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Research Article

"Performance Based Analysis & Design of Floating & Non-Floating Column with and Without Seismic Effect on Multistoreyed Building"

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ABSTRACT

In modern urban construction, architectural demand for aesthetic flexibility, functional spaces often lead to the use of structural features such as floating columns. A floating column which is a vertical straight member in a structural building that rests on a beam or slab and cannot transferring the load directly to the foundation. This method creates discontinuities in the load transmission path, which can be crucial, particularly under lateral loads like those caused by earthquakes, even if it allows design freedom and space optimization.

Buildings with floating columns behave very differently than those with traditional (non-floating) columns, especially during seismic activity. The stability and integrity of buildings situated in seismic zones are put to the test by dynamic forces. When floating columns lack a continuous load route, stress concentration may rise, and the structure may be more susceptible to damage or collapse in the event of an earthquake. For this study, a residential building with 21 floors (G+20) is analyzed in four configurations, one with floating columns and the other without and other two are the alternate floors. The structure is predictable to be in Seismic Zone III, as per IS 1893:2016. The buildings are modelled using Staad Pro V8i.

This study aims to analyze and compare the total behavior of multistoried buildings with floating and non-floating columns under both static and seismic loading conditions with help of by using structural analysis software. The major parameters such as base shear, story displacement, inter-story drift, and whole structural stability are evaluated. The goal is to understand the impact of floating columns on building performance and to propose design considerations that can improve the seismic resistance of such structures.

Keywords: Floating columns, STAAD PRO, Transfer beam, Story Displacement, Story Drift,

INTRODUCTION

Stub columns, also known as floating columns, are unattached to any kind of footing on the ground. Unlike an ordinary column, this floating column does not transfer the load. The joint of the floating column and beam girder will experience a significant shear force, bending moment, and torsion when a significant amount of earthquake force act on the building.To make access to the public area at the base more comfortable, a larger opening at ground level is used to stop the stub column at the ground and first floor levels of a high-rise building. By using girder beams to collect the vertical and side along loads from the elevated structure portion and then transfer them to the widely separated section below, the larger opening at the ground floor level is achieved.

In modern high-rise construction, the design and structural integrity of buildings are paramount. Among the many structural elements employed, floating columns and transfer beams play a important role in ensuring the stability and functionality of multi-story buildings. These structural components help manage the complex distribution of loads, facilitate design flexibility, and enable efficient use of space. This study purpose is providing a comprehensive understanding of floating columns, transfer beams, and their application in a real-world design context, particularly focusing on their behavior under various load conditions and the challenges they present in structural design.

OBJECTIVES

To study and evaluate the structural performance of buildings with floating column and normal (non-floating) column structure.To understand the effect of floating columns on load distribution, lateral displacement, base shear, and story drift due

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to gravity and lateral loads (like wind or seismic loads).To be able to understand the applicability and drawbacks of employing floating columns in high-rise buildings preferably located in seismic prone regions. This was necessary to compare design parameters like member forces, moments and deflections in each structure type. To guide design recommendations for safe floating column adoption in a contemporary building architecture.

METHODS

- **PRESENT STUDY**: **Comparative Analysis: -** A G+20 story building is modeled in structural analysis software STAAD Pro in Four configurations: **Model 1:** With regular (non-floating) columns, **Model 2:** With central floating columns, **Model 3:** With central alternate floating columns, **Model 4:** With 1st , 6th,11th & 16th floor floating columns.
- **Load Application:** Dead loads, live loads, and lateral loads (earthquake and wind) are applied according to IS 875 and IS 1893 standards (for India) or relevant codes.
- **Parameters Studied:** Story displacement, Base shear, Bending moments and shear forces, Story drift, Time period and mode shapes (for dynamic analysis)
- **Seismic Performance:** Special attention is given to how floating columns affect the building's seismic response and vulnerability.
- **Results Interpretation:** The behavior of both structures is compared to identify Increase in critical forces and moments in beams supporting floating columns, Weak story effects, overall structural stability, Conclusion and **Recommendations-**Based on the study, conclusions are drawn regarding where and when floating columns can be safely used.
- **Plan and Elevations-**

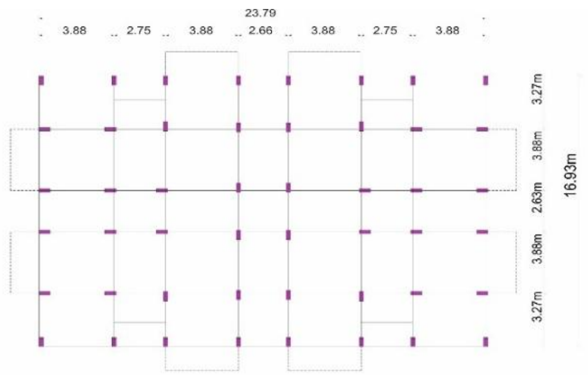

FIGURE1 -MODEL CASE 1

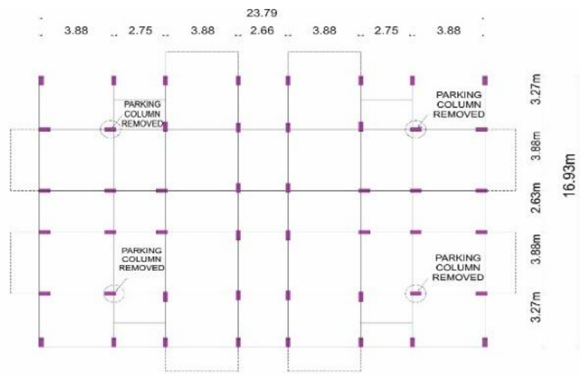

FIGURE 2 -MODEL CASE 2

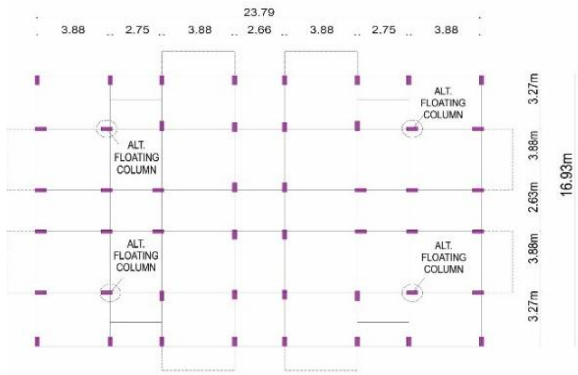

FIGURE 3 -MODEL CASE 3

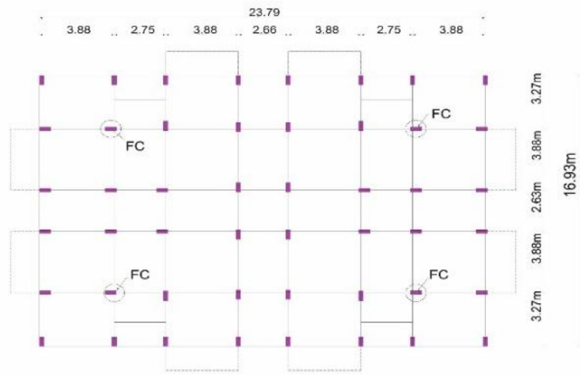

FIGURE 4 -MODEL CASE 4
FC.COLUMN AT 1ST,6TH,11 TH,16TH FLOOR
FC FLOOR

Figure 1 -Four types of Model building configuration plans

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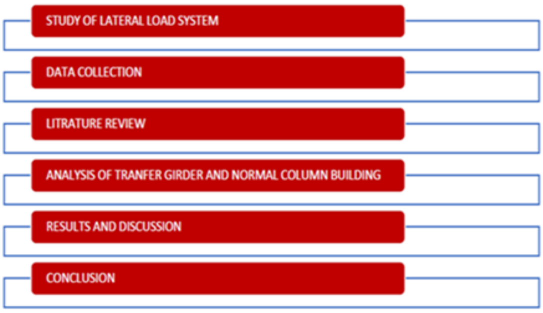
- **FLOWCHART FOR ANALYSIS AND DESIGN**



The image outlines the steps of a study or research project, specially related to structural engineering, focusing on building analysis under lateral loads. The steps presented in a flowchart style includes study of lateral load system, data collection, literature review, analysis of transfer girder with floating column and normal column building, results and discussion, conclusion.

Fig: Flowchart For Analysis And Design

LITERATURE REVIEW

In this review, major findings of a vast literature addressing modeling of multi-story buildings with floating columns and transfer beams under seismic loads are summarized.

1. Ashish G. Pakmode et al. (2016)-This study investigates how earthquake excitations affect multi-story buildings with different floating column configurations using finite element methods using Staad pro. Study observed a 56.96% increase in story displacement in buildings with floating columns under seismic loading. Analysis reported that the story drift increase of approximately 48.09% at the top floor for buildings with floating columns.

2. Kandukuri Sunitha et al. (August 2017)-This research compares high-rise buildings with and without floating columns located at different intermediate floor levels under lateral and seismic forces. The analysis was conducted using ETABS.

The presence of floating columns resulted in higher lateral displacements and story drifts compared to buildings without floating columns. This indicates a reduction in the building's lateral stiffness, making it more susceptible to the study observed a decrease in base shear in buildings with floating columns.

3. Arpit Shrivastav et al. (May 2018)-Three building models with different heights considering G+7, G+11, and G+15 are considered under seismic zones IV and V. The study information compares building structures with and without shear walls. Floor areas range from 28mx28m to 32mx32m, and uniform beam dimensions of 0.3mx0.5m are used across all the models. In this paper, in zone V, 16 story model is not safe for both without and with a shear wall. Hence it is advised to increase the size of column to decrease the displacement values.

4. Shivam Wankhade et al. (January 2020)-Buildings having floating columns at 8th story in G+12, G+14 and G+16 has been considered for present study. The analysis of structures is carried out on ETABS, in seismic zones II to V. The finding indicates high lateral displacement and story drift in higher seismic zones and work concludes to suggest not to go for floating columns in these seismic

5. Gulchaman Khan and Prof. Mayur Singi (2018)-The analysis considers the 8, 12, and 16 story high-rise buildings with and without shear walls on seismic Zone V using ETABS 2016. It points out that floating columns, although enabling design flexibility, confer additional weakness during earthquakes. Shear walls reduce displacement and drift, thereby worsening the overall stability of the structure. According to the study, floating columns indeed provide design flexibility; however, they increase vulnerability of the structure during earthquakes, particularly in high-rise buildings located in Zone V (a high-risk seismic area).

- **BUILDING MODELING**

For this study, a residential building with 21 floors (G+20) is analyzed in four configurations, one with floating columns and the other without and other two are the alternate floors. The structure is predictable to be in Seismic Zone III, as per IS 1893:2016. The buildings are modelled using STAADPRO V8i. The analytical models include all relevant components affecting mass, strength, stiffness, and durability. The structural system includes beams, conventional and floating columns, slabs, grid slabs, foundations, and staircases, allowing a comprehensive assessment of the building's show under seismic and other loading conditions.

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Figure 3 -G.+ 20 Floor High Rise Building 3d

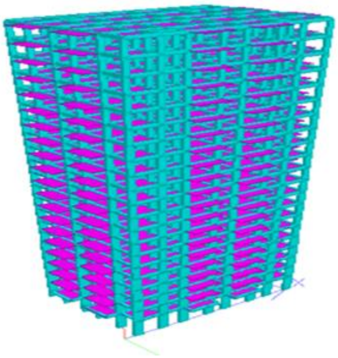

Table 2-Summary of Structural and Seismic Design Parameters for (G+20) Building

S. No.	Parameter	Value	Unit / Description
1	Seismic Zone	Zone 3	-
2	Zone Factor (Z)	0.24	-
3	Importance Factor (I)	1	-
4	Response Reduction Factor (R)	3	-
5	Soil Type	Medium	-
6	Building Configuration	G + 20	20 stores
7	Building Dimensions	23.79m × 16.93 Mx 67.50 M	L x B x H
8	No. of Bays	In x direction-7 In y direction-5	In both X and Y directions
9	Width of Each Bay	Refer to the plan	M
10	Story Height	Parking 4.50 M & other Floor 3.15 M	m (per story in Y direction)
11	Beam Dimensions	0.30m x 0.60m-For Regular building 0.60x1.20 –FC BUILDING 0.45X1.20- FC BUILDING AFTER REDUCTION	B x D
12	Column Dimensions	0.60mx 1.20Mx4.50m 0.60X1.20MX3.15M 0.45X1.20X3.15M 0.45X0.90X3.15M 0.30X0.75X3.15M	B x D x H
13	Slab Thickness	0.150 M	-
14	Concrete Cover	0.025m (Beams), 0.040m (Columns)	M
15	Loads Considered	Dead Load, Live Load, Earthquake Load	X and Y Directions
16	Imposed Load on Slab	3	kN/m²
17	Grade of Concrete	M40	fck = 40 N/mm²
18	Grade of Steel	Fe500 HYSD	fy = 500 N/mm²

Table 1-Section Properties of the G+20 Residential Building-

S. No.	Parameter	Description
1	Area of Building	23.79 m × 16.93 m (Total = 402.74 sq. m)
2	Grade of Concrete	M40 – Column M40 – Girder Beam M40 – Regular Beam M40 – Slab
3	No. of Floors	G + 21
4	Total Height	67.50 m
5	Storey Heights	Parking Floor: 4.5 m Residential Floor: 3.15 m
6	Building Type	Residential Building
7	Loading	Dead Load (Frame Load) Live Load (IS Code) Floor Finish Included
8	Load Combinations	As per IS 456:2000
9	Wall Thickness	150 mm (External), 150 mm (Internal)
10	Beam Sizes	300 mm × 600 mm (Regular) 300 mm × 1200 mm (FC Building) 450 mm × 1200 mm (FC Building)
11	Column Sizes	600 mm × 1200 mm

- **Types of Loads**

Types of loads are considered in the analysis and design of the structure: [IS456-2000]-Dead Load (DL), Live Load (LL), Wind Load (WL), Earthquake Load (Seismic Load)

following are the List of IS Codes Used in Analysis and Design

The analysis and design of the structure are carried out in accordance with the following Indian Standard (IS) codes-IS Code Description- IS 456:2000, IS SP-16:1980, IS 875 (Part 1):1987, IS 875 (Part 2):1987, IS 875 (Part 3):1987, I S 1893 (Part 1):2016

Following Load Combinations Used:

- 1.5 (DL + LL),
- 1.2 (DL + LL ± EQX),
- 1.2 (DL + LL ± EQY),
- 1.5 (DL ± EQX),
- 1.5 (DL ± EQY),
- 0.9 DL + 1.2 LL ± 1.2 EQX,
- 0.9 DL + 1.2 LL ± 1.2 EQY

DL - Dead Load, LL - Live Load, EQX - Earthquake Load in X direction, EQY -Earthquake Load in Y dire

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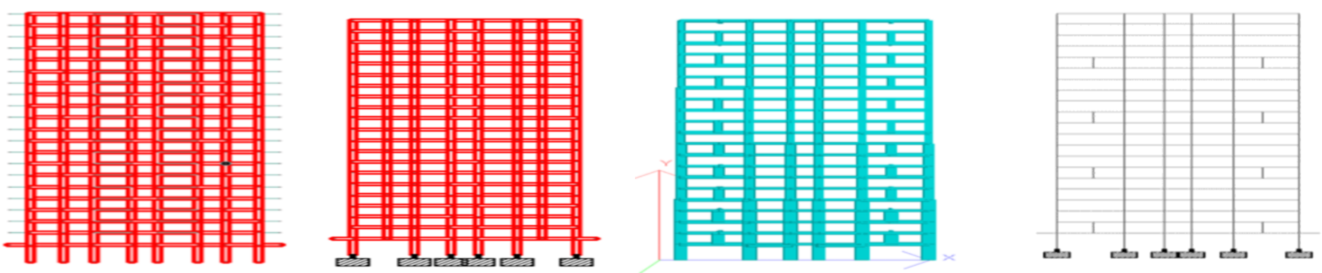
PROBLEM STATEMENT--I have selected high-rise building (G+20), It is obligatory to analyze lateral loads acting on the building to know the behaviour of transfer Girder Beam and comparing the stability of it with Normal Column Building. The structure must be modelled and analyzed for various response parameters of earthquakes for selected lateral load resisting systems. The building is modelled and analyzed using staddpro vi8 softwarection.

- Table3-Building Properties and Technical Specifications

Parameter	Details
Number of Stories	G+20
Total Height of Building	67.50 m
Height of Ground Parking Storey	4.5 m
Height of Service Storey	3.15 m
Height of Typical Stories	3.15 m
Dimensions of Building	23.79MX16.93M
Size of Girder Beam	600mm × 1200 mm
Size of secondary beam	300 mm × 600 mm
Size of Columns	600 mm × 1200 mm (Initial), 450mm × 900mm (After Reduction)
Size of Floating Columns	300 mm × 600 mm, 300 mm × 900mm
Slab Thickness	150 mm
Location	Pune, Maharashtra
Basic Wind Speed	44 km/h
Response Reduction Factor	5
Importance Factor	1
Grade of Concrete	M40 (Design Mix)
Grade of Reinforcing Steel	Fe500
Density of Concrete	25 kN/m³
Supports at Base	Fixed
Supports at Floating Columns at Service Floor	Hinged
Diaphragm	Rigid

- ✓ PROBLEM STATEMENT SHOWING DETAILS OF BUILDING MODEL-
- ✓ Table 4-DETAILS OF MODEL CASE STUDY FOR BUILDING

Model No.	Building Model Description
MODEL 1	RC structure without Floating Columns – A Normal G+20 storey building.
MODEL 2	RC structure with Floating Column – Columns are removed in the center of the parking frame (Floating column located at the first floor to above all floors).
MODEL 3	RC structure with Floating Column – (Floating column located at alternate floors).
MODEL 4	RC structure with Floating Column – (Floating column located at 1st,6th ,11th and 16th floors).



MODEL -1 **MODEL -2** **MODEL -3** **MODEL -4**

Figure4–Front 3d Cut Section View – 4 Building Case

- Implementation of Is 1893 Provision In Stadd pro Vi8 – we get the final output.

RESULTS

Clause 6.3.1.2 of IS 1893-2016 -allows for the analysis of the structure for a variety of load combinations by applying lateral loads in the X and Z directions. The greatest displacement at each floor for the specified load combinations is recorded in the X and Z directions and is displayed as a graph below. Story displacement is the term used to define the lateral movement of a

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structure brought on by lateral pressure. The establishment of Floating column in a building result in an increase in the story displacement.

- **Results After Analysis-** Graph With Table Values Is Given Below for Story Displacement

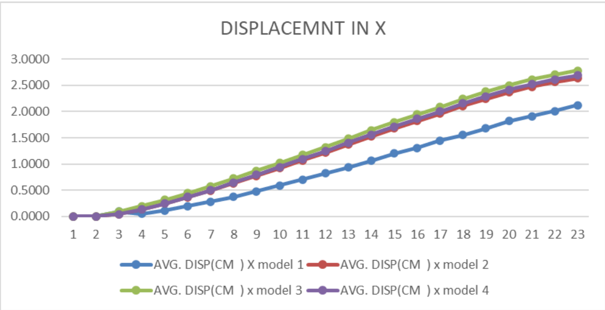

Figure 5 -Graph for Story Displacement in X-Direction

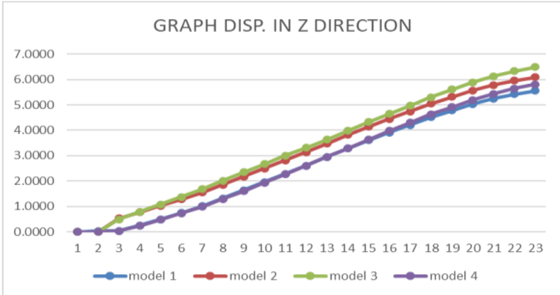

Figure 6 -Graph for Story Displacement in Z Direction

	DISP IN X			
STORY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
0	0.0000	0.0000	0.0000	0.0000
1	0.0893	0.0430	0.0912	0.0421
2	0.1913	0.1329	0.1958	0.1322
4	0.3079	0.2439	0.3163	0.2462
5	0.4317	0.3644	0.4432	0.3715
6	0.5595	0.4898	0.5751	0.5021
7	0.7026	0.6309	0.7206	0.6474
8	0.8486	0.7754	0.8701	0.7929
9	0.9962	0.9216	1.0202	0.9427
10	1.1443	1.0684	1.1717	1.0941
11	1.2919	1.2147	1.3219	1.2449
12	1.4506	1.3722	1.4826	1.4059
13	1.6064	1.5268	1.6425	1.5605
14	1.7578	1.6769	1.7978	1.7135
15	1.9034	1.8213	1.9461	1.8615
16	2.0424	1.9590	2.0884	2.0025
17	2.1920	2.1074	2.2393	2.1538
18	2.3299	2.2439	2.3792	2.2902
19	2.4540	2.3668	2.5043	2.4147
20	2.5628	2.4742	2.6144	2.5238
21	2.6545	2.5645	2.7067	2.6151
22	2.7289	2.6376	2.7817	2.6885

Table 5-Story Displacement In X-Direction

		DISP IN Z		
STORY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
0	0	0.0000	0.0000	0.0000
1	0.0375	0.0375	0.4940	0.0347
2	0.0375	0.2460	0.7880	0.2395
4	0.246	0.4889	1.0785	0.4744
5	0.4889	0.7440	1.3716	0.7226
6	0.744	1.0077	1.6723	0.9830
7	1.0077	1.3204	2.0083	1.2954
8	1.3204	1.6389	2.3446	1.6024
9	1.6389	1.9601	2.6744	1.9308
10	1.9601	2.2815	2.9995	2.2634
11	2.2815	2.6005	3.3137	2.5953
12	2.6005	2.9442	3.6349	2.9522
13	2.9442	3.2799	3.9806	3.2864
14	3.2799	3.6043	4.3224	3.6368
15	3.6043	3.9144	4.6537	3.9765
16	3.9144	4.2071	4.9738	4.2996
17	4.2071	4.5096	5.3040	4.6321
18	4.5096	4.7859	5.6103	4.9173
19	4.7859	5.0322	5.8858	5.1945
20	5.0322	5.2450	6.1288	5.4397
21	5.245	5.4211	6.3337	5.6473
22	5.4211	5.5578	6.4985	5.8139

Table 6-Story Displacement In Z-Direction

- **Results After Analysis-** Graph with Table Values Is Given Below for Story Drift

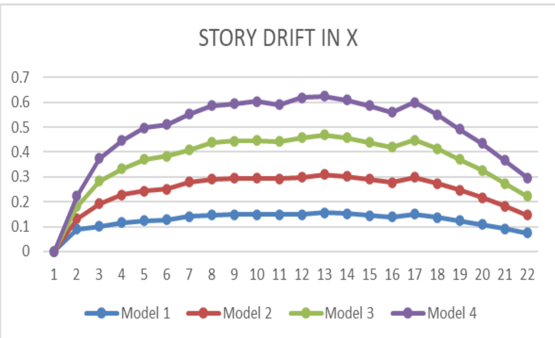

Figure 7 -Graph for Story Drift in X-Direction

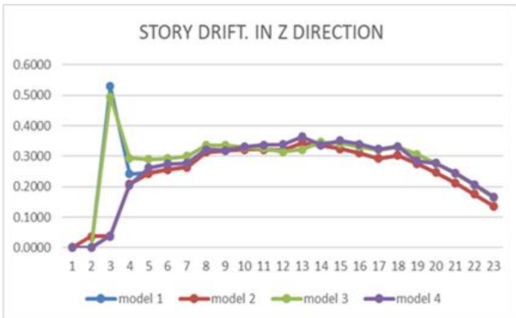

Figure 8 -Graph for Story Displacement in Z-Direction

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	DRIFT GRAPH IN X			
	STORY DRIFT IN X (IN CM)			
Floor NO.	**Model 1**	**Model 2**	**Model 3**	**Model 4**
1	0	0	0	0
2	0.0893	0.043	0.048	0.0421
3	0.102	0.0899	0.0912	0.0901
4	0.1166	0.1111	0.1046	0.1141
5	0.1238	0.1204	0.1269	0.1258
6	0.1279	0.1233	0.1319	0.128
7	0.1406	0.139	0.1295	0.1428
8	0.146	0.1445	0.1485	0.1465
9	0.1476	0.1462	0.1495	0.1498
10	0.148	0.1467	0.1515	0.1573
11	0.1476	0.1441	0.1502	0.1485
12	0.1492	0.1484	0.1607	0.161
13	0.1558	0.1546	0.1589	0.1547
14	0.1514	0.1502	0.1553	0.1529
15	0.1456	0.1444	0.1483	0.148
16	0.139	0.1377	0.1423	0.1411
17	0.1497	0.1484	0.1508	0.1513
18	0.1379	0.1366	0.1399	0.1364
19	0.1242	0.1228	0.1229	0.1221
20	0.1087	0.1074	0.1101	0.1091
21	0.0917	0.0904	0.0923	0.0913
22	0.0744	0.0731	0.0749	0.0733

Table 7- Story Drift In X-Direction

		DRIFT IN Z		
STORY	MODEL 1	MODEL 2	MODEL 3	MODEL 4
0	0	0	0	0
1	0.5293	0.0375	0.494	0.0398
2	0.242	0.2085	0.294	0.2055
4	0.2461	0.243	0.2905	0.262
5	0.2564	0.2551	0.2931	0.2747
6	0.2645	0.2636	0.3007	0.2774
7	0.3133	0.3127	0.336	0.3216
8	0.3188	0.3185	0.3363	0.3193
9	0.3215	0.3213	0.3297	0.3312
10	0.3215	0.3214	0.3251	0.3373
11	0.3191	0.319	0.3166	0.3381
12	0.3438	0.3437	0.3526	0.3638
13	0.3358	0.3357	0.3457	0.3371
14	0.3245	0.3245	0.3418	0.3504
15	0.3101	0.3101	0.3313	0.3397
16	0.2928	0.2927	0.32	0.3232
17	0.3027	0.3025	0.3302	0.3324
18	0.2764	0.2763	0.3064	0.2852
19	0.2465	0.2463	0.2755	0.2772
20	0.213	0.2128	0.2429	0.2452
21	0.1762	0.176	0.2049	0.2076
22	0.1369	0.1367	0.1648	0.1666

Table 8- Story Drift In Z-Direction

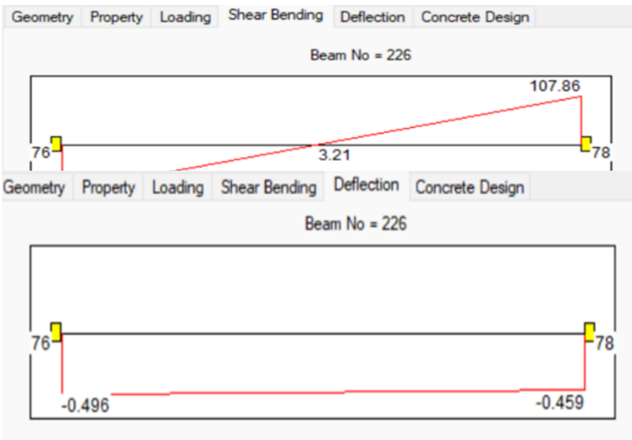
Base shear zone 3--(KN)			
Along x-direction		Along y-direction	
model		model	
Case 1	85068.49	Case 1	85068.49
Case 2	84955.09	Case 2	84955.09
Case 3	84409.36	Case3	84409.36
Case 4	84081.92	Case 4	84081.92

Table 9- Base Shear Value

Type of building	Total ast required for whole building
Normal building –case 1	1148368
Case-2	1157899
Case-3	1153233
Case 4	1144265

Table 10- Area of reinforcement Required Table

- **Validation Of Analysis in Staad pro-**



The Maximum displacement of Floating Column Building =64.98mm

The Maximum displacement of Normal Column Building =55.58 mm

Displacement of Both of the Buildings is within a permissible limit given by Code 1893- 2016

Maximum Bending Moment of Transfer Girder at Combination 1.2(DL+LL) =107.86 KN-M.

Check for Depth-Provided Transfer Girder Beam Size =600 X 1200

BM/bd2 = {(107.86 X 106)/1.5} / (600X1200) = 0.055 Hence Depth Provided for Beam Depth is SAFe

Figure 9- beam no.226 after post processing b.m. and deflection.

DISCUSSION

Important Conclusions from the Analysis:

1. **Lateral Displacement**: As a building's height increases, it also increases the displacement. While compared to structures without floating columns, those with floating columns show a greater displacement.
2. **Story Drift**: Compared to buildings without floating columns, those with floating columns display higher story drift values.
3. **Story Shear**: When compared to regular structures, FC structures usually have lower story shear values.
4. **Time Period**: Buildings with floating columns have a more natural time period compared to those without floating column.

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