Comparative Study on RCC and Steel-Concrete Composite Building using Linear Static Analysis
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Abstract—Steel-Concrete composite constructions are nowadays very popular owing to their advantages over conventional Concrete and Steel constructions. Concrete structures are bulky and impart more seismic weight and less deflection whereas Steel structures instill more deflections and ductility to the structure, which is beneficial in resisting earthquake forces. Composite Construction combines the better properties of both steel and concrete along with lesser cost, speedy construction, fire protection etc. Hence the aim of the paper is to compare seismic performance of a 3D (G+5) story RCC and Steel-Concrete Composite building frame situated in earthquake zone IV. All frames are designed for same gravity loadings. Beam and column sections are made of either RCC & Steel-concrete composite sections. Equivalent static method is used for seismic analysis. ETAB2015 software is used and results are compared. Comparative study concludes that the composite frames are best suited among concrete constructions in terms of materials and weight with better seismic behavior.

Key words: Steel- Concrete Composite Building, RCC building, Seismic Analysis, ETAB2015

I. INTRODUCTION

In India most of the building structures fall under the category of low rise buildings. So, for these structures reinforced concrete members are used widely because the construction becomes quite convenient and economical in nature. But since the population in cities is growing exponentially and the land is limited, there is a need of vertical growth of buildings in these cities. So, for the fulfillment of this purpose a large number of medium to high rise buildings are coming up these days. For these high rise buildings it has been found out that use of composite members in construction is more effective and economic than using reinforced concrete members.

The use of Steel in construction industry is very low in India as compared to many developing countries. Experiences of other countries indicate that this is not due to the lack of economy of Steel as a construction material. There is a great potential for increasing the volume of Steel in construction, especially in the current development needs in India. Also now-a-days, the composite sections using Steel encased with concrete are economic, cost and time effective solution in major civil structures such as bridges and high rise buildings.

II. COMPOSITE STRUCTURE

Composite Steel-Concrete structures are used widely in modern bridge and building construction. 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. In such a composite T-beam as shown in fig 1, the comparatively high strength of the concrete in compression and high strength of the steel in tension.

Fig. 1: Cross Section of a typical composite member

Steel concrete composite construction combines the compressive strength of concrete with the tensile strength of steel to evolve an effective and economic structural system. Over the years, this specialized field of construction has become more and more popular in the western world and developed into a multifaceted design and construction technique. Apart from composite beam, slab and column, options like composite truss is also being explored in the field of composite construction.

III. BUILDING DETAILS

The basic planning and the loading conditions are considered same for RCC, Steel-concrete composite structure. In case of RCC structure, the structural members slab, beam and column are considered RCC and designed as per IS456:2000 and in case of steel concrete composite structure the composite beams are designed with structural steel section anchored to the steel deck slab with the help of shear studs and columns are considered made of RCC having structural steel section in its core and reinforcement in the concrete outside and designed as per AISC360:10. The lateral loads are considered to be carried by the beam column frame as a moment resisting frame. For the analysis and design, the following design basis have considered:

<table>
<thead>
<tr>
<th>Type of building</th>
<th>Residential Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of frame</td>
<td>Moment Resisting Frame</td>
</tr>
<tr>
<td>Total height of building</td>
<td>16.5 m</td>
</tr>
<tr>
<td>Plan of the building</td>
<td>20m × 20m</td>
</tr>
<tr>
<td>Thickness of external walls</td>
<td>230mm</td>
</tr>
<tr>
<td>Live load</td>
<td>4.0kN/sq.m</td>
</tr>
<tr>
<td>Grade of Concrete</td>
<td>M20</td>
</tr>
<tr>
<td>Grade of reinforcing Steel</td>
<td>Fe415</td>
</tr>
<tr>
<td>Grade of structural steel</td>
<td>Fe 410 N/mm2, Fy = 250 N/mm2</td>
</tr>
<tr>
<td>Density of Concrete</td>
<td>25 kN/m3</td>
</tr>
<tr>
<td>Density of brick masonry</td>
<td>20 kN/m3</td>
</tr>
</tbody>
</table>
### Table 1. Design Basis

<table>
<thead>
<tr>
<th>Member</th>
<th>RCC</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corner Column</td>
<td>300mmX530mm</td>
<td>300mmX380mm with encased ISMB150</td>
</tr>
<tr>
<td>Inner Column</td>
<td>300mmX530mm</td>
<td>300mmX380mm with encased ISMB175</td>
</tr>
<tr>
<td>Beam</td>
<td>300mmX530mm</td>
<td>ISMB200</td>
</tr>
<tr>
<td>Slab/Deck</td>
<td>150mm slab</td>
<td>150mm Deck</td>
</tr>
</tbody>
</table>

### Table 2. Structural Member Sizes

<table>
<thead>
<tr>
<th>Zone</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil type</td>
<td>Rock</td>
</tr>
<tr>
<td>Importance factor</td>
<td>1.0</td>
</tr>
<tr>
<td>Response reduction</td>
<td>5.0</td>
</tr>
<tr>
<td>Seismic zone factor</td>
<td>0.24 for zone IV</td>
</tr>
<tr>
<td>Damping ratio</td>
<td>5% (For RCC&amp; Composite structure)</td>
</tr>
</tbody>
</table>

### IV. ANALYSIS

The explained 3D building model is analyzed using Equivalent Static Method. The building models are then analyzed by the software ETABS2015. Different parameters such as Base shear, Story drift, Mode shapes, Time Period, Frequency and Story Shear are studied for the 1.2(DL+LL+EQX) Loading combination. 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.

### V. NUMERICAL RESULTS AND DISCUSSION

The time period of both the structures are calculated and the maximum time period is of composite building, it means it is more flexible to oscillate back and forth when lateral forces act on the building. Also results show that R.C.C building has least time period which says it is very less flexible amongst both the structures.

- **Fig. 2:** Plan of building
- **Fig. 3:** 3D model of RCC Building
- **Fig. 4:** 3D model of Composite Building
- **Fig. 5:** Mode shape Vs Time Period
- **Fig. 6:** Mode shape Vs Frequency
- **Fig. 7:** No. of Story Vs Story Force

The story force in composite building is less than the RCC structure in linear static analysis.
Base Shear for RCC frame is maximum because the weight of the RCC frame is more than the composite frame.

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Composite structure gives more ductility to the structure as compared to the R.C.C. which is best suited under the effect of lateral forces. From graph it is clear that the lateral forces acting on a RCC structure are much more than composite structure, hence composite structure is less susceptible against seismic forces action on structure.

Due to rise in steel rates at initial stage, one may find composite section a bit higher in cost. But due to its speedy construction one can complete the project very fast as compared to RCC. So in the cases where speedy construction is required one can use composite construction.

1) In composite structure the self-weight of the frame is less and therefore substantial reduction in cost of the foundation.

2) The most important benefit of composite column is that it has more flexural stiffness than the R.C.C. sections in spite of the smaller dimensions. Due to this increased stiffness the composite column experience less deflection than the R.C.C. columns.

3) Under earthquake considerations because of the inherent ductility characteristics, Steel-Concrete structure will perform better than a conventional R.C.C. structure.

4) High ductility of steel material leads to better seismic resistance of the composite section. Steel component can be deformed in a ductile manner without premature failure and run withstand numerous loading cycles before fracture.

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6) Base Shear for RCC frame is maximum because the weight of the RCC frame is more than the composite frame.

7) Composite material not only have a high stiffness but also have greater damping capacity compared with metals and metals matrix composite.

8) The analysis of the composite building shows that the axial forces, moments and shear forces of the structure are very less for the same loadings as compared to the RCC building. The reduced moments and axial forces ultimately results in the reduced dimensions of the columns and beams of composite building. Hence one can conclude that the composite construction is more economical then the conventional RCC construction.

VI. CONCLUSION

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REFERENCES


