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COMPARATIVE STUDY OF SEISMIC ANALYSIS OF BUILDING USING VARIOUS EARTHQUAKE RESISTANT SYSTEMS BY TIME HISTORY METHOD

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Abstract - In the events like earthquake safety of people in a building depends first on capacity of building to resist earthquake shaking and then stands upright after the earthquake without or with few damage and maintenance. Various Elements like dampers, base isolators, shear wall, elevated water tank, etc., are use to dissipation of energy. Effectiveness of these elements is based on its type and position of these elements. In this research paper, seismic analysis of G+9 , G+15, G+20 storey residential structure is studied based on Storey displacement and storey drift of structure by Time History Method. Time history data is obtained From PEER Ground Motion Database. Based on maximum storey displacement and maximum storey drift, effect of cross bracing, Fluid viscous damper, shear wall and base isolation is compared with Ordinary moment resisting structure is studied. Effective and suitable model is found out by placing these elements at the corner of Structure in different models.

Key Words: storey displacement, maximum storey drift, time history analysis, cross bracing, Fluid Viscous damper, base isolation

1. INTRODUCTION

Dynamic actions like wind and earthquakes have major impact on buildings. But, design for wind forces and for earthquake effects are distinctly different. Controlling the damage of structural element and sequence of damage in various structural elements is the main focus of earthquake resistant design of structure. Safety of people in a building depends first on the capability building to resist movements due to earthquake, and then on standing upright after the earthquake without or with few damage and maintenance. Losses due to building collapses can be reduce and protecting contents, services & utilities of buildings. Various Elements are use to dissipation of energy; also to control systems into structures to reduce excessive structural vibration. Seismic effect on building can be reduce by using non structural elements or components like dampers, isolators, elevated water tank. Out of various seismic resisting elements Bracing, base isolation and dampers are effective and these are more commonly used. Effectiveness of these elements is based on its type and position of these elements. As per various research papers, Out of different bracings cross bracing is most effective; Fluid Viscous damper in dampers and Lead Rubber Bearing (LRB) type of base isolators are most effective. Storey displacement is displacement of a storey with respect to base of a structure. Whereas storey drift is the ratio of displacement of two consecutive floor to height of that floor.

Objectives of study :-

i. Compare ordinary moment resisting structure with structure with Fluid viscous damper, cross Bracing, shear wall and LRB Base isolation.
ii. Study behaviour of these models on basis of storey displacement. Obtain effective type of model in case of maximum storey displacement.
iii. Study behaviour of these models on basis of storey drift. Obtain effective type of model in case of maximum storey drift.

2. MODELLING AND ANALYSIS

A square shaped (G+9), (G+15) and (G+20) storey residential buildings are modelled and analysed in ETABS Software using conventional columns, beams & slabs as shown in fig. As per IS:1893(Part-1) -2002 Dead load, Live load and Seismic loads are considered. These models are analyzed using Time History Analysis Method for Severe intensity earthquake (zone IV). The details of the modeled building are listed below.

Fig.1: Architectural plan

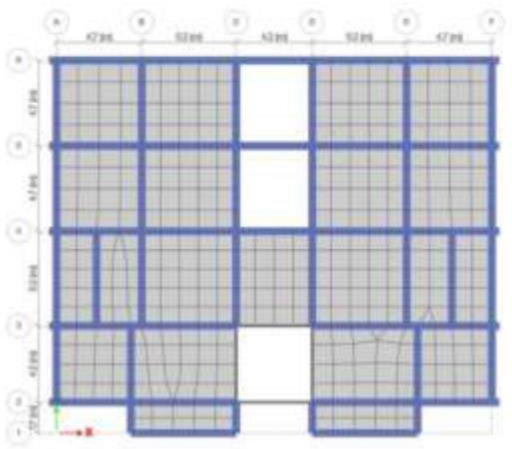


Fig.2: Centerline plan

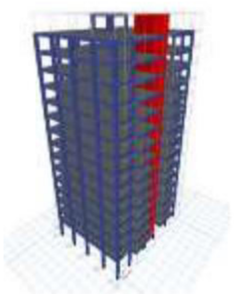
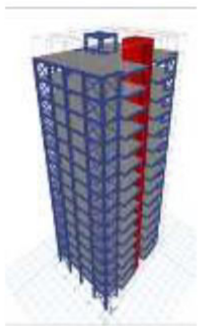
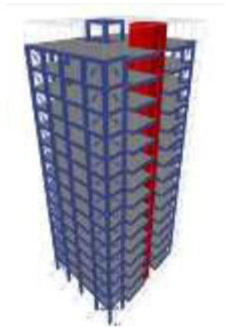




Fig.3: Base Isolation **Fig.4:** Cross Bracing **Fig.5:** FV damper

Table 1: Model Details

Type of Model	G+9 Storey	G+15 Storey	G+20 Storey
Floor to floor height (in mm)	3000	3000	3000
Beam size (mm x mm)	450x350	500x400	600x450
Column size (mm x mm)	600x350	800x400	1000x450
Slab thickness (in mm)	125	125	125
Grade of concrete	M25	M25	M25
Seismic Zone (z)	0.24	0.24	0.24
Importance factor (I)	1	1	1
Soil Type	Medium Type 2	Medium Type 2	Medium Type 2
Base Isolation	LRB base isolator	LRB base isolator	LRB base isolator
Damper	Fluid Viscous Damper	Fluid Viscous Damper	Fluid Viscous Damper
Bracing	Cross Bracing	Cross Bracing	Cross Bracing

Different Loads :-

i. Dead Load (DL) = Self weight of Slab, beam and column (generated by Etabs software)

ii. Live load (LL) = 3 kN/m2

iii. Super dead load (SDL)

a. Floor finish = 1.5 kN/m2

b. Masonary = 1.8 kN/m2

iv. Time History data = CORRALIT , From PEER Ground Motion Database

Specifications :-

i. Base isolation

Effective stiffness U1 – 11.75 * 105 kN/m
Effective stiffness U2 & U3 – 1175.42 kN/m
Yield Strength U2 & U3 – 34.7 kN Effective damping – 5%

ii. Bracing

Type – cross bracing
Section – angle section 150*150*15

iii. Damper

Type – Fluid Viscous Damper (FVD)
Mass – 44kg
Weight – 250
Directional property – U1 Fixed

Load combinations :-

Based on IS 1893-2002,

i. 1.5 (DL + LL + SDL)

ii. 1.2 (DL + LL + SDL ± EQX)

iii. 1.2 (DL + LL + SDL ± EQY)

iv. 1.5 (DL + SDL ± EQX)

v. 1.5 (DL+ SDL ± EQY)

vi. 0.9 DL + 0.9 SDL ± 1.5 EQX

vii. 0.9 DL + 0.9 SDL ± 1.5 EQY

Methodology:-

i. Modelling of structure in Etabs. Defining Material properties for concrete and Reinforcement bars.

ii. Defining Section properties to all sections of proper size with proper properties. For dampers, base isolation define proper link properties.

iii. Assign links as per requirement of damper or base isolation or bracing. Assign supports to structure.

iv. Define mass source.

v. Define and Assign Loads to respective members.

vi. Define time history function. Use proper time history data with required number of steps. Assign time history function in load cases.

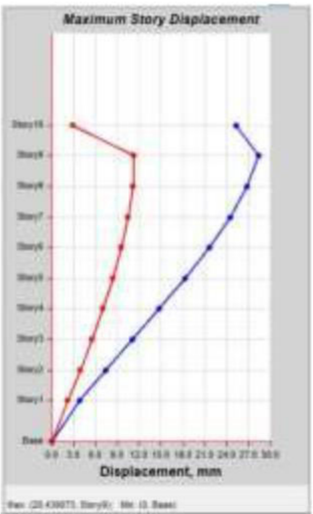
vii. Checking the Model. Then performing analysis on model.

viii. Obtain required parameters like maximum storey displacement , maximum storey drift, maximum storey shear, maximum storey overturning moment.

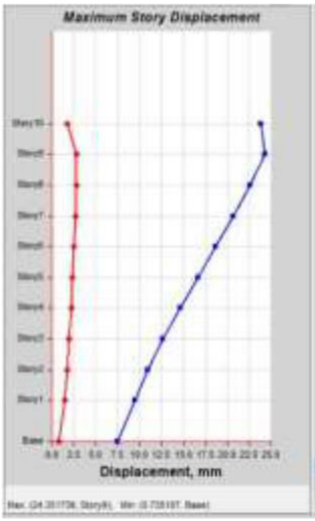
3. RESULT AND DISCUSSION

3.1 Maximum Storey Displacement

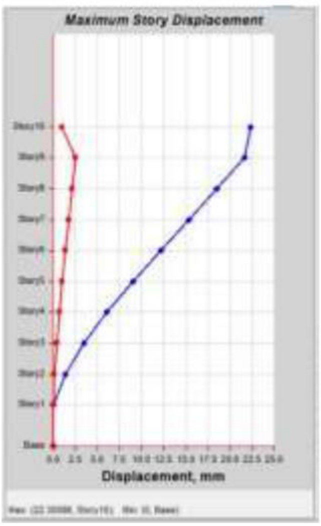
Storey displacement is the absolute value of displacement of the storey under the action of lateral force. It is a critical parameter for structural evaluation or design. The magnitude of lateral displacement indicates the damage state and the vulnerability of the building. Following graphs shows Storey displacement of G+9 Storey building,



(a)



(b)



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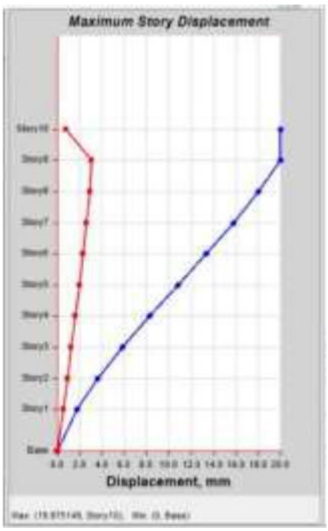
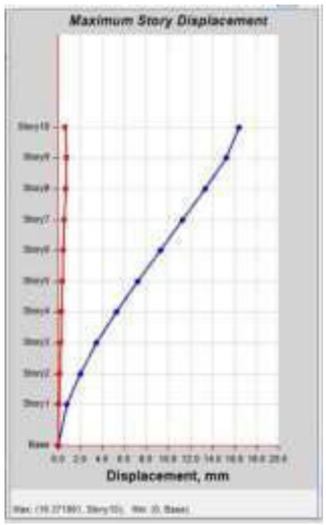


(d)



(e)

Fig 6: Storey Displacement for a, b, c, d & e G+9 structure respectively.

For G+9 Storey structure, Maximum Story Displacement can be obtained From above graphs. Similarly for G+15 and for G+20 structures Maximum Story Displacement is obtained and shown in table below,

Table 2: Maximum Storey Displacement

	Ordinary Moment resisting Building (a)	With Base Isolation (b)	With Fluid Viscous Damper (c)	With Cross Bracing (d)	With shear wall (e)
G+9	28.4390	24.351	22.3001	19.9751	16.371
G+15	40.5128	39.577	38.0697	32.8450	29.061
G+20	43.8385	41.128	44.4286	38.5299	34.648

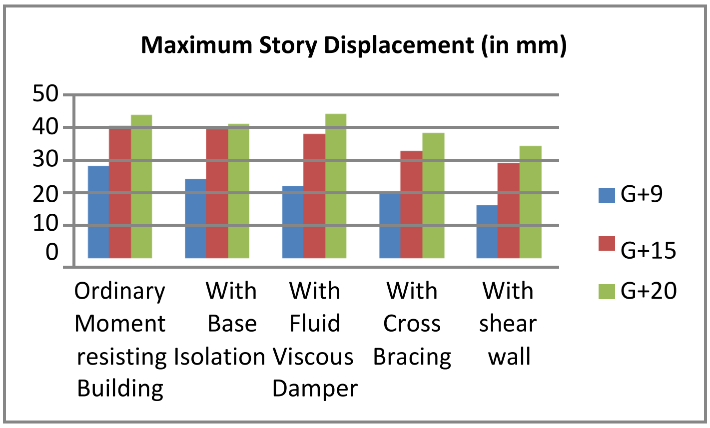


Fig 7: Maximum storey displacement for G+9, G+15 & G+20 model

From above charts and graphs, we can clearly observe that, Storey displacement is zero or nearly zero at base of structure and maximum at top of structure. Thus Storey displacement increases with increase in storey level.

In ordinary moment resisting building, for G+9 structure maximum displacement is 28.439 mm, for 15 storey, it is 40.5mm and for 20 stories it is 43.83mm.

For G+9 storey structure with Base isolation, it decreases by 14.3% ; for G+15 and G+20 structure, it decreases by 2.3% & 6.3% respectively.

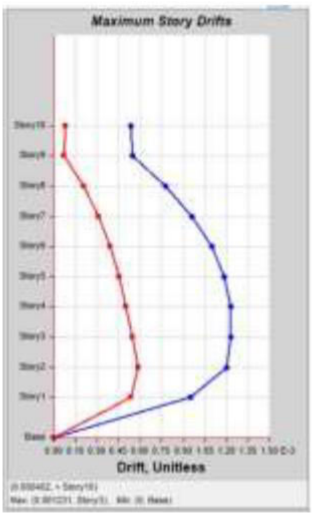
For G+9 storey structure with Fluid Viscous Damper, it decreases 21.58% ; for G+15 and G+20 structure, it decreases 6.03% & 1.34% respectively.

For G+9 storey structure with Cross Bracing, it decreases 29.76% ; for G+15 and G+20 structure, it decreases 18.9% & 12.1% respectively.

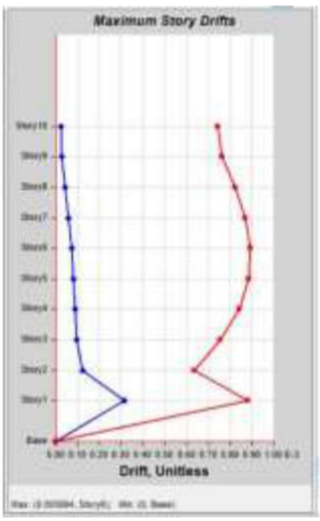
For G+9 storey structure with shear wall, it decreases 42.4% ; for G+15 and G+20 structure, it decreases 28.2% & 20.9% respectively.

3.2 Maximum Storey Drift

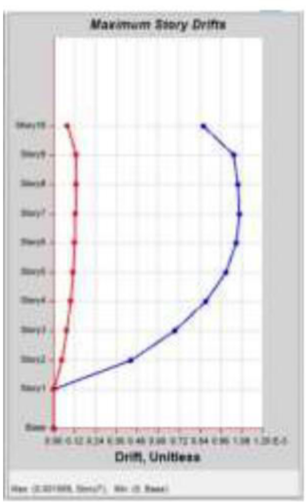
Storey drift is the difference between displacement at top storey and displacement at bottom storey respect to the height of storey. In other words, Storey drift is the drift of one level of a multistory building relative to the level below.



(a)



(b)



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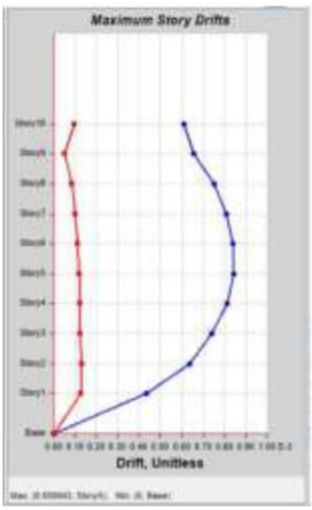

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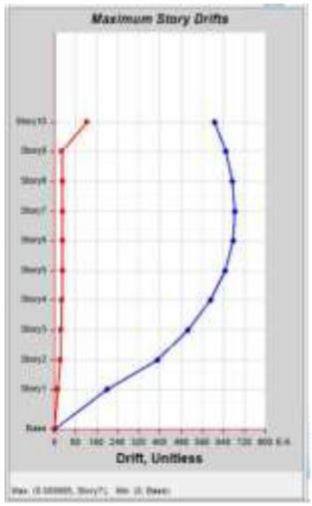

(e)

Fig 8: Storey drift for a, b, c, d & e G+9 strucure respectively

For G+9 Storey structure Maximum Story Drift can be obtained From above graphs, similarly for G+15 and for G+20 structures Maximum Story Drift is obtained and shown in table below,

Table 3:- Maximum Story Drift (10^-3)

	Ordinary Moment resisting Building (a)	With Base Isolation (b)	With Fluid Viscous Damper (c)	With Cross Bracing (d)	With shear wall (e)
G+9	1.231	0.894	1.069	0.843	0.685
G+15	1.151	1.009	1.07	0.863	0.764
G+20	0.892	0.813	0.946	0.77	0.701

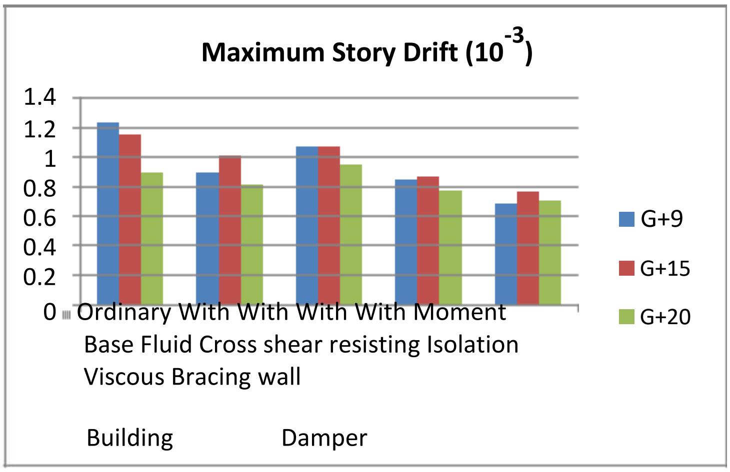

Fig 9: Max. storey drift of G+9, G+15 & G+20 model

From above charts and graphs, we can clearly observe that, Storey drift is zero or nearly zero at base of structure and increases for few stories and decreases further.

In ordinary moment resisting building, for G+9 structure maximum drift is 1.231*10^-3, for 15 storey and for 20 stories, it is 1.151*10^-3 & 0.892*10^-3 respectively.

For G+9 storey structure with Base isolation, it decreases 27.37% ; for G+15 and G+20 structure, it decreases 12.33% & 8.85% respectively. But in this case, due to Base isolators, only base and 1st story moves continuesly and suddenly decreases from storey 2 and above.

For G+9 storey structure with Fluid Viscous Damper, it decreases 13.16% ; for G+15, it decreases 7.03%. But for G+20 structure, it increases 6.05% to 0.946*10^-3.

For G+9 storey structure with Cross Bracing, it decreases 31.51% ; for G+15 and G+20 structure, it decreases 25.02% & 13.67% respectively.

For G+9 storey structure with shear wall, it decreases 44.35% ; for G+15 and G+20 structure, it decreases 33.62% & 21.41% respectively.

4. CONCLUSION

i. Maximum Storey displacement increases with increase in storey level.

ii. As compared to Ordinary Moment resisting structure, for G+9, G+15 and G+20 storey structure, the maximum reduction in maximum storey displacement occurs in structure with shear wall, then with cross bracing, then with Fluid Viscous Damper, and with Base isolation.

iii. Structure with shear wall reduces 42.4% storey displacement and is suitable out of other seismic resisting components on basis of maximum storey displacement only.

iv. Maximum Storey drift increases with increase in storey level.

v. As compared to Ordinary Moment resisting structure, for G+9, G+15 and G+20 storey structure, the maximum reduction in maximum storey displacement occurs in structure with shear wall, then with cross bracing, then with Base isolation and with Fluid Viscous Damper.

vi. Structure with shear wall reduces 44.35% storey drift and is suitable out of other seismic resisting components on basis of maximum storey drift only.

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