PARAMETRIC STUDY ON SLENDER COLUMN FOR FLAT PLATE STRUCTURE

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Abstract

This paper deals with effect of slender column on flat plate structure. The column is called slender if the height of is increased for functional purpose. The study is conducted on 18 flat-plate reinforced cement concrete (RCC) structural models. Among these18 models, 54 columns at three different locations (i.e. corner, edge and inner columns) are chosen for study. The models are developed using ETABS Software. Parametric study is performed by considering six different height of column ranging from 3048 mm to 6858 mm, using an increment of 762 mm along with three slab panels of size 4572 mm x 4572 mm, 6096 mm x6096 mm and 7620 mm x 7620 mm with five panels in both ways, considering both gravity and environmental load. The effect of slenderness ratio on load carrying capacity, design load and steel ratio is considered along with this the effect of additional moment due to slender compression member is also taken into account. It is observed that, columns in flat-plate structures are generally very sensitive if they are slender. It is observed that as the column length increases from 5502 mm and further, the steel ratio suddenly increases and it exceeds maximum allowed. As slenderness ratio increases, ratio of design load to the critical buckling load increases. Also resulting in increase of additional moment, decreasing load carrying capacity of column. This forces the design engineer to study effect of different parameter of the structure while designing high rise flat plate structure.

Keywords: *Flat Plate Structure, ETABS, Slenderness, Environmental load, design load and buckling load.*

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1. INTRODUCTION

The slender column is one having smaller cross sectional dimensions as compared to its length. In a structure, a slender column has less strength as compared to short column with the same sectional area. Due to this the slender column carries lesser load as compared to the short column. Generally in India the two type of structure is constructed such as beam-column frame structure and flat plat structure including sway & non sway frame.

Slender columns are those members whose ultimate load carrying capacities are affected by the slenderness effect, which produces additional bending stresses or instability of columns. Therefore, evaluation of a slender column involves consideration of the column length in addition to its cross section. The column having ratio of effective length to its list lateral dimension exceed or equal to 12 according to IS 456-2000 is treated as slender column.

The slender column is developed in multistoried structure due to increasing ground floor height for functional purpose or architectural purpose. On the other hand, the modern trend is towards taller and slender structures.

Flat plate buildings have been damaged on a very large scale, because these structure are analyzed and designed as per IS code. Hence it is required to evaluate actual performance of flat plate structure subjected to dynamic and gravity loads.

2. MODELLING AND ANALYSIS

2.1 Model Development

ETABS version 9.7.4 is chosen for the parametric study. All the flat-plate models consist of G+12 stories and are of a square shape building with opening at middle. Every floor consists of five panels in each direction and a shear wall at the middle of the building. The foundation for columns and shear walls are assigned as fixed support.

The ground floor is increased from 3048 mm to 6858 mm height with an increment of 762 mm for the parametric study purposes. The other story height is 3048 mm and kept unchanged in all structures and analysed.

The clear cover of concrete column is 30 mm. The compressive strength of concrete is 25 MPa. Strength of steel is 500 MPa and Modulus of Elasticity is 25000 (N/mm^2).

2.2 Problem Statement

The parametric study of 18 models (3 models for each floor panel size having 6 varying column lengths) is done for flat-plate structure with opening at the middle of building with tube shape shear wall of 230 mm thickness in core of the structure. Following are three cases of slab panel sizes designed by direct design method using IS 456-2000 and all slab depth is safe for shear.

Table -1: Parameters for parametric study (a)

Case	Floor panel size in mm@ opening size in mm x mm.	Slab Thick. in mm	Peri. beam size in mm	Drop panel size in mm @ thickness in mm
1	4572 x4572 @1524 x1524	215	230 x 500	1524 x 1524 @ 60
2	6096 x 6096 @3048 x 3048	260	380 x 380	2000 x 2000 @ 70
3	7620 x 7620 @ 3048 x 3048	300	600 x 600	2540 x 2540 @ 80

Table -2: Parameters for parametric study (a cont...)

Cases	Column position	Column length @ ground level in mm	Column size in mm
Case 1	Corner column	3048 to 6858 @ 762 increment	300 x 385
	Edge column	similar	385 x 450
	Inner column	similar	450 x 450
Case 2	Corner column	similar	300 x 500
	Edge column	similar	385 x 750
	Inner column	similar	450 x 600
Case 3	Corner column	similar	300 x 650
	Edge column	similar	385 x 1200
	Inner column	similar	450 x 850

Table -2: Earthquake Parameters (IS1893-2000)

1	Dead load on Terrace Floor	2.5 KN/m^2
2	live load on Terrace Floor	1.5 KN/m^2
3	Dead load on Remaining floor	1 KN/m^2
4	live load on Remaining floor	2.5 KN/m^2
5	Parapet Wall Load on beam	5.52 KN/m
6	Wall Load on Remaining beam	11.72 KN/m
7	Basic wind speed	44 m/sec
8	Type of Structure	SMRF
9	Seismic Zone	III
10	Type of Soil	Medium soil
11	Damping	5 %
12	Zone factor (Z)	0.16
13	Importance factor	1
14	Response Reduction Factor	5 (SMRF)

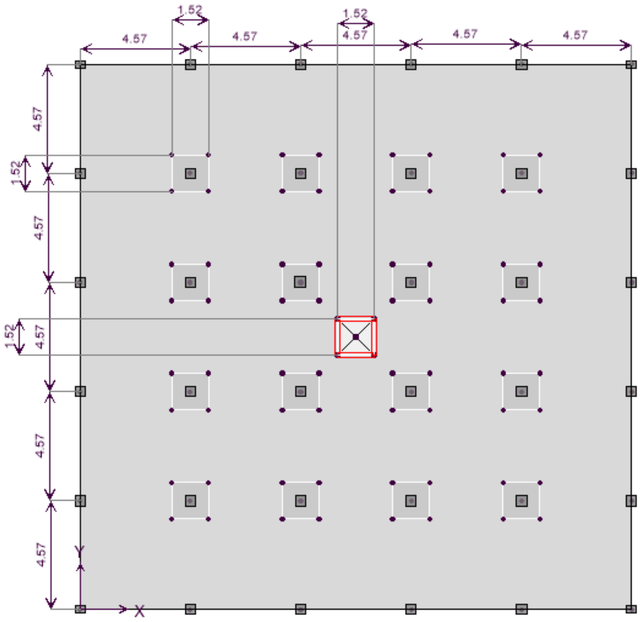

Fig -1: Plan of G+12 storied flat slabs building of case1 consider for study in ETABS

2.3 Load Combination considered for Study

Following load combinations are considered for study.

1) 1.5(DL+ LL)
2) 1.5 (DL ± Spect1)
3) 1.2 DL ± 0.3 LL ± 1.2 Spect1
4) 1.5 DL ± 1.5 WLX
5) 1.2 (DL ± LL ± WLX)
6) 0.9 DL ± 1.5 Spect1
7) 0.9 DL ± 1.5 WLX

3. VALIDATION OF RESULTS

For the validation of results, a G+12 storied flat slab building has been analyzed by the IS 1893-2000 code method manually and using ETABS v 9.7.4 software. The dynamic analysis is carried out for case1 with floor height of size 3048 mm for the entire floor. All parameters are defined in Table 1 and Table 2. The time period of 2.662 sec. (from ETABS) is used for manual calculation.

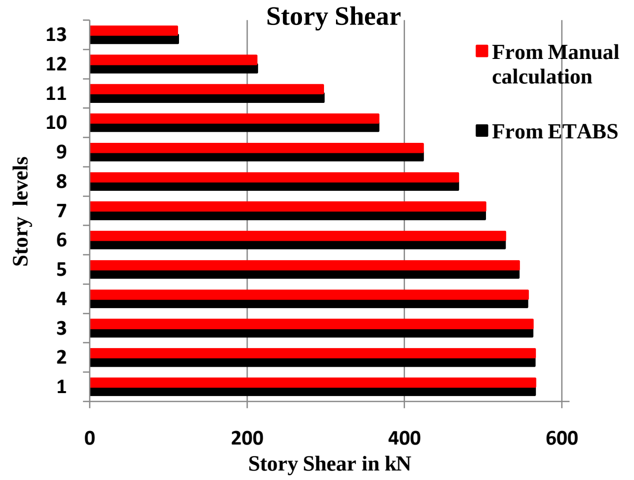

Chart -1: Variations of story shear for case 1

Table -3: Validation by software result

Parameters	From ETABS	From manual calculation	% of Error
Base Shear in kN	566.15	566.4974	0.06
Total Seismic Weight of Structure in kN	69260.56	69302.21	0.06

Result of Base shear obtained from manual calculation and from ETABS v9.7.4 is 566.4974 KN and 566.15 KN respectively. The percentage difference is 0.06%, hence results of software is valid.

4. RESULT AND DISSCUSTION

4.1 Effect on Column

Chart no. 2, 3,5,6,8 and 9 shows result of critical buckling load (P_c), design load (P_u), ratio of design load to the critical buckling load (P_u/P_c), and slenderness ratio for different cases. The end conditions, effectively held in position and restrained against rotation at one end and restrained against rotation but not held in position at other is provided, this end condition is considered for study in which effective length of column is taken as 1.2 x L.

The buckling load is calculate from following equation, where k is effective length factor, l is length of compression member, E is the elastic modulus of column, I is the minimum moment of inertia.

$$P_c = \frac{\pi^2 EI}{(kl)^2}$$

The slenderness ratio is calculated by following equation,

$$\lambda = \frac{l_{ex}}{D}$$

Where, λ is slenderness ratio, l_{ex} is effective length in respect of the major axis, and D is the depth in respect of the major axis,

4.1.1 Corner Column

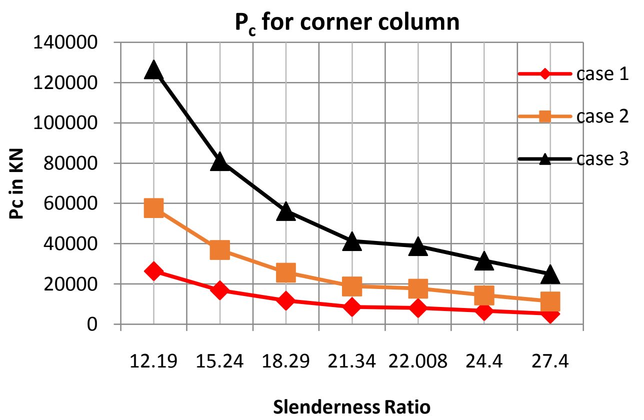

Chart-2: P_c load variation for corner column for all cases

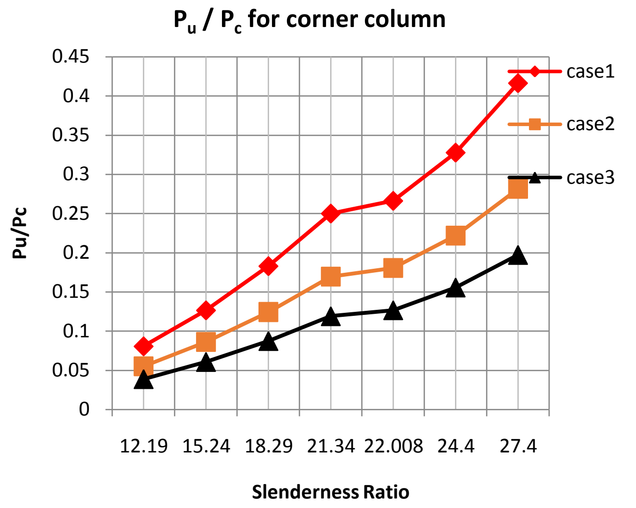

Chart-3: variation of P_u/P_c in corner column for all cases

According to (IS 456cl.39.7.1), the design of slender compression members shall be based on the forces and the moments determined from an analysis of structure, including the effect of deflection on moments and forces.

When the effect of deflections is not taken into account in the analysis, additional moment shall be taken into account in the appropriate direction. Following chart 4 shows additional moment in corner column due to slender effect from ETABS.

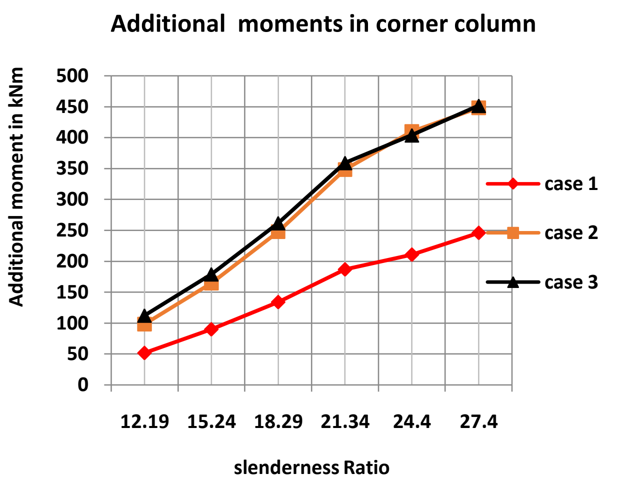

Chart-4: Additional moment in corner column for all cases

Closure

For all cases, corner column fails when slenderness ratio exceeds 22 and shows slender behavior while P_u increases about 29% of P_c. P_c decreased by 27.5% when slenderness ratio increases about 14.91% with P_u increased about 0.25% for all cases. When slenderness ratio increases by 14.91%, the additional moment due to slender compression member is increases by 24.90%.

4.1.2 Edge Column

The Edge column fails when slenderness ratio exceeds 17.15 while slenderness limit from IS 456 is given as 23.1.The column shows slender behavior when P_u increases about 29.22% of P_c. P_c decreased about 27.5% when slenderness ratio increases about 14.91% with Pu increased about 0.12% for all cases. Following chart shows variation of P_u and P_c on edge column.

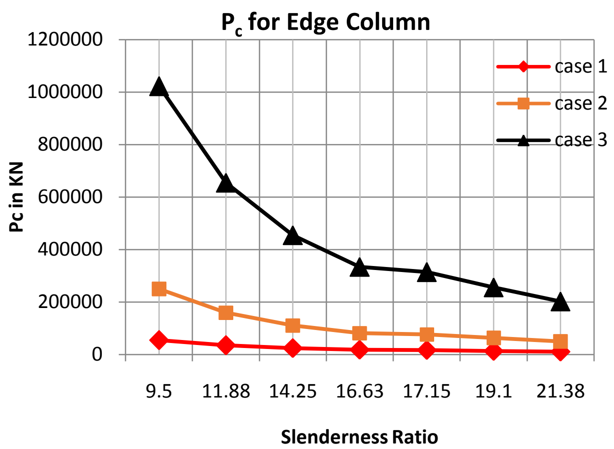

Chart-5: P_c load variation in edge column for all cases

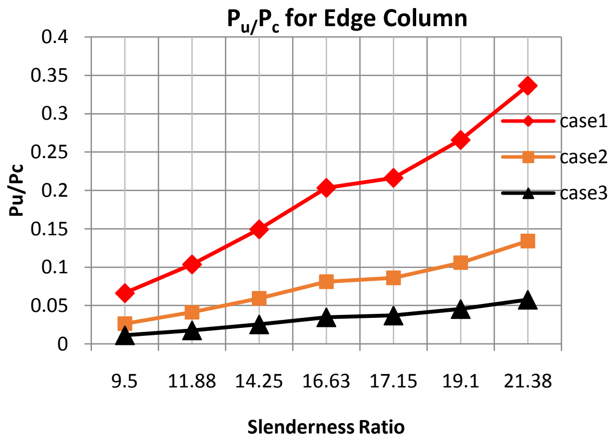

Chart-6: variation of P_u/P_c in edge column for all cases

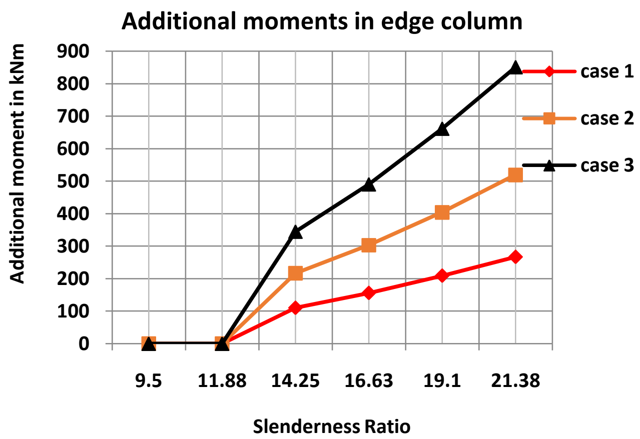

Chart-7: Additional moment in edge column for all cases

For slender edge column, the slenderness ratio increases by 12.64%, the additional moment due to slender compression member is increases by 25.534%.

4.1.3 Inner Column

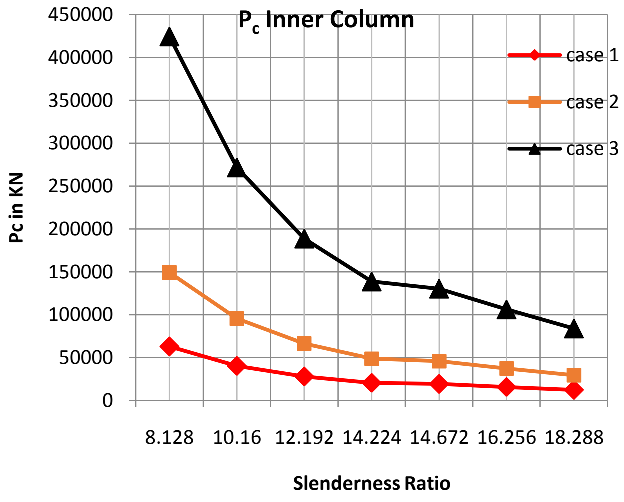

Chart-8: P_c load variation in inner column for all cases

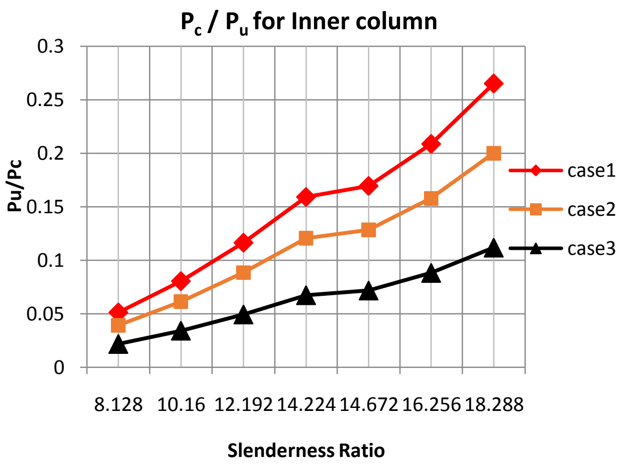

Chart-9: variation of P_u/P_c in inner column for all cases

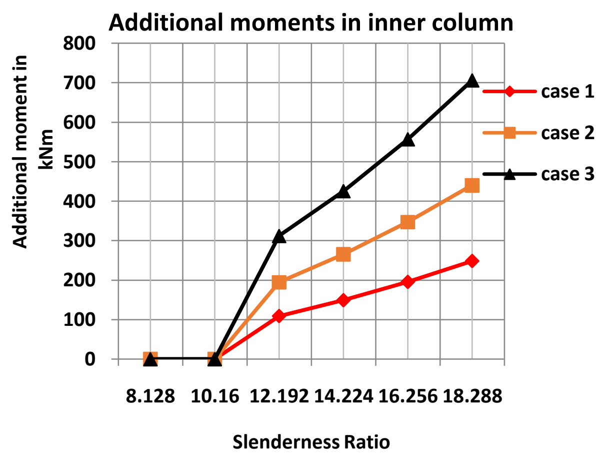

Chart-10: Additional moment in inner column for all cases

Closure

For case 3, inner columns fail when slenderness ratio exceeds 16.256. The column shows slender behavior when P_u increases about 26.26 % of P_c. When slenderness ratio increases about 14.91%, P_c decreased about 27.5% and P_u increased about 0.8% for all cases. For slender inner column, the slenderness ratio increases by 12.64%, the additional moment due to slender compression member is increases by 23.845%.An inner column for case 3 needs more attention than for same column in case1.

5. CONCLUSION

From the research work done as per above, following conclusion can be drawn, Design load increases about 30% of critical buckling load for all panels. The buckling load decreases by 27.5% along with increase in additional moments by 25%, when slenderness ratio increases about 14.91%.Thus in flat plate structure, corner and edge columns are more sensitive to slender effect than that of inner column. A corner column for all case needs more attention than edge and inner column.

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