Research Paper

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Development of Program and Parametric Study of Various Composite Columns

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ABSTRACT

Composite columns are in an increased usage for construction of high-rise and medium-rise buildings, bridges and other structures. With the use of composite columns, composite decking and composite beams, high-rise structures can be erected in an extremely efficient manner. In the present study, comparative study of Steel-Concrete composite columns with Steel columns is considered for the G+30 storied residential buildings. Various program developed in excel software for different types of composite columns. Three models are prepared considering concrete fully encased column, circular concrete filled steel column and square concrete filled steel column. A three dimensional modeling, analysis and design of all the structures are carried out with the help of ETABS 2013 software. Here, the main parameters of comparison are column sections provided, column axial force, column bending moments (Mx, My), support reaction, base shear, storey drift, storey displacement, quantities of concrete and structural steel and cost of the columns. The results are compared in the tabulated form and graphs are also prepared and found that composite columns are more economical.

INTRODUCTION

The construction of steel as well as composite structures is very low in India compared to other developing countries. The composite columns are economic, cost and time effective solution for high-rise and medium-rise buildings, bridges and other structures. Composite column is a column with two different materials or two different grades of material to form a structural member. Thus if it is adopted in India, could be very beneficial to the Indian community. Programs developed here provide facility for analysis and design of different types of composite columns. Standard tables like manuals also developed to facilitate easy design process.

OBJECTIVE

In India, many consulting engineers are reluctant to accept the use of composite Steel-Concrete structure because of its unfamiliarity, lack of provisions of IS guidelines and complexity in its analysis and design. But literatures say that if properly configured, then composite Steel-Concrete system can provide extremely economical structural systems with high durability, rapid erection and superior seismic performance characteristics. Also, the IS rolled steel sections available to serve as column section are not capable to take the load of such high-rise buildings which enforce the Indian structural engineer to use other countries' column sections.

COMPOSITE COLUMNS

A composite column is a steel-concrete composite member mainly subjected to compression and bending, comprising either a concrete encased steel section or concrete filled tubular section. Composite columns can be classified into two principle types: 1) Fully or partially encased in concrete and 2) Concrete filled steel hollow section. Fig. 1 shows the different types of composite columns.

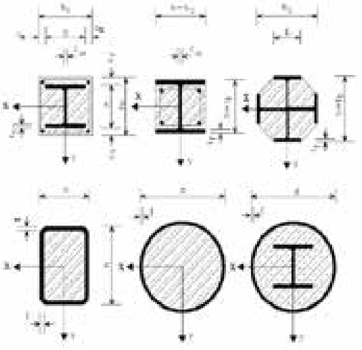

Figure 1: Typical sections of composite columns

MODELLING OF BUILDINGS

The steel and composite buildings are modelled using ETABS 2013 software. All the four models are kept identical in modelling and analysis except some points mentioned. The building plan is kept symmetric about both the axis. The building considered here is a residential building having G+30 stories and plan dimensions of 36m X 22.5m (see fig. 2 and 3). The height of the each storey is kept same as 3.0m and the total height of the building is kept as 96m.The depth of foundation below G.L. is kept as 3.0m and parapet height is kept as 1.0m. The slab thickness considered is 100mm. The thickness of external and internal walls is kept as 230mm and 115mm respectively. To reduce lateral forces, shear walls of thickness 230mm is provided at the corners of the building. The secondary beams are provided for the one way load distribution. The provision for lift is kept inside the building.

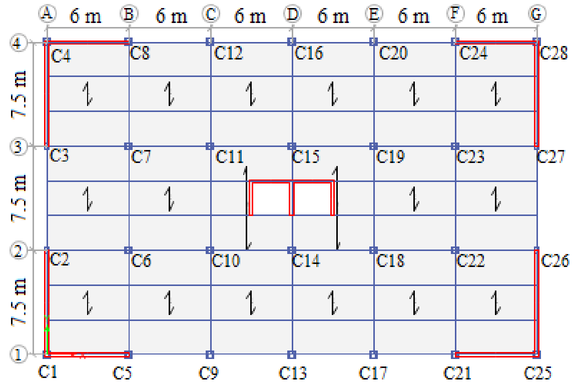

Figure 2: Plan dimensions of building

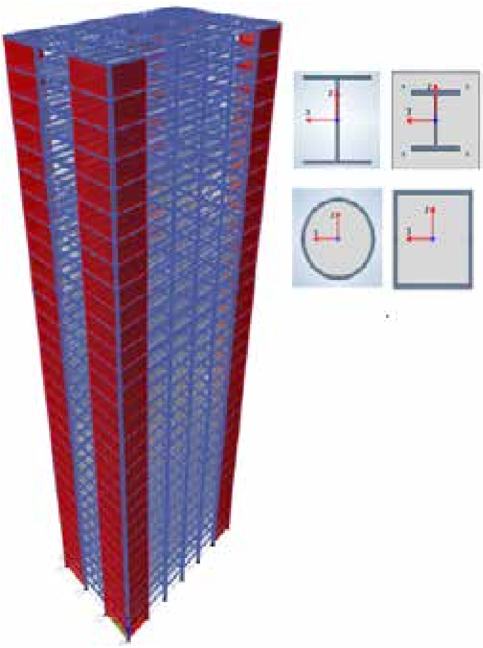

Figure 3. 3D model of building

ANALYSIS OF BUILDING
The building is located in the seismic zone-III and the provisions of IS: 1893 (Part 1) - 2002 is considered. For wind analysis, the provisions of IS: 875 (Part 3) – 1987 is considered. Also, the soil condition is considered to be medium. The response reduction factor is taken 5 for steel building and 4 for composite buildings and the importance factor is taken as 1.5 for both the structures. The live load is taken as 1.5 kN/m^2 for terrace floor and 2.0 kN/m^2 for typical floors and floor finishing is taken as 1.0 kN/m^2. The design load combinations are taken as per IS: 1893. The grade of structural steel is Fe250 while the grade of concrete is M30 except for composite columns it is M60.

DESIGN OF BUILDING
For designing Eurocode 3 is used for steel structure and Eurocode 4 is used for composite structures. Also in both the structures, the optimization of beam as well as column sections is done to have economy in cost of the structures. Column sections are optimized after every 10 stories.

RESULTS
The Steel-Concrete composite columns are compared with steel columns. Four columns are considered for the comparison, Corner column-C1, Side column-C2, Side column-C5 and Central column-C6.

TABLE - 1
COLUMN SECTIONS

Column No.	Floor	Steel	Fully Encased Section	Circular Tube Filled Section	Square Tube Filled Section
	G.F. to 10th Floor	H400X678	H400X314 (650X725)	D610X25	400X400X30
Type-1	11th to 20th Floor	H400X509	H320X300 (600X550)	D508X10	400X400X12.5
	21st to 30th Floor	H400X288	H260X225 (475X475)	D355X10	350X350X10
	G.F. to 10th Floor	H400X634	H400X262 (625X700)	D610X16	400X400X20
Type-2	11th to 20th Floor	H400X463	H260X172 (450X475)	D406X10	400X400X10
	21st to 30th Floor	H400X288	H260X93 (425X475)	D355X10	300x300x10
	G.F. to 10th Floor	H400X990	H400X288 (625X725)	D610X25	400X400X40
Type-3	11th to 20th Floor	H400X744	H260X225 (475X475)	D457X12.5	400X400X16
	21st to 30th Floor	H400X422	H260X114 (425X475)	D355X10	300X300X16
	G.F. to 10th Floor	H400X990	H400X509 (700X750)	D711X25	400X400X40
Type-4	11th to 20th Floor	H400X634	H320X300 (600X550)	D508X20	400X400X16
	21st to 30th Floor	H400X314	H260X142 (450X475)	D406X12.5	300X300X16

Fig. 4. Support Reaction

Cost of Concrete (M60 Grade): 8000 Rs Per m^3

Cost of Structural Steel (FE 250): 75 Rs per kg

Fig. 8. Cost (in Crores)

CONCLUSIONS
- The axial forces and bending moments are higher in composite columns as compared to steel columns.
- From the result tables, it is seen that the composite columns are more economical one as compared to steel columns.
- Also, if we compare the composite columns, the circular concrete filled steel columns are the most economical one.
- In case of circular concrete filled steel columns, confinement provided by the closed steel section to the concrete, develops a hoop-tension which increases the overall load-carrying capacity of the section.
- Composite columns possess increased strength and increased stiffness, leading to reduced slenderness and increased buckling resistance for a given cross sectional di-

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