International Journal of Scientific & Engineering Research Volume 11, Issue 10, October-2020
ISSN 2229-5518

Seismic Performance & Structural Stability Analysis of Floating Column Building

Parveen Hamza, Gokul Raveendran K, Dr.C.Justine Jose

Abstract— Many buildings are planned and constructed with architectural complexities. The complexities include various types of Irregularities like floating columns at various levels and locations. Floating column is a distinctive feature in high rise buildings in the present modern construction. As per IS: CODE-1893:2016 clause no-7.1, floating column construction is prohibited but there is no limitation and restriction for research work. This study is done to obtain the seismic response of a building and to analyze and build the structure in which there will be less damages to the structure and its component under the excitation of earthquake. A G+9 storied building with architectural complexity such as External Floating Columns is analyzed statically and dynamically for various earthquake zones IV and V. In overall study of seismic analysis, worst case scenario is found out. The worst case is then taken into consideration and suitable strengthening is provided and displacement, drift graphs are plotted. This Building is designed and analyzed with the help of SAP2000.v20 Software.

Index Terms— Floating Column, Static Analysis,Time History Dynamic Analysis, Strengthening, X-Bracing, Storey displacement, storey Drift

---

1 Introduction

Earthquakes disasters had always been one of the natural hazards under which buildings are mainly caused by damage or collapse. Indian subcontinent has been experienced with some of the most severe earthquake in the world. Hence, it is necessary to take in to account the seismic analysis for the design of multistory buildings. The objective of seismic analysis started as the structure should be able to endure minor shaking intensity without sustaining any damage. High rise building is the most complex built structure since they are many conflicting requirements and complex building systems to integrate. Buildings are the symbol of modern society. Due to lack of space, increasing population and also for aesthetic view and functional requirements, Construction of high rise building in urban cities are required to have column free space. For this purpose, the concept of floating column is coming in picture. These columns are highly disadvantageous in building built in seismically prone areas. As per IS:1893-2002 earthquake code the India is classified into different zone for which it specifies the seismic zone factor and it is very important to analyze & design the building for seismic force to prevent damages occur due to earthquake. The code of earthquake engineering has been designed with the aim that people get enough time to escape from the building, the building is less damaged and the building comes in faster use. Code of practice for earthquake engineering has been designed with the aim that human lives are protected, damage is limited and service structures remain operational.The effect of earthquake on building depends on the shape and regularity of the structure. The irregular structure will have more severe effect than regular structure, the irregularity may be horizontally or vertically.

2 FLOATING COLUMN

Floating column is nothing but a vertical member or element that rests on a beam, but doesn't transfer load directly to the foundation. Generally, the columns rest on the foundation to transfer loads coming from slabs and beams, floating column acts as a point load on the beam and this beam transfers the load to the column below it, that beam is called a transfer beam. Floating columns arises in use to bid extra open space for assembly hall of parking purpose. The floating column building does not generate any problem under only vertical loading condition but it rises susceptibility in earthquake(lateral loading condition, due to vertical discontinuity. During the earthquake the lateral forces established in higher storey have to be transmitted by the proposed cantilever beams due to this the overturning forces are established over the column of the ground floor. A column is supposed to be a vertical member beginning from foundation level and shifting the load to the ground. The term floating column is also a vertical component which (due to architectural design/ site situation) at its lower level rests on a beam which is a horizontal member. The beams in turn assign the load to other columns below it. A typical floating column building is shown in Figure 1.

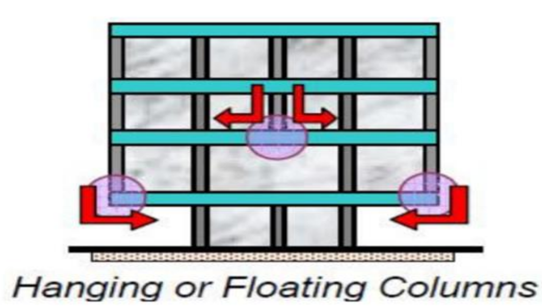

Figure 1: Floating Column Building

2.1 Earthquake Behaviour of Floating Column

During earthquake, the behavior of building depends on its geometrical shape, size and how the earthquake force carried to the ground. Usually in every building load is transferred from horizontal members (beams and slabs) to vertical members (walls and columns) and then to the foundation. A structure having floating column can be classified as vertically irregular as it causes irregular distribution of mass, strength and stiffness along the building height. Absence of any column at any level of structure changes the load transfer path and load of this floating column is transferred through the horizontal beams below it, known as transfer girders.

2.2 Bracing

The bracing systems are used to resist horizontal forces like seismic action, wind load and to transmit to the foundation. The bracing members are arranged in many forms, which carry solely tension, or alternatively tension and compression. Such systems reduce bending moment and shear force in the columns. By the provision of braces in a structure, it becomes more stable as the result of transferring of loads sideways and it helps in reducing the sway of structure.

2.2.1 Concentric Braces

The braces provided in a structure can be called as concentric if the center lines of bracing members are intersected with that of beams and columns as shown in Figure 2.

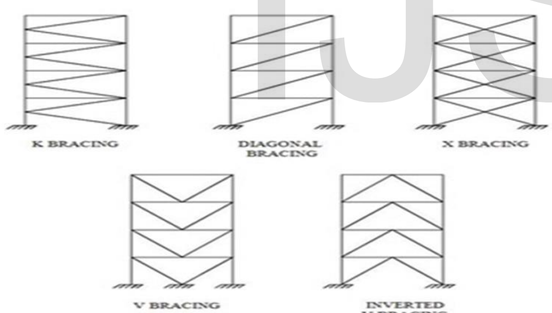

Figure 2: Concentric braces

These help in increasing the lateral stiffness of the structure and natural frequency correspondingly decreases the lateral drift. However, the increase in the stiffness may attract a larger inertia force due to the earthquake. And the bracing decreases the bending moments and shear forces in columns, they increase the axial compression in the columns to which they are connected. Figure 2 includes the various types of concentric bracings.

3 MODELLING

A 10-storey building where floating column is provided at alternate floor levels such as in ground storey, second storey, fourth storey, sixth storey and eighth storey. A 10-storey building without floating column is also taken into account. Model specificatios are provided in Table 1.

TABLE 1
MODEL DATA

PARAMETERS	SPECIFICATIONS
Soil Type	Medium (II)
Seismic zone	IV and V
Height of Building	31.5m
Floor Height	3.15m
Thickness of Slab	150mm
Beam Size	230×380m
Column Size	450×450mm
Floating Column	300×300mm
Live Load	2.5kN/m²
Floor Finish	1kN/m²
Material properties	M30 grade of concrete and fe 500 grade of steel

A normal 10-storey building is also considered i.e. without floating column.

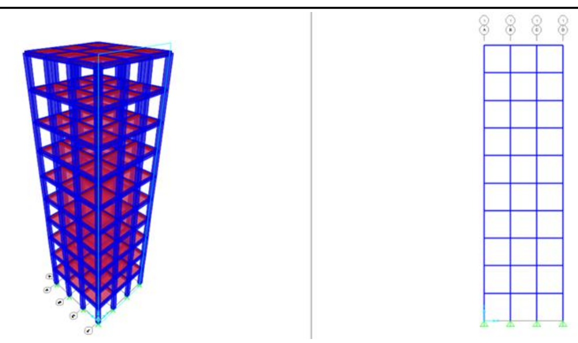

Figure 3: Extruded 3D view of model showing building without floating column

- *Parveen Hamza is currently pursuing masters degree program in structural engineering in VAST, Thrissur, India. E-mail: parveenhamzapj@mail.com*
- *Gokul Raveendran K is currently Assistant professor in department of civil engineering in VAST, Thrissur, India.*
- *Dr.C. Justine Jose is currently Professor in department of civil engineering in VAST, Thrissur, India.*

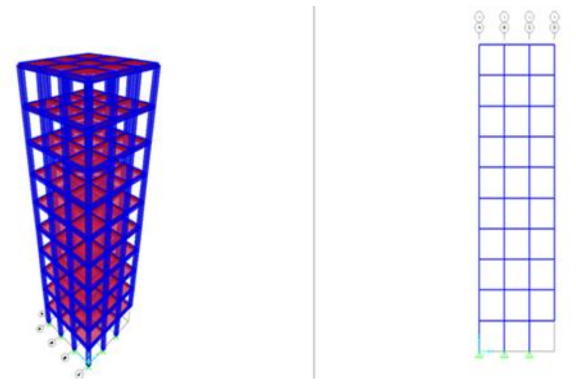

Figure 4 : Extruded 3D view of model showing building with floating column at ground storey

Similarly, floating column at corner in the second, fourth, sixth, eighth storey models are also considered.

3.1 Analysis and Results

The static earthquake analysis is done. Maximum displacement and maximum drift are shown in Table 2. From the analysis it is observed that the displacement increases as the storey increases. The displacement is maximum in the 10th storey.The drift is maximum in the 1st storey when the floating column is provided at the ground storey and is then decreasing towards the upper storeys. The displacement and drift is maximum in Zone 5.

TABLE 2
STATIC ANALYSIS RESULTS

	Zone	Displacement (m)	Drift(m)
Without floating column	4	0.0333	0.0071
	5	0.0417	0.0088
Floating column at ground storey	4	0.0409	0.0082
	5	0.0497	0.0101
Floating column at second storey	4	0.0391	0.0071
	5	0.0478	0.0088
Floating column at fourth storey	4	0.0373	0.007
	5	0.0458	0.0088
Floating column at sixth storey	4	0.0355	0.007
	5	0.0439	0.008
Floating column at eighth storey	4	0.034	0.007
	5	0.0423	0.088

Comparison of storey displacement and storey drift in zone 4 and 5 is shown from Figure 5 to 16.

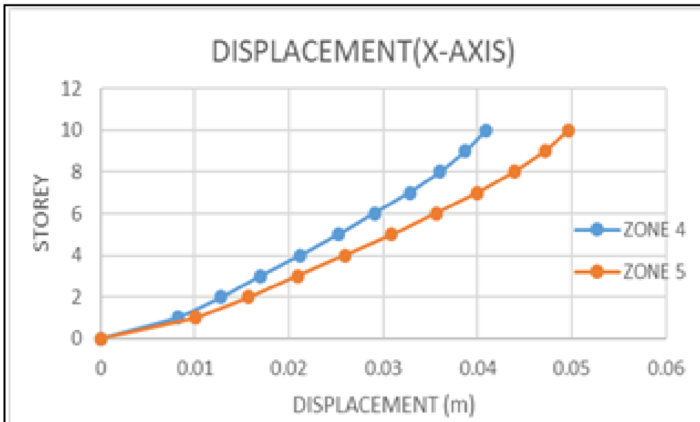

Figure 5: Comparison of storey displacement in zone 4 and 5 (Floating column at ground storey)

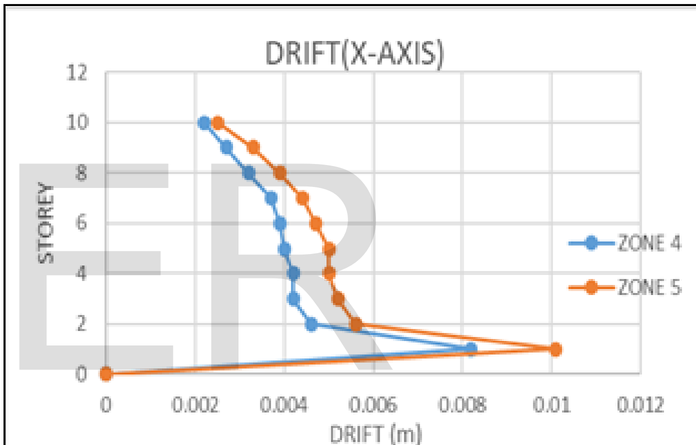

Figure 6: Comparison of storey drift in zone 4 and 5 (Floating column at ground storey)

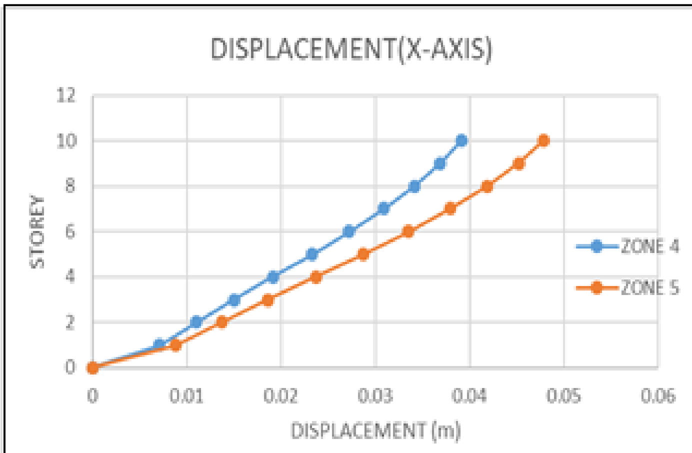

Figure 7: Comparison of storey displacement in zone 4 and 5 (Floating column at second storey)

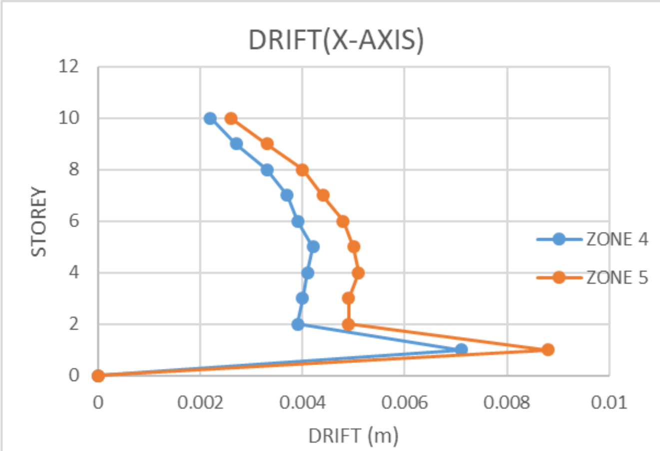

Figure 8: Comparison of storey drift in zone 4 and 5 (Floating column at second storey)

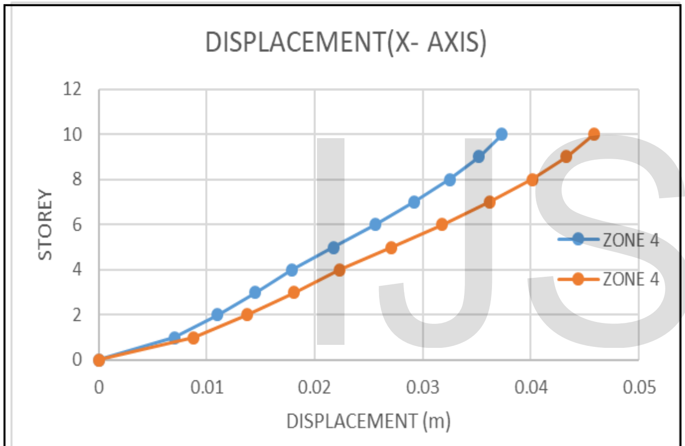

Figure 9: Comparison of storey displacement in zone 4 and 5 (Floating column at fourth storey)

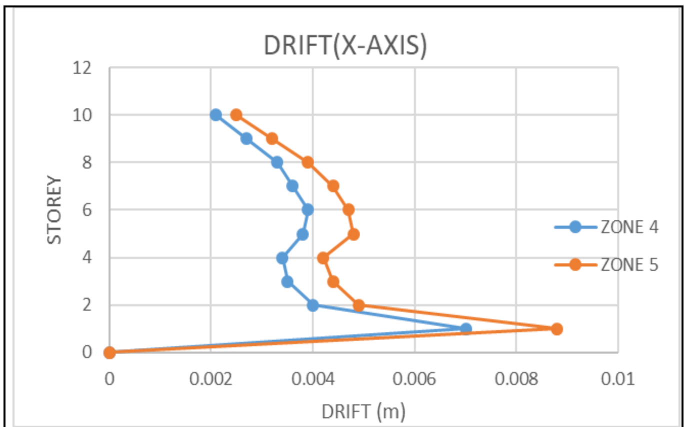

Figure 10: Comparison of storey drift in zone 4 and 5 (Floating column at fourth storey)

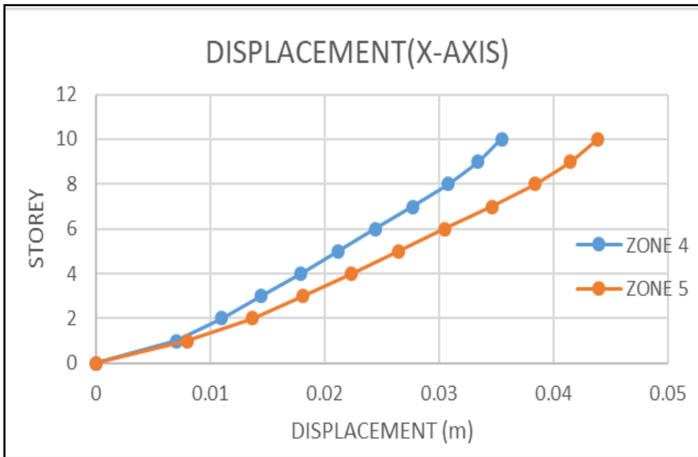

Figure 11: Comparison of storey displacement in zone 4 and 5 (Floating column at sixth storey)

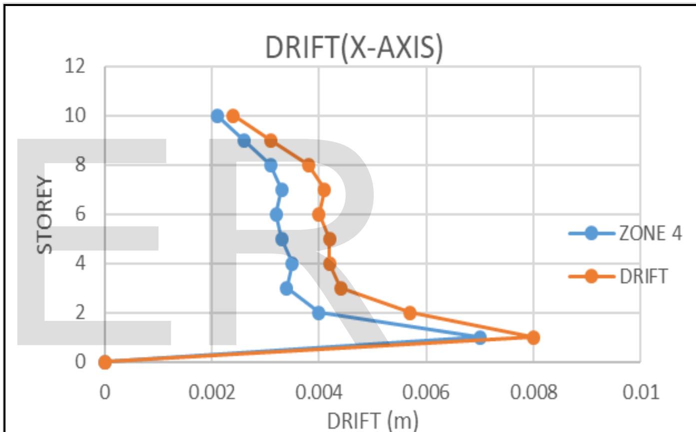

Figure 12: Comparison of storey drift in zone 4 and 5 (Floating column at sixth storey)

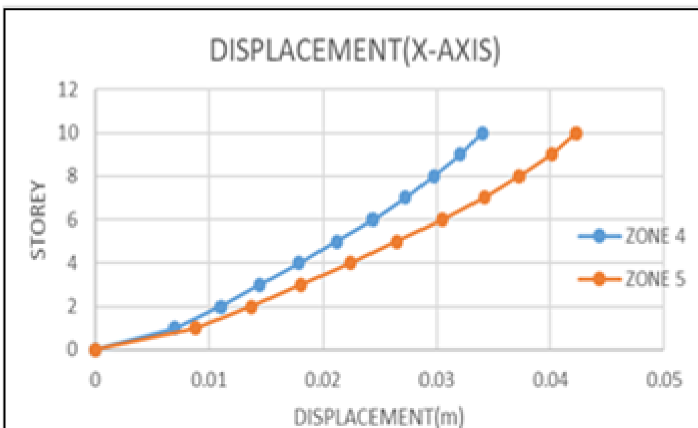

Figure 13: Comparison of storey displacement in zone 4 and 5 (Floating column at eighth storey)

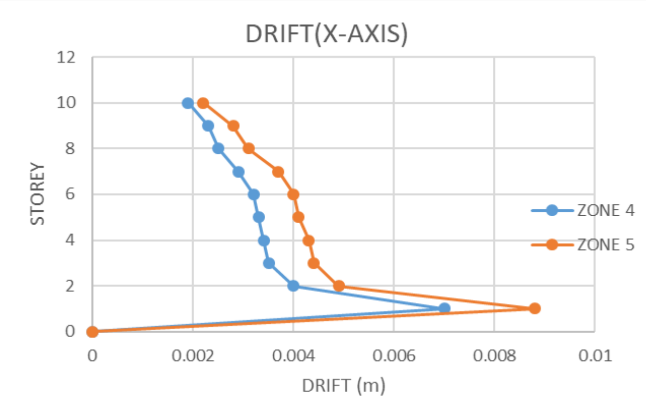

Figure 14: Comparison of storey drift in zone 4 and 5 (Floating column at eighth storey)

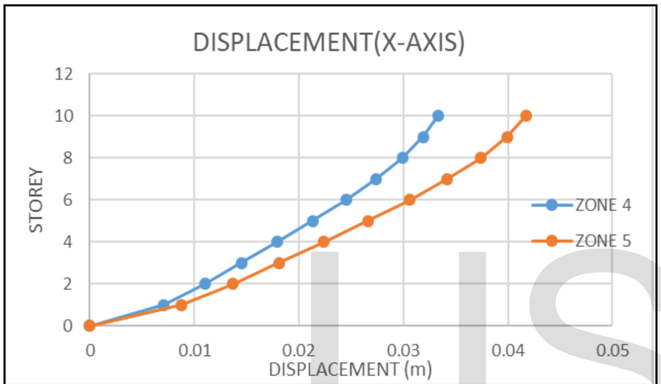

Figure 15: Comparison of storey displacement in zone 4 and 5 (without floating column)

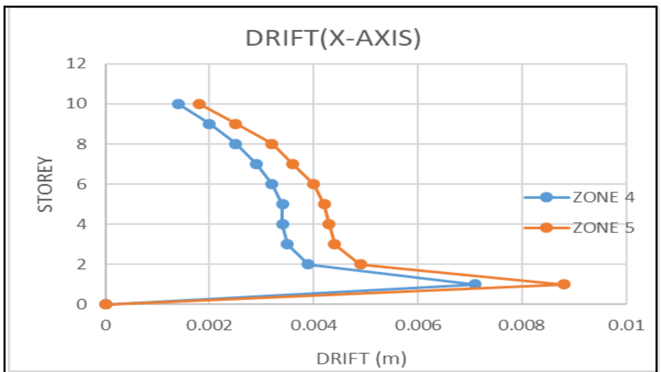

Figure 16: Comparison of storey drift in zone 4 and 5 (without floating column)

3.2 Conclusions

Following conclusions are drawn from the present study;

- Displacements of various floors in longitudinal direction i.e. x-direction is determined and it has been seen that when floating column is provided storey displacement is slightly higher than the normally constructed building without considering any discontinuity.
- Drift of a particular storey increases due to the existence of floating column in the structure but is maximum at the ground storey. Here the drift value is within the permissible limit, that is less than 0.0126m i.e. 0.004 times the storey height which is 3.15m.
- From static analysis, it has been concluded that when floating column is provided at the corner of the building, the drift is within the limit. Therefore, the building is safe from the analysis.

4 Dynamic Analysis of Floating Column Building

4.1 Model of building

Step by step procedure to be carried out.

- Creation of model with floating column provided at the corner in the ground storey
- Assigning material properties to the model.
- Application of different boundary conditions.

4.2 Time History Analysis

For carrying out time history analysis data is used from PEER NGA strong motion database record with Imperial Valley-02, 5/19/1940, El Centro Array #

4.3 Analysis and Results

The deformed shape of the floating column building when time history analysis is performed is obtained as shown in the Figure 17.

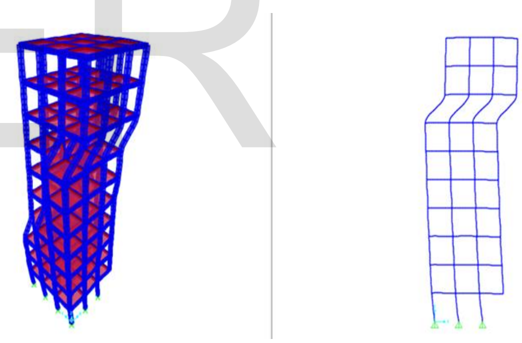

Figure 17: Deformed shape of the structure

The maximum displacement and drift obtained when floating column is provided in the ground floor at corner is :

Maximum displacement (m) = 0.1759

Maximum drift (m) = 0.0447

The displacement is very much higher than that obtained in the static analysis of floating column building provided at the ground storey.

4.4 Conclusions

From the analysis, it is observed that:

- The drift value for the bare structure with floating column provided at corner of the ground storey is not within the permissible limit i.e. 0.0126m which is 0.004 times the height of each storey (3.15m).
- So, strengthening should be provided in order to prevent the structure from collapse.

5 Strengthening of Floating Column Building

Various strengthening techniques are adopted in floating column building in order to minimise the drift value to prevent the structural collapse.

5.1 Increasing depth of beam

The concept of floating column mainly comprises of disrupting flow of transfer of earthquake force. Floating columns are to be designed as a normal compression member. But while designing transfer beam, it is designed as beam carrying all that load of column as a single point load. But it is to be kept in mind that earthquake force developed must be brought down along the shortest oath that is load is distributed among two intermediate columns supporting that beam. Floating column is supported by high shear capacity beams/ deep beams.

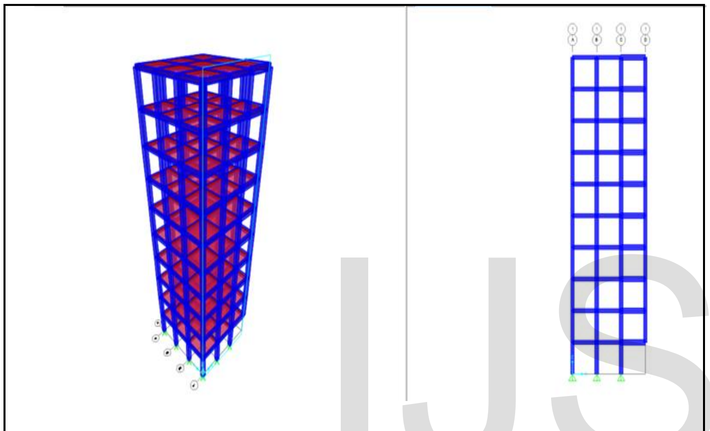

Figure 18: Extruded 3D view model of floating column building provided with increased beam depth

5.1.1 Analysis and result

The maximum displacement and drift obtained when depth of beam is increased :

Maximum displacement (m) = 0.1651
Maximum drift (m) = 0.0416

Here the displacement value increases with the storey height and is less than that of the displacement obtained in the above case where the bare floating column is considered.
Also, the drift value is less than that of the drift obtained for bare frame structure but not within the permissible limit.

5.1.2 Conclusion

From the analysis, we can see that:

- The drift value for the bare structure with floating column provided at corner of the ground storey is not within the permissible limit i.e., 0.0126m which is 0.004 times the height of each storey (3.15m).
- The lateral displacement is less than that of the bare frame structure but is very much higher than that of the displacement obtained where static analysis is done for floating column provided at the ground floor of the building.

5.2 X-Bracing at Base

X-bracing is a structural engineering practice where the lateral load on a building is reduced by transferring the load into the exterior columns. Cross bracing can increase a building's capability to withstand seismic activity. Here X-bracing is provided at the ground storey and above it where the floating column is provided.

Figure 19 shows the 3D model of floating column building provided with bracing.

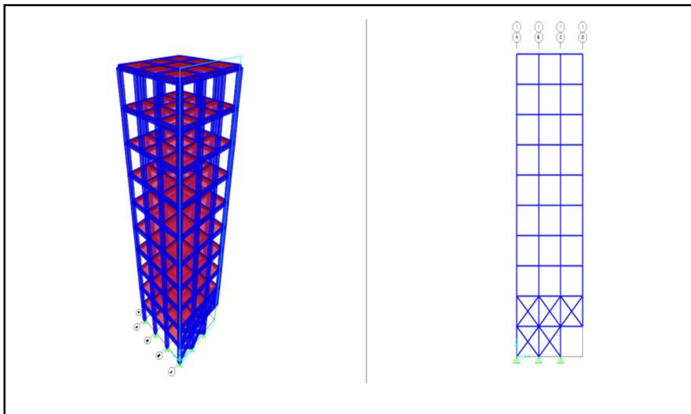

Figure 19: Extruded 3D view model of floating column building provided with bracing at the base

5.2.1 Analysis and result

The deformed shape of the building when time history analysis is performed is shown in the figure 6.8.

Maximum displacement (m) = 0.1045
Maximum drift (m) = 0.0145

Here the displacement value is less than that of the displacement obtained in the above case where beam depth is increased is for floating column building. Also, the drift value is less than that of the drift obtained for floating column structure where depth of beam is increased but not within the permissible limit.

5.2.2 Conclusion

From the analysis, we can see that:

- The drift value for the structure with floating column provided at corner of the ground storey with bracings is not within the permissible limit i.e., 0.0126m which is 0.004 times the height of each storey (3.15m).
- The lateral displacement is less than that of the deep beam structure but is very much higher than that of the displacement obtained where static analysis is done for floating column provided at the ground floor of the building.

5.3 X-Bracing at Corner

Here the bracing is provided at the corner of the building and throughout all above the storeys and is shown in Figure 20.

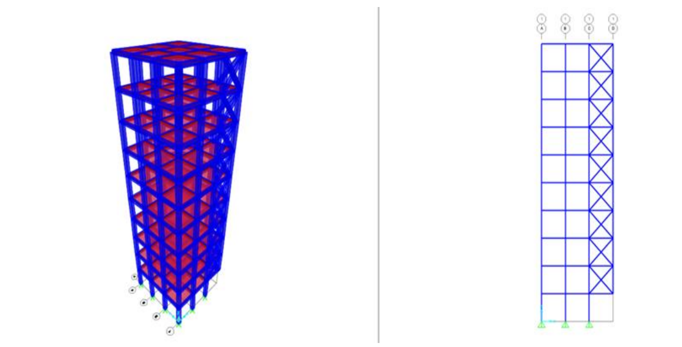

Figure 20: Floating column building provided with bracings at the corner on all storeys

5.3.1 Analysis and result

Maximum displacement (m) = 0.1339
Maximum drift (m) = 0.0414

Here the displacement value increases is less than that of the displacement obtained in the above case where bracing is provided at the base of the floating column building.

Also, the drift value is less than that of the drift obtained for the case where bracing is provided at the base of floating column structure but not within the permissible limit.

5.3.2 Conclusion

From the analysis, we can see that:

- The drift value for the structure with floating column provided at corner of the ground storey with bracings provided at the corner on all storeys is not within the permissible limit i.e., 0.0126m which is 0.004 times the height of each storey (3.15m).
- The lateral displacement is less than that of the floating column structure provided with bracings at the base but is very much higher than that of the displacement obtained where static analysis is done for floating column provided at the ground floor of the building.

5.4 X-Bracing at Corner and Base

Here the bracing is provided at the corner on all storeys and base of the building aas shown in the below Figure 21.

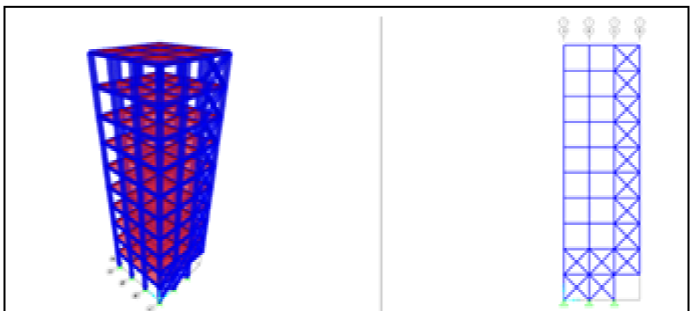

Figure 21: Floating column building provided with bracings at the corner on all storeys and the base

.

5.4.1 Analysis and result

Maximum displacement (m) = 0.0789
Maximum drift (m) = 0.0100

Here the displacement value is less than that of the displacement obtained in the above all cases of the floating column building.

Also, the drift value is less than that of the drift obtained for the cases above of floating column structure and is within the permissible limit.

5.4.2 Conclusion

Here when bracing is provided at the corner and base, the drift value is very much lesser than any of the above cases and is within the permissible limit i.e. 0.004×height of storey.

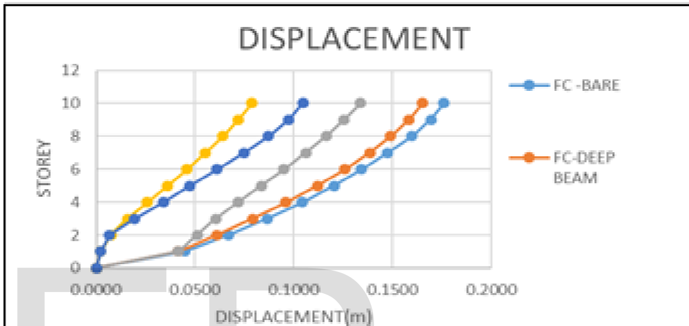

Figure 22: Comparison of storey displacement

In Figure 22, the displacement is much lower for the case where bracing is provided for the floating column building at corner on all storeys and the base. So. for this lateral displacement, the building is safe. Figure 23 shows the comparison of drift in all five cases.

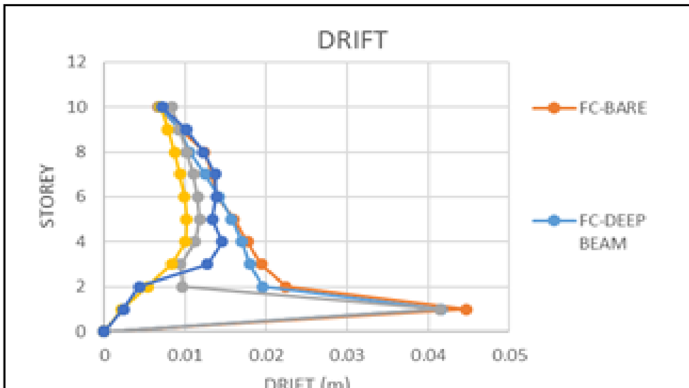

Figure 23: Comparison of storey drift

From the analysis, it is observed that:

- The drift value for the structure with floating column provided at corner of the ground storey with bracings provided at the corner on all storeys and at the base is within the permissible limit i.e., 0.0126m which is 0.004 times the height of each storey (3.15m). The maximum 0.010037m which is less than 0.0126m.
- The lateral displacement is less than that of all the above obtained cases but is very much higher than that of the displacement obtained where static analysis is done for floating column provided at the ground floor of the building.

6 Conclusions

In this study, the behaviour of floating column building has been analysed by non-linear time history analysis. The behaviour of the buildings with and without floating columns are analysed under seismic load. Static and dynamic analysis are carried out on a building by comparing five cases for the strengthening purpose.

From the study, it is concluded that:

- Maximum story displacement and story drift is more in floating column building compared to normal building.
- Displacements of various floors in longitudinal direction i.e. x-direction is determined and it has been seen that when floating column is provided storey displacement is slightly higher than the normally constructed building without considering any discontinuity.
- Drift of a particular storey increases due to the existence of floating column in the structure.
- In static analysis the building with floating column provided at corner side, gives the maximum storey displacement but is less than in the case if dynamic analysis.
- In static analysis, the floating column building does not fail as the drift is within the limits. But in dynamic analysis, the building will collapse as drift value exceeds the limit.
- It has been seen that chances of failure of buildings with floating column are much higher as compared to the buildings without floating column. So Floating column building is unsafe than a Normal building.
- The location of floating column is made significant impact on building, by analytically it cannot be said that which location is most appropriate for all types of building. Every time we need to be carried out careful analysis.
- The introduction of bracings provided at the corner on the floating column building and at the base as a strengthening method gives much lower storey displacement and srey drift and is within the permissible limit 0.0126m.
- So, if bracings are provided in the corner on all storey and at the base, the floating column building can be made safe but this can vary when floating column is introduced at different positions.

References

[1] Mohasinkhan N Bargir and Ajim G Mujawar (2020) "Earthquake Analysis of High-Rise Building with Floating Column." Springer

[2] Kishalay MT, Kamrujjaman NM (2018) "Evaluation of seismic performance of floating column building." Am J Civil Eng 06

[3] Shivam Tyagi and Prof. B.S Tyagi (2018) "Seismic Analysis of Multistorey Building with Floating Column" International Research Journal of Engineering and Technology vol.5

[4] Trupanshu Patel, Jasmin Gadhiya and Aditya Bhatt (2017) "Effect of Floating Column on RCC Building with and without Infill Wall Subjected to Seismic Force" International journal of Engineering Trends and Technology vol.47

[5] Y.Abhinay, Dr. H.Sudarsana Rao, and Dr. Vaishali G Ghorpade (2017) "Comparison of Seismic Analysis of a Floating Column Building and a Normal Building" International Journal of Materials Science vol.12

[6] Jamdar Ameerhussain Suhelahmed and Prakarsh Sangave (2017) "Seismic Response of Multi-storey Structure with Floating Columns" International Journal of Research Publications in Engineering and Technology vol.3

[7] Sasidhar T and P. Sai Avinash (2017) "Analysis of Multistoried Building with and without Floating Column" International Journal of Civil Engineering and Technology vol.8

[8] Ms.Waykule(2016) "Comparative Study of floating column of multi storey building" Int. Journal of Engineering Research and Application vol.7

[9] Jayashri Sarode and Mr. Amol.S. Pote (2016) "Analysis of Floating Column Building of Composite and RCC Beam Girder and Comparison with RCC Frame" International Journal of Approximate Reasoning.

[10] Wahidi A, Ramaseshu D (2016) "Seismic Analysis of Multistory Building with Floating Column" Asian Journal Civil Engineering

[11] Saritha Singla and Ashfi Rahman (2015) "Effect of Floating Columns on Seismic Response of Multistoried RC Framed Building" International Journal of Engineering and Research Technology

[12] Srikanth and Yogendra (2014) "Seismic Response Of Complex Buildings With Floating Column For Zone II AND Zone V" International Journal of Engineering Research, vol 2

[13] Nautiyal Prema (2014). "Seismic Response Evaluation of RC Frame Building With Floating Column Considering Different Soil Conditions" IEEE Trans. Power System, vol. 19

[14] Sukumar Behera (2012) "Seismic Analysis of Multistory Building with Floating Column" Department of Civil Engineering, National Institute of Technology Rourkela

[15] Kara and Celep(2012) "Nonlinear seismic response of structural systems having vertical irregularities due to discontinuities in columns" WCEE

[16] Behela S (2012) "Seismic analysis of multistorey building with floating column"" Department of Civil Engineering, National Institute of Technology Rourkela