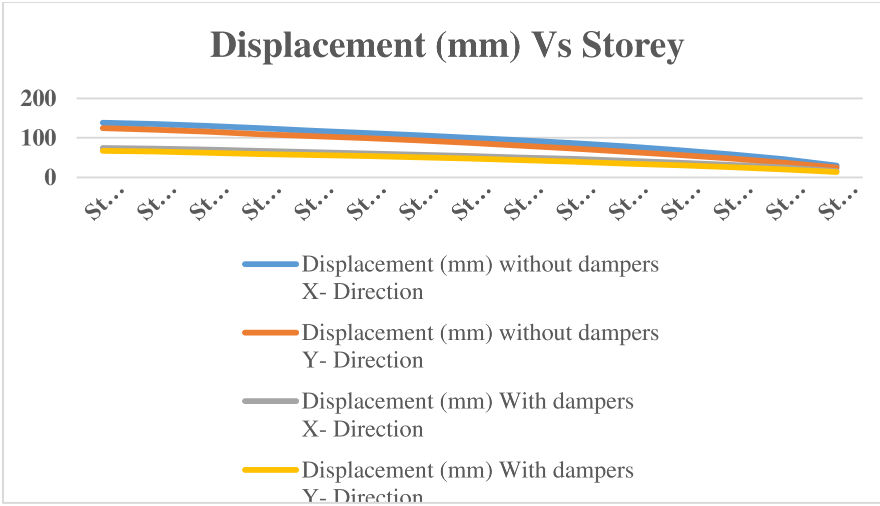
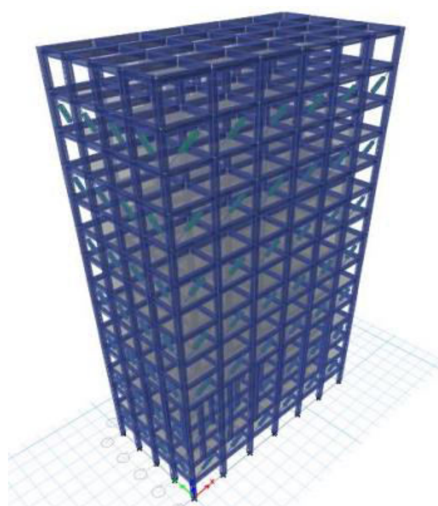


[Fig.5.5: Displacement v/s storey Height for G+15 building]



[Fig.5.6: G+15 Building with dampers applied at alternate storey]

Table 5.6: Modal Parameters of G+15 building

CASE	Modes	Time period (secs) WOD	Time period (secs) WD	Frequency (cycles/sec) WOD	Frequency (cycles/sec) WD
Modal	1	2.082	1.925	0.48	0.518
Modal	2	2.019	1.836	0.495	0.545
Modal	3	1.868	1.662	0.532	0.602

VI.CONCLUSION

- 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.
- It can be concluded that, with the application of viscous dampers the seismic performance of the structures can be improved against earthquakes.

- The seismic responses such as Displacement, drift increases as the seismic zones changes for II to V.
- Non-Linear dynamic analysis shows the actual response of the structure subjected to earthquakes.
- 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.
- In G+5 building with the application of Viscous dampers we can see a reduction of displacement by 42%.
- 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%.
- Storey drift of all the buildings is within the permissible limit of 0.004H.
- Application of Viscous dampers significantly increases the stability and stiffness of the structures.

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