

EFFECT OF FLOATING COLUMNS ON MULTI-STOREYED BUILDINGS

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Abstract: — The columns which are supported on a beam instead of the rigid foundation are called as the floating columns. Floating columns are adopted to fulfil the room sizes criteria of architects. In the recent days, lots of multi-storeyed buildings are constructed with floating column for getting more space at parking areas for movement and for aesthetic point of view. But, such buildings are highly gets damaged during earthquake in highly seismic zone as compared to regular building. Structure with the floating column must be sound enough to resist earthquake forces. The earthquake forces developed at the different floor levels in the building need to be brought down along the height to the ground by the shortest path, if any deviation or discontinuity such as floating columns results in poor performance of the building. In this study, the effect of floating columns on RC frame G+9 structure has been studied for zone III. This work is done to study the response of RC frame building with floating columns under earthquake loading. For all the models of the building, response spectrum analysis is carried out. The work includes analysis of the structure by using ETABS software. The comparative results for the building models have been studied for various parameters such as base shear, storey shear, storey drift, storey displacement, stiffness, beam forces, column forces and time period.

Keywords— Floating column, RC frame, Response spectrum analysis, ETABS etc.

1. INTRODUCTION

Earthquakes perhaps the most unpredictable and devastating of all the natural disasters. They cause great destruction in terms of human casualties, and also have a tremendous economic impact on the affected area. The concern about seismic hazards has led to the awareness and demand for the structures designed to withstand seismic forces. To make the buildings and structures safe in earthquake prone areas lies on the designers, architects, and engineers who conceptualize these structures. Many urban multistorey 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. The total seismic base shear experienced by a building during an earthquake is dependent on its natural period and the seismic force distribution is dependent on the distribution of stiffness and mass along the height. The behaviour of a building during earthquakes depends critically on its overall size, shape and geometry, in addition to how the earthquake forces are carried to the ground.

The floating column which is a vertical element, its lower level rests on a beam which is a horizontal member. This horizontal member in turn transfer the load to other columns below it. The load from the floating column act as a concentrated load on the transfer beam. The floating columns are implemented, especially above the base floor, so that added open space is accessible for assembly hall or parking purpose. Floating columns are usually adopted above the ground story level. So that, maximum space is made available in the ground floor which is essentially required in the apartments, mall or other commercial buildings where parking is a major problem.

2. LITERATURE REVIEW

Nikhil Bandawal (2014) focused on the various types of irregularities like floating columns at various levels and various levels and locations. Earthquake load as specified in IS 1893 (part 1): 2002 are considered in the analysis of building . A G+06 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. This building is design and analyse with the help of STAAD-Pro software. It is concluded that external floating columns may increase displacements at various nodes, external and internal floating columns and Internal floating columns may increase axial force F_x and shear in z direction (F_z) at all floors. internal and external floating columns increases the M_x and M_z values at all floors for all zones.

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 out using software STAAD Pro V8i software. It was observed that in building with floating columns there is an increase in fundamental time period in both X-direction as well as Z-direction as compared to building without floating columns, By introduction of floating columns in a building base shear and spectral acceleration decreases. Thus, it has this technical and functional advantage over conventional construction.

S.B Waykule and Dr. C.P. (2016) studied about analysis of G+5 Building with and without floating column in highly seismic zone v. Two models are created such as floating column at 1st and without floating column building. Linear static and time history analysis are carried out of all the two models and comparison of seismic response parameter such as time period, base shear, storey displacement, storey drift and dynamic response are done by varying the location of floating column floor wise by using linear static and time history analysis. It was observed that in building with floating column has more time period, less base shear, more displacement, more storey drift compared to building without floating column.

Rupali Goud (2017) compared the response of two RC frame buildings with and without floating columns under earthquake loading and under normal loading. The buildings were modified in four different ways. The effect of earthquake forces on these models building models for various parameters were carried out with the help of response spectrum analysis using Staad-Pro. Parameters such as storey drift, storey displacement and amount of steel required were compared with the results of normal RC building.

3. OBJECTIVES OF WORK

The objective of this study is to carry out the analysis of the multi-storeyed building against earthquake load as per Indian standard code of practice IS 1893(Part 1):2002.

1. To check the behaviour of RC framed building with and without floating columns under seismic load.
2. Determination of seismic response of all the models by using response spectrum analysis for zone III earthquake loading. The base of the building frame is assumed to be fixed.
3. To study the response of base shear, storey drift, storey displacement, storey stiffness, storey shears and time period of the models with and without floating columns.
4. To determine the affect of shear force and moment in columns and beams among the RC framed models with and without floating column.

4. MODELLING OF THE BUILDING

In this project, building selected is G+9 RCC framed multi-storeyed building in the zone III region. The building was analysed in the normal condition with all the columns are present. The building is divided into 3 cases depending on the position of removal of columns. The results that are obtained in all the cases are compared with the regular building. The structure was then modelled in the E-TABs and analysis to determine the seismically induced lateral force distribution and response of the structure in seismic zone III in accordance with IS 1893(part1):2002, the structure is categorised as irregular, response spectrum analysis was performed. Since we are considering concrete building the value of damping was taken as 5% of critical, and building was assumed to be founded on a site having soil type of type-2.

The load combinations were as per IS 1893(part1):2002 and seismic forces were considered in one direction simultaneously.

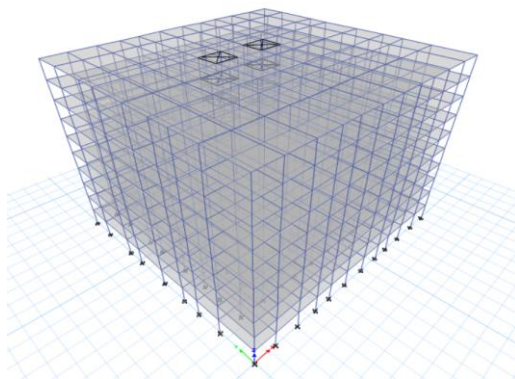


Fig. 1 Regular building in 3D view

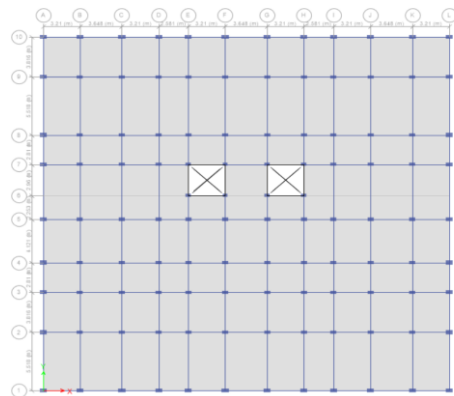


Fig. 2 Model1 plan of Regular building

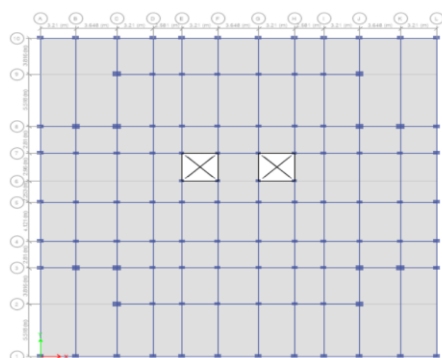


Fig. 3 Model2 plan of building with floating columns in 1st, 2nd & 3rd floors (8 floating columns in each floor)

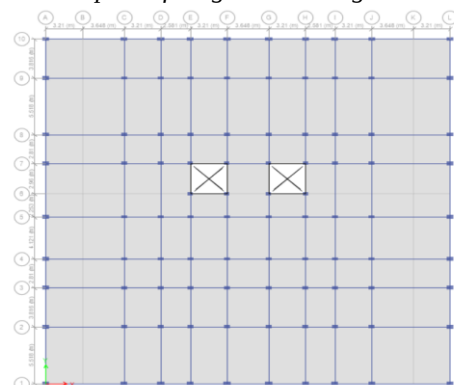


Fig. 4 Model3 plan of building with floating columns in addition to model2 (18 floating columns in each floor)

Table1. Specifications of the regular building

Parameters	Regular building
Floor Height	3.0m
Height of the Building	30m
Seismic zone	Zone III
Soil Type	Medium
Thickness of slab	150mm
Beam Dimensions	230mmX370mm, 300mmX450mm
Column dimensions	300mmX450mm, 370mmX600mm, 300mmX530mm,
Grade of Concrete	M30

5. MODELLING OF THE BUILDING

Analysis is carried out for G+9 building by considering all earthquake load combination. The parameters used for comparison are base shear, storey shear, column forces, storey drift, storey maximum displacement, storey stiffness between regular frame and floating columns frame.

5.1 Base Shear:

Base shear is the horizontal reaction at the base against horizontal earthquake load. This base shear is acting at the base or supports of the structure or wherever structure is fixed and it depends on the seismic mass and stiffness of building.

Table2. Base shear along x-direction

Base Shear V_B (KN)			
Direction	Model 1	Model 2	Model 3
X	2517.24	2534.07	2559.99

Table3. Base shear along y-direction

Base Shear V_B (kN)			
Direction	Model 1	Model 2	Model 3
Y	1916.58	1984.38	1852.88

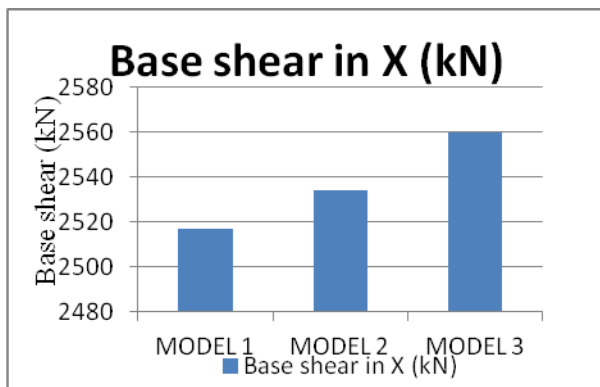


Fig.5 Comparison of base shear in x direction

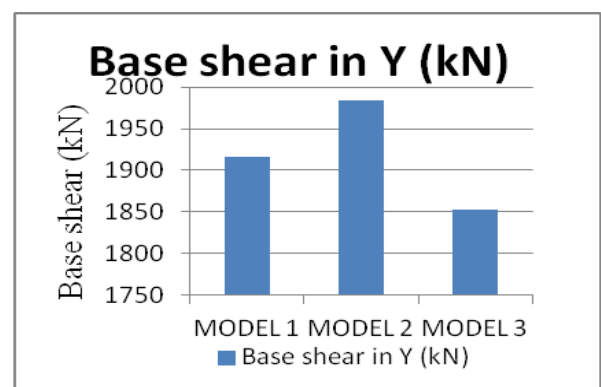


Fig.6 Comparison of base shear in y direction

5.2 Storey Shear:

The forces which are induced at every storey during earthquake are known as storey forces. For a building, storey forces goes on increasing for lower stories and it will be maximum for bottom storey.

Table4. Storey shear along x-direction (kN)

Location	MODEL 1	MODEL 2	MODEL 3
Storey10	283.16	286.00	272.12
Storey9	784.39	792.27	761.91
Storey8	1173.54	1185.72	1155.20
Storey7	1469.30	1483.98	1464.84
Storey6	1714.19	1728.32	1720.50
Storey5	1928.34	1940.18	1939.42
Storey4	2120.42	2131.15	2140.84
Storey3	2300.20	2321.25	2344.09
Storey2	2448.1	2468.68	2493.56
Storey1	2517.24	2534.07	2559.99

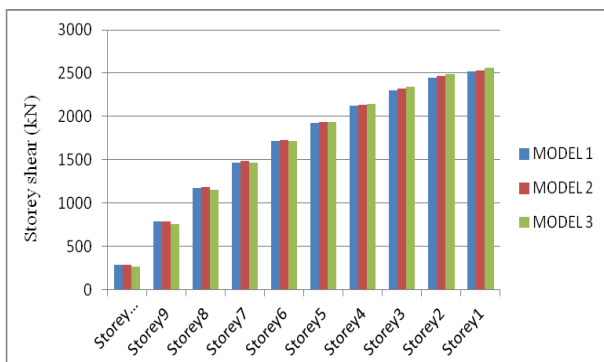


Fig.7 Comparison of storey shear in x direction

Table5. Storey shear along y-direction (kN)

Location	MODEL 1	MODEL 2	MODEL 3
Storey10	248.48	259.16	234.27
Storey9	652.19	677.38	616.88
Storey8	941.04	980.09	895.34
Storey7	1147.49	1193.49	1101.31
Storey6	1299.93	1347.99	1255.49
Storey5	1431.43	1480.63	1386.87
Storey4	1563.76	1616.87	1517.59
Storey3	1704.15	1771.64	1661.15
Storey2	1835.26	1908.35	1779.22
Storey1	1916.58	1984.38	1852.88

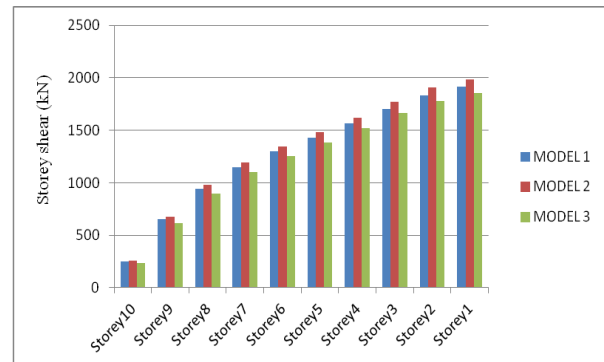


Fig.8 Comparison of storey shear in y direction

5.3 Storey Drift:

Storey drift is defined as the difference between the relative storey displacements. Storey drift is directly proportional to the storey displacement.

Table6. Storey drift along x-direction (mm)

Location	MODEL 1	MODEL 2	MODEL 3
Base	0	0	0
Storey1	0.509	0.486	0.62
Storey2	0.848	0.844	0.995
Storey3	0.906	0.877	0.906
Storey4	0.897	0.872	0.691
Storey5	0.857	0.864	0.744
Storey6	0.79	0.803	0.748
Storey7	0.691	0.706	0.675
Storey8	0.557	0.573	0.552
Storey9	0.388	0.406	0.388
Storey10	0.212	0.232	0.214

Table7. Storey drift along y-direction (mm)

Location	MODEL 1	MODEL 2	MODEL 3
Base	0	0	0
Storey1	0.78	0.688	0.867
Storey2	1.138	1.091	1.254
Storey3	1.154	1.108	1.23
Storey4	1.136	1.237	1.094
Storey5	1.094	1.262	1.06
Storey6	1.017	1.179	0.991
Storey7	0.90	1.052	0.879
Storey8	0.735	0.877	0.722
Storey9	0.521	0.652	0.517
Storey10	0.281	0.399	0.287

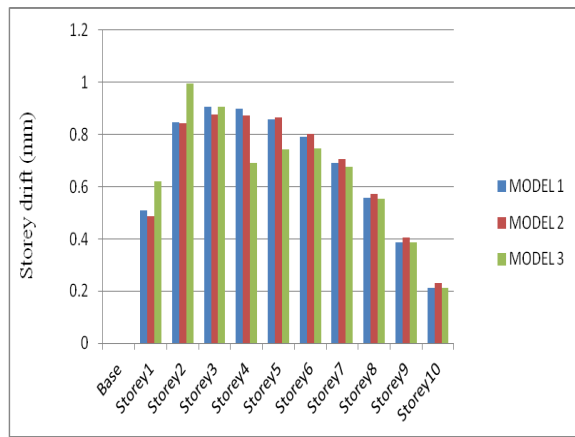


Fig.9 Comparison of storey drift in x direction

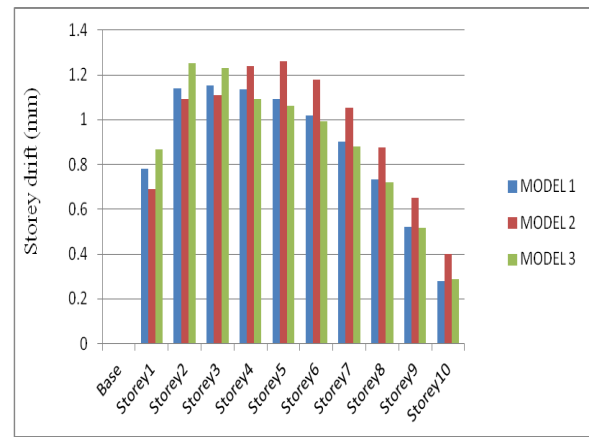


Fig.10 Comparison of storey drift in y direction

5.4 Storey Displacement:

Storey displacement is the lateral movement of the structure caused by lateral force. The deflected shape of a structure is the most important and most clearly visible point of comparison for any structure. No other parameter of comparison can give a better idea of behaviour of the structure than comparison of storey displacement.

The reason for high storey displacements in buildings with floating columns is that the stiffness of the building decreases due to the presence of floating columns. Due to discontinuity of stiffness, the flexibility increases and strength decreases resulting in high displacements. Storey displacement is proportional to the storey stiffness, as storey stiffness increases storey displacement decreases and viceversa.

Table8. Storey displacement along x-direction (mm)

Location	MODEL 1	MODEL 2	MODEL 3
Base	0	0	0
Storey1	1.5	1.5	1.8
Storey2	4.1	4	4.8
Storey3	6.8	6.6	7.5
Storey4	9.5	9.2	9.6
Storey5	12	11.8	11.8
Storey6	14.4	14.2	14.1
Storey7	16.5	16.3	16.1
Storey8	18.2	18	17.8
Storey9	19.3	19.2	18.9
Storey10	20	19.9	19.6

Table9. Storey displacement along y-direction (mm)

Location	MODEL 1	MODEL 2	MODEL 3
Base	0	0	0
Storey1	2.3	2.1	2.6
Storey2	5.8	5.3	6.4
Storey3	9.2	8.6	10
Storey4	12.6	12.4	13.2
Storey5	15.8	16.1	16.4
Storey6	18.8	19.7	19.3
Storey7	21.5	22.8	22
Storey8	23.7	25.5	24.1
Storey9	25.2	27.4	25.7
Storey10	26.1	28.6	26.5

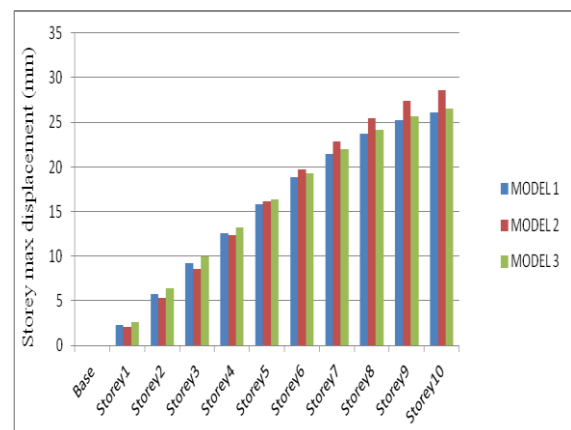
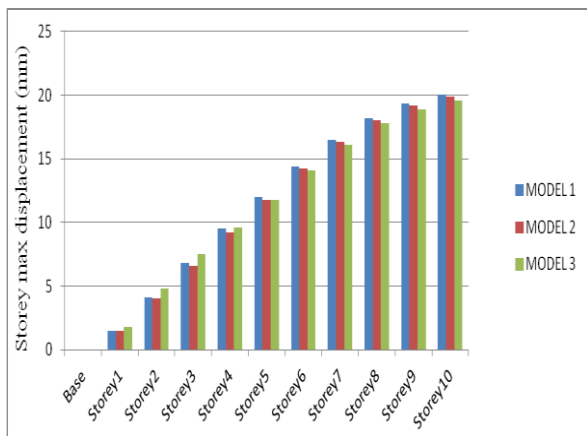


Fig.11 Comparison of storey displacement in x direction Fig.12 Comparison of storey displacement in y direction

5.5 Storey stiffness:

Table10. Storey stiffness along x-direction (kN/m)

Location	MODEL 1	MODEL 2	MODEL 3
Storey10	879213.14	831007.071	848522.092
Storey9	1296710.414	1258265.026	1275920.02
Storey8	1341486.906	1313848.945	1346732.777
Storey7	1345024.01	1323057.682	1379927.452
Storey6	1348561.408	1331279.252	1422611.065
Storey5	1355057	1348193.291	1557803.423
Storey4	1365511.318	1409959.279	1767636.017
Storey3	1395609.878	1449401.423	1381259.204
Storey2	1515562.865	1536138.151	1282133.358
Storey1	2529635.386	2673799.241	2104904.983

Table11. Storey stiffness along y-direction (kN/m)

Location	MODEL 1	MODEL 2	MODEL 3
Storey10	605780.197	603382.904	584536.691
Storey9	793332.848	790141.235	778771.77
Storey8	804578.358	803292.168	794516.331
Storey7	806694.433	805770.046	800143.51
Storey6	807630.126	807450.308	803445.136
Storey5	810459.379	816042.087	811303.616
Storey4	815464.543	890583.597	821055.607
Storey3	825514.483	949217.829	743700.85
Storey2	859291.985	926786.632	747050.873
Storey1	1261087.6	1469828.255	1087029.956

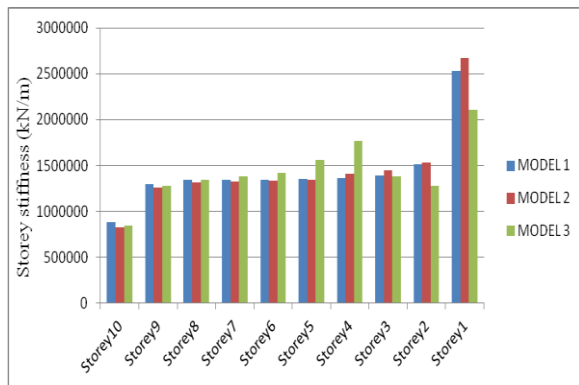


Fig.13 Comparison of storey stiffness in x direction

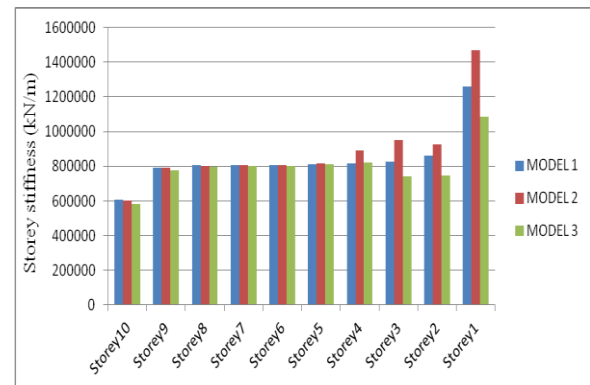


Fig.14 Comparison of storey stiffness in y direction

5.6 Time Period:

Fundamental time period is the time taken by the building to undergo a cycle of to and fro movement. The introduction of floating columns decreases the time period due to increase in the stiffness of structure.

Table 12. Comparison of Time period (sec)

Mode	MODEL 1	MODEL 2	MODEL 3
1	1.724	1.664	1.786
2	1.33	1.318	1.372
3	1.308	1.301	1.307
4	0.566	0.557	0.582
5	0.433	0.436	0.45
6	0.424	0.424	0.434
7	0.33	0.323	0.333
8	0.249	0.248	0.25
9	0.241	0.239	0.237
10	0.23	0.221	0.232
11	0.174	0.168	0.178
12	0.17	0.166	0.17

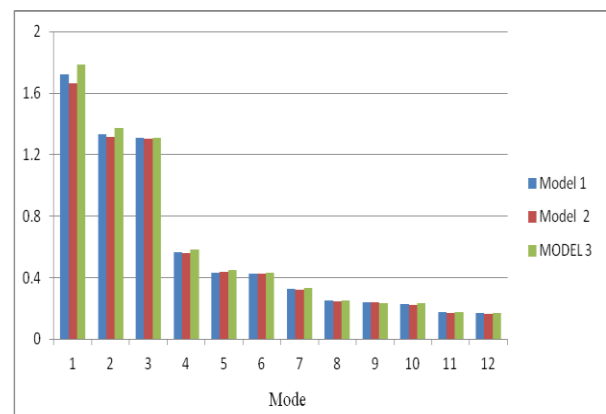


Fig.14 Comparison of Time period in sec.

5.7 Beam forces:

The following were the bending moment values of the continuous beam (B23,B24....B30) of the storey4 for all the models.

Table 13. Bending moment values of continuous beam(kN-m)

Label	Location	Model 1	Model 2	Model 3
B23	End-I	-111.86	-245.85	-118.90
B23	Middle	41.41	47.55	46.12
B23	End-J	-7.67	133.50	-12.41
B24	End-I	-77.97	113.77	-72.28
B24	Middle	16.40	22.57	17.83
B24	End-J	20.86	-159.53	13.45
B25	End-I	-72.19	-71.66	-68.60
B25	Middle	5.79	-7.99	4.56
B25	End-J	39.46	19.88	32.91
B26	End-I	-89.25	-101.15	-87.36
B26	Middle	22.20	20.51	23.61
B26	End-J	25.96	33.91	22.29
B27	End-I	-99.76	-104.28	-95.61
B27	Middle	38.30	37.51	40.89
B27	End-J	-6.97	-5.60	-12.42
B28	End-I	-74.02	-95.26	-69.96
B28	Middle	0.83	-5.27	0.31
B28	End-J	33.59	49.09	25.80
B29	End-I	-108.73	-237.46	-105.45
B29	Middle	44.33	51.90	47.30
B29	End-J	-11.68	129.90	-15.20
B30	End-I	-67.88	117.77	-57.78
B30	Middle	21.72	27.44	23.60
B30	End-J	19.99	-157.48	6.49

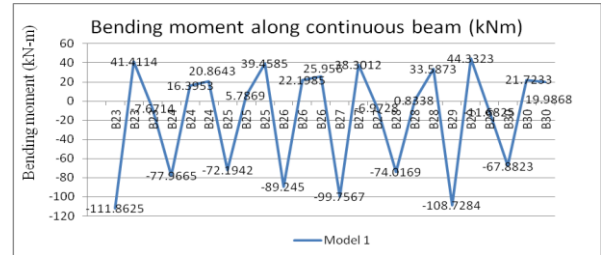


Fig.15 Bending moment along continuous beam in model1

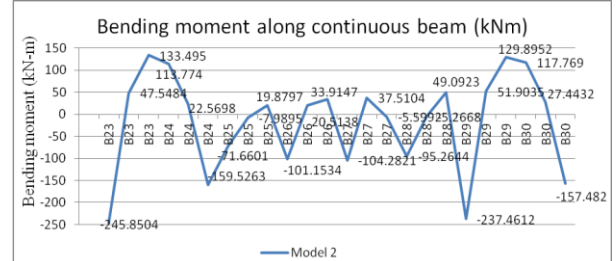


Fig.16 Bending moment along continuous beam in model2

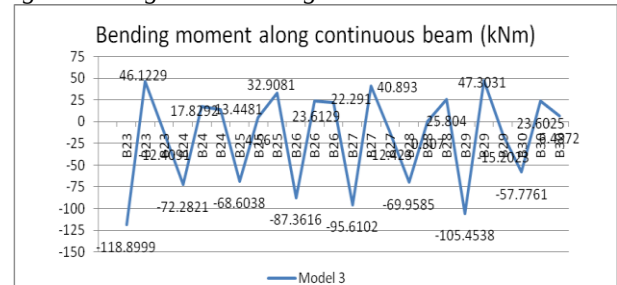


Fig.17 Bending moment along continuous beam in model3

5.8 Column forces:

The following were the bending moment values of the column (C5) for all the models.

Table 14. Bending moment values of the column (kN)

Location	Label	MODEL1	MODEL2	MODEL3
Storey10	C5	32.01	59.29	104.07
Storey9	C5	44.48	51.22	81.80
Storey8	C5	56.44	63.61	122.30
Storey7	C5	65.26	73.10	140.93
Storey6	C5	71.35	79.65	123.47
Storey5	C5	74.97	85.08	283.38
Storey4	C5	76.49	84.87	429.36
Storey3	C5	76.03	71.82	250.37
Storey2	C5	76.77	77.92	140.35
Storey1	C5	78.61	97.07	154.64

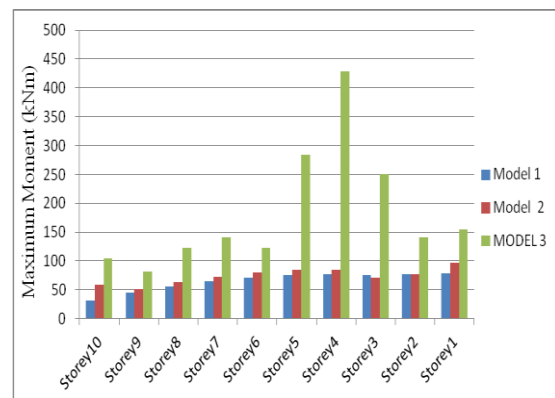


Fig.18 Maximum moment in column C5

6. CONCLUSIONS

1. It is observed that in building with floating column there is an increase in fundamental time period as compared to building without floating columns. The introduction of floating columns in the RC building increases the time period due to decrease in stiffness of building. The storey having floating columns in it has lesser columns and therefore lesser stiffness resulting in the decreases of overall stiffness of the building.
2. The storey displacements are observed to be increasing when floating columns are introduced in the building. The displacements were more in model3 as compared to model1 in Y-direction. It was also observed that displacements increase marginally along the height of the building.

3. The storey drift is maximum for model3 along x direction and model2 along y direction due to presence of floating columns. The maximum storey drift values in both directions were not exceeded the allowable limit 0.004h.
4. It is observed that there is considerable increase in stiffness from top to bottom of the building for all the model cases. The building with floating columns has less stiffness compared to regular building. Due to discontinuity of stiffness, the flexibility increases and strength decreases resulting in higher displacements.
5. The bending moment values of the continuous beam in the frame has got maximum values in model2. The reason for increase of bending moment in model2 is because of floating column effect.
6. The maximum bending moment of the column C5 occurred at the storey4 which is just above the storey with floating columns. Out of all the models, model-3 has maximum bending moment of 429.35kNm.
7. It is observed that the structure without floating column has maximum storey shear. The shear force gradually increases from minimum at the top storey to maximum at the 1st storey for all the cases considered.

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