Comparative Analysis of Composite and Regular Column Buildings under Seismic Loads

Siddalingaprasad Y. B[1], B. S. Sureshchandra[2]

[1]*M Tech, Department of civil engineering, Dr.Ambedkar Institute of Technology, Karnataka, India*
[2]*Associate professor, Department of civil engineering, Dr.Ambedkar Institute of Technology, Karnataka, India*

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Abstract –*Steel and composite steel – concrete structures are widely used in modern buildings, bridges, sports stadium, towers and off-shore structures. Composite structures are usually constructed by composite columns or steel columns and steel beams supporting composite slabs or concrete slab. It is noted that, steel is the most effective in carrying tension and concrete is most effective in resisting compression composite members make the best use of material properties. As earthquake load is most damaging natural hazards to the building. The design and construction of structures which is capable of resisting adverse effects, composite columns have high resistance under earthquake loading. The objective of this paper is to evaluate the comparison of composite columns with regular concrete column. This paper mainly emphasizes behavior of structure with different columns like fully encased, partially encased and rectangular concrete filled tube sections. It is observed that behavior of columns under lateral loading. Modelling and analysis of building is by using SAP2000. The results are compared and tabulated, compared and final conclusion are tabulated from the output of SAP2000. Various results are obtained. And these are evaluated by using various graphs.*

***Key Words:* fully encased column, partially encased column, concrete filled tube, SAP2000, Response spectrum Story shear, Base shear, Story drift**

1. INTRODUCTION

Composite columns use the advantages of both steel and concrete. The concrete encased with steel or concrete infilled columns are widely used in high rise buildings, and as beams in low rise industrial buildings. There are number of different advantages such structural system as structural, space utilization and speed of construction. The inherent buckling problems of thin walled steel tubes can be overcome by infilling concrete, optimum utilization of concrete by using strength in fully and partially encased columns. These members ideally suited for all application because of their effective use of materials. Fully encased columns are good in fire resistance, no need of form work for rectangular concrete filled tube sections. Provides high strength for given dimension and provides slenderness ratio, and more stiffness for column.

1.1 OBJECTIVE

- To compare the composite columns with regular column building.
- To find the structural behavior of columns with different columns.
- To compare base shear variation in different models
- Moments carried by columns.

1.2 LITRATURE REVIEW

Suman Adhikari, Mehabuba Begam. these two scientist worked on the topic "comparative study of different types of composite sections" published by IICST in 2015 composite members mainly steel concrete sections the main objective of this work to give idea about plot of flexural strength of column under normal load they taken three different composite columns namely fully encased section partially encased section and tubular sections, these columns are compared by providing varying steel percentage to the columns and also by comparing with different eccentric loading the results are compared and gave conclusion by small eccentricity by fully encased columns show high compression value and flexural resistance compared to tubular sections.

Tobia ZORDAN, Bruno BRISEGHELLA: They worked on nonlinear experimental response of non-conventional composite steel and concrete connection. An experiment was carried out on a set of full scale specimens of a non-conventional connection between a concrete column and a composite steel and concrete beam defined on the basis of a number of requirements. The proposed connection, conceived in the ambit of semi rigid joints, is aimed at combining general ease of construction with a highly simplified assembly procedure with a satisfying transmission of hogging moment at supports in continuous beams. An experiment was designed to test the mechanical properties of the connection. Three identical specimens were made. The geometric characteristics of the specimens are described. The paper investigated the response of an "easy to assemble" joint under uniformly increasing hogging moment. Its building method aimed to require the smallest number of skilled workers and to minimize the overall building yard time towards a general limitation of construction costs.

Furthermore, the layout proposed allows, as much as possible, the reduction of tolerance problems due to the connection between steel and concrete.

Piquer, D. Hernández-Figueirido: They both worked on the topic protected steel columns vs partially encased columns: Fire resistance and economic considerations this work contains column, this paper presents a comparison study between partially encased composite columns and I-shaped steel columns with and without protection. A range of geometric cross-sections and material properties have been tested and the Pareto frontier has been used to show the cheapest columns with the best performance This article carries out a comparison between PEC, non-protected and protected steel columns, evaluating the cost of different solutions for the same problem considering fire resistance of the column As it was expected, steel columns show poor performance in fire conditions and only 4.9% of the columns analyzed resist 60 min. The resistance of steel columns with protection and PEC columns is quite good at high temperatures. The percentage of columns resisting until 2 h in a fire environment is considerable In order to obtain the optimal solution, columns with the best performance in fire conditions, the Pareto frontier has been represented. The Pareto frontier is used in multi criteria decision-making, and is a subset of the feasible solution points with at least one optimized objective. They gave conclusion will be based on the results obtained, it can be stated that the behavior of rolled steel columns without any protection in fire conditions, is very inadequate: they are very expensive with poor performance at high temperatures. Protecting steel columns with commercial products with low thermal conductivity materials is suitable: all the feasible columns with protection resist 60 min and most of these columns could resist about 120 min before collapsing. Nevertheless, selecting an economical protecting materials is important. The economic cost of the column could be 7 times higher depending of the column configuration chosen.

1.3 METHODOLOGY

Response spectrum method is used as methodology**,** in the present study the modelling and analysis of the G+6 story regular concrete, fully encased, partially encased and rectangular concrete filled columns model are prepared by using SAP2000 software equivalent static and response spectrum analysis are adopted. In this building load transfer process is from slab to beam, beam to column, and columns to foundation, from foundation directly transfer to soil strata. Results are extracted like story displacement, story shear, base shear for different models like fully encased, partially encased, rectangular concrete filled columns and regular concrete models. Results are compared and graphs are plotted for the results for evaluation.

2. MODELLING

In the present dissertation work, G+6 stories of regular and composite models are taken, with a dimension 24m x 24m plan dimension.

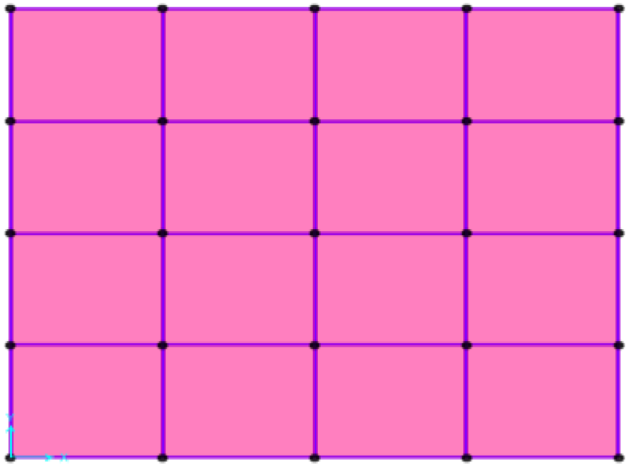


Fig -1: plan of the model.

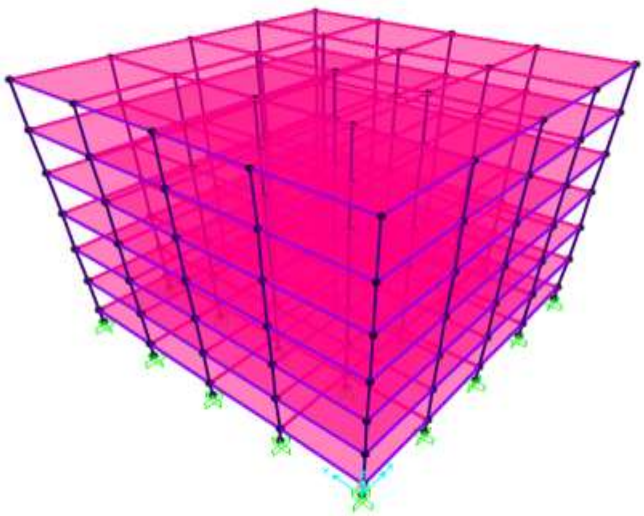
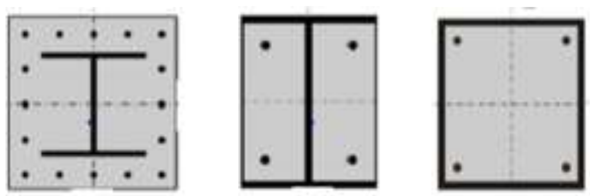


Fig -2: 3D view of model.



Fully encased partially encased concrete filled

Fig -3: different type's composite column sections.

Table -1: Details of material property and section properties

Material property and section property				
Section properties	Regular concrete	Fully encased	Partially encased	Rectangular tube
Grade of concrete	M-40	M-40	M-40	M-40
Grade of steel	Fe-415	Fe-415	Fe-415	Fe-415
Structural steel	-	Fe-345	Fe-345	Fe-345
Size of column	0.45x0.6 m	0.4 x 0.4 m	0.35 x 0.35 m	0.35 x 0.35 m
Size of beam	0.3 x 0.6 m	0.3 x 0.6 m	0.3 x 0.6 m	0.3 x 0.6 m
Reinforcement	16 # 20 dia	12 # 20 dia	8 # 20 dia	6 # 20 dia
Structural steel	-	ISHB 250	ISHB 350 With 350 mm flange	350 x 350 Tube with 9.7 mm thick

Table -2: Details of building and seismic loads

Building details		Seismic load details	
Building height	23.1 m	zone	III
Height of story	3.6 m	Soil type	medium
Span	6 m	Damping ratio	5%
No of bays	5	Importance factor	1
Type of support	Fixed	Response reduction	3

Load formulation

Various loads considered

- Dead load had been taken = 1.5KN/m² (IS 875 (part I) - 1987
- Live load had been taken = 4KN/m² (IS 875 (part II) – 1987
- Live load on roof = 1.5KN/m²
- Seismic load from IS 1893(part-1) -2002

3. RESULTS AND DISCUSSION

- Reduction in cross sectional area of column

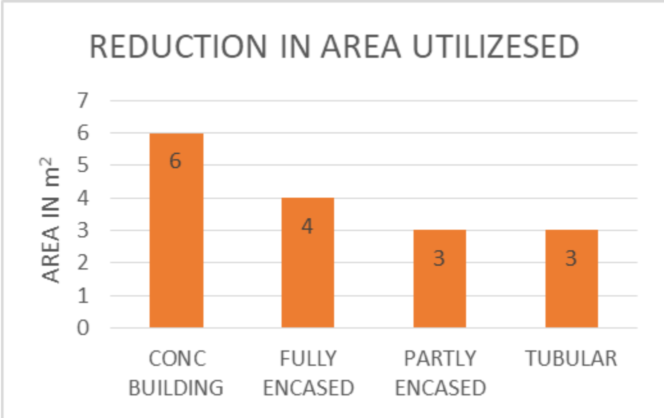


Chart -1: cross sectional area reduction

The total area acquired by columns in concrete column building is 6 square meter, this is almost 1.06% of the total are plan. Tubular composite column uses 3 square meter and this is just 0.53% of the total area of the building plan. Partially encased column uses 3 square meter of cross sectional area this is also 0.53% of the total plan area. Fully encased column uses 4 square meter of the area this is around 0.675% of the total cross sectional area.

- Story shear

Story shear of each model are computed with help of software

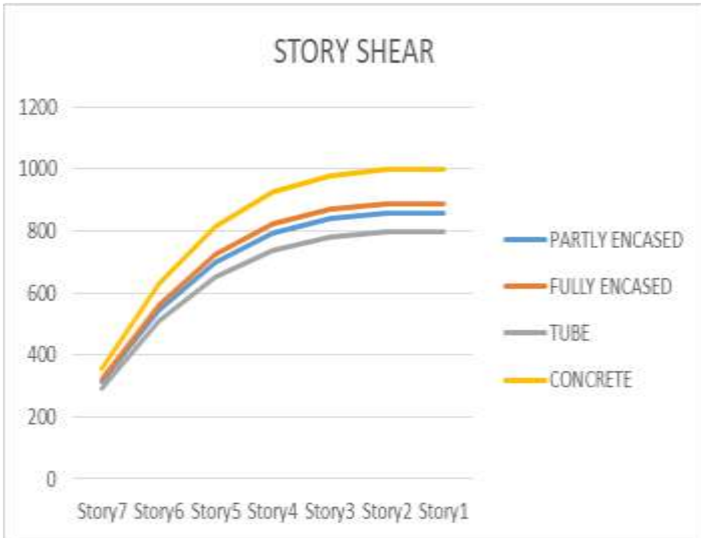


Chart -2: story shear comparison.

From the graph we can observe that story shear values for the building with concrete columns will show max story shear value compared to building having composite column. The building with tubular composite column will show less story shear and hence it is more stable to earthquake load. The building with fully encased and partially encased columns also provides less story shear value compared to concrete columns .From this discussion we will get clear idea about variation of story shear under different columns condition.

❖ Base shear

Base shear in different models like regular concrete building, fully encased, partially encased and rectangular tube columns are taken and compared.

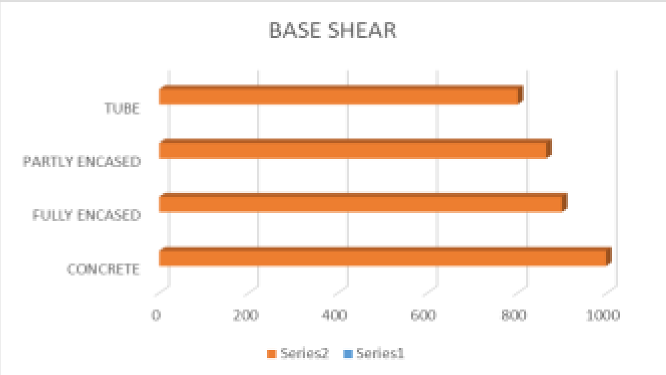


Chart -3: Base shear comparison.

From the chare it clearly shows that as the mass of the building increases base shear increases, in regular concrete column model due to high mass high stiffness base shear is comparatively high. Composite models are less in total mass of structure, shows less base shear and good performance with lateral loadings. Steel section in the composite columns shows ductility and reduces the effect of earthquake loads. Concrete filled rectangular tube columns shows best resistance under earthquake loads.

Story stiffness

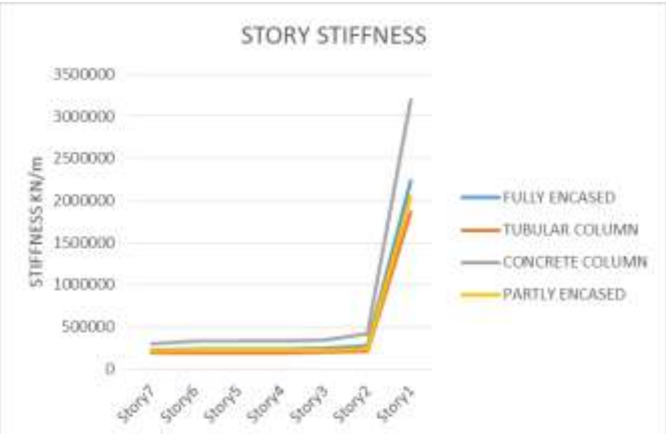


Chart -4: Story stiffness

From the below graph observed that the building having regular concrete column will show high stiffness value compared to composite columns. The building with rectangular tube column will show very less stiffness. The building with partially encased and fully encased columns moderate stiffness.

❖ Moment's comparison

Chart -5: Moments comparison

From above chart it is observed that high cross sectional area of columns attract more moments and less cross sectional area attract less moments. But composite column absorbs more moments in less cross sectional area. The difference in cross sectional area of column is 50% but moments attracted by composite columns are 70% of the capacity of regular columns.

4. CONCLUSIONS

In the present study, an attempt has been made to find which type of composite column is effective in lateral load resistance in seismic response spectrum analysis. The analysis is carried out in zone III the mode shapes corresponding to each mode are obtained

- The results shows that by using the partially encased and tubular column composite columns we save 50% of the total cross sectional area used by the concrete columns, in the same way by using fully encased columns we can reduce 37% of the total area used by the columns

- The building with concrete columns shows max base shear value due to high seismic weight of building. Rectangular tube structure having less base shear value. High story stiffness value of the building with concrete columns will act as rigid structure. Rigid structures attracts lateral forces and time period taken under earthquake load is less hence concrete column model get more base shear and get most affected to lateral loads.

- Composite columns building has less mass per story and provide more resistance to shear hence it shows very less story shear value these buildings are less affected to earthquake loads.

- Due to heavy sections and less tensile strength of concrete the building will show high stiffness. Due to this reason the building attracts more lateral load and get affected by earthquake load, by this base shear get increased to higher value. In the same way composite columns acts as flexural columns and more sustainable to earthquake load.

- But composite column absorbs more moments in less cross sectional area. The difference in cross sectional area of column is 50% but moments attracted by composite columns are 70% of the capacity of regular columns.

From the analysis results, it was conclude that composite columns performed better compared to regular concrete column building with minimum cross sectional area of column. These columns are suitable for all types of building,

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