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Comparative Study of RCC and Steel-Concrete Composite Building based on Seismic Analysis

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Abstract- **In India, reinforced concrete structures are generally used for being most convenient & economical system for low-rise buildings. However, for medium to high-rise buildings such type of structures doesn't suffice economy due to increased dead load, unsubstantial stiffness, span restriction and complex formwork. So efficient and economical design solution is need of time. Steel concrete composite construction is not adopted widely because of out of league analogy and involved complexity in its analysis and design. However, steel concrete composite construction has got wide acceptance in developed countries over virgin steel and virgin concrete construction. Composite Construction combines the positive properties of both steel and concrete along with speedy construction, fire protection etc. The paper includes comparative study of seismic performance of a 3D (G+8) Storey RCC and Steel Concrete Composite Building frame situated in earthquake zone IV. Equivalent Static Method and Response Spectrum Method are used for seismic analysis. ETAB 2015 software is used and results are compared.**

Keywords- Steel Concrete Composite Building, RCC building, Seismic Analysis, ETAB2015.

1. INTRODUCTION

In India most of the building structures fall under the category of low rise buildings. So, for these structures reinforced concrete members are widely used due to ease in construction & economy achieved. However, population growth at alarming rate & limited land resource has posed need of vertical growth of buildings in these metropolis. So, for the fulfillment of the 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 over reinforced concrete members is more effective and economical.

2. 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 figure 1, the comparatively high strength of the concrete in compression and high strength of the steel in tension are utilized in combination.

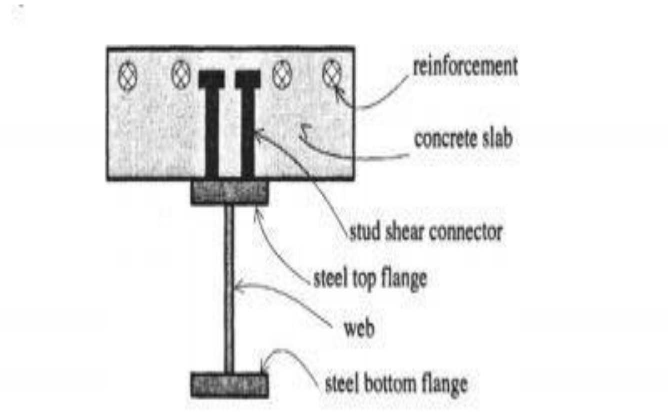

Figure 1. Cross Section of a typical Composite Member

Steel concrete composite construction combines the compressive strength of concrete with the tensile strength of steel to evolve an effective and economic structural system. Such a specialized system of construction is gaining popularity as multifaceted design and construction technique. Apart from composite beam, slab and column, options like composite truss are also being explored in the field of composite construction.

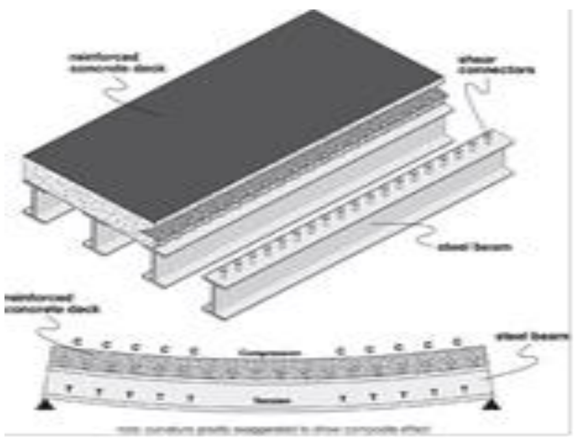

Figure 2. Cross Section of Composite Beam

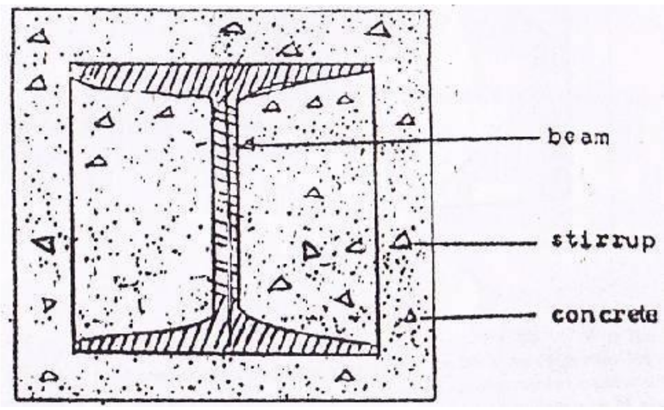

Figure 3. Cross Section of Composite Column

3. BUILDING DETAILS

The building considered here is G+8 storey office building located in seismic zone IV. The plan of building is shown in figure 4. The basic planning and the loading conditions are considered same for both RCC & Composite Steel Concrete Structure. In case of RCC structure, the structural members slab, beam and column are designed as per IS456:2000 and in case of Steel Concrete Composite Structure, members are designed as per Eurocode 4. 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. Lateral loads are considered to be carried by the beam column frame as a moment resisting frame. For the analysis and design, following design data is considered:

Table 1: Design Basis

Type of building	Office Building(G+8)
Type of frame	Moment Resisting Frame
Total height of building	28.5 m
Height of each storey	3.0m
Plinth height	1.5m
Plan of the building	20m × 30m
Thickness of external walls	230mm
Live load	5.0 kN/sq.m
Grade of Concrete	M20
Grade of reinforcing Steel	Fe415
Grade of structural steel	Fu= 410N/mm2, Fy = 250 N/mm2
Density of Concrete	25 kN/m3
Density of brick masonry	20 kN/m3
Zone	IV
Soil type	Rock
Importance factor	1.0
Response reduction	5.0
Seismic zone factor	0.24 for zone IV
Damping ratio	5% For RCC structure & 3% Composite structure

Table 2: Structural Member Sizes

Member	RCC	Composite
Column	300mmX750mm	450mmX600mm with encased ISHB400
Beam	300mmX530mm	ISMB300
Slab/Deck	120mm slab	120mm Deck

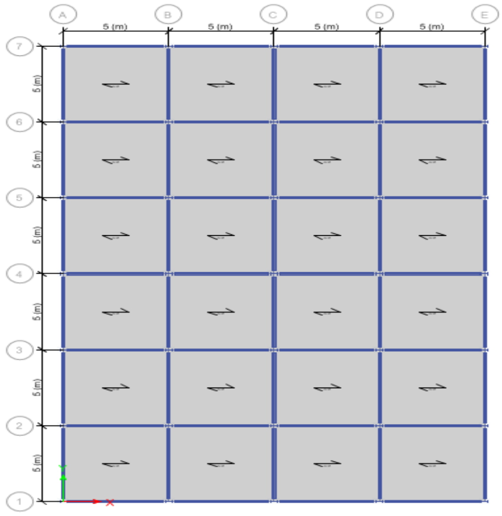
Figure 4. Plan of building

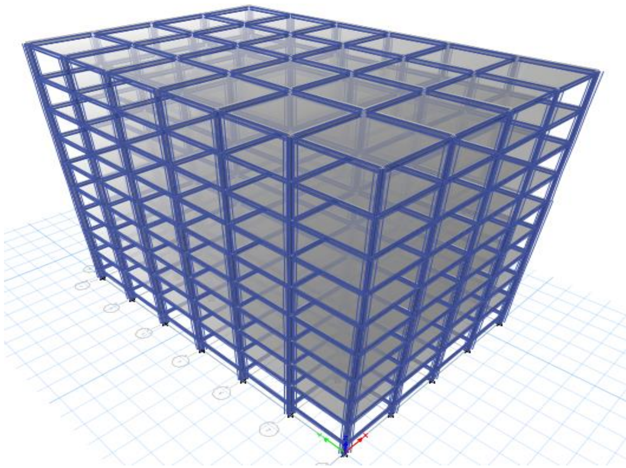
Figure 5. 3D model of Composite Building

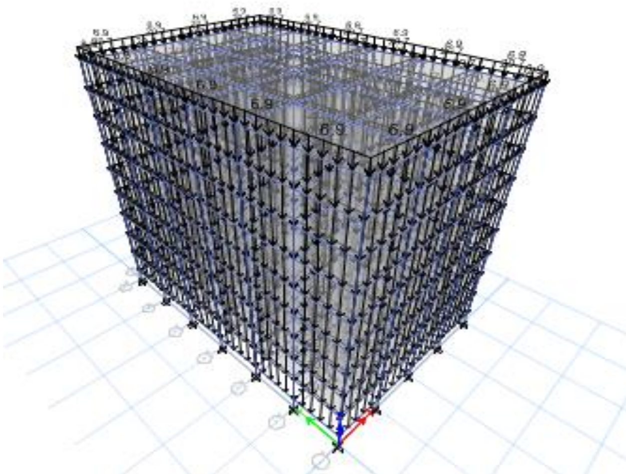
Figure 6. 3D model of Composite Building with Loading

4. ANALYSIS

The explained 3D building model is analyzed using Equivalent Static Method and Response Spectrum Method. The building models are then analyzed by the software ETABS2015. Different parameters such as storey stiffness, storey drift, base shear, weight of structure, lateral forces, mode shapes, natural time period, frequency are studied for the seismic loads in X-direction. 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.

5. NUMERICAL RESULTS AND DISCUSSION

a. The graph shows that RCC frame gives higher value of stiffness as compared to composite frames because of higher dimensions of column cross sections used in the RCC frames as compared to composite frames.

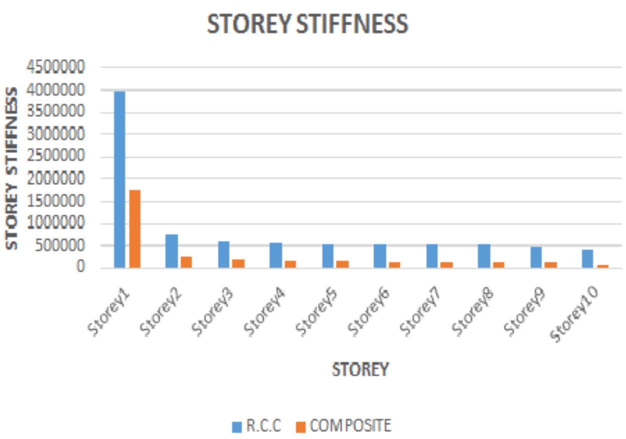

Figure 7. Storey Vs Storey Stiffness

b. The graph shows that storey drift value obtained by equivalent static method in X-direction is more for composite frame as compared to RCC frame. RCC frame has the lower values of storey drift because of its higher stiffness.

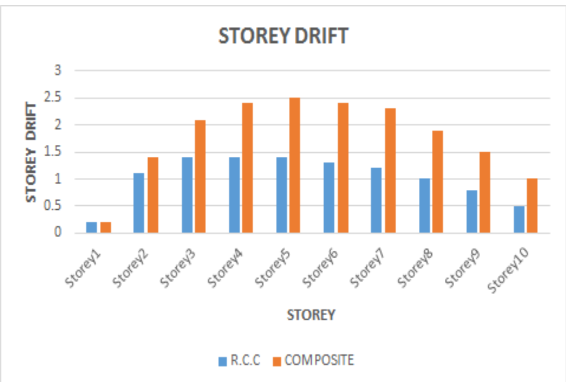

Figure 8. Storey Vs Storey Drift

c. The natural time period of both the structures are calculated and natural time period for composite building, is higher than RCC building; which implies that 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 lower natural time period which implies that it is less flexible amongst both the structures.

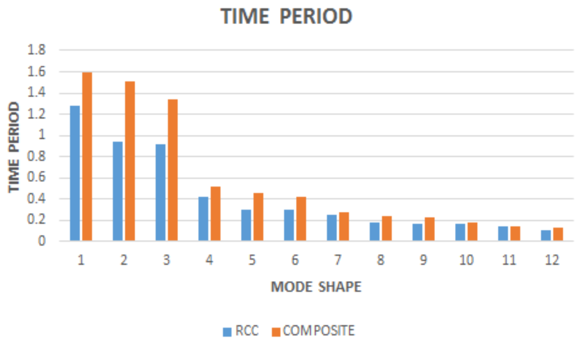

Figure 9. Mode shape Vs Time Period

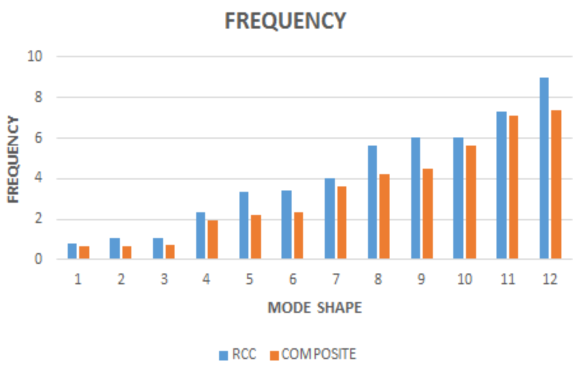

Figure 10. Mode shape Vs Frequency

d. Base Shear for RCC frame is on higher side compared to composite frame because weight of RCC frame is more than the composite frame.

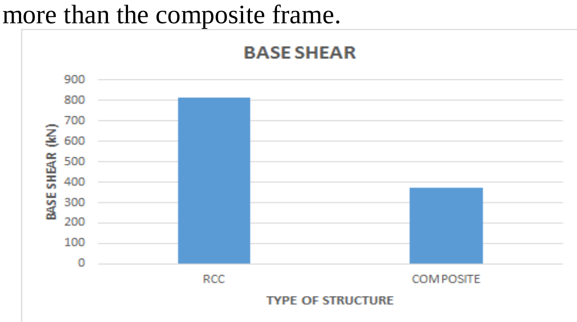

Figure 11. Type of structure Vs Base shear

e. Composite structure grant more ductile behavior as compared to the R.C.C. structure 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 structures are less susceptible to action of seismic forces.

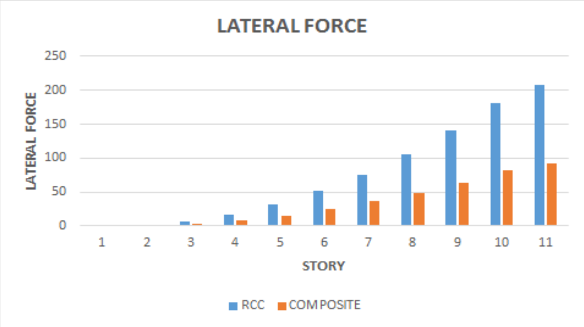

Figure 12. No. of Storey Vs Lateral Force

f. Weight of the RCC frame is more than the composite frame because of larger cross section.

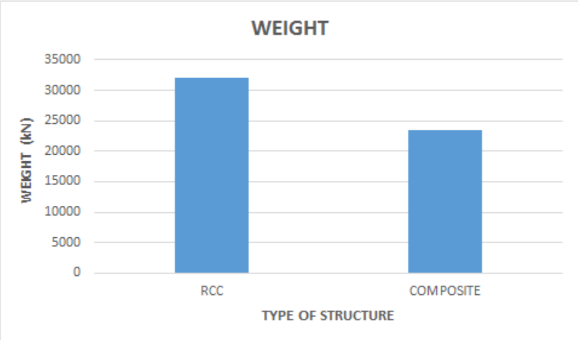

Figure 13. Type of Structure Vs Weight

6. CONCLUSION

1. In composite structures, the self-weight of frame is less and therefore substantial reduction in cost of construction of foundation is observed.
2. Under seismic considerations because of the inherent ductility characteristics, steel-concrete structure will perform better than a conventional R.C.C. structure.
3. High ductility of steel material leads to better seismic resistance of the composite section. Steel component shows ductile behavior without premature failure and can withstand numerous loading cycles before fracture.
4. Steel being cost inducing construction material can pose material cost on higher side. But speedy construction, reduced dead load & various other factors can counteract overall project cost.
5. Base Shear for RCC frame is on higher side because the weight of the RCC frame is more than the composite frame.
6. 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.

7. REFERENCES

1. D.R. Panchal and P.M. Marathe, “Comparative Study of R.C.C, Steel and Composite (G+30 Storey) Building”, Institute of Technology, Nirma university, Ahmedabad – 08-10 December, 2011, pp382-481.
2. Fahim Sadek and H. S. Lew, “Robustness of Composite Floor Systems with Shear Connections: Modelling, Simulation, and Evaluation”, Journal of Structural Engineering (ASCE), Nov2008, pp17-25.
3. IS: 1893, Criteria for earthquake resistant design of structures – general provisions for buildings, Part 1, Bureau of Indian Standards, New Delhi, 2002.
4. IS: 456, Code of practice for plain and reinforced concrete code of practice, Bureau of Indian Standards, New Delhi, 2000.
5. IS: 800, Code of practice for general construction in steel, Bureau of Indian Standards, New Delhi, 2007.
6. IS: 875, “Code of practice for design load (other than earthquake) for buildings and structures” Bureau of Indian Standards, New Delhi, 2002.
7. IS: 11384, “Code of practice for composite construction in structural steel and concrete” Bureau of Indian Standards, New Delhi, 1985.
8. Roberto T. Leon and Jerome F. Hajjar, “Analysis and Design of Steel-Concrete Composite Frame Systems”, Structures Congress(ASCE), 2014
9. S. S. Charantimath and Swapnil B. Cholekar , “Comparative Study on Structural Parameter of R.C.C and Composite Building”, Civil and Environmental Research, Vol.6, Issue.6, 2014,pp.2224-5790.
10. Shweta A. Wagh and Dr. U. P. Waghe, “Comparative Study of R.C.C and Steel Concrete Composite Structures”, International Journal of Engineering Research and Applications, Vol. 4, Issue 4(Version 1), April 2014, pp.369-376.
11. Syed R and S. H. Mahure, “Study of Seismic and Wind Effect on Multi Storey R.C.C. Steel and Composite Building”, International Journal of Engineering and Innovative Technology (IJEIT) Vol. 3, Issue 12, June 2014.
12. William P. Jacobs and Jerome F. Hajjar, “Review and Comparison of Encased Composite Steel-concrete column detailing requirements”, International Conference on Composite Construction in Steel and Concrete, 2010.
13. Farghaly A, “Parametric study on equivalent damping ratio of different composite structural building systems”, Steel and Composite Structures, Vol. 14, Issue 4, 2013, pp. 349-365.
14. Isao N and Hiroshi K, “Guidelines: Seismic Design of Composite Reinforced Concrete and Steel Buildings”, Journal of Structural Engineering, Vol.130, Feb2014, pp. 336-342.
15. Reza M and Enrico S, “Analysis of Steel-Concrete Composite Frames with Bond-Slip”, Journal of Structural Engineering, Vol.127, Issue 11, 2001, pp. 1243-1250.
16. Daniels J and Crisinel M, “Composite Slab Behaviour and Strength Analysis”, Journal of Structural Engineering, Vol.119, Issue 1, 1993, pp. 16-35.
17. Rao M and Nadella S, “Dynamic Analysis and Damping of Composite Structures Embedded with Viscoelastic Layers”, Composites, Elsevier Science Direct, Vol.28, 1997, pp.547-554.
18. Stevenson J.D, “Structural damping values as a function of dynamic response stress and deformation level”, Nuclear Engineering and Design, Vol.60, 1980, pp.211-237.