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Study of Building Frames with Floating Columns under Seismic Loading

Agarwal Ajaya[1], Gupta Archana Bohra[2]

Assistant Engineer (Civil), Rajasthan Rajya Vidyut Prasaran Nigam Ltd., Jodhpur, India [1]

Associate Professor, Dept. of Structural Engineering, M.B.M. Engineering College, J.N.V. University, Jodhpur, India [2]

Abstract —*Earthquakes are natural disasters that damage life and property. These disasters cannot be predicted or prevented but structures can be made to resist them. There are points of weakness, which may occur due to irregularities in structures, at which the failure of a structure begins.. Therefore the study of various irregularities in structures becomes important. In this study, three dimensional reinforced concrete (RC) frame models with floating columns have been compared with models with no irregularity. Displacement, base shear, storey drift and bending moment are the parameters considered.*

Keywords*-Seismic behaviour, RC frames, floating columns, displacement, storey drift, base shear, bending moment*

I. INTRODUCTION

Natural disasters cause great destruction to life and property. Earthquake cannot be predicted or prevented but the structures can be made to resist earthquake forces. The damage patterns in reinforced concrete frames during the past earthquakes have been studied in detail. During an earthquake, at the point of weakness, failure of structure starts. This weakness may arise due to discontinuity in mass, stiffness and geometry of structure. The structures which are having this discontinuity are termed as irregular structures. It is a well known fact that structural regularity is an important issue for a good seismic response. Structural regularity is easy to achieve through a careful design; it is still very common that, in reality, different irregularities can occur, which changes the seismic performance of the building. Now days, the need and demand of the new generation and growing population has made the engineers inevitable towards planning of irregular configurations. Architectural demands are generally the cause of such irregularities. Many buildings in the present scenario have irregular configurations both in plan and elevation, which in future may be subjected to earthquakes. That is why, it is important to identify the performance of the structures to withstand against disaster mainly due to earthquake.

Practically, many existing buildings contain irregularity, and some of them have been designed to be irregular to fulfil various functions, e.g. basements created by eliminating central columns for commercial purposes, reduction in the size of beams and columns in the upper stories to fulfil functional requirements, storing heavy mechanical appliances etc. This particular difference in the usage of a specific floor in comparison to adjacent floors results in irregular distribution of mass, stiffness and strength along the building height. In addition to this, many other buildings are accidentally designed irregular due to a variety of reasons such as non-uniformity in construction practices and the material used. However, these irregular structures (designed as per code provisions) generally exhibit poor seismic performance as is shown by the past records.

A. REGULARITIES AND IRREGULARITIES IN STRUCTURES

A building is said to be a regular when the building configurations are almost symmetrical about the axis and it is said to be irregular when it lacks symmetry and discontinuity in geometry, mass or load resisting elements. A regular structure can be envisaged to have uniformly distributed mass, stiffness, strength and structural form. When one or more of these properties is non-uniformly distributed, either individually or in combination with other properties in any direction, the structure is referred to as being irregular.

In the present study, structures with floating columns have been considered. A column is a vertical member starting from foundation level and transferring the load to the ground. There are many projects in which floating columns are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available in the ground floor. These open spaces may be required for assembly hall or parking purpose. The column is a concentrated load on the beam which supports it. The floating column is a vertical member which rest on a beam and doesn't have a foundation. This term also refers to a vertical element which ends at its termination level resting on a beam which is a horizontal member. The floating column act as a point load on the beam and this beam transfers the load to the columns below it. This type of construction does not create any problem under vertical loading conditions. But during an earthquake a clear load path is not available for transferring the lateral forces to the foundation. STAAD analysis package is useful for the analysis of all structures, to get all nodal displacements. STAAD-PRO can solve typical problems like static analysis and seismic analysis. Therefore, in the present study, STAAD PRO V8i has been used for the analysis of all the models.

II. RESEARCHES IN THE PAST

Malaviya P. and Saurav(2014) did a comparative study on the effect of floating columns on the cost analysis of a structure which they designed on STAAD PRO V8i. A 15m x 20m, 2 storey regular structure was considered for the study. The analysis showed that it is not advisable to propose such structures.

Thaarani S. (2016) performed a comparative study on seismic response of multi-storey building with and without floating column. It was concluded that storey displacement increased along the height of the building.

Patil N.A. and Shah R.S. (2016) presented a comparative study of floating and non-floating columns with and without seismic behaviour. The results revealed that the building with non-floating columns was preferable over the building with floating columns during earthquake.

Bandwal N., Pande A. (2014) focused on the various types of irregularities like floating columns at various levels and locations.

Rahman A. (2015), has analysed a multi-storey building with and without floating columns by using response spectrum analysis.

Rohilla I. & Gupta S.M.(2015) have 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.

III. PROBLEM FORMULATION

A standard building having four-storey has been considered. This standard model is named as Model 1.The storey height is taken 3.5 m. The depth of foundation is taken to be 1.5 m. The building has 4×4 m bays. Four models have been developed for this basic model for each of the 4 seismic zones as given in IS 1893:2002. Therefore the 4 models which are corresponding to Model 1 are Model1 Z2, Model1 Z3, Model1 Z4 and Model1 Z5. The elevation, plan and the rendered view of the building under consideration are shown below.

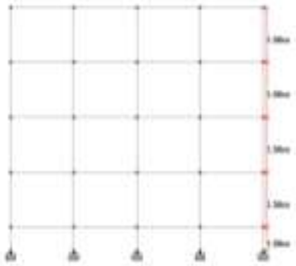

Figure 1 - Model1 elevation

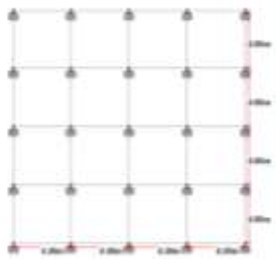

Figure 2 - Model1 plan

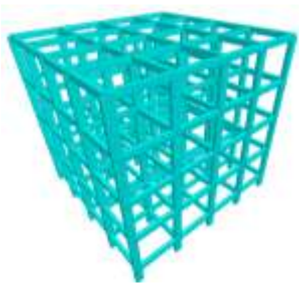

Figure 3 - Model1 rendered view

The following beam size has been taken:-
Beam size – 450 × 300 mm, Column size – 600 × 300 mm
Seismic load definition:-
Seismic load is as per IS 1893-2002. Following are the parameters:-
Zone factor – For each model 4 different zone factors have been taken. For
Zone II – 0.1,Zone III– 0.16,Zone IV– 0.24,Zone V– 0.36
Ordinary moment resisting reinforced concrete frame has been assumed.
Type II Medium soil has been taken.Response reduction factor – 3
Importance factor – 1, Damping ratio – 5%
The following loading pattern has been taken:-

1. EQ +X – earthquake load acting in the positive X- direction
2. EQ –X – earthquake load acting in the negative X-direction
3. EQ +Z – earthquake load acting in the positive Z-direction
4. EQ –Z – earthquake load acting in the negative Z- direction
5. Dead load-Self weight, Floor load = 5 kN/m^2 ,Load bearing wall load = 15 kN/m^2 , Non-load bearing wall load = 7.5 kN/m^2
6. Live load = 3 kN/m^2
7. 1.5DL +1.5 LL
8. 1.2DL + 1.2 LL
9. 1.2DL + 1.2 LL ±1.2EQ ±X
10. 1.2DL + 1.2LL ±1.2EQ ±Z
11. 1.5DL
12. 1.5DL ±1.5EQ ±X
13. 1.5DL ± 1.5EQ ±Z
14. 0.9DL ± 1.5EQ ±X
15. 0.9DL ± 1.5EQ ±Z

Total number of nodes – 150
Total number of beams - 365

In the present study, models with floating columns have been compared with the standard model i.e. Model1. Models with floating columns are named as F1 and F2. This is the third set of models. These models have been developed for all the 4 seismic zones. Therefore the models corresponding to vertical irregularities are Model F1 Z2, Model F1 Z3, Model F1 Z4, Model F1 Z5, Model F2 Z2, Model F2 Z3, Model F2 Z4 and Model F2 Z5.

Models with floating columns have been compared with the basic model i.e. Model 1. The models with floating columns have been shown (rendered views has been given):-

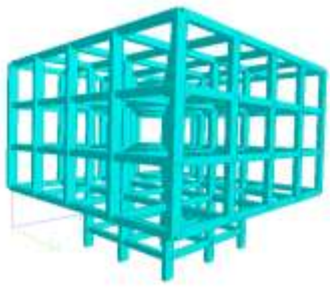

Figure 4 - Model F1 3-D rendered view

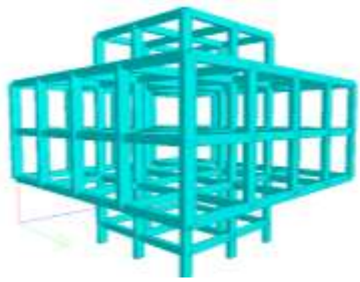

Figure 5 - Model F2 3-D rendered view

Total number of nodes – 118
Total number of beams – 301

Total number of nodes – 102
Total number of beams – 253

In the observation part, the parameters namely displacement, storey drift, base shear and bending moment of Node No.128 and Column No. 76 has been studied. The location of the Node No.128 and Column No. 76 is given below. The values for the above parameters have been tabulated and plotted graphically for the comparative study.

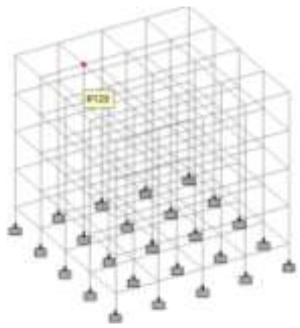

Figure 6 – Location of Node 128 considered

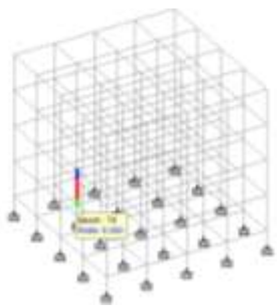

Figure 7 - Location of Column 76 considered

IV. RESULTS AND DISCUSSIONS

As described, one standard structure (for all 4 zones gives 4 models), 2 structures with floating columns(for all 4 zones gives 8 models) have been analysed. All the above mentioned 12 models have been analysed on the software STAAD PRO. These models were analysed for various load cases. In the observations, displacement, base shear and bending moment for two load cases have been listed. The two load cases used are 1) load case 1 in which earthquake load is acting in +X direction and 2) load case 3 in which earthquake load is acting in +Z direction. bserved for all the models, with vertical irregularity, for all the four seismic zones have been tabulated with the bending moment observed for the standard model. After every individual table, all the values have been compared by representing them graphically. For all the models with floating columns, values for displacement, base shear and bending moment have been tabulated along with the standard model. The values for these displacements, base shear and bending moment have also been plotted graphically.

The numerical values of the displacements of the frames having node no. 128 have been given in Table 1. As per IS 456, the allowable lateral displacement is H/500, where H is building height. Here the height of building is 15.5 m. Therefore the allowable lateral displacement is 31mm. According to IS-1893:2002 (part I), maximum limit for storey drift with partial load factor 1.0 is 0.004 times of storey height. Therefore the allowable limit is 14mm.

The values of the displacement for the standard model and models with floating columns have been tabulated below. Graph representing these values is drawn below.

Table 1- Effect of floating columns in building frames on displacement

NODE 128						
	STANDARD MODEL		FLOATING COLUMN IRREGULARITY F1		FLOATING COLUMN IRREGULARITY F2	
ZONE	X(mm)	Z(mm)	X(mm)	Z(mm)	X(mm)	Z(mm)
II	5.699	11.791	13.374	25.954	10.001	19.878
III	9.118	18.866	21.398	41.527	16.001	31.805
IV	13.677	28.299	32.096	62.29	24.002	47.707
V	20.515	42.449	48.145	93.436	36.003	71.561

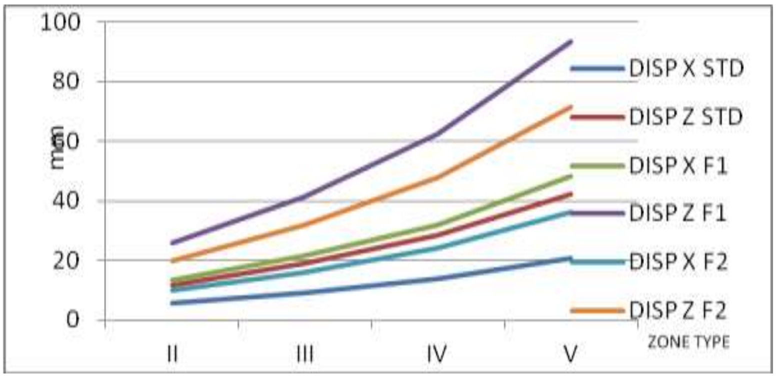

Figure 8- Effect of floating columns in building frames on displacement

The values of the base shear for the standard model and models with floating columns of the frame having Column No. 76 have been tabulated below. Graph representing these values is drawn below.

Table 2- Effect of floating columns in building frames on base shear

COLUMN 76						
	STANDARD MODEL		FLOATING COLUMN IRREGULARITY F1		FLOATING COLUMN IRREGULARITY F2	
ZONE	X(kN)	Z(kN)	X(kN)	Z(kN)	X(kN)	Z(kN)
II	15.555	17.485	32.123	36.093	26.316	29.568
III	24.888	27.977	51.397	57.748	42.106	47.309
IV	37.332	41.965	77.096	86.622	63.158	70.963
V	55.998	62.947	115.644	129.934	94.738	106.445

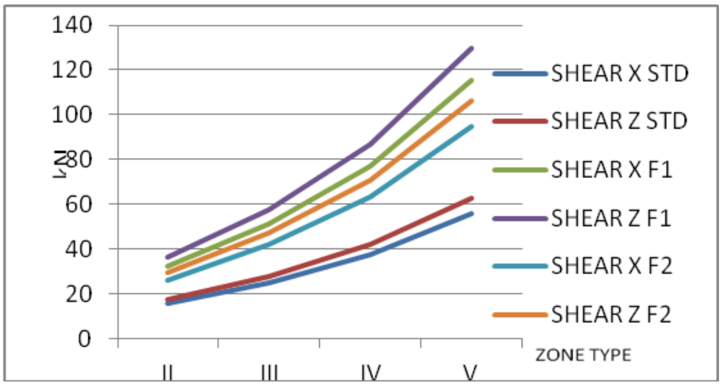

Figure 9- Effect of floating columns in building frames on base shear

The values of the bending moment for the standard model and models with floating columns of the frame having Column No. 76 have been tabulated below. Graph representing these values is drawn below.

Table 3- Effect of floating columns in building frames on bending moment

COLUMN 76						
	STANDARD MODEL		FLOATING COLUMN IRREGULARITY F1		FLOATING COLUMN IRREGULARITY F2	
ZONE	X(kN-m)	Z(kN-m)	X(kN-m)	Z(kN-m)	X(kN-m)	Z(kN-m)
II	31.937	31.563	66.662	65.344	54.358	53.611
III	51.099	50.501	106.659	104.55	86.973	85.778
IV	76.648	75.752	159.988	156.825	130.46	128.668
V	114.972	113.628	239.983	235.238	195.69	193.001

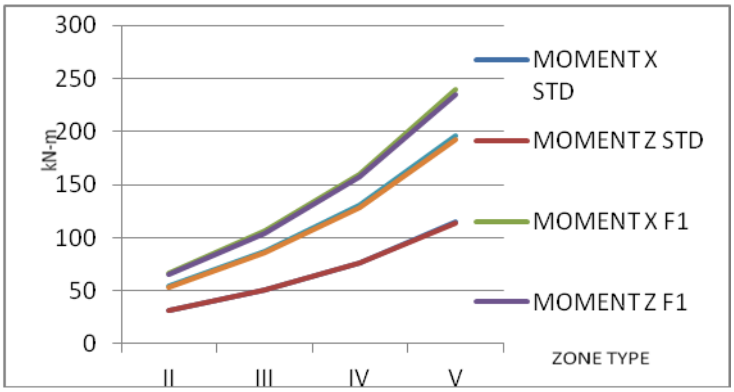

Figure 01- Effect of floating columns in building frames on bending moment

V. CONCLUSIONS

In this study, the effects of effect of floating columns have been compared with standard symmetrical model of a building frame under seismic coefficient method of earthquake loading. On the basis of the observations based on results and discussions of the above said models, following conclusions can be made:-

A. LATERAL DISPLACEMENT

- It was observed that the displacement increased by 134.67% in all the 4 zones in Model F1 in X direction as compared to the standard model. The displacement increased by 75.48% in Model F2.
- There was an increase of 120.11% in displacement in Z direction for Model F1 and an increase of 68.58% in Model F2 in Z direction was observed.
- In the standard model, Model F1 and Model F2, when load is applied along both X and Z directions, the lateral displacement exceed the allowable limit of 31mm.

B. STOREY DRIFT

- When load is applied along X direction, the storey drift increases by 162.3% in Model F1 as compared to standard model. In case of Model F2, when load is applied along X direction, the storey drift is 38.6% more than that of the standard model.
- When load is applied along Z direction, an increase of 140.8% is observed in Model F1. In Model F2, when load is applied along Z direction, an increase of 27.3% is observed as compared to standard model.
- The storey drift, when load is applied along Z direction, is 72.5% more than the storey drift observed, when load is applied along X direction for both models F1and F2.
- Maximum storey drift is observed at the bottom storey. The storey drift at the bottom floor in Model F1, when load is applied along X direction, is 50% more than the storey drift at the top floor and when load is

applied along Z direction, the storey drift at the bottom floor is 103% more than the storey drift at the top floor.

- The storey drift at the bottom floor in Model F2, when load is applied along X direction, is 131% more than the storey drift at the top floor and when load is applied along Z direction, the storey drift at the bottom floor is 215.7% more than the storey drift at the top floor.
- In both the models F1 and F2, when load is applied along Z direction, the storey drift exceeds the allowable value of 14mm.
- The storey drift becomes quite high with the introduction of floating columns.

C. BASE SHEAR

- It was observed that the base shear increased by 106.5% in all the 4 zones in Model F1 in X direction. Along the X direction, an increase of 69.180% in base shear was observed in Model F2 in all four zones.
- There was an increase of 106.42% in base shear in Z direction for Model F1. An increase of 69.10% in base shear in Model F2 along Z direction was observed.
- The base shear increases with the introduction of floating columns.

D. BENDING MOMENT

- It was observed that the bending moment increased by 108.72% in all the 4 zones in Model F1 along X direction. An increase of 70.20% in bending moment in Model F2 was observed along X direction.
- There was an increase of 107% in bending moment along Z direction for Model F1. An increase of 69.85% in Model F2 along Z direction was observed.
- The bending moment increases with the introduction of floating columns.

VI. REFERENCES

[1] Bandwal N., Pande A., “To Study Seismic Behaviour of RC Building with Floating Columns’’, International journal of Scientific Engineering and Technology and Research, ISSN 2319-8885 Vol.03, Issue.08, May-2014, PP 1593-159, 2014.
[2] IS: 1893(Part-1):, “Criteria for Earthquake Resistant Design of Structures”, 2002
[3] IS: 456: 2000, “Plain And Reinforced Concrete-Code of Practice”.
[4] Malaviya P. and Saurav, “Comparative Study Of Effect Of Floating Columns On The Cost Analysis Of a Structure Designed On STADD PRO V8i”, International Journal of Scientific & Engineering Research, Volume 5, Issue 5, May, 2014.
[5] Patil N.A. and Shah R.S., “Comparative Study of Floating and Non-Floating Columns With and Without Seismic Behaviour”, International Conference on Science and Technology for Sustainable Development (ICSTSD), 2016.
[6] Rahman A., “Effect of Floating Columns on Seismic Response of Multi-Storey RC Framed Buildings”, International Journal of Engineering Research & Technology (IJERT) eISSN: 2278-0181, Vol. 4, Issue 06, June, 2015.
[7] Rohilla I., Gupta S.M., “Seismic Response Of Multi-Storey Irregular Building With Floating Column”, IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163, 2015
[8] Commercial Software on structural analysis and design STAAD. PRO V8i.
[9] Thaarani S., “Comparative Seismic Response of Multistorey Building With and Without Floating Column”, International Conference on current Research in Engineering Science and Technology (ICCREST-2016).
[10] Tso, W.K. and Bozorgnia,Y.,”Effective Eccentricity for Inelastic Seismic Response of Buildings”, Earthquake Engineering And Structural Dynamics, Volume.14, No.3, pp.413-427, 1986.

