PUSHOVER ANALYSIS OF STEEL STRUCTURE

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Abstract

Earthquake is the disturbance that happens at some depth below the ground level which causes vibrations at the ground surface. The buildings which do not designed for seismic force, may suffer extensive damage or collapse if shaken by a severe ground motion. The Pushover analysis first came practice in 1980's, but the potential of the pushover analysis has been recognized for last two decades years. In this procedure mainly estimate the base shear and its corresponding displacement of structure. Pushover analysis is a very useful tool for the evaluation of New and existing structures.

In the present study, carbon steel frames are selected because of its high strength and carbon steel is commonly used in steel frame construction in India. Modeling of the steel frame under the push over analysis using Seismostruct software and the results so obtained has been compared. Conclusions are drawn based on the target displacement of the structure by using idealized Force-Displacement curve. Finally results conclude that Circular hollow section is preferred for construction of tall steel structure than 'I' section.

Key words: Pushover analysis, Seismostruct, Base shear, Displacement, Pushover curve 'I' section, Circular hollow section, X-direction, Y-direction

1. INTRODUCTION

In this thesis study is based on pushover analysis of steel frames structure. This chapter presents a summary of various parameters defining the material property, plan of steel structure, computational models, basic assumptions and the steel frame geometry considered for this study. In the present study, steel frames are modeled and analyzed using the software Seismostruct.

The buildings are assumed to be symmetric in plan, and hence a single plane frame may be considered to be representative of the building along both directions. Typical bay length and column height in this study are selected as 5m and 4m respectively. A configuration of 4 storey and 4 bays, 6 storeys' and 4 bays, 8 storey and 4 bays are considered in this study.

Two different types of sections are considered for modeling of steel structure. They are (i) Indian standard I section and (ii) Indian standard hollow circular section. In first type of modeling of structure ISMB 350 used as column and ISMB 300 used as beam and in second type of modeling of structure ISCHS 300 used as column and beam. Analysis is carried out for G+3, G+5, G+7 storey building located in zone III and zone V. Target displacement for each analysis are noted and compared.

1.1. Objective of the study

The objective of this work is to evaluate through an analytical study, the seismic performance of three dimensional G+3, G+5, G+7 storey symmetric steel building .following are the main objective.

- To analyze the seismic performance of the steel structure with more degree of accuracy with seismostruct software by using Non-linear Static Analysis Method.
- To understand the behaviour of steel frame structure when subjected to earthquake forces.
- To find out the target displacement of the structure by using Idealized Force-Displacement Curve.

- To study the behaviour of hollow and solid steel section frame structure subjected to the Pushover Analysis.

1.2. Scope of the present study

Modeling of the steel frame structure under the push over analysis using Seismostruct software and the results so obtained has been compared. Conclusions are drawn based on the target displacement of the structure by using idealized Force-Displacement curve.

2. METHODOLOGY FOLLOWED

1. A three dimensional model that represents the overall structural behavior is created.
2. Gravity loads, dead loads and live loads are applied to the structural model initially.
3. Calculate nominal base shear.
4. Define lateral load.
5. Define PGA value.
6. Base shear and roof displacement are recorded at point of yielding.
7. Perform pushover analysis.
8. Check pushover curve and target displacement.
9. The roof displacement is plotted with the base shear to get the pushover curve.

Pushover analysis procedure chart is shown in Figure 1

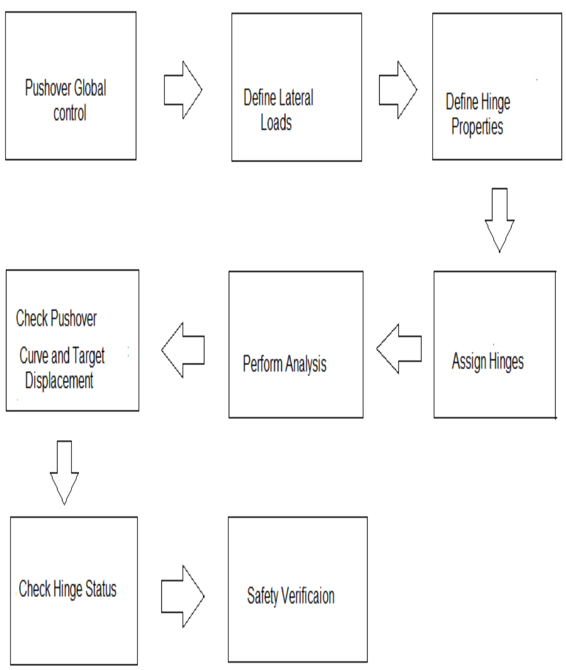


Figure 1: Pushover Analysis Procedure Charts

2.1 Building description

The buildings are assumed to be symmetric in plan, and hence a single plane frame may be considered to be representative of the building along both directions. Input details for structural modeling is shown in Table 1

Table 1 Input detail for structural modeling

Type of section	I Section	Circular hollow section
Number of bays	4	4
Number of frame	5	5
Bay length(m)	5	5
Storey's height(m)	4	4
Frame spacing(m)	5	5
column	ISMB 350	ISHCS 350
beam	ISMB 300	ISHCS 350
Strength of steel	Fe 500	Fe 450

Plan of steel frame building, 3-D rendering for X-axis loading for (G+3) stories , 3-D rendering for Y-axis loading for (G+3) stories, 3-D rendering for X-axis loading for (G+5) stories, 3-D rendering for Y-axis loading for (G+5) stories, 3-D rendering for X-axis loading for (G+7) stories ,3-D rendering for Y-axis loading for (G+7) stories in Seismostruct software are shown in Figure 2 ,3,4,5,6,7and 8 respectively.

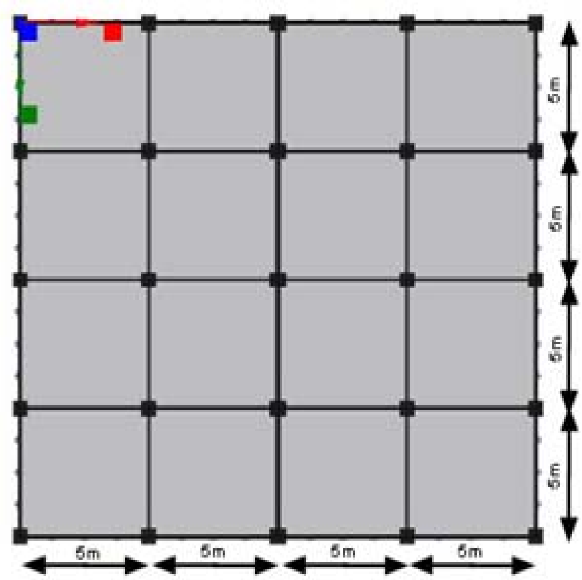


Figure 2: Plan of steel frame building

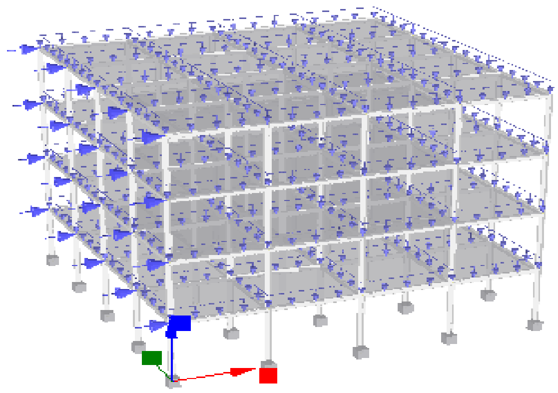


Figure 3: 3-D rendering for x-axis loading for (G+3) stories in Seismostruct.

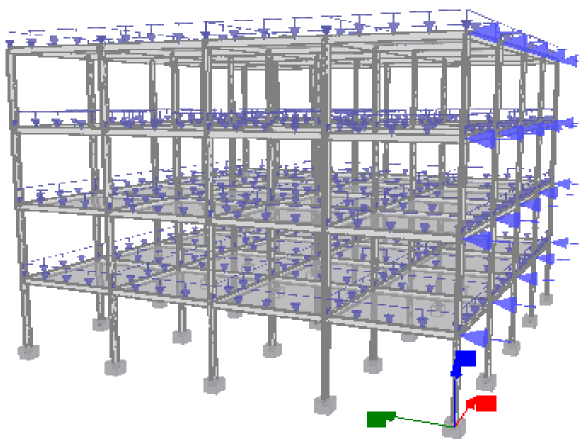


Figure 4: 3-D rendering for y-axis loading for (G+3) stories in Seismostruct.

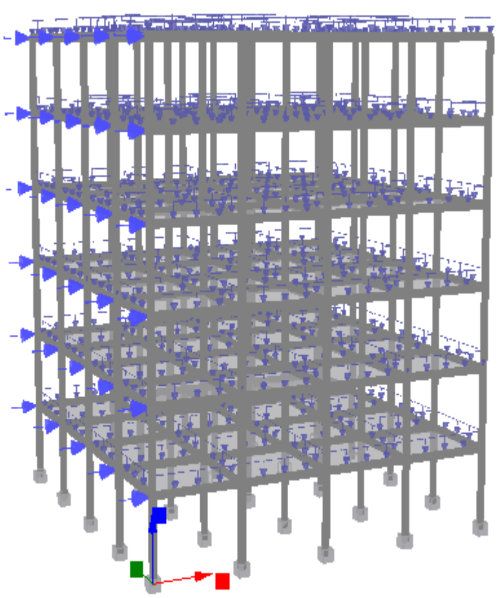


Figure 5: 3-D rendering for x-axis loading for (G+5) stories in Seismostruct.

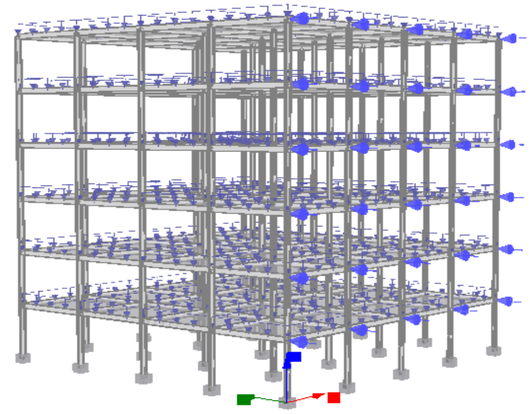


Figure 6: 3-D rendering for y-axis loading for (G+5) stories in Seismostruct.

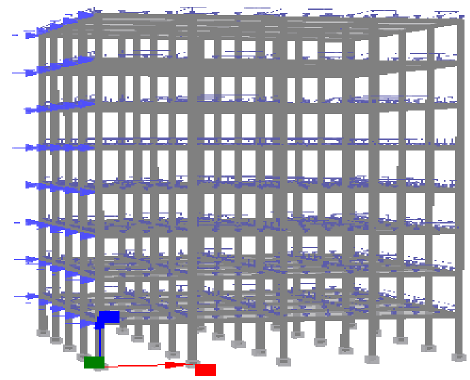


Figure 7: 3-D rendering for x-axis loading for (G+7) stories in Seismostruct.

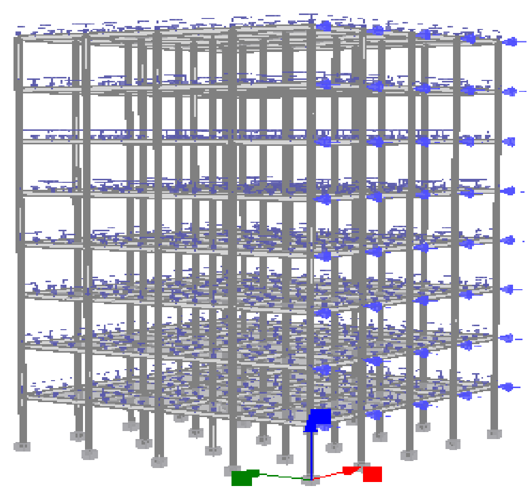


Figure 8: 3-D rendering for y-axis loading for (G+7) stories in Seismostruct

2.2 Calculation of base shear

Dead load calculations for g+3, g+5 and g+7 stories steel structure for 'I' and 'Circular hollow' section are calculated . Base shear calculation for (G+3,G+5 and G+7) building in different zones are given in Table 2

Table 2 calculation of base shear for different zone

	G+3	G+5	G+7
Zone III (I section)	397.6kN	618.18kN	838.75kN
Zone V (I section)	894.6kN	1390.90kN	1887.2kN
Zone III (circular hollow section)	405.3kN	629.04kN	852.72kN
Zone V (circular hollow section)	912.0kN	1415.34kN	1918.63kN

3. PUSHOVER CURVE

Selected frame model is analyzed using pushover analysis. Also presents the behavior of different steel frame building in different zones using pushover curves obtained from push over analysis. The results obtained from these analyses are compared with different steel frame structure located in different zone. Combined displacement against base shear curve for steel structure of different storey in X-direction located in zone III and zone V for 'I' section is shown in Figure 9

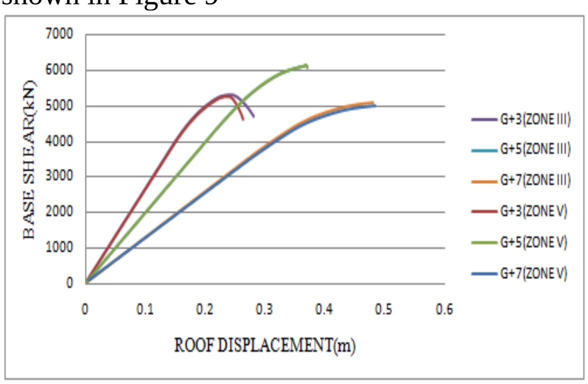


Figure 9: Combined pushover curve for different storey steel structure in X-direction in zone III and zone V for 'I' section

Combined displacement against base shear curve for steel structure of different storey in Y-direction located in zone III and zone V for 'I' section is shown in Figure 10

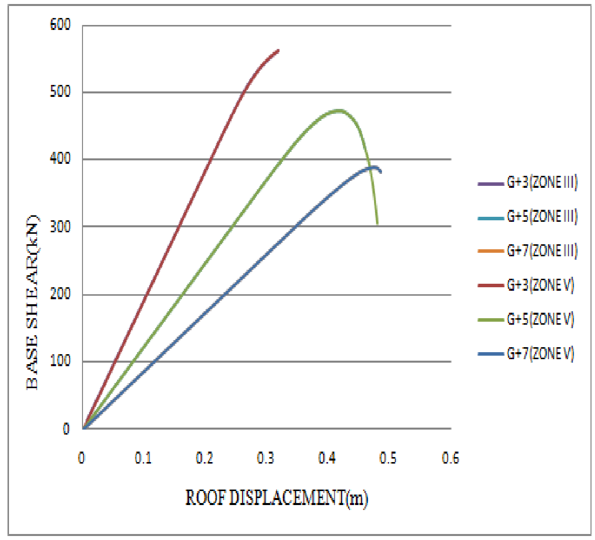


Figure 10: Combined pushover curve for different storey steel structure in Y-direction in zone III and zone V for 'I' section

Combined displacement against base shear curve for steel structure of different storey in X and Y-direction located in zone III and zone V for 'circular hollow section' section is shown in Figure 11

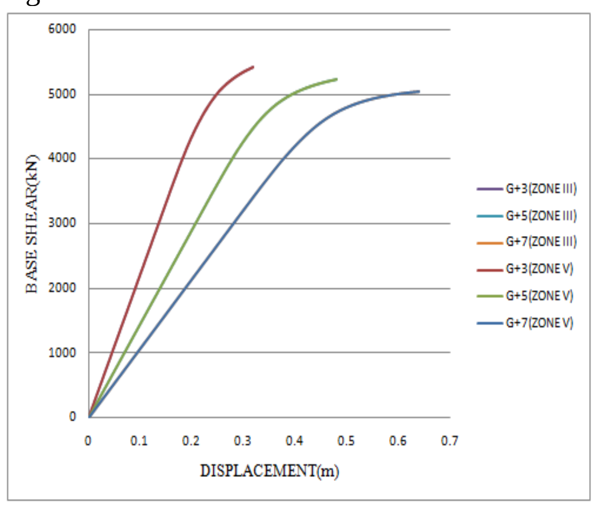


Figure 11: Pushover curve for different storey steel structure in X and Y direction in zone III and zone V for circular hollow section

3.1 Idealized pushover curve in seismostrut

The roof displacement is plotted with the base shear to get the pushover curve. Idealized pushover curve for the (G+3) steel frame building in X – direction and Idealized pushover curve for the (G+3) steel frame building in Y – direction are shown in Figure 12 and Figure 13

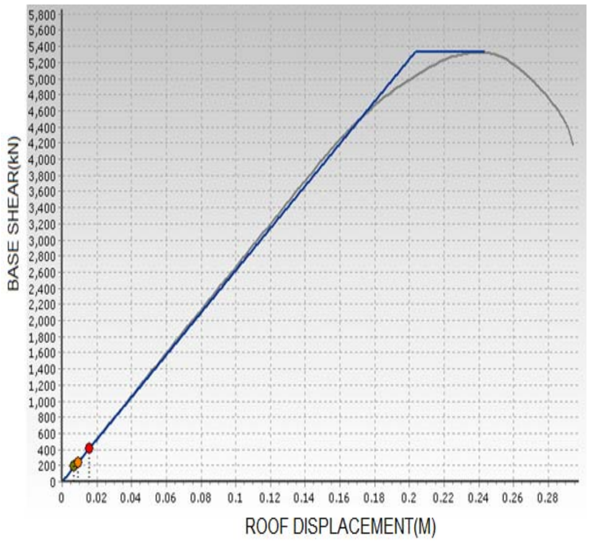


Figure 12: Idealized pushover curve for the (G+3) steel frame building in X – direction

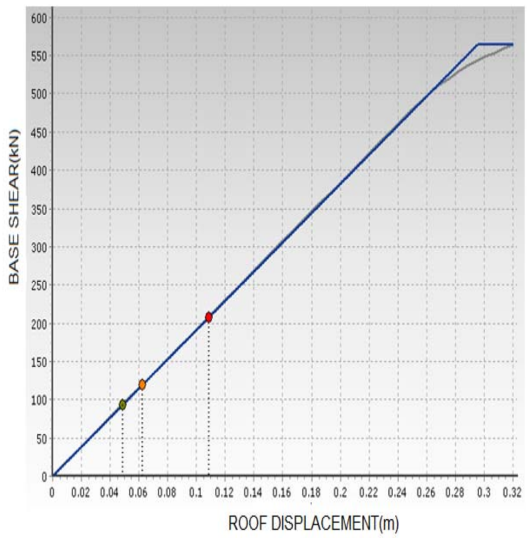


Figure 13: Idealized pushover curve for the (G+3) steel frame building in Y – direction

Similarly these types of Roof displacement vs. Base shear graphs are obtained for different analysis. Analysis are carried out for building located in zone III and zone V and obtain results of base shear and displacement are compared and given below. Designed base shear and roof displacement for steel structure located in zone III in X and Y direction and Designed base shear and roof displacement steel structure located in zone V in X and Y direction and Designed base shear and roof displacement for steel structure located in zone III and Zone V for 'Circular hollow section' in X and Y direction are given in Table 3, Table 4 and Table 5 respectively.

Table 3 Designed base shear and roof displacement for 'I' section steel structure located in zone III in X and Y direction

Storey level	Direction	Base shear(kN)	Displacement (m)
G+3	X	5322.62	0.2432
	Y	563.38	0.32
G+5	X	6117.24	0.3694
	Y	474.09	0.4176
G+7	X	5098.66	0.5138
	Y	387.94	0.4736

Table 4 Designed base shear and roof displacement for 'I' section steel structure located in zone V in X and Y direction

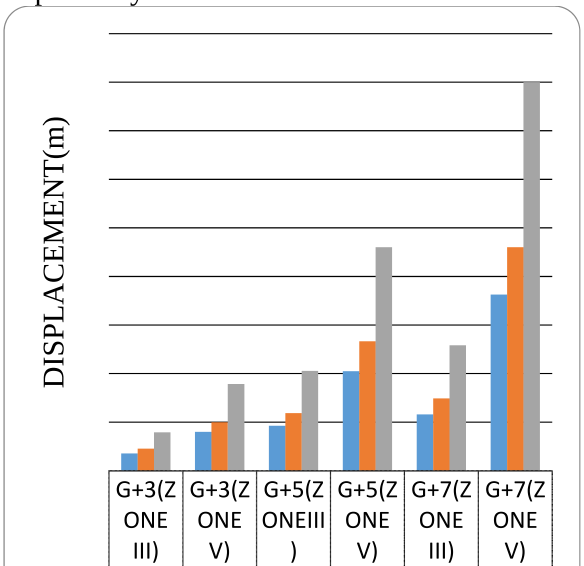
Storey level	Direction	Base shear(kN)	Displacement(m)
G+3	X	5242.12	0.2387
	Y	561.48	0.32
G+5	X	6117.32	0.3694
	Y	474.09	0.4176
G+7	X	4972.38	0.4637
	Y	387.94	0.4736

Table 5 Designed base shear and roof displacement for 'Circular hollow section' steel structure located in zone III and zone V in X and Y direction

Storey level	Zone	Base shear(kN)	Displacement (m)
G+3	III	5407.02	0.32
	V	5407.02	0.32
G+5	III	5232.75	0.48
	V	5232.75	0.48
G+7	III	5047.53	0.64
	V	5047.53	0.64

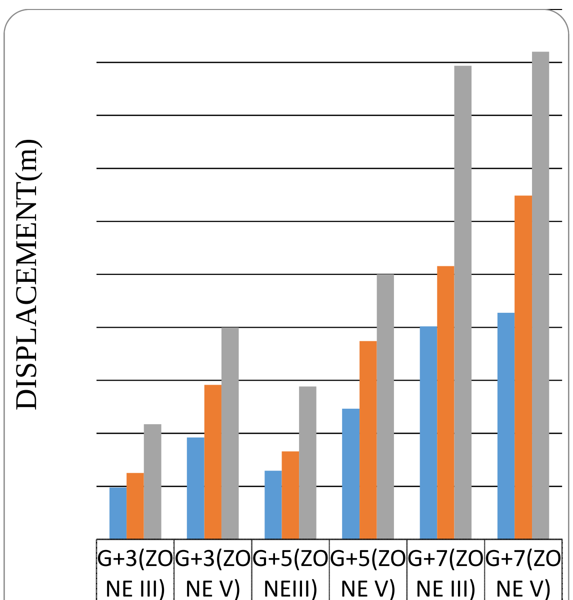
4. COMPARISON OF PERFORMANCE LEVEL FOR DIFFERENT STEEL STRUCTURE FRAME

Performance level for 'I' section steel frame in X-direction for zone III and zone V, Performance level for 'I' section steel frame in Y-direction for zone III and zone V, Performance level for 'circular hollow' section steel frame in X and Y-direction for zone III and zone V shown in Figure 14 and Figure 15 and Figure 16 respectively.



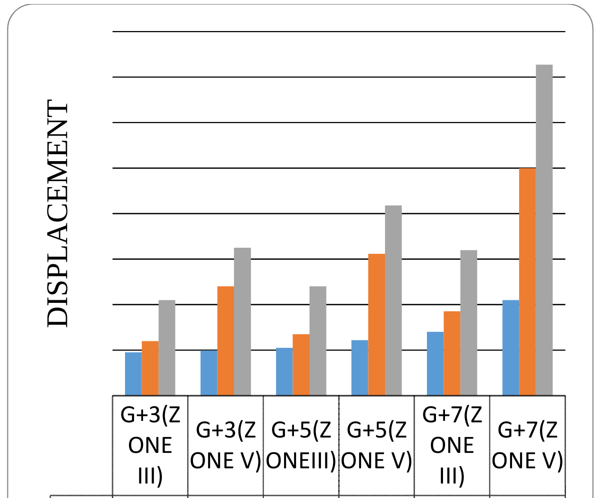
	G+3(ZONE III)	G+3(ZONE V)	G+5(ZONEIII)	G+5(ZONE V)	G+7(ZONE III)	G+7(ZONE V)
OL	0.0071	0.016	0.0185	0.041	0.0232	0.0726
DL	0.0091	0.02	0.0237	0.0533	0.0298	0.092
SD	0.0159	0.0357	0.0411	0.092	0.0516	0.16

Figure 14: Performance level for 'I' section steel frame in X-direction for zone III and zone V



	G+3(ZONE III)	G+3(ZONE V)	G+5(ZONEIII)	G+5(ZONE V)	G+7(ZONE III)	G+7(ZONE V)
OL	0.0488	0.0961	0.0648	0.1233	0.2009	0.2137
DL	0.0626	0.1458	0.0831	0.187	0.2578	0.3243
SD	0.1086	0.2	0.14415	0.25	0.4469	0.46

Figure 14: Performance level for 'I' section steel frame in Y-direction for zone III and zone V



	G+3(ZONE III)	G+3(ZONE V)	G+5(ZONEIII)	G+5(ZONE V)	G+7(ZONE III)	G+7(ZONE V)
OL	0.019	0.0198	0.021	0.0244	0.028	0.042
DL	0.024	0.048	0.027	0.0623	0.037	0.1
SD	0.042	0.065	0.048	0.0836	0.064	0.1454

Figure 15: Performance level for 'circular hollow' section steel frame in X and Y-direction for zone III and zone V

5. CONCLUSION

On the basis of present study following conclusion are drawn:

1. Target displacement is less in case of pushover loading is in X direction for higher base shear and more in case of pushover loading in Y direction for small base shear steel structure modelled with 'I' section.
2. In pushover curve for 'I' section different storey steel structure loaded in X-direction in zone III, for 0.25m displacement, there is decrease in base shear of 7.69% compared to G+3 and G+5 storey and base shear of 39.40% compared to G+3 and G+ 7 storeys.
3. In pushover curve for 'I' section different storey steel structure loaded in Y-direction in zone III, for 0.25m displacement, there is decrease in base shear of 42.59% compared to G+3 and G+5 storey and base shear of 59.25% compared to G+3 and G+ 7 storeys.
4. In pushover curve for 'I' section different storey steel structure loaded in X-direction in zone V, for 0.25m displacement, there is decrease in base shear of 4% compared to G+3 and G+5 storey and base shear of 37.74% compared to G+3 and G+ 7 storeys.

5. In pushover curve for ‘I’ section different storey steel structure loaded in Y-direction in zone V, for 0.25m displacement, there is decrease in base shear of 34.375% compared to G+3 and G+5 storey and base shear of 55.20% compared to G+3 and G+ 7 storeys.
6. In pushover curve for ‘circular hollow’ section different storey steel structure loaded in X and Y-direction in zone III and zone V, for 0.25m displacement, there is decrease in base shear of 23.76% compared to G+3 and G+5 storey and base shear of 25.97% compared to G+3 and G+ 7 storeys.
7. Target displacement for operational level, damage limitation, and significant damage is increases from lower zones to higher zones because of intensity of earthquake is more.
8. Target displacement observed in case of pushover loading is in X direction and in Y direction for steel structure modelled with ‘circular hollow’ section are same due to symmetrical section.
9. Circular hollow section is preferred for construction of tall steel structure than ‘I’ section.

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