Seismic Analysis of Multi-storied Building with Floating Column

Shivam Wankhade[1], Prof. M. Shahezad[2], Dr.N.W.Ingole[3]

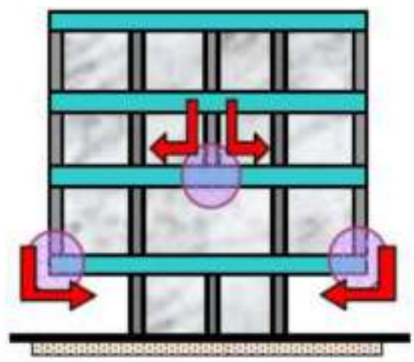
[1]*PG student, Civil Engg. Department, PRMIT & R, Badnera, SGBAU University, Maharashtra, India.*
[2]*Professor, Civil Engg. Department, PRMIT & R, Badnera, SGBAU University, Maharashtra, India.*
[3]*Professor, Civil Engg. Department, PRMIT & R, Badnera, SGBAU University, Maharashtra, India.*

Abstract - *In recent times, multi-storey buildings in urban cities are required to have column free space due to shortage of space, population and also for aesthetic and functional requirements. For this buildings are provided with floating column at one or more storey. In the seismic region the construction of these floating columns are highly disadvantages. The earthquake forces that are developed at different floor levels in a building need to be carried down along the height to the ground by shortest path. Deviation or discontinuity in this load transfer path results in poor performance of the building. The object of present work is to study the behaviour of multistorey buildings having floating column under various seismic forces. For this purpose three cases of multi-storey buildings are considered having 12 storey, 14 storey and 16 storey. All three cases are considered having floating column at 8th storey and also analysed for zone II, zone III, zone IV and zone V by using software ETABS 2017. Observation shows that the provision of floating column is advantageous in increases FSI of the building but is a risky factor and increases the vulnerability of the building. It is observed from the analysis that lateral displacement and storey drift of building increases from lower to higher zones because the magnitude of intensity will be more for higher zones. This analysis work provides a beneficial help on the parameter lateral displacement and storey drift in the multistorey building having floating column.*

Key Words Floating column, Seismic analysis, Lateral displacement, Storey Drift, ETABS 2017.

1. INTRODUCTION

A column is said to be a vertical member starting from foundation and transferring the load to the bottom level. When a vertical element ends at its lower level and rests on beam which is horizontal member that is floating column. It act as a point load on the beam and the load transfers by these beams to the column below it. Theoretically these types of structures can be analysed and designed. This is widely used in high storied buildings for both commercial and residential purpose. These building are considered to be safe under gravity loads and are designed only for gravity loads not for seismic loads. Hence these buildings may be unsafe in seismic prone areas. When these floating columns are employed in buildings in seismic prone areas, the entire earthquake of the system is shared by the column or the shear wall without considering any contribution from floating columns. Many urban multistorey buildings in India today have open first storey as an unavoidable future. 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 distribution is 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. 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 2001 Bhuj 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.



Hanging or Floating Columns

2. OBJECTIVES OF STUDY

1. To study the behavior of multistorey buildings having floating column under earthquake excitations.
2. To compare the behavior of multistorey buildings with floating columns under different seismic zone.
3. To find whether the structure is safe or unsafe with floating column when built in seismically active areas.
4. Find out the effect on different design parameters under seismic effects due to presence of floating column.
5. Design of building with floating column using ETABS 2017.
6. To compare the results of all the models as obtained.

3. METHODOLOGY

For analysis and study purpose multi-storey building that is G+12, G+14, G+16 buildings are consider and the models are developed as multi-storey building with floating column where these floating column are present at 8th story of the building analysing it at different zones as zone II to zone V as per codal provisions. Response spectrum analysis is adopted which shows best result.

4. MODEL DESCRIPTION

Three cases of residential buildings are considered. In case-I, total 12 storeys are provided with building area 21m x 21m. In case-II, total 14 storeys are provided with building area 21m x 21m. In case-III, total 16 storeys are provided with building area 21m x 21m. For all cases floating column provided from 8th storey. To study the behaviour the response parameters selected are lateral displacement and story drift. All the cases are assumed to be located in zone II, zone III, zone IV, zone V. Height of each storey is kept 3.0m and other concerned data is given in tabular form in table -1

Table -1: Building Description

No. of Storey	G+12	G+14	G+16
Beam Diamension	Zone II to IV 230mm X 450mm	Zone II to III 230mm X 450mm	Zone II to V 300mm X 700mm
	Zone V 300mm X 700mm	Zone IV to V 300mm X 700mm	
Column Diamension	Zone II to IV 300mm X 750mm	Zone II to III 300mm X 750mm	Zone II to V 450mm X 900mm
	Zone V 450mm X 900mm	Zone IV to V 450mm X 900mm	
Thickness of Slab	150mm	150mm	150mm
Seismic Zone	II to V	II to V	II to V
Type of Soil	Medium	Medium	Medium
Frame Type	SMRF	SMRF	SMRF
Response Reduction Factor	5	5	5
Importance Factor	1.2	1.2	1.2
Time Period	0.707	0.824	0.942
Live load	3 KN/m2	3 KN/m2	3 KN/m2
Floor Finish	1KN/m2	1KN/m2	1KN/m2
Wall load on exterior beam	12KN/m	12KN/m	12KN/m
Wall load on Interior beam	6KN/m	6KN/m	6KN/m
Grade of Concrete	M30	M30	M30
Grade of Steel	Fe500	Fe500	Fe500

Case I :

In case I building area of 21m x 21m is taken. The is of (G+12) configuration, having story height of 3m. The size of beam are taken as 230mm x 450mm and column are taken as 300mm x 750mm throughout the height of building. For the overall building the dimension of beam, column are same in both X and Y direction. Floating column are present at 8th story of the building analysing it at different zones as zone II to zone V as per codal provisions. For zone V building members are failed to withstand for the applied gravity load and lateral loads. So another building considering for zone V is created by changing the dimension of member to make the building to withstand for the applied gravity loads and lateral loads. For this model all beam dimensions are taken as 300mm x 700mm and for column dimensions are taken as 450mm x 900mm.

Case II :

In case II building area of 21m x 21m is taken. The is of (G+14) configuration, having story height of 3m. The size of beam are taken as 230mm x 450mm and column are taken as 300mm x 750mm throughout the height of building. For the overall building the dimension of beam, column are same in both X and Y direction. Floating column are present at 8th story of the building analysing it at different zones as zone II to zone V as per codal provisions. For zone IV and V building members are failed to withstand for the applied gravity load and lateral loads. So another building considering for zone IV and zone V is created by changing the dimension of member to make the building to withstand for the applied gravity loads and lateral loads. For this model all beam dimensions are taken as 300mm x 700mm and for column dimensions are taken as 450mm x 900mm.

Case III:

In case III building area of 21m x 21m is taken. The is of (G+16) configuration, having story height of 3m. The size of beam are taken as 230mm x 450mm and column are taken as 300mm x 750mm throughout the height of building. For the overall building the dimension of beam, column are same in both X and Y direction. Floating column are present at 8th story of the building analysing it at different zones as zone II to zone V as per codal provisions. For all zones building members are failed to withstand for the applied gravity load and lateral loads. So another building considering for all zones is created by changing the dimension of member to make the building to withstand for the applied gravity loads and lateral loads. For this model all beam dimensions are taken as 300mm x 700mm and for column dimensions are taken as 450mm x 900mm.

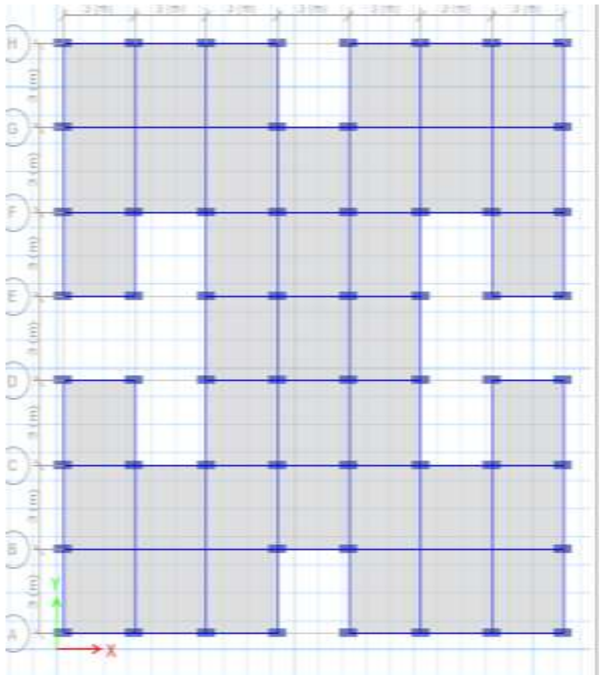


Fig - 1 Plan of Building with Floating Column at 8th Floor

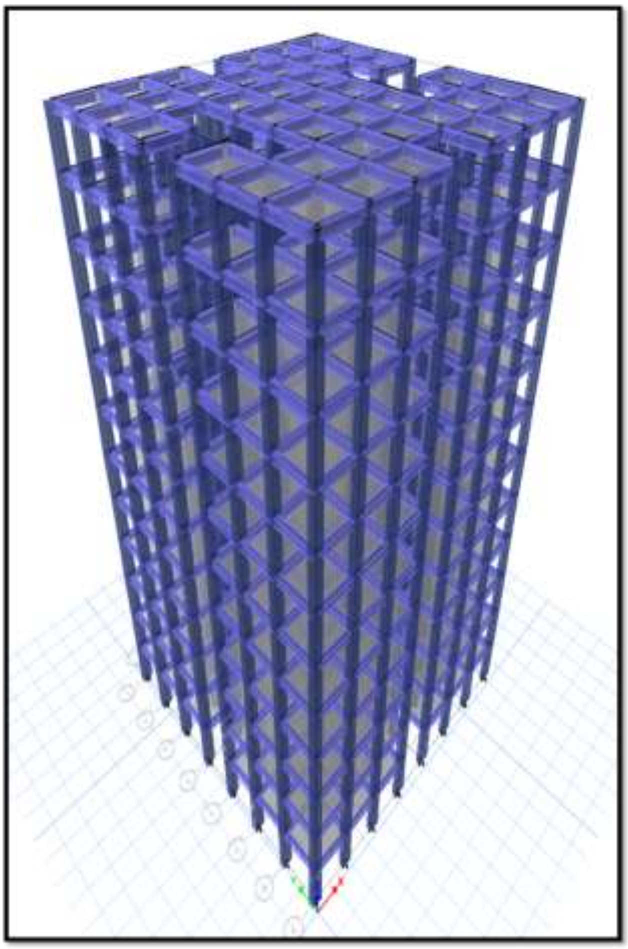


Fig -2 3D View of Building

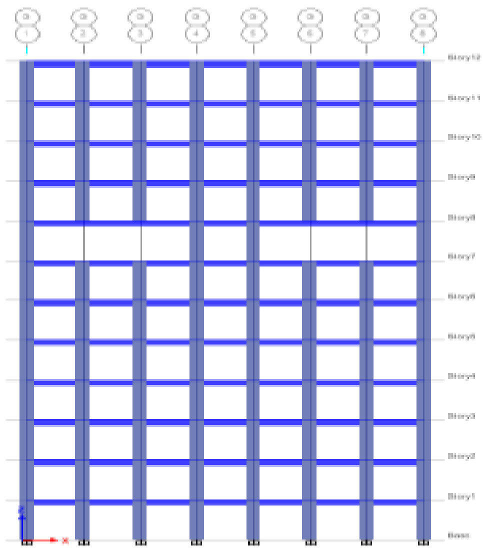


Fig -3 Elevation of 12 storey building with floating column

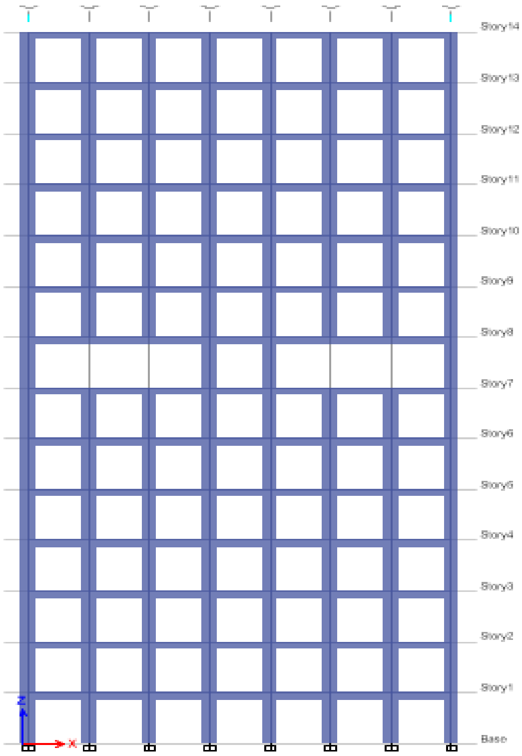


Fig -4 Elevation of 14 Storey Building with Floating Column

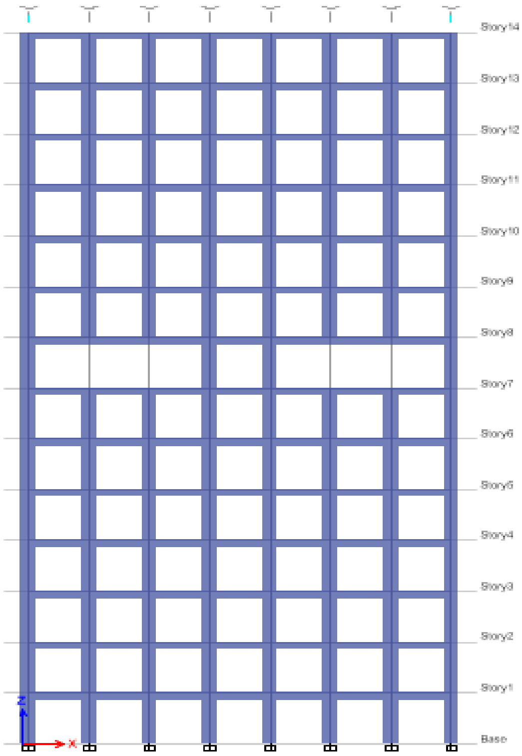


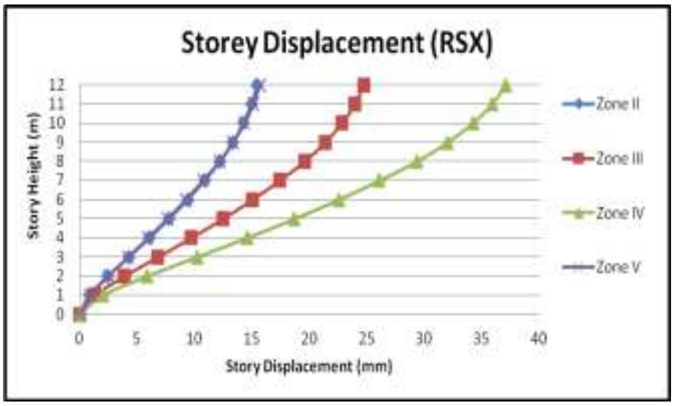
Fig -5 Elevation of 16 Storey Building with Floating Column

5. RESULT AND DISCUSSION

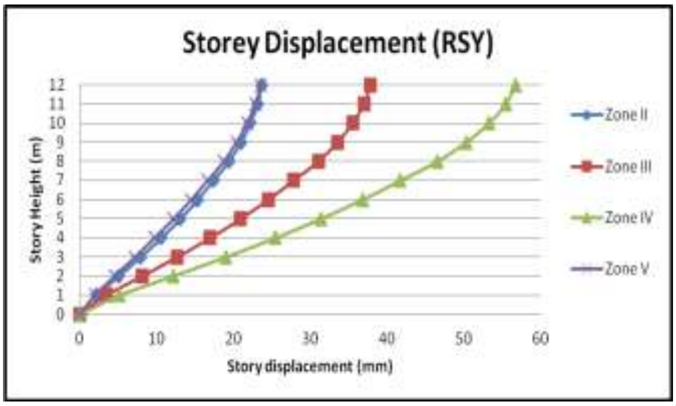
Response spectrum analysis is carried out on all the cases for all seismic zones. The results are presented in the form of graphs.

5.1 Lateral Displacement

Story 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. Graph is plotted by taking displacement as the abscissa and the storey level as the ordinate for different cases in the transverse and longitudinal direction. As per code IS 456 : 2000 clause 20.5 page 33, displacement should not be greater than total height of the structure by H/500.

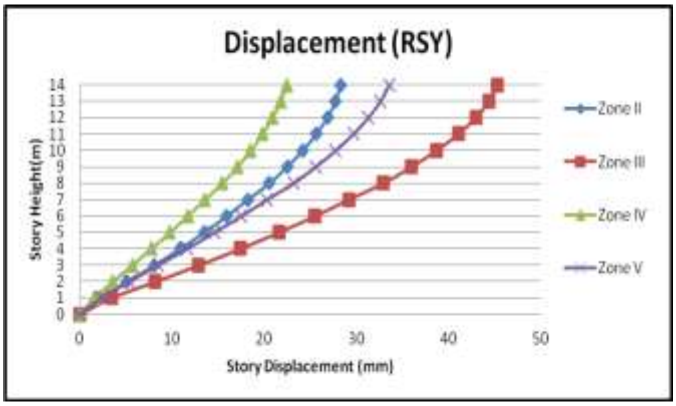


Graph- 5.1 Storey displacement in X-direction for 12 storey building with floating Column

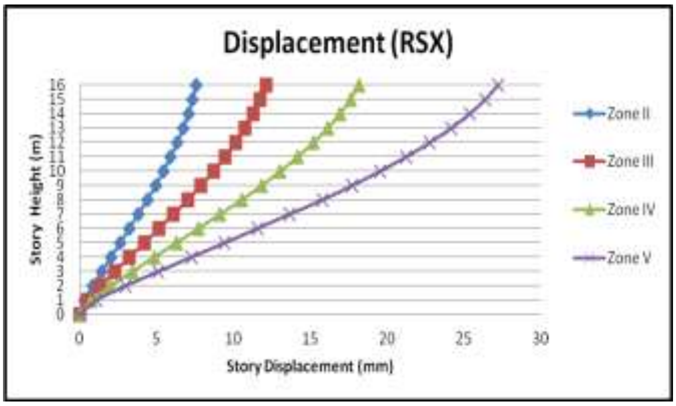


Graph- 5.2 Storey displacement in Y-direction for 12 storey building with floating Column

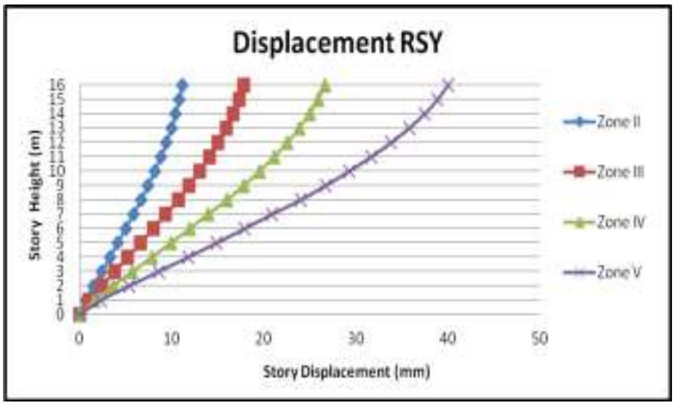
Graph- 5.3 Storey displacement in X-direction for 14 storey building with floating column



Graph- 5.4 Storey displacement in Y-direction for 14 storey building with floating column



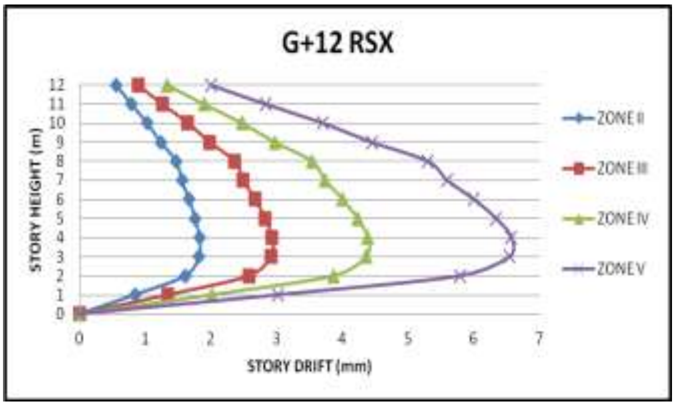
Graph- 5.5 Storey displacement in X-direction for 16 storey building with floating column



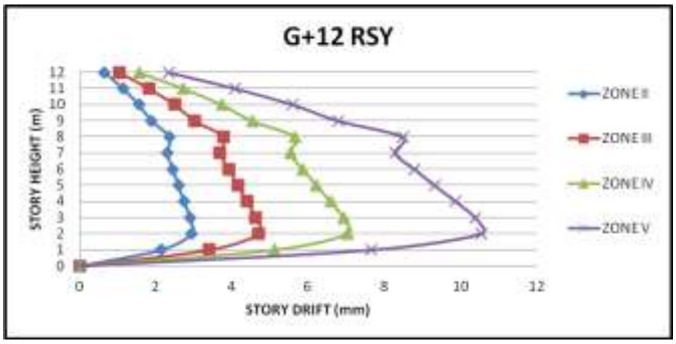
Graph- 5.6 Storey displacement in Y-direction for 16 storey building with floating column

5.2 Storey Drift

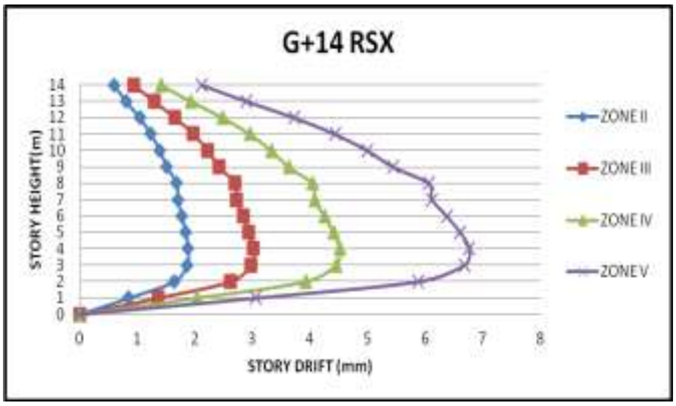
Story drift is the relative displacement of the floor and calculated as the difference of deflections of the floors at the top and bottom of the story under a difference of deflections of the floors at the top and bottom of the story under consideration. According to IS1893:2016 (part I), maximum limit for storey drift with partial load factor 1.0 is 0.004 times of storey height. Here for 3m height and load factor of 1.5, through maximum drift will be 12 mm.



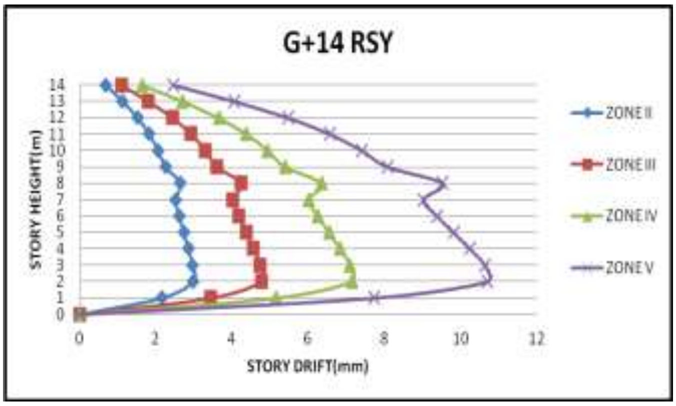
Graph- 5.7 Inter storey drift in X-direction for 12 storey building with floating column



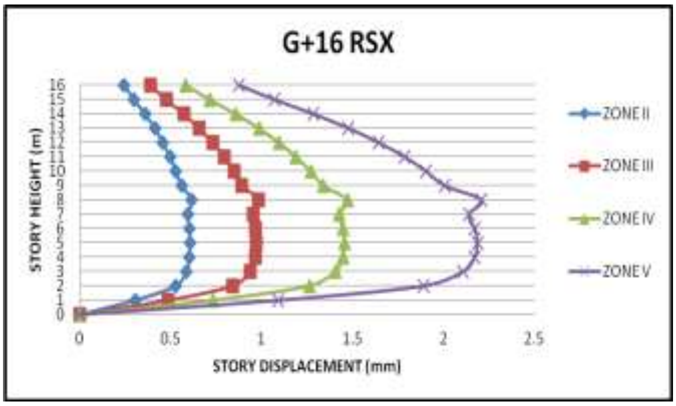
Graph- 5.8 Inter storey drift in Y-direction for 12 storey building with floating column



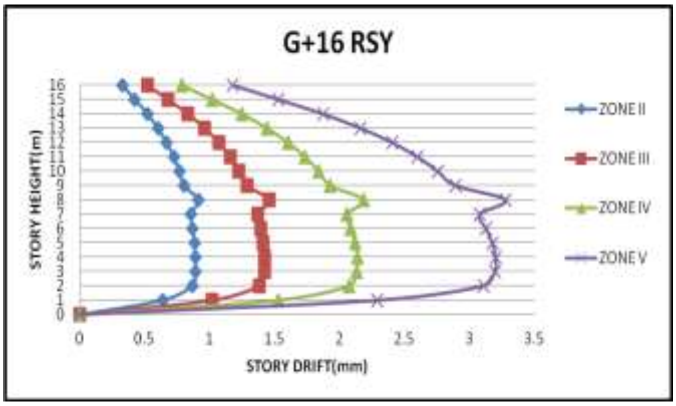
Graph- 5.9 Inter storey drift in X-direction for 14 storey building with floating column



Graph- 5.10 Inter storey drift in Y-direction for 14 storey building with floating column



Graph- 5.11 Inter storey drift in X-direction for 16 storey building with floating column



Graph- 5.12 Inter storey drift in Y-direction for 16 storey building with floating column

5.3 Fundamental Time Period

Fundamental time period is the time taken by the building to undergo a cycle of to and fro movement. The mode of oscillation with smallest natural frequency(and largest natural period) is called fundamental mode, the associated natural period is called the fundamental time period. Usually, natural periods of 1 to 20 storey normal reinforced concrete and steel buildings are in the range of 0.05 - 2.00 sec. In this study fundamental time period determined from model analysis. The variation of fundamental time period of various models are as follows:

Model 1 : G+12 Building with floating column.

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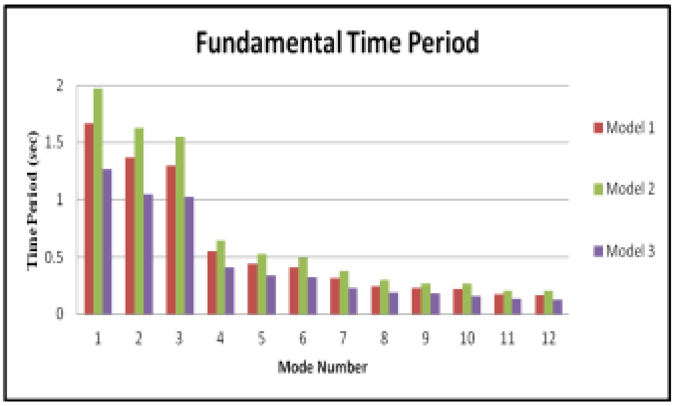

Graph- 5.13 Variation of Fundamental Time Period of three model.

6. CONCLUSIONS

Within the scope of present work following conclusions are drawn:

1. In all models storey drift and displacement values are less for lower zone and it goes on increase for higher zone because the magnitude of intensity will be more for higher zone.

2. In zone V 12 storey building model, zone IV and V 14 storey building models and all zones 16 storey building models displacement values crosses the maximum permissible limit. Hence it is advised to increase size of beam and column to reduce displacement values.
3. For all cases displacement value is more for cases in Y-direction(RSY) when compared to cases in X-direction (RSX).
4. The storey drift and displacement is more for floating column buildings because as the columns are removed the mass gets increased and hence drift also increases.
5. Drift value for all cases are safe within maximum permissible limit and follow around similar path along storey height with maximum value lying somewhere near about middle storey.
6. The taller building have larger fundamental time period and also fundamental time period of building increase with increase in mass. Fundamental time period of buildings reduce with increase in stiffness.
7. Fundamental time period of floating column building is greater than normal building.

The final conclusion is that do not prefer to construct floating column buildings. With increase in dimensions of all member also it getting more displacement than normal building and cost for construction also increased. So avoid constructing floating column for higher storey.

7. FUTURE SCOPE

1. Further it should study for floating column at various position of building.
2. Floating column in irregular geometry.
3. Research can also be done on steel floating column.
4. Design and estimation of building is necessary used for improving the seismic performance of structure.
5. The reaction at footing level is to be investigated and modified for present study.

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