© June 2025 | IJIRT | Volume 12 Issue 1 | ISSN: 2349-6002

Dynamic Analysis of Buildings with Floating Columns

Mohd Faiz Ahmed[1], Mr. R Narender Kumar[2]
[1]*Student, ME, Department of Civil Engineering with Specialization in Construction Management*
[2]*Associate Professor, Department of Civil Engineering, Lords Institute of Engineering and Technology, Himayat Sagar, Hyderabad, India*

***Abstract*—In Present era, Reinforced Concrete buildings with floating column is a typical feature in the modern multistory construction in India. Such features are highly importance of explicitly recognizing the presence of the floating column in the analysis of building. Past earthquake experiences demonstrate the fact that buildings with rectangular plan or box type buildings perform well than buildings with irregular shaped plans. During Bhuj (2001) earthquake, majority of the buildings got damaged were not designed for seismic loading and most of the buildings were not engineered. It also implicates that irregular buildings are undesirable as they do not possess sufficient seismic resistance. Hence, it is necessary that all buildings must be designed for seismic loading and irregular configuration must be avoided. However, irregular buildings are inevitable in few circumstances and hence, more attention has to be given in understanding their behaviour.This work investigates the comparative study on the dynamic analysis of multistory buildings with floating columns at various positions is evaluated by response spectrum analysis (as per the recommendation of IS1893:2002) with the help of ETABS 2017 software. The main parameters evaluated in this study are base shear, torsional moments, overturning moments, storey displacements, deflections and storey drifts. A total of 3 models and a building without floating columns are considered and compared with each other according to the position of floating columns and percentage variation with regular building is done. For each structural system 140mm thickness of the slab, square columns of 600mm size, square beams of 300mm size and varying thickness of drops of 2000mm size are considered. In each model G+4 stories are considered.It was observed that the torsional moments, overturning moments and base shear increases at central column float position as more load is concentrated at centre of the building with respect to regular building. By increasing the thickness of column drops to flat slab, storey displacements decrease as overall stiffness of building increases whereas drift values follow a non-linear path along storey height with maximum value laying the third storey. It was also observed that the change in the deflections is very less with respect to regular building at different positions in that storey where floating columns are located and these are under permissible limits.**

***Index Terms*—Flat slab, floating column, response spectrum method, seismic loading.**

I. LITERATURE REVIEW

Erberik, M. A. and Elnashai, A. S., (2004) focused on the study of earthquake records compatible with the design spectrum selected to represent the variability in ground motion. Inelastic response-history analysis was used to analyze the random sample of structures subjected to the suite of records scaled in terms of displacement spectral ordinates, whilst monitoring four performance limit states. The fragility curves developed from this study were compared with the fragility curves derived for moment-resisting RC frames. The study concluded that earthquake losses for flat-slab structures are in the same range as for moment-resisting frames. Differences, however, exist. The study also showed that the differences were justifiable in terms of structural response characteristics of the two structural forms.

Apostolska R P, Necevska-Cvetanovska G S, Cvetanovska J P and Mircic N (2008) States that, flat-slab building structures possesses major advantages over traditional slab-beam-column structures because of the free design of space, shorter construction time, architectural –functional and economical aspects. Because of the absence of deep beams and shear walls, flat-slab structural system is significantly more flexible for lateral loads then traditional RC frame system and that make the system more vulnerable under seismic events. The results from the analysis for few types of construction systems which is presented in the paper show that flat slab system with certain modifications (design of beam in the perimeter of the building and/or RC walls) can achieve rational factor of behaviour considering EC8 and can be consider as a system with acceptable seismic risk. Modifications with additional construction elements improve small bearing capacity of the system and Increase strength and stiffness, improving seismic behaviour of flat-slab construction system. Selected results from the analysis are presented in the paper.

Bothara S. D. and Varghese V. (2012) studied the comparative effect of the seismic performance of Flat Slab and Grid Slab system consisting of beams spaced at regular intervals in perpendicular directions, monolithic with slab. In their work, the authors performed the dynamic analysis of a 9-Storey building with flat slab and grid slab using Response Spectrum Method and the comparative results are shown in terms of storey drift, shear force and maximum moment. Importance of drops in flat slabs for increasing the shear strength was confirmed. Grid slabs showed lesser drift vis-à-vis flat slabs at higher levels. However, up to four stories, the drift was identical.

Sable, K. S., V. A. Ghodechor and S. B. Khandekar (2012) focused on tall commercial buildings which are primarily a response to the demand by business activities to be as close to each other, and to the city centre as possible, thereby putting intense pressure on the available land space. Structures with a large degree of indeterminacy are superior to the ones with less indeterminacy, because more members are monolithically connected to each other and if yielding takes place in any one of them then a redistribution of forces takes place. Therefore, it is necessary to analyze seismic behavior of building for different heights to see what changes are going to occur if the height of conventional building and flat slab building changes. The paper investigated the comparison of conventional reinforced concrete building system, i.e., slab, beam and column to the flat slab building. The results were compared for different heights of building. The authors concluded that the natural time period increased as the height of building (No. of stories) increased, irrespective of type of building viz. conventional structure, flat slab structure and flat slab with

Analytical Models and Methodologyl

This chapter deals with the methodology adopted for carrying out the dissertation study. The following sections present the geometric properties of the building models. It also gives clear idea of analysis using ETABS 2017 software along with the assumptions in generating models by considering Response Spectrum Analysis.

Building Models used in the Study

Four analytical flat slabs cum conventional slab models namely M1, M2, M5 & M7 were used in the study and their representative of the general buildings usually constructed in India. The plan dimensions and heights were taken so as to satisfy the municipality norms for the buildings. All the models are considered to be Special RC Moment Resisting Frames (SMRF). The live load and super imposed dead load (floor finish) is taken as 4 KN/m2 and 1.5 KN/m2. The specific weight of RCC is 25 KN/m3. The section properties of the structural members were chosen such that the structure fulfilled the safety and serviceability requirements specified in the design codes IS 456:2000 and IS 1893:2002. The zone factor is taken as 0.16 and importance factor is taken as one (1) and soil used is medium type. Table 3.1 list the characteristics of the analytical models which are shown and figure 3 gives the idea of position of floating column at different locations.

Models Description

Model 1: Flat Slab building without floating column.

Model 2: Flat Slab building with centre float column at ground floor level.

Model 5: Flat Slab building with intermediate float column at ground floor level.

Model 7: Flat Slab building with corner float column at ground floor level.

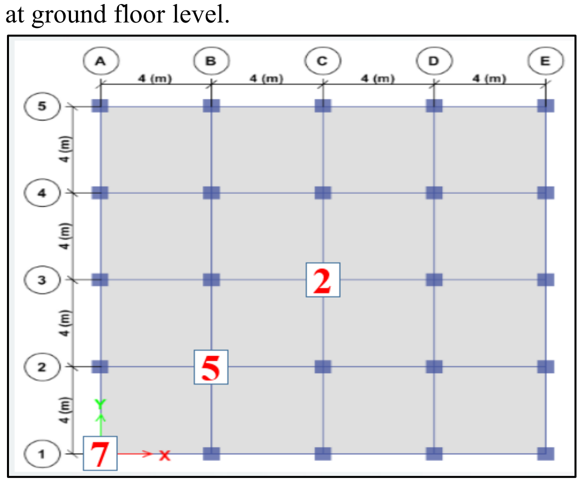


Figure 3: Floating Column Positions

Table 3.1: Characteristics of analytical building models

Property/Models	M1	M2	M5	M7
Plan Dimensions (m)	16 X 16			
Span of Slab (m)	4			
Thickness of Slab (mm)	140			
Size of Drop (m)	2 X 2			
Thickness of Drop (mm)	160	160,190	160,200,280	160,260
Size of Columns (mm)	600 X 600			
Size of Beams (mm)	300 X 300			
Floor height (m)	3			
Height of Building (m)	15			
Horizontal floor system	Beams and slabs in ground storey and flat slab with drop in top stories			

Figures 3.1 to 3.4 show the plan, elevation and isometric view of building models taken for study.

Response Spectrum Analysis

Response spectra provide a very handy tool for engineers to quantify the demands of earthquake ground motion on the capacity of buildings to resist earthquakes. Data on past earthquake ground motion is generally in the form of time-history recordings obtained from instruments placed at various sites that activated by sensing the initial ground motion of an earthquake. The amplitudes of motion can be expressed in terms of acceleration, velocity and displacement. The first data reported from an earthquake record is generally the peak ground acceleration (PGA) which expresses the tip of the maximum spike of the acceleration ground motion. To determine the dynamic response of a structure, dynamic equilibrium equation of the structure must be solved for each time step of the ground motion record using the solution of the previous time step as the initial conditions. The dynamic equilibrium equation is given as:

$P(t) = Mn\, u''(t) + Cn\, u'(t) + Kn\, u(t)$

Modal Superposition

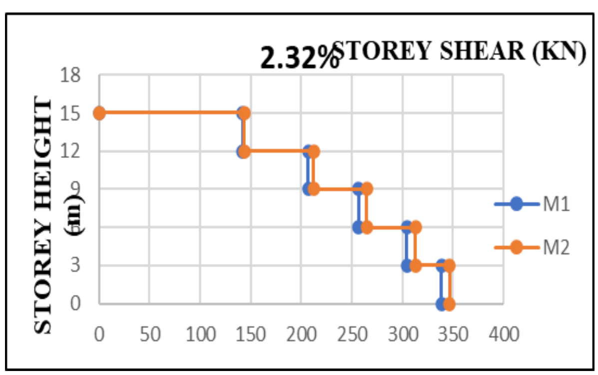
The concept of modal superposition derives from the idea that each natural mode of vibration of the structure, of which there are exactly n, can be treated as an independent linear single-degree-of-freedom (SDOF) system; each modal SDOF system has its own pattern of deformation, its own natural period and its own viscous damping. As a result, the dynamic equilibrium equation can be solved independently for each mode and combined to determine the total response. Since modes with the lowest natural frequencies contribute more significantly

II. RESULTS AND DISCUSSIONS

Flat Slab Building with and Without Floating Columns

Comparison Of Storey Shear Of G+4 Floating Column Building on Different Models

Storey Height (m)	Storey Shear (KN)			
	Model 1	Model 2	Model 5	Model 7
15	0	0	0	0
15	141.777	143.655	140.692	140.562
12	141.777	143.655	140.692	140.562
12	206.625	212.408	207.655	205.510
9	206.625	212.408	207.655	205.510
9	256.808	264.849	258.785	255.461
6	256.808	264.849	258.785	255.461
6	304.363	312.639	305.634	302.567
3	304.363	312.639	305.634	302.567
3	338.731	346.611	339.326	336.762
0	338.731	346.611	339.326	336.762



4.1: Comparison Of Storey Shear Of G+4 Floating Column Building On Different Models Under Seismic Load.

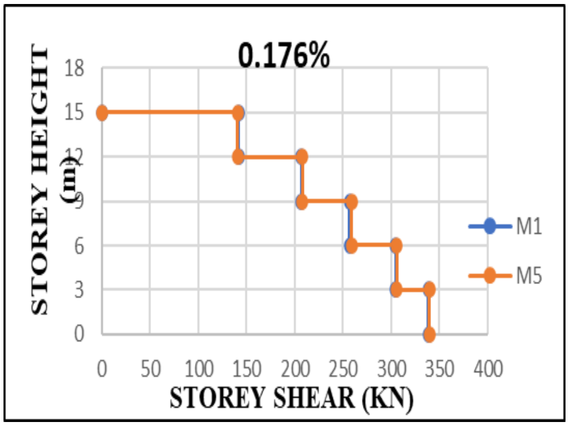


Figure 4.2: Comparison Of Storey Shear Of G+4 Floating Column BuildingAt Position B-2 Under Seismic Load

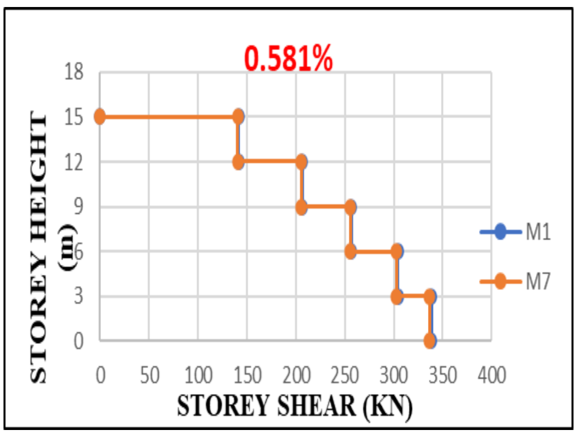


Figure 4.3: Comparison Of Storey Shear Of G+4 Floating Column BuildingAt Position A-1 Under Seismic Load.

4.2.2 Comparison of Torsional Moments Of G+4 Floating Column Building on Different Models

Table 4.2: Comparison of Torsional Moments Of G+4 Floating Column Building on Different Models Under Seismic Load.

Models	M1	M2	M5	M7
Torsional Moments (kN-m)	2709.672	2772.931	2805.343	2809.822

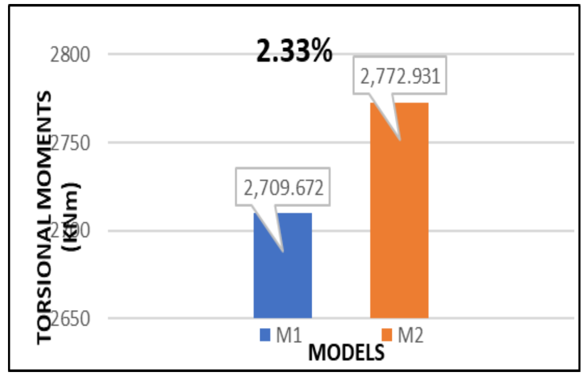


Figure 4.4: Comparison of Torsional Moments Of G+4 Floating Column Building At

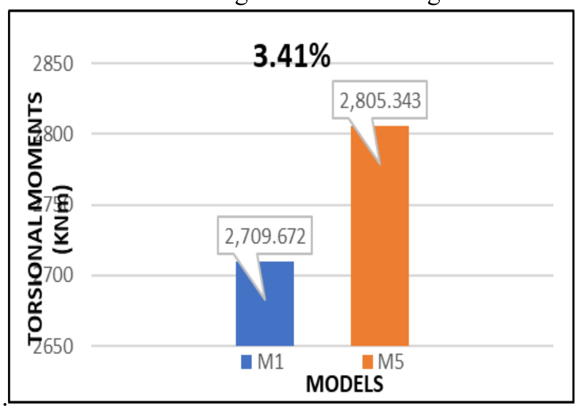


Figure 4.5: Comparison of Torsional Moments Of G+4 Floating Column Building At Position B-2 Under Seismic Load.

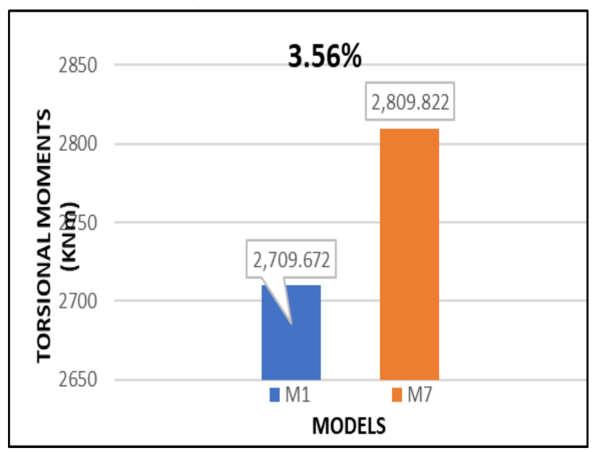


Figure 4.6: Comparison of Torsional Moments Of G+4 Floating Column Building at Position A-1 Under Seismic Load.

Comparison Of Storey Displacement Of G+4 Floating Column Building on Different Models

Table 4.3: Comparison Of Storey Displacement Of G+4 Floating Column Building on Different Models Under Seismic Load.

Storeys/Models	M1	M2	M5	M7
5	8.539	8.324	8.082	8.555
4	6.536	6.425	6.289	6.557
3	4.378	4.347	4.323	4.4
2	2.276	2.291	2.323	2.294
1	0.6682	0.6853	0.7071	0.6912
Base(0)	0	0	0	0

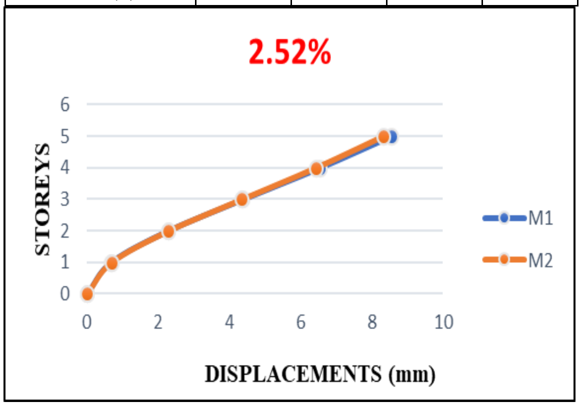


Figure 4.7: Comparison Of Storey Displacement Of G+4 FloatingColumn Building At Position C-3 Under Seismic Load.

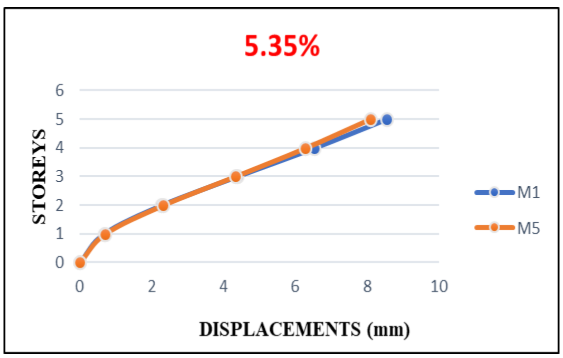


Figure 4.8: Comparison Of Storey Displacement Of G+4 FloatingColumn Building At Position B-2 Under Seismic Load.

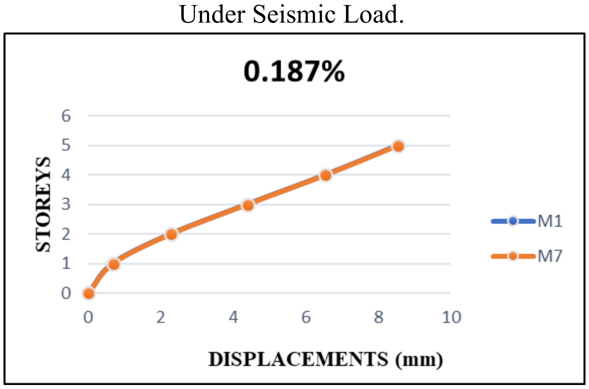


Figure 4.9: Comparison Of Storey Displacement Of G+4 Floating Column Building At Position A-1 Under Seismic Load.

Comparison Of Storey Drift Of G+4 Floating Column Building On Different Models

Table 4.5**:** Comparison Of Storey Drift Of G+4 Floating Column BuildingOn Different Models Under Seismic Load.

Storeys/Models	M1	M2	M5	M7
5	0.00068	0.00064	0.00063	0.00068
4	0.00073	0.00070	0.00068	0.00073
3	0.00070	0.00069	0.00067	0.00070
2	0.00053	0.00053	0.00053	0.00054
1	0.00022	0.00022	0.00023	0.00023
Base(0)	0	0	0	0

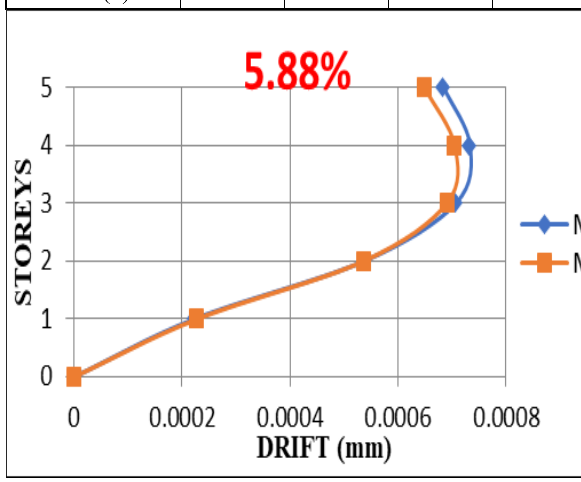


Figure 4.13: Comparison Of Storey Drift Of G+4 Floating Column Building At Position C-3 Under Seismic Load.

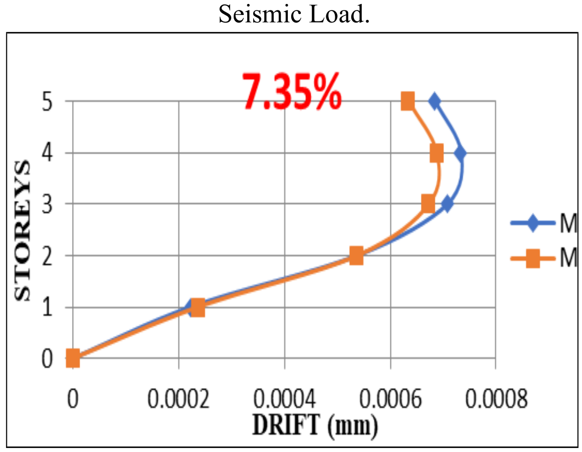


Figure 4.14: Comparison Of Storey Drift Of G+4 Floating Column Building at Position B-2 Under Seismic Load.

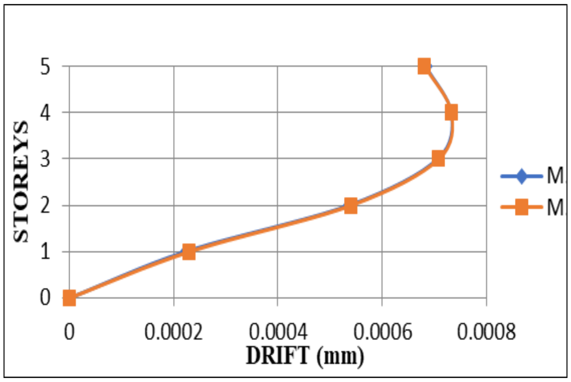


Figure 4.15: Comparison Of Storey Drift Of G+4 Floating Column Building at Position A-1 Under Seismic Load.

Comparison of Deflections Under Floating Column on Different Models

Table 4.6: Comparison of Deflections Under Floating Column on Different Models Under Seismic Load.

Models	M1	M2	M5	M7
Deflections(mm)(DL+LL)	2.138	6.222	5.581	7.896

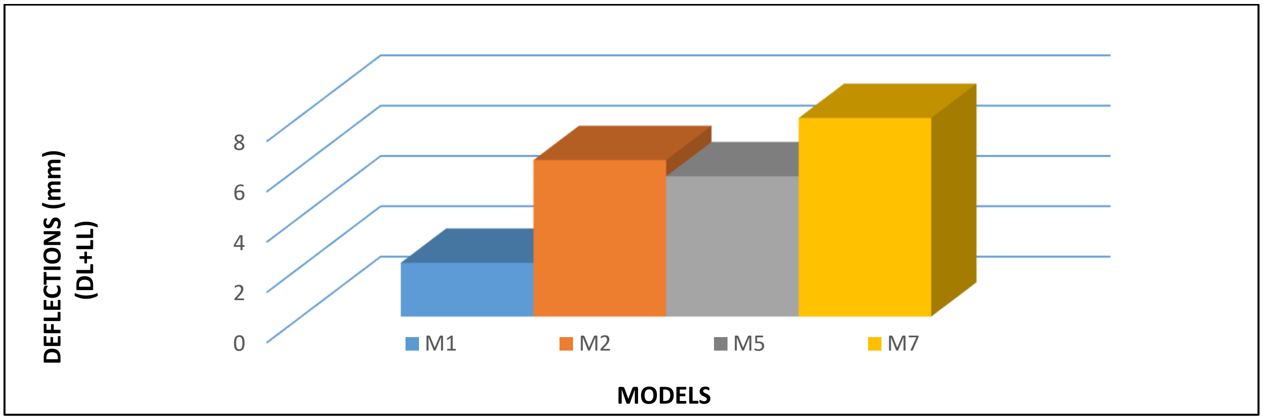


Figure 4.16: Comparison of Deflections Under Floating Column on DifferentModels Under Seismic Load.

Comparison of Volume of Concrete and Area of Steel of G+4 Floating Column Building With Respect To G+4 Regular Building

Models	Area of steel (mm^2)					Volume of Concrete (mm^3)		
	Columns	Beams		Drops		Drops	Columns	Beams
		Top	Bottom	Top	Bottom			
Model 1	360000	15460	10228	4166	1629	4.1E+10	1.3500E+11	1.44E+10
Model 2	357120	20012	13744	5391	2490	4.29E+10	1.3392E+11	1.44E+10
Model 5	357120	20076	13162	7434	5654	4.42E+10	1.3392E+11	1.44E+10
Model 7	357120	19038	12668	4947	9648	4.26E+10	1.3392E+11	1.44E+10

Table 4.7: Comparison of Percentage Change of Concrete And Steel of G+4 Floating Column Building With Respect To G+4 Regular Building

Elements	Materials		M 1&2	M 1&5	M 1&7
Beams	Concrete		-	-	-
	Steel	Top	22.746	22.992	18.794
		Bottom	25.582	22.291	19.261
Columns	Concrete		0.806	0.806	0.806
	Steel		0.806	0.806	0.806
Drops	Concrete		4.428	7.239	3.756
	Steel	Top	22.723	43.960	15.787
		Bottom	34.578	71.188	83.116

Table 4.8: Comparison of Percentage Change Of Concrete and Steel of G+4 Floating Column Building with Respect To G+4 Regular Building Under Seismic Load

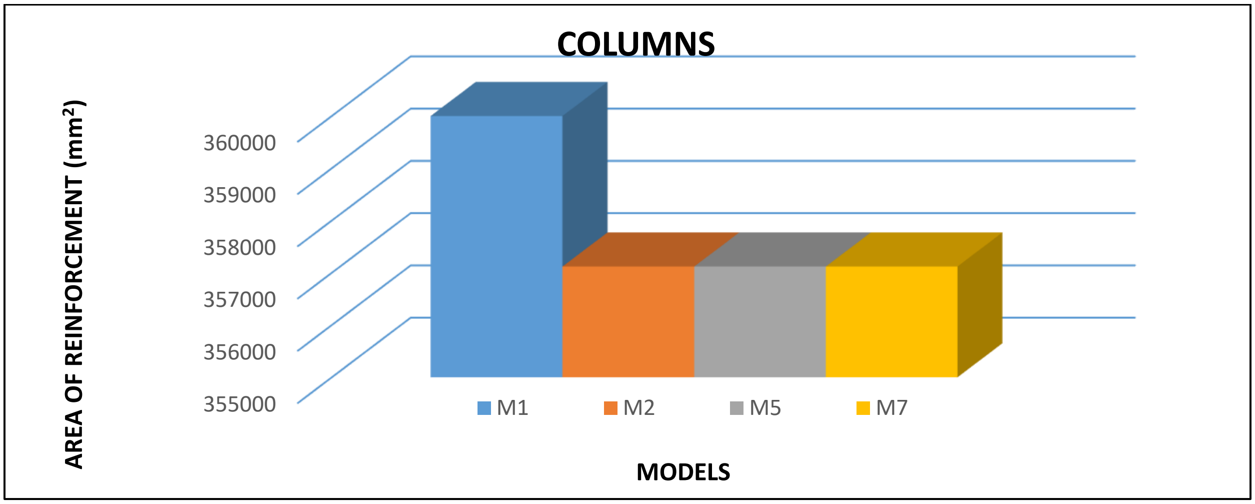


Figure 4.17: Comparison of Columns Reinforcement Under Floating Column On Different Models Under Seismic Load.

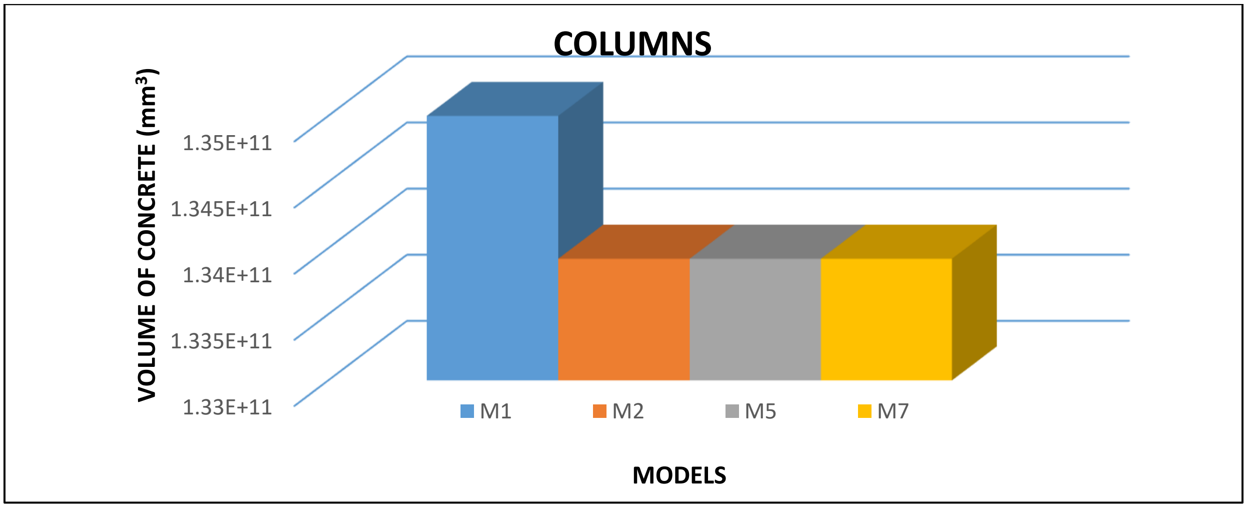


Figure 4.18: Comparison of Volume of Concrete (Columns) Under FloatingColumn OnDifferent Models Under Seismic Load

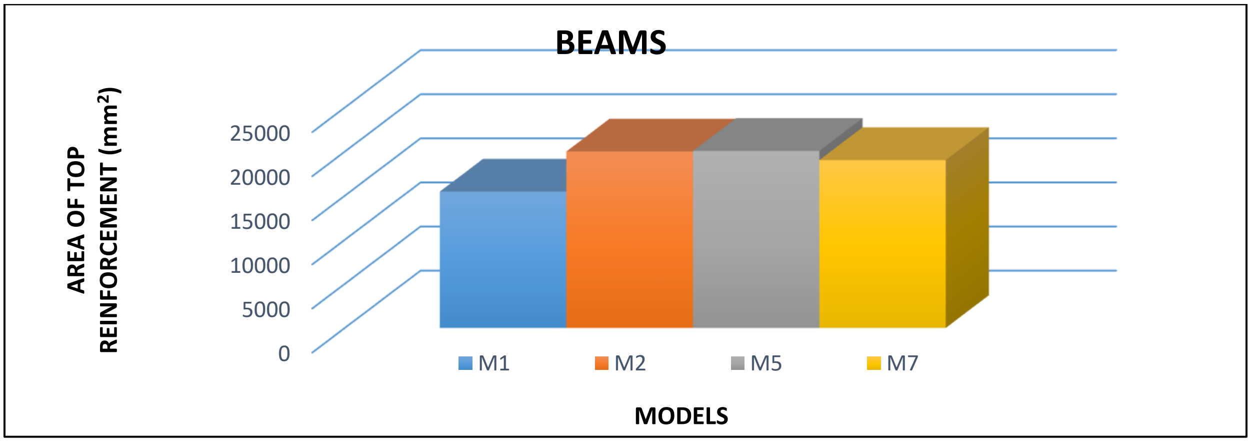


Figure 4.19: Comparison of Beams Reinforcement (Top) Under FloatingColumn OnDifferent Models Under Seismic Load

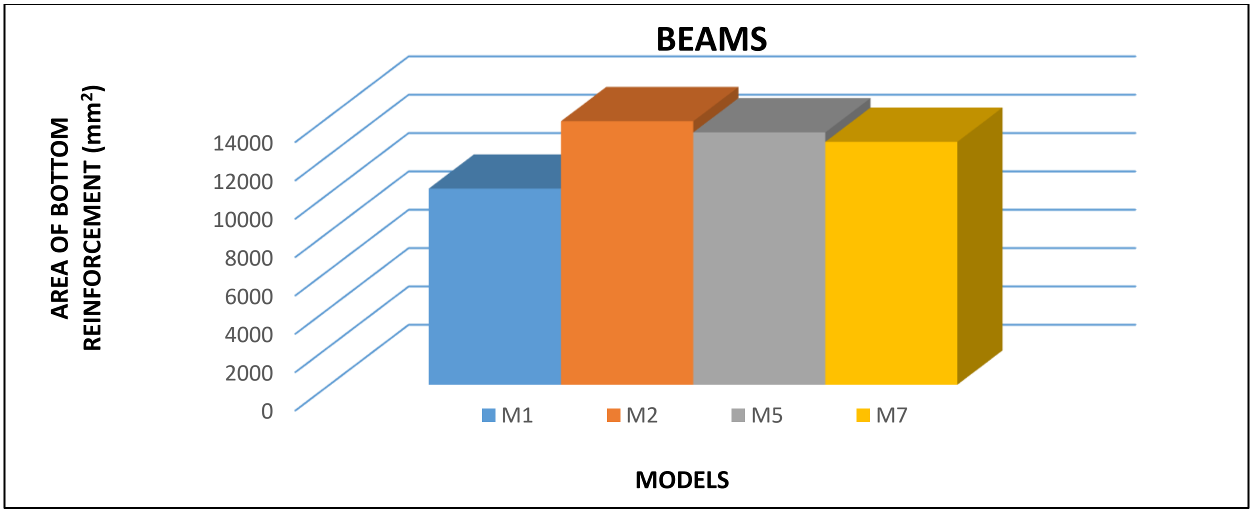


Figure 4.20: Comparison of Beams Reinforcement (Bottom) Under Floating Column OnDifferent Models Under Seismic Load.

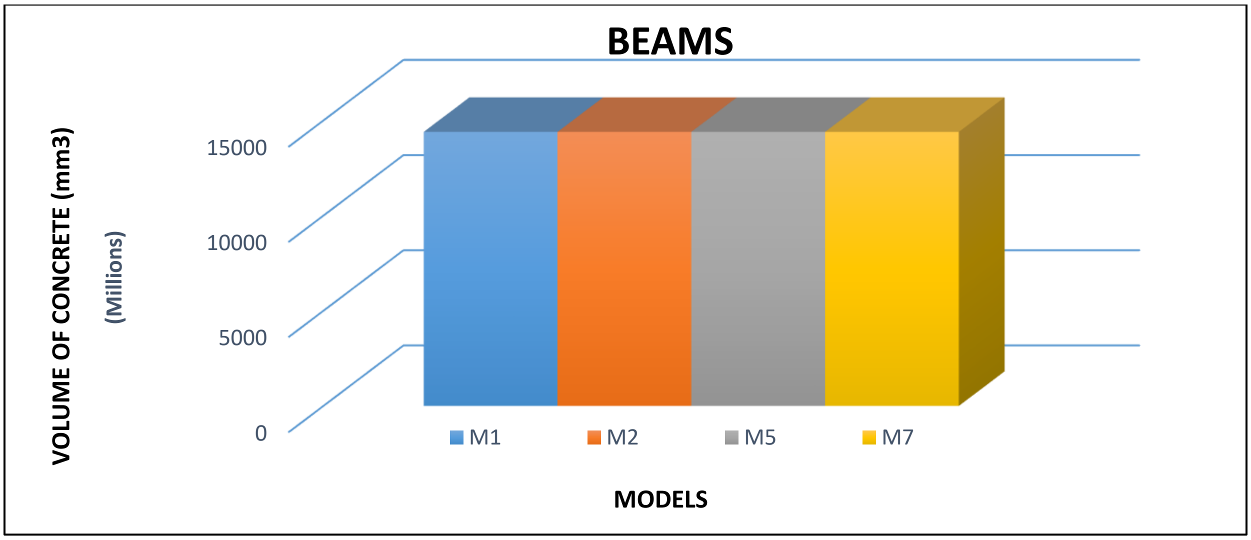


Figure 4.21: Comparison of Volume of Concrete (Beams) Under Floating Column OnDifferent Models Under Seismic Load

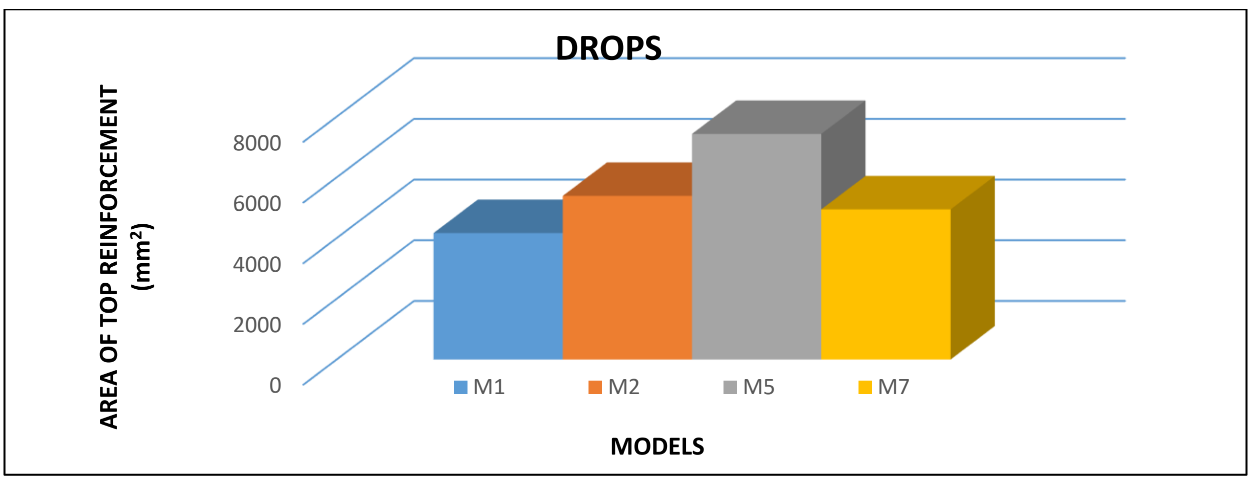


Figure 4.22: Comparison of Drops Reinforcement (Top) Under Floating Column OnDifferent Models Under Seismic Load.

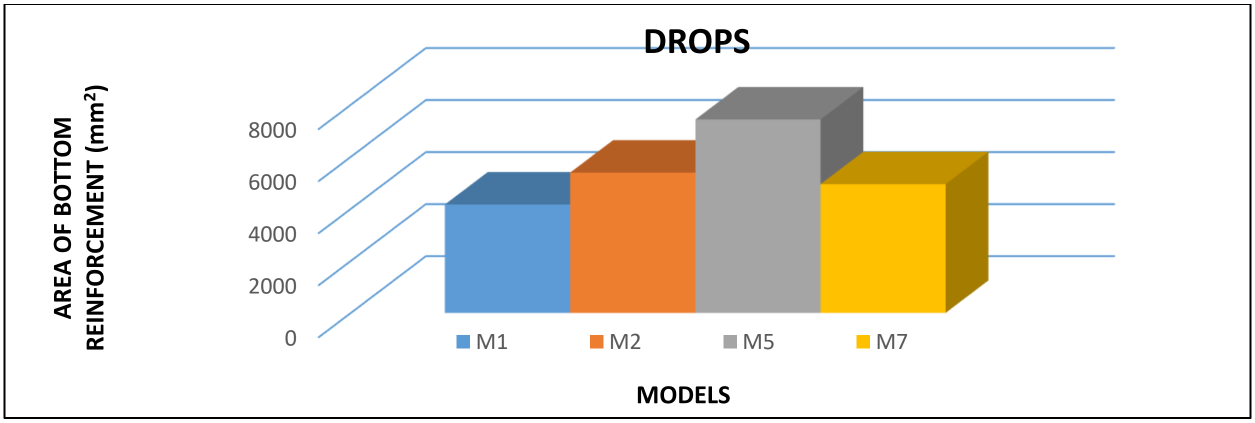


Figure 4.23: Comparison of Drops Reinforcement (Bottom) Under Floating Column OnDifferent Models Under Seismic Load

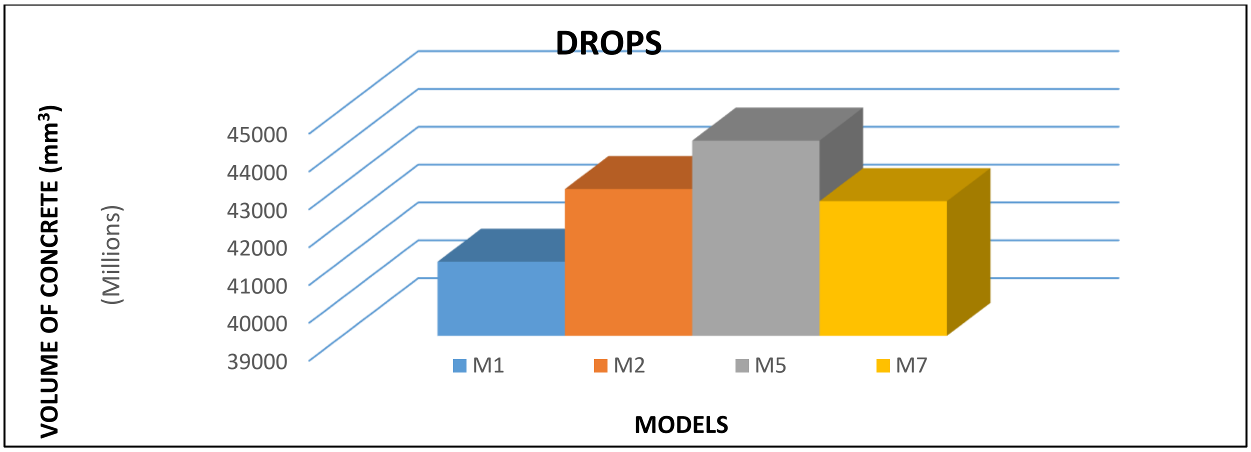


Figure 4.24: Comparison of Volume of Concrete (Drops) Under Floating Column OnDifferent Models Under Seismic Load.

III. CONCLUSIONS

Within the scope of present work, following conclusions are drafted:

Under Seismic Loading

- By increasing the thickness of column drops to flat slab, storey displacements decrease from 2% to 6% as overall stiffness of building increases.
- For all the cases considered, drift values reduce by 6% to 7% and follows a non-linear path along storey height with maximum value laying the fourth storey.
- The absolute maximum base shear occurs in the central column float position of about 2%more due to maximum load carried by the central column and decreases at corner column float position of about 0.6% as less load carried by it.
- It was observed that deflections increase from 62% to 73% with respect to regular building at different positions in that storey where floating columns are located and these are under permissible limits.
- Maximum torsional moments occur at central column float position as shear stress is more at centre of building which increases by 2% and decreases at intermediate and corner columns float position as less shear is carried by them of about 2% to 4%.
- Due to load variations, Overturning moment increases by 3% at central column float position and reducing to0.5% at corner columns float positions with respect to regular building.

Hence from the above conclusions, it is advisable to avoid floating columns at centre of buildings especially in seismic zone areas.

- In Columns of all the models, there will be only 0.806% decrease in volume of concrete as well as in area of reinforcement with respect to regular building i.e., without float as one column is removed from each model.

- In Beams, top reinforcement increases from18% to 23%whereas bottom reinforcement increases from 19% to 26% to resist shear in beams.
- No change in volume of concrete as all the beams size remains unchanged.
- In Drops, top reinforcement increases from 15% to 44% whereas bottom reinforcement increases from 34% to 84% to resist punching shear due to the effect of float.

Finally, it is concluded that the flat slab floating column building leads to the increase in thickness of the drops in the structure, to increase the stiffness and for the earthquake resistant design of the building which results in significant variations of the responses in the structure.

REFERENCES

[1] A.P. Mundada, S.G. Sawdatkar (2014). "*Comparative seismic analysis of multistory building with and without floating column*", IEEE Trans. Power System, vol. 19, no. 1, pp. 356–365.

[2] Apostolska R P, Necevska-Cvetanovska G S, Cvetanovska J P and Mircic N (2008). "Seismic performance of flat-slab building structural systems", *The 14th World Conference on Earthquake Engineering,* October 12-17, Beijing, China.

[3] Badgire Udhav S., Shaikh A.N., Maske Ravi G. (2015). "Analysis of Multistorey Building with Floating Column", *International Journal of Engineering Research*, (ISSN: 2319-6890), Volume No.4, Issue No.9, pp: 475-478.

[4] Basavaraj H. S, Rashmi B. A (2015). "Seismic Performance of RC Flat Slab Building Structural Systems", *International Journal of Informative and Futuristic Research (IJIFR)*, Vol. 2, Issue 9, May 2015, ISSN: 2347-1697, pp. 3069-3084.

[5] BIS (Bureau of Indian Standards). (2002). "Criteria for Earthquake Resistant Design of Structures, Part 1 – General Provisions and Buildings." *IS 1893:2002 (Part – 1),* New Delhi.