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SEISMIC ANALYSIS OF MULTI-STOREY BUILDING WITH FLOATING COLUMNS

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Abstract - *The Hanging or Floating Columns is a vertical member which rests on beam without foundation and the column acts as a point load on beam is known as floating column. In the present days, multi-storey building with floating columns are less resistance to the earthquake. But many times due to architectural and client requirements there is a need for floating columns in the multi-storey building. Therefore, we cannot avoid the floating columns, but we can identify the optimum locations of floating columns in buildings to improve the earthquake response of multi-storey buildings with floating columns. In the present work we have considered 3 cases to study the optimum locations of floating columns in buildings.* ***Case -1****: 20% of Commercial space and 80% of Residential space of floating columns.* ***Case -2:*** *50% of Commercial space and 50% of Residential space of floating columns.* ***Case -3:*** *80% of Commercial space and 20% of Residential space of floating columns. In all these 3 cases we are studying the optimum locations of floating columns. Also the results are shown in graphs. The analysis of this study is done by using ETABS 2017 software.*

Key Words**:** ***Floating Columns, Response Spectrum, ETABS***

1. INTRODUCTION

The suspended or floating column structure has aroused great interest from the architects and structural based appearance from all over the world. The advantage of this is to create a more open free space can be obtained by restricting the use of columns. They are most commonly used in urban areas with limited space. These structures are not dynamic and reliable, so you need to be familiar with the floating column structure. In the process of urbanization, complex multi-storey buildings emerge in endlessly. At different floor levels and discontinuity of column positions, the result may get varied and thus the poor performance of structure is identified. The seismic forces are developed and this must get reduced only by the shortest path of building height to the ground. Basically the columns are placed vertically in all over the structures.

1.1 History

During 2001, there was a major earthquake which was caused in Gujarat city (India). Where it has destroyed lots of high rise or tall buildings and human's life leads to death in that earthquake. This major accident was caused by named **BHUJ earthquake (2001).** Buildings with floating columns on different floor levels, will the beams that have not reached the foundation level. In these cases, the transfer of load is not distributed evenly all over the structure when earthquake occurs, and thus results in the collapse of buildings. Therefore while constructing the soft stories they deserve a special consideration for the design and then analyzed.

1.2 What is Floating Column?

The Floating Column (FC) is also a vertical member in the structure. For the architectural design purpose and client requirement the placement of this floating column will be irregular in every intermediate floors and lots of discontinuity will be present in it. These floating columns are not very simple to design, where it doesn't transfers the structural load to the foundation directly. The entire load is been transferred to a horizontal member called Girder Beams, where this beams supports like a point load to columns and acts as a foundation for floating columns is shown in below fig :1.1

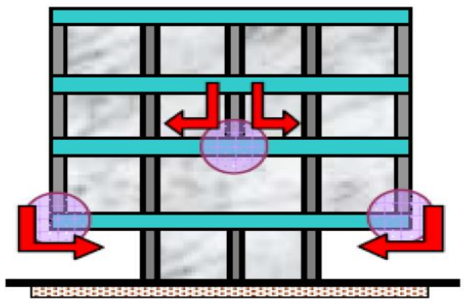

Fig 1.1: Hanging or Floating Columns

1.3 Objectives

The main objectives of the proposed work are as follows:

1. To Study the seismic response of a multi-storey building with floating columns starting from the 1st floor.
2. To Study the seismic response of a multi-storey building with floating columns starting from the 5th floor.
3. To Study the seismic response of a multi-storey building with floating columns starting from the 9th floor.
4. To compare all the results obtained.

2. LITERATURE REVIEW

Ashish. G. Pakmode et.al, (2016) [1], In this paper work we can study the behavior of earthquake excitations in the multi-storey buildings with an combinations of various floating columns in finite element methods and with scheme of Newmark's Direct Integration method is been used to solve the linear dynamic and solution in time. The complete analysis of Self Load, Imposed Load, Earthquake Load and Response Spectrum is done by using STAAD PRO.

Kandukuri Sunitha et.al, (Aug 2017) [2], In this present study there is a comparision of high rise buildings with normal and floating columns buildings where the floating column is present in the different intermediate floor levels for external lateral forces and earthquake zones. The author studied that the multi-storey structure is been safe or unsafe if the hanging columns if been constructed in seismically active areas. Providing of shear wall to structures give best results and it's been safe to structures. The analysis is done through ETABS

Pushkar Rathod et.al, (Oct 2017) [3], The author in this study has analyzed the high earthquake prone areas damages are been considered with seismic analysis. In this there are 4 different shapes of irregular buildings are chosen for both the static and dynamic analysis. The modal analysis method in a linear dynamic response procedure solves and it seems to be superimposes of free vibration is seen in different mode shapes to characterized the displacement pattern. The deformation of buildings is more in unsymmetrical plans when compared to symmetrical plans of a new structures in high seismic zones. Symmetrical plans have better stability.

Arpit Shrivastav et.al, (May 2018) [4], In this the author has chosen 3 types of model cases with three different storey height of building. Where G+7, G+11 and G+15 are considered. All these structures are tested under seismic zone 4 and 5. All this structures are based on with shear walls and without shear walls buildings of comparisons. We can see a special 2 floor areas with 28x28m for lower levels and 32x32m for the higher levels. The beam sizes for all the 3 cases are 0.3x0.5m.

Gulchaman Khan et.al, (Jan 2019) [5], The 3 different floor levels of heights are taken as 8 storey,12 storey and 16 storey buildings and analyzed for Zone-5 with and without Shear wall. The lateral displacement and storey waft of construction decreases to better zones where the depth may be more in higher zones and the usage of shear wall with those parametric values also reduces in models.

Shivam Wankhade et.al, (Jan 2020) [6], The author is been described that the floating column is been located at one or more storey. The discontinuity of columns in the transfer loading path may get low results for bad performance of the structure. All this 3 cases of 12th storey, 14th storey, 16th storey buildings were been considered and in this the floating columns are situated in the 8th storey which is been very common in all the 3 cases of the buildings. It is analyzed for all the earthquake zones of II, III, IV and V by Etabs. From lower to higher zones the lateral displacement and storey drift will be increased, where the magnitude of intensity will be more the construction of the floating column in higher seismic active zone areas are restricted.

Sreadha A R et.al, (Apr 2020) [7], In this study they have considered 2 models of buildings where the buildings has with and without floating columns at different flor levels. But they cannot be designed for the seismic loads. We can see a major difference where the earthquake load on structure is distributed and transferred to the shear construct walls without much loads on the FC. These 2 models is taken under earthquake zone IV and analyzed and it is constructed in a medium type of soil condition. The output values are extracted from etabs and taken for static analysis and compared all the seismic parameters. The building with FC exhibits higher storey drift and storey displacement when compared to building without floating columns.

Harsha P.V et.al, (July 2020) [8], The author studies and analyzed the G+10 storied nominal building and G+10 storied floating column building for lateral external forces. To study the behavior of floating column under earthquake excitations and to find out whether the floating column structure is safe or unsafe in seismic zone III. They have chosen the 10 models of different varieties of shear wall design. The shear wall will be at center (Box Type), at corner (L-shape) and on the sides of the structures. The shear wall at three different positions are been placed in the building to check and allocate the best shear wall positions. This paper concludes that to find the best and critical location of floating columns in G+10 storey. The response spectrum analysis is done using ETABS software.

3. METHODOLOGY

3.1 Response Spectrum Analysis

The procedure to compute the peak response of structure during the earthquake directly from the earthquake response spectrum without the need of time history analysis is called response spectrum analysis. A typical design response spectrum (IS-1893) is shown below in Fig 3.1

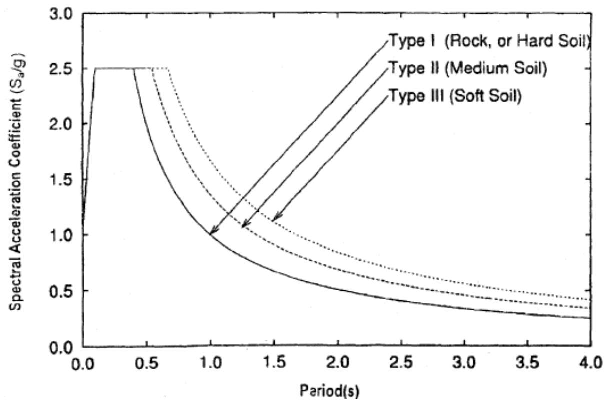

Fig 3.1: Design Graph of Response Spectrum

Response spectrum is a plot of maximum response of a SDF for various value of the period for a given input. The IS-1893 gives an average Response spectrum can be employed in earthquake resistant design.

3.2 Model Plans

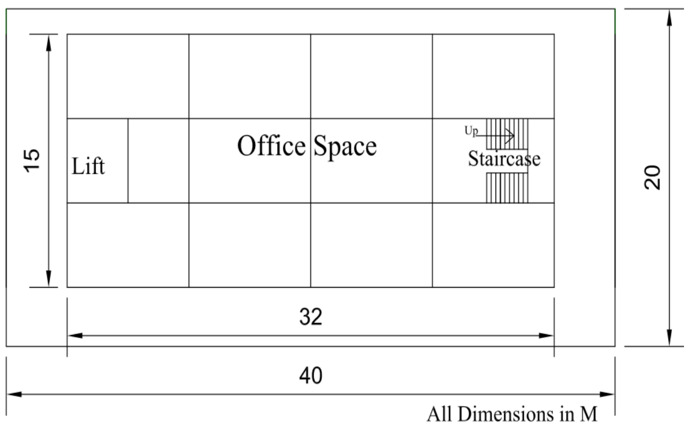

Fig 3.2: Plan

- This commercial space indicates the columns placement for all the 3 cases of models are similar and it is shown in figure 3.3

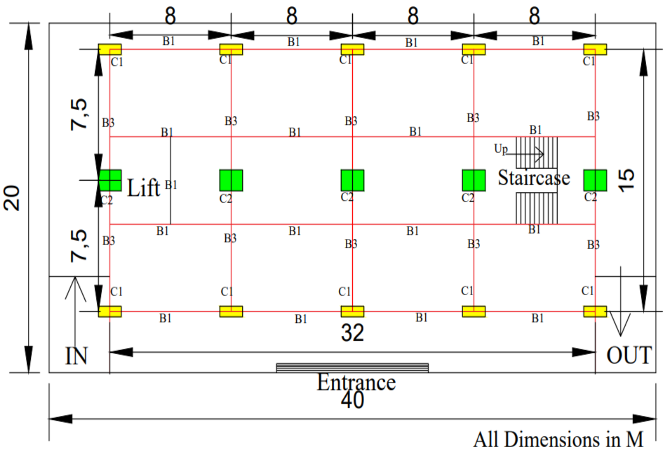

Fig 3.3: Column and Beam Placement in Commercial Spaces

- This residential space indicates the floating columns placement for all the 3 cases of models are similar and it is shown in figure 3.4

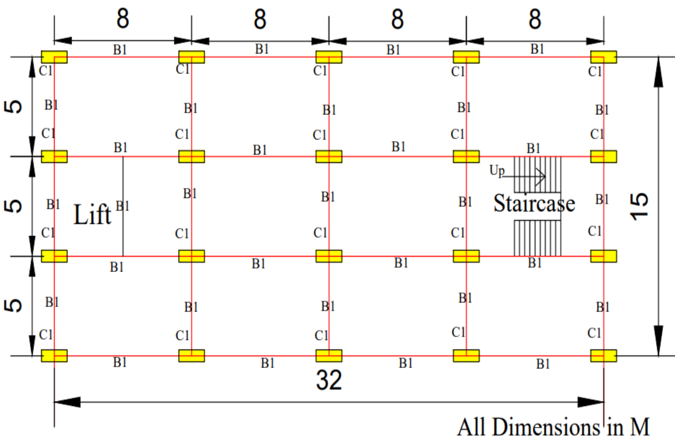

Fig 3.4: Column and Beam Placement in Residential spaces of Floating Columns

3.3 Modelling Details

1. Material Properties:

Table 3.1: Material Properties

Sl. No	Descriptions	Details	
	Grade of Concrete	Slabs	M30
		Beams, B1 & B2	M30
		Girder Beam, B3	M50
		Columns, C1 & C2	M40
	Grade of Rebar Steel	(HYSD) Bars	Fe 550
	Density of Concrete	25 KN/m^3	

	Density of Hollow Light Weight Concrete Block	11 KN/m³

2. Structural Details

Table 3.2: Structural details of the building

Sl. No	Descriptions	Details
	Building Type	Commercial + Residential
	Type of Structure	Floating Columns of RCC Frame Structure
	Site Dimension	40m x 20m
	Plan built-up Area Dimension	32m x 15m
	Plan Area	480 sq.m
	Building Shape	Rectangular
	Total Height of the Building (Basement +G+10+Terrace+Lift MR)	56m
	Height of Stories	4m (Floor to Floor)
		5.5m (At Girder Beam Floor)

3. Structural Properties

Table 3.3: Sectional properties of floating building

Sl. No	Descriptions		Values
	Beam sizes	B1	600mm x 450mm
		B2	750mm x 750mm
		B3 (Girder Beam)	1500mm x1750mm
	Column sizes	C1	1500mm x 600mm
		C2	1500mm x1200mm
	Slab Thickness		175mm
	Wall Thickness		200mm
	Retaining Wall Thickness		200mm

4. Wall Load Details

Table 3.4: Wall Load Details

Sl. No	Descriptions	Calculations	
	Wall Load on Beam	0.2 x (4-0.55) x 11	7.6 KN/m
	Wall Load on Girder Beam Floor	0.2 x (5.5-0.5) x 11	11 KN/m
	Parapet Wall Load on (Terrace + Lift MR)	0.2 x 1.2 x 11	2.7 KN/m

5. Load Considered

Table 3.5: Load Consideration

Sl. No	Loads	Values
	Live Load on Slab	4 KN/m² (For Slabs)
		5 KN/m² (For Staircase Slab)
	Floor Finish Load on Slab	1.5 KN/m²
	Lift Machine Room Load on Slab	12 KN/m²

6. Seismic Load Details

Table 3.6: Seismic load details of the building

Sl. No	Descriptions		Values	
	Seismic Zone		Zone - II	
	Zone factor, Z		0.10 (As per code)	
	Response reduction factor, R		3	
	Importance factor, I		1.2	
	Soil type, Sa/g		II (Medium)	
	Damping ratio		5%	
	Time period	X-dir = Tx	$0.09h/\sqrt{dx}$ = (0.09 x 56)/ $\sqrt{32}$	0.890 sec
		Y-dir = Ty	$0.09h/\sqrt{dy}$ = (0.09 x 56)/ $\sqrt{15}$	1.304 sec
	Scale factor		Ig/2R = (1.2 x 9.81)/2 x 3	1.962

7. Wind Load Details

Table 3.7: Wind load details of the building

Sl. No	Descriptions		Values	
1.	Wind Speed, Vb (m/s)		33	
2.	Terrain Category		3	
3.	Importance Factor		1.15	
4.	Risk Coefficient (k1)		1	
5.	Topography (k3)		1	
6.	Wind Exposure Parameters			
7.	Windward Coefficient, Cp		Leeward Coefficient, Cp	
	X-dir (0^0)	0.7	X-dir (0^0)	-0.4
	Y-dir (90^0)	0.8	Y-dir (90^0)	-0.1

8. Types of Loads

Table 3.8: Types of Loads considered

SL.No	Load Case Name	Load Case Type
1	Dead	Linear Static
2	Live	Linear Static
3	Floor Finish FF	Linear Static
4	Wall	Linear Static
5	Parapet wall	Linear Static
6	Lift MR	Linear Static
7	EQX	Linear Static
8	EQY	Linear Static
9	WLX	Linear Static
10	WLY	Linear Static
11	R Spec X	Response Spectrum
12	R Spec Y	Response Spectrum

9. Load Combinations

DLEQX=1.2 (DL+LL+R SPECX)

DLEQY=1.2 (DL+LL+R SPECY)

3.4 Types of Models.

The types of models used for this proposed study are as follows:

1. **Case -1:** 20% of Commercial space and 80% of Residential space of floating columns over the height of building.

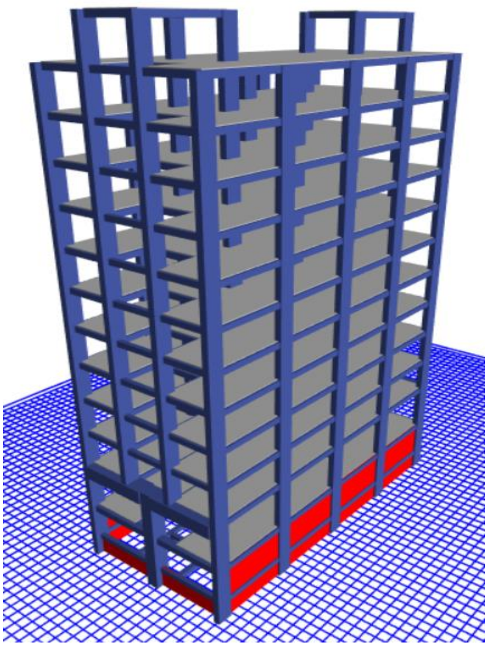

Fig 3.5: 3D model of Case-1

2. **Case -2:** 50% of Commercial space and 50% of Residential space of floating columns over the height of building.

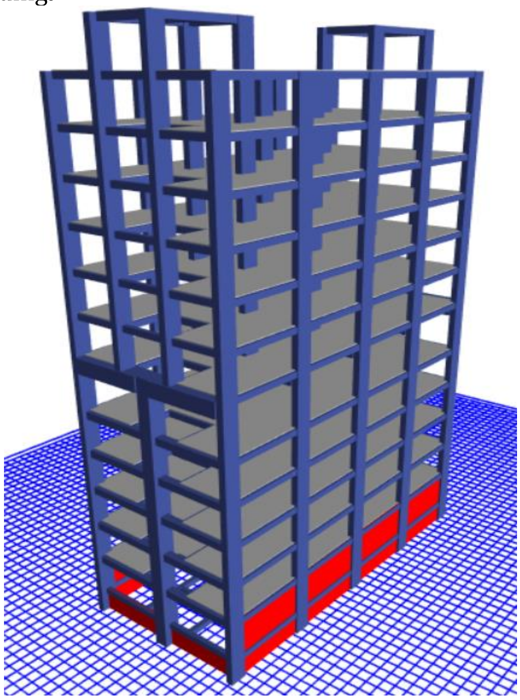

Fig 3.6: 3D Model of Case-2

3. **Case -3:** 80% of Commercial space and 20% of Residential space of floating columns over the height of building.

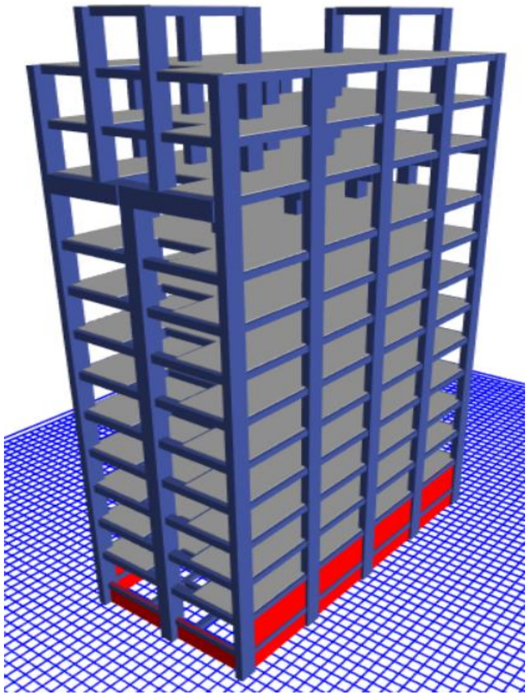

Fig 3.7: 3D model of Case-3

3.5 Optimum Locations of Floating Columns and Girder Beam

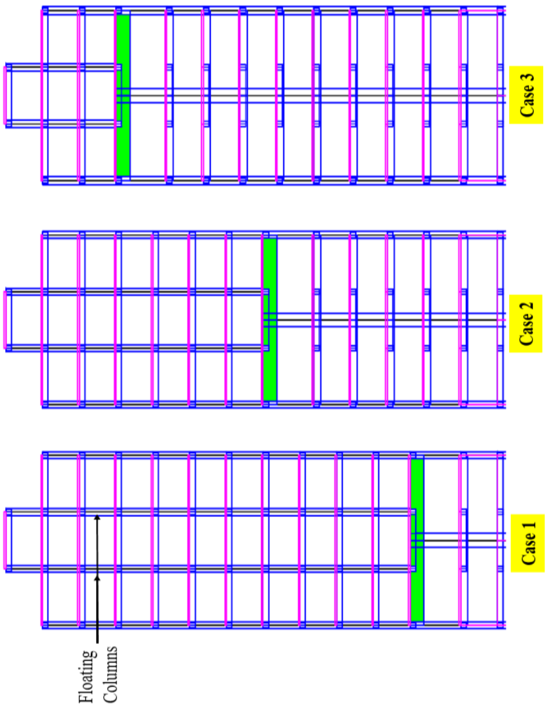

Fig 3.8: Optimum Location of Main Girder Beam

4. RESULTS AND DISCUSSIONS

4.1 Maximum Storey Displacement, (mm)

- **X-Direction**

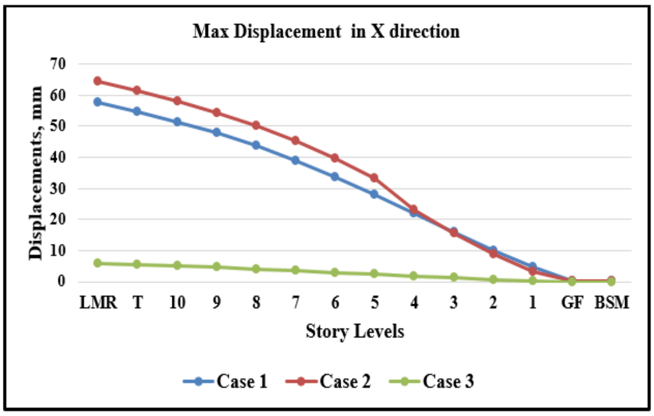

Fig 4.1: Displacement Graph in X directions

- **Y-Direction**

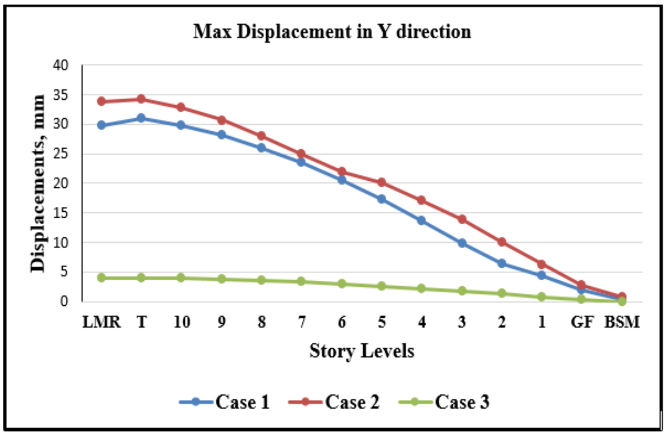

Fig 4.2: Displacement Graph in Y directions

4.2 Maximum Storey Drifts Ratio

- **X-Direction**

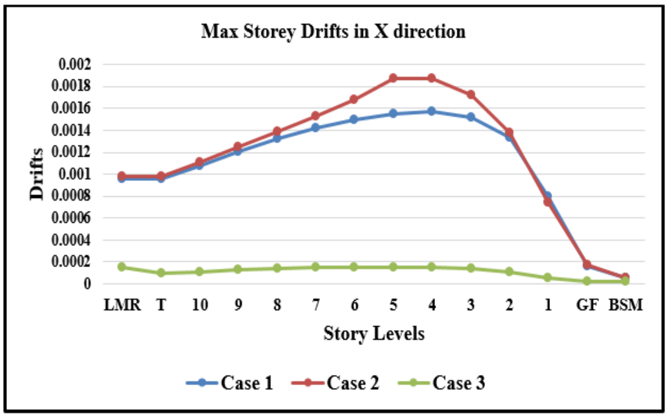

Fig 4.3: Drift Graph in X directions

- **Y-Direction**

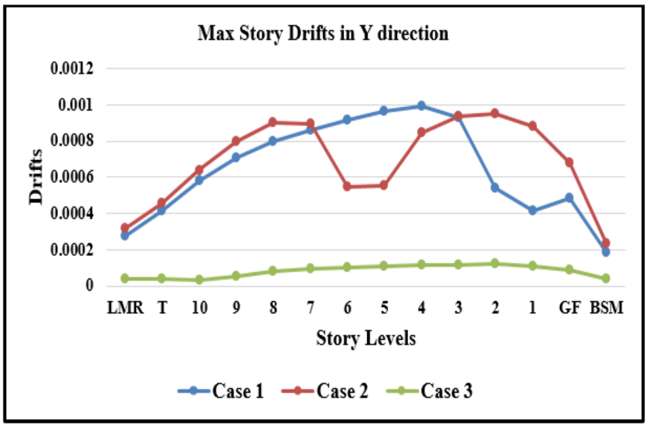

Fig 4.4: Drift Graph in Y directions

4.3 Storey Shear, (KN)

- X-Direction

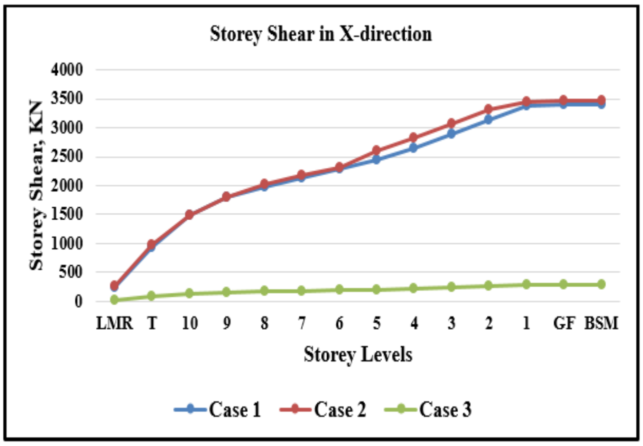

Fig 4.5: Storey Shear Graph in X directions

- Y-Direction

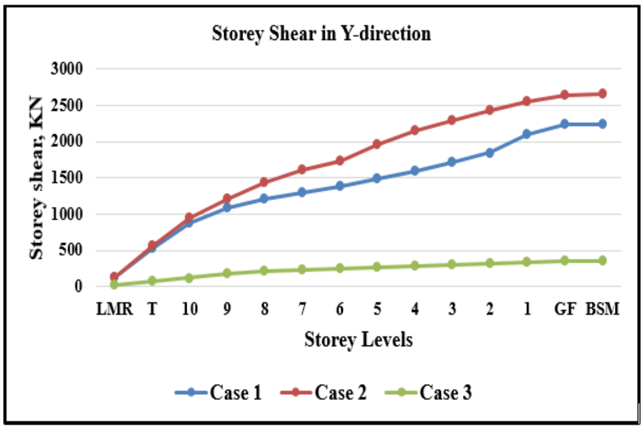

Fig 4.6: Storey Shear Graph in Y directions

4.4 Time Period, (Sec)

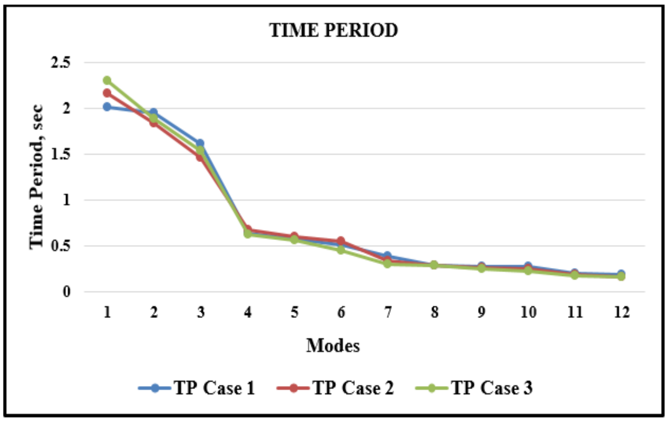

Fig 4.7: Time Period Graph

4.5 Frequency, (Hz)

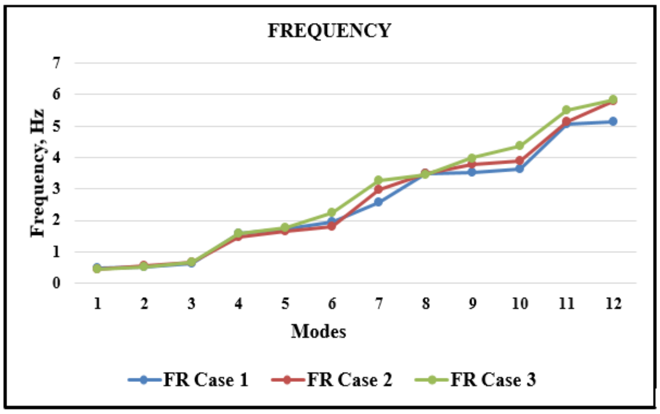

Fig 4.8: Frequency Graph

5. CONCLUSIONS

- In the present work the Seismic analysis of Multi-Storey building with floating columns is analysed in the different locations (Storey levels) of the building, where as lower, middle and upper storey levels over the height. Response spectrum analysis was conducted for all the 3 cases of building.
- The behavior of seismic and wind for Floating Columns are been analyzed by Static method and Dynamic method in ETABS software.
- Finding out the optimum locations of Floating Columns in all the 3 cases of the structure over the height of building. And here the Case-3 holds good and construction will be safe.
- For reducing the weight of structure the hollow light weight concrete blocks are been used for the construction of main walls and parapet walls. Whereas we can reduce nearly 50% of blocks weight on structure.
- Though the parametric study of Time Period, Frequency, Displacement, Storey Drift and Storey Shear, it is found that more floating columns floors (i.e Case-1 & Case- 2) in the building will be slightly acts poor in the performance under seismic excitation.
- Whereas in Case- 3 model performs better in the construction. By considering all these above parameters, Case-3 performs good and it has resistance of 86% to 92% under seismic excitation.
- Floating columns for the multi-storey buildings give an good aesthetic view as well as it provides more open space areas.

6. FUTURE SCOPE

- The study can be done for comparing all the seismic zones such as Zone II, Zone III, Zone IV and Zone V. And other wind speeds

- In future the floating column can be studied and analysed by using Time history method.
- The double storey height of each floor of floating columns can also be studied for different storey levels.
- Placing of floating columns in the intermediate floors and irregularities of buildings can be studied.
- Footing analysis of floating column structure and addition of shear walls can also be studied.
- Pushover analysis for different floating column structures can be carried out.

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