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Seismic Analysis of High-Rise Structure Considering the Effect of Floating Columns

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ABSTRACT
In recent times, many buildings are planned and constructed with architectural complexities. The complexities include various types of irregularities like floating columns at various level and locations. These floating columns are highly disadvantageous in building built in seismically active areas. The earthquake forces that are developed at different floor levels in building need to be carried down along the height to ground by shortest path, but due to floating column there is discontinuity in the load transfer path which results in poor performance of building. In this current study structure is analyzed by using Response Spectrum Analysis by assuming that as the structure shall be exposed to different zones [zone lll, zone v]. The analysis is finished using ETABS software. This present work is to verify the safety of the structure with the existence of floating column after being built in areas where seismic action is very high. Comparison of various parameters such as base shear, inter storey drift and storey displacement is done.
Keywords :- Floating column, Structural Analysis, Base Shear, storey displacement, High Rise Structures

I. INTRODUCTION

The term building in Civil Engineering is used for the structure having various components 1ike foundation, walls, columns, f1oors, roofs, doors, windows, venti1ators, stairs 1ifts, various types of Floor finishes etc. Structural analysis and design is used to produce a structure capable of resisting all applied 1oads without damage during its intended 1ife.

In modern period, mu1ti-storey building in metropolitan cities are required to have co1umn free space due to 1ack of space, more popu1ation and also for aesthetica1 point of out1ook, functional requirments and also For the purpose of parking ha1l, usua1ly the bottom storey is kept free without any constructions, excluding the co1umns which transmit the structural weight to the 1and. For a 1odges and comercial bui1ding, where the 1ower f1oors contain dining ha1ls, forum rooms, 1obbies, show rooms or parking areas, 1arge space necessary for the movement of people or vehic1es. As we know narrow1y spaced co1umns based on the p1ans of higher f1oor are not suitable in the 1ower f1oor. For this, Structure f1oating co1umns are provided at different storeys. These f1oating co1umns are high1y inconvenient in a structure which is bui1t in high seismic zones. The seismic forces that are initiated at various stories in a structure need to be passed down throughout the e1evation to the ground by the undeviating pathway.

Here in these structure Floating Columns are introduced at various stories mainly due to aesthetical view according to the architectural plan. Floating columns are provided at storey such as story 3 , story 4, story 5, story 6, story 7 and story 8. The structure is of eight storey. The floating columns are mainly introduced on the cantilever slabs and cantilever beams. Comparison of structure with floating columns and without floating columns for seismic zone v, and finding out the better structure which can be implemented.

II. OBJECTIVES

The main objective of the work is to study the behavior of High Rise Structure considering floating columns and without floating columns for seismic zones v under earthquake excitations.

- ✓ To Ana1yze a (G+7) building using ETABS software.
- ✓ To find the seismic response of high rise structures considering various Floating Columns as per IS 1893: 2016 in zone v.
- ✓ To evaluate the performance of Floating Columns subjected to Earthquake loads.
- ✓ To perform Dynamic Analysis using ETABS software.
- ✓ To find the Joint displacement, Inter storey drift, and base shear.

III. METHODOLOGY

In this work G+7 storey building is ana1ysed using ETABS software. A complete review is made for study of Response of high rise structures considering Floating Columns and without Floating Columns.

- ✓ Floating column is introduced according to the functional requirement.
- ✓ Response spectrum method (Dynamic analysis) carried for zones v.
- ✓ Generation of response spectrum for soil type medium for the seismic zone v. according to IS 1893: 2016 has been used for the dynamic analysis.
- ✓ The RC frame is designed by considering Dead loads, Live loads, Earthquakes loads.
- ✓ The results are obtained in terms of Storey Displacement, Storey Drift, and Base shear.

METHODS OF SEISMIC ANALYSIS OF STRUCTURE

- ✓ Equivalent Static analysis or Static analysis
- ✓ Dynamic analysis

RESPONSE SPECTRUM METHOD

Response spectrum Analysis is also known as Linear dynamic analysis, it is used to measure the contribution from each of the natural mode of vibrations to indicate maximum seismic response of the elastic structure.

Architectural Details of Building

4.1 Introduction: Here the Architectural details of the building is collected, such a building plans as showed in fig 1 to 4, Building data as showed in Table 1, Type of Model such as floating columns or without floating columns in the building as showed in Table 2, Location of the site such as Bangalore so that the zone can be identified for the analysis.

Storeys	**M 1**	**M 2**	**Grade of concrete**
Height of storey	3.2m	3.2m	
Thickness of wall	230mm	230mm	
Size of column	230X230 mm 230X200 mm	230X300 mm	M40
Size of beam	230X200 mm 230X300 mm	230X200 mm 230X300 mm	M30
Shear Wall thickness	100mm	100mm	M40
Slab thickness	125mm	125mm	M30

Table 1 : Building data

SL NO	Description	Model
1	Model with Floating Columns in Seismic zone V.	M 1
2	Model without Floating Columns in Seismic zone V.	M 2

Table 2 : Description

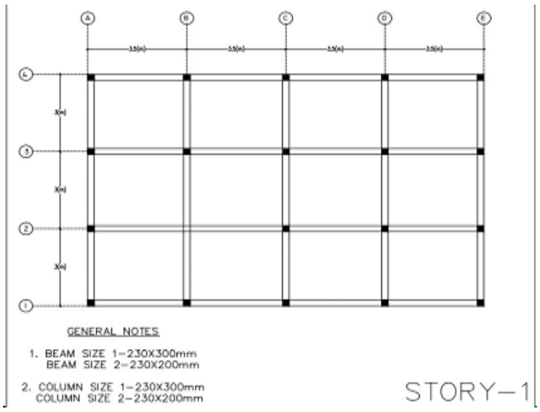

Fig 1: Story 1

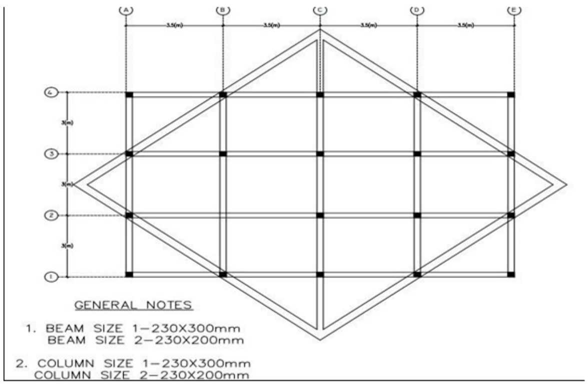

Fig 2: Story 2 and Story 6

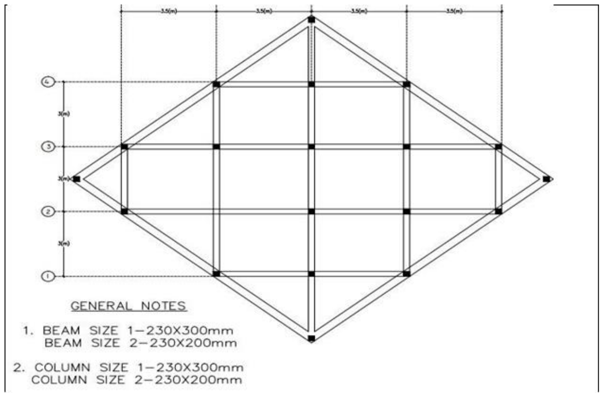

Fig 3: Story 3, Story 4 and Story 5

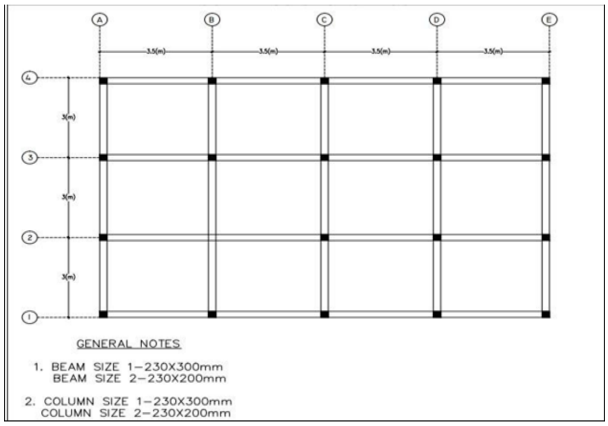

Fig 4: Story 7 and Story 8

MODELLING OF STRUCTURE

Introduction : Modelling of Structure is the First step in the ETABS software, where the code books and units are selected. And the material properties are defined such as Grade of concrete and Rebars. And then the Frame and Shell properties are defined, and the Frames and shells are assigned to the grids. And Load patterns are defined as per Dynamic Analysis. The Seismic data is collected from the IS 1893:2016 code book as shown in the Table 3.

Model	**1**	**2**
Zone	Zone 5	Zone 5
Reduction factor (R)	5	5
Importance factor (I)	1	1
Zone factor (Z)	0.36	0.36
Sa/g	Medium soil	Medium soil

Table 3 : Seismic data

As per methodology various 1oads are considered such as Dead 1oads, Live 1oads, Super Dead, Wa1l 1oads, Earthquake 1oads.

Dead loads: These loads may include self-weight of members based on size of section and density of material. The dead load are as in IS: 875(Part 1)-1987.

Live loads: These loads may include moving or variable loads according to their occupancy. The live load are as in IS: 875(Part 2)-1987. Live load considered for typica1 floor is 3 KN/m2 and for terrace 2 KN/m2.

Wall loads: These loads super imposed loads which include the self-weight of wall. The analysis is made by using Porotherm blocks.

Wall load = (width x Height of wall x density) Wall load = (0.23x2.85x8) = 5 KN/m2

Earthquake loads: These loads are as per IS:1893(Part 1) 2016. Zone considered is zone V factor is 0.36 , importance factor is 1(All other type of buildings), soil is of medium type.

Design procedure using ETABS

In this Study ETABS software is used for Modelling the structure for Various zones considering with and without Floating Columns. By passing through various steps mentioned below from fig 1 to fig 23, It is Modeled with respect to the Indian codes.

DESIGN OF STRUCTURE

Introduction: Design of the structure is the next process after the analysis, where in Design of Structure it is checked that all the beams , columns and shear wall are passing and are with in the limit. If the beams ,columns and shear wall are failing and are if not in the limit the frame and wall sections should be revised. The percentage of rebars is obtained so that the structure can be detailed and can be practically implemented

Design of Slabs

One long edge is continuous

f_{ck}= 30 N/mm^2, f_y = 500 N/mm^2 L_x = 3 m, L_y= 3.5 m

L_y/L_x =1.167< 2, Hence **design two-way slab**

L/d = 26

f_s = 0.58f_y = 0.58 x 500 = 290

Modification factor = 1.2

∴L/d = 31.2

Depth = (3000/31.2)= 96.153 mm

Overall depth D = 125mm, d=100mm

Assume 1000mm width

b) Loads:

Self-weight of slab	= 0.125X1X25	= 3.125 kN/m^2
Live load(Referring IS 875 part-II)		= 3 kN/m^2
Floor Finish		= 1 kN/m^2
Total load = 7.375 kN/m^2		
Factored load, W_u	= 1.5x7.375	= 11.0625 kN/m^2

Ultimate design moments and shear force:

α_x=Bending moment coefficient in X-direction

α_y= Bending moment coefficient in Y-directionα_x(-ve) = 0.0465 (Hogging)

α_x(+ve) = 0.03468 (Sagging)

α_y(-ve) = 0.037 (Hogging)

α_y(+ve) = 0.028 (Sagging)

Moment and shear force calculations

M_{ux}(-ve)	= $\alpha_x W l^2$	= 4.6147 kN-m (Hogging)
M_{ux}(+ve)	= $\alpha_x W l^2$	= 3.452 kN-m (Sagging)
M_{uy}(-ve)	= $\alpha_y W l^2$	= 3.6838 kN-m (Hogging)
M_{uy}(+ve)	= $\alpha_y W l^2$	= 2.7875 kN-m(Sagging)

c) Check for depth:

Mulim = 0.133f_{ck}bd^2

$11.0625 \times 10^6 = 0.133 \times 25 \times 1000 \times d^2$

d = 52.6 mm < 100mm, Hence safe

d) Reinforcements:

A_{st}min= 0.12% of gross area = (0.12x1000x125)/100 = 150mm^2 $M_u = 0.87 f_y A_{stx} d \left[1 - \frac{Ast_x f_y}{bdf_{ck}}\right]$

A_{stx} = 119.178 mm^2<150mm^2 Take A_{stx} = 150 mm^2

1) Hence provide 8mm Ø bars @ 200mm c/c in Long direction at top and bottom

One Short edge is continuous

f_{ck}= 30 N/mm^2, f_y = 500 N/mm^2 L_x = 3 m, L_y= 3.5 m

L_y/L_x =1.167< 2, Hence **design two-way slab**

L/d = 26

$f_s = 0.58 f_y = 0.58 \times 500 = 290$

Modification factor = 1.2

∴L/d = 31.2

Depth = (3000/31.2)= 96.153 mm

Overall depth D = 125mm, d=100mm

Assume 1000mm width

b) Loads:

Self-weight of slab	= 0.125X1X25	= 3.125 kN/m^2
Live load(Referring IS 875 part-II)		= 3 kN/m^2
Floor Finish		= 1 kN/m^2

Total load = 7.375 kN/m^2

Factored load, W_u = 1.5x7.375 = 11.0625 kN/m^2

Ultimate design moments and shear force: α_x=Bending moment coefficient in X-direction α_y= Bending moment coefficient in Y-directionα_x(-ve) = 0 (Hogging)

α_x(+ve) = 0.05636 (Sagging)

α_y(-ve) = 0.057 (Hogging)

α_y(+ve) = 0.043 (Sagging)

Moment and shear force calculations

u x M_{ux}(-ve) = $\alpha_x W\ l^2$ = 0 kN-m (Hogging)

M_{ux}(+ve) = $\alpha_x W\ l^2$ = 5.6113 kN-m (Sagging)

u x M_{uy}(-ve) = $\alpha_y W\ l^2$ = 5.675 kN-m (Hogging)

M_{uy}(+ve) = $\alpha_y W\ l^2$ = 4.281 kN-m(Sagging)

u x

u x

c) Check for depth:

Mulim = $0.133 f_{ck} bd^2$

11.0625 $x10^6$ = 0.133 x 25 x1000xd^2

d = 52.6 mm < 100mm, Hence safe

d) Reinforcements:

A_{st}min= 0.12% of gross area = (0.12x1000x125)/100 = 150$mm^2$$M_u = 0.87\ f_y A_{stx}\ d\ [1 - \frac{Ast_x f_y}{bdf_{ck}}]$

A_{stx} = 145.63 mm^2<150mm^2Take A_{stx} = 150 mm^2

2) Hence provide 8mm Ø bars @ 200mm c/c in Short direction at top and bottom.

$M_u = 0.87\ f_y A_{sty}\ d\ [1 - \frac{Ast_y f_y}{bdf_{ck}}]$

d = 100-(10/2)-(8/2) = 91 mm

A_{sty} = 147.33 mm^2<150mm^2Take A_{sty} = 150 mm^2

3) Hence provide 8mm Ø bars @ 200mm c/c in Long direction at top and bottom

Two Adjacent edge is discontinuous

f_{ck}= 30 N/mm^2, f_y = 500 $N/mm^2$$L_x$ = 3 m, L_y= 3.5 m

L_y/L_x =1.167< 2, Hence **design two-way slab**

L/d = 26

$f_s = 0.58f_y = 0.58 \times 500 = 290$

Modification factor = 1.2

∴L/d = 31.2

Depth = (3000/31.2)= 96.153 mm

Overall depth D = 125mm, d=100mm

Assume 1000mm width

b) Loads:

Self-weight of slab	= 0.125X1X25	= 3.125 kN/m^2
Live load(Referring IS 875 part-II)		= 3 kN/m^2
Floor Finish		= 1 kN/m^2

Total load = 7.375 kN/m^2

Factored load, W_u	= 1.5x7.375	= 11.0625 kN/m^2

Ultimate design moments and shear force: α_x=Bending moment coefficient in X-direction α_y= Bending moment coefficient in Y-directionα_x(-ve) = 00.05769(Hogging)

α_x(+ve)	= 0.04335 (Sagging)
α_y(-ve)	= 0.047 (Hogging)
α_y(+ve)	= 0.035 (Sagging)

Moment and shear force calculations

u x	M_{ux}(-ve)	$= \alpha_x W l^2$	= 5.743 kN-m (Hogging)
u x	M_{ux}(+ve)	$= \alpha_x W l^2$	= 4.316 kN-m (Sagging)
u x	M_{uy}(-ve)	$= \alpha_y W l^2$	= 4.679 kN-m (Hogging)
u x	M_{uy}(+ve)	$= \alpha_y W l^2$	= 3.484 kN-m(Sagging)

c) Check for depth:

$Mulim = 0.133 f_{ck} bd^2$

$11.0625 \times 10^6 = 0.133 \times 25 \times 1000 \times d^2$

d = 52.6 mm < 100mm, Hence safe

d) Reinforcements:

A_{st}min= 0.12% of gross area = (0.12x1000x125)/100 = 150mm^2 $M_u = 0.87\, f_y A_{stx}\, d\, [1 - \frac{Ast_x f_y}{bdf_{ck}}]$

A_{stx} = 149.154 mm^2<150mm^{2}Take A_{stx} = 150 mm^2

4) Hence provide 8mm Ø bars @ 200mm c/c in Short direction at top and bottom.

$M_u = 0.87\, f_y A_{sty}\, d\, [1 - \frac{Ast_y\, f_y}{bd f_{ck}}]$

d = 100-(10/2)-(8/2) = 91 mm

A_{sty} = 120.87 mm^2<150mm^{2}Take A_{sty} = 150 mm^2

5) Hence provide 8mm Ø bars @ 200mm c/c in Long direction at top and bottom.

Interior Panel

f_{ck}= 30 N/mm^2, f_y = 500 N/mm^2L_x = 3 m, L_y= 3.5 m

L_y/L_x =1.167< 2, Hence **design two-way slab**

L/d = 26

$f_s = 0.58 f_y = 0.58 \times 500 = 290$

Modification factor = 1.2

∴L/d = 31.2

Depth = (3000/31.2)= 96.153 mm

Overall depth D = 125mm, d=100mm

Assume 1000mm width

b) Loads:

Self-weight of slab	= 0.125X1X25	= 3.125 kN/m^2
Live load(Referring IS 875 part-II)		= 3 kN/m^2
Floor Finish		= 1 kN/m^2
Total load = 7.375 kN/m^2		
Factored load, W_u	= 1.5x7.375	= 11.0625 kN/m^2

Ultimate design moments and shear force: α_x=Bending moment coefficient in X-direction α_y= Bending moment coefficient in Y-directionα_x(-ve) = 0.04102 (Hogging)

α_x(+ve) = 0.03068 (Sagging)

α_y(-ve) = 0.032 (Hogging)

α_y(+ve) = 0.024 (Sagging)

Moment and shear force calculations

u x $M_{ux}(-ve) = \alpha_x W l^2 = 4.084$ kN-m (Hogging)

u x $M_{ux}(+ve) = \alpha_x W l^2 = 3.05$ kN-m (Sagging)

u x $M_{uy}(-ve) = \alpha_y W l^2 = 3.186$ kN-m (Hogging)

u x $M_{uy}(+ve) = \alpha_y W l^2 = 2.3895$ kN-m(Sagging)

c) Check for depth:

Mulim = $0.133 f_{ck} bd^2$

$11.0625 \times 10^6 = 0.133 \times 25 \times 1000 \times d^2$

d = 52.6 mm < 100mm, Hence safe

d) Reinforcements:

A_{st}min= 0.12% of gross area = (0.12x1000x125)/100 = 150mm^2 $M_u = 0.87 f_y A_{stx} d [1 - \frac{Ast_x f_y}{bdf_{ck}}]$

A_{stx} = 105.197 mm^2<150mm^2 Take A_{stx} = 150 mm^2

6) Hence provide 8mm Ø bars @ 200mm c/c in Short direction at top and bottom.

$M_u = 0.87 f_y A_{sty} d [1 - \frac{Ast_y f_y}{bdf_{ck}}]$

d = 100-(10/2)-(8/2) = 91 mm

A_{sty} = 81.707 mm^2<150mm^2 Take A_{sty} = 150 mm^2

Hence provide 8mm Ø bars @ 200mm c/c in Long direction at top and bottom.

IV. CONCLUSION

- ✓ This specific chapter is concerned with the remarkable outcomes of the current study carried. Distinct models with Floating columns and without Floating columns for various seismic zones for reinforced concrete structure have been modelled. And based on the limited studies the following conclusions can be drawn.
- ✓ From Joint Displacement along X direction it is observed that for the model 1 with floating columns and model 2 without floating columns for Seismic zone v, the Maximum Joint Displacement is for model 2 varying the percentage difference of 10 to 20% with model 1.
- ✓ From Joint Displacement along Y direction it is observed that for the model 1 with floating columns and model 2 without floating columns for Seismic zone v, the Maximum Joint Displacement is for model 2 varying the percentage difference of 10 to 20% with model 1.
- ✓ From Inter Story Drift along X direction it is observed that for the model 1 with floating columns and model 2 without floating columns for seismic zone v, the maximum Inter Story Drift is for model 2 varying the percentage difference of 10 to 20% with model 1.
- ✓ From Inter Story Drift along Y direction it it is observed that for the model 1 with floating columns and model 2 without floating columns for seismic zone v, the maximum Inter Story Drift is for model 2 varying the percentage difference of 10 to 20% with model 1.
- ✓ From Base Shear along X direction it is observed that the model 1 with floating columns and

model 2 without floating columns for seismic zone v ,the maximum Base shear is for model 1 varying the percentage difference of 10 to 20% with model 2.

- ✓ From Base Shear along Y direction it is observed that the model 1 with floating columns and model 2 without floating columns for seismic zone v ,the maximum Base shear is for model 1 varying the percentage difference of 10 to 20% with model 2.
- ✓ From the study it is found that, the structure with floating columns requires less cross sections of Frame object.
- ✓ Floating Columns in the High Seismic Zones should be avoided as it may effect in terms of displacement, Inter story drift, and base shear.

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