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Reduction of Axial Forces in Column in Multistoried Building using Optimum Size Approach at Earthquake Zone III

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***Keywords*— Axial forces, Columns, Strength, Durability, Software Models, High-Rise Structures**

Abstract*— *In India, construction plays a very important role with the introduction of high-rise structures that has been increasing gradually. Along with this, the structure should be strong enough that each element should be economic and strong. The Reduction of Axial forces in Columns in Multistory building using Optimum size change approach is a new idea. It reduces the size of columns at the different levels of the building to reduce its self-weight. On other hand, the structural weight should be minimized when the self-weight of the same will be reduced and proved to be an economic structure. In this project a G+13 Storey structure is analyzed using six different cases named as OS Case A to OS Case F assumed to be situated in seismic Zone III. The plinth area is in use as 625 m2 and all the cases have compared with each parameter. The project concluded that efficient Case is OS Case E on comparing 6 maximum axial force reduction cases that ultimately reduce the overall cost of the project.

I. INTRODUCTION

In India, Multi-storey building construction is at its peak in big cities because land cost for the construction is going high day by day in large cities of India. The land is minimum against population in the large cities therefore to reduce these problems multi-storey buildings are the only option where minimum land is caused and provide more convenience and safety to the people. To reduce the chances of failure and provide more stability to multi-storey structures under seismic and wind forces many methods and analysis are in trend.

Axial Force- If the load on a column is applied through the centre of gravity of its cross section, it is called an axial load. Axial force is the compression or tension force acting in a member. If the axial force acts through the centroid of the member it is called concentric loading. If the force is not acting through the centroid it's called eccentric loading. Eccentric loading produces a moment in the beam as a result of the load being a distance away from the centroid.

II. OBJECTIVES & METHODOLOGY

There are different cases considered for different G+13 storied building of same building height, so that response of the seismic behavior of the structure can be predicted. Different models details are shown in table 1 below:

Table 1: List of models framed

S. No.	**Abbreviation**	**Models framed for analysis**		
		Column Size	Beam Size	Applied Storey
1.	OS Case A	0.65m x 0.60m	0.55m x 0.40m	Up to G + 5
		0.60m x 0.50m	0.55m x 0.35m	Up to G + 13

2.	OS Case B	0.65m x 0.60m	0.55m x 0.40m	Up to G + 5
		0.60m x 0.50m	0.55m x 0.35m	Up to G + 12
		0.60m x 0.45m	0.50m x 0.35m	Up to G + 13
3.	OS Case C	0.65m x 0.60m	0.55m x 0.40m	Up to G + 5
		0.60m x 0.50m	0.55m x 0.35m	Up to G + 11
		0.60m x 0.45m	0.50m x 0.35m	Up to G + 13
4.	OS Case D	0.65m x 0.60m	0.55m x 0.40m	Up to G + 5
		0.60m x 0.50m	0.55m x 0.35m	Up to G + 10
		0.60m x 0.45m	0.50m x 0.35m	Up to G + 13
5.	OS Case E	0.65m x 0.60m	0.55m x 0.40m	Up to G + 4
		0.60m x 0.50m	0.55m x 0.35m	Up to G + 9
		0.60m x 0.45m	0.50m x 0.30m	Up to G + 13
6.	OS Case F	0.65m x 0.60m	0.55m x 0.40m	Up to G + 4
		0.60m x 0.50m	0.55m x 0.35m	Up to G + 8
		0.60m x 0.45m	0.50m x 0.30m	Up to G + 13

Note: Here OS means optimized structure.

Details of the Models:

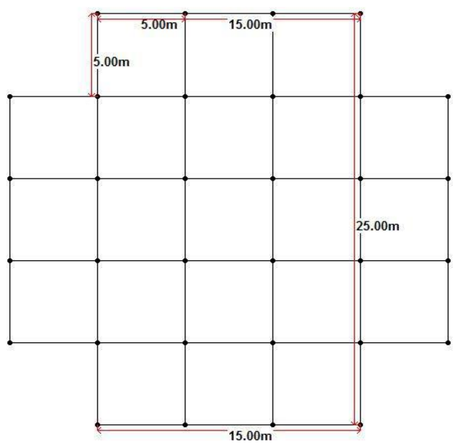

Fig.1: 2D Plan of the Structure

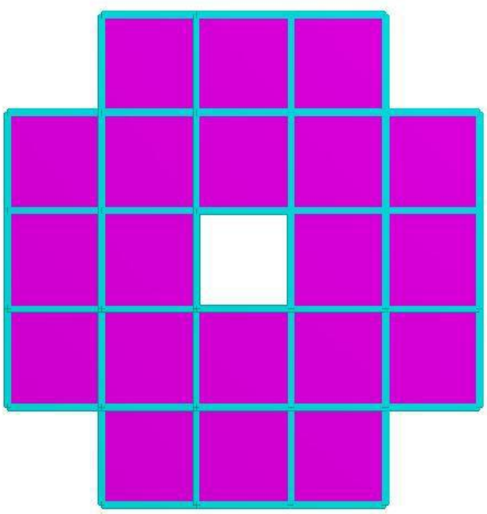

Fig.2: 3D Plan of the Structure

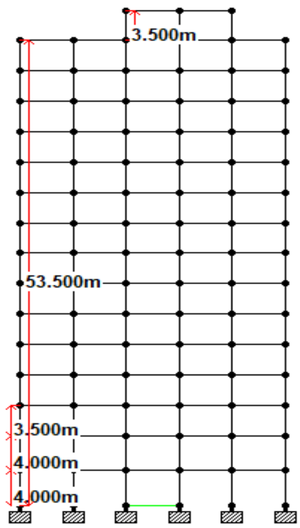

Fig.3: Front View of the Structure

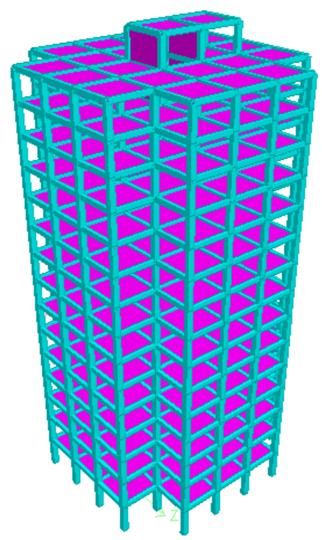

Fig.4: 3D View of the Structure for all cases

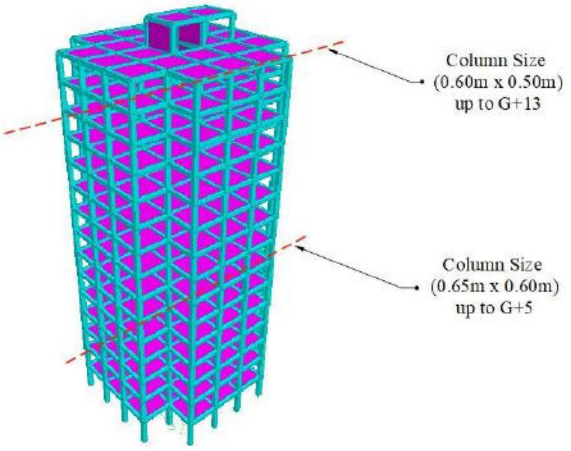

Fig.5: Figure of Axial Force Reduction Case – OS Case A

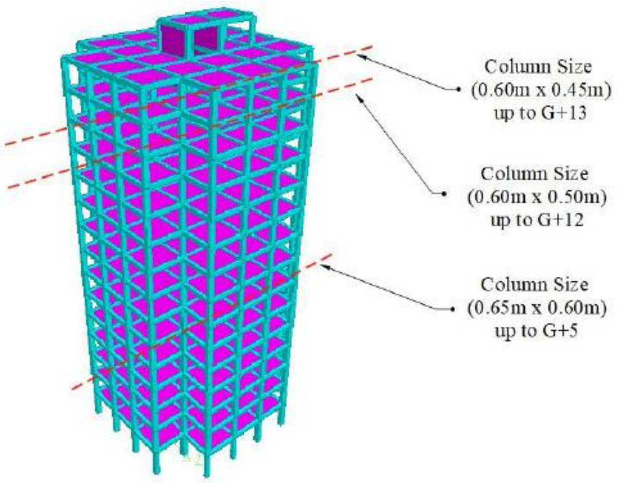

Fig.6: Figure of Axial Force Reduction Case – OS Case B

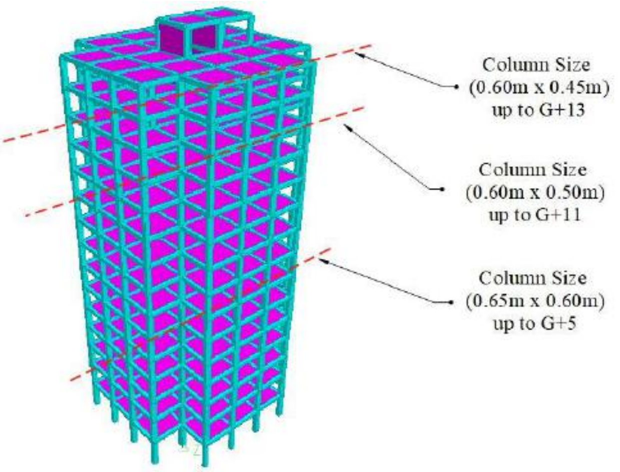

Fig.7: Figure of Axial Force Reduction Case – OS Case C

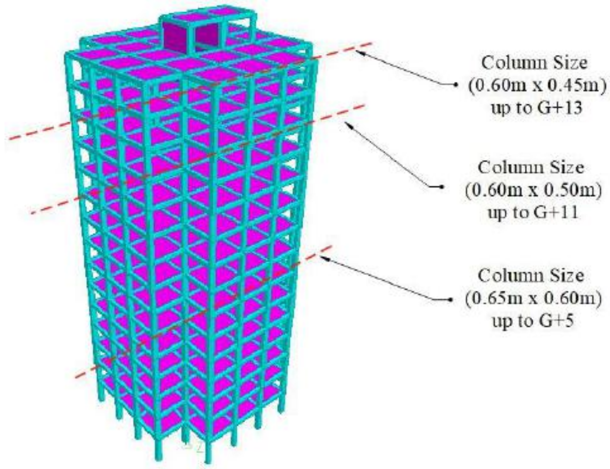

Fig.8: Figure of Axial Force Reduction Case – OS Case D

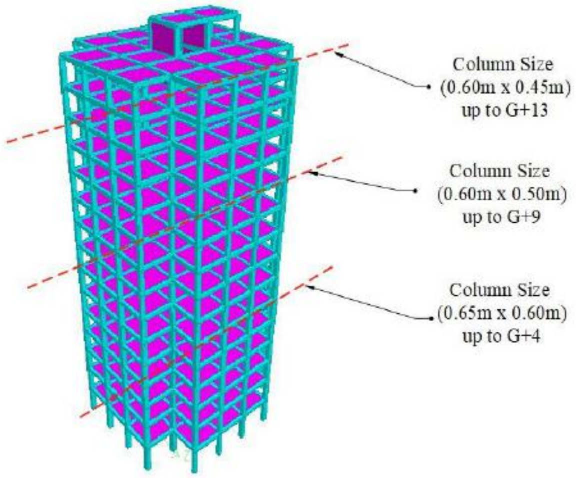

Fig.9: Figure of Axial Force Reduction Case – OS Case E

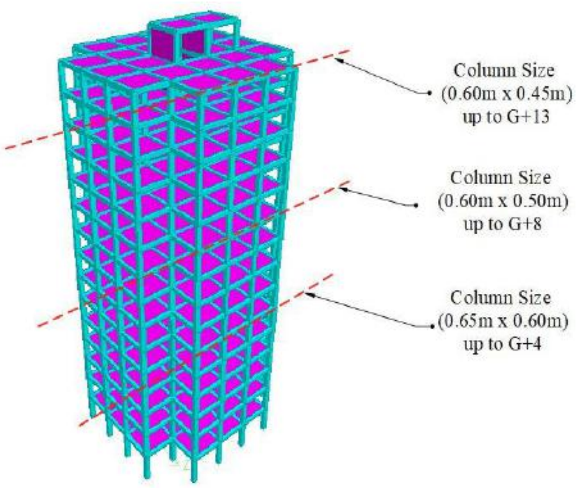

Fig.10: Figure of Axial Force Reduction Case – OS Case F

Table 2: Details of Axial Force Reduction Case – OS Case A

Column Size	Beam Size	Applied Storey
0.65m x 0.60m	0.55m x 0.40m	Up to G + 5
0.60m x 0.50m	0.55m x 0.35m	Up to G + 13

Table 3: Details of Axial Force Reduction Case – OS Case B

Column Size	Beam Size	Applied Storey
0.65m x 0.60m	0.55m x 0.40m	Up to G + 5
0.60m x 0.50m	0.55m x 0.35m	Up to G + 12
0.60m x 0.45m	0.50m x 0.35m	Up to G + 13

Table 4: Details of Axial Force Reduction Case – OS Case C

Column Size	Beam Size	Applied Storey
0.65m x 0.60m	0.55m x 0.40m	Up to G + 5
0.60m x 0.50m	0.55m x 0.35m	Up to G + 11
0.60m x 0.45m	0.50m x 0.35m	Up to G + 13

Table 5: Details of Axial Force Reduction Case – OS Case D

Column Size	Beam Size	Applied Storey
0.65m x 0.60m	0.55m x 0.40m	Up to G + 5
0.60m x 0.50m	0.55m x 0.35m	Up to G + 10
0.60m x 0.45m	0.50m x 0.35m	Up to G + 13

Table 6: Details of Axial Force Reduction Case – OS Case E

Column Size	Beam Size	Applied Storey
0.65m x 0.60m	0.55m x 0.40m	Up to G + 4
0.60m x 0.50m	0.55m x 0.35m	Up to G + 9
0.60m x 0.45m	0.50m x 0.30m	Up to G + 13

Table 7: Details of Axial Force Reduction Case – OS Case F

Column Size	Beam Size	Applied Storey
0.65m x 0.60m	0.55m x 0.40m	Up to G + 4
0.60m x 0.50m	0.55m x 0.35m	Up to G + 8
0.60m x 0.45m	0.50m x 0.30m	Up to G + 13

Building and Seismic Parameters:

Table 8: Description of parameters taken for analysis

Building configuration	G + 13
Building type	Semi - commercial building
Total plinth area	625 m^2
Building Length	5m @ 5 bays = 25m
Building Width	5m @ 5 bays = 25m
Height of building from Foundation Level	57 m
Height of each floor	3.5 m
Depth of footing	4 m
Beam dimensions 1	550 mm x 400 mm
Beam dimensions 2	550 mm x 350 mm
Beam dimensions 3	500 mm x 350 mm
Beam dimensions 4	500 mm x 300 mm
Column dimensions 1	650 mm x 600 mm
Column dimensions 2	600 mm x 500 mm
Column dimensions 3	600 mm x 450 mm
Slab thickness	135 mm
Staircase waist slab	135 mm
Shear wall thickness	130 mm
Material properties	Concrete (M30), Steel (Fe 500)

Table 9: Seismic parameters on the structure

Importance factor I	1.2
Fundamental natural period of vibration (T_a)	$0.09*h/(d)^{0.5}$ $Ta_x = Ta_z$
Fundamental natural period (Ta_x) for X direction	1.026 seconds

Fundamental natural period (Ta_z) for Z direction	1.026 seconds
Response reduction factor R	4
Damping ratio	5%
Zone factor	0.16
Zone	III
Soil type	Medium soil

III. RESULTS AND DISCUSSION

Point of comparison

Following heads shows the point of comparison of result parameters between various models during earthquake forces for building and its various cases. They are as follows:-

- To determine Base shear response when seismic forces are applied in X and Z direction to the structure when size of beams and columns changes at different floor levels.
- To determine and compare member Torsion values in beam and Torsion values in column with efficient case among all 6 axial force reduction cases.
- To examine column Axial Forces with efficient case among all 6 axial force reduction cases.
- To analyze the maximum nodal displacement case in X and Z horizontal plane direction with most efficient case that provides more stability among 6 axial force reduction cases.
- To determine storey drift in both X and Z direction with efficient case among all 6 axial force reduction cases.

Table 10: Maximum Displacement in X direction for all Axial Force Reduction cases

Model Cases	Maximum Displacement (mm)
	For X Direction
OS Case A	209.286
OS Case B	209.157
OS Case C	209.669
OS Case D	210.624
OS Case E	214.184
OS Case F	215.923

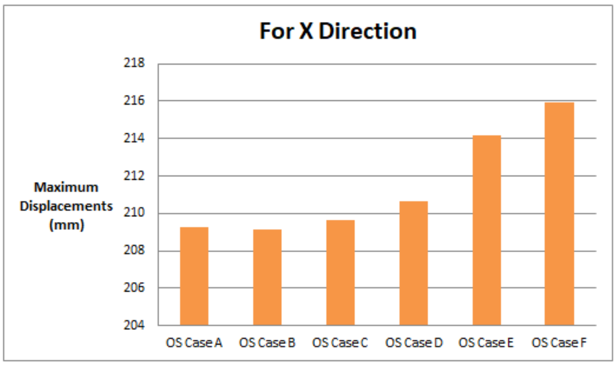

Fig.11: Graphical Representation of Maximum Displacement in X direction for all Axial Force Reduction cases

Table 11: Maximum Displacement in Z direction for all Axial Force Reduction cases

Model Cases	Maximum Displacement (mm)
	For Z Direction
OS Case A	186.431
OS Case B	187.768
OS Case C	189.257
OS Case D	190.968
OS Case E	195.036
OS Case F	197.133

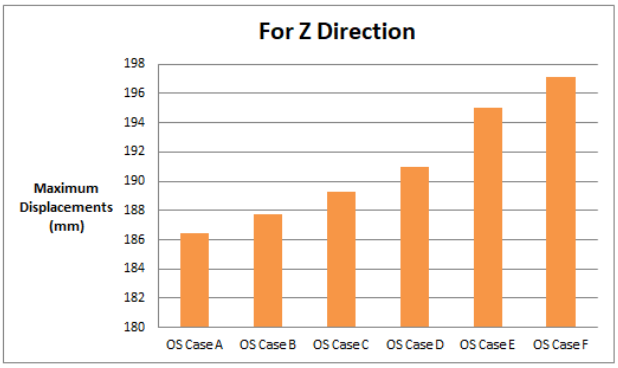

Fig.12: Graphical Representation of Maximum Displacement in Z direction for all Axial Force Reduction cases

Table 12: Storey Drift in X direction for all Axial Force Reduction cases

S. No.	Height (m)	Storey Drift (cm) For X Direction OS Case A	OS Case B	OS Case C	OS Case D	OS Case E	OS Case F
1	0	0	0	0	0	0	0
2	4	0.5141	0.5133	0.5127	0.5121	0.5107	0.5103
3	8	0.937	0.9357	0.9348	0.934	0.9325	0.9321
4	11.5	0.9717	0.9703	0.9695	0.969	0.9688	0.9687
5	15	1.0893	1.0878	1.0871	1.0868	1.0884	1.0887
6	18.5	1.1721	1.0706	1.17	1.1699	1.1736	1.1744
7	22	1.2258	1.2243	1.224	1.2243	1.2215	1.2231
8	25.5	1.2472	1.2458	1.2458	1.2464	1.313	1.3157
9	29	1.3119	1.3106	1.311	1.3124	1.3287	1.3331
10	32.5	1.3006	1.2995	1.3005	1.3029	1.3176	1.3243
11	36	1.264	1.2633	1.2652	1.269	1.2841	1.2904
12	39.5	1.2058	1.2056	1.2088	1.2145	1.2277	1.2657
13	43	1.1289	1.1297	1.1346	1.1399	1.1803	1.205
14	46.5	1.0387	1.0408	1.0453	1.0752	1.1032	1.1134
15	50	0.9419	0.9435	0.9691	0.9887	1.0041	1.014
16	53.5	0.8057	0.8245	0.8412	0.8502	0.8648	0.8732
17	57	0.8745	0.8879	0.9062	0.9193	0.937	0.947

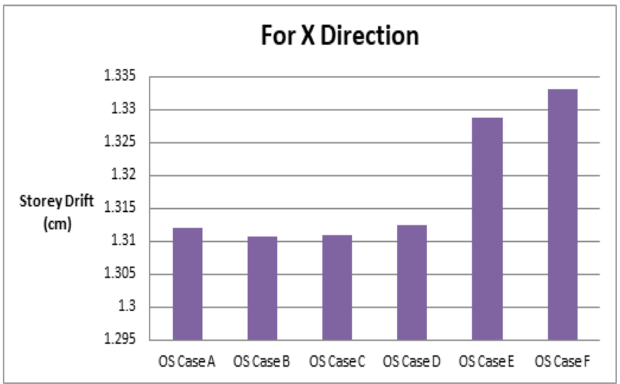

Fig.13: Graphical Representation of Storey Drift in X direction for all Axial Force Reduction cases

Table 13: Storey Drift in Z direction for all Axial Force Reduction cases

S. No.	Height (m)	Storey Drift (cm) For Z Direction OS Case A	OS Case B	OS Case C	OS Case D	OS Case E	OS Case F
1	0	0	0	0	0	0	0
2	4	0.3646	0.3643	0.3642	0.3641	0.3465	0.3467
3	8	0.7321	0.7317	0.7317	0.7321	0.6879	0.6889
4	11.5	0.8457	0.8454	0.8458	0.8466	0.7903	0.792
5	15	1.0071	1.0071	1.0079	1.0093	0.9392	0.9418
6	18.5	1.1295	1.1299	1.1313	1.1334	1.0535	1.0573
7	22	1.221	1.2218	1.224	1.2271	1.1248	1.1299
8	25.5	1.2701	1.2716	1.2746	1.2788	1.2261	1.2334
9	29	1.3565	1.359	1.3634	1.3694	1.2579	1.2676
10	32.5	1.37	1.3738	1.3799	1.3879	1.2703	1.2836
11	36	1.3658	1.3712	1.3793	1.39	1.2605	1.2695
12	39.5	1.3389	1.3464	1.3571	1.3716	1.2256	1.2671
13	43	1.2952	1.3052	1.3197	1.33	1.2052	1.2226
14	46.5	1.2408	1.2545	1.2655	1.3096	1.1495	1.166
15	50	1.1875	1.1985	1.2415	1.2623	1.0933	1.1094
16	53.5	1.0979	1.1386	1.1595	1.1795	1.0106	1.0255
17	57	1.3838	0.967	0.9903	1.257	0.8292	0.8422

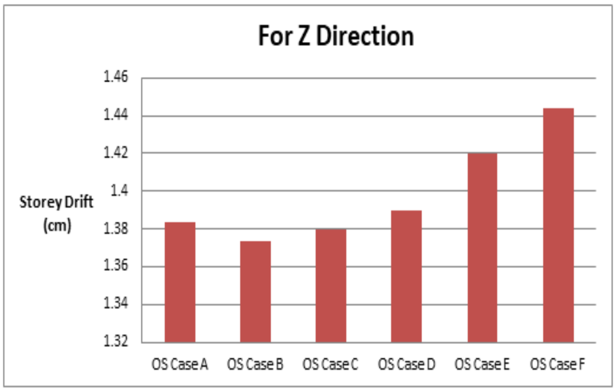

Fig.14: Graphical Representation of Storey Drift in Z direction for all Axial Force Reduction cases

Table 14: Base Shear in X and Z direction for all Axial Force Reduction cases

Model Cases	Base Shear (KN)	
	X direction	Z direction
OS Case A	5192.32	6167.61
OS Case B	5188.19	6156.67
OS Case C	5177.71	6139.10
OS Case D	5165.44	6118.11
OS Case E	5119.21	6054.94
OS Case F	5115.13	6034.89

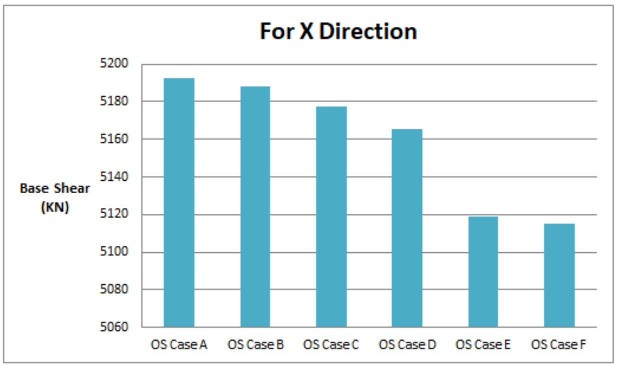

Fig.15: Graphical Representation of Base Shear in X and Z direction for all Axial Force Reduction case

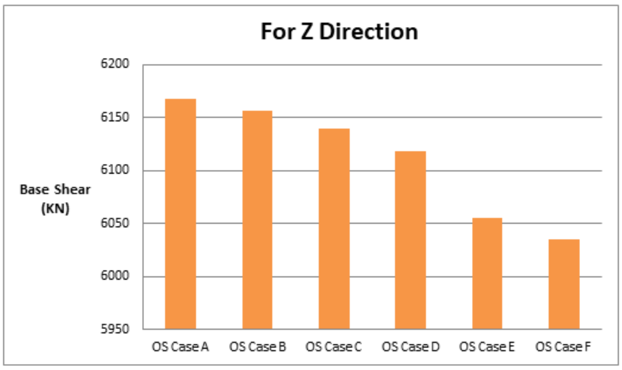

Fig.16: Graphical Representation of Base Shear in Z and Z direction for all Axial Force Reduction case

Table 15: Time Period and Mass Participation Factor for all Axial Force Reduction cases

Model Case	Time Period (Sec.)	Participation X %	Time Period (Sec.)	Participation Z %
OS Case A	2.452	57.205	2.583	70.447
OS Case B	2.451	57.17	2.584	70.339
OS Case C	2.451	57.107	2.587	70.203
OS Case D	2.453	57.042	2.593	70.038
OS Case E	2.466	56.997	2.615	69.714
OS Case F	2.471	56.947	2.624	69.518

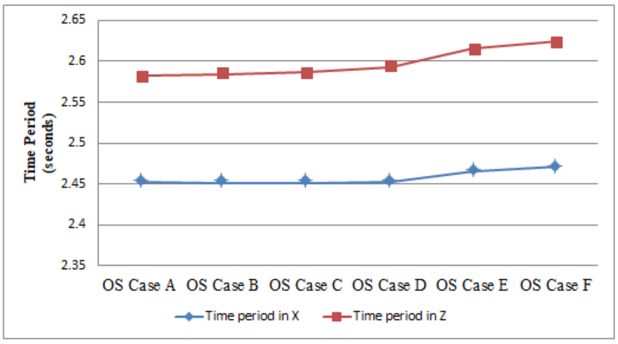

Fig.17: Graphical Representation of Time Period Time Period for all Axial Force Reduction cases

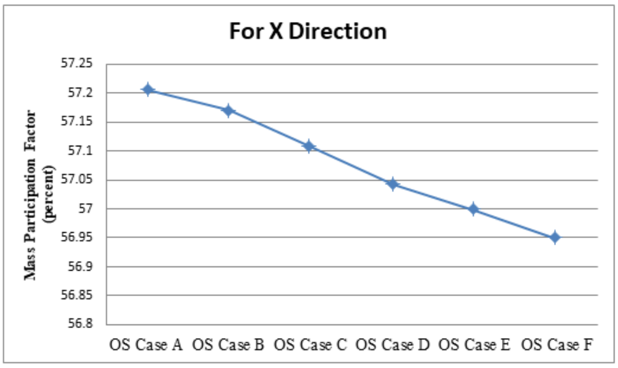

Fig.18: Graphical Representation of Mass Participation Factor in X direction for all Axial Force Reduction cases

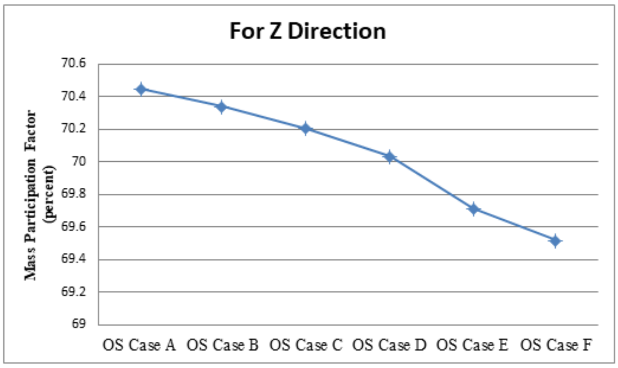

Fig.19: Graphical Representation of Mass Participation Factor in Z direction for all Axial Force Reduction cases

Table 16: Maximum Axial Forces in Column for all Axial Force Reduction cases

Model Case	Column Axial Force (KN)
OS Case A	10734.37
OS Case B	10720.15
OS Case C	10715.47
OS Case D	10714.54
OS Case E	10734.36
OS Case F	10743.193

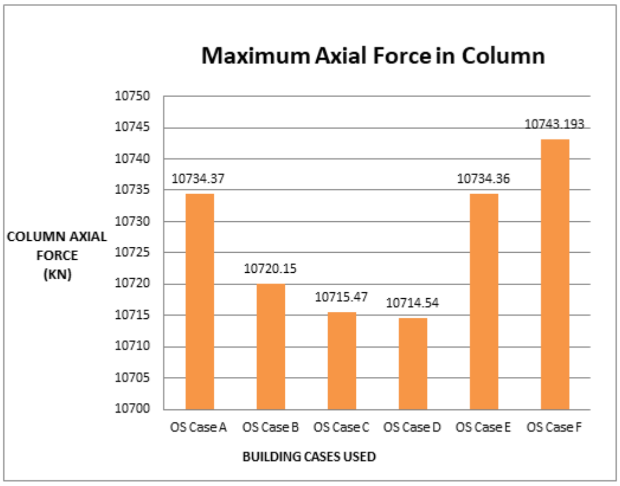

Fig.20: Graphical Representation of Maximum Axial Forces in Column for all Axial Force Reduction cases

Table 17: Maximum Torsional Moment in Beams along X and Z direction for all Axial Force Reduction cases

Model Case	Beam Torsional Moment (along X direction) (KNm)	Beam Torsional Moment (along Z direction) (KNm)
OS Case A	12.393	13.381
OS Case B	13.014	13.348
OS Case C	12.856	13.32
OS Case D	13.048	13.294
OS Case E	13.282	13.765
OS Case F	13.41	13.751

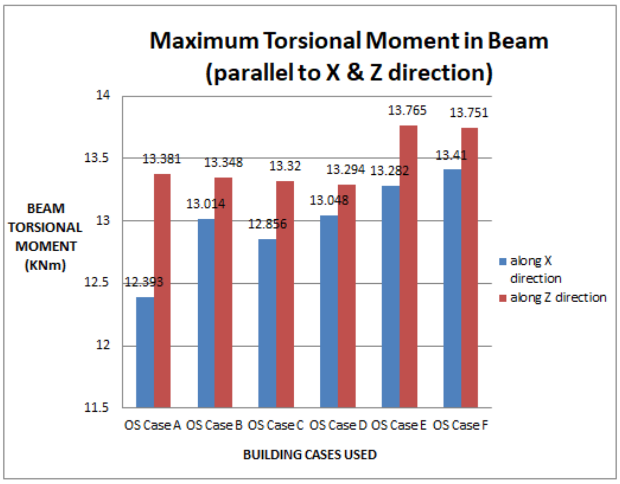

Fig.21: Graphical Representation of Maximum Torsional Moment in beams along X and Z direction for all Axial Force Reduction cases

Table 18: Final conclusive outcomes

S. No.	Abbreviation	Models framed for analysis			Member Status
		Column Size	Beam Size	Applied Storey	
1.	OS Case A	0.65m x 0.60m	0.55 m x 0.40 m	Up to G + 5	Passed
		0.60m x 0.50m	0.55 m x 0.35 m	Up to G + 13	
2.	OS Case B	0.65m x 0.60m	0.55 m x 0.40 m	Up to G + 5	Passed
		0.60m x 0.50m	0.55 m x 0.35 m	Up to G + 12	
		0.60m x 0.45m	0.50 m x 0.35 m	Up to G + 13	
3.	OS Case C	0.65m x 0.60m	0.55 m x 0.40 m	Up to G + 5	Passed
		0.60m x	0.55 m x	Up to	

		0.50m	0.35 m	G + 11	
		0.60m x 0.45m	0.50 m x 0.35 m	Up to G + 13	
4.	OS Case D	0.65m x 0.60m	0.55 m x 0.40 m	Up to G + 5	Passed
		0.60m x 0.50m	0.55 m x 0.35 m	Up to G + 10	
		0.60m x 0.45m	0.50 m x 0.35 m	Up to G + 13	
5.	OS Case E	0.65m x 0.60m	0.55 m x 0.40 m	Up to G + 4	Passed
		0.60m x 0.50m	0.55 m x 0.35 m	Up to G + 9	
		0.60m x 0.45m	0.50 m x 0.35 m	Up to G + 13	
6.	OS Case F	0.65m x 0.60m	0.55 m x 0.40 m	Up to G + 4	Fail
		0.60m x 0.50m	0.55 m x 0.35 m	Up to G + 8	
		0.60m x 0.45m	0.50 m x 0.35 m	Up to G + 13	

IV. CONCLUSIONS

Reduction of Axial Forces in Columns in Multistoried Building under seismic loading, as we investigate concerning the decrease of axial force of six different model made in analysis software and here is such a sort of conclusion regarding each models for find out the minimum axial force in the structure. In term of given models subsequent outcome are take out from this proportional study.

- On comparing all six models it has been concluded that the maximum displacement in OS Case B in X and OS Case A in Z direction.
- On comparing all six models it has been concluded that the maximum Storey Drift in OS Case B in X and Z direction.
- As per comparative results in Base Shear, OS Case F is very effective than other models in both X and Z.
- As per comparative results in Mass Participation Factor, OS Case F is very effective than other models in both X and Z.
- As per comparative outcome in axial force, OS Case D is very effective than other models.
- On analyzing the Torsional Moment in beams along X direction and Z direction OS Case C and OS Case D is efficient respectively.

As far as concern the reduction of Axial Forces in Columns in Multistoried Building under seismic loading with different size of members in different top floors concluded that OS Case E is very effective in axial force comparing OS Case A to F the axial forces are decreased and OS Case E is identified the least axial force. OS Case F has failed in structural components when analysis has done and its axial force is higher than other cases.

As per the above analysis states that mention above all the cases OS Case E is very effective and safe case among all and can be recommended when this type of construction will take place.

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