Seismic Analysis of Multi-Storeyed Buildings with Floating Columns-A Comparative Study

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Abstract: In the present study Seismic analysis of G+11 storey buildings without and with floating columns and floating columns having bracings at the perimeter in Zone Ⅳ using ETABS 2016(Version 16.2.1) software. Analysis is done by Response spectrum method for all the models as per IS 1893-Part 1 (2002) codal provision and seismic parameters such as storey displacement, storey drift ratio, storey stiffness, storey shear, time period are compared. All the models shows a similar kind of variations in the storey displacement and different kind of variations in storey drift. Displacement and drift in X-direction are found to be less than Y-direction in all the models. Maximum value of storey displacement and drift ratio is observed in Model M5: Floating columns at 7^{th} and 9^{th} floor in both X and Y directions, least value observed in Model M8: floating columns at 6^{th} and 8^{th} floor and having bracings at the perimeter in X and Y directions. Maximum value of storey stiffness is observed in Model M8, least value observed in Model M5.Storey stiffness values in X-direction is more than the Y-direction and all the models shows different kind of variations. . Maximum value of storey shear is observed in Model M8, least value observed in Model M5. Storey shear values in X-direction is more than the Y-direction, all the models shows similar kind of variations. All the models shows similar kind of variations in the time period. And Model M8 shows minimum time period.

Keywords: earthquake, floating column, storey

I. INTRODUCTION

Generally, earthquakes are caused due to the movement of Earth's tectonic plates. Therefore, earthquakes are most recurrent along the edges of the tectonic plates, where one plate is moving relative to the adjacent plate. The majority of the Earth's volcanic activity also occurs where the plates meet. Most of the earthquakes are associated with volcanoes. Earthquakes directly affect ground shaking and in turn can create Landslides, Tsunamis, and Liquefaction of ground and may also cause damage to structure by way of shaking etc.

The response of buildings to an Earthquake is a function of the nature of foundation soil, material, form, size & mode of construction, duration and characteristics of ground motion. This response depends on the natural period of vibration and damping of the structure. During earthquake, amplitude of vibration generally build up in a few cycles. The effects of an earthquake are terrible and shocking. Various building like, Hospitals, Schools, etc, are damaged due to it.

1.1 Floating Column

A column is supposed to be a vertical member beginning from foundation level and transferring the load to the ground. The word-floating column is a vertical element, which at its lower level rests on a beam, which is a horizontal member. The beams in turn transfer the load to other columns below it. Due to discontinuity in the load path results poor performance of the structure. There are several projects in which floating column is adopted, so that more space available in the floor. These open space can be used as assembly hall, party hall etc, which has been shown in figure1

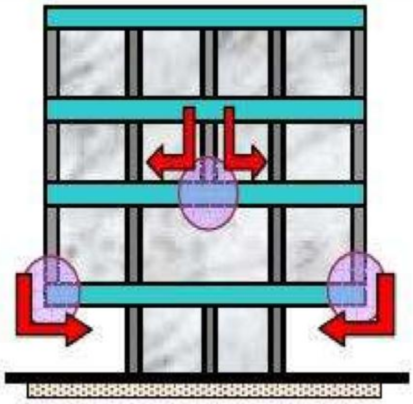


Figure 1. Floating column

I.2 RESPONSE SPECTRUM ANALYSIS:

It is the linear dynamic analysis. In the response spectrum method, the highest response of a structure during an earthquake is obtained directly from the earthquake response spectrum. In this method, the response of a Multi-Degree-of Freedom (MDOF) system is expressed as the superposition of modal response being determined from the spectral analysis of Single-Degree-of Freedom (SDOF) system, which is then combined to compute the total response. Modal analysis leads to the response history of structure to a specified ground motion.

II. OBJECTIVES

1. To develop different RC building models without and with floating columns, and with floating columns having bracings at the perimeter using E-TABS Software.
2. Application of loads and all necessary input data for analysis.
3. To carry out Response spectrum analysis as per IS1893-2002 for the developed RC building models.
4. To obtain different seismic parameters viz. storey displacement, storey drift ratio, storey shear, storey stiffness and time-period.
5. Comparing the results of RC building without and with floating columns, and with floating columns having bracings at the perimeter for all the developed models.

III. METHODOLOGY

To achieve the stated objectives, the following methodology has been carried out in the present study,

a. Development of RC building models:

RC building without and with floating columns, with floating columns having bracings at the perimeter are modelled using ETABS 2016 software as per IS 875-Part 1 (1987) for dead load and live load as per IS875-Part 2(1987).

b. Seismic analysis of developed RC building models:

Response spectrum analysis for seismic Zone IV as per IS 1893-Part 1(2002) codal provisions are considered for seismic analysis of developed RC building models.

c. Comparison of seismic analysis results:

Comparisons are made for developed RC building models without and with floating columns, floating columns having bracings at the perimeter considering storey displacement, storey drift ratio, storey shear, storey stiffness and time- period from response spectrum analysis.

IV. LITERATURE REVIEW

Udaygowda M L and Karthik S (2018) have analyzed G+30 storey RC building without floating columns, with floating columns at different positions using SAP 2000 Ver.19 analysis was done by Equivalent static and dynamic time history analysis in different zones.at every 10m column sections are reduced. It was observed that response of floating columns will be depend on the type of analysis performed and response will be more for the time history analysis. Building with floating columns shows a higher drift, displacement and time-period. It was found that drift are exceeding the limits for building with floating column. It was recommended that floating column should be provided with the bracings for the better seismic performance.

In another study Keerthi Gowda B.S and Syed Tajoddeen (2014) analyzed G+10 storey RC building without floating columns, with floating columns and RC building with floating columns after providing bracings. The models were developed using ETABS software. Analysis was performed by response spectrum technique as per IS 1893-Part 1(2002). It was observed that multi-storey buildings with floating columns performed poorly under seismic excitation. Thus to improve seismic performance of the multi-storey building, lateral bracings were provided.

One more study conducted by S.B. Wakule Dr. C. P. Pise (2016) have analyzed G+5 storied building with and without floating column in Zone V as per IS1893 (Part 1) 2002. The floating column located at first floor, modelling and analysis carried out in sap 2000 v17 by linear static analysis and time history analysis and compared both the analysis results. It was concluded that storey drift increases 5-10% for building with floating column compared to building without floating column and time-period increases 5-10% for building with floating column than the building without floating column. Below table represents various parameters considered in analyzing the multi-storey building.

Table 1.Parameters considered in modelling multi-storey building

SI. No	Parameter	Remarks
1	Structural type	Commercial
	Total stories	12(G+11)
3	Plan dimension	(36×28)m
4	Total height of the building	43.6m
5	Bays width in X- and Y-directions	4m
6	Size of column	(750×750)mm
7	Size of beam	(400×450)mm
8	Thickness of slab	150mm
9	Storey height	3.3m
10	Grade of concrete for beams	M30
11	Grade of concrete for columns	M30
12	Grade of concrete for slabs	M30
13	Grade of steel	Fe500
14	Poisson's ratio of concrete	0.2
15	Density of concrete	$25kN/m^3$
16	Density of concrete block	$18kN/m^3$
17	Type of bracing	X-bracing
18	Size of bracing	ISHB 450 at 92.5 Kg
19	Live load on the floor	$4kN/m^2$
20	Dead load on the floor	$1.5kN/m^2$
21	Wall load	12.58kN/m
22	Parapet wall load	3.16kN/m
23	Damping ratio	5%
24	Soil type	Medium
25	Zone factor	Ⅳ(severe)
26	Importance factor	1.5
27	Response reduction factor	5

Table 2. RC Building Models for Analysis

SL No.	**Model No**	**Floating column**	**Bracings at Perimeter**	
			X-Direction	**Y-Direction**
1	M1	-	-	-
2	M2	2nd and 4th floor	-	-
3	M3	3rd and 5th floor	-	-
4	M4	6th and 8th floor	-	-
5	M5	7th and 9th floor	-	-
6	M6	2nd and 4th floor	2nd to 8th bay	2nd to 6th bay
7	M7	3rd and 5th floor	2nd to 8th bay	2nd to 6th bay
8	M8	6th and 8th floor	2nd to 8th bay	2nd to 6th bay
9	M9	7th and 9th floor	2nd to 8th bay	2nd to 6th bay

Table 2 represents the floating column without and with, floating columns having bracings at perimeter.

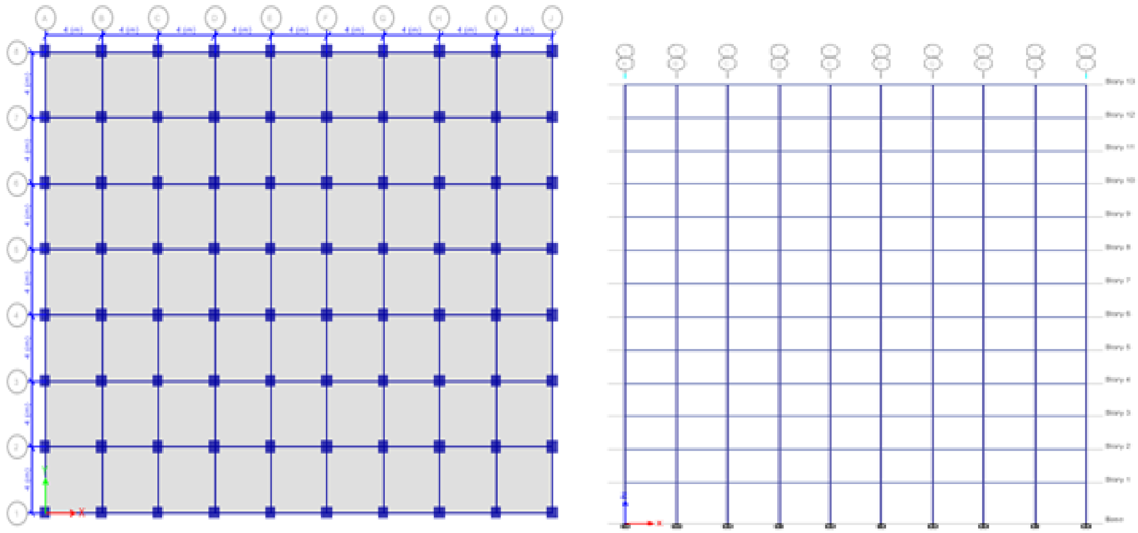


Figure 2. Plan elevation views of Model M1

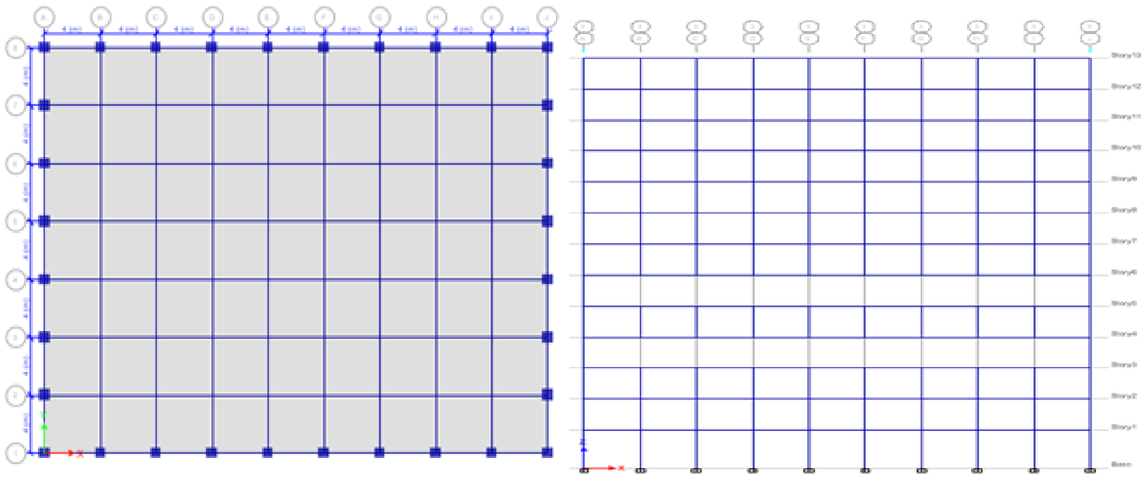


Figure 3. Plan elevation views of Model M2

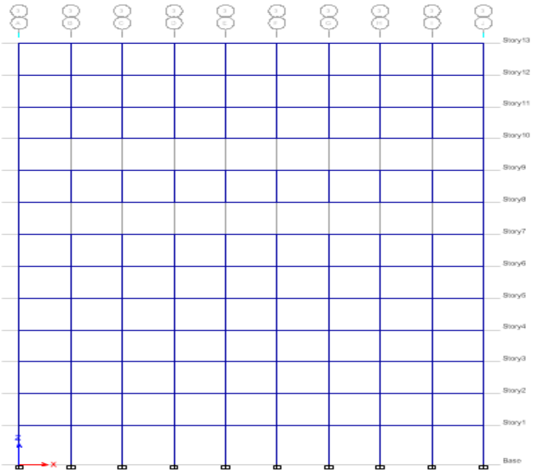


Figure 4. Model M3 (Elevation)

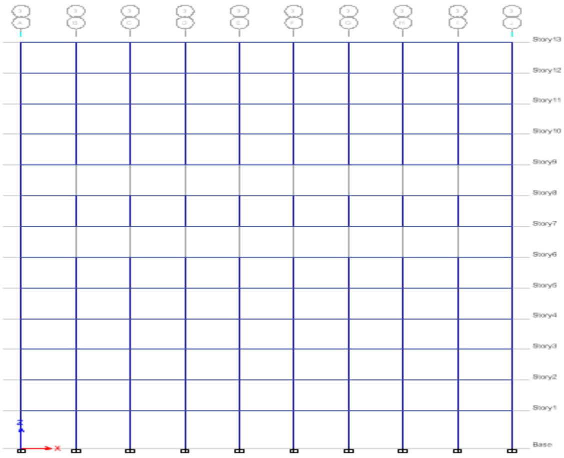


Figure 5. Model M4 (Elevation)

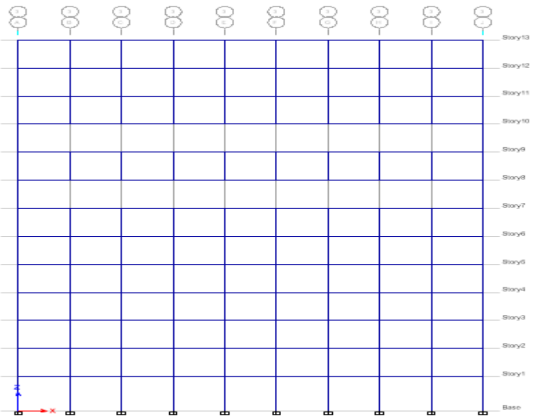


Figure 6. Model M5 (Elevation)

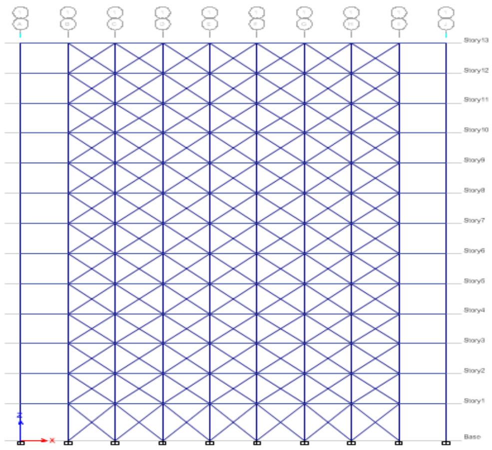


Figure 7. Model M6 (Elevation)

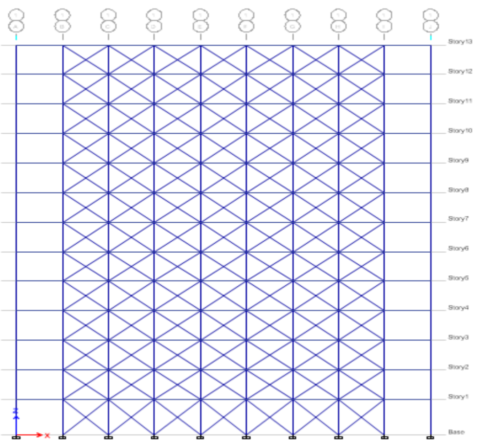


Figure 8. Model M7 (Elevation)

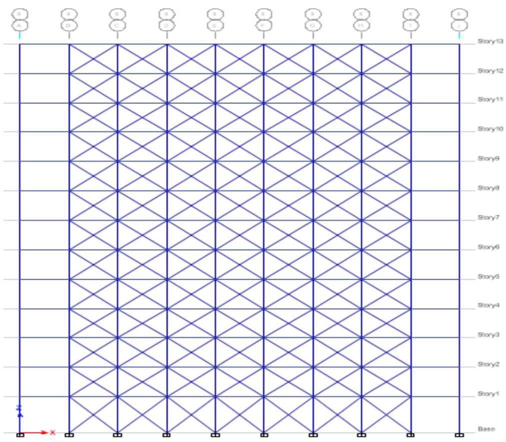


Figure 9. Model M8 (Elevation)

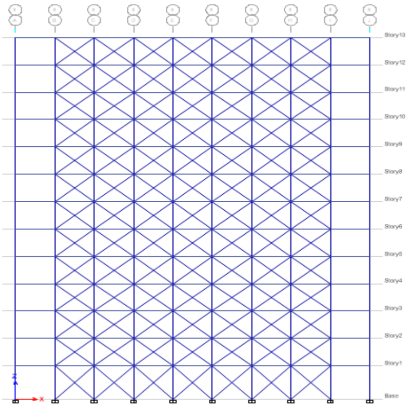
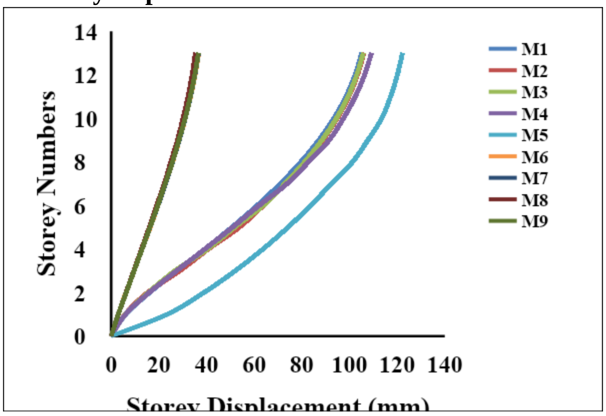


Figure 10. Model M9 (Elevation)

V. RESULTS AND DISCUSSION

5.1: Storey displacement



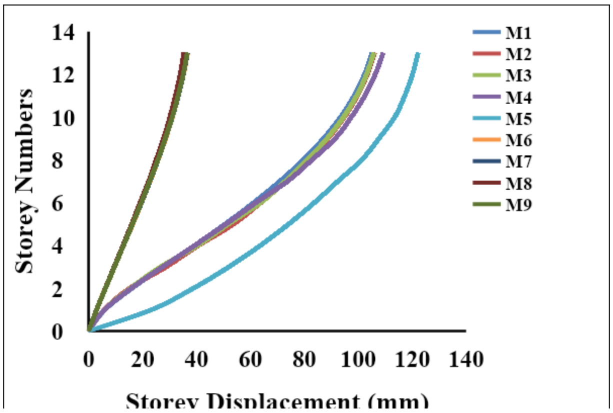
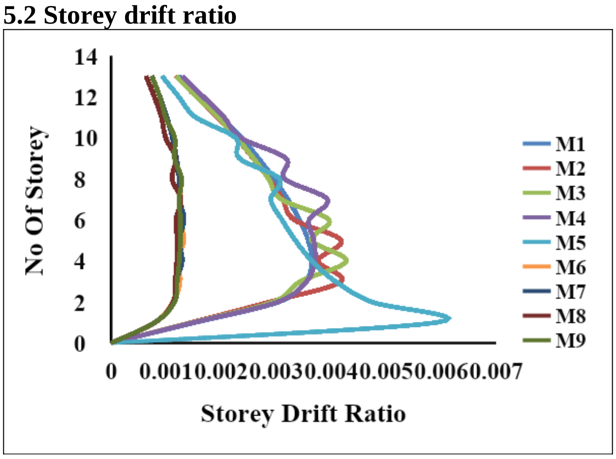


Figure 11. variation of storey displacement in X-dir   Figure 12. Variation of storey displacement in Y-dir

Figures 11 and 12 represents variation of displacement obtained from RSA in both X and Y directions for all the developed RC building models. The displacement values in Y-direction are observed to be more than in X-direction. It is observed that, in all the figures the variations are similar.

5.2 Storey drift ratio



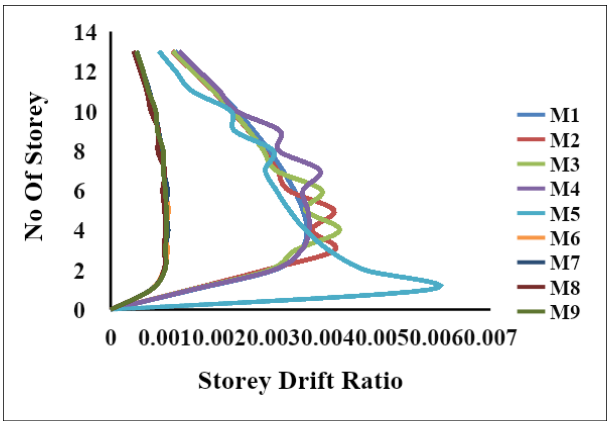
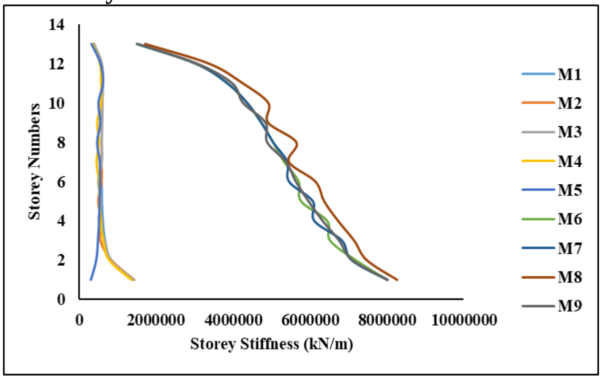


Figure 13. Variation of storey drift ratio in X-dir   Figure 14. Variation of storey drift ratio in Y-dir

Figures 13 and 14 represents storey drift ratio obtained from RSA in both X and Y directions for all the developed RC building models and storey drift ratio values in Y-direction is observed to be more than in X-direction. It is observed that, in all the figures it shows different kind of variations.

5.3 Storey stiffness



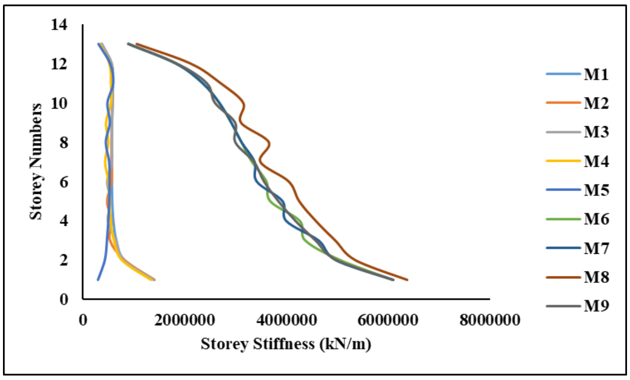


Figure 22. Maximum storey stiffness in both X and Y-directions Figure 16. Variation of storey stiffness in Y-dir

Figures 15 and 16 represents variation of storey stiffness obtained from RSA in both X and Y directions for all the developed RC building models and storey stiffness values in X-direction is observed to be more than in Y-direction. It is observed that, in all the figures shows different kind of variations.

5.4 Storey shear

Figures 17 to 18 represents storey shear obtained from RSA in both X and Y directions for all the developed RC building models and storey shear values in X-direction is observed to be more than in Y-direction. It is observed that, in all the figures similar kind of variation.

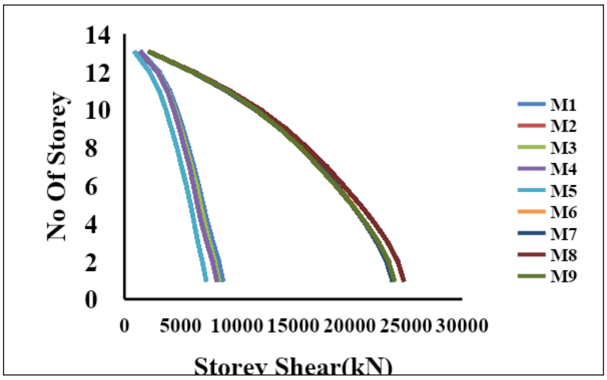


Figure 17. Variation of storey shear in X-dir

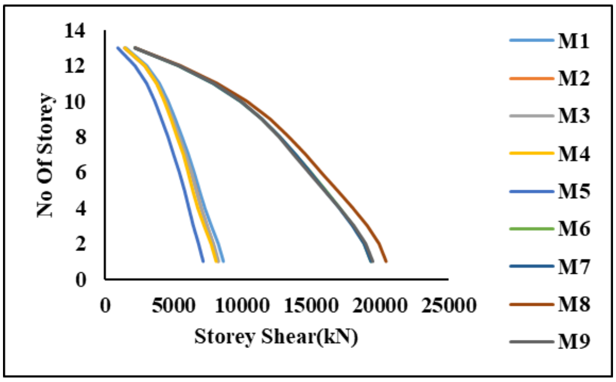


Figure 18. Variation of storey shear in Y-dir

5.5 Time period

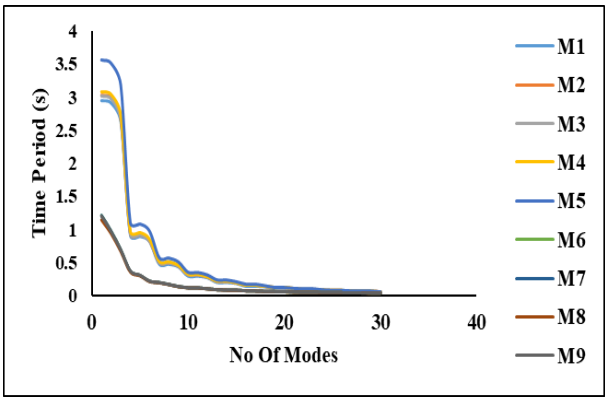


Figure 19. Variation of Time period

Figure 19 represent different similar variation of time period obtained from RSA.

VI. Discussion on Results Obtained From RSA

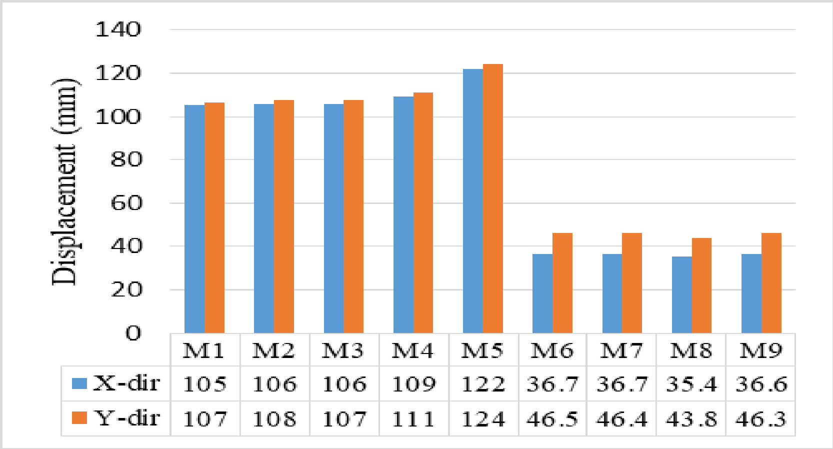


Figure 20. Maximum storey displacement in both X and Y-directions

From Figure 20 it can be conclude that model Model M5 shows maximum displacement and Model M8 shows minimum displacement in both X and Y- directions compared to all the models.

6.2 Storey drift ratio

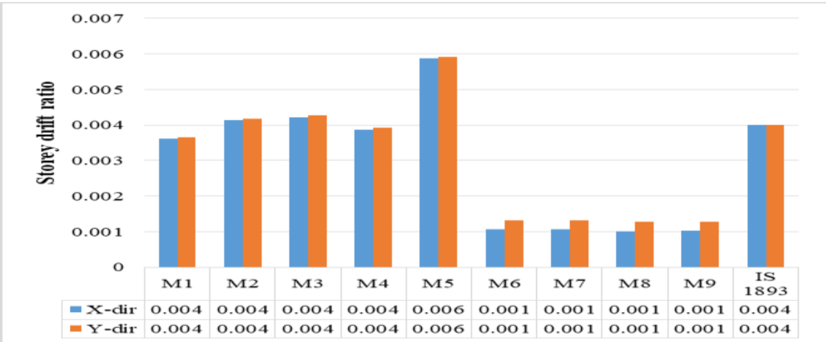


Figure 21. Maximum storey drift in both X and Y-directions

From the Figure 21 it can be conclude that Model M2, M3, M4, M5 shows maximum drift and are exceeding the limit as per Cl. 7.11.1 of IS 1893–Part 1 (2002), and other models are showing minimum drift ratio compared M2, M3, M4,M5 models.

6.3 Storey stiffness

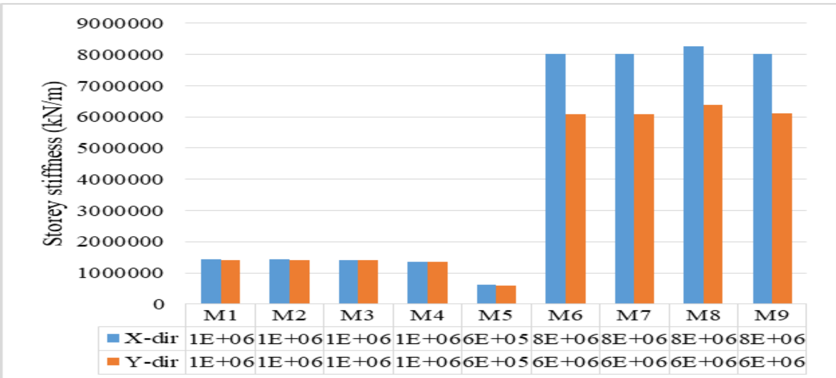


Figure 22. Maximum storey stiffness in both X and Y-directions

From Figures 4.59 and 4.56 it can be conclude that model Model M8 shows maximum stiffness and Model M5 shows minimum stiffness in both X and Y- directions compared to all the models.

6.4 Storey shear

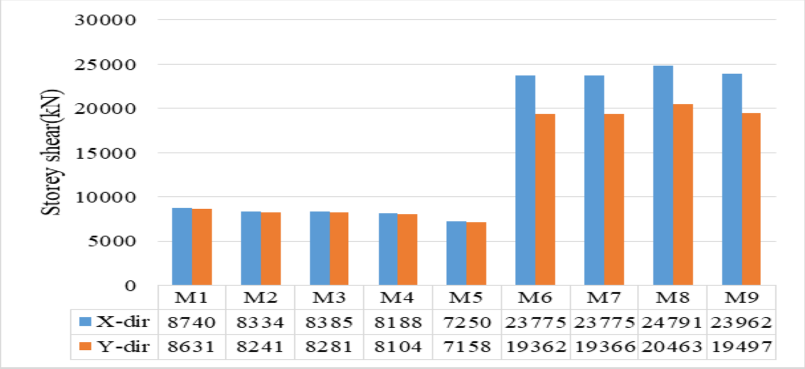


Figure 23. Maximum storey shear in both X and Y-directions

From Figure 23 it can be conclude that Model M8 shows maximum storey shear and Model M5 shows minimum storey shear in both X and Y- directions compared to all the models.

6.4 Time period

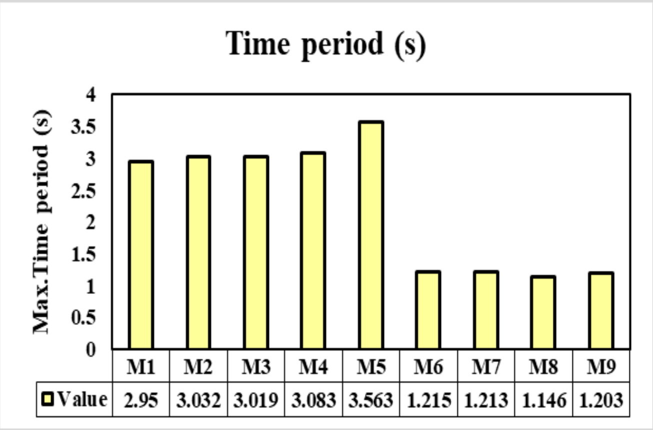


Figure 24. Maximum time period

From the figure 4.62 Model M5 shows maximum time period and Model M8 shows minimum time period compared to all the models.

VII. CONCLUSION

1. Storey displacement values obtained from RSA show a similar variations in both X and Y directions for all developed RC building models and displacement values in Y-direction is observed to be more than in X-direction.
2. storey drift ratio obtained from RSA in both X and Y directions for all the developed RC building models and storey drift ratio values in Y-direction is observed to be more than in X-direction. It is observed that, in all the models shows different kind of variations.
3. Storey stiffness obtained from RSA in both X and Y directions for all the developed RC building models and storey stiffness values in X-direction is observed to be more than in Y-direction. It is observed that, in all the Models shows different kind of variations.
4. storey shear obtained from RSA in both X and Y directions for all the developed RC building models and storey shear values in X-direction is observed to be more than in Y-direction.
5. Model M5 shows maximum displacement and Model M8 shows minimum displacement in both X and Y- directions compared to all the models.

6. Model M2, M3, M4, M5 shows maximum drift and are exceeding the limit as per Cl. 7.11.1 of IS 1893–Part 1 (2002), and other models are showing lesser drift ratio compared Models M2, M3, M4, M5.
7. Model M8 shows maximum stiffness and Model M5 shows minimum stiffness in both X and Y-directions compared to all the models. And Model M8 shows maximum storey shear and Model M5 shows minimum storey shear in both X and Y- directions compared to all the models.
8. Model M5 shows higher time period and Model M8 shows lesser time period compared to all the models.

Concluding Remarks: Addition of bracings for buildings with floating columns reduces the storey displacement and storey drift values and increases the storey stiffness and storey shear thus to making the building stable and strong against the seismic loads.

It is suggested to avoid providing of floating columns in buildings without providing the bracings, shear wall or any other lateral load resisting elements.

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