Comparative study of Reinforced Concrete frame structure & Steel-Concrete composite structure subjected to static and dynamic loading

Parag P. Limbare, Prof. P. A. Dode

Abstract— The word ‘composite’ in composite material signifies that two or more materials are combined on a macroscopic scale to form a useful material and the individual materials are easily distinguishable. In the present work RCC structure with steel concrete composite options are considered for comparative study of G+20 story building which is situated in earthquake zone II and for earthquake loading, the provisions of IS: 1893 (Part1)-2002 is considered. The design and analysis of the structure are carried out with the help of STAAD-PRO software. The results are compared and found that composite structure more economical.

Index Terms— Composite column, Static analysis, shear Connectors, STAAD-PRO Software

I. INTRODUCTION

A composite member is formed when a steel component, such as an I beam, is attached to a concrete component, such as a floor slab or bridge deck. This paper includes comparative study of Reinforced concrete frame structure with Steel Concrete Composite structure having G+ 20 story which situated in earthquake zone II. Equivalent Static Method and Response Spectrum Method of Analysis is used. For modelling of Composite and R.C.C. structures, STAAD-PRO software is used and the results are compared. Comparative study includes deflection, axial force, story drift, base shear. It is found that composite structure is more economical and speedy than R.C.C. structure.

II. COMPOSITE CONSTRUCTION SYSTEM

Abroad, the use of structural steel has been growing, and has now become one of the important input materials of construction. In India, until nineties, availability of structural steel was in less and weather resistant and/or strength grades were not readily available. Thus, steel did not make much in-roads in building construction and highways, and its share in bridge construction also started decreasing. This coupled with many other reasons led to stagnation of steel demand, while large scale production capacity has been created in the country during initial liberalization period of our country. Hence, proper development of steel application sectors has become an important issue and the steel framed composite construction is considered to be a cost effective solution for multi-storied buildings due to optimum use of materials.

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1. Shear connectors
Shear connections are essential for steel concrete construction as they integrate the compression capacity of supported concrete slab with supporting steel beams/girders to improve the load carrying capacity as well as overall rigidity.

Figure 1. Shear connector

2. Profiled Deck
Composite floors using profiled sheet decking have become very popular in the West for high-rise buildings. Composite deck slabs are generally competitive where the concrete floor has to be completed quickly and where medium level of fire protection to steel work is sufficient.

Figure 2. Profiled deck slab

3. Encased column
Steel concrete composite column is conventionally a compression member in which the steel element is a structural steel section. There are three types of composite columns used in practice which are Concrete Encased, Concrete filled, Battered Section.
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4. Composite beam
Composite beams, subjected mainly to bending, consist of steel section acting compositely with flange of reinforced concrete.

III. BUILDING DESCRIPTION
The building considered here is a residential building having G + 20 storied located in seismic zone II and for earthquake loading, the provisions of the IS:1893(Part1)-2002 is considered. The wind velocity 55m/s. The plan of building is shown in fig. 5. The building is planned to facilitate the basic requirements of a commercial building. The plan dimension of the building is 30 x 23 m. Height of each storey for composite and RCC is 4.2m. The floor plans were divided into five by six bays in such a way that center to center distance between two grids is 5 meters by 5 meter respectively. The study is carried out on the same building plan for RCC and composite construction with some basic assumptions made for deciding preliminary sections of both the structures. The basic loading on both types of structures are kept same, other relevant data is tabulated in table 1.

IV. LOAD COMBINATIONS
The gravity loads and earthquake loads will be taken for analysis. The basic loads are Dead loads (DL), Imposed load (LL), Earthquake load (EQ) along X and Y in positive and negative direction. As per IS 1893 (Part I): 2002 Clause no. 6.3.1.2, the following Earthquake load cases have to be considered for analysis.

1.5(DL + LL)
0.9DL ± 1.5EQ
1.5(DL ± WL)
1.5(DL ± EQ)
0.9DL ± 1.5WL
1.2(DL + LL ± WL)
1.2(DL + LL ± EQ)

Table 1. Data required for analysis

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>RCC STRUCTURE</th>
<th>COMPOSITE STRUCTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan dimension</td>
<td>30m x 23 m</td>
<td>30m x 23 m</td>
</tr>
<tr>
<td>Total height of building</td>
<td>85m</td>
<td>85m</td>
</tr>
<tr>
<td>Height of each storey</td>
<td>4.2m</td>
<td>4.2m</td>
</tr>
<tr>
<td>Height of parapet</td>
<td>1.0m</td>
<td>1.0m</td>
</tr>
<tr>
<td>Depth of foundation</td>
<td>3.3m</td>
<td>3.3m</td>
</tr>
<tr>
<td>Size of beams 6.0m span</td>
<td>300x650 mm</td>
<td>ISWB 450</td>
</tr>
<tr>
<td>Size of beams 4.0m span</td>
<td>230x500 mm</td>
<td>ISMB 200</td>
</tr>
<tr>
<td>Size of columns</td>
<td>400 mm X 1200 mm</td>
<td>800 mm X 600mm + ISHB 450</td>
</tr>
<tr>
<td>Thickness of slab</td>
<td>125mm</td>
<td>100 mm</td>
</tr>
<tr>
<td>Thickness of walls</td>
<td>230mm</td>
<td>230mm</td>
</tr>
<tr>
<td>Seismic zone</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>Wind speed</td>
<td>55m/s</td>
<td>55m/s</td>
</tr>
<tr>
<td>Soil condition</td>
<td>Medium soil</td>
<td>Medium soil</td>
</tr>
<tr>
<td>Importance factor</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Zone factor</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Floor finish</td>
<td>1.2 kN/m2</td>
<td>1.2 kN/m2</td>
</tr>
<tr>
<td>Live load at all floors</td>
<td>2.0 kN/m2</td>
<td>2.0 kN/m2</td>
</tr>
<tr>
<td>Grade of concrete beam/column</td>
<td>M40</td>
<td>M40</td>
</tr>
<tr>
<td>Grade of concrete slab</td>
<td>M35</td>
<td>M35</td>
</tr>
<tr>
<td>Grade of reinforcing steel</td>
<td>Fe500</td>
<td>Fe500</td>
</tr>
<tr>
<td>Density of concrete</td>
<td>25 kN/m3</td>
<td>25 kN/m3</td>
</tr>
<tr>
<td>Density of brick</td>
<td>20 kN/m3</td>
<td>20 kN/m3</td>
</tr>
<tr>
<td>Damping ratio</td>
<td>5%</td>
<td>5%</td>
</tr>
</tbody>
</table>
V. ANALYSIS

The explained 3D building model is analyzed using Equivalent Static Method and Response spectrum method. The building models are then analysed by the software Staad Pro. Different parameters such as deflection, story drift, shear force & bending moment are studied for the models. Seismic codes are unique to a particular region of country. In India, Indian standard criteria for earthquake resistant design of structures IS 1893 (PART-1): 2002 is the main code that provides outline for calculating seismic design force. Wind forces are calculated using code IS-875 (PART-3) & SP64.

VI. RESULTS AND DISCUSSION

![Graph for Weight of Structure](image)

**Table 2: Variation of Wt. of Structure in KN**

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCC</td>
<td>95566.5</td>
</tr>
<tr>
<td>Composite</td>
<td>73922.534</td>
</tr>
</tbody>
</table>

![Graph for Axial force](image)

**Table 3: Variation of Axial force (KN)**

<table>
<thead>
<tr>
<th></th>
<th>Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCC</td>
<td>4523</td>
</tr>
<tr>
<td>Composite</td>
<td>3754</td>
</tr>
</tbody>
</table>

![Graph for Base Shear](image)

**Table 4: Variation of Base Shear in X direction**

<table>
<thead>
<tr>
<th></th>
<th>Forces</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCC</td>
<td>2498.29 KN</td>
</tr>
<tr>
<td>Composite</td>
<td>2001.77 KN</td>
</tr>
</tbody>
</table>

![Graph for Story Displacement](image)

**Table 5: Time Period in seconds**

<table>
<thead>
<tr>
<th></th>
<th>Time Period in sec.</th>
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</thead>
<tbody>
<tr>
<td>RCC</td>
<td>2.9</td>
</tr>
<tr>
<td>Composite</td>
<td>3.45</td>
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</tbody>
</table>

![Graph for Story Drift](image)

**Table 6: Variation of Story Displacement in X Direction (mm)**

<table>
<thead>
<tr>
<th>Story No</th>
<th>RCC</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>46.1</td>
<td>58.3</td>
</tr>
<tr>
<td>15</td>
<td>41.2</td>
<td>48.8</td>
</tr>
<tr>
<td>10</td>
<td>26.5</td>
<td>34.1</td>
</tr>
<tr>
<td>5</td>
<td>12.4</td>
<td>15.4</td>
</tr>
</tbody>
</table>

**Table 7: Variation of Story Drift in X Direction (mm)**

<table>
<thead>
<tr>
<th>Story No</th>
<th>RCC</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.000266</td>
<td>0.000258</td>
</tr>
<tr>
<td>15</td>
<td>0.000799</td>
<td>0.000750</td>
</tr>
<tr>
<td>10</td>
<td>0.00111</td>
<td>0.000997</td>
</tr>
<tr>
<td>5</td>
<td>0.001301</td>
<td>0.001050</td>
</tr>
</tbody>
</table>
VII. CONCLUSION

1. From table 2, it is clear that the wt. of Composite structure is reduced by 23.52% as compared with RCC structure.
2. The story displacement of Composite structure is 20.93% more as compare with RCC.
3. From table 4, it is clear that the base shear of Composite structure is reduced by 24.8% as compared with RCC structure.
4. From table 3, It is clear that the axial force in Composite structure is less as compare with RCC by 20.48%.
5. From table 5, It is clear that the time period of Composite is more as compare to RCC by 18.97%.
6. Time required for construction of composite structure is less as compare with RCC structure because no form work is required.

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REFERENCES


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