Seismic Analysis Of High Rise Structure Considering The Effect Of Floating Columns & Plan Irregularities

Naresh Reddy G N,
Assistant Professor, School of Civil Engineering, REVA University, Bengaluru, India

Umraz Khan M
PG Student, School of Civil Engineering, REVA University, Bengaluru, India

ABSTRACT

In recent times, many structures are planned and constructed with architectural complexities. These complexities include floating columns at various levels and locations. The earthquake forces that are developed at different storeys in the structure need to be transferred along the height to the ground by shortest path, but presence of floating columns cause a discontinuity in the load transfer path, resulting in poor seismic performance of the structure. In this paper, a high rise structure is analyzed for seismic performance in very severe seismic intensity zone. An attempt is made to compare the seismic performance of two structures with and without floating columns and irregular floor plans at different storeys. The software package ETABS was used for modelling and analysis. The findings in the study were interpreted and the results indicated that a structure with floating columns in an earthquake zone of severe seismic intensity are prone to larger deformations and hence are not advisable for construction, in comparison with a similar structure without floating columns.

Keywords*: Structures, analysis, floating columns, response spectrum, interstorey drift, displacements, base shear, ETABS*

INTRODUCTION

High rise structures in metropolitan cities are designed to have column free space due to increased utility area, floor-area ratio, lack of space and for aesthetics. To achieve this, the concept of floating columns is often adopted, wherein, some designated columns are provided at intermittent floors unlike conventional columns rising from the base till the top of the structure[1]. The presence of floating columns directly influences the response of the structure, especially during seismic activity. The seismic forces that are induced at various stories in a structure require to be transferred down to the foundation throughout the elevation by an undeviating pathway. However, due to presence of floating columns at various stories, the load transfer path is discontinuous and hence the response of the structure is altered[2].

In this paper, seismic performance of two G+7 RCC framed structural models with and without floating columns is studied. The floor plans of the two models are oriented in such a way so as to induce plan irregularities. Model 1 (M1) is a structure with floating columns in storey 3, 4, 5, 6, 7 and 8. Model 2 (M2) is a structure with all the columns rising from the base to the topmost storey, i.e., without floating columns. The two models M1 and M2 are considered in earthquake Zone V as prescribed in codal provisions of IS1893:2016 [3], [4]. An attempt is made to understand and interpret the effect of floating columns in a structure which is in earthquake zone of severe seismic intensity. The main objectives of this study are to

i. To Analyze a (G+7) building using ETABS software.
ii. To find the seismic response of high rise structures considering various Floating Columns as per IS l893: 20l6 in zone V and medium soil type.
iii. To evaluate the performance of Floating Columns subjected to Earthquake loads.
iv. To perform Dynamic Analysis using ETABS software.
v. To find the Joint displacement, Inter storey drift, and base shear.
vi. To Draw conclusion of the Response Structure.

ISSN: 2233-7857 IJFGCN
Copyright ⓒ2020 SERSC

DESCRIPTION OF STRUCTURAL MODELS

The description of the two structural models M1 and M2 are given in Table 1.

Table 1: Description of models M1 and M2

Description	Model M1	Model M2	Grade of concrete
No. of storeys	G+7	G+7	-
Storey height	3.2m	3.2m	-
Wall thickness	230mm	230mm	-
Column size	230X230mm 230X200mm	230X300mm	M40
Beam size	230X200mm 230X300mm	230X200mm 230X300mm	M30
Shear wall thickness	100mm	100mm	M40
Slab thickness	125mm	125mm	M30
Floating columns	3rd, 4th, 5th, 6th, 7th & 8th storey	Nil	M40

The typical floor plan of storey 1 of Models M1 and M2 is shown in Figure 1.

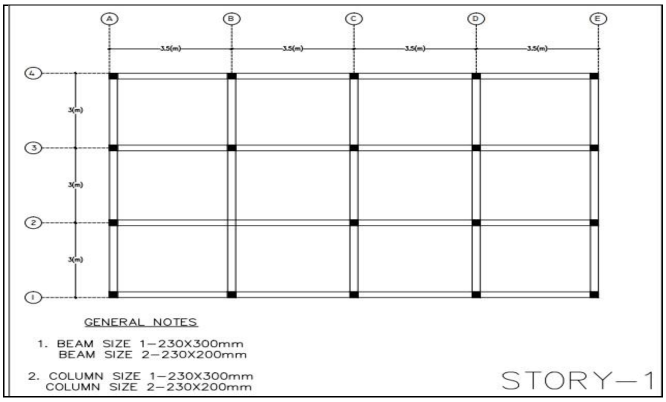

Figure 1: Typical floor plan of storey 1

The typical floor plan of storey 2 and storey 6 of Models M1 and M2 is shown in Figure 2.

ISSN: 2233-7857 IJFGCN
Copyright ©2020 SERSC

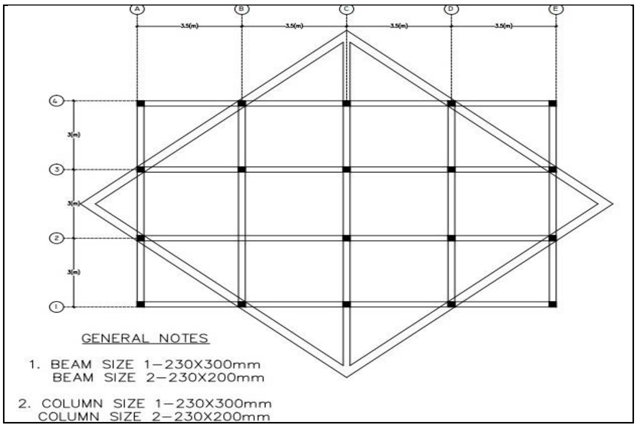

Figure 2: Typical floor plan of storey 2 and storey 6

The typical floor plan of storey 3, storey 4 and storey 5 of Models M1 and M2 is shown in Figure 3.

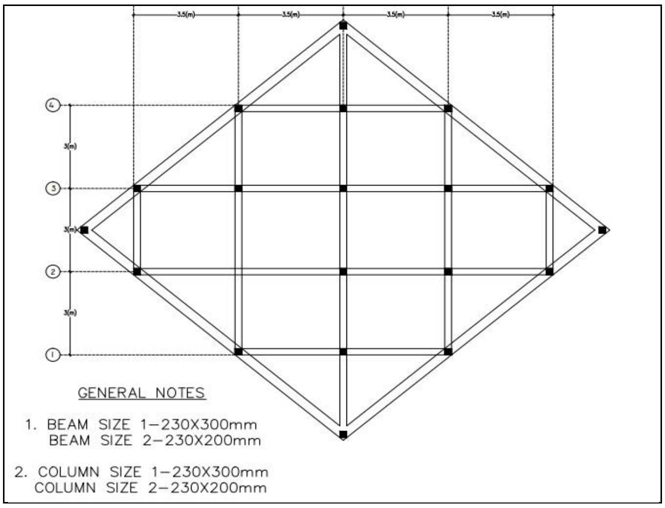

Figure 3: Typical floor plan of storey 3, storey 4 and storey 5

The typical floor plan of storey 7 and storey 8 of Models M1 and M2 is shown in Figure 4.

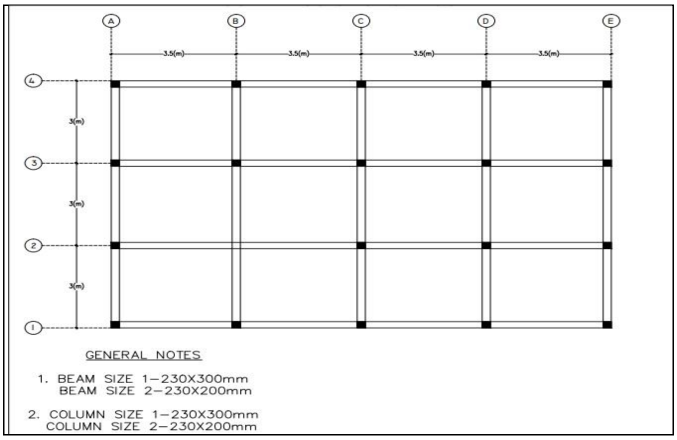

Figure 4: Typical floor plan of storey 7 and storey 8

MODELLING OF STRUCTURES M1 and M2

The details of load data given as input for the analysis of structural models M1 and M2 are as follows.

ISSN: 2233-7857 IJFGCN
Copyright ©2020 SERSC

i. Dead loads: These loads include self-weight of members based on size of sections and density of material. Dead loads are considered based on slab, beam and column sizes by ETABS.
ii. Live loads: These loads include moving or variable loads according to their occupancy. The live load is as given in IS: 875(Part 2)-1987. Live load considered from storey 1 to storey 7 is 3 kN/m^2 and for storey 8, i.e., terrace is 2 kN/m^2.
iii. Wall loads: These loads are super imposed loads which include the self-weight of wall. The wall load is calculated considering the walls are made by using Porotherm blocks of density 8 kN/m^3. The wall load is calculated as width of wall x height of wall x density, which is taken as 5 kN/m^2. The wall loads are applied as UDL on beams.
iv. Seismic data: The seismic data is considered as per provisions of IS:1893:2016. The seismic data for structural models M1 and M2 are shown in Table 2.

Table 2: Seismic data considered in analysis

Description	**Model M1**	**Model M2**
Zone	Zone 5	Zone 5
Response reduction factor (R)	5	5
Importance factor (I)	1	1
Zone factor (Z)	0.36	0.36
Soil type	Medium soil	Medium soil

STEPS INVOLVED IN MODELLING USING ETABS

The software package ETABS version 2018 was used for modelling and analysis of the two structural models M1 ad M2. The various steps involved in modelling stage are briefly listed below.

i. The metric SI units and Indian design codes were selected in model initialization.
ii. The storey data and grid data was given as per the models.
iii. Material properties were defined for the structural members. Grade of concrete was defined as M30 for beams and slabs. M40 was defined for columns and rebar of grade Fe500 was defined.
iv. Section properties for slabs, beams, columns and shear walls were defined as per the description given in Table 1.
v. Load cases for live load and response spectrum were defined as per the description given in Table 2, followed by defining of rigid diaphragm.
vi. Load patterns were defined for equistatic loads and response spectrum cases in both X and Y directions, followed by defining the load combinations and mass source as per IS codes.
vii. After defining all the requirements, the model was prepared by drawing using frame elements and slabs.
viii. The loads were applied on slabs and beams to complete the model.
ix. The model was finally checked for any errors and it was ensured there are no errors in the model.

The 3D view of the structural model is shown in Figure 5.

ISSN: 2233-7857 IJFGCN
Copyright ⓒ2020 SERSC

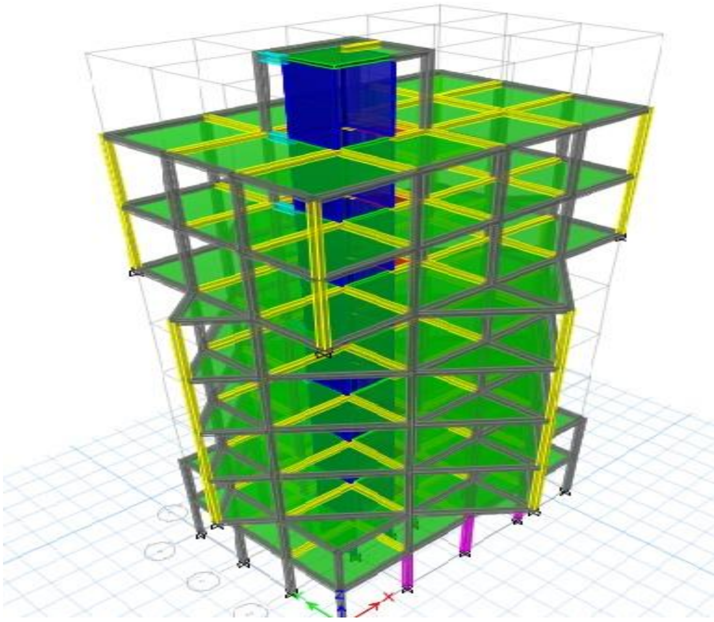

Figure 5: 3D view of structural model M1

ANALYSIS OF STRUCTURAL MODELS M1 & M2

After modelling and checking the models for any errors, the analysis options were set for performing dynamic analysis and the analysis was done for models M1 and M2. The results of the analysis were viewed and interpreted. The analysis results considered for understanding the effect of floating columns were maximum point displacement, interstorey drift, and base shear in both X and Y directions in plan.

RESULTS AND DISCUSSIONS

1) Maximum point displacements

It was found that the maximum point displacements for both structural models M1 and M2 were found to be occurring at the topmost floor, i.e., storey 8.

The maximum point displacement in X direction for model M1 with floating columns was found to be 59mm and that for model M2 without floating columns was found to be 55.1mm. Hence, it is inferred that the influence of floating columns in these models has resulted in an increase in maximum point displacement by about 7%. The location of maximum point displacement in X direction for models M1 and M2 are shown in Figure 7 and Figure 8 respectively.

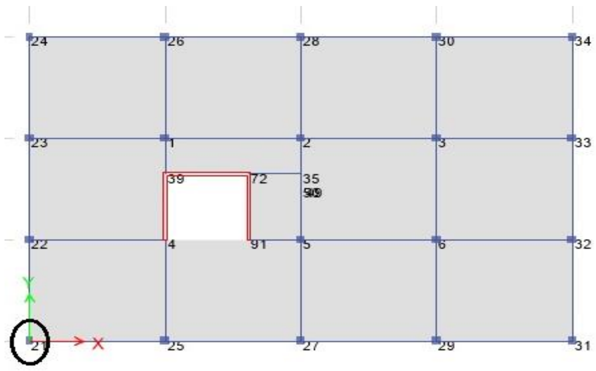

Figure 7: Location of maximum point displacement in X direction for model M1

ISSN: 2233-7857 IJFGCN
Copyright ⓒ2020 SERSC

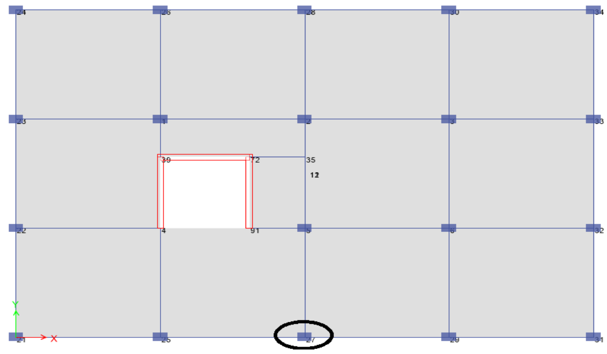

Figure 8: Location of maximum point displacement in X direction for model M2

The maximum point displacement in Y direction for model M1 with floating columns was found to be 81.8mm and that for model M2 without floating columns was found to be 76.2mm. Hence, it is inferred that the influence of floating columns in these models has resulted in an increase in maximum point displacement by about 7%. The location of maximum point displacement in X direction for models M1 and M2 are shown in Figure 9 and Figure 10 respectively.

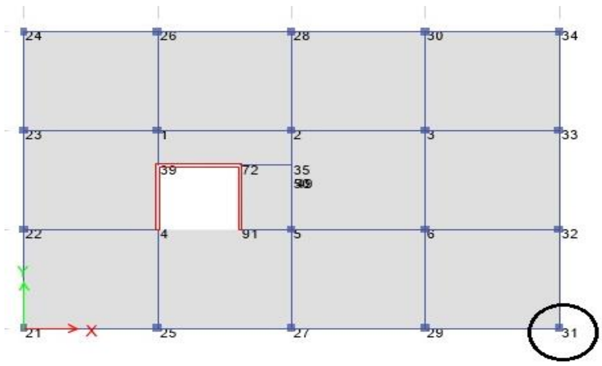

Figure 9: Location of maximum point displacement in Y direction for model M1

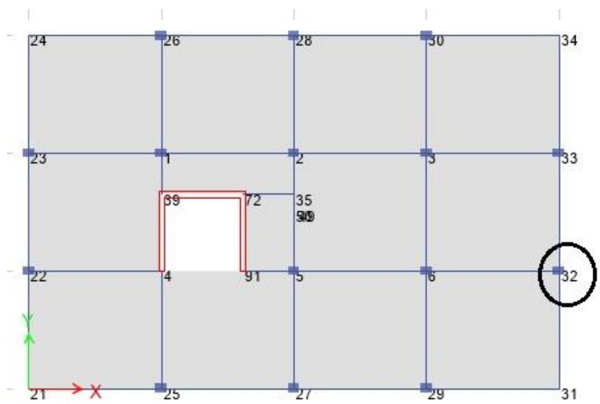

Figure 10: Location of maximum point displacement in Y direction for model M2

The variation of maximum point displacements for structural models M1 and M2 in both X and Y directions is shown in Figure 11.

ISSN: 2233-7857 IJFGCN
Copyright ⓒ2020 SERSC

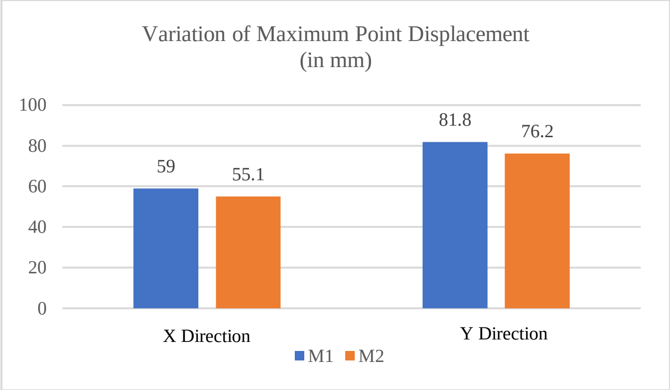

Figure 11: Variation of maximum point displacements

2) Interstorey drift

Interstorey drift is the difference between the diaphragm displacements between two consecutive storeys, it gives the relative displacement of two consecutive storeys with respect to each other.

The maximum interstorey drift in X direction for model M1 with floating columns was found to be 7.1mm and that for model M2 without floating columns was found to be 6.6mm. Hence, it is inferred that the influence of floating columns in these models has resulted in an increase in maximum interstorey drift by about 7%.

The maximum interstorey drift in Y direction for model M1 with floating columns was found to be 9mm and that for model M2 without floating columns was found to be 8.2mm. Hence, it is inferred that the influence of floating columns in these models has resulted in an increase in maximum interstorey drift by about 9%.

The variation of maximum interstorey drift for structural models M1 and M2 in both X and Y directions is shown in Figure 12.

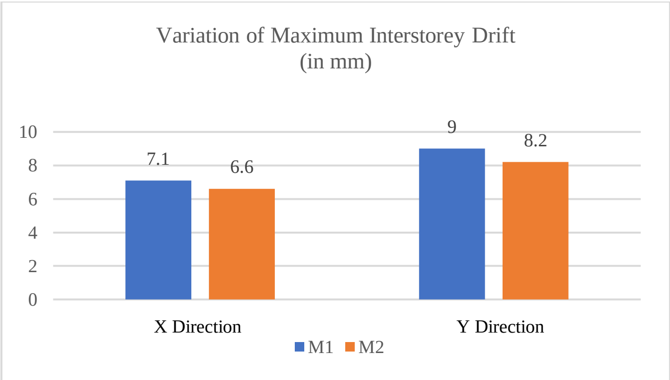

Figure 12: Variation of maximum interstorey drift

3) Base shear

Base shear is an estimate of the maximum lateral force that is expected to be induced due to seismic ground motion at the base of the structure.

The base shear in X direction for the model M1 with floating columns was found to be 600kN, while that for model M2 without floating columns was found to be 524.12kN. Hence it is inferred that the presence of floating columns in model M1 has resulted in increase in base shear by about 13%, in comparison with model M2.

The base shear in Y direction for the model M1 with floating columns was found to be 501.78kN, while that for model M2 without floating columns was found to be 432.11kN. Hence it is inferred that

ISSN: 2233-7857 IJFGCN
Copyright ⓒ2020 SERSC

the presence of floating columns in model M1 has resulted in increase in base shear by about 14%, in comparison with model M2.

The variation of base shear for structural models M1 and M2 in both X and Y directions is shown in Figure 13.

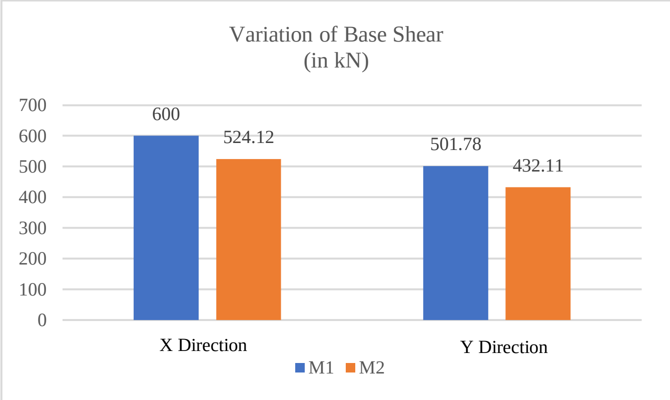

Figure 13: Variation of base shear

The results obtained in terms of maximum point displacements, maximum interstorey drift and base shear for both structural models M1 and M2 in X direction are shown in Table 3.

Table 3: Comparison of results for M1 & M2 in X Direction

Description	**X Direction**		**% variation**
	M1	M2	
Maximum point displacement	59mm	55.1mm	**7%**
Maximum interstorey drift	7.1mm	6.6mm	**7%**
Base shear	600kN	524.12kN	**13%**

The results obtained in terms of maximum point displacements, maximum interstorey drift and base shear for both structural models M1 and M2 in Y direction are shown in Table 4.

Table 3: Comparison of results for M1 & M2 in Y Direction

Description	**Y Direction**		**% variation**
	M1	M2	
Maximum point displacement	81.8mm	76.2mm	**7%**
Maximum interstorey drift	9mm	8.2mm	**9%**
Base shear	501.78kN	432.11kN	**14%**

CONCLUSIONS

The following conclusions are drawn from analyzing the structural models M1 and M2 for seismic performance with respect to the influence of floating columns.

i. It was observed that there is an increase in point displacements and storey displacements in structures having floating columns.
ii. It was observed that there is an increase in interstorey drift in structures having floating columns.

ISSN: 2233-7857 IJFGCN
Copyright ⓒ2020 SERSC

iii. It was also observed that the base shear increases in structures with floating columns in comparison with structures without floating columns.
iv. It is not suggested to construct structures having floating columns in areas prone to higher seismic ground motion.
v. The presence of floating columns in a structure results in poor performance during ground motion.
vi. As the displacements increase in structures with floating columns, the section sizes of structural members require to be increased, resulting in uneconomical sections.

REFERENCES

[1] Awkar J. C. and Lui E. M. (1997), "Seismic Analysis and Response of Multistory Semi-Rigid Frames", Journal of Engineering Structures, Volume 21, Issue 5, Page no: 425-442.
[2] Indian Standard, IS 456-2000, "Plain and Reinforced Concrete-Code of Practice," BIS, New Delhi, India.
[3] Indian Standard, IS 1893-2016 (Part I), "Indian Standard Criteria for Earthquake Resistant Design of Structures", New Delhi, India.
[4] K.V. Sudheer Dr. E. Arunakanthi (2015), "Design and analysis of a high-rise building with and without floating columns". International Journal for Scientific Research & Development, Volume 3, Issue 10, pp: 760-65.
[5] Maison B. F. and Ventura C. E. (1991), "Dynamic Analysis of Thirteen Story Building", Journal of Structural Engineering, Vol. 117, No. 12, Page no: 3783-3803.
[6] Sarita Singal, Er. Ashfi Rahman (2015) "Effect of floatin
g columns on seismic response of multi-storeyed RC framed buildings". International Journal of Research in Engineering and Technology, Volume 4 Issue: 6 pp: 1131-1136.
[7] Sharma R. K, Shelke N. L (2016), "Dynamic Analysis of RCC Frame Structure with floating column", International Journal of Advanced Research in Science, Engineering and Technology, Vol. 3, Issue 6, pp. 2302-2307.

ISSN: 2233-7857 IJFGCN
Copyright ⓒ2020 SERSC