

## Analysis of Pre-fabricated Residential Building Considering Earthquake Zone-II

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Received: 22nd October 2019, Accepted: 20th November 2019, Published: 31st December 2019

### Abstract

Steel-Concrete composite construction are assembly of steel beam, concrete floors and profile sheets by achieving the shear connection with the help of mechanical shear keys. Composite structure is very famous now days as they provides structural efficiency with rapid and also provides affordable wide range of structures. In this study, composite structure and reinforced concrete structures are considered for study of G+4 residential building. This building comes in earthquake zone II. Equivalent Static Method of analysis is used. For modelling of Composite and reinforced concrete structures, Results were analysed in STAAD.pro software and compared for displacement, S.F. and B.M. The displacement in top storey, bottom storey and 3<sup>rd</sup> storey is more in reinforced concrete as compared to composite structure. The bending moment in top storey, bottom storey and 3<sup>rd</sup> storey is more in reinforced concrete as compared to composite structure. Similarly shear forces and axial forces were compared for reinforced concrete building and composite building.

### Keywords

Pre-fabricated Building, Composite, Shear Connectors, Shear Force, Axial Force, Displacement

### Introduction

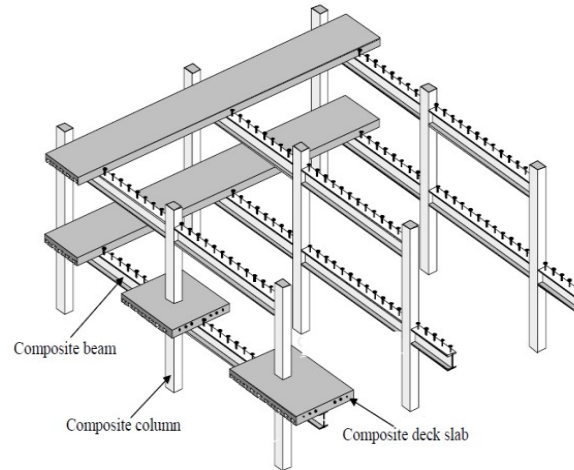
India is a developing country as enormous house building development is occurring in different parts of the country. Since 30% of Indian populace lives in towns and urban communities consequently development is more in urban spots. The prerequisite of shelter is gigantic yet there will consistently be a lack of house accessibility as the present development innovation can't satisfy the rising need each year. Subsequently one needs to think for elective development framework like pre-built steel structures. Subsequently one needs to think for elective development framework like pre-built steel structures.[2] India has an introduced steel limit of 35 to 40 million tones and clear steel utilization is around 27 to 30 million tonnes. There is a surplus limit of level steel items accessible in India especially of hot and cold moved sheets. These steel parts can be used in the development of pre-built structure segments. In India, fortified solid individuals are generally utilized in the confining framework for the vast majority of the structures since this is the most advantageous and financial framework for low-ascent structures. These steel parts can be used in the development of pre-built structure segments. In the pre-built structure idea, the total planning is done at the processing plant and the structure parts are brought to the site in knockdown condition. These parts are then fixed/jointed at the site and rose with the assistance of cranes. The pre-built structure calls for extremely quick development of structures and with great stylish looks and quality development. Pre-built Buildings can be utilized widely for development of modern and private structures. The structures can be multi-celebrated (4-6 stories). These structures are reasonable for different natural perils. This study was carried out to give a concise depiction of various components of steel concrete framework for structures, to examine the cost-adequacy and duration of G+ 4 residential building projects of composite frames over conventional reinforced concrete frames for buildings. Analysis was carried out by using STAAD.pro and deflection, axial forces, maximum bending moment of different components of the building was carried out.

**Pre- Engineering Composite Building:** The primary structural component used in composite construction consists of profiled steel deck slab, composite beams and columns, shear keys and shrinkage reinforcement as shown in figure 1.

**Composite Deck Slab:** Composite slab consists of profiled steel deck, concrete, shear connectors, intermediate stiffeners, temperature reinforcement and steel beams. They are assembled together to get a very rapid and cost effective slab by utilising best properties of each component to optimize construction techniques. These profiled steel sheets act as a tensile reinforcement as well as permanent formwork for concreting. The profiled steel sheets are used to lay on built-up steel beam by connecting them with the help of shear connectors. The composite floor works as permanent formwork giving solidness to the general structure framework while appropriating wind and seismic shears to the horizontal load resisting systems.[11]

**Composite Beam:** In regular composite development, solid slab rest over steel beam support. Under load, these two parts act autonomously and a relative slip happens at the interface if there is no shear connection between them. With the help of proper shear connection, this slip can be resisted and structure can behave partially connected. In spite of the fact that steel and cement are the most usually utilized materials for composite

members, different materials, for example, pre-stressed concrete and timber can likewise be utilized. It is very well known that concrete is weak in tension and steel is weak in buckling. By the composite activity between the two, both materials strength can be utilized properly. For the most part in steel-concrete composite beams, steel beams are indispensably connected with pre-assembled or cast in situ strengthened concrete slabs.



**Figure 1: Steel-Concrete Composite Frame**

**Composite Column:** Steel-concrete columns are axial or compression members, involving both of a solid encased hot rolled steel section or a filled hollow segment of hot rolled steel. It is commonly utilized as a load bearing component in a composite confined structure. Composite individuals are for the most part exposed to compression and bending. At present, there is no IS code covers the guidelines of the composite compression members. IS 11384-1985 IS 11384-1985 for composite construction doesn't make a particular reference to composite sections. For this study European code-part 4 was used, which consolidates the most recent research on composite development. This strategy likewise receives the European clamping bends for steel sections as a fundamental of segment structure.

**Shear Connector:** Shear keys or connectors play a critical role in profiled deck composite slab. These keys are provided throughout the length of the slab as well as at the supports. Main functions of these shear keys are to enhance the shear bond between steel sheet and concrete and transfer longitudinal shear along the steel concrete interface.[8,10] As per IS: 11384-1985 there is three main types of shear connectors; rigid shear connectors, flexible shear connectors and anchorage shear keys. The total shear force at the interface of concrete and steel beam is around 8 times the total load carried by the beam. Mechanical shear keys are suitable for shear bond connection.

### Methodology

**Case Study:** Live prefabricated project of Shrinivas Eco home Pvt. Ltd. was considered for the study and analysis. Project was affordable prefabricated demo building situated in Nandanvan, Nagpur. It was essentially a pre-assembled G+4 residential framed steel structure as shown in figure 2. The total build-up area of a building was 2682 sq. feet. It consisted of 16 flats having carpet area of 465 sq. feet of each flat. Every flat was 1 BHK and total height of building was 17.5 m. Square stepped footing of 3.5 m depth was constructed. This project was completed in 3 months.

**Column:** Column and beams were made up of steel which was prefabricated and imported from China. I-sections were used for column and beams of same nominal size as used in RCC structure as shown in figure 3. The columns and beams were having zinc-rich anticorrosive coating to protect them from corrosive agencies. Bolted connections were used.



Figure 2: Pre-Engineered Residential Building, Nagpur

Figure 3: Composite Frame Assembled at Site

**Slab:** Slabs were made up of galvanized profiled steel sheet of 0.8 mm thickness. These sheets were used as tensile reinforcement and they also acted as permanent formwork during construction of slab. The steel reinforcement was of Fe 500 grade with main bar of 10 mm and distribution bars of 8 mm. Total thickness of slab was 150 mm.

**Wall:** Wall panel has used in building rather than brick masonry. There were two types of panel one was male panel and another was female panel. Magic bond was used to fill the wall joint. Magic bond consisted of thermocol, 70% fly ash, 22% cement, 7-8% Lime, 1-2% gypsum. The size of panel was 2x8 feet having weight of 160 kg and load bearing capacity 3 tons. External walls were 150 mm thick and internal walls were 90mm thick. U-groove was used to clamp the panel to the column and beam. Calcium silicate coating was used over the panel.

**Staircase:** Doglegged staircase of mild steel which was prefabricated was used over which 50 mm mortar laid and then fixed.

As there are no IS codes [3-6] available for the of design pre-engineering or pre-fabricated buildings. Composite profiled slabs are designed based on limit state method by referring International codes such as BS 5950-part 1, [1] part 2 and part 3. IS 456:2000 [7] was followed wherever it was applicable as which follows limit state philosophy. The design had guaranteed a sufficient degree of safety and serviceability of structure. The structure checked for ultimate and serviceability limit states. STAAD.pro.V8i software was used for the analysis of the building. Different parameters such as deflection, shear force & bending moment were studied for the models.

## Results and Discussion

**Cost & Time Analysis:** Table 1 to 4 shows the cost estimation for one member of both the frames.

Material	Rate	Quantity		Amount	
		RCC.	C.B.	RCC.	C.B.
Steel	Rs. 40/Kg	112Kg	103 Kg	4480	4360
Concrete	4500/m <sup>3</sup>	1.12m <sup>3</sup>	.075m <sup>3</sup>	5040	3375
Formwork	80/m <sup>2</sup>	9.28m <sup>2</sup>	-	743	-
	Total			Rs.10263	Rs.7735

Table 1: Cost Analysis of Slab

Material	Rate	Quantity		Amount	
		RCC.	C.B	RCC.	C.B.
Steel	Rs. 40/Kg	76Kg	140 Kg	3040	5600
Concrete	4500/m <sup>3</sup>	.25m <sup>3</sup>	-	1125	-
Formwork	80/m <sup>2</sup>	7.18m <sup>2</sup>	-	575	-
	Total			Rs.4740	Rs.5600

Table 2: Cost Analysis of Beam

Material	Rate	Quantity		Amount	
		RCC.	C.B	RCC.	C.B.
Steel	Rs. 40/Kg	108Kg	158Kg	4320	6320
Concrete	4500/m <sup>3</sup>	0.4 m <sup>3</sup>	-	1800	
Formwork	80/m <sup>2</sup>	10.24 m <sup>2</sup>	-	820	
	Total			Rs.6940	Rs.6320

Table 3: Cost Analysis of Column

	RCC Building	Composite Building
Total cost of Single element	Rs.21943	Rs.19625
Difference	Rs.2288	
Percentage Profit	10.42%	
Time of Completion of project	9 months	3.5 Months
Time saved	5.5 Months	
Percentage of time saved	61.11%	
Direct Cost of G+4	Rs.12000000	Rs.10500000
Profit By Rent		Rs.-528222
Grand total	Rs.12000000	Rs.9971778
Saving	Rs.2028222	
Total Percentage Of Saving	16.91%	

Table 4: Comparison of Cost and Time Analysis of R.C.C. and Composite Building

Deflection versus height of the building for reinforced concrete structure and composite structure was plotted and it can be seen from figure 4 that the deflection in composite structure is nearly 2 times than that of reinforced concrete structure and is in permissible limit. Figure 5 and 6 show that the S.F. and axial force in reinforced concrete structure is greater than composite structure. Figure 7 shows that there is remarkable fall in bending moment of axial member in composite structure.

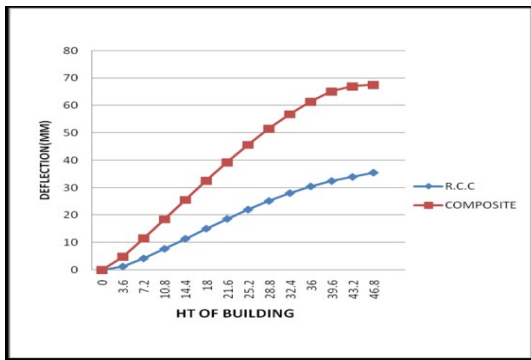


Figure 4: Deflection Versus Height of the Building for R.C.C. and Composite Structure

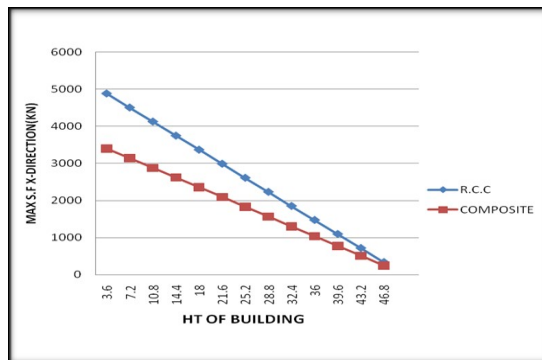


Figure 5: Maximum Shear Force of R.C.C. and Composite Structure in x-Direction

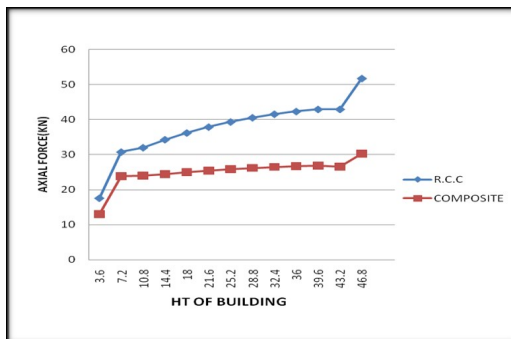


Figure 6: Comparison of Axial Force in R.C.C. and Composite Structure

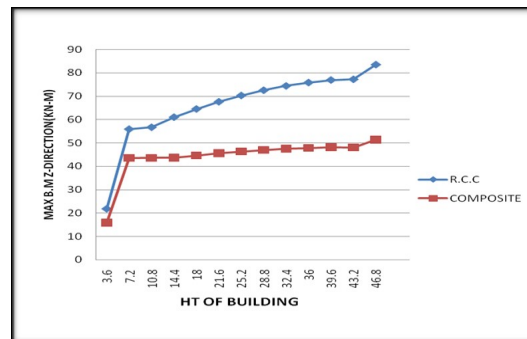


Figure 7: Maximum Bending Moment of Column (R.C.C. and Composite)

### Conclusions

From the above research it can be said that the deflection in top storey, bottom storey and 3rd storey is more in reinforced concrete structure as compared to composite structure. The bending moment in top storey, bottom storey and 3rd storey is more in reinforced concrete structure as compared to composite structure. It can also be concluded that

1. The axial forces in composite frame structure are 20% more as compared to reinforced concrete columns.
2. Composite beam though possess heavy self-weight but its moment carrying capacity is 3 times more than the reinforced concrete structure.
3. Percentage of steel is within the permissible limit of concrete, it indicates practically no shear as compared to reinforced concrete structure.
4. The storey drift in conventional structure less than that of composite framed structure but the deflection is within the permissible limit.
5. No time pollution saves 61.11% of time.
6. Foundation cost will be reduced due to the light weight construction as compared to reinforced concrete structure.
7. Composite frame structures are suggested for high rise structures.

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