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Seismic Analysis of Multi-storey Residential Building (G+5) with and without Edge Floating Columns by using ETABS

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ABSTRACT:

Buildings are required for the different purposes like residential, commercial and different conventional buildings. The strength is main requirement for any building in past. But now the thing serviceability is also a crucial criterion to be considered. The process of constructing any type of building is already well known. So now the challenge is satisfying the serviceability criteria. It involves appearance, correct utilization of space for parking at ground floors, best walkability in shopping places. In auditoriums, there should be a clear view of performances for audiences without any obstructions, in present day modernization, the swimming pools are present also at respective floors etc. For satisfying all the above requirements, the only major obstruction is “COLUMN”. By deleting this part in required place can fulfill all the serviceability criteria which also makes an issue in strength deduction. Here it comes the introducing of floating column i.e., if we remove one column in any floor, the remaining columns in next floors will looks like floating. This got the through for our project by considering the different models by removing the columns at different locations in different floors. We have chosen the multi storied (G+5) residential building for this.

This paper will study the analysis of building to withstand from static loads and dynamic loads & base shear, story drift and story displacement for 3 models, Model 1: Building without floating column, Model 2: Building with edge floating column from 1st story, Model 3: Building with center floating column at 4th story.

Keywords: Floating column, Edge floating column, Center floating column, Story displacement, Story drift, Story shear, Multi storey Building, Residential building, Static forces, Seismic forces, Response Spectrum Analysis, Auto CAD, ETABS.

Introduction:

A floating column, also known as a hanging column, is a structural element in building construction where a column is supported by a beam instead of directly resting on a foundation or the ground [1]. This design allows for more open space at the ground level, creating larger uninterrupted areas for various purposes such as parking, retail spaces, or recreational areas [2].

The concept involves transferring the load of the column through the beam to other supporting columns or walls, effectively "floating" the column above the ground level [3]. This is achieved through careful design and engineering to ensure that the beam can adequately distribute the load and that the structure remains stable and safe [4-6].

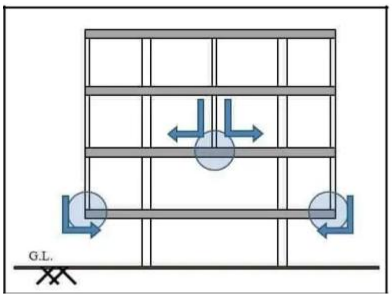

Figure 1: Floating column

Objectives:

- To analyze and compare the static and seismic load of Multi storey building without and with edge floating column.
- To compare story shear, drift and displacement with respect to each story of all models.

Modelling:

3.1 Description of the building

Table 1: Building data

Building type	G+5 RC Building
Depth of foundation	2.5 m
Height of each story	3 m
Total height of the building	17.5 m
Size of beam	300 X 450 mm
	300 X 500 mm
	300 X 550 mm
Size of column	300 X 450 mm
	300 X 600 mm
	450 X 450 mm
Slab	150 mm
External wall thickness	230 mm
Internal wall thickness	150 mm
Height of parapet wall	1.2 m

Table 2: Loads

Type of load	Value
External wall load	12 kN/m

Internal wall load	6 kN/m
Live load	2 kN/m
Earthquake load	Based on IS 1893 - 2002
Load combination	1.2 (DL + LL + EQX)

3.2 Model 1: Building without floating column

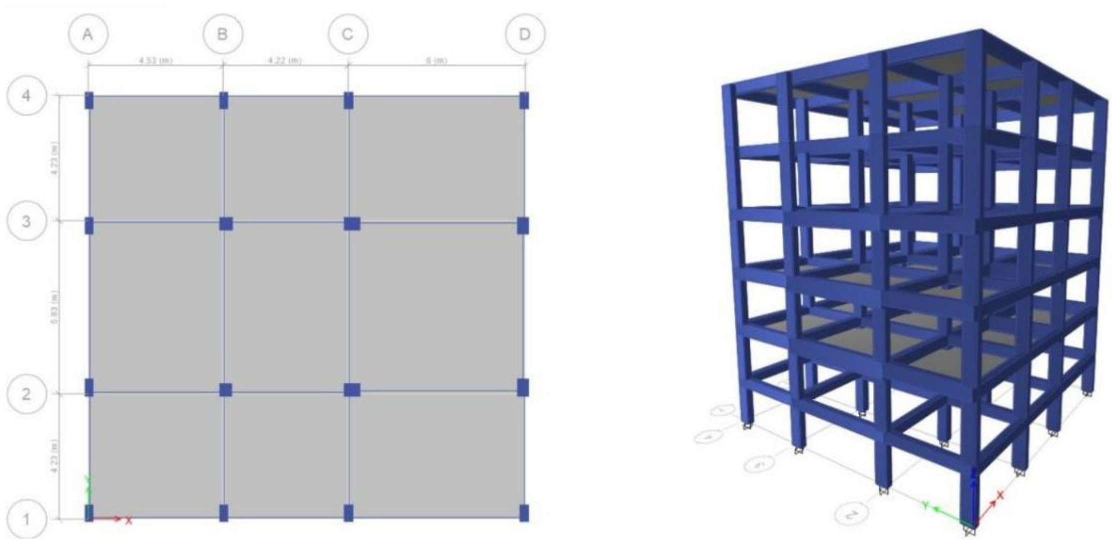

Figure 2: Plan and 3D view of Building without floating column

3.3 Model 2: Building with Edge floating column from 1st story

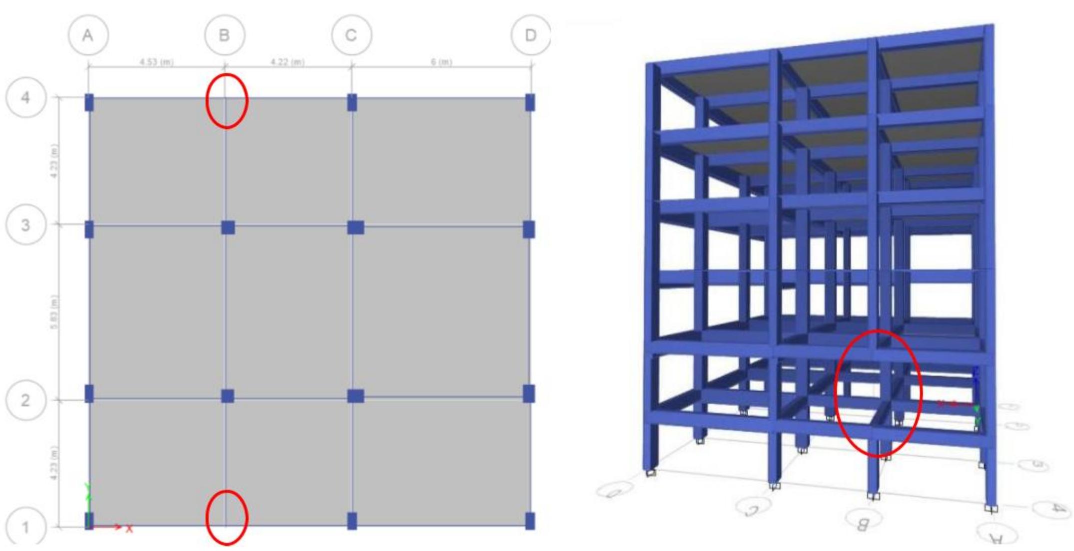

Figure 3: Plan and 3D view of Building with edge floating column

3.5 Types of Loads

Static loads:

- Dead
- Live

Load combination:

- 1.2 (DL + LL + EQX)

IS Codes used:

- IS 1893:2002 [Earthquake loads]
- IS 456:2000
- IS 875:1987 (Part - 2)

Analysis:

4.1 Static analysis:

Static analysis in ETABS offers crucial insights into how a structure behaves under constant loads, providing valuable information about internal forces and deformations. This analysis provides detailed data on the internal forces experienced by beams, columns, and other structural elements. In this static analysis we adopt load combination of 1.2(DL+LL+EQX) [7-10].

4.2 Seismic analysis:

Seismic analysis (dynamic analysis) plays a vital role in assessing a building's ability to withstand seismic forces. This analysis calculates two key metrics. *Story shears and drifts*. Story shears represent the lateral forces acting on each floor, while drifts represent the resulting lateral displacements experienced by those floors. By analyzing these values, engineers can ensure the building can resist the lateral forces and deformations imposed by an earthquake, preventing collapse.

Additionally, Story displacement provides the absolute lateral movement of a specific floor relative to the base of the structure. This value reflects the overall building deformation due to the earthquake loads. Essentially, these measures help engineers design buildings that are flexible enough to sway during an earthquake without exceeding their structural capacity.

5. Results:

The analysis results will focus on three key parameters, *story displacements, story drifts, and story shear* with respect to *Response Spectrum Analysis*. By comparing these values across different scenarios, the study will determine the most suitable configuration for the building's structural integrity.

5.1 Story Displacement (Response spectrum method)

Table 3: Story displacement (Response Spectrum Analysis) X-Direction

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Floors	Without floating column (mm)	With edge floating column
Story5	189.399	193.503
Story4	175.365	179.807

Story3	151.303	156.253	
Story2	116.68	122.164	
Story1	72.699	77.931	
Plinth Level	23.682	25.703	
Base	0	0	

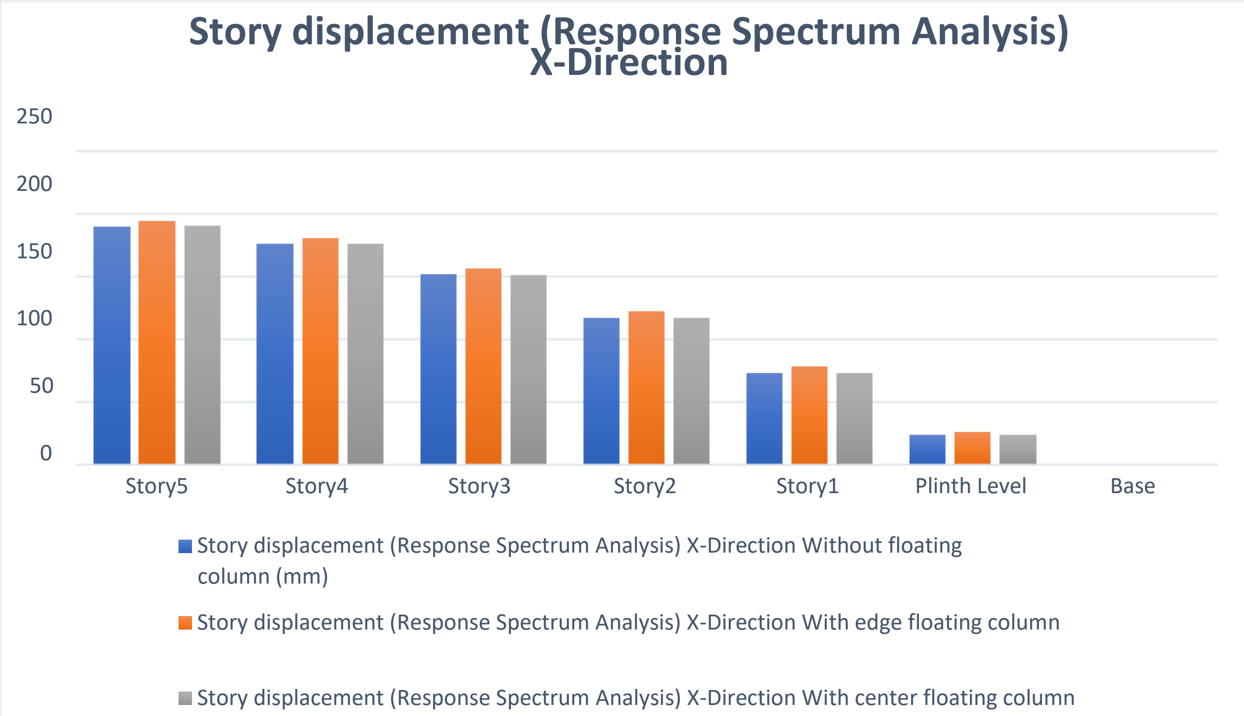

Figure 4: Story displacement (Response Spectrum Analysis) X-Direction

5.2 Story Drift (Response spectrum method)

Table 4: Story drift (Response Spectrum Analysis) X-Direction

Floors	Without floating column	With edge floating column	With centre floating column
Story5	0.005189	0.005057	0.005133
Story4	0.00854	0.008352	0.008878
Story3	0.011852	0.011664	0.011854
Story2	0.014761	0.014839	0.014719

Story1	0.0167	0.019049	0.016651
Plinth Level	0.009473	0.010281	0.009446
Base	0	0	0

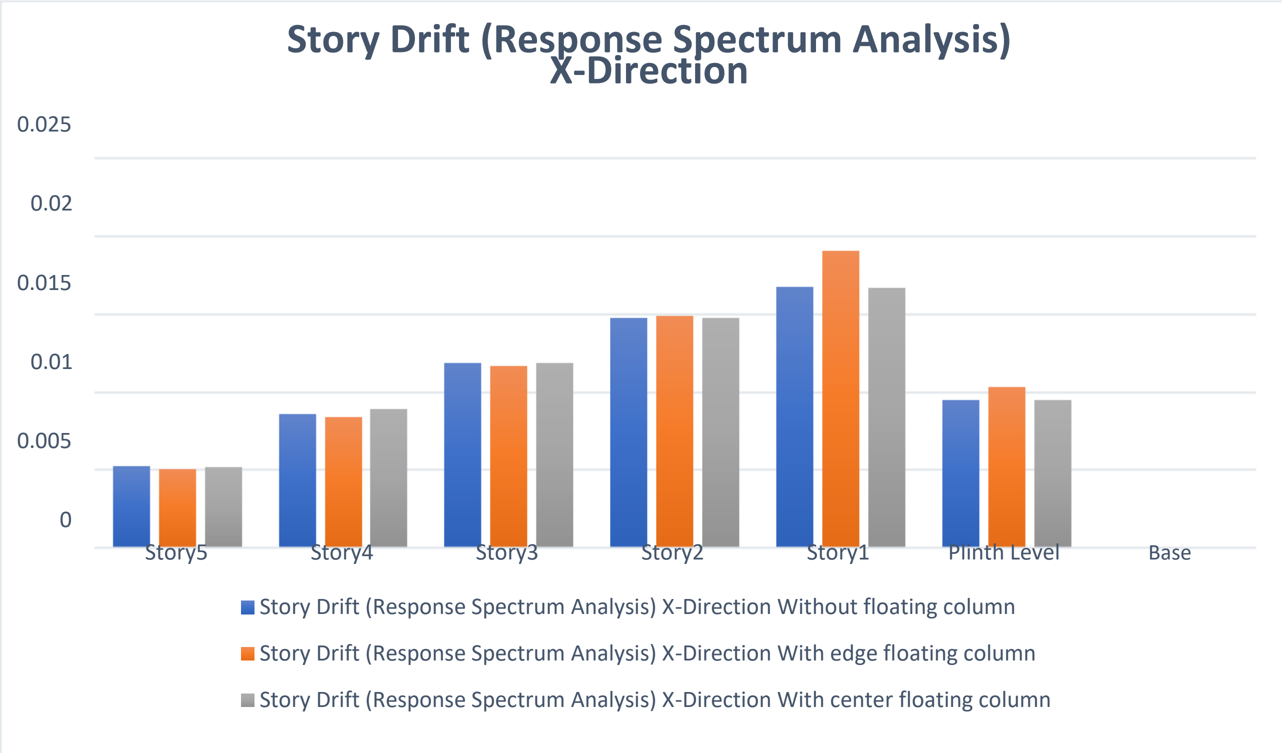

Figure 5: Story drift (Response Spectrum Analysis) X-Direction

5.3 Story shear (Response spectrum method)

Table 5: Story shear (Response Spectrum Analysis) X-Direction

Floors	Without floating column (KN)	With edge floating column	With centre floating column
Story5	855.2742	827.3653	855.3669
Story4	1545.5355	1502.5781	1545.1282
Story3	2096.6121	2047.4009	2089.5629
Story2	2550.2817	2498.8392	2541.9896
Story1	2912.0511	2859.1041	2903.4269
Plinth Level	2980.792	2921.6154	2972.1242

Base	0	0	0

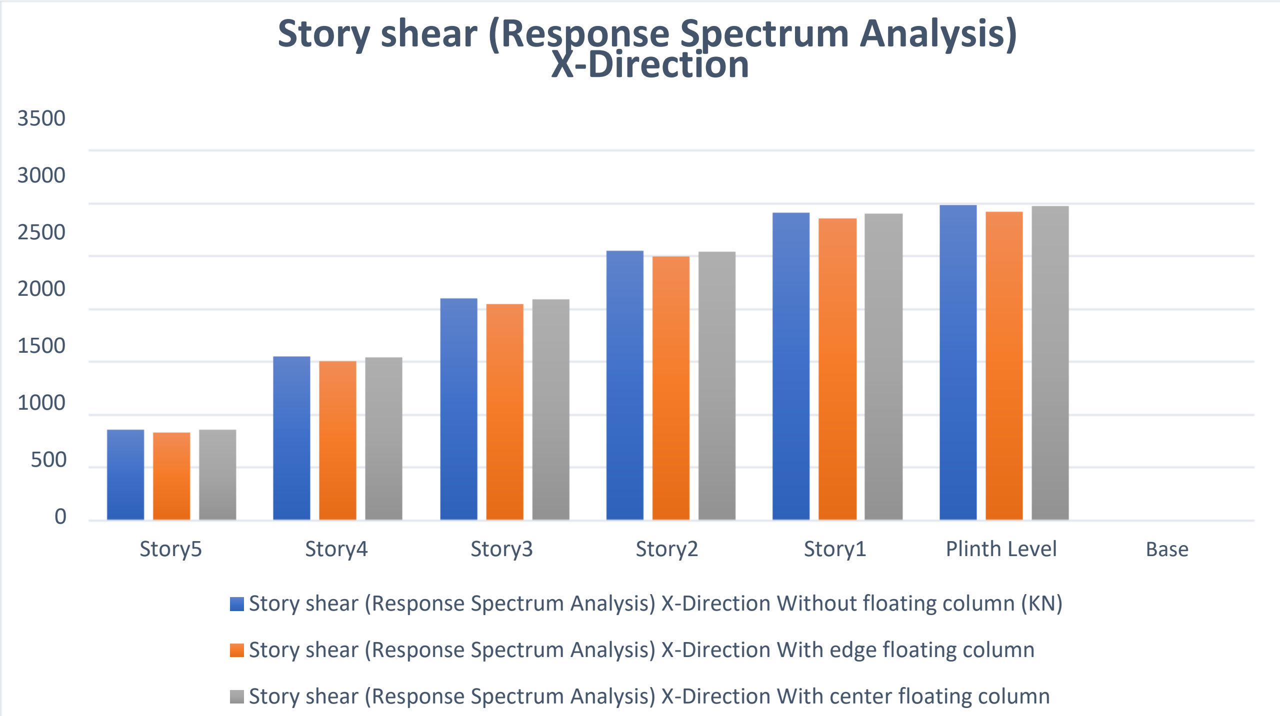

Figure 6: Story shear (Response Spectrum Analysis) X-Direction

5.4 Base Reactions:

Table 6: Base reactions of Model 1

Load Case/Combo	FX	FY	FZ	MX	MY	MZ
Dead	0	0	13765.8	98318.2	-102126	0
Live	0	0	2107.78	15060.1	-15545	0
RSA X Max	2882.66	12.462	0	149.976	34846.3	20716.3
RSA Y Max	12.462	4001.86	0	48855.1	138.478	34139.7
1.2(DL+LL+EQX)	-389.94	0	19048.3	136054	-146665	2785.79
Earthquake X	-324.95	0	0	0	-4549.7	2321.49
Earthquake Y	0	-467.99	0	6552.5	0	-3494.5

Table 7: Base reactions of Model 2

Load Case/Combo	FX	FY	FZ	MX	MY	MZ
Dead	0	0	13738.8	98125.4	-102003	0
Live	0	0	2107.78	15060.1	-15545	0
RSA X Max	2819.81	7.1754	0	85.79	34085.2	20253.3
RSA Y Max	7.1754	3995.86	0	48854	78.6641	32683.1
1.2(DL+LL+EQX)	-378.71	0	19015.9	135822	-146361	2705.57
Earthquake X	-315.59	0	0	0	-4420	2254.64
Earthquake Y	0	-456.19	0	6389.19	0	-3407

Table 8: Base reactions of Model 3

Load Case/Combo	FX	FY	FZ	MX	MY	MZ
Dead	0	0	13750.6	98167.2	-102056	0
Live	0	0	2107.78	15060.1	-15545	0
RSA X Max	2874.33	10.4705	0	124.213	34746.1	20631.7
RSA Y Max	10.4705	3991.74	0	48732.7	112.285	34109.8
1.2(DL+LL+EQX)	-389.12	0	19030.1	135873	-146569	2777.36
Earthquake X	-324.27	0	0	0	-4540.8	2314.46
Earthquake Y	0	-467.22	0	6542.49	0	-3491.9

Conclusions

- From the above models, Interior placement of a floating column at the 4th story reduces maximum story displacement by 1.96% compared to a edge floating column placed from the 1st story to top of the building.
- Buildings experience the greatest amount of story drift at the level where an edge floating column is present.
- Compared to a building without floating columns, story shear decreases by up to 3.26% in a building with an edge floating column, while it increases by 0.01% in a building with an internal floating column.
- Placing floating columns in corners leads to greater story displacement and drift. This occurs because corner columns have less structural support to resist lateral forces from wind or earthquakes.
- Floating columns are primarily designed to carry vertical loads, such as gravity (dead and live loads), but they are not well-suited to resist lateral forces induced by wind or earthquakes.
- The floating column method will be adopted unless the building has specific space requirements.

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