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STRUCTURAL RESPONSE OFFLAT SLAB STRUCTURE FOR SLENDER COLUMN

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ABSTRACT

Now a day's flat slab structural system take more attention due to its advantages and flexibility. When height of column increased for architectural flexibility then column called as slender column. Dynamic analysis is carried out on G+12 storied commercial buildings using ETABS software. 12 Models of G+12 commercial building having different panel sizes and column heights are created using ETABS software.These 12 models are of three different panel sizes with four various ground column height while the other columns height keep constant. Analysis gives the effect of parameters like Base shear, Storey Drift, Frequency of Structure and time period on Flat slab structure having slender columnit is observed that, when height of ground column increased then base shear, storey shear and frequency of structure get reduced. While in case of storey drift and storey displacements get decreased.

Keywords – Base Shear, Dynamic Analysis, Slender Column, Flat Slab, Time Period, Storey Drift

I. NTRODUCTION

A reinforced concrete flat slab is a slab supported directly by columns without beams and also known as beamless slab. It gives adequate strength and reduction in negative bending moment at support due to thickened close to the columns supporting to it. In metropolitan cities like Pune, Mumbai there are advantage to use the flat slab structural system but it may be damaged severely if design and analysed using only IS code with conventional practices. Hence necessary to know the seismic performance of flat slab structures under dynamic loading and designed with recommendations made using this analysis.

Slender column is one who's effective length to width (i.e. shorter c/s dimension) is greater than 12 then it is known as slender column. A slender column also called as long column. Due to axial compression slender columns get deflected. Due to this deflection failure may occurs, hence separate consideration of BM due to displacement and eccentricity in design required. If we consider load carrying capacity of short column then it is greater than that of slender column but in this advance construction world, increasing architectural requirements there is need to construct the structure taller. Adoption of proper design and analysis we can achieve this requirement.

Static analysis method is used by number of researchers to know about seismic response of flat slab structures. It is observed that, flat slab structures are sensitive to the earthquake excitation and proper dynamic analysis is necessary to investigate its performance under dynamic loading. Hence dynamic analysis using response spectrum method is carried out using ETAB software.

IJARSE
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II. OBJECTIVES

2.1 To analyse the flat slab structures having slender columns underseismic loading.

2.2 To know the effect of change in ground column height and panel size on seismic parameters.

2.3 To make guideline for design of flat slab structures.

III. MODEL DESCRIPTION AND ANALYSIS

3.1 Model Development

ETABS 2015 is selected for the study purpose. All twelve models created in ETABS are G+12 storied commercial building located at Mumbai having square shape. Floors consist of 5 panels in each direction having square shape. Models consist of square shape opening at the middle of structure with 230 mm shear wall in all direction. End condition of both column and shear wall assumed as fixed. Floor to floor height of building is 3048 mm except ground column height. The height of base column is increase by 760 mm from 3048 mm to 5334 mm. Use M25 grade concrete and Fe500 reinforcement. Assume cover for beam, column and shear wall as 25 mm, 30 mm, and 25 mm respectively. Take E = $2.5x10^3$ $N/mm^{2,}$ F_{ck} = 25 $N/mm^{2,}$$F_y$= $N/mm^{2.}$

3.2 Analysis

The 12 modelsof 3 different panel sizes with 4 ground column heights. Middle opening with 230 mm thick shear wall located in all four directions. The beam is provided to the outer periphery of the building as modification in structure. Other parameters used in study aretabulated as follows.

Table 1 Details Of Loading And Earthquake Parameter

Dead load (floors)	- 1 KN/m^2	Response Reduction Factor	- 5
Live load (floors)	- 2.5 KN/m^2	Importance Factor	- 1
Dead load (terrace)	- 2.5 KN/m^2	Damping Ratio	- 5%
Live load (terrace)	- 1.5 KN/m^2	Seismic Zone	- III
Diaphragm	- Rigid	Zone Factor	- 0.16
Type of Structure	- SMRF	Soil Type	- Medium (Type II)

Table 2 Details Of Flat Slab, Drop, Peripheral Beam And Mid Opening

Case No	Panel Size (mm)	Middle Opening (mm)	Slab Thk. (mm)	Peripheral Beam (mm)	Drop size (mm)	Thickness of drop (mm)
1	4600 x 4600	1500 x 1500	215	230 x 500	1500 x 1500	60
2	6100 x 6100	2000 x 2000	260	380 x 380	2000 x 2000	70
3	7600 x 6100	2500 x 2500	300	600 x 600	2500 x 2500	80

IJARSE
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Table 3 Details Of Columns

CaseNo	Position of column	Height of column at ground floor With 760 mm increment	Column size(mm)
Case 1	Corner columns	3048 mm to 5334 mm	300 x 385
	Edge columns	3048 mm to 5334 mm	385 x 450
	Inner Columns	3048 mm to 5334 mm	450 x 450
Case 2	Corner columns	3048 mm to 5334 mm	300 x 500
	Edge columns	3048 mm to 5334 mm	385 x 750
	Inner Columns	3048 mm to 5334 mm	450 x 600
Case 3	Corner columns	3048 mm to 5334 mm	300 x 650
	Edge columns	3048 mm to 5334 mm	350 x 1200
	Inner Columns	3048 mm to 5334 mm	450 x 850

3.3 Load Combinations

Load combinations used in analysis are as follows -

- 1.5 (DL + LL)
- 1.5 (DL ± EQx)
- 1.5 (DL ± EQy)
- 1.2 (DL + LL ± EQx)
- 1.2 (DL + LL ± EQy)
- 90 DL ± EQx
- 90 DL ± EQy

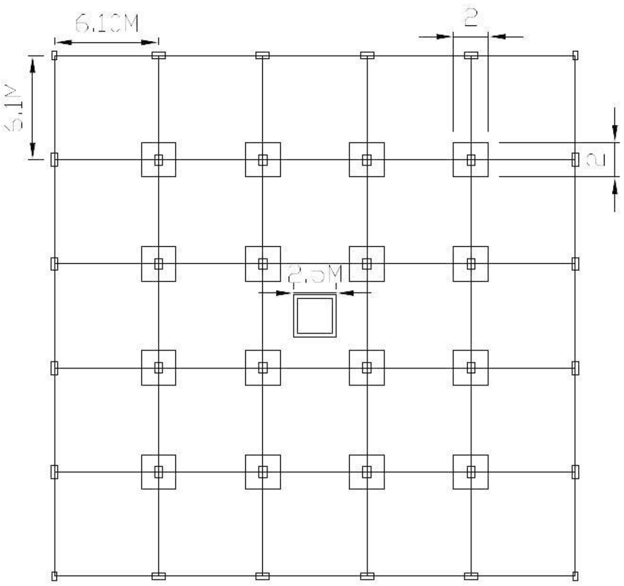

Fig. 1 Plan View Of G+12 Storey Structure Case 2 Used For Study

IV. VALIDATION OF SOFTWARE RESULTS WITH MANUAL CALCULATIONS

G+12 storied commercial building is analysed using IS: 1893-2002 and ETABS 2015 software. Time period used in manual calculation is taken from ETAB. Model of case 2 with column height 3048 mm is used for validation of software results. Dynamic analysis for Model in case 2 is done with use of parameters mentioned in model description and above tables.

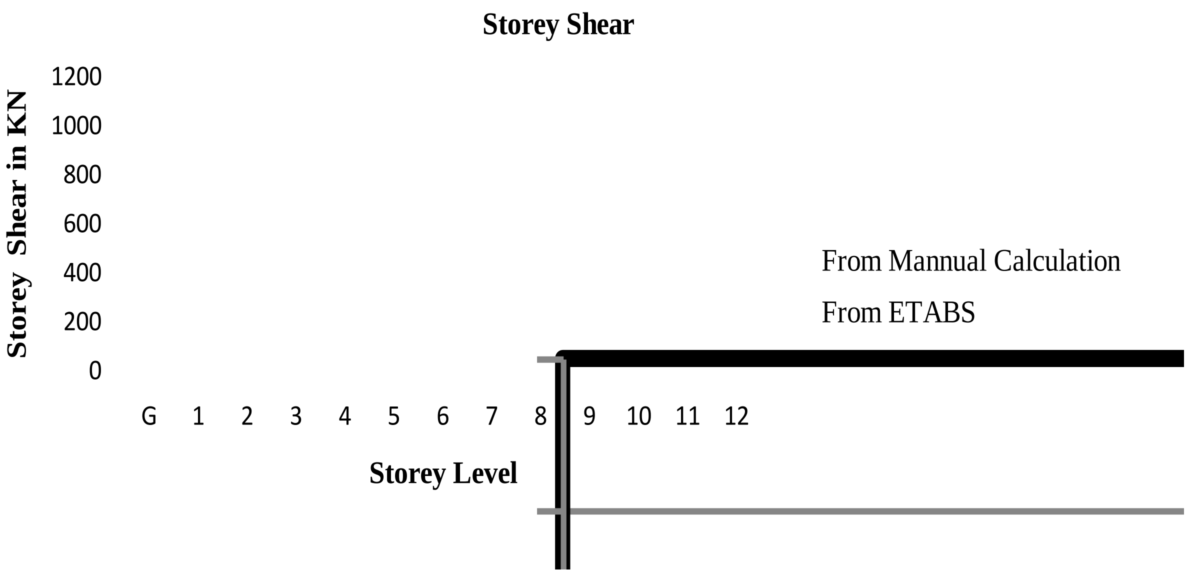

Fig. 2 Graphical Representation Of Storey Shear From ETABS And Manual Calculation

Base shear obtained from ETABS is 1085.34 KN and 1085.9 KN from manual calculation. There is 0.14% Difference Between the software results and manual calculation as shown in Figure 2. Hence software results are valid and can be used.

V. RESULT AND DISCUSSION

5.1 Effect Of Slender Column On Base Shear

A horizontal forces induced at the base of structure due to earthquake are known as base shear force. Base shear variation due to change in column height about ground floor by analysis using response spectrum method shown in table 4

Table 4 Effect Of Slender Column On Base Shear

Column Length at GL (m)	Base Shear (KN)			Avg. Decrease in base shear
	Case 1	Case 2	Case 3	
3.048	417.12	1085.90	1725.46	2.17 %
3.81	410.52	1069.21	1685.67	
4.572	398.76	1050.64	1646.78	
5.334	389.07	1025.23	1608.76	

Above table show the result of base shear. Base shear is decrease with increase in storey height for all cases. Similarly storey shear also varies with pattern like base shear. There is 2.17% decrease in base shear.

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5.2 Effect Of Slender Column On Storey Drift

Storey drift is a drift of one level of a multi-storey building relative to the level above or below. IS 1893 (Part 1): 2002 Clause 7.11.1 prescribes that the minimum storey drift shall not be exceeding 0.004 times the storey height.

Table 5 Effect Of Slender Column On Storey Drift

Column Length @ GL (m)	Storey drift (mm)			Avg. Increase in Storey drift
	Case 1	Case 2	Case 3	
3.048	0.220	0.153	0.168	11.6136%
3.81	0.248	0.178	0.195	
4.572	0.268	0.202	0.219	
5.334	0.275	0.228	0.241	

Change in storey drift is as per table no 5. For all cases we observe that, storey drift is increased with increase in height of column. Average increase in storey drift is 11.6136% is observed here.

5.3 Effect Of Slender Column On Storey Displacement

Storey displacement is the lateral displacement of the storey relative to the base. Total displacement of the building measured with respect to base is displacement.

Table 5 Effect Of Slender Column On Storey Displacement

Column Length @ GL (m)	storey displacement (mm)			Avg. increase in storey displacement
	Case 1	Case 2	Case 3	
3.048	20.5	19.4	18.0	2.8915%
3.81	21.2	19.9	18.2	
4.572	21.3	20.3	18.6	
5.334	23.1	21.4	18.9	

Storey displacement for all cases considered for study as shown in table 5. Average increase in storey displacement is 2.8915% and its increase with increase in storey height.

5.4 Effect Of Slender Column On Frequency

Frequency of any accelerating object is the number of oscillations completed by object per unit time. It is very important parameter in structural analysis. A modal analysis of structure, calculate the made shapes of that structure gives Eigen values and Eigen vectors.

Table 6 Effect Of Slender Column On Frequency

Column Length @ GL (m)	frequency (radian/sec)			Avg. Decrease offrequency
	Case 1	Case 2	Case 3	
3.048	2.2836	2.7911	3.50838	2.7332
3.81	2.2190	2.6952	3.4316	
4.572	2.1506	2.5950	3.3227	
5.334	2.0794	2.4841	3.2371	

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Change in frequency with change in ground column height is as shown in table no 6. we can conclude that frequency of structure in all cases is get reduced with increase in height of column. Average frequency of structure is 2.7332 (radian/ sec).

VI .CONCLUSION

From Response spectrum analysis of G+12 commercial flat slab structures we conclude that, Base shear of the structure reduced by 2.17% with increase in height of structure about ground column. Similarly storeys shear also increase with increased height. When height of structure increased, frequency of structure also decreased. Average frequency obtained is 2.7332 radians/ sec. In case of storey drift and storey displacement, it get increased by 11.6136% and 2.8915% respectively.

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