Seismic Analysis of Multi-Storey Building with and without Floating Column

Noufiya Ashraf
Department of Structural &construction Management
Mangalam College of Engineering
Kottayam, Kerala

Gokul P V
Assistant Professor
Department of Structural &construction Management
Mangalam College of Engineering
Kottayam, Kerala Kottayam

***Abstract*— The 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. In order to have more area for parking space and for other amities, concept of floating columns in multi-storey framed structure is becoming popular stability used structural integrity of such structures while resisting earthquake becomes critical. For this buildings are provided with floating columns at one or more storey. In this Equivalent static method, response spectrum and time history method were used for analysis in ETABS-2017. Software was used and structure was assumed to be situated in earthquake Zone III**

Keywords*— Floating column, Shear wall, Earthquake, Storey displacements, Storey drift, Storey shear, Equivalent static method, Response spectrum method, High rise building. And the parameters like Base shear, Storey drift, and Displacement were evaluated.

1. INTRODUCTION

India is a developing country, where urbanization is at the faster rate in the country including adopting the methods and type of constructing buildings which is under huge development in the past few decades. As a part of urbanization multi-story buildings with architectural provisions are constructed. These necessities are nothing but soft story, floating column, hefty load, the lessening in stiffness, etc. Now a day's many urban multi-storey buildings have open first storey as an unavoidable feature. This is mostly being adopted to accommodate car parks or reception lobbies in the first storey. Whereas the total seismic base shear as practiced by a building during an earthquake is reliant on its natural period. The seismic force distribution is depending the distribution of stiffness and mass along the height. The behaviour of a structure during earthquakes rest on critically on its complete shape, size and geometry, along with how the storey shear are moved to the ground. The storey shears at different storeys in a building necessity to be transferred down to the ground by the shortest path; any discontinuity in the structural members results in the change in the load path. Buildings having vertical setbacks basis a sudden variation in earthquake forces at the levels of discontinuity. The discontinuities in the load path is formed in the buildings with floating columns at a middle storeys or ground storey and do not continue up to foundation. Hence, there is need of understanding the behaviour of earthquake, also constructing and developing earthquake resistant structures. Thus, shear walls are introduced to resist the lateral forces formed during earthquake. They are known as the vertical elements of the horizontal force resisting structure. Shear walls in the construction counters the effect of lateral loads acting on structure. Specifically, significant for high rise structures, shear walls thus act against lateral forces produced by airstream, earthquake and unequal settlement loads. Urbanization and Growing of high rise buildings is the need of current population and earthquakes have the potential for causing the greatest damages to those tall structures. Hence, it is needed to take in to account the seismic load for the design of high-rise structure. Commonly the shear wall building will be strong. But the floating column structure, how behaviour with the shear wall will be studied in this study.

Floating Column: A column is a vertical compression member which starts from foundation level and continues up to top level which transfers the load to the ground. The term floating column is also a vertical component which at its lower-level rests on a beam which is a horizontal member. Structures with columns that suspend or float on beams at a middle level and do not go all the way to the footing, have breaks in the load transfer path. The beams in turn transfer the load to other columns under it. In such columns the loads were measured as a point load. Floating column does not have any structural continuity because they are built over the beam. There are many projects in which floating columns are already accepted, particularly above the ground floor, so that more open space is available on the ground floor.

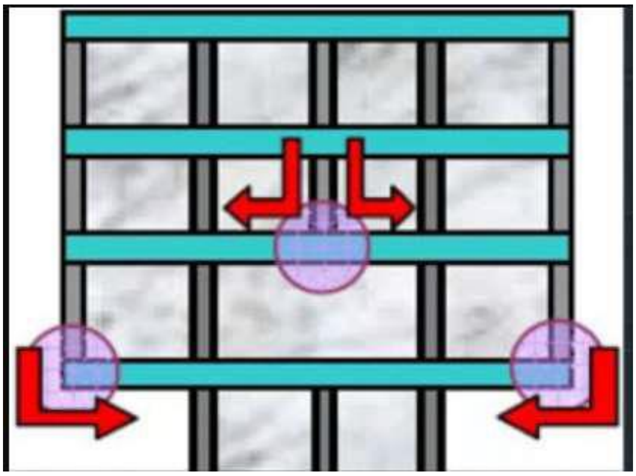

Fig 1.1 Floating column (Google)

Shear Wall: Shear wall is an earthquake resistant component used to resist the horizontal forces such as airstream force, seismic force. These forces act equivalent to the plane of the wall. Shear wall commonly provided in high rise building. It will introduce from foundation level up to prolonged to the building height. Shear wall thickness may differ from 150mm to 400mm. Reduces lateral sway of the building. Rigid vertical diaphragm transfers the loads into Foundations. Moment-resistant frame must be provided along the other route to resist strong earthquake effects. Shear walls behaviour depends upon material used, wall thickness, wall length, wall positioning in building surround. Structures that contain shear walls from reinforced concrete are generally prevalent for using in areas and countries that earthquake-prone.

2. MODELING AND BUILDING DATA

2.1 With Floating Columns

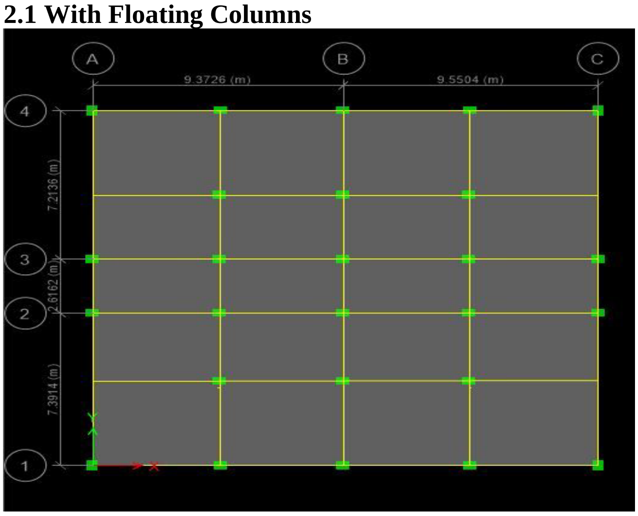

Figure 2 Plan of building with floating column

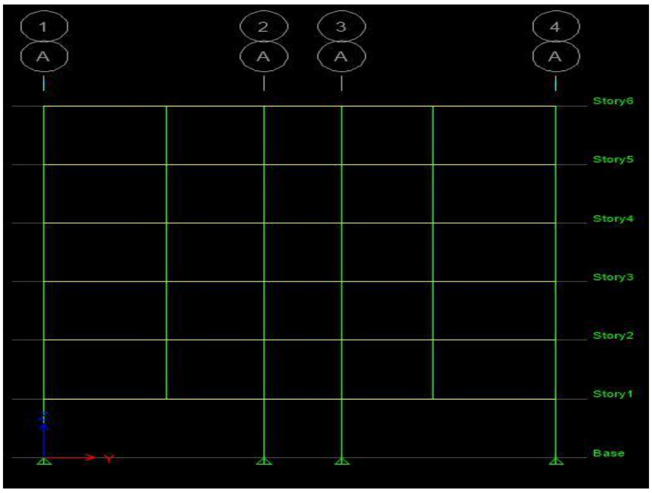

Figure 3 Elevation of building with floating column

2.2. Building Data

Plan Dimension/Plinth Area		19mx18m
Total Site Area		809.66 Sq.m
No of storey's		G+5
Total Built up Area		1710 Sq.m
Each storey height		3m
Thickness of external wall		230mm
Thickness of internal wall		115mm
Thickness of parapet wall		115mm
Thickness of slab		125mm
Floor finish		1 KN/m^2
Live load on floors		2.5KN/m^2
Live load on roof		2KN/m^2
Density of concrete		25 KN/m^3
Density of brick		20 KN/m^3
Grade of concrete (fck)		M25
Grade of steel (fy)		Fe 500
Without floating column	Beam	230mmx425mm
	Column	230mmx550mm
With floating column	Beam	400mmx400mm 400mmx450mm
	Column	400mmx550mm 500mmx500mm

Table 1 Building data and Dimensions

3.LITERATURE REVIEW

Research on the behaviour of the floating column with different models is described below:

SARIKA YADAV et. al. [2016], discussed the behaviour of multi-storey buildings having floating columns under seismic forces and observes the effect of shear wall in the same building. For this purpose, three cases of multi-storey buildings are considered having 8 storey, 12 storey and 16 storey. All the three cases are analysed for zone III, zone IV and zone V by using software STAAD Pro. The work provides a good source of information on the parameters lateral displacement and storey drift in the multi-storey buildings having floating columns with and without shear wall.

On the basis of analysis and results following conclusions have been made:

The storey drift and displacement is more for floating column buildings. Drift and displacement values are less for lower zones and it goes on increases for higher zones because the magnitude of intensity will be the more for higher zones. By providing shear wall drift and displacement values reduces as compared to without shear wall models for all the zones. As drift values are safe within maximum permissible limits in without shear wall models so there is no necessity of providing shear walls from drift view point. In zone V buildings are not safe for both without and with shear wall. Hence it is advised to increase size of column to reduce the displacement values.

ISHA ROHILLA et. al. [2015], discussed the critical position of floating column in vertically irregular buildings for G+5 and G+7 RC buildings for zone II and zone V on Type - II soil. The parameters used for study are storey drift, storey displacement and storey shear using ETAB software. On the basis of analysis and results following conclusions have been made:

Floating columns should be avoided in high rise building in zone 5 because of its poor performance. Storey displacement and storey drift increases due to presence of floating column. Storey shear decreases in presence of floating column because of reduction mass of column in structure. Increasing dimensions of beams and columns of only one floor does not decreases storey displacement and storey drift in upper floors so dimensions should be increased in two consecutive floors for better performance of building.

KAVYA N et. al. [2015], Compare the seismic behaviour of the RC multi-storey buildings with and without floating column. The analysis is carried out for G+3 storey building situated at zone IV, using ETAB software. To determine seismic behaviour of the buildings the seismic parameters such as lateral displacement, base shear, fundamental time period and inter storey drift are studied. On the basis of analysis following conclusions are drawn:

The natural time periods obtained from the empirical expressions do not agree with the analytical natural periods. And it can also be concluded from the analysis that the natural time period depends on the building configuration. There is more increase in the lateral displacement and inter storey drift for the floating column buildings compared with the regular building. Both parameters increase along the height of the building. As the columns are removed the mass and stiffness gets increased hence the drift and base shear also increases. Therefore, the base shear is more for the floating column buildings compared to the conventional buildings.

SARITA SINGLA et. al. [2015], Studied and analyse the seismic response of multi-storeyed RC framed buildings with and without floating columns. G+6 multi-storied building, with special moment resisting frame was selected for study which is located in Zone IV on Type II soil. 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.

Following are some of the conclusions which are drawn on the basis of this study.
It was observed that in building with floating columns there is an increase in fundamental time period in both X direction (about 5-8%) as well as Z-direction (about 3-7%) as compared to building without floating columns due to decrease in stiffness of structure. By introduction of floating columns in a building base shear and spectral acceleration decreases due to increase of natural period of vibration of structure. Thus, it has this technical and functional advantage over conventional construction. Buildings with floating columns in ground floor are more vulnerable during earthquake. It was also observed that deflections increase marginally in that storey where floating columns are located. Due to discontinuity of stiffness, the flexibility increases and strength decreases resulting in high displacements in structure having floating column.

Following are some of the conclusions which are drawn on the basis of this study.
The probabilities of failure of without floating column are less as compared to with floating column and the probabilities of failure with floating column is more than floating column with inclined compressive member i.e. struts. Due to the provisions of struts in the building with floating columns, the deflection is greatly reduced. This is because struts provide stability to the columns balancing the moments. Column shear values are increasing or decreasing significantly depending upon position and orientation of floating column. Provision of floating column is advantageous in increasing FSI of the building but is a risky factor and increases the vulnerability of the building

SRIKANTH.M. K et. al. [2014], studied the importance of presence of the floating column in the analysis of building and also, along with floating column some complexities were considered for ten storey building at different alternative location and for lower and higher zones. Alternate measures, involving stiffness balance of that storey where floating column is provided and the storey above, are proposed to reduce the irregularity introduced by the floating columns. The high rise building is analysed for earthquake force by considering two type of structural system. Frame with only floating column and floating column with complexities for reinforced concrete building. The entire work consists of four models and these models were analysed for lower (II) and higher (V) seismic zones for medium soil condition.
Based on the study the conclusions are as follows:
The displacement of the building increases from lower zones to higher zones, because the magnitude of intensity will be more for higher zones, similarly for drift, because it is correlated with the displacement. Storey shear will be more for lower floors, then the higher floors due to the reduction in weight when we go from bottom to top floors. And with this if we reduce the stiffness of upper floors automatically there will be a reduction in weight on those floors so in the top floors the storey shear will be less compared to bottom stories. Whether the floating columns on ground floor or in eight floors the displacement values increase when a floating column is provided in edge and middle than the outer face of the frame.

PRERNA NAUTIYAL et. al. [2014], investigated the effect of a floating column under earthquake excitation for various soil conditions and as there is no provision or magnification factor specified in I.S. Code, hence the determination of such factors for safe and economical design of a building having floating column is done. For the analysis purpose two models have been considered.
From the study it is concluded that the base shear demands for medium soil are found higher than that of the hard soil in both cases (i.e. G+3 and G+ 6 models). As the height of the building increases, variation in base shear from medium to hard soil condition decreases. For different soil conditions (medium to hard) the max moments vary from 22- 26% for four storied building model and 16-26% for six storied

building model. It has been found that max. variation in values of max. moments comes at the ground floor (26%) for both the cases whereas the min. variation comes at the top floor (22% for case 1 and 16% for case 2). It can further been concluded that as the height of the building increases the variation of max. moments gets reduced for different soil conditions.

SABARI S et. al. [2014], studied the behaviour of multi-storey buildings with and without floating columns under earthquake excitations. RC Frames of different stiffness on floor wise and height of building are considered. The time history analysis of these RC Frames has been done by subjecting the whole system to BHUJ earthquake ground motion, using FEM Package SAP2000. A comparative study is carried out both for 2D and 3D RC frame structures with and without floating columns. A study is carried out to find variation in time period and structural response for various parameters like floor displacement, base shear, shear force, bending moment and torsion for the beams and axial force for all the models. The compatible time history and
Bhuj earthquake data has been considered. It is concluded that by increasing the column size the maximum displacement and inter storey drift values are reducing.

PRATYUSH MALAVIYA et. al. [2014], studied the effect of floating columns on the cost analysis of a structure designed on STAAD Pro V8i. For this purpose, a 2 storied regular structure is considered. Modelling, analysis, estimation and design of the structure is done separately on the software. Analysis is performed on the zone II, zone III, zone IV and zone V. It is concluded that in the framed structure with no floating columns the nodal displacements are minimum with uniform distribution of stresses at all beams and columns. As a result, it is most economical.

A.P. MUNDADA et. al. [2014], studied the architectural drawing and the framing drawing of the building having floating columns. Existing residential building of G+ 7 has been selected for the project work. The load distribution on the floating columns and the various effects due to it is also been studied in the paper. For this purpose, 3 cases are taken in case 1 no floating column is introduced, in case 2 floating column are introduced, in case 3 struts are provided below the floating column.

Following are some of the conclusions which are drawn on the basis of this study.
The probabilities of failure of without floating column are less as compared to with floating column and the probabilities of failure with floating column is more than floating column with inclined compressive member i.e. struts. Due to the provisions of struts in the building with floating columns, the deflection is greatly reduced. This is because struts provide stability to the columns balancing the moments. Column shear values are increasing or decreasing significantly depending upon position and orientation of floating column. Provision of floating column is advantageous in increasing FSI of the building but is a risky factor and increases the vulnerability of the building

KEERTHIGOWDA B. S et. al. [2014], examined the adverse effect of the floating columns in building. Models of the frame are developed for multi-storey RC buildings with and without floating columns to carry out comparative study of structural parameters such as natural period, base shear, and horizontal displacement under seismic excitation. The RC building with floating column after providing lateral bracing is analysed. A comparative study of the results obtained is carried out for three models. The various models such as bare frame without floating columns, bare frame with floating columns and bare frame with floating column after providing bracings have been analysed using ETABS 9.7.1. The building with floating columns after providing bracings showed improved seismic performance. Through the parametric study of storey drift, storey shear, time period and displacement, it was found that the multi-storey buildings with floating columns performed poorly under seismic excitation. Thus to improve seismic performance of the multi-storey RC building, lateral bracings were provided. The bracings improved seismic performance of multi-storey building considerably as different parameters such as storey drift, storey shear, time period and displacement improved up to 10% to 30%.

CONCLUSION

On the basis of the study following conclusion can be drawn: It was observed that there is an increase in storey drift in buildings having floating columns. It was observed that the storey drift and base shear is more in soft soil than medium soil and hard soil in all the cases. The highest storey drift is experienced at 16th storey in P+20 storey building and at 1st storey in P+3 storey building when floating columns are provided at first floor and second floor. In P+3 storey building storey drift is more when floating column are provided at first floor. Base shear is more in building having floating column than building without floating column for P+20 storey building. Base shear is almost same in P+3 storey building with and without floating columns. Base shear in building having floating column is almost same for all the cases in P+20 storey building. Values of base shear and storey drift are much more in seismic zone V than seismic zone III.

Hence it can be concluded that providing floating column in a high rise building in Seismic Zone V is very vulnerable. Construction of high rise building on soil type III (soft soil) is so much hazardous because as it can observe from the graphs that for all the cases the storey drift and base shear both the parameters show maximum values in soft soil.

REFERENCES

[1] Umesh P, Shivanand S Hallur (2015), "Seismic Analysis of G+5 Framed Structures with and Without Floating Columns Using ETABS-2013 Software".
[2] Nakul A. Patil, Riyaz Sameer Shah (2015), "Comparative Study of Floating and Non-Floating Columns with and Without Seismic Behaviour- A Review".
[3] Sarika Yadav and Raksha Parolkar, "Seismic Behaviour of Multi-storey Buildings Having Floating Columns", International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online), Vol. 4, Issue 1, 2016.
[4] Sk. Shama Banu and G. Shani Priyanka, "Study of Behaviour of Seismic Evaluation of Multi-storeyed Building with Floating Column", International Journal of Computer Engineering in Research Trends, ISSN (O): 2349-7084, Volume 2, Issue 12, pp. 983-988,2015.
[5] A vanish Pardhi, Parakh Shah, Satish Yadav, Pundlik Sapat and Amit Kumar Jha, "Seismic Analysis of RCC Building with & Without Floating Columns", International Conference On Emerging Trends in Engineering and Management Research, ISBN: 978-81-932074-7-5, 2016.
[6] IS 1893(Part 1): 2002" Criteria for Earthquake Resistant Design of Structures Part 1 General Provisions and Buildings (Fifth Revision) Bureau of Indian Standards New Delhi.
[7] ETABS-2017 software is used to analysis of all models.