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Seismic Analysis of Multi-Storey Building with Floating Column

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ABSTRACT

In present scenario buildings with floating columns are of typical feature in the modern multi storey construction practices in urban India. Such types of constructions are highly undesirable in building built in seismically active areas. This paper studies the analysis of a G+4, G+9 and G+14 storey normal building and floating column building for external lateral forces. The G+4, G+9 and G+14storey RCC building is studied by considering effect of floating column in the modeling. The analysis is done by the use of ETABS. This paper also studies the variation of the both structures by applying the intensities of the past earthquakes i.e., applying the ground motions to the both structures, from that lateral displacement, storey drift, time period and response of time history values are compared. This study is to find whether the structure is safe or unsafe with floating column when built in seismically active areas and also to find floating column building is economical or uneconomical.

Keywords: ***Floating Columns, Earthquake, Storey Drift, Time Period***

INTRODUCTION

Many urban multistory buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storey. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height. The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks (like the hotel buildings with a few storey wider than the rest) cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 2001 Bhuj earthquake. Buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation, have discontinuities in the load transfer path.

PROBLEM STATEMENT

A G+4, G+9, G+14 storied building with floating column and building without floating column located in zone III of India as per code IS 1893(Part1):2002 were taken for the investigation.

In this study, first a normal building without floating column is modeled as model1.

In model 2 floating columns located at ground floor,

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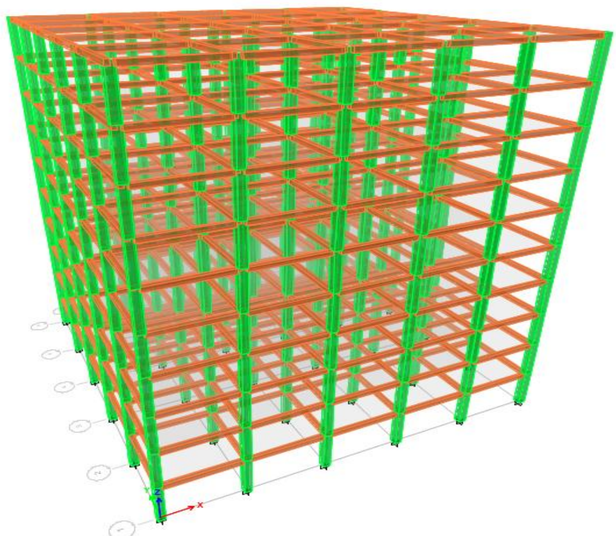
In model 3 floating column building with bracings at corners,
In model 4 floating column building with shear wall at corners,
In model 5 floating column building with bracings at peripheral sides,
In model 6 floating column building with shear wall at center,
In model 7 floating column building with shear wall at peripheral sides.
Modeling and analysis was carried out in ETABS V15.

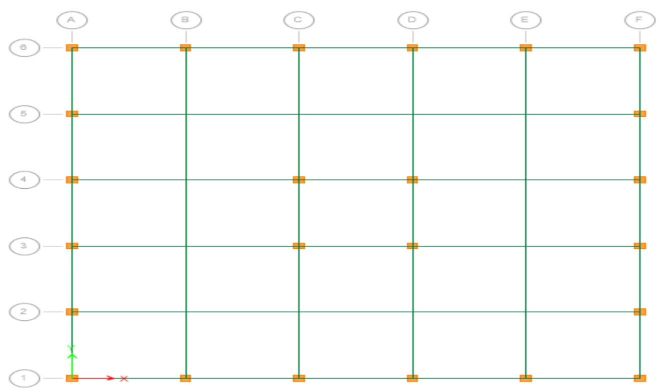
STRUCTURAL PLANNING

Model 1:



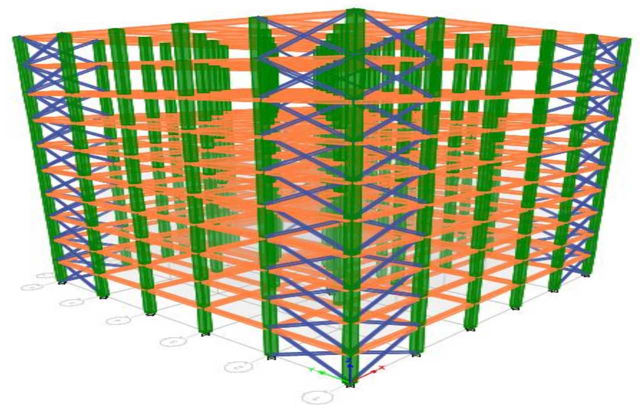
3D view without floating column

Model 2:



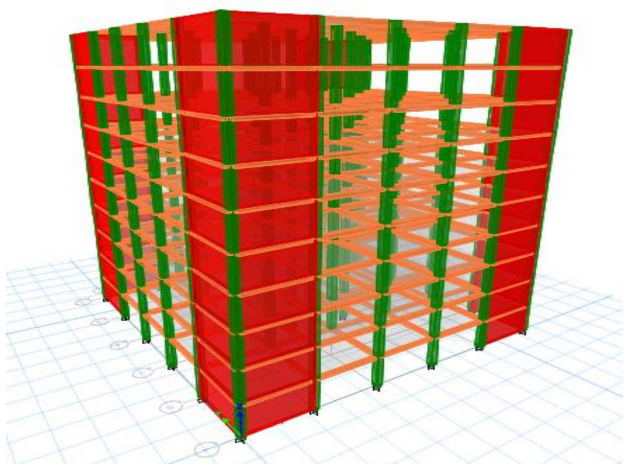
Plan of the building with floating column

Model 3:



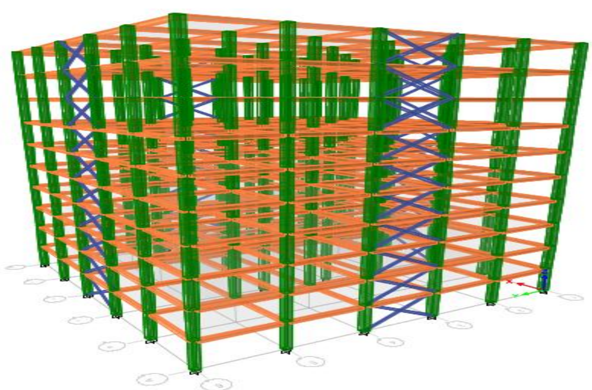
3D view with floating column with bracing at corners

Model 4:



3D view floating column building with shear wall at corners

Model 5:



3D view floating column building with bracing at peripheral side

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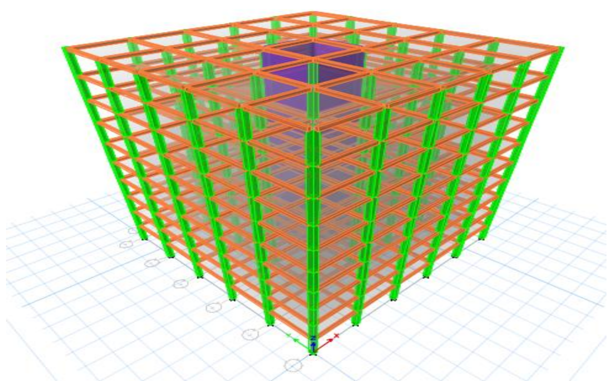
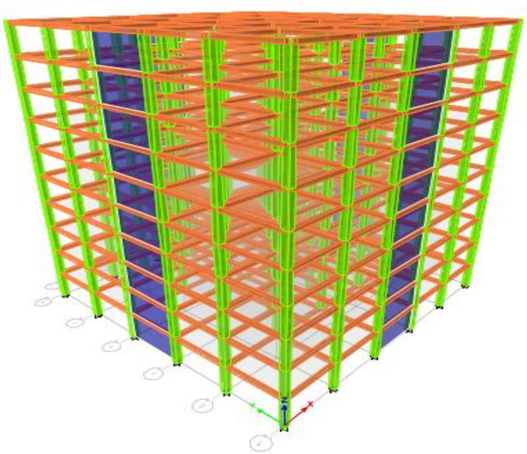
Model 6:



3D view floating column building with shear wall at centre

Model 7:



3D view floating column building with shear wall at peripheral side

RESULTS

STOREY DRIFT - ZONE -3

EQ-X 'mm'

The values of storey drift that is the inter storey displacement for two consecutive floors are correspondingly compared with the help of graphs. As the zone intensity increases, storey drift increases. The storey drift in any storey due to the minimum specified design lateral force, with partial load factor of 1.0, Shall not exceed 0.004 times the storey height. This limit is not exceeded in any storey under any seismic zone for both regular and irregular structures.

X – Direction Storey Drift in MM

Y-Direction No of Floors

(G+4)

Storey Height	model1 (mm)	model2 (mm)	model3 (mm)	model4 (mm)	model5 (mm)	model6 (mm)	model7 (mm)
0	0	0	0	0	0	0	0
3	8.3	11.2	2.5	0.2	4.1	0.3	0.5
6	12.2	13.6	3.1	0.4	5	0.5	1.1
9	11.5	12.8	3.2	0.5	5.2	0.6	1.4
12	9.6	10.1	2.9	0.5	4.6	0.7	1.6
15	5.7	6	2.2	0.5	3.3	0.6	1.5

(G+9)

Storey height	model 1 (mm)	model 2 (mm)	model3 (mm)	model4 (mm)	model5 (mm)	model6 (mm)	model7 (mm)
0	0	0	0	0	0	0	0
3	5.3	7	2.2	0.3	3.3	0.4	0.6
6	10.5	11.5	3.2	0.7	5	0.8	1.5
9	12	12.7	3.6	1	5.6	1.1	2.2
12	12.2	12.8	3.9	1.2	5.9	1.4	2.7
15	11.7	12.3	4.1	1.4	6	1.6	3.1
18	10.8	11.3	4.1	1.5	6	1.7	3.3
21	9.5	10	4	1.6	5.7	1.8	3.5
24	7.8	8.2	3.7	1.6	5.2	1.8	3.5
27	5.8	6.1	3.3	1.6	4.5	1.8	3.5
30	3.3	3.9	2.7	1.5	3.5	1.8	3.4

(G+14)

Storey Height	model1 (mm)	model2 (mm)	model3 (mm)	model4 (mm)	model5 (mm)	model6 (mm)	model7 (mm)
0	0	0	0	0	0	0	0
3	4.1	5.1	2.3	0.4	3.2	0.6	0.4
6	8.5	9.1	3.7	0.9	5.2	1.2	0.9
9	9.6	10.3	4.2	1.3	5.9	1.7	1.3
12	10.1	10.7	4.6	1.6	6.3	2.1	1.6
15	10.3	10.8	4.9	1.9	6.6	2.5	1.9
18	10.2	10.6	5.1	2.2	6.7	2.8	2.2
21	9.9	10.3	5.2	2.4	6.8	3	2.4
24	9.5	9.9	5.2	2.5	6.7	3.2	2.5
27	9	9.3	5.1	2.6	6.5	3.3	2.6
30	8.3	8.5	5	2.7	6.2	3.4	2.7
33	7.6	7.6	4.8	2.8	5.8	3.4	2.8
36	6.4	6.4	4.4	2.8	5.2	3.4	2.8
39	5.2	5.2	4	2.7	4.6	3.4	2.7
42	3.8	3.8	3.6	2.7	3.9	3.3	2.7
45	2.5	2.5	3	2.6	3.1	3.2	2.6

2 LATERAL DISPLACEMENT

The deformation of a cantilever column under lateral loads usually consists of two parts: the bending deformation and the shear deformation. The bending and the shear deformations can be represented with different shape functions along the column height. Assuming that the entire frame structure behaves like a shear beam

(G+4)

Storey Height	model1 (mm)	model2 (mm)	model3 (mm)	model4 (mm)	model5 (mm)	model6 (mm)	model7 (mm)
0	0	0	0	0	0	0	0
3	8.3	11.2	2.5	0.2	4.1	0.3	0.5
6	21.5	24.8	5.6	0.6	9.1	0.8	1.6
9	34.3	37.6	8.8	1	14.3	1.4	3
12	44.4	47.7	11.7	1.5	18.9	2.1	4.5
15	50.4	53.7	13.9	2	22.3	2.7	6.1

(G+9)

Storey Height	model 1 (mm)	model2 (mm)	model3 (mm)	model 4 (mm)	model5 (mm)	model6 (mm)	model7 (mm)
0	0	0	0	0	0	0	0
3	5.3	7	2.2	0.3	3.2	0.4	0.6
6	15.8	18.5	5.4	1	8.2	1.2	2.1
9	27.8	31.2	9	1.9	13.8	2.3	4.3
12	39.9	43.9	12.9	3.1	19.7	3.7	7
15	51.7	56.2	17	4.5	25.7	5.2	10
18	62.5	67.5	21.1	5.9	31.7	7	13.3
21	72	77.5	25.1	7.5	37.4	8.8	16.8
24	79.9	85.7	28.8	9.1	42.5	10.6	20.3
27	85.6	91.7	32.1	10.7	47	12.4	23.8
30	89.3	95.6	34.8	12.2	50.5	14.2	27.2

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(G+14)

Storey Height	model1 (mm)	model2 (mm)	model3 (mm)	model4 (mm)	model5 (mm)	model6 (mm)	model7 (mm)
0	0	0	0	0	0	0	0
3	4.1	5.1	2.4	0.4	3.1	0.6	0.8
6	12.6	14.2	6.1	1.2	8.4	1.8	2.7
9	22.7	24.5	10.3	2.5	14.3	3.4	5.3
12	33.3	35.2	14.9	4.2	20.6	5.6	8.7
15	44.1	46	19.8	6.1	27.2	8.1	12.6
18	54.7	56.6	24.9	8.3	33.9	10.9	16.9
21	65	66.9	30.1	10.7	40.7	14	21.5
24	74.9	76.8	35.4	13.2	47.4	17.2	26.3
27	84.1	86	40.5	15.9	53.9	20.5	31.2
30	92.6	94.5	45.5	18.6	60	23.9	36.1
33	100	102	50.2	21.3	65.8	27.4	41
36	106.6	108.5	54.7	24.1	71	30.8	45.8
39	111.8	113.7	58.7	26.8	75.7	34.2	50.4
42	115.6	117.4	62.3	29.5	79.5	37.5	54.9
45	118.1	120	65.3	32.2	82.6	40.6	59.1

ESPONSES OF TIME HISTORY ANALYSIS

In this present study, we made use of Nepal Earthquake data, and quote out the responses, method adopted was linear time history analysis.

(G+4)

Storey Height	Model 1 (mm)	Model 2 (mm)	Model 3 (mm)	Model 4 (mm)	Model5 (mm)	Model6 (mm)	Model7 (mm)
0	0	0	0	0	0	0	0
3	1.5	2.2	0.4	0.1	0.9	0.1	0.1
6	3.7	4.5	0.9	0.2	1.7	0.3	0.3
9	5.6	6.5	1.3	0.5	2.3	0.4	0.6
12	7	7.8	1.7	0.7	2.7	0.6	0.9
15	7.7	8.5	2	0.9	3.1	0.8	1.3

(G+9)

Storey Height	model 1 (mm)	model 2 (mm)	model3 (mm)	model 4 (mm)	model5 (mm)	model6 (mm)	model7 (mm)
0	0	0	0	0	0	0	0
3	1	1.4	0.5	0.1	0.8	0.1	0.1
6	2.9	3.5	1.1	0.4	1.9	0.4	0.4
9	5.1	5.8	1.7	0.7	3	0.7	0.8
12	7.2	8	2.3	1.1	4.1	1	1.3
15	9.2	10.2	2.7	1.6	5	1.4	1.8
18	10.9	12.2	3.3	2.1	6	1.9	2.4
21	12.3	13.8	3.8	2.7	7	2.3	2.9
24	13.5	14.9	4.3	3.2	7.8	2.8	3.5
27	14.6	15.7	4.8	3.8	8.4	3.3	4.1
30	15.4	16.4	5.2	4.3	9	3.7	4.7

(G+14)

Storey Height	model1 (mm)	model2 (mm)	model3 (mm)	model4 (mm)	model5 (mm)	model6 (mm)	model7 (mm)
0	0	0	0	0	0	0	0
3	0.9	1.1	0.9	0.1	1	0.2	0.3
6	2.8	3.1	2.2	0.5	2.6	0.7	1
9	4.9	5.2	3.6	0.9	4.3	1.3	1.9
12	7.2	7.5	5.2	1.5	5.9	2.1	3.1
15	9.4	9.7	6.8	2.1	7.6	3	4.4
18	11.5	11.7	8.5	2.9	9.3	4	5.8
21	13.3	13.5	10.1	3.6	11	5.1	7.3
24	14.9	15.1	11.6	4.4	12.6	6.2	8.7
27	16.2	16.4	13.1	5.3	14.1	7.3	10.1
30	17.2	17.5	14.5	6.1	15.4	8.4	11.6
33	18.1	18.3	15.6	7	16.7	9.6	13
36	18.8	19	16.6	7.8	17.7	10.7	14.3
39	19.4	19.6	17.4	8.6	18.6	11.8	15.6
42	19.8	20	18.2	9.5	19.4	12.9	16.8
45	20.1	20.3	18.8	10.3	20.1	14	18

TIME PERIOD

Here are the time period obtained from the models in respective three modes, based on modal participation factor

(G+4)

	mode1	mode2	mode3
model1	1.717	0.539	0.298
model2	1.801	0.568	0.315
model3	0.885	0.29	0.201
model4	0.323	0.101	0.069
model5	1.125	0.363	0.255
model6	0.366	0.108	0.071
model7	0.54	0.133	0.084

(G+9)

	mode 1	mode 2	mode 3
model1	2.548	0.805	0.441
model2	2.656	0.84	0.461
model3	1.516	0.452	0.247
model4	0.847	0.19	0.098
model 5	1.846	0.568	0.304
model 6	0.965	0.334	0.202
model 7	1.264	0.269	0.123

(G+14)

	mode 1	mode2	mode3
model1	3.957	1.269	0.71
model2	4.006	1.286	0.719
model3	2.796	0.852	0.452
model4	1.82	0.39	0.17
model5	3.203	0.998	0.539
model6	2.059	0.458	0.205
model7	2.515	0.595	0.259

CONCLUSION:

The Following conclusions are made from the present study

1. The behavior of multi storey building with and without floating column is studied under different earthquake excitation. The static analysis is done and It is concluded that by the maximum displacement and storey drift values are increasing for floating columns.
2. In the present study , comparing the story drift values showing that , in all the buildings model

4 (model with shear wall at corners) given a better performance, next to that model 6 (model with shearwall at centre) is better.

3. Comparing the displacement values model 4 was better in Seismic equivalent analysis. Coming to the Earthquake excitation , i.e., Time history analysis (Nepal Earthquake), model 6 given a bit better performance in G+4, and G+9, but in G+14 Model 4 was good.
4. In Comparing bracing buildings, there were performed good in lesser height building than high rise. It is clearly shown the building with bracing system worked well in case of smaller height than in high rise building; difference is stated in higher stories of the building. Although was also a good recommendation.
5. Comparing time period, model 4(model with shear wall at corners) is good in all cases, next to it is model 6 (model with shear wall at centre).
6. The axial forces are increasing in the columns other than floating columns due to transfer of loads of the floating columns to the conventional columns.
7. Visually shear wall building shown best behavior in all the cases as per safety, but installation of shear wall in buildings having lesser height won't be recommended as of economic note.
8. So, as of the conclusion, model 3 is recommended for G+4, and model 4 and model 6 are equally good in case of G+9, G+14.

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