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Effects of Floating Columns on RC Buildings

Jwala Prakash Pulami, Dr.Rajan Suwal, PhD.

Abstract— The construction of reinforced concrete buildings with floating columns in different types of buildings has lifted few years back due to requirements of space for public use as well for parking purposes in different buildings. As the upper stories are needed with more working areas in real field buildings with floating columns are constructed. The RC buildings with G+3, G+5 and G+7 storied realistic residential, public buildings are taken for the modeling. Linear Dynamic analysis i.e. Modal Spectrum Analysis was performed with the software ETABS20. All three structures are analyzed with floating column at varying distances of 0.9m, 1.5m and 2.1m from the main columns in the buildings.

From the study it is found that the smaller buildings have more seismic effects than in bigger buildings. As the floating columns are kept in any direction, it has higher effects on the direction where the floating column is kept. Due to floating column the cross section of structural members should be increased than that of structure without floating column i.e. 26.065% in average to resist the effects generated by introduced floating column. For floating columns kept in X-direction at different span displacement is decreased by 0.3021% in average due to change in Centre of gravity in the building as mass changes. For Y-direction, displacement is increased by 1.259% in average, as the weight is constant through the axis. Average drift is also affected by the floating column in which the drift is maximum at the storey where floating column is introduced. And the base shear is maximum at 2.1m from main column at first storey as the mass is maximum for the 2.1m and at first storey. As the span is decreasing the base shear is found to be decreased and as the span increases for the same storey the base shear is found to be increased. when floating columns are kept on higher storeys the seismic parameters are lesser in terms of displacement, storey drift and base shear than that when floating columns are kept in lower storeys.

Index Terms— Floating Columns, RC Building, and Main Column.

1 Introduction

THE Earthquake is a natural disaster caused due to the sudden release of huge energy in the earth's crust which will results in seismic waves. When such seismic waves reach the foundation level of buildings it experiences motion due to which causes in huge losses of lives, destruction of structures like buildings, bridges, dams etc

Different Seismic zones where different Multi-storey RC framed building are designed and constructed based on IS codes. Such buildings are also being constructed introducing floating columns. 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. The load transferring phenomena is from superstructures (slab to beam to column) to substructure i.e. foundation and finally to the soil. If the load transferring path is disturbed the structure cannot perform seismic resistance.

2 Literature Review

1. *Thakur and Khatun.,(2022)* have presented comparative analysis of multi-storied building for the building having floating column and without having floating column. The study Comparative seismic analysis of Multi-storied building with and without floating column was carried out using STAAD Pro software for multi-storied buildings constructed with and without floating columns. A G+7 multi-storey building was taken with and without floating column for the analysis and seismic prone area for the comparative seismic analysis zone IV. Behaviors of both the buildings with and without floating column were analyzed. Buildings with undesirable structural irregularities experience more shaking and damage during seismic vibrations which indicated 56.6% storey displacement at the top floor, 17.4% base shear at top floor and decreased to

0.4% at first floor as the mass of building. Time history analysis indicates lesser value of time period (0.37 sec) after changing dimensions of structural members as compared to the time period observed in buildings with floating columns and without floating columns also the value of storey drift increased to 48.09% in the top floor of building consider with an application of floating column.

2. *Gwalani and Singh (2023*) performed on seismic vulnerability of reinforced concrete buildings with discontinuity in columns. Analysis results show that the collapse failure mechanism of low- and mid-rise buildings. The results also underline the importance of strong column–weak beam design in the seismic performance of the floating column buildings. The vertical component of ground motion is also observed to be relatively more crucial in floating column buildings.
3. *Eldar and Singh (2022)* performed the analysis of irregular multistorey buildings with and without floating columns under seismic loading. The study was focused on analysing of seismic behaviours of G + 10 irregular buildings considering floating columns and without floating columns to compare with a regular building and analyzed in ETABS V19 software, and then analytical findings were explained in terms of maximum storey drift, maximum storey displacement, and torsional irregularityItwas found that providing floating columns in irregular buildings was found increasing storey drift and storey displacement significantly.
4. *Bhensdadia and Shah (2015)* performed Pushover analysis of RC frame structure with floating column and soft story in different earthquake zones. Three RC bare frame structures with G+4, G+9, G+15 stories respectively were analyzed and compared the base force and displacement in different earthquake zones using SAP 2000 14. It was found that base shear was increased with the increase of mass and number of story of the building. The displacement of building increases from lower zones to higher zones, similarly for drift, because it found correlated with the displacement. Whether the floating columns on ground floor or in eight floors the displacement values were found increasing when a floating column provided in edge and middle than the outer face of the frame.

3 STATEMENTS OF PROBLEM

Huge structures are being constructed as the population is increasing. Buildings for shelter, business purposes, public use, and institutional and purposes are being constructed with different structural components of different materials. Space for multi-purpose like parking, storage and other purposes are required in field buildings with floating columns are designed and constructed. For the safe design and construction, study about the effect of floating columns is needed. Constructions of building with ground floor left open are ongoing which are of different purposes like residential, public, institutional and other purposes. Such buildings are requires to evaluate the effects of floating column on RC building. As studies are going on based on the floating columns, study is needed to simplify previous studies based on the floating columns on buildings. Different buildings with varying dimensions have different seismic parameters. Similarly, buildings with floating columns are needed to analyze different seismic parameters of building with different conditions. As in the context of Nepal, there is no codal provision for the overhanging columns or floating columns the design and construction is ongoing randomly. So the study is needed to reduce the risk after construction of buildings.

4 OBJECTIVES OF STUDY

- The main object of the research is to find the effects of floating column on RC Buildings.

5 DIMENSIONS AND MODELS

In the present model mainly three moment resisting framed realistic RCC building models of G+3, G+5 and G+7 without floating columns and with floating columns at 0.9m, 1.5m and 2.1m at different stories are designed. For the model taken the plan area of buildings are 10.4m×5m, 23.75m×11.5m and 43.35m×22.2m. The storey height of the first model is 3m and storey heights of second and third models are 3.6m.

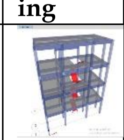
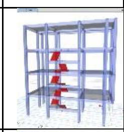
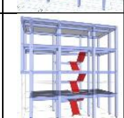
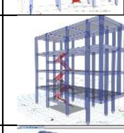
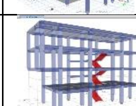
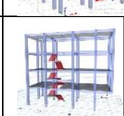
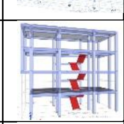
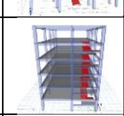
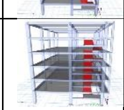
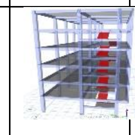
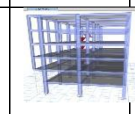
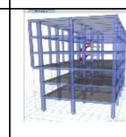
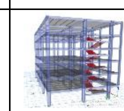
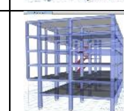
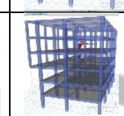
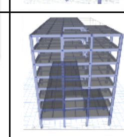
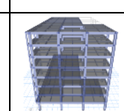
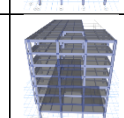
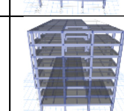
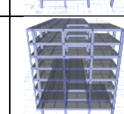
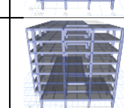
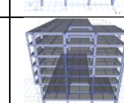
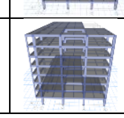
Table.1 Details of Building Models

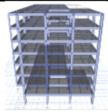
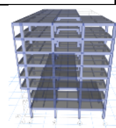
	Height	**Column**	**Beam**	**Slab**
G+3 (Residential Building)	12m	C1(0.35m ×0.35m) FC(0.30m ×0.30m)	MB=0.35m ×0.30m	0.125m
G+5 (Office Building)	21.6m	(0.60m×0.60m) FC (0.35m×0.35m)	MB=(0.50 m×0.35m) SB=(0.250 m×0.30m)	0.125m

- *Jwala Prakash Pulami is currently pursuing master's degree program in structural engineering in Graduate School of Engineering, Mid-West University, Nepal,*
- *Dr.Rajan Suwal,PhD. is currently working as Associate.Prof at Institute of Engineering, Trivhuwan University, Nepal*

G+7 (Hospital Building)	28.8m	(0.65m×0.65m) FC (0.35m×0.35m)	MB=(0.65 m×0.40m) SB=(0.25m ×0.50m) Face Beam=(250 mm×300mm)	0.125m

Table.2 Table of Models

S. N	Etabs modeling	Name of Model	Notation	Remarks
1		Model-1 without floating Column	M-1	
2		Model-1 with floating column at 0.9m at First Floor	M-1 0.9 1	
3		Model-1 with floating column at 0.9m at Second Floor	M-1 0.9 2	
4		Model-1 with floating column at 1.5m at First Floor	M-1 1.5 1	
5		Model-1 with floating column at 1.5m at Second Floor	M-1 1.5 2	
6		Model-1 with floating column at 2.1m at First Floor	M-1 2.1 1	
7		Model-1 with floating column at 2.1m at Second Floor	M-1 2.1 2	
8		Model-2 without floating Column	M-2	
9		Model-2 with floating column at 0.9m at First Floor	M-2 0.9 1	
10		Model-2 with floating column at 0.9m at Second Floor	M-2 0.9 2	
10		Model-2 with floating column at 0.9m at Third Floor	M-2 0.9 3	
11		Model-2 with floating column at 1.5m at First Floor	M-2 1.5 1	
12		Model-2 with floating column at 1.5m at Second Floor	M-2 1.5 2	
13		Model-2 with floating column at 1.5m at Third Floor	M-2 1.5 3	
14		Model-2 with floating column at 2.1m at First Floor	M-2 2.1 1	
15		Model-2 with floating column at 2.1m at Second Floor	M-2 2.1 2	
16		Model-2 with floating column at 2.1m at Third Floor	M-2 2.1 3	
17		Model-3 without floating column	M-3	
18		Model-3 with floating column at 0.9m at First Floor	M-3 0.9 1	
19		Model-3 with floating column at 0.9m at Second Floor	M-3 0.9 2	
20		Model-3 with floating column at 0.9m at Third Floor	M-3 0.9 3	
21		Model-3 with floating column at 1.5m at First Floor	M-3 1.5 1	
22		Model-3 with floating column at 1.5m at Second Floor	M-3 1.5 2	
23		Model-3 with floating column at 1.5m at Third Floor	M-3 1.5 3	
24		Model-3 with floating column at 2.1m at First Floor	M-3 2.1 1	

25		Model-3 with floating column at 2.1m at Second Floor	M-3 2.1 2	
26		Model-3 with floating column at 2.1m at Third Floor	M-3 2.1 3	

6 DATA PROCESSING PROCEDURES

For Data Processing ETABS software and IS codes are used Response Spectrum analysis is done for different selected models which were designed on the basis of NBC and the response curve for this method is generated on the basis of IS 1893: 2016. Also for the selected models for this study as per IS 1893(Part 1): 2016 the permissible storey displacement is 48mm for Model-1, 86.4mm for Model-2 and 115.2mm for Model-3 For ULS and permissible drift is 0.012 mm For Model-1, 0.0144mm for Model-2 and Model-3.
Data analysis is done by the following steps:
Step 1: Preparation of 2-D and 3-D model of building frame, using different irregular plan geometry, and material properties of different types of existing buildings.
Step 2: Assigning of Different load to different models
Step 3: Estimation of design lateral force on building using IS: 875
Step 4: Analysis of the model by Response Spectrum Method

7 RESULTS

7.1 Seismic Parameters Results of Different Irregular Models Due to RSA

The storey displacement, storey drift and Base Shear for the building Models of Model-1, Model-2 and Model-3 in X direction and Y direction are found to be different but the for regular building ,Type O building and Type L building is almost same in X direction and Y direction. Among all the models maximum top storey displacement, storey drift and torsional irregularity is found to be in L shape buildings in both X and Y direction but ,Minimum Displacement is found to be in C type buildings in X direction and for Y direction minimum displacement is found in H type Buildings

6.1.1 *Comparison of Structural Member Cross-Sections without floating Column and With Floating columns*

Table.3 Comparison of Structural Member Cross-Sections without floating Column and With Floating columns

In Table.3 when floating columns are introduced in the existing building mass in the building also increases which leads to failure of the building so to design a building with floating columns the structural members should be revised and section should be provided enough. The comparison helped to find the column sections should be increased by 24.16% in average for all Models and Cross-section of beam is to be increased by 27.97% in average for all members.

Comparison of Structural Member Cross-Sections Without floating Column and With Floating columns				
Models	**Initial columns cross-section (sqm)**	**Columns cross-section (sqm) after FC**	**Difference in cross-section in sqm**	**Percentage of of increase in cross-section**
Models-1	0.09	0.1225	0.0325	36.11
Models-2	0.3025	0.36	0.0575	19.00
Models-3	0.36	0.4225	0.0625	17.36
	Average Percentage of of increase in column cross-section			**24.16%**
Models	**Initial Beam cross-section (sqm)**	**Beam cross-section (sqm) after FC**	**Difference in cross section in sqm**	**Percentage of of increase in cross-section**
Models-1	0.075	0.105	0.03	40
Models-2	0.135	0.175	0.04	29.62
Models-3	0.2275	0.26	0.0325	14.28
	Average Percentage of of increase in Beam cross-section			**27.97 %**

6.1.2 Maximum storey Displacement

The permissible storey displacement is 48mm for Model-1, 86.4mm for Model-2 and 115.2mm for Model-3 For ULS as per IS 1893(Part 1): 2016. Figure.4 represents Comparison of storey displacement for Model-1, Model-2 and Model-3 at different storeys at 0.9m, 1.5m and 2.1m at X-direction and Y-direction. For the Model-1 as floating columns are kept in X-direction it has effect on both directions. The maximum displacement found at M-1 2.1 1 is 0.879mm at X axis and minimum is for M-1 which is 0.646mm and M-1 0.9 2 is 1.005mm. For Y-direction the maximum displacement found at M-1 2.1 2 is 1.09mm and minimum is for M-1 which is 0.786 mm and M-1 0.9 1 is 1.04 mm. For the Model-2 as floating columns are kept in X-direction it has effect on both directions. The maximum displacement found at M-2 2.1 1 is 2.493 mm at X-axis and minimum is for M-2 which is 2.942 mm and M-2 0.9 3 is 3.043mm and the displacement is decreased by 0.4217% in average for each storey. For Y-direction the maximum displacement found at M-2 2.1 3 is 3.172 mm at Y axis and minimum is for M-2 which is 2.942mm and M-2 0.9 3 is 3.041mm and displacement is increased by 1.029% average in Y direction. In Model-3 as floating columns are kept in X-direction it has effect on both directions. The maximum displacement found at M-3 2.1 3 is 3.296 mm at X-axis and minimum is for M-3 which is 3.166 mm and M-3 0.9 3 is 3.225mm and the displacement is decreased by 0.1825% in average. For Y-direction the maximum displacement found at M-2 2.1 3 is 3.172 mm at Y axis and minimum is for M-2 which is 2.942mm and M-2 0.9 3 is 3.041mm and displacement is increased by 1.49% in average in Y direction. These are due to decreasing of mass when floating columns are kept at higher storeys and increasing of mass as floating columns are kept apart from main column in the axis where floating column is introduced.

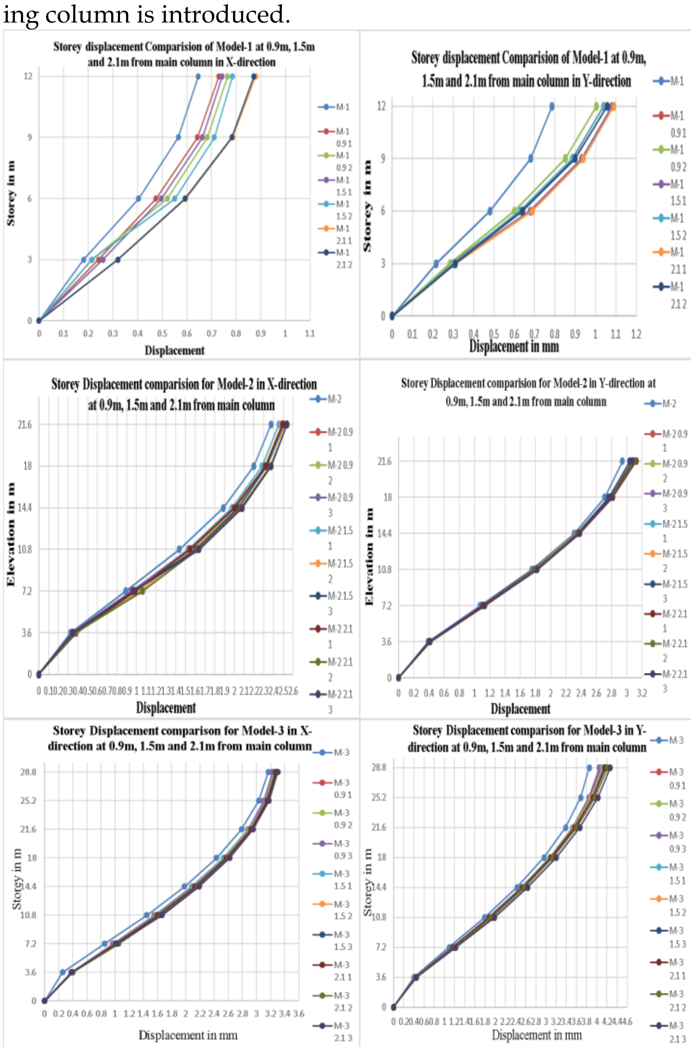


Figure 4: Storey Displacement Comparison for Model-1, Model-2 and Model-3 at different storeys at 0.9m, 1.5m and 2.1m at X-direction and Y-direction.

6.1.3 Maximum Storey Drift

The permissible drift is 0.012 mm For Model-1, 0.0144mm for Model-2 and Model-3 for ULS and for all other models drift is under 0.012 and 0.0144mm Figure.5 shows the comparison of storey drift or all models.If floating columns are kept in X-direction it has effect on both directions. The maximum drift found at M-1 2.1 2 is 9.00E-05mm at x-axis. Similarly, for Y-direction the maximum drift found at M-1 2.1 2 is 0.000126mm in fist storey of 2.1m from main column at Y-axis drift increases as the floating columns are kept on higher storeys and at farther distance. For the Model-2 as floating columns are kept in X-direction it has effect on both directions. The maximum drift found at M-2 2.1 2 is 0.00079mm at X-axis and minimum is at M-2 0.9 3 is 5.40E-05mm. Similarly, for Y-direction the maximum drift found at M-2 2.1 2 is 0.00023mm at X- axis at third floors and minimum is for M-2 0.9 1 is 0.00019mm. For the Model-3 as floating columns are kept in X-direction it has effect on both directions. The maximum drift found at M-3 2.1 2 is 0.000178mm at X-axis and minimum is at M-2 0.9 3 is 0.00017mm in First storey. Similarly, for Y-direction the maximum drift found at M-3 1.5 3 is 0.000209mm at X- axis at first sotorey's top and minimum is for M-3 0.00019mm.

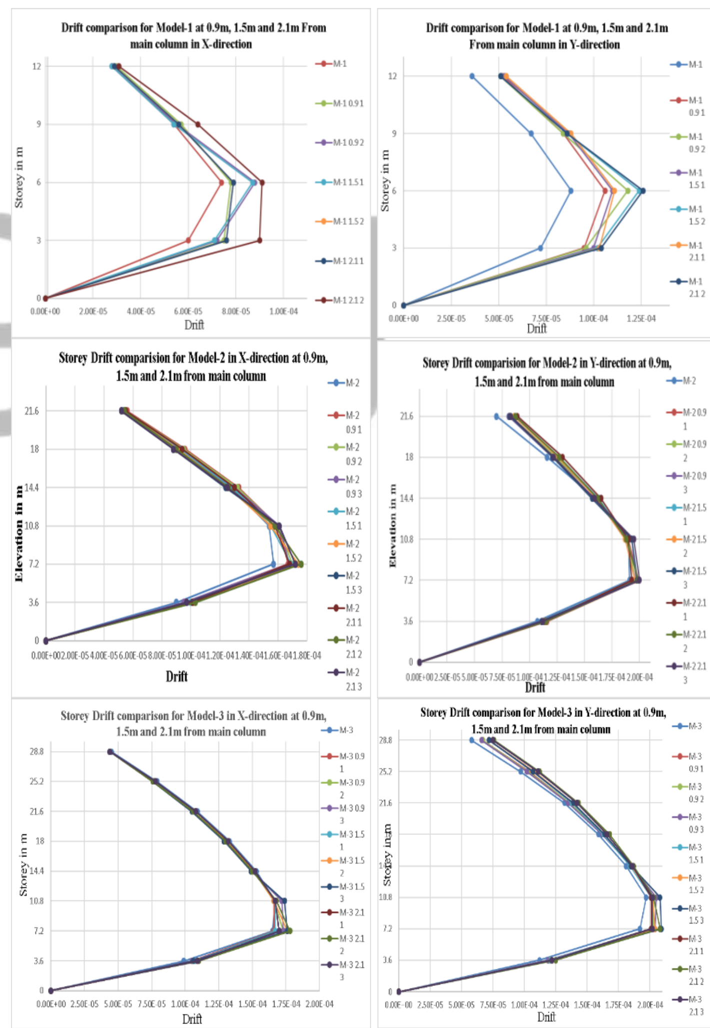


Figure 5: Storey Drift Comparison for Model-1, Model-2 and Model-3 at different storeys at 0.9m, 1.5m and 2.1m at X-direction and Y-direction

6.1.3 Base Shear

In Model-1 as floating columns are kept in X-direction it has effect on both directions. The maximum Base shear found at M-1 2.1 1 is 25.7KN and minimum at M-1 0.9 2 is 21.907KN at X-axis. Similarly, for Y-direction the maximum base shear found at M-1 2.1 1 is 28.1545KN and minimum is for M-1 0.9 2 is 25.9953KN as the floor is gone upward and the span is shorter the base shear is decreased . For the Model-2 as floating columns are kept in X-direction it has effect on both directions. The maximum Base shear found at M-2 2.1 1 is 118.2923 KN at X-axis and minimum is for M-2 104.093KN and M-2 0.9 3 is 104.4549 KN as the span varies the base shear is decreased by 4.68% from 0.9m to 2.1m in average. Similarly, for Y-direction the maximum Base Shear is found at M-2 2.1 1 is 100.1849 KN and minimum base shear are found on M-2 91.3209KN and at M-2 0.9 3 93.8376KN and as the floating columns are kept on different storey and different span the base shear decreases by 2.057% in average due to decrease in the mass. In Model-3 as floating columns are kept in X-direction it has effect on both directions. The maximum Base shear found at M-3 2.1 1 is 330.399 KN at X-axis and minimum is for M-2 295.428 KN and M-3 0.9 3 is 309.726KN at base as the span is decreasing the base shear is found to be decreased by 2.933% in average . Similarly, for Y-direction the maximum Base Shear is found at M-3 2.1 1 is 301.764KN and minimum base shear are found on M-3 273.748 KN and at M-3 0.9 3 283.179 KN and as the floating columns are kept on far span base shear in Y-direction is decreased by1.79% in average.

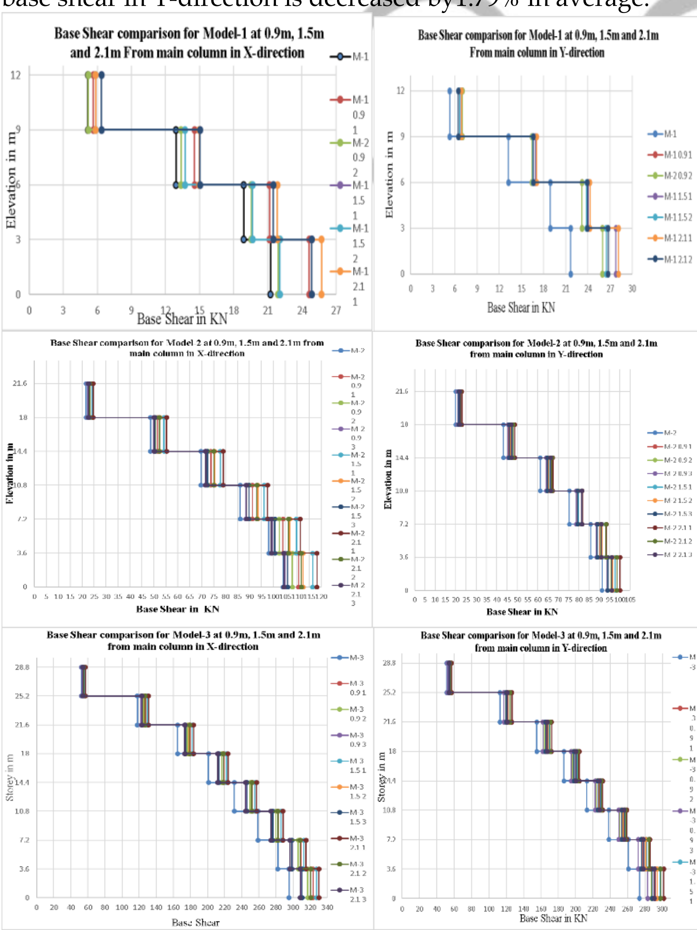


Figure 6: Base Shear Comparison for Model-1, Model-2 and Model-3 at different storeys at 0.9m, 1.5m and 2.1m at X-direction and Y-direction.

7 CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

From the above study, the modeled model-1and Model-2 residential building of storey height 3m, 3.6 and total height 12, 21.6m analyzed. Following conclusions are made:

1. From the study it is found that the smaller buildings have more seismic effects than in bigger buildings. As the floating columns are kept in any direction, it has higher effects on the direction where the floating column increases the mass. Due to floating column the cross section of structural members should be increased than that of structure without floating column i.e. column by 24.16% in average and beams by 27.9717% in average to resist the effects generated by introduced floating column.

2. As floating columns are introduced in the building, it has effects on seismic performance. For floating columns kept in X-direction at different span displacement is decreased by 0.3021% in average due to decrease in mass as the floor goes upper which causes the change in Centre of gravity in the building. For Y-direction, displacement is increased by 1.259% in average, as the weight is constant through the axis. The floating column in which the drift is maximum at the storey where floating column is introduced also affects average drift as it increases by 2.73% as floating columns are kept on higher storeys and as the span increases drift is found to be decreasing in Y-direction by 0.56% where in Y-direction it increases by 4.11% . And the base shear is maximum at 2.1m from main column at first storey as the mass is maximum for the 2.1m and at first storey. As the span is decreasing the base shear is found to be decreased by3.08 % in average . Similarly, for Y-direction as the floating columns are kept on same span and storey is varied base shear in Y-direction is decreased by 1.923% in average. However, as the span increases for the same storey the base shear is increased by 1.05% in average.

3. As the floating columns are kept on higher storeys the seismic parameters are lesser in terms of displacement, storey drift and base shear than that when floating columns are kept from lower storeys.

7.2 Recommendations

- IS codes has been used for limited soil condition and limited seismic zone, for further study NBC code is recommended for study with different seismic conditions.
-For the study of effects of floating column when kept in all directions is recommended.

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