Nonlinear analysis on RCC Building having different Shapes of Projection and Vertical Irregularities

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Abstract: In the present scenario, many structures with large hanging or projection parts are planned and constructed for architectural view which creates complexities. Geometry of the structure decides the behavior of structure during earthquake. Structures with large hanging parts are very vulnerable to seismic effect because of load transfer mechanism which is different from regular buildings. In this paper to verify the effect of earthquake force on different projection type modals keeping the projection area different and also mass distribution and geometric orientation of projection is different. Initially building with various heights such as G+4, G+9 and G+14 is modeled then different type of projection at alternate floor is applied and analysed for seismic zone III with the help of ETABS. Result of different models shows the response parameters and its difference are compared graphically to determine behaviour of structure.

Index Terms **– Alternate Floor Projection in building, Symmetrical Shapes, H:Shapes, +:Shapes, H+:Shapes, Asymmetrical Shapes, Response Spectrum, Time History, ETABS.**

I. INTRODUCTION

Present day construction technology in which leading concern is given for architectural and aesthetic importance. These need shaping most of multistoried buildings having open ground storey as prime feature used for parking area, reception and other needs. Increase in trend of constructing structure to fulfill such type of need leads to irregular structures such as large projection, discontinuity in structural member etc. becomes vulnerable during earthquake. It is tedious procedure of calculation to understand the behavior of structure because even if area of building is same but due to change in mass distribution and geometric orientation affect the behavior of building. Various Parameters such as soil condition, geographical location and seismic zone factor affect the structure due to ground vibration and lateral force.

In modern days there is different computer aided analysis and designing software are available. In past study work has been carried out for floating column but to understand the response structure due to discontinuity in structural member and large projection, hypothetical modeling developed and analyzed with the help of ETABS software. Attempt has been made to create hypothetical situation and compare the response of three symmetrical and one asymmetrical buildings having alternate floor projection with different geometric orientation.

By creating virtual model in ETABS software different projection combinations are applied due to difference in geometry and predict the behavioral change and for such complex and unsymmetrical structure Response Spectrum and Time History method is required.

II. OBJECTIVES

- To check response of alternate floor projection effect on structure in three symmetrical shapes (+, H, combined +H) and one asymmetrical shape (+)
- To evaluate the response by Response Spectrum Analysis for zone-III and for hard and medium soil condition as well as Non-Linear Time History Analysis.
- To obtain parameter like Maximum Storey Displacement, Base Shear, Drift and compared with each different shape of projection.

III. LITERATURE REVIEW

[4]Kishalay Maitra, N. H. M. Kamrujjaman Serker investigated that in different cases of the building by varying the location of floating column and increasing the column size result showed storey displacement increased by 56.96% in floating column building compared to normal building also torsional irregularity found when floating column was introduced asymmetrically.

[3]Kirankumar Gaddad, Vinayak Vijapur investigated that displacement is 6% and storey shear is 9% increase in floating column at base also displacement is 45% and storey shear 40% decreased in shear wall at corner and also it is decreased 40% and 31% respectively in combined floting column and shear wall model.

[6]Suvradeep Saha, investigated that structure with different projection have different parameter because of difference in mass and geometric orientation also storey drift and base shear is increased about 3% to 19% in H and H+ shape compared to + type shape.

[11]Vinod Kumar Meena, Dr. Om Prakash, Avinash Kumar Mishra investigated that variation in the moments of beam and column depend on the location of building also it can concluded that the location of most critical storey is at 50% height of the structure; at 7m in 14m building (G+3), at 10.5m 21m height building (G+5).

IV. METHODOLOGY

In present work the analysis of following structure with different projection combination at alternate floor has been carried out with 5 storey, 10 storey and 15 storey.

i) Regular structure without projection (Square Building)
ii) Symmetrical structure (Square building) combined with three different projection combination at alternate floor (Plus +, H, combined +H)
iii) Asymmetrical structure with projection at alternate floor (plus shape)

The plan areas of the all structures are different when projection is applied also there is change in mass distribution and geometrical orientation. The beam and column dimensions are same in similar storey building for the analysis and also the material properties such as Poisson ratio, Density of RCC, Density of Masonry, Young's modulus, Compressive strength of Steel and Concrete etc. are kept constant in all buildings.

Following are the method of analysis used for present study to understand the behavior of structure with different shapes of large projection at alternate floor

- Response Spectrum Analysis
- Time History of 2001 – Bhuj Earthquake

The parameter consider are Base Shear, Displacement, Drift to compare the behavioral change in different structure due to Projection at alternate floor.

V. PROBLEM FORMULATION

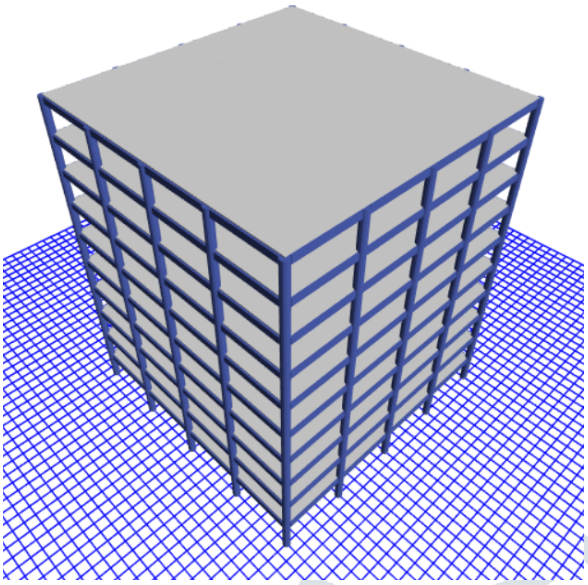
A square symmetric structure is taken as initial model for 5, 10 and 15 storey building on which three types of projection at alternate floor (+, H, combined +H) has been applied. The dimension of the initial square structure is 24m X 24m on 6m X 6m grid and each panel of projection is 6m X 6m is applied on it. Similarly the dimension of asymmetrical shape initially taken as 30m X 18m on 6m X 6m grid and each projection panel 6m X 6m is applied in such way that it becomes asymmetric.

- **Structure and Section Details:**

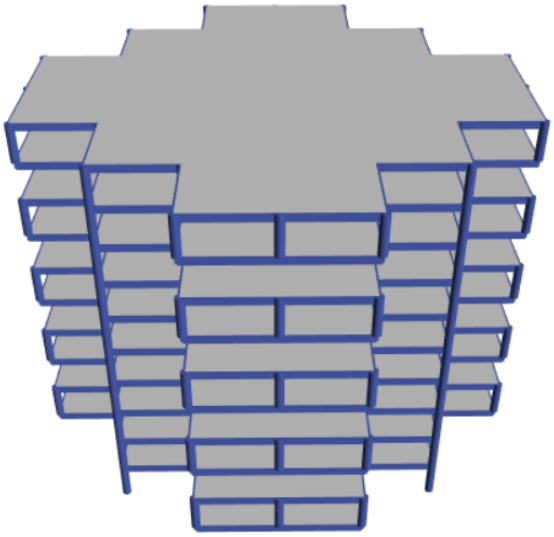
Regular Building without projection	
Plan Dimension	24m X 24m
No. of Bays in X-Axis	4
No. of Bays in Y-Axis	4
Symmetrical Building with Projection(+, H, +H)	
No. of Bays in X-Axis	6
No. of Bays in Y-Axis	6
Asymmetrical Building with Projection(+)	
No. of Bays in X-Axis	7
No. of Bays in Y-Axis	5
General Specification	
Width of single bay in both axis	6m
Height of the floor	3m
Grade of Steel	Fe500
Grade of Concrete	M35
Live Load	3 KN/m^2
Floor Finish	1.5 KN/m^2
Seismic Zone	III
Soil Condition	Hard and Medium
Importance Factor (I)	1
Response Reduction Factor (R)	5

Storey	**5 storey**	**10 storey**	**15 storey**
Beam	300mm X 525mm	300mm X 550mm	400mm X 625mm
Column(circular)	575mm	650mm	700mm
Slab Thickness	140mm	140mm	140mm
Panel Size	6m X 6m	6m X 6m	6m X 6m

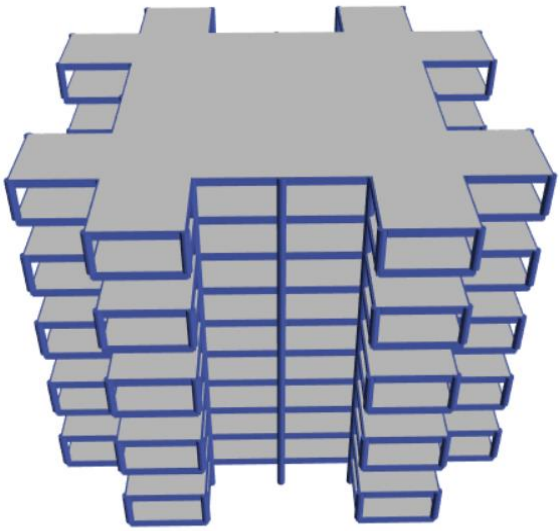
Following are the structures with different shapes of projection at alternate floor has been carried out with 5 storey, 10 storey and 15 storey.



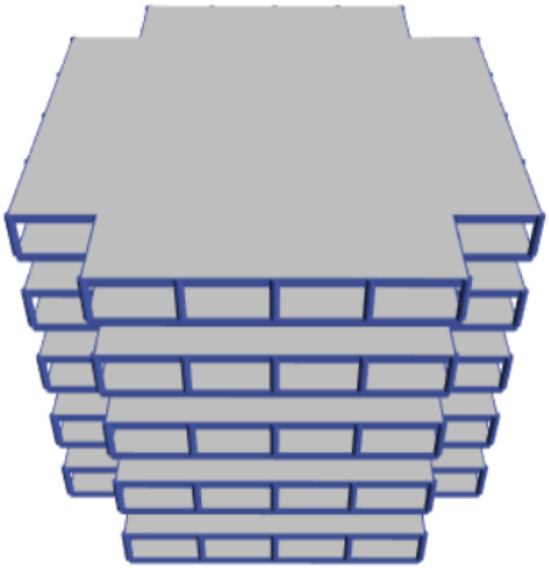
REGULAR SQUARE SHAPE BUILDING



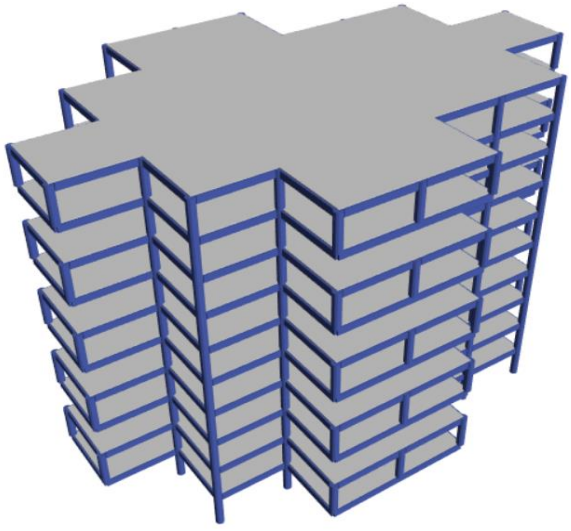
+ SHAPE BUILDING



H SHAPE BUILDING



H+ COMBINED SHAPE BUILDING

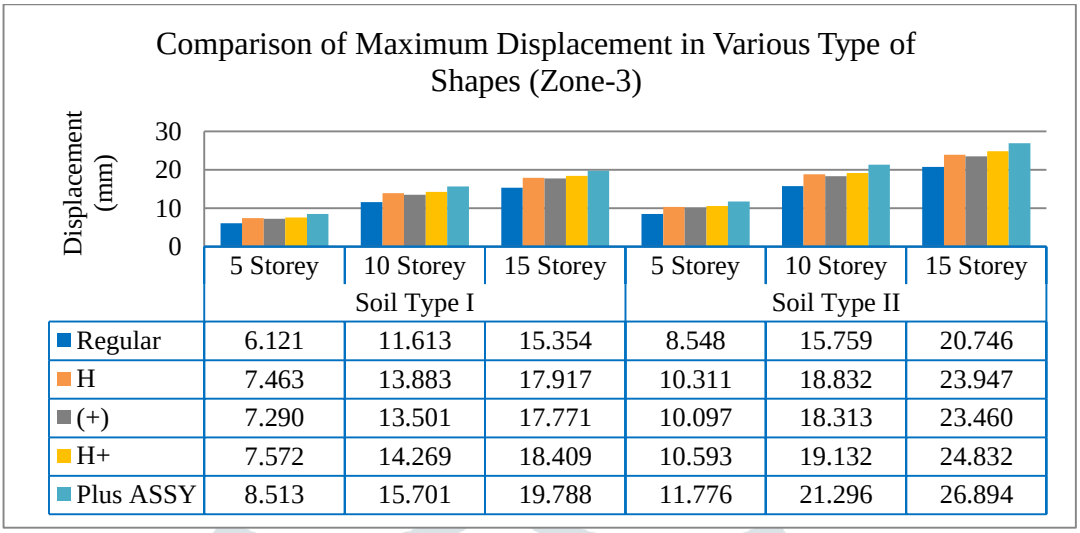


ASYMMETRIC SHAPE BUILDING

V. RESULTS

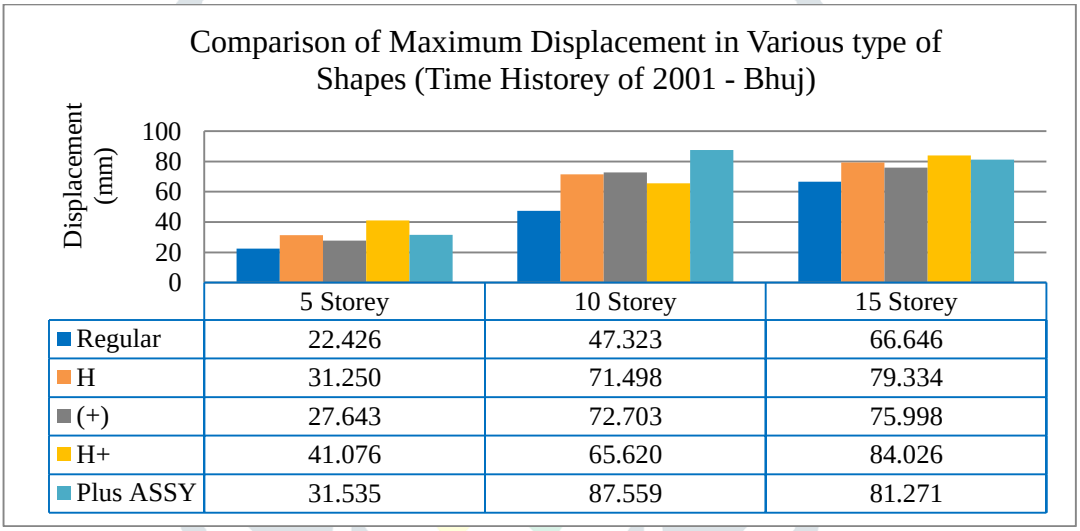
Following are the results of 5, 10 and 15 storey buildings with different projection combination at alternate floor.

- **Maximum Storey Displacement**



	Soil Type I			Soil Type II		
	5 Storey	10 Storey	15 Storey	5 Storey	10 Storey	15 Storey
Regular	6.121	11.613	15.354	8.548	15.759	20.746
H	7.463	13.883	17.917	10.311	18.832	23.947
(+)	7.290	13.501	17.771	10.097	18.313	23.460
H+	7.572	14.269	18.409	10.593	19.132	24.832
Plus ASSY	8.513	15.701	19.788	11.776	21.296	26.894

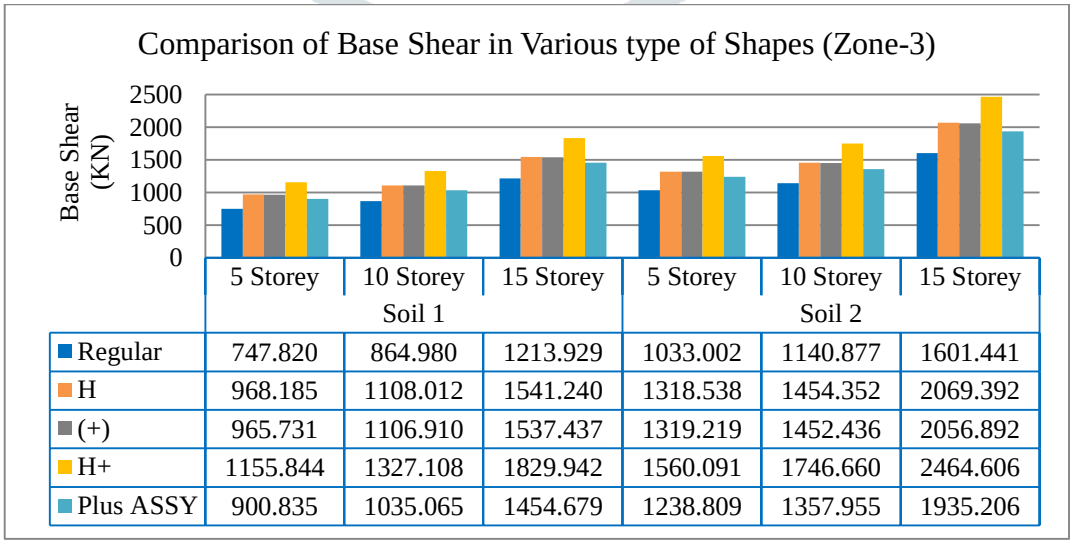
Maximum Storey Displacement of 5, 10 and 15 Storey



	5 Storey	10 Storey	15 Storey
Regular	22.426	47.323	66.646
H	31.250	71.498	79.334
(+)	27.643	72.703	75.998
H+	41.076	65.620	84.026
Plus ASSY	31.535	87.559	81.271

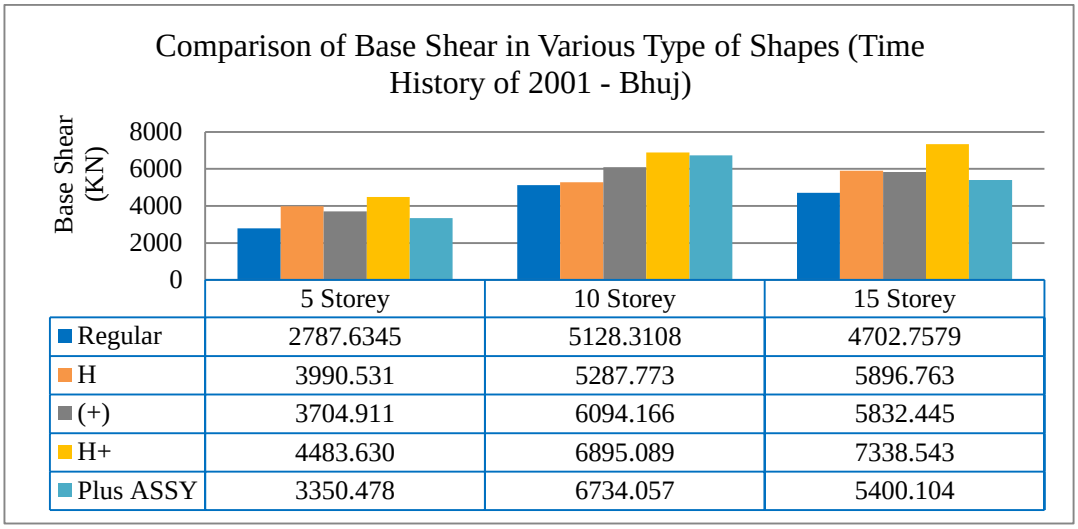
Maximum Storey Displacement of 5, 10 and 15 storey

- **Base Shear**



	Soil 1			Soil 2		
	5 Storey	10 Storey	15 Storey	5 Storey	10 Storey	15 Storey
Regular	747.820	864.980	1213.929	1033.002	1140.877	1601.441
H	968.185	1108.012	1541.240	1318.538	1454.352	2069.392
(+)	965.731	1106.910	1537.437	1319.219	1452.436	2056.892
H+	1155.844	1327.108	1829.942	1560.091	1746.660	2464.606
Plus ASSY	900.835	1035.065	1454.679	1238.809	1357.955	1935.206

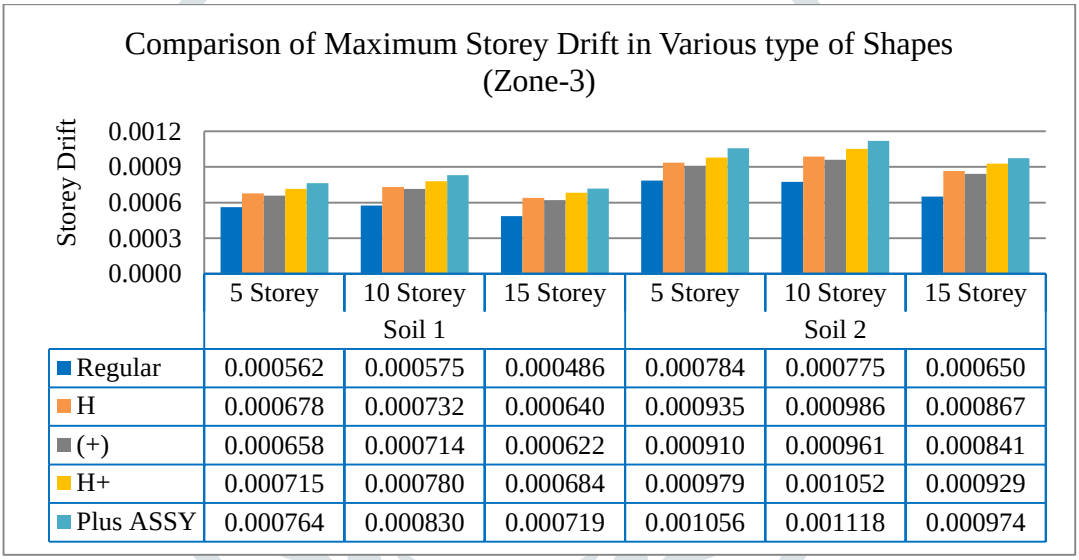
Base Shear of 5, 10, and 15 Storey



	5 Storey	10 Storey	15 Storey
Regular	2787.6345	5128.3108	4702.7579
H	3990.531	5287.773	5896.763
(+)	3704.911	6094.166	5832.445
H+	4483.630	6895.089	7338.543
Plus ASSY	3350.478	6734.057	5400.104

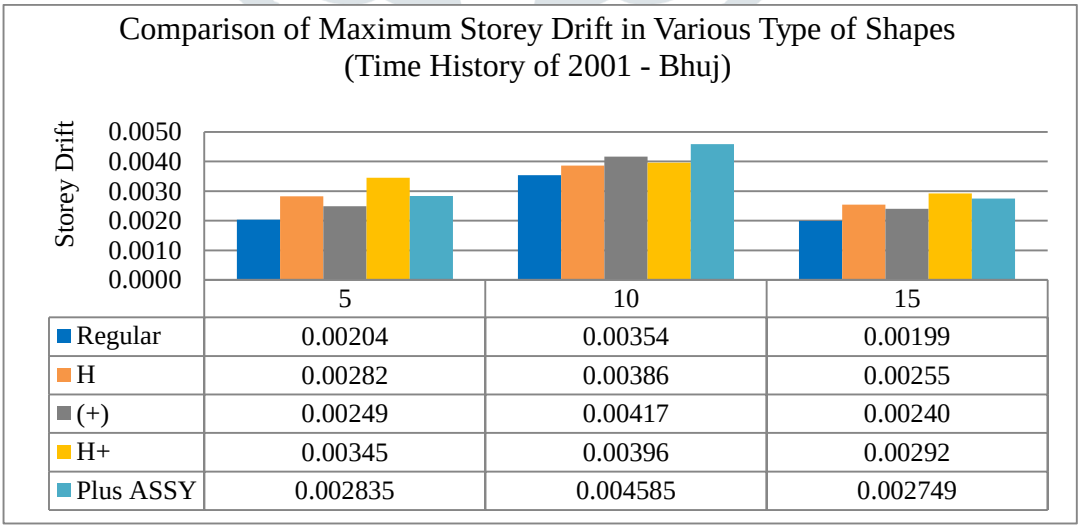
Base Shear of 5, 10 and 15 Storey

- **Storey Drift**



	5 Storey	10 Storey	15 Storey	5 Storey	10 Storey	15 Storey
	Soil 1			Soil 2		
Regular	0.000562	0.000575	0.000486	0.000784	0.000775	0.000650
H	0.000678	0.000732	0.000640	0.000935	0.000986	0.000867
(+)	0.000658	0.000714	0.000622	0.000910	0.000961	0.000841
H+	0.000715	0.000780	0.000684	0.000979	0.001052	0.000929
Plus ASSY	0.000764	0.000830	0.000719	0.001056	0.001118	0.000974

Storey Drift of 5, 10 and 15 Storey



	5	10	15
Regular	0.00204	0.00354	0.00199
H	0.00282	0.00386	0.00255
(+)	0.00249	0.00417	0.00240
H+	0.00345	0.00396	0.00292
Plus ASSY	0.002835	0.004585	0.002749

Storey Drift of 5, 10 and 15 Storey

VI. CONCLUSION

- The displacement for Response spectrum analysis increases up to 21.96%, 19.10%, 23.71% and 39.08% respectively for H,+, H+ combined and asymmetric + shape compared to regular building of 5 storey for hard soil and change in result for medium soil is around 2%.
- The displacement for Response spectrum analysis increase up to 19.55%, 16.26%, 22.87% and 35.20% respectively for H, +, H+ combined and asymmetrical + shape compared to regular building of 10 storey for hard soil and change in result foe medium soil is around 1.5%.

- The displacement for Response spectrum analysis increase up to 16.69%, 15.74%, 19.89% and 28.88% respectively for H, +, H+ combined and asymmetrical + shape compared to regular building of 15 storey for hard soil and change in result for medium soil is around 2%.
- In Time history analysis least displacement result found in + shape of 5 storey and H+ shape of 10 and 15 storey building compared to regular building.
- It is found that result of maximum base shear obtained by Response spectrum analysis is increases about 52% to 55% in H+ shape, 27% to 30% in H shape and plus shape also about 20% in asymmetrical + shape compared to regular building for all 5, 10 and 15 storey with both I and II soil condition.
- It is found that result of maximum base shear obtained by Time history analysis is increases about 60.84%, 34.45% and 56.04% in H+ Shape building respectively of 5,10 and 15 storey compared to regular building.
- The storey drift for RS analysis increases up to 20.64%, 17.08%, 27.22% and 35.94% respectively for H, +, H+ and asymmetric plus shape compared to regular building of 5 storey for hard soil and change in result for medium soil is around 2.5%.
- The storey drift for RS analysis increases up to 27.30%, 24.17%, 35.65% and 44.35% respectively for H, +, H+ and asymmetric plus shape compared to regular building of 10 storey for hard soil and change in result for medium soil is around 0.5% to 1%.
- The storey drift for RS analysis increases up to 31.69%, 27.98%, 40.74% and 47.94% respectively for H, +, H+ and asymmetric plus shape compared to regular building of 15 storey for hard soil and change in result for medium soil is around 2%.
- In time history analysis least storey drift result found in plus shape compared to other shapes with regular building of 5, 10 and 15 storey.

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