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Design and Analysis of Multi-storey Building Using Composite Section

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Abstract
In the present study design and analysis and design of multi-storey RCC, steel, composite and structure with shear wall is done. To check the behaviour of composite structure various composite sections like encased I section, circular encased I sections and filled tube sections are considered. The design of multi-storey RCC, steel, composite and structure with shear wall is done using ETABS software. The various responses of the RCC structures are compared with the composite structure by keeping same column section. The considered responses are drift, displacement, stiffness, base shear and weight of the structure. The seismic analysis of the structure is done using linear dynamic method by considering SRSS method as per IS 1893 (Part-I): 2016. It is observed that displacement, drift, and base shear of composite structure is less as compared to steel and RCC structures and composite structures have more stiffness as compared to RCC and steel structures. The weight of composite structures is low as compared to RCC structures. But the weight of composite structures is high as compared to steel structures.
Keywords: *composite beam, composite column, encased I section, filled tube I section, circular I section, ETABS*

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I. INTRODUCTION

Composite construction in India is very low compared to other country. In other country composite construction is growing rapidly. composite building have same thermal expansion, an perfect combination of strengths with the concrete being efficient in compression and the steel being efficient in tension. Additionally, the concrete provides corrosion protection and thermal insulation to the steel at high temperatures. Finally, it can prevent slender steel sections from lateral-tensional buckling.

1.1 Element of composite structure

1. **Shear connector**
   Shear connectors are used to join structural steel and concrete, and they are crucial for steel-concrete construction because they combine the compression strength of supported concrete slabs with supporting steel beams to increase structural stiffness and load carrying capability. Shear connectors come in three basic categories: anchoring shear connectors, rigid shear connectors, and flexible shear connectors.
2. **Composite slab**
   A composite slab is a floor system made up of regular concrete that is permanently laid over a cold-formed steel deck, with the steel deck serving as both tension reinforcement during construction and a form work for the concrete at that time. The composite slab is made up of a profiled steel sheet and an upper concrete topping that are joined together at the end so that the steel-concrete interface can withstand horizontal shear force.
3. **Composite beam**
   A reinforced concrete slab is cast with shear connectors over a steel beam to create a steel concrete composite beam. Concrete slabs are simply positioned on top of and supported by steel beams in typical composite construction. Because there is no connection between the concrete and the steel beam, these two components behave independently when loads are applied. Steel beam and concrete slab function as a composite beam when a shear connector is installed between them, eliminating the slide between them. The composite beam can alternatively be built using precast or cast-in-place reinforced concrete slabs, profiled sheeting, and concrete topping.
4. **Composite column**
   A steel concrete composite column is a compression member made of either a hollow hot-rolled steel section filled with concrete or a partially concrete-encased hot-rolled steel section. It is typically utilised as a load-

bearing element in a structure with a composite frame. In a composite column, the bond and friction between the steel and concrete would interact to resist the external loading. High-rise buildings can be constructed very quickly and efficiently by using composite columns, decking, and beams. Increased strength, stiffness, and buckling resistance are all benefits of composite columns. High bearing is provided by partially concrete encasing.

II. LITERATURE REVIEW

(Suresh Kumawat & Kalurkar, 2014)

In massive civil structures like bridges and high-rise buildings, composite sections made of steel covered in concrete are a time, money, and cost-effective alternative. Due to the great ductility of steel, composite structures have sections that are more seismically resistant. Steel components may sustain multiple loading cycles before breaking and can be bent in a ductile way without premature failure. It is clear that a composite structure has a higher transverse and longitudinal storey stiffness than an RCC structure. In comparison to an RCC construction, the storey stiffness of a composite structure is 12% to 15% higher in the transverse direction and 6% to 10% higher in the longitudinal direction. In comparison to the RCC structure, the composite structure has a higher frequency and shorter time period due to its increased stiffness. The seismic forces are lowered by 15% to 20% because the dead weight of composite structures is found to be 15% to 20% lower than that of RCC structures**.**

(Shah & Pajgade, n.d.)

In the study and design of a G+15 story building with composite columns and R.C.C. columns, the deflection and story drift in the composite structure are about twice as great as that of the R.C.C. structure, but the deflection is within the permissible limit. R.C.C. constructions exhibit more axial and shear forces than composite structures. In some levels. The maximum bending moment of composite structure beams is slightly higher than that of R.C.C. structure.

(Charantimath et al., 2014)

R.C.C. is not a great material for high rise buildings, hence the composite option is preferred. Composite constructions weigh far less than RCC structures, which minimizes the price of the foundation. In all three global directions, it is clear from applying both seismic analysis approaches that nodal displacements in a composite structure are smaller than those in an RCC structure. This is so because a composite structure's members are more rigid than those of an RCC structure. Axial forces in columns have been reduced by an average of 24.55%, 27.28%, and 40.61% in composite framed structures compared to R.C.C. framed structures.Composite structures are more economical to build than RCC structures. The optimum solution is high-performance composite constructions.

(Kumar & Maru, 1063)

There are several ways and situations in which steel, RCC, and composite structures can be compared. However, I found that fire protection is essential in the instance of steel or composite structures. It might affect the design standards, like the nominal cover and slab thickness. In addition to hard soil, the conditions of the soil can also be changed and contrasted for worse cases. In India, such elements are typically not fully taken into account.

2.1 Objective

1. To Study the behavior of the stress-strain curve for composite section.
2. To compare the parameters like weight, base shear, storey displacement and storey drift, storey stiffness of R.C.C, Steel and composite structure.
3. Design framed with shear wall Structure.
4. To Analysis and design of RCC, Steel and composite Structure will be using linear dynamic method by considering SRSS method as per IS 1893 (Part-I): 2016.

III. DATA OF THE BUILDING

- Analysis of G+25 storey RCC, Steel and composite building and with shear wall building using 3 types of composite section Encased I section, Encased circular I section, filled tube section.

Table 1. Data of the RCC building

No of storey	G+25
Total area	30m x 30m
Length of Bays in X direction	6m
Length of Bays in Y direction	6m
Grade of steel	Fe500
Grade of Concrete	M30

Column dimension	1000 X 1000 mm
Beam dimension	600 X 600 mm
Slab thickness	150 mm
Shear wall thickness	300 mm
Floor Finish	1.5 kN/m^2
Wall Load	13.8 KN/m2
Live Load	3 KN/m2
Zone	3

Table 2. Data of Steel building

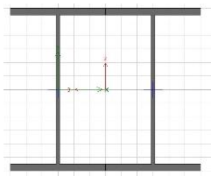
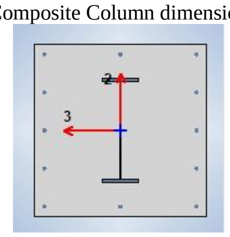
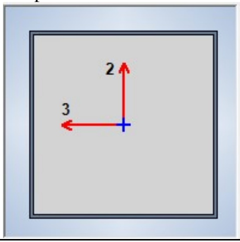
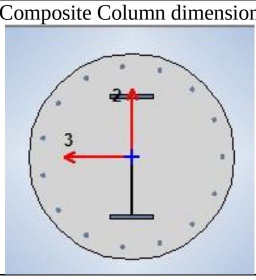
No of storey	G+25
Total area	30m x 30m
Length of Bays in X direction	6m
Length of Bays in Y direction	6m
Grade of steel	Fe500
Column dimension 	Depth = 600 mm,Top and bottom flange width = 300 mm, Top and bottom flange thickness = 25 mm, Web thickness = 12.5 mm
Beam dimension	Main Beam and Secondary beam ISMB 600
Deck Slab thickness	150 mm
Shear wall thickness	300 mm
Floor Finish	1.5 KN/m2
Live Load	3 KN/m2
Zone	3

Table 3. Data of Composite building

No of storey	G+25
Total area	30m x 30m
Length of Bays in X direction	6m
Length of Bays in Y direction	6m
Grade of steel	Fe500
Grade of Concrete	M30

Composite Column dimension 	Concrete section = 1000 X 1000 mm, Embedded I-Section ISMB 600
Composite Column dimension 	Total depth = 1000 mm, Total width = 1000 mm, Flange and web thickness = 20 mm
Composite Column dimension 	Diameter 1000 mm
Beam dimension	Main Beam ISMB 600
Deck Slab thickness	Composite Profile Deck Slab thickness = 150 mm, Thickness of concrete above Profile Sheet = 70 mm, Depth of Profile Sheet = 80 mm, Thickness of Profile Sheet = 1 mm, Diameter of Shear Stud = 19 mm, Height of Shear Stud = 130 mm
Shear wall thickness	300 mm
Floor Finish	1.5 KN/m2
Live Load	3 KN/m2
Zone	3

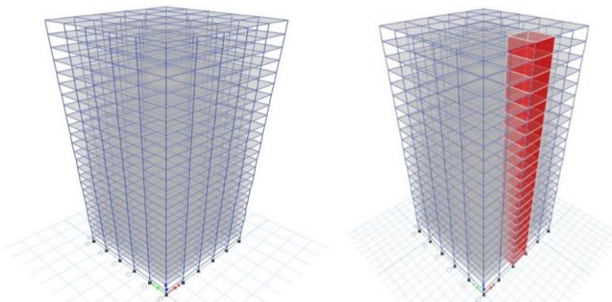


Figure 1: 3D view of RCC, Steel and composite building and with shear wall

IV. RESULT AND DISCUSSION

The research study aimed to analyze the behavior of an RCC, steel and composite structure and with shear wall building. The study compared the results of displacement, story drift, and stiffness the structure.

5.1 Displacement result

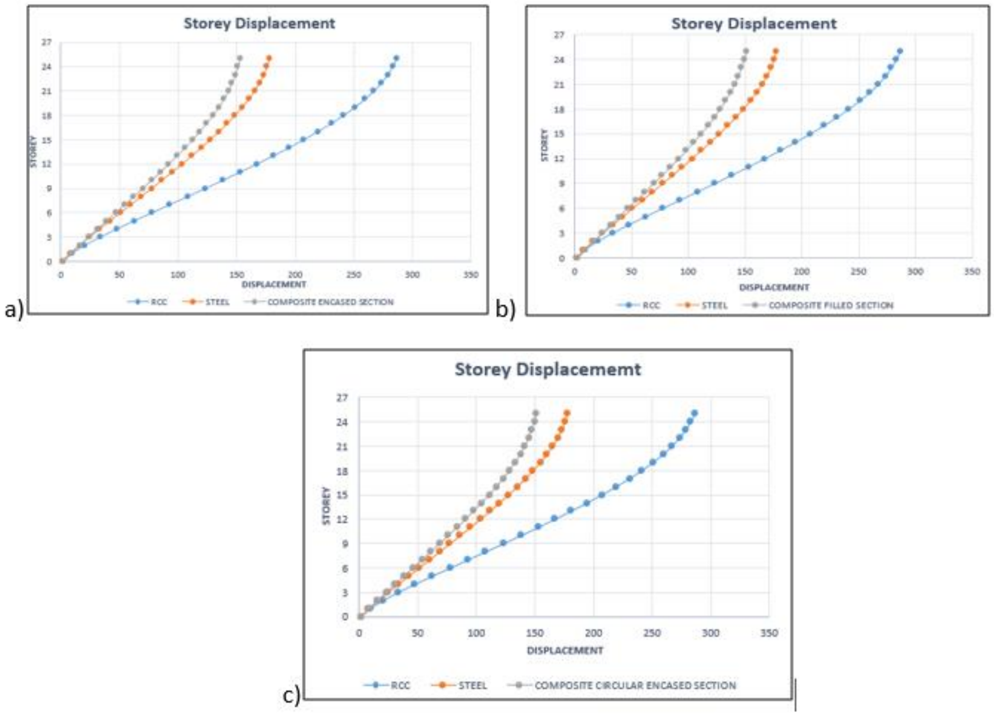


Figure 2 Comparison of storey displacement

In above all figures, Displacement in RCC structure is very high compared to steel structure, but steel structure displacement is slightly more than composite structure. Some floors in steel composite structures have similar displacements.

5.2 Drift Result

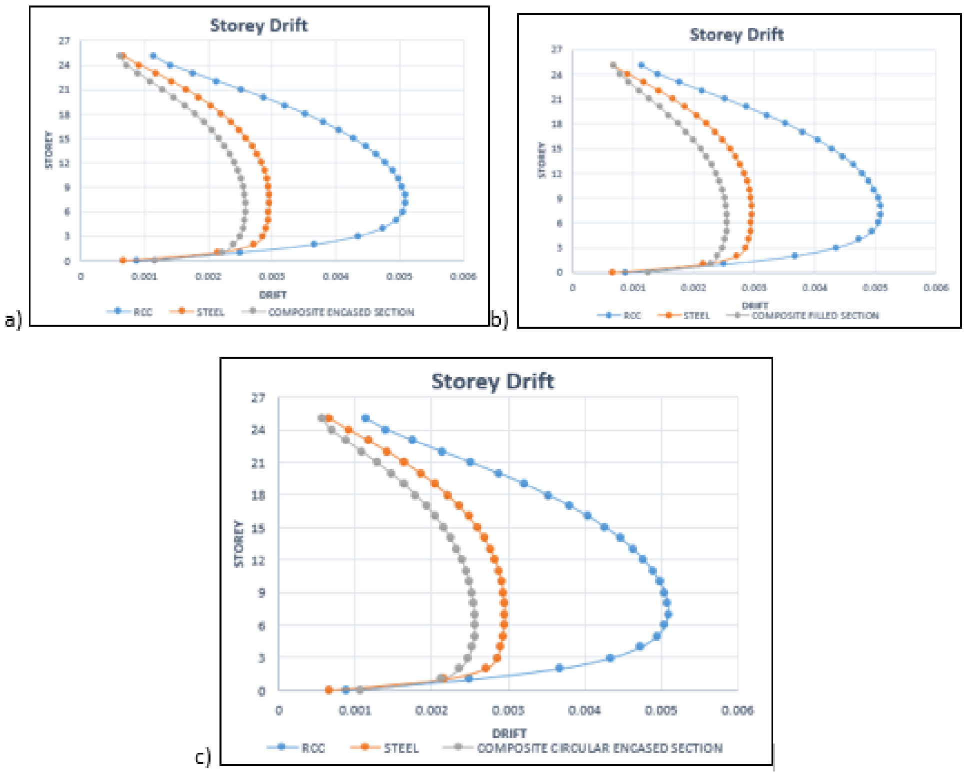


Figure 3 comparison of storey drift

In above all figures, Drift in RCC structure is very high compared to steel structure, but steel structure drift is slightly more than composite structure. Some floors in steel composite structures have similar drift.

5.3 Stiffness Result

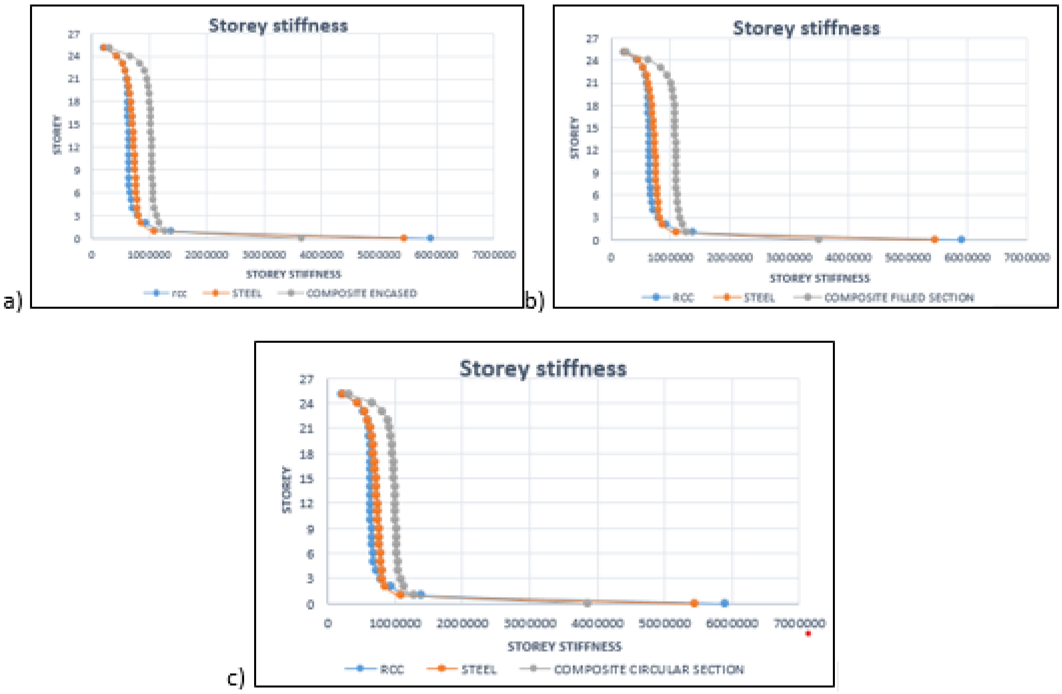


Figure 4 comparison of storey stiffness

In above all figures, stiffness in composite structure is very high compared to Rcc and steel structure, but steel structure stiffness is slightly more than Rcc structure.

V. CONCLUSION

From the above study it can be concluded that the

1. Displacement of Transverse direction in RCC Structure and Steel Structure vary between 30% to 37%. As similar way RCC Structure and composite Structure vary between 34% to 46% and Longitudinal direction RCC Structure and Steel Structure vary between 43% to 46%. As similar way RCC Structure and composite Structure vary between 47% to 53%.
2. RCC Structure displacement is more as compared to steel and composite Structure.
3. Drift in Transverse direction of RCC Structure and Steel Structure vary between 35.2% to 41.4%. As similar way RCC Structure and composite Structure vary between 47% to 49.5% and Longitudinal direction RCC Structure and Steel Structure vary between 44.18% to 47.2%. As similar way RCC Structure and composite Structure vary between 48.8% to 50.3%.
4. Drift in Composite Structure is low as compared to RCC and Steel Structure.
5. Storey Stiffness in Transverse direction of RCC Structure and Steel Structure vary between 0.4% to 2%. As similar way RCC Structure and composite Structure vary between 47.8% to 55.8% and Longitudinal direction RCC Structure and Steel Structure vary between 9.3% to 10%. As similar way RCC Structure and composite Structure vary between 23.3% to 25.2%.
6. Storey Stiffness in Transverse direction of RCC Structure and Steel Structure vary between 0.4% to 2%. As similar way RCC Structure and composite Structure vary between 47.8% to 55.8% and Longitudinal direction RCC Structure and Steel Structure vary between 9.3% to 10%. As similar way RCC Structure and composite Structure vary between 23.3% to 25.2%.
7. Storey Stiffness is high in Composite Structure as compared to RCC and Steel Structure.
8. Base shear of RCC Structure is more than the Steel Structure and composite Structure.

Weight of RCC Structure is high as compared to composite Structure and Weight of Composite Structure is high as compared to Steel Structure.

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