International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.3, 2015

RESEARCH ARTICLE

ISSN: 2321-7758

COMPARATIVE STUDY OF FLAT PLATE STRUCTURE WITH RCC BEAM COLUMN STRUCTURE

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Article Received:12/05/2015 | Article Revised on:19/05/2015 | Article Accepted on:25/05/2015

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ABSTRACT

This paper deals with effect of slender column on flat plate structure and RCC beam column structure with 12 flat-plate and beam column Reinforced Cement Concrete (RCC) structural models. The comparative study of flat plate structure with RCC beam column structure is carried out. Among these 12 models, 6 models are of flat plate structure and remaining models for beam column structure are identified for study. The models are developed using ETABS Software. Parametric study is performed by considering six different lengths of column ranging from 3048 mm to 6858 mm, using an increment of 762 mm along with slab panels of size 4572 mm x 4572 mm with five panels in both ways, with both gravity and environmental load. The present objective of this work is to compare behavior of flat plate structure with beam column structure. It is observed that, the slenderness ratio increases with increasing story drift, displacement and time period along with decreasing stiffness ratio for both the structure. For this reason, a designer should study effect of different parameter while designing of high rise flat plate structure and beam column structure.

Keywords— Flat Plate Structure, ETABS, Slenderness, Environmental load, drift, displacement, time period and stiffness ratio.

INTRODUCTION

Generally in India two type of structure is constructed such as beam-column frame structure and flat plat structure including sway & non sway frame. In case of beam -column structure the load of slab is transfer to foundation through the beam and column but in flat slab the load is transfer directly to column is suitably spaced below the slab.

A flat slab is a typical type of construction in which a reinforced slab is built monolithically with the supporting column and is reinforced in two or more direction. Because exclusion of beam necessarily due to deflection control, slab thickness needs to be increased and due absence of beam a plain ceiling is obtained this gives an attractive appearance from architectural point of view.

The behavior of this type of structural system under gravitational loads is well established. The flat slab is often thickened closed to supporting columns to provide adequate strength in shear and to reduce the amount perimeter of the critical section, for shear and hence, increasing the capacity of the slab for resisting two-way shear and to reduce negative bending moment at the support.

Flat slab structures are significantly more flexible than traditional concrete slab under seismic loading. The flat slab structure gives benefits such as flexibility in room layout, saving building height, shorter construction time, ease of installation of M&E services, prefabricated welded mesh and buildable score.

MODELLING AND ANALYSIS

Model development

ETABS version 9.7.4 is chosen for study. All the models consist of G+12 stories and are 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 3048mm 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 500MPa and Modulus of Elasticity 25000 (N/mm^2).

Problem Statement

The parametric study of 12 models (2 models for each floor panel size having 6 varying column lengths) is done for flat-plate structure and beam column structure with a tube shape shear wall of 230 mm thickness in core of the structure. Following are two cases of flat plate structure and RCC beam column structure consider for study.

Case1. For flat plate structure (FPS) having 4.572 m x 4.572 m panel size.

Case2. For beam column structure (BCS) having 4.572 m x 4.572 m panel size.

Table -I: Parameters for parametric study (a)

Cases	Floor panel size in mm@ opening size in mm x mm.	Slab Thick. in mm	Peri. beam size in mm	Inner beam size in mm	Drop panel size in mm @ thickness in mm
Flat plate structure (F.P.S.)	4572 x4572 @1524 x1524	215	230 x 500	-	1524 x 1524 @ 60
RCC beam column structure (B.C.S.)	similar	135	230 x 380	230x450	-

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

Cases	Column position	Column length @ ground level in mm	Column size in mm
FPS	Corner column	3048 to 6858 @ 762 increment	300 x 385
	Edge column	similar	385 x 450
	Inner column	similar	450 x 450
BCS	Corner column	similar	230 x 380
	Edge column	similar	230 x 650
	Inner column	similar	230 x 750

Table- III: Earthquake parameters

Type of Structure	SMRF
Seismic Zone	III
Type of Soil	Medium soil
Damping	5 %
Zone factor (Z)	0.16
Importance factor	1
Response Reduction Factor	5 (SMRF)

Type of loading

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

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Load Combination Considered for study

Following load combinations are considered for study. Whereas DL is dead load, LL is live load, Spect 1and WLX is spectrum load and wind load in x direction respectively.

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

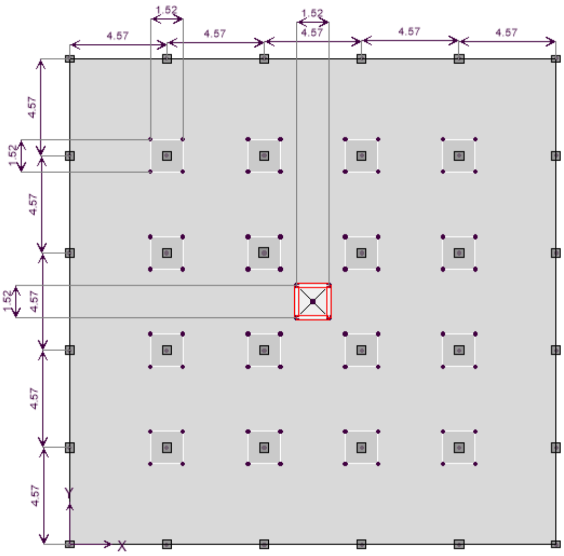

Fig. 1: Plan of G+12 storied flat slabs building of case 1 consider for study in ETABS

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 flat plate structure with floor height of size 3048 mm for the entire floor. All parameters are defined in table I, II and III. The time period of 2.662 sec. (from ETABS) is used for manual calculation.

Table- IV: Result of story shear for software validation

Story	Story Shear in kN From ETABS	Story Shear in kN From Manual calculation	% of Error
13	112.21	110.9085	1.15984
12	212.78	211.8696	0.42786
11	297.28	296.7049	0.19344
10	367.11	366.8168	0.07987
9	423.68	423.6074	0.01714
8	468.38	468.4789	0.02112
7	502.6	502.8337	0.04650
6	527.74	528.074	0.06329
5	545.2	545.602	0.07372
4	556.37	556.8199	0.08085
3	562.66	563.1299	0.08352
2	565.45	565.9344	0.08566
1	566.15	566.4974	0.06136

Result of story shear obtained from manual calculation and from ETABS v9.7.4 is same in nature. For base shear, the percentage difference is 0.061362%, hence results of software is valid.

RESULT AND DISSCUSTION

The Performance of Flat plate structure v/s RCC beam column structure

The purpose of the present work is to study the behavior of multistoried flat plat structure and compare with RCC beam column structures under seismic forces. For this purpose, 12 models of multistory buildings are considered. To study the behavior of both structures, the response parameters selected are drift and lateral displacement. All the RCC beam column structure models are of G+12 stories having a square shape building. Every floor consists of five panels in each direction with opening of 1524 mm x1524 mm at the middle of the building with shear wall of 230 mm thick. Following table 3 shows the different parameters for RCC beam column structure required for study. All other parameters consider for both the structures is same.

Drift and displacement

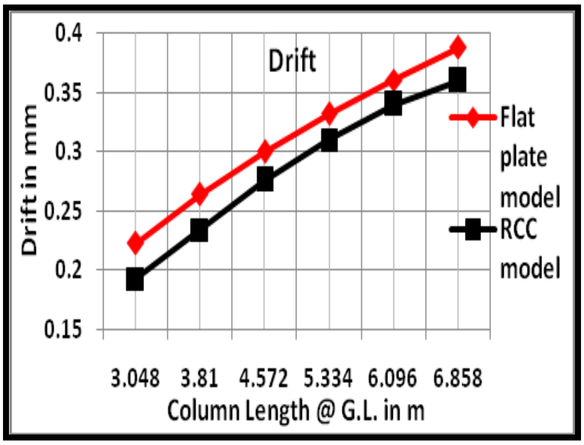

Fig. 2: variation of drift in FPS and BCS

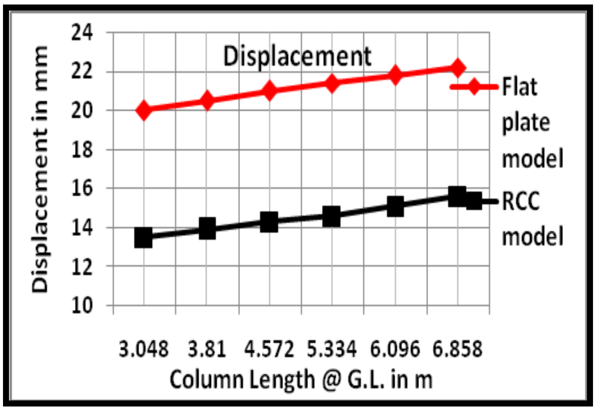

Fig. 3: variation of displacement in FPS and BCS

Closure

When slenderness ratio increases by 14.91% the maximum ground story drift of flat plate structure increases by 10% and that of RCC beam column structure increases by 11.62%. Slenderness ratio increases by 14.91% resulting in increase of 2% and 2.85% in maximum top storey displacement of flat plate structure and RCC beam column structure respectively. Both, drift and displacement are lesser in RCC beam column structure as compared to flat plate structure by 8.75% and 31% respectively

Stiffness Ratio

Stiffness ratio (S_r) is the ratio of bending stiffness of column to the bending stiffness of beam section.Whereas I_c and I_b is the moment of inertia of column and beam respectively, d is span length and h is height of story.

$$S_r = \frac{I_c \times d}{I_b \times h}$$

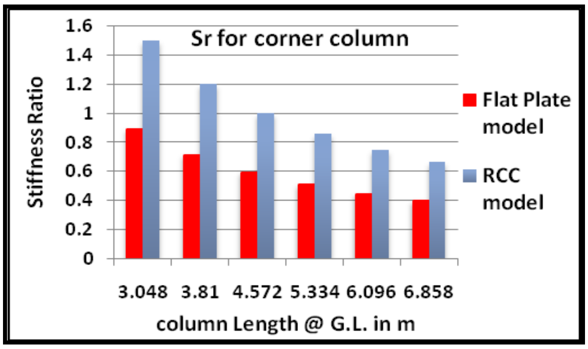

Fig. 4: variation of stiffness ratio for corner column in FPS and BCS

Closure

The stiffness ratio of corner and edge column decreases about 14.91% for both the structure, when slenderness ratio increases about 14.91%.

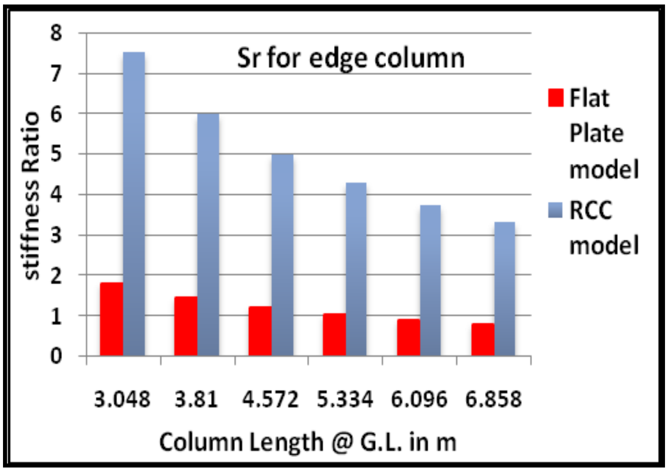

Fig. 5: variation of stiffness ratio for edge column in FPS and BCS

Time period

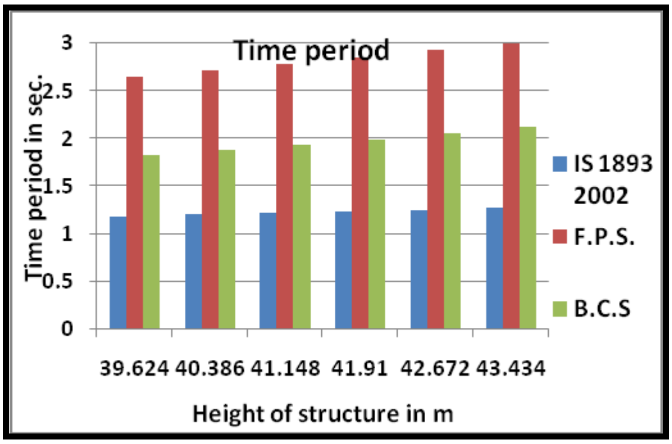

Fig. 6: comparison of time period between IS 1893 and ETABS

Closure

As height of building is increased by 1.81%, the time period from IS 1893 and from ETABS is increased by 1.36% and 2.67% respectively. The time period is greater in ETABS as compared to approximate time period in IS 1893-2002 by 47%.

CONCLUSIONS

From the research work done as per above, following conclusion can be drawn,

When slenderness ratio increases by 14.91%, the maximum ground story drift of flat plate structure increases by 10% and that of RCC beam column structure increased by 11.62%. This is because the stiffness of column decreases with increasing slenderness ratio. The values of the storey drifts for all the stories are found to be within the limit specified by IS code (IS: 1893-2002).

When slenderness ratio increases by 14.91%, the maximum top story displacement of flat plate structure increases by 2% and that of RCC beam column structure increased by 2.5 %.

The stiffness ratio of corner column and edge column decreases about 14.95% for both the structure when slenderness ratio increases about 14.91 % causing increase in shear lag effect.

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