Comparative Analysis and Design of Multi-Story Composite and Conventional Reinforced Concrete Frame Structure (G+21) by using ETABS

Pallavi Wagh[1], Dr. S.K Kulkarni[2], Vishwajeet Kadlag[3]

[1]M.E (Structure) Student, Department of Civil Engineering, Dr. D. Y. Patil School of Engineering and Technology, Charholi, Pune-412105, Maharashtra, India
[2,3]Professor, Department of Civil Engineering, Dr. D. Y. Patil School of Engineering and Technology, Charholi, Pune-412105, Maharashtra, India

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ABSTRACT:- *This paper deals with the Comparative Study of composite and concrete structure. The composite structure is more prominent over steel and concrete structure in relation with Strength, Costs, and Time Period requirements. There is no need for formwork because the steel beam is able to sustain its self-weight of steel and concrete, by itself or with the assistance of a few temporary props. This Paper also deals with the design of composite building structures with fixed base. In this paper Seismic analysis of a multi-story residential building is made by using different construction materials like Concrete, Structural Steel and Composite of Structural Steel and*

Concrete. Effect of building is studied with respect to base shear, total dead load, story drift values in both X- and Y- direction. Steel-concrete composite systems for buildings are built by connecting the steel beam to the concrete slab or profiled deck slab with the help of mechanical shear connectors so they seems like a single unit and act accordingly. In the present work, the steel concrete composite with RCC options are choose for comparative study of G+21 story building which is situated in earthquake zone-III and for earthquake loading, the provisions of IS: 1893 (Part1)-2002 is considered. Here, we used ETAB Software for the three dimensional modelling and the analysis of the structure.

Keywords:
Composite Beam, Composite Column, Base Shear, Total Dead Load, Cost, IS1893(part1)-2002, Composite Structure, RCC, ETABS.

1. INTRODUCTION

The most important and most frequently encountered combination of construction material is the steel and concrete and it has applied in many Multi-Story commercial buildings and factories as well as in bridges too. These materials can be used in mixed structural systems, for example concrete cores encircled by steel tubes as well as in composite structures, where members consisting of steel and concrete act together compositely.
The purpose of this work is to introduce steel-concrete composite members and construction: to explain the composite action of the two different materials, to show how the structural members are used, particularly in building construction and there advantage over concrete structures, to give a brief introduction to composite building structure.

As Steel-concrete composite systems has become quite popular in recent times because of their advantages over conventional construction. Composite construction combines the better properties of the both i.e. concrete and steel and results in speedy construction. In the present work included Comparative study of R.C.C. and COMPOSITE (G+21 STORY) building. The comparative study includes the deflections of members, sizes and their material consumptions in composites with respect to R.C.C. and Steel section. The seismic forces and the behaviour of the building under seismic condition in composite with respect to R.C.C. and Steel and total cost of the building.

2. SIGNIFICANCE

In composite structure, the advantage of bonding property of steel and concrete is taken into consideration so that they will act as a single unit under loading. These essentially different materials are completely compatible and complementary to each other; they have almost the same thermal expansion; they have an ideal combination of strengths with the concrete efficient in compression and the steel in tension; concrete also gives corrosion protection and thermal insulation to the steel at elevated temperatures. In general, since composite systems realize the most efficient use of steel, reinforced concrete, and composite members in a structural system, this type of construction is often more economical than traditional either all-steel or all-reinforced concrete construction. Steel and composite beams in a floor system lead to reduced floor depth, and lighter overall floor weights. This in turn leads to lower building mass and more economical foundations.

3. PROBLEM STATEMENT

A G+21 RCC and composite structure having plan dimensions as 40mX40m is modelled and analysed in E-tabs. The total height of the building is 77m having typical story height of 3m. The size of beam is (300x500) mm and column sizes are taken as per concrete design calculations.

For the columns, the values are:

a. 400x650 and
b. 350X550

The structure is analysed for seismic zone III under medium soil condition. The grade of concrete is M25 for slab and beam, for column M30 grade is used for RCC and for Composite and grade of steel is HYSD500
The basic parameters considered for the design are:
Live load: 1.5 KN/m^2
Wall load: 14 KN/m (230 mm external wall)
Earthquake parameters considered are Zone: III
Soil type: Hard soil Importance factor: 1
Response reduction factor: 3
The above mentioned building models are analysed using Response spectrum method. The building models are analysed using ETABS software. The different parameters such as time period/mode shapes, lateral displacement, story drift, axial forces, bending moments, base shear of the structure are compared for composite and RCC structures.

4. MATERIAL PROPERTIES

Composite beams, subjected mainly to bending, section consist of composite action with flange of reinforced concrete. To act together, mechanical shear connectors are provided to transmit the horizontal shear between the steel beam and concrete slab, ignoring the effect of any bond between the two materials. These also resist uplift forces acting at the steel concrete interface. If there is no connection between steel beam and concrete slab interface, a relative slip occurs between them when the beam is loaded. Thus, each component will act independently. With the help of deliberate and appropriate connection between concrete slab and steel beam the slip can be minimized or even eliminated altogether. If slip at the interface is eliminated or drastically reduced, the slab and steel member will act together as a composite unit.

In composite columns both the steel and concrete would resists the external loading by interacting together by bond and friction. Additional reinforcement in the concrete encasement prevents excessive spalling of concrete both under normal load and fire condition. The principal merit of steel-concrete composite construction lies in the utilization of the compressive strength of concrete slabs in conjunction with steel beams, in order to enhance the strength and stiffness of the steel girder. More recently, composite floors using deck slab have become very popular in the West for high rise office buildings. Composite deck slabs are particularly competitive where the concrete floor has to be completed quickly and where medium level of fire protection to steel work is sufficient. However, composite slabs with profiled deck slab is unsuitable when there is heavy concentrated loading or dynamic loading in structures such as bridges. The alternative composite floor in such cases consists of reinforced or pre-stressed slab over steel beams connected together to act monolithically.

5. MODELLING AND ANALYSIS

The modelling for both RCC and composite structures are carried out in ETABS. Given below are the screenshots of the structure modelled in software.

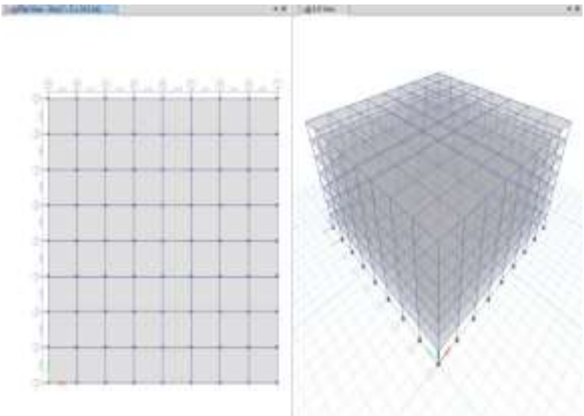

Fig 1: screenshot of G+7 RCC model in ETABS

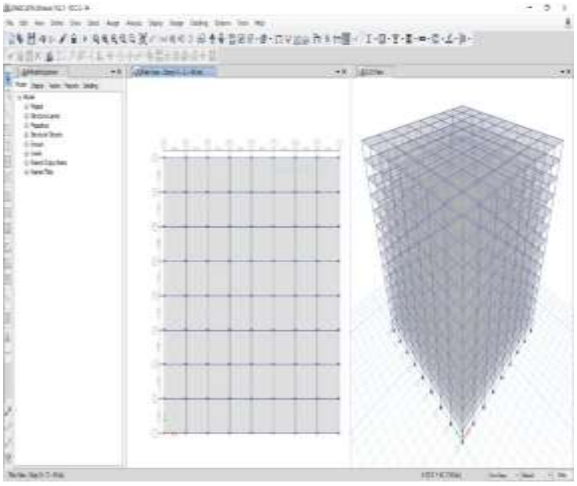

Fig 2: screenshot of G+14 RCC model in ETABS

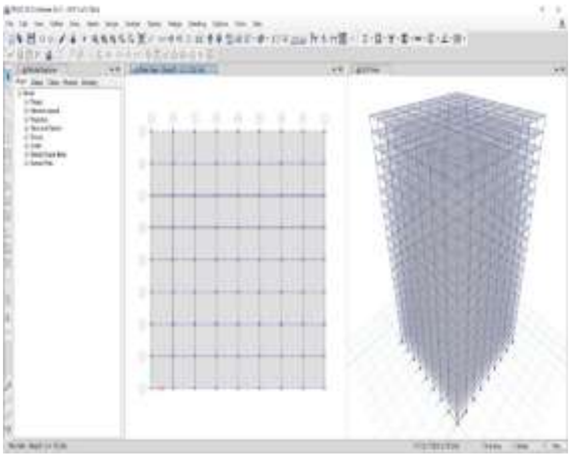

Fig 3: screenshot of G+21 RCC model in ETABS

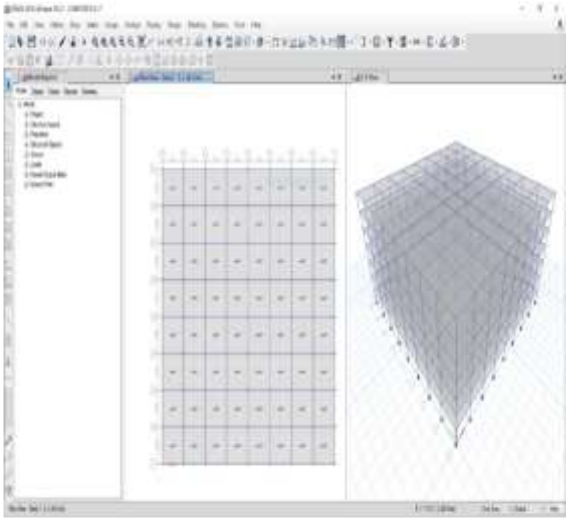

Fig 4: screenshot of G+7 CS model in ETABS

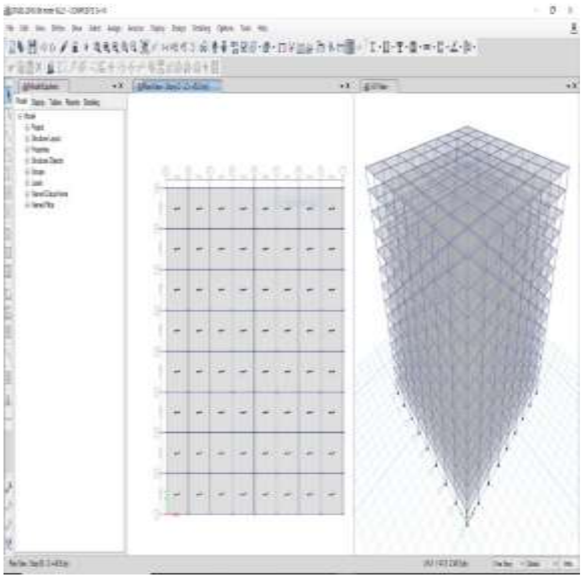

Fig 5: screenshot of G+14 CS model in ETABS

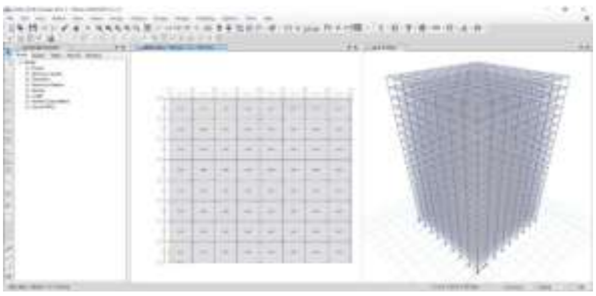

Fig 6: screenshot of G+21 CS model in ETABS

Base Shear

Table 1: Base shear as calculated by software for RCC and composite structure

	No. of Stories	7	14	21
Base Shear	RCC	139230.6708	284308.766	424619.1059
	CS	137097.3903	234559.974	351390.645

Axial Force:

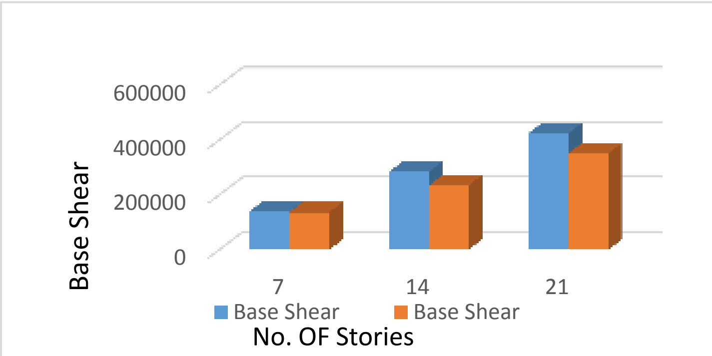

Figure 8: Comparison of Axial Force for RCC and Composite Structure

Table 2: Values of Axial Force for RCC and Composite Structure

	No. of Stories	7	14	21
Axial Force	RCC	2752.9422	2754.2096	3719.4195
	CS	1990.5945	2469.162	3541.60844

Shear Force

Shear Force

Table 3: Values for Shear Force for RCC and Composite Structure

	No. of Stories	7	14	21
Shear Force	RCC	18110.99	17722.51	17759.86
	CS	17174.86	14910.99	16304.97

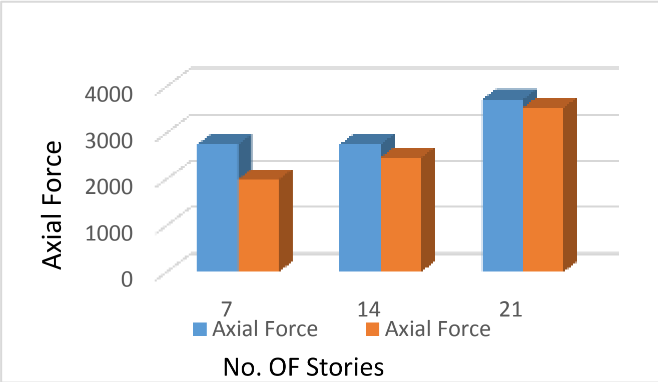

Figure 9: Comparison of Shear Forces for RCC and Composite Structures.

Maximum Bending Moment

Table 4: Values of Max. Bending Moment for RCC and Composite Structures

	No. of Stories	7	14	21
Maximum Moment	RCC	362219.94	354203.42	355322.141
	CS	343497.14	298219.95	326099.3468

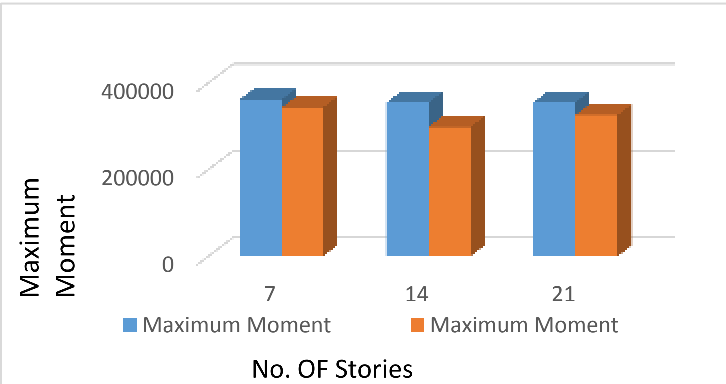

Figure 10: Comparison of Bending Moment for RCC and Composite Structures

Story Drift

Table 5: Values of Story Drift for RCC and Composite Structures

	No. of Stories	7	14	21
Story Drift	RCC	2.13	2.71	2.78
	CS	1.35	1.85	2.15

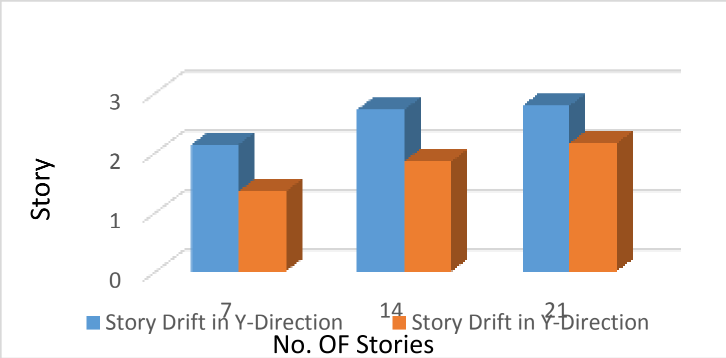

Figure 11: Comparison of Story Drift for RCC and Composite Structures.

6. DISCUSSIONS

- As the results, show the composite option is better than R.C.C. Because Composite option for high rise building is best suited.
- Weight of composite structure is quite low as compared to RCC structure due to smaller structural steel sections are required compared to non-composite construction. Therefore, reduction in overall weight of the composite structure compared to the RCC construction results less foundation costs.
- It is clear that the nodal displacements in a composite structure, by both the methods of seismic analysis, compared to an R.C.C. structure in all the three global directions are less which is due to the higher stiffness of members in a composite structure compared to an RCC structure.
- Composite structures are more economical than that of RCC structure. Composite structures are the best solution for high rise structure as compared to RCC structure. Speedy construction facilitates quicker return on the invested capital and benefits in terms of rent.

7. CONCLUSIONS

- Base Shear is the component of Weight hence RCC structures have higher values of Base Shear than Composite Structure. Fig 7 shows the variation of base shear according to increased storey levels for both RCC and Composite Structures. Percentage difference between the both is 18%.
- From Fig 8 shows the variation of axial forces in RCC and composite structure. RCC structures have higher values of Axial Forces due the increased weight and less ductile nature of structural elements than composite structures. Percentage difference varies from 11% to 28%. As the number of storey increases difference between both values goes on increasing.
- From Fig.9 and Fig.10, RCC structures have higher values of Shear Force and bending moment due to increased dead weight of the structure. Percentage difference varies from 8% to 16%. As the number of storey increases difference between both values of shear force goes on increasing. RCC structures have higher values of Bending Moment due the increased weight of structural elements than composite structures.
- Fig 11 shows the variation of storey drifts of RCC and Composite structures. Percentage difference varies from 22% to 32%.

8. REFERENCES

1. Sattainathan Sharma, G. R. Iyappan, J. Harish, October-December 2015, “Comparative study of cost and time evaluation in RCC, steel & Composite high rise building”
2. Deepak M. Jirage, Prof. V. G. Sayagavi, Prof. N. G. Gore, September 2015.
3. “Comparative Study of RCC and Composite Multi-storeyed Building”
4. IS 456:2000, Indian Standard code of practice for Plain and Reinforced concrete, Bureau of Indian Standards, New Delhi, India.
5. IS 800:2007, Indian Standard code of practice for General Construction in steel, Bureau of Indian Standards, New Delhi, India.
6. IS 875 Code of Practice for design loads for buildings and structures, Bureau of Indian Standards, New Delhi, India. 1987; 1(5).

7. IS 11384: Code of Practice for Design of Composite Structure, Bureau of Indian Standards, New Delhi, India, 1985
8. Prof. Prakash Sangave, Mr. Nikhil Madur, Mr. Sagar Waghmare, Mr. Rakesh Shete, Mr. Vinayak Mankondi, Mr. Vinayak Gundla, February-2015, "Comparative Study of Analysis And Design of R.C and Steel Structures".