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Seismic analysis of multistorey building with floating columns by Using staad.Pro software

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ABSTRACT

At present buildings with floating column is a typical feature in the modern multi-storey construction in urban India. The floating columns are adopted especially above the ground floor, where transfer girders are employed, so that more open space is available in the ground floor. As the load path in the floating columns is not continuous, they are more vulnerable to the seismic activity. Sometimes, to meet the requirements these type of aspects cannot be avoided though these are not found to be of safe. Hence, an attempt is taken to study response of a G+5 and G+10 RC buildings with Floating Columns in different Zones. Finally, analysis & results in the high rise building such as storey drifts, storey displacement, and Base shear were shown in this study. Design and Analysis was carried out by using Staad.pro software. 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: G+5 and G+10 RC buildings, Earth Quakes etc.,

INTRODUCTION

Many urban multi to rey buildings in India today have open first storey asanuna voidable 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 distributionis 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 2001Bhuj 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. Most of the buildings in Ahmedabad & Gandhidham are covering the maximum possible area on a plot within the available bylaws. Since balconies are not counted in the Floor space index (FSI), building having balconies overhanging in the upper stories beyond the footprint area at the ground storey, overhangs up to 1.2m to 1.5 m in plan are usually provided on each side of the building. In the upper storey, the perimeter columns of the ground storey are discontinued, and floating columns are provided along the overhanging perimeter of the building.

Figure1: Failure of R.C. Building with floating columns

This type of construction does not create any problem under vertical loading condition. But during an earthquake a clear load path is not available for transferring the lateral forces to the foundation. Lateral forces accumulated in upper floors during the earthquake have to be transmitted by the projected cantilever beams. Overturning forces thus developed overwhelm the columns of the ground floor. Under this situation the columns begin to deform &buckle, resulting in total collapse. This is because of primary deficiency in the strength of ground floor columns, projected cantilever beams& ductility of beam- column joints. The ductile connection at the exterior beam-columns joints is indispensible for transferring these forces. Fig shows damage in residential concrete building due to floating columns. This is the second most notable & spectular causes of failure in buildings. The 15th August Apartment and Nilima park apartment's buildings in Ahmedabad are the typical example of failure in which, infill walls present walls in the upper floors are discontinued in the lower floors. In this study, two cases of building model G+3 andG+5 were used for whole analysis.

The organizational framework of this study divides the research work in the different sections. The Literature review is presented in section 2. Further, in section 3 shown Properties of material, in section 4 shown Results and discussions. Conclusion and future work are presented by last sections 5.

LITERATURE REVIEW

Nikhil1 &Pande (2014) , focuses on the various types of irregularities like floating columns at various levels and locations. Buildings are critically analysed for the effect of earthquake. Earthquake load as specified in IS 1893 (part 1): 2002 are considered in the analysis of building. A G+6 storied building with different architectural complexities such as external floating columns, internal floating columns and combination of internal and external floating columns is analysed for various earthquake zones. In overall study of seismic analysis, critical load combinations are found out. For these critical load combinations, case wise variation in various parameters like displacements, moments and forces on columns and beams at various floor level are compared and significant co-relationship between these values are established with graphs. This building is designed and analyze with the help of STAAD-Pro Software.

P.V. Prasad & T. RajaSekhar (2014), carried out study on the behaviour of multi-storey building with and without floating columns under different earthquake excitation. The compatible time history and Elcentro earthquake data has been considered. The PGA of both the earthquake has been scaled to 0.2g and duration of excitation are kept same. A finite element model has been developed to study the dynamic behavior of multistory frame. The dynamic analysis of frame is studied by varying the column dimension. It is concluded that with increase in ground floor column the maximum displacement is reducing and base she a varies with the column dimensions.

Siddharth Shah (2015), made an attempt to reveal the effects of floating column & soft story in different earthquake zones by seismic analysis.

Rohilla1 & Gupta2,(2015), has discussed the critical position of floating column in vertically irregular buildingsforG+5 andG+7RCbuildingsfor zone II and zone V. Also the effect of size of beams and columns carrying the load of floating column has been assessed. Also for each model 2 cases of irregularities have been taken. Each model consists of two bays at the spacing of 5 m each and 1 bay at 6m spacing in X direction. However in Y- direction achbay is at spacing of 5m.The importance factor and response reduction factor have been used a s1 and 5 respectively in the analysis. Earthquake has been considered in X direction only. The response of building such as storey drift, storey displacement and storey shear has been used to evaluate the results obtained using ETABS software. The authors said :

- Floating columns should be avoided in high rise building in zone 5 because of its poor performance.
- Storey displacement and storey drift increases due to presence of floating column.
- Storey displacement increases with increase in load on floating column.
- Storey shear decreases in presence of floating column because of reduction mass of column in structure.

Er. Ashfi Rahman (2015),has analysed a multi-storey building with and without floating columns by using response spectrum analysis. Different cases of the building are studied by varying the location of floating columns floor wise and within the floor. The structural response of the building models with respect to fundamental time period, Spectral acceleration, Base shear, Storey drift and Storey displacements is investigated. The analysis is carried outusingsoftwareSTAADProV8i software.

A.P. Mundada Ȧ* and S.G. Sawdatkar Ȧ (2014): In this paper the study is carried out on a building with and without floating columns. The building considered is a residential l building having G+7. Total building consists of 2 phases. 1st phase consists of lower two storey provided for parking purpose. 2nd phase is of residential flats from 1st floor to 7thfloor.Three cases was considered:

Case 1 It is the model in which all the columns are rested on the ground. All the columns rise up to the top floor of the building and no column is floated or terminated at any level it refers to normal frame building.

Case 2a In this all the column are not rested on the ground level. Certain columns are floated from the first floor to upper floors. Also some columns are terminated at 1st floor from which the columns are floated. In this case, the plan covers more area than as compared to case1.Cantilever projections are also provided at certain points.

Case 2b It is same as case 2.a except that struts are provided below the floating columns in order to balance the moments and provides stability. Certain columns i.e. similar columns in all three models are considered and checked for its moments in X and Z directions, deflection and column shear at each floor. The results are presented in the form of graphs using STADD. Pro. Based on the analysis results following conclusions are drawn,

- The probability of failure of Case 2a is higher by comparing values of Mx and Mz with other cases.
- The probabilities of failure of without floating column are less as compared to with floating column. In this case, the moment values are significantly less than with floating column(Case2a)
- The difference in the probabilities of failure with floating column is more than floating column with inclined compressive memberi.e struts. (Case2b).

PROPERTIES OF MATERIAL

GENERAL

There are different methods available for the analysis of frame structures subjected to earthquake loads. The methods of analysis can be broadly classified into the following types.

1. Gravity Analysis
2. Linear Static Method (Equivalent Static Method)
3. Linear Dynamic method (Response Spectrum and Linear Time History Method)
4. Non-Linear Static Method (Pushover Analysis)
5. Non-Linear Dynamic Method (Non-linear Time History Analysis)

Out of these four methods, Gravity analysis and Linear static method, is considered for the Analysis and Design of regular & Irregular G+8 Structure.

EQUIVALENT STATIC METHOD

The equivalent static method is the simplest method of analysis because the forces depend on the code based fundamental period of structures with some empirical modifiers. The design base shear is to be computed as whole, and then it is distributed along the height of the building based on some simple formulae appropriate for buildings with regular distribution of mass and stiffness. The design lateral force obtained at each floor shall then be distributed to individual lateral load resisting elements depending up on the floor diaphragm m action.

Inherently, equivalent static lateral force analysis is based on the following assumptions,

- Structure is rigid.
- Perfect fixity exits between structure and foundation.
- During ground motion every point on the structure experiences ame accelerations
- Dominanteffectofearthquakeisequivalenttohorizontalforceofvaryingmagnitudeover the height.
- Approximately determines the total horizontal force(Bases hear) on the structure

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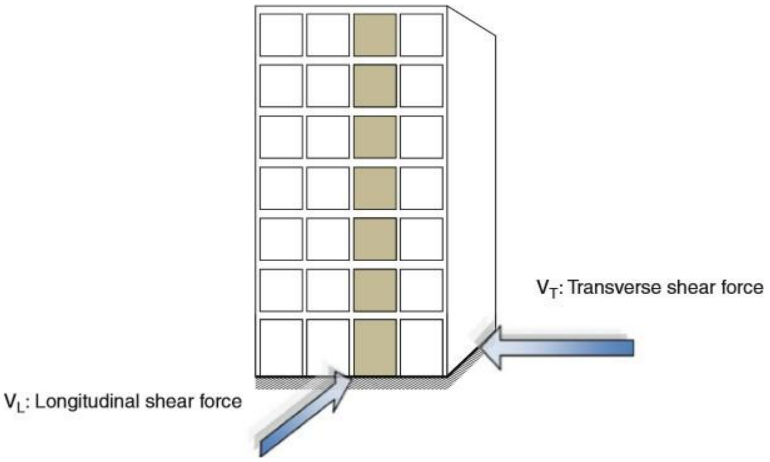


Figure 2:Equivalent lateralforcealongtwo orthogonalaxis

Earthquake Demand On Buiding Sseismic Design Force:
Earthquake shaking is random and time variant. But, most design codes represent theearthquake-inducedinertiaforcesastheneteffectofsuchrandomshakingintheform of design equivalent static lateral force. This force is called as the Seismic Design Base Shear VB and remains the primary quantity involved in force-based earthquake-resistant design of buildings. This force depends on the seismic hazard at the site of the building represented by the Seismic Zone Factor Z. Also, in keeping with the philosophy of increasing design forces to increase the elastic range of the building and thereby reduce the damage in it, codes tend to adopt the Importance Factor I for effecting such decisions. Further, the net shaking of a building is a combined effect of the energy carried by the earthquake at different frequencies and the natural periods of the building. Codes reflect this by the introduction of a Structural Flexibility Factor Sa/g.

MODELLING OF G+5 AND G+10 STRUCTURES

A. General
In this study, analysis is made for multi-s toreyed G+5 and G+10 structure with floating column. These are analyzed for gravity loads and seismic loads in the software as per IS 1893(Part-1):2002 condition of analysis.

B. Design Considerations
He G+5 and G+10 structure with floating column is considered for the present study. Plan and Elevation view of the frame model considered for the study are shown below.

The present study deals with 2-different kinds of Building models:

1. G+5 model with floating column
2. G+10 model with floating column

Plan & Elevation

Figure 3:Plan of G+5 & G+10 Structure

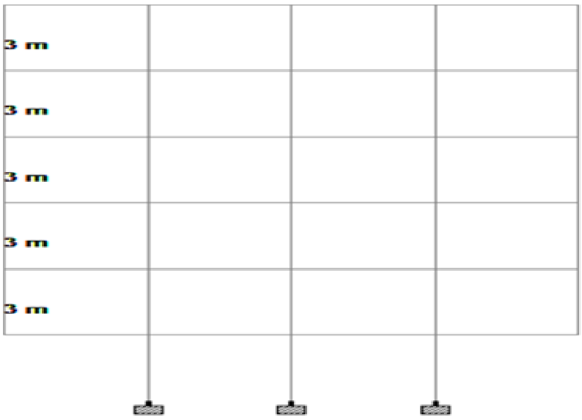


Figure 4:Elevation of G+5 Floating column

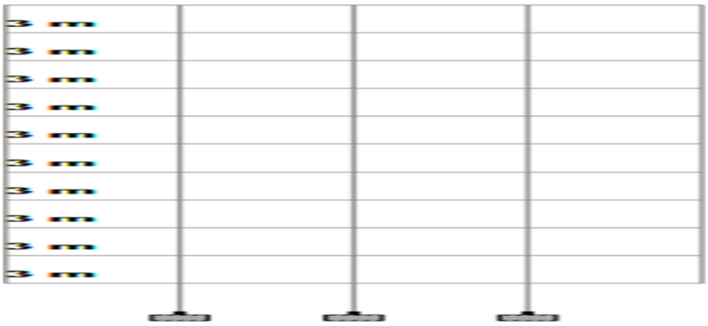


Figure 5: Elevation of G+10 Floating column

RESULTS AND DISCUSSIONS

A. General

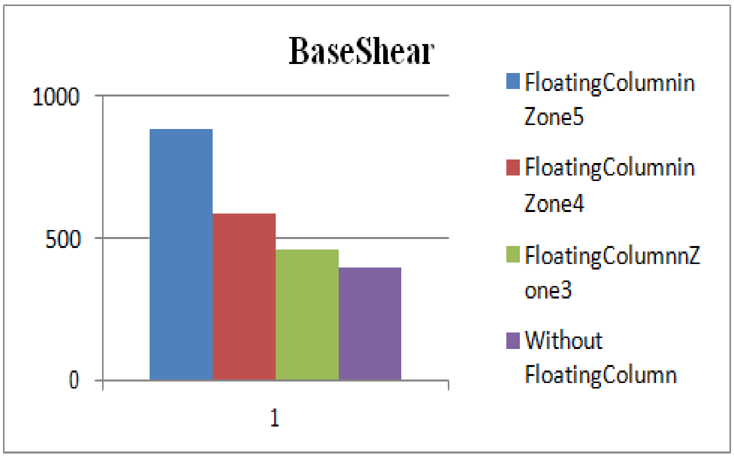
This chapter discusses the results obtained in the present work. To understand the behavior of the structures with floating column, the building models have been subjected to dead load, live load, seismic Forces and load combinations and their responses are studied. The parameters studied are – displacements, storey drifts, bases hear and story shear

B. Comparison Of Bases Hear

Base she aris the horizontal reaction at the base against horizontal earthquake load. These bases hear is acting at the base or supports of the structure or wherever structure is fixed. The variation in bases hears due to floating column and non-floating column are tabulated in below tables also variation in bases hears is shown through graphs.

Table I: Cube Compressive Strengths of different types of concrete

Structure without Floating column Bases hear (kN)		**Structure with Floating column Bases hear (kN)**		
		Zone 5	Zone 4	Zone 3
Static analysis	397	881.7	587	391



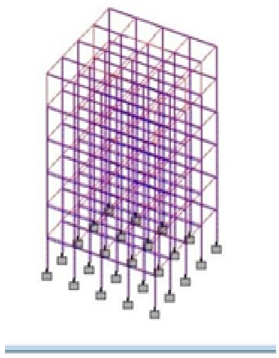


Figure. 2:Comparison of Base Shear (G+5)

Table II. Comparision of base shear of G+10 for different Zones

Structure without Floating column Bases hear (kN)		**Structure with Floating column Bases hear (kN)**		
		Zone5	Zone4	Zone3
Static analysis	249	784	1043	931

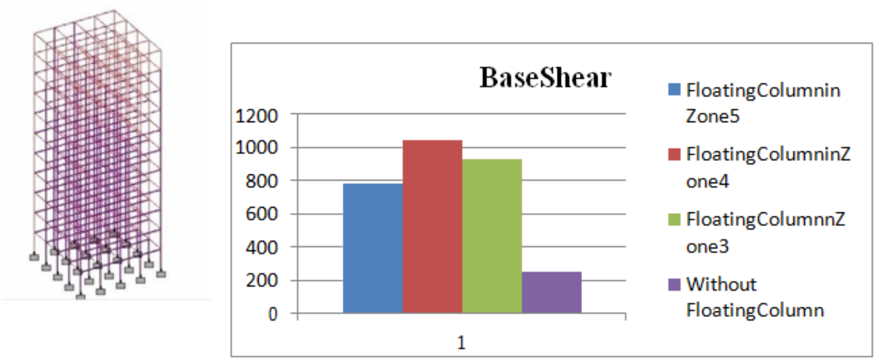


Figure.3:Comparison of Base Shear (G+10)

From the above results it was observed that base shear increases for the floating column buildings as compared to without floating column building. Also, the base shear found to be higher in G+10 building than G+5 building. From which we can conclude that as height increases bases hear increases.

C. Comparison Of Displacements

Storey displacement is the lateral movement of the structure caused by lateral force. The deflected shape of a structure is most important and most clearly visible point of comparison for any structure. No other parameter of comparison can give a better idea of behavior of the structure than comparison of storey displacement. By the application of lateral loads in X and Z directions the structure can be analyzed for various load combinations given by clause 6.3.1.2 of IS 1893:2002. For the given load combinations maximum displacement at each floor is noted in and are shown below in the form of tables and graphs

Table III.Comparison of displacements of G+5 for different Zones

Storey Level	**Structure without Floating column Displacements (mm)**	**Structure with Floating column Displacements(mm)**		
		Zone5	Zone4	Zone3
Ground Floor	4.64	46.16	30.8	20.3
First Floor	12.24	76.218	50.8	33.8
Second Floor	19.9	109.2	72.8	48.5
Third Floor	26.9	142.17	94.7	63.19
Fourth Floor	32.4	172.5	115.039	76.6
Fifth Floor	35.8	199.2	132.8	88.4

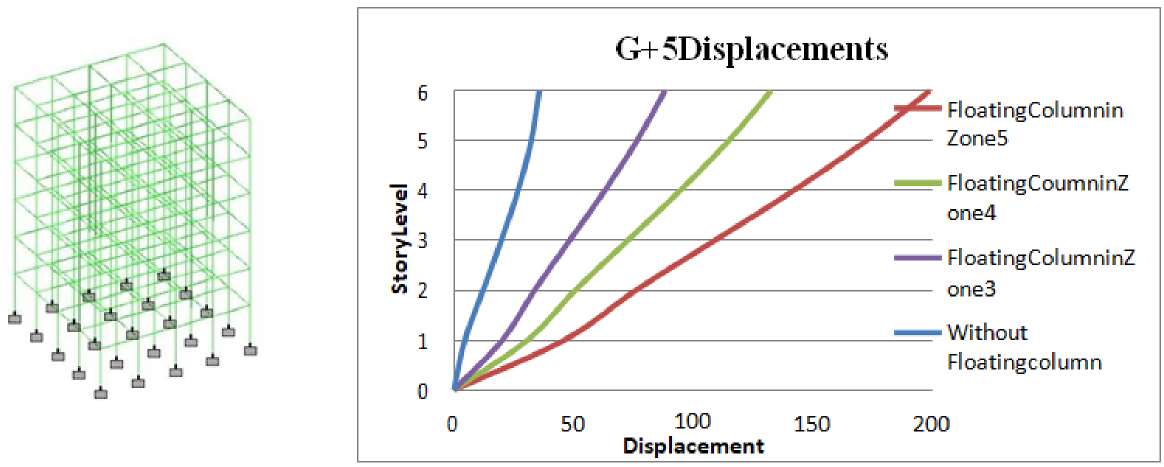


Figure. 4: Comparison of Displacements Table

Table IV. Comparison of displacements of G+10 for different Zones

Storey Level	Structure without Floating column Displacements(mm)	Structure with Floating column Displacements(mm)		
		Zone5	Zone4	Zone3
Ground Floor	1.5	49.2	33.063	29.4
First Floor	3.9	80.73	53.8	49.12
Second Floor	6.4	115.152	76.7	70.4
Third Floor	8.8	151	100.6	92.7
Fourth Floor	11.25	187.01	124.6	115.14
Fifth Floor	13.4	222.4333	148.28	137.2
Sixth Floor	15.31	256.62	171.08	158.8
Seventh Floor	16.8	288.9	192.6	179.5
Eighth Floor	17.9	318.94	212.6	199
Ninth Floor	18.6	346.05	230.6	217
Tenth Floor	19.14	370.54	247.1	233

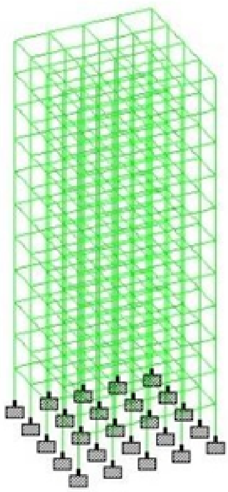


Figure.5: Comparison of Displacements

From the observation of the results it was observed that displacement of the building increases from lower zones to higher zones because the magnitude of intensity will be more for higher zones.

D. Comparison Of Storey Drifts

Storey drift is the relative displacement of the floor. The results variation of storey drift due to floating column in different zones are tabulated in below tables, also variation of storey drifts are shown through graph.

Table V.Comparison of storey drifts of G+5 for different Zones

Storey Level	Structure without Floating column Drifts(mm)	Structure with Floating column Drifts(mm)		
		Zone5	Zone4	Zone3
Ground Floor	4.64	46.16	30.8	20.3
First Floor	.6	30.056	20	13.5
Second Floor	7.66	32.98	22	14.7
Third Floor	7	32.97	21.9	14.69
Fourth Floor	5.5	30.33	20.339	13.41
Fifth Floor	3.4	26.7	17.761	11.8

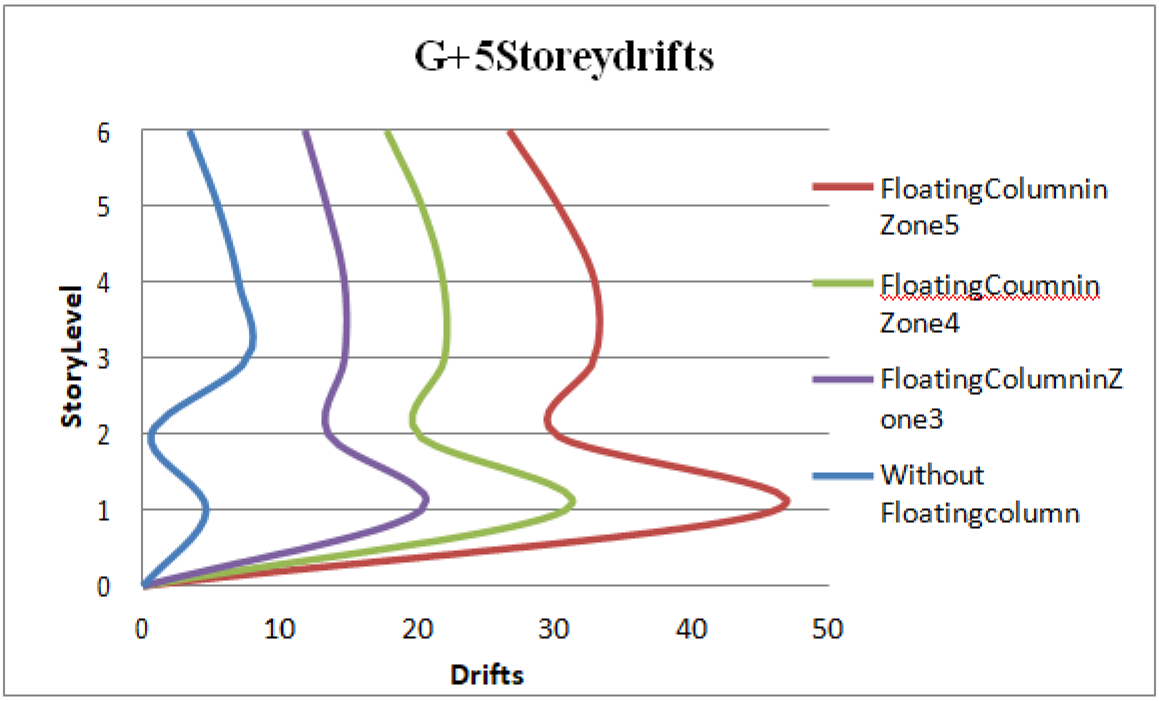
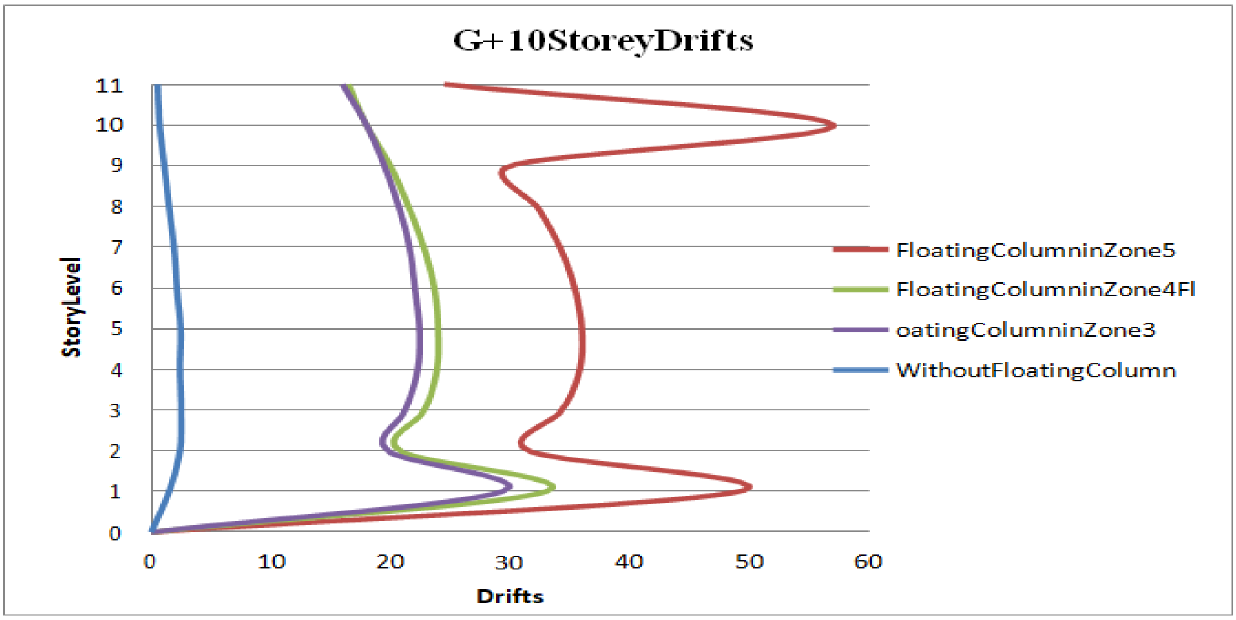


Figure. 6: Comparison of Storey drifts (G+5)

Table VI. Comparison of storey drifts of G+10 for different Zones

Storey Level	Structure without Floating column Drifts(mm)	Structure with Floating column Drifts (mm)		
		Zone5	Zone4	Zone3
Ground Floor	1.5	49.2	33.063	29.4
First Floor	2.4	3153	20.737	19.72
Second Floor	2.5	34.422	22.9	21.28
Third Floor	2.4	35.85	23.9	22.3
Fourth Floor	2.45	36.01	24	22.44
Fifth Floor	2.15	35.42	23.68	22.06
Sixth Floor	1.91	34.19	22.8	21.6
Seventh Floor	1.49	32.28	21.52	20.7

Eighth Floor	1.1	30	20	19.5
Ninth Floor	0.7	57.06	18	18
Tenth	0.54	24.496	16.5	16



E. Comparison Of Storey Shear

Table VII. Comparison of storey Shear of G+5 and G+10 for different Zones

Storey Level	Structure without Floating column Storey Shear (kN)	Structure with Floating column Storey Shear (kN)		
		Zone5	Zone4	Zone3
Ground Floor	4.4	9.5	6.3	4.23
First Floor	17.9	39.8	26.5	17.6
Second Floor	40.3	89.6	59.7	39.82
Third Floor	71.7	159.2	106.19	70.7
Fourth Floor	112.15	248.8	165.9	110.62
Fifth Floor	150.7	334.5	223.05	148.7

Table VIII. Comparison of storey Shear of G+10 for different Zones

Storey Level	Structure without Floating column Storey Shear (kN)	Structure with Floating column Storey Shear (kN)		
		Zone5	Zone4	Zone3
Ground Floor	0.8	3.599	2.3	3
First Floor	3.336	15.175	10.117	11

Second Floor	7.507	34.145	22.76	22
Third Floor	13.345	60.702	40.46	36
Fourth Floor	20.852	94.847	63.23	54
Fifth Floor	30.027	136.57	91.05	76
Sixth Floor	40.870	185.9	123.93	101
Seventh Floor	53.382	242.8	161.87	129
Eighth Floor	34.353	307.304	204.86	162
Ninth Floor	22.6	379.387	252.92	197
Tenth	21.688	104.74	69.8	155

From the above results it states that the building with floating columns experienced more storey shear than that of the normal building. This is due to the use of more quantity of materials than a normal building. So the floating column building is uneconomical to that of a normal building.

CONCLUSION

The analytic study is carried out in order to compare the response of G+5 and G+10 RCC building with floating columns in different zones. The structures are designed using IS: 456:2000 and IS1893:2002 codes. From the study the following conclusions are obtained

- It was observed that in building with floating column has less base shear as compared to building without floating column.
- By the application of later al load sin X and Y direction at each floor, the lateral displacements off loading column building are more compared to that of a normal building and also displacement of the building increases from lower zones to higher zones because the magnitude of intensity will be more for higher zones. So, the floating column building is unsafe for construction when compared to a normal building.
- By the calculation of storey drift at each floor for the buildings it is observed that floating column building in zone 5 will suffer extreme storey drift than normal building. The storey Drift is maximum at 1^{st} and 2nd storey levels.

The building with floating columns experienced more storey shear than that of the normal building. This is due to the use of more quantity of materials than a normal building. So the floating column building is uneconomical to that of a normal building

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