Comparative Seismic Analysis of RC Framed Buildings with and without floating columns

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Abstract: In big cities, it is generally seen that in multi storey buildings (both residential and commercial) an open space is reserved for parking generally at the ground floor. Also in office buildings, a wide open space is required for the purpose of assembly hall and auditoriums. To meet these requirements it is necessary to plan the building without or with minimal use of floating columns. In this research, Linear Static Analysis is performed to observe the responses of a building without floating column and a building with floating columns in seismic zone V under soft soil type III using ETABS.

Index Terms **: Floating Columns, Linear Static Analysis, Story drift, Story displacement, Story shear.**

I. INTRODUCTION

Column is a vertical member starting from foundation level and transferring the load to the ground. The floating column is also the vertical member but it starts from the lower story level and rests on the transfer beam, this beam transfers the forces to the column below it. Conventional Civil Engineering structures are designed on the basis of strength and stiffness criteria. In case of earthquake forces the demand is for ductility. Larger is the capacity of the structure to deform plastically without collapse, more is the resulting ductility and the energy dissipation. This causes reduction in effective earthquake forces .The behavior of a building during earthquakes depends mainly 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. These columns have a discontinuous path for load transfer hence they are considered unsafe from earthquake point of view.

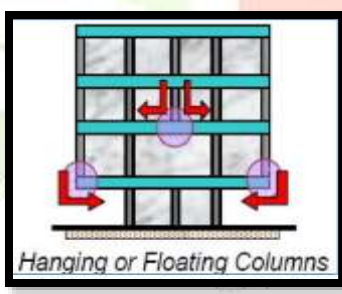

Fig 1: Floating Columns

Linear Static Analysis

A linear static analysis is an analysis where a linear relation holds between applied forces and displacements. In practice, this is applicable to structural problems where stresses remain in the linear elastic range of the used material. linear analysis is an efficient method of solving a structure as it assumes the structure to behave in an elastic manner.

Linear static analysis has two main assumptions:

1) The structure's behavior is linear (must obey Hooke's Law).
   - Forces are linearly proportional to deformation. If you double the loads, the response (displacements, strains, stresses) also double. Stress is proportional to strain.
   - When the loading is removed the material must return to it's original shape. (No plastic deformation).
   - Boundary conditions do not vary during the application of loads.

2) The loading is static.

- Magnitude and direction do not change with time.
- All loads are applied slowly and gradually until they reach their full magnitudes. Inertial and damping properties are ignored due to negligibly small accelerations and velocities.
- Time variant loads which induce considerable inertial and/or damping forces may warrant dynamic analysis.

II. OBJECTIVE

The objective of research is to:
1) Analyse both structures by Linear Static Analysis using ETABS.
2) Compare the responses of building with floating columns and building without floating columns.
3) Make a comparison of storey drift, storey shear and storey displacement for buildings with and without floating columns.

III. METHODOLOGY

Using ETABS, two G+7 buildings are modeled, one without floating columns and one with floating columns at alternate floors. As shown in the figures.
The models have been designed as follows:
Model 1: A G+7 building without floating columns
Model 2: A G+7 building with floating columns at alternate floors. i.e. at first floor, third floor, fifth floor and seventh floor.

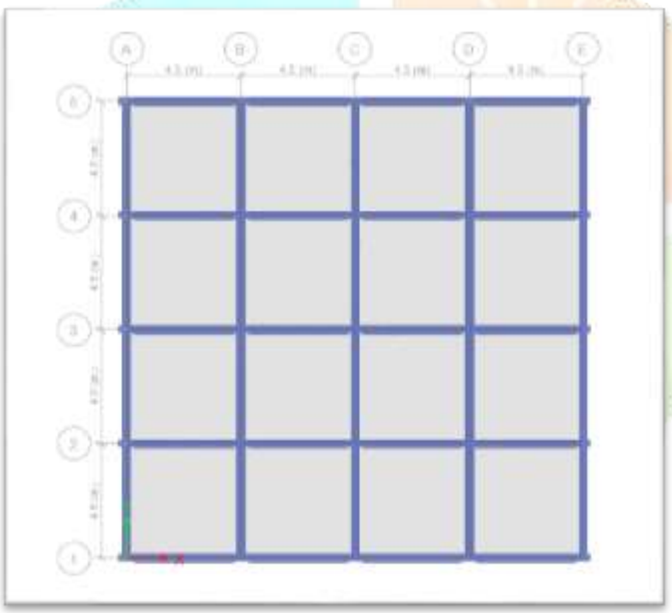

Fig 2: Plan of Model 1

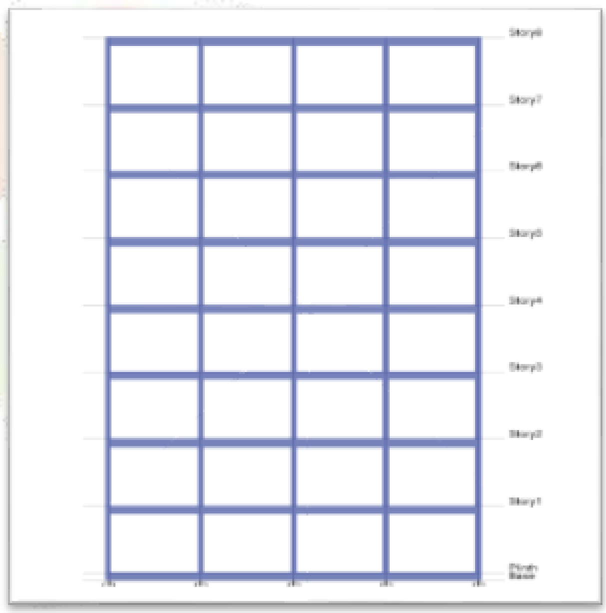

Fig 3: Elevation of Model 1

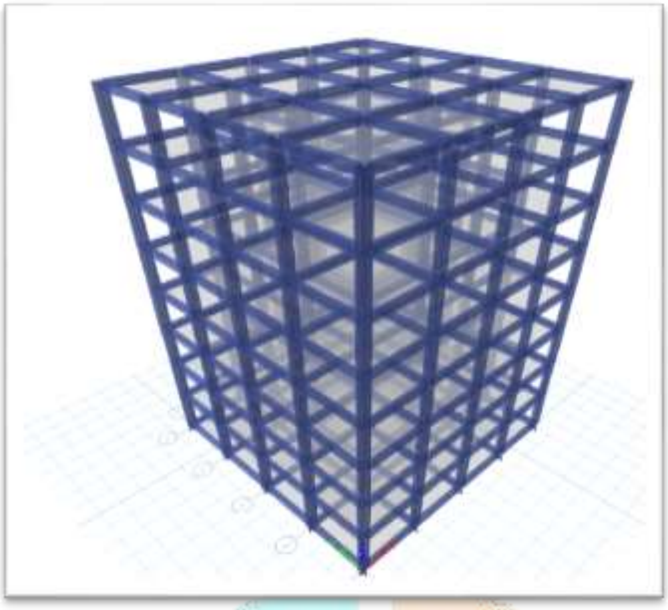

Fig 4: 3D view of Model 1

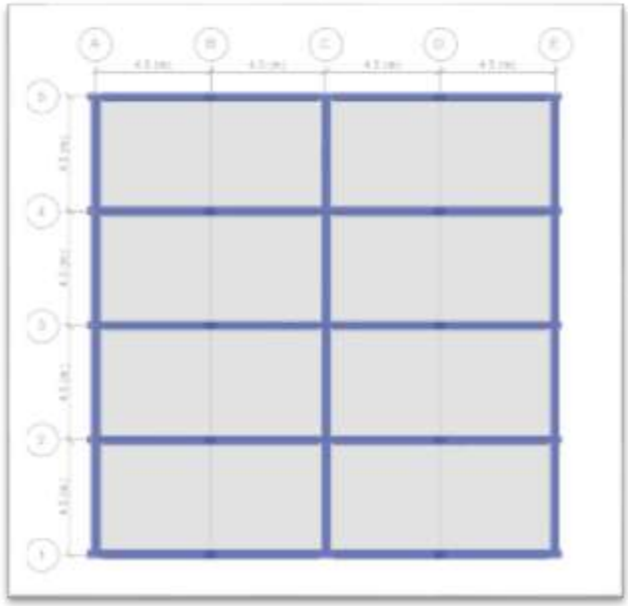

Fig 5: Plan of Model 2

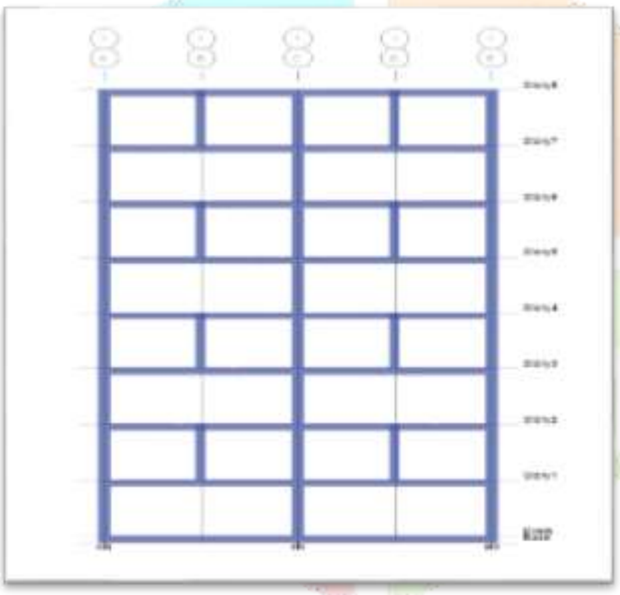

Fig 6: Elevation of Model 2

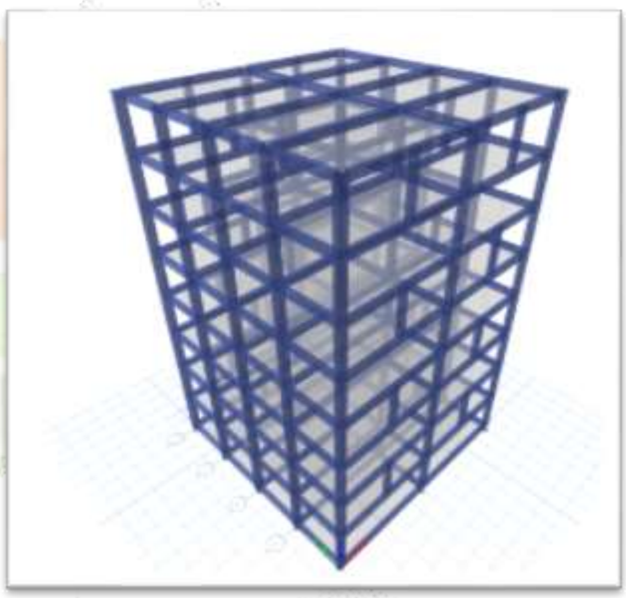

Fig 7: 3D view of Model 2

IV. DETAILS OF THE PLAN

Building Dimensions	18m x18m
Height of the building	29.25m
Storey Height	3.6m
Distance between columns	4.5m
Grade of Concrete used	M30
Grade of steel used	HYSD500
Size of Columns	0.3x0.6m
Size of floating columns	0.3x0.45m
Size of beams	0.3x0.6m
Depth of slab	200mm
Thickness of external walls	0.20 m
Thickness of internal walls	0.12 m
Soil type	III
Seismic Zone	V

Importance Factor	1
Dead load on slab	5 KN/m2
Live load on slab	4 KN/m2
Wall load on external beams	14.4 KN/m
Wall load on internal beams	8.64 KN/m
Type Of Building	Office Building

V. Result and Discussion

The results after performing Linear Static analysis in ETABS 2015 are given in tabular form as below. The storey drift, storey displacement and storey shear have been compared for both the models in both directions. The model is analyzed keeping the base support as fixed the comparison is done in the following tables. Load combinations are provided as given in IS 1893(Part 1:2002).

Story Drift

According to IS 18939(Part 1):2002 Storey Drift is the displacement of one level relative to other level above or below. In ETABS it is taken as the difference between the displacements of adjacent storey divided by the story height. Storey drift in any storey due to minimum specified design lateral force with partial load factor of 1.0 should not exceed 0.004 times the storey height.

Storey drift results for both the models are given below.

Model 1

Story	Elevation m	X-Dir	Y-Dir
Story8	29.25	0.001302	0.00157
Story7	25.65	0.002029	0.002631
Story6	22.05	0.002622	0.003435
Story5	18.45	0.003037	0.003992
Story4	14.85	0.003294	0.004343
Story3	11.25	0.003406	0.004526
Story2	7.65	0.003315	0.004569
Story1	4.05	0.002413	0.004013
Plinth	0.45	0.000427	0.00057
Base	0	0	0

Model 2

Story	Elevation m	X-Dir	Y-Dir
Story8	29.25	0.001479	0.001972
Story7	25.65	0.002857	0.003528
Story6	22.05	0.003078	0.004407
Story5	18.45	0.004384	0.005397
Story4	14.85	0.003931	0.005608
Story3	11.25	0.004987	0.006141
Story2	7.65	0.003898	0.005887
Story1	4.05	0.003304	0.005203
Plinth	0.45	0.000729	0.000843
Base	0	0	0

Story Displacement

It is total displacement of ith storey with respect to ground and there is maximum permissible limit prescribed in IS codes for buildings. Maximum displacement in each storey due to all the applied forces according to load combinations as provided in IS 1893(Part 1:2002) are given below.

Model 1

Story	Elevation m	X-Dir mm	Y-Dir mm
Story8	29.25	77.22	104.846
Story7	25.65	72.561	99.202
Story6	22.05	65.258	89.729
Story5	18.45	55.822	77.363
Story4	14.85	44.889	62.991
Story3	11.25	33.031	47.358
Story2	7.65	20.769	31.063
Story1	4.05	8.855	14.625
Plinth	0.45	0.192	0.257
Base	0	0	0

Model 2

Story	Elevation m	X-Dir mm	Y-Dir mm
Story8	29.25	100.388	137.415
Story7	25.65	95.173	130.351
Story6	22.05	84.921	117.656
Story5	18.45	73.91	101.831
Story4	14.85	58.133	82.402
Story3	11.25	44.058	62.253
Story2	7.65	26.104	40.142
Story1	4.05	12.154	18.985
Plinth	0.45	0.328	0.379
Base	0	0	0

Story Shear

Storey Shear are the lateral forces that occur on each floor because of earthquake. It is the ratio of story shear force when story collapse occurs to story shear force when total collapse occurs. Story shear at top and bottom of each story is given in the following tables.

Model 1

Story	Elevation m	Location	X-Dir kN	Y-Dir kN
Story8	29.25	Top	-961.97	-692.2547
		Bottom	961.97	692.2547
Story7	25.65	Top	-1724.7095	-1241.1388
		Bottom	1724.7095	1241.1388
Story6	22.05	Top	-2288.3714	-1646.7622
		Bottom	2288.3714	1646.7622
Story5	18.45	Top	-2683.0051	-1930.7493
		Bottom	2683.0051	1930.7493
Story4	14.85	Top	-2938.6602	-2114.7243
		Bottom	2938.6602	2114.7243
Story3	11.25	Top	-3085.386	-2220.3114
		Bottom	3085.386	2220.3114
Story2	7.65	Top	-3153.232	-2269.1349
		Bottom	3153.232	2269.1349
Story1	4.05	Top	-3172.2477	-2282.819
		Bottom	3172.2477	2282.819
Plinth	0.45	Top	-3172.4763	-2282.9835
		Bottom	3172.4763	2282.9835
Base	0	Top	0	0
		Bottom	0	0

Model 2

Story	Elevation m	Location	X-Dir kN	Y-Dir kN
Story8	29.25	Top	-644.5363	-462.701
		Bottom	644.5363	462.701
Story7	25.65	Top	-1191.1739	-855.1224
		Bottom	1191.1739	855.1224
Story6	22.05	Top	-1565.2376	-1123.656
		Bottom	1565.2376	1123.656
Story5	18.45	Top	-1848.0624	-1326.6909
		Bottom	1848.0624	1326.6909
Story4	14.85	Top	-2017.7231	-1448.4873
		Bottom	2017.7231	1448.4873
Story3	11.25	Top	-2122.8781	-1523.9761
		Bottom	2122.8781	1523.9761
Story2	7.65	Top	-2167.9028	-1556.2986
		Bottom	2167.9028	1556.2986

Story	Elevation m	Location	X-Dir kN	Y-Dir kN
Story1	4.05	Top	-2181.5309	-1566.0819
		Bottom	2181.5309	1566.0819
Plinth	0.45	Top	-2181.6823	-1566.1906
		Bottom	2181.6823	1566.1906
Base	0	Top	0	0
		Bottom	0	0

Summary of results obtained:

1) Story drift is more in model 2 as compared to model 1. i.e. building with floating columns gives more drift in each storey.
2) In both the models, storey drift is minimum at the plinth level. Then storey drift gradually increases till third storey and then decreases again.
3) In model 1, storey drift is maximum at the third floor in X direction while it is maximum at second floor in Y direction.
4) In Model 2, storey drift is maximum at third storey in both directions.
5) Storey displacement increases elevation in both the models in both X and Y directions.
6) Storey displacement in floating column building is found to be more on each floor.
7) Storey displacement in floating column building is 23% more than the non floating column building at the eighth floor in both X and Y directions. This is because the regularity of the structure.
8) Storey shear reduces in the floating column building due to the change in cross sections of columns as the floating column with smaller cross section replace the large cross section columns at each floor.
9) As the seismic weight decreases in case if floating columns, storey shear decreases.

VI. CONCLUSIONS:

From the study it has been observed that floating columns might have adverse effects on the earthquake response of the building. So buildings in earthquake zones should be designed keeping the aspect of ductility in mind. From the above research it has been concluded that the building with floating columns has been found to be weaker than building without floating columns in aspects of story drift and story displacement. But due to the lighter mass of floating columns, storey shear is effective for it.

VII. ACKNOWLEDGEMENT

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