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Comparative Structural Analysis and Design of RCC and Steel–Concrete Composite Multi-Storey Buildings under Wind and Seismic Loads

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ABSTRACT: With the growing need for multi-storey structures, the selection of structural solutions to provide acceptable strength, stiffness and serviceability under lateral loading situations has become increasingly important. In this paper, a comparative structural analysis and design of reinforced cement concrete (RCC) and steel-concrete composite multi-storey buildings under wind and seismic loads are presented. A prototype of a G+10 commercial building was modeled in STAAD.Pro CONNECT Edition using the same geometry, loadings, support conditions, and design assumptions for both structural systems. The analysis and design were carried out as per IS 456:2000, IS 800:2007, IS 875 (Parts 1–3):2015, IS 1893 (Part 1):2016, and IS 13920:2016. The structural reactions such as storey displacement, storey drift, base shear, natural time period, internal forces and structural weight were investigated and compared. The results reveal that the steel–concrete composite building had less lateral displacement, less storey drift, less foundation shear, stronger stiffness and better material utilization than the RCC building due of its higher strength-to-weight ratio. While the RCC construction was still more inexpensive in terms of initial construction cost, the composite system showed better structural efficiency and long-term performance and thus a viable alternative for medium- and high-rise buildings subjected to considerable wind and seismic loads.

KEYWORDS: Reinforced Cement Concrete, Steel–Concrete Composite Building, Multi-Storey Building, Wind Load, Seismic Load, STAAD.Pro, Structural Analysis, Lateral Load

I. INTRODUCTION

The rapid urbanization and population growth all over the world has led to a huge demand for multi-storey residential, commercial and institutional structures. The shortage of urban land has pushed vertical development and the design process has been dominated by considerations of structural efficiency, safety and economy. Modern buildings are subjected to gravity loads as well as large lateral forces due to wind and earthquake. These lateral loads regulate the design of medium- and high-rise structures and significantly impact their stability, serviceability and overall structural performance.

Reinforced Cement Concrete (RCC) has been the most extensively used structural system in the past. The reasons for this are its longevity, resistance to fire, ready availability of resources and affordable construction. However, RCC structures generally have a high self-weight which increases seismic inertia forces, foundation requirements and member sizes. With increasing height of the building the constraints are increasingly pronounced.

The development of steel–concrete composite construction as an efficient alternative has been achieved through the combination of the compressive strength of concrete and the tensile strength and flexibility of structural steel. Composite systems offer numerous engineering advantages including lower structural weight, greater stiffness, longer spans, quicker construction and better seismic behaviour. These features have increased its usage in commercial complexes, office buildings, airports, hospitals and other high rise buildings.

Advances in structural computational engineering allow for additional advances in the analysis and design of complex building systems. STAADPro CONNECT Edition provides precise 3D modeling, finite element analysis, automatic load generation and code based structural design as per Indian Standards. The software provides a realistic assessment of structural reaction to the combined gravity, wind and earthquake stress.

The present study is a comparative study between RCC and steel-concrete composite multi-storey buildings of same geometric configuration, loading and boundary conditions. The comparison has been made on the basis of important structural factors such storey displacement, storey drift, base shear, natural time period, member forces and structural weight. The aim is to determine the structural system that gives better overall performance while satisfying the requirements of the relevant Indian Standards. The results serve as a practical guide to structural engineers in the selection of suitable structural solutions for contemporary multi-storey buildings.

II. REVIEW OF LITERATURE

The behaviour of RCC and steel-concrete composite buildings under gravity and lateral loading circumstances has been researched by many researchers. Previous studies indicate that RCC structures offer good strength, durability and fire resistance but with greater structural weight, resulting in larger seismic forces and increased foundation demands.

Steel-concrete composite construction has gained much attention as it provides better strength to weight ratio, better stiffness and speedier construction. The researchers have discovered that the composite buildings generally show less storey displacement, reduced inter-storey drift, higher seismic performance and better material utilization compared to the traditional RCC structures. Composite beams and columns are an efficient combination of the benefits of structural steel and reinforced concrete, resulting in a higher load-carrying capacity and structural efficiency.

Comparative studies using finite element software such as STAAD.Pro. The self-weight of the composite structures has been lowered using Pro and ETABS to lessen the seismic inertia forces and improve the dynamic responsiveness. Studies also have demonstrated that prefabricated steel components increase construction time but provide high quality and dimensional correctness. Research has been carried out recently to optimise member sizes, improve ductile behaviour and assess the effect of wind and earthquake loads on multi-storey buildings. A number of studies have compared RCC and composite structures, but further studies considering same modelling assumptions, loading conditions and design standards are still required to reach reliable engineering conclusions. In this work, we meet this condition by performing a systematic comparison analysis using STAAD.Pro as per current Indian Standards.

III. MATERIALS AND METHODS

A comparative analytical analysis was carried out on a prototype G+10 commercial building utilizing STAAD.Pro CONNECT Ed Two different three-dimensional structural models are established: one is a conventional RCC moment-resisting frame and the other is a steel-concrete composite frame. For a fair comparison, the two models were given the same architectural layouts, geometric dimensions, loading circumstances, support conditions and design criteria.

The prototype building has ten floors above ground level and a total height of 33 m. The building layout is 24 m × 18 m and there is a regular bay spacing in two primary axes. The fixed supports were assumed at the foundation level and the floor slabs were viewed as stiff diaphragms for the distribution of the lateral loads.

Table.1. Building Specifications

Parameter	Specification
Building Type	Commercial
Structural Systems	RCC and Composite
Number of Storeys	G + 10
Total Height	33 m
Plan Dimensions	24 m × 18 m
Floor Height	3.0 m
Analysis Software	STAAD.Pro CONNECT Edition
Support Condition	Fixed
Design Codes	IS 456, IS 800, IS 875, IS 1893

Material properties were assigned according to the relevant Indian Standards. RCC members were designed using M30 concrete and Fe500 reinforcement, whereas the composite building incorporated E250 structural steel with reinforced concrete slabs.

Table.2.Material Properties

Material	Grade	Property
Concrete	M30	Elastic Modulus = 27.4 GPa
Reinforcement Steel	Fe500	Yield Strength = 500 MPa
Structural Steel	E250	Yield Strength = 250 MPa
Unit Weight of Concrete	—	25 kN/m ³
Elastic Modulus of Steel	—	200 GPa

Self-weight, floor finish, wall load and live load were incorporated in gravity loads. Wind loads were automatically generated as per IS 875 (Part 3):2015 using the supplied basic wind speed, terrain category and topography factor. Earthquake loads were computed using Equivalent Static Method as given in IS 1893 (Part 1):2016 assuming Zone III, medium soil, significance factor and response reduction factor.

The finite element solver in STAAD.Pro was used for the linear elastic analysis. The software produced nodal displacements, support reactions, storey drift, internal member forces and natural time periods. Design of structural members was carried out as per IS 456:2000 for RCC members and IS 800:2007 for structural steel members. The ratios of members' utilization were also examined for code compliance.

The analytical findings obtained for both structural systems are compared utilizing the major response parameters such storey displacement, storey drift, base shear, natural time period, axial force, shear force, bending moment, structural weight and material efficiency. The technique used is objective and establishes a framework for evaluating the relative performance of RCC and steel–concrete composite buildings under similar loading situations.

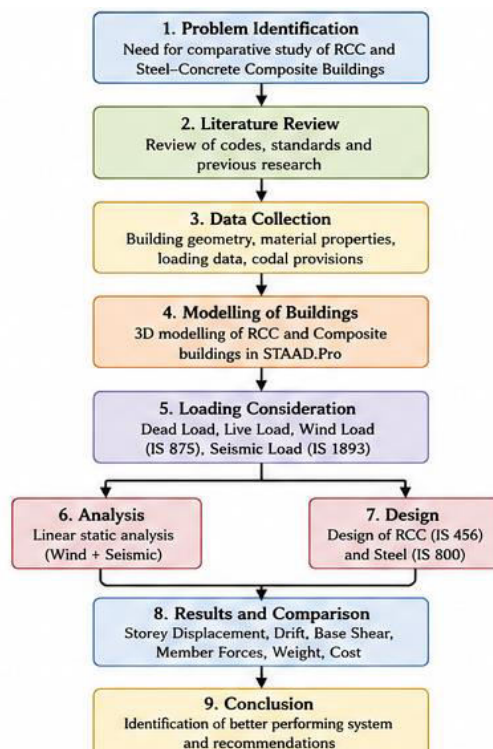


Figure.1. Research Methodology Flowchart

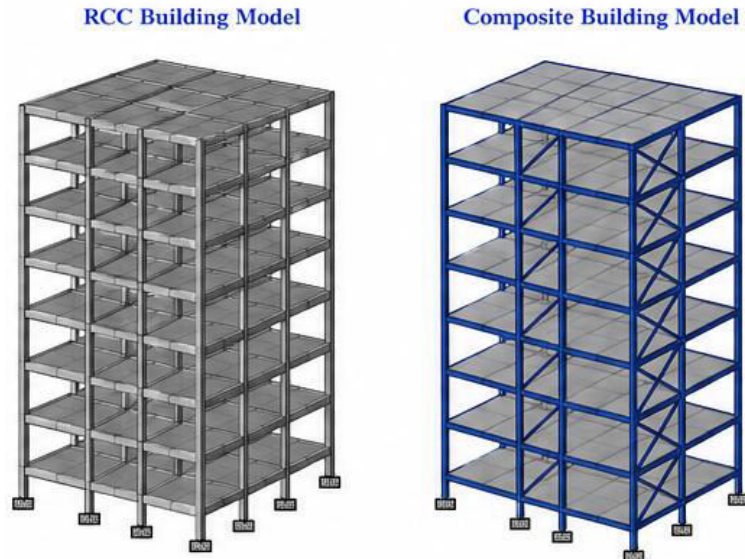


Figure.2. Three-Dimensional Building Models (RCC and Composite)

IV. RESULTS AND DISCUSSION

The structural performances of the RCC and steel concrete composite multi-storey structures have been examined by STAAD under the same gravity, wind and seismic loadings. Pro CONNECT Edition. Both the analytical models followed the relevant provisions of IS 456:2000, IS 800:2007, IS 875 (Parts 1–3): 2015 and IS 1893 (Part 1): 2016. The comparison was carried out for the major reaction parameters such storey displacement, storey drift, base shear, natural time period, structural weight and overall design efficiency.

The analytical results show that both of the structural systems meet the set safety and serviceability requirements. However, the composite construction always performed better from the structural point of view, because of its better strength to weight ratio and its stronger lateral stiffness. The composite system had a lesser self-weight, which resulted in lower seismic inertia forces and hence smaller base shear and lower internal member forces.

The greatest inter-storey displacement for both structures was at roof level. This value increases with the height of the building. However, the composite building had lower values of displacement since the structural steel members have more stiffness and at the same time reduced the total dead load. Reduced displacement provides better serviceability by reducing damage to non-structural parts and improving occupant comfort during strong wind and seismic occurrences. Similarly, the values of storey drift were well below the acceptable limitations established by IS 1893 (Part 1):2016 for both the structural systems. The composite building showed decreased drift values along the entire height of the building, implying an increased lateral loading resistance and inter-storey deformation control. The lower drift also enhances the structural stability and reduces the risk of cracking in partitions and façade elements.

The seismic reaction also showed a substantial variation. Earthquake forces are directly proportional to structural mass, so lighter composite building attracted lower foundation shear than RCC building. Therefore, the seismic forces transmitted to the beams, columns and foundations were reduced, and so was the seismic performance.

The modal study further revealed that the natural time period of the composite building was less than that of the RCC building indicating higher structural stiffness. The enhanced stiffness allowed the composite structure to resist lateral deflection more effectively while still keeping adequate serviceability.

The comparison of the forces in members indicated that the composite building developed relatively lower axial forces, shear forces and bending moments in various structural parts. These reductions allow for a more efficient use of the

beam and column sections without sacrificing structural safety. Also, the reduced structural weight led to the minimization of foundation reactions and optimization of materials.

The RCC building had a lesser initial cost of construction as the concrete materials were easily available and the construction procedures were customary. However, it required larger member sizes and more quantities of concrete and reinforcing. The composite solution, in contrast, was more material efficient, constructed faster thanks to prefabricated steel components and exhibited better longterm structural performance.

The comparative analysis confirms that the steel-concrete composite building performs better than the structural steel building under lateral loading due to the reduction in structural weight, improved stiffness, improved seismic resistance and efficient utilization of material despite the structural systems satisfying the codal requirements.

Table.3. Comparison of Structural Response Parameters

Parameter	RCC Building	Composite Building	Better System
Storey Displacement	Higher	Lower	Composite
Storey Drift	Higher	Lower	Composite
Base Shear	Higher	Lower	Composite
Natural Time Period	Longer	Shorter	Composite
Axial Force	Higher	Lower	Composite
Shear Force	Higher	Lower	Composite
Bending Moment	Higher	Lower	Composite
Structural Weight	Higher	Lower	Composite

Interpretation: The composite building exhibited lower lateral deformation and internal forces, indicating superior structural efficiency under wind and seismic loading.

Table.4. Overall Performance Comparison

Performance Criterion	RCC	Composite	Remarks
Structural Safety	✓	✓	Excellent
Wind Performance	Good	Excellent	Composite performs better
Seismic Performance	Good	Excellent	Lower inertia forces
Material Efficiency	Moderate	High	Better utilization
Structural Weight	Higher	Lower	Advantage Composite
Construction Speed	Moderate	Fast	Prefabrication advantage
Initial Cost	Lower	Higher	RCC economical initially
Life-Cycle Performance	Good	Excellent	Composite preferred
Sustainability	Moderate	Better	Lower material consumption

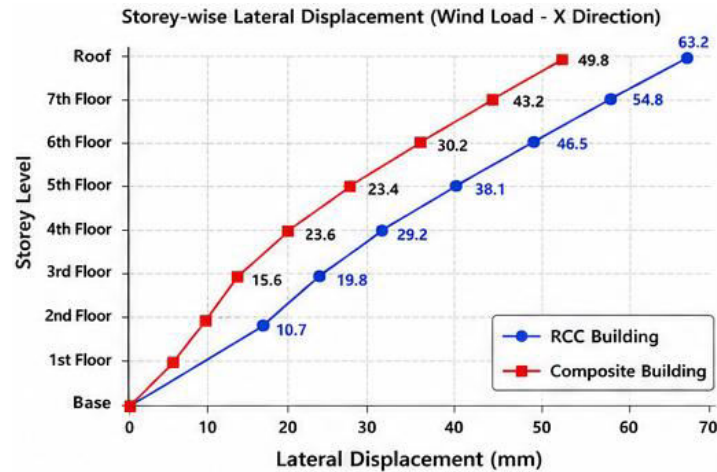


Figure.3. Storey Displacement Comparison

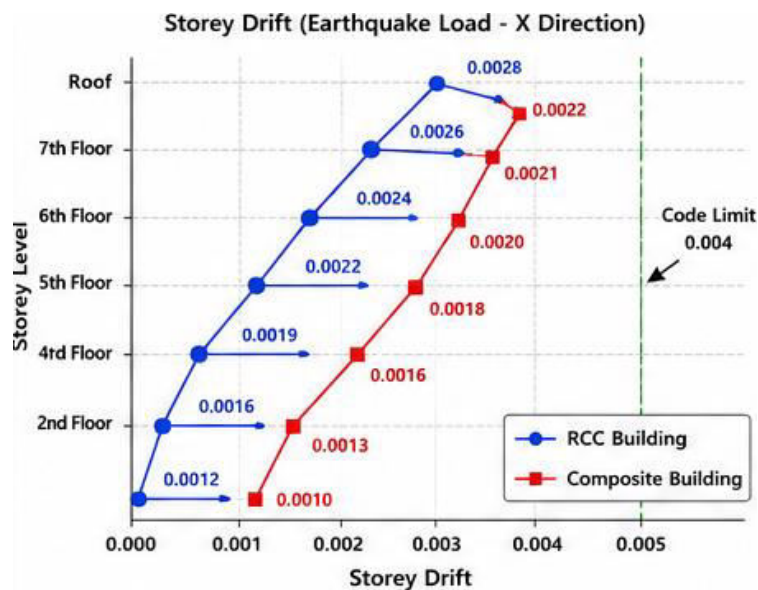


Figure.4. Storey Drift Comparison

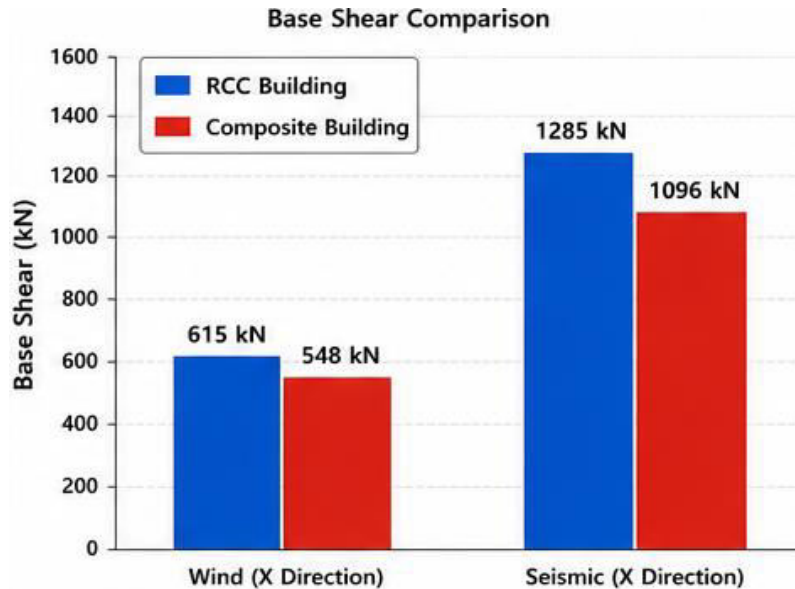


Figure.5. Base Shear Comparison

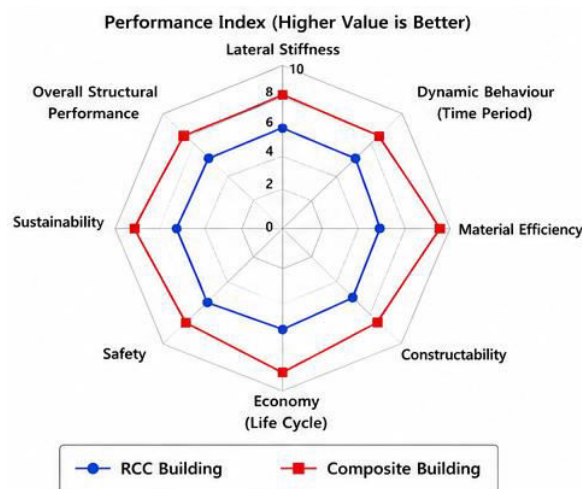


Figure.6. Overall Performance Comparison

V. CONCLUSION

The present work deals with comparison of structural performance of RCC and steel-concrete composite multistorey structures under the effect of wind and seismic loads utilizing STAAD.Pro CONNECT Edition. The structural systems met the requirements of the applicable Indian Standards and had sufficient safety and serviceability. However, the composite building displayed lower drift and less storey displacement, smaller base shear, higher stiffness and better material efficiency due to its lower structural weight and higher strength to weight ratio. While the initial cost of RCC construction is still inexpensive, steel-concrete composite construction offers better long term structural performance, faster construction and better seismic resistance. It is therefore a good option for medium and high rise buildings.

REFERENCES

- [1] Bureau of Indian Standards. (2000). *IS 456:2000. Plain and reinforced concrete—Code of practice*. Bureau of Indian Standards.
- [2] Bureau of Indian Standards. (2007). *IS 800:2007. General construction in steel—Code of practice*. Bureau of Indian Standards.
- [3] Bureau of Indian Standards. (2015). *IS 875 (Part 1):2015. Code of practice for design loads (other than earthquake) for buildings and structures: Part 1 Dead loads*. Bureau of Indian Standards.
- [4] Bureau of Indian Standards. (2015). *IS 875 (Part 2):2015. Code of practice for design loads (other than earthquake) for buildings and structures: Part 2 Imposed loads*. Bureau of Indian Standards.
- [5] Bureau of Indian Standards. (2015). *IS 875 (Part 3):2015. Code of practice for design loads (other than earthquake) for buildings and structures: Part 3 Wind loads*. Bureau of Indian Standards.
- [6] Bureau of Indian Standards. (2016). *IS 1893 (Part 1):2016. Criteria for earthquake resistant design of structures: Part 1 General provisions and buildings*. Bureau of Indian Standards.
- [7] Bureau of Indian Standards. (2016). *IS 13920:2016. Ductile detailing of reinforced concrete structures subjected to seismic forces—Code of practice*. Bureau of Indian Standards.
- [8] Subramanian, N. (2021). *Design of steel structures* (2nd ed.). Oxford University Press.
- [9] Pillai, S. U., & Menon, D. (2021). *Reinforced concrete design* (4th ed.). McGraw Hill Education.
- [10] Bentley Systems. (2024). *STAAD.Pro CONNECT Edition technical reference manual*. Bentley Systems.
- [11] Yadav, R., & Singh, A. (2021). Comparative seismic analysis of RCC and composite buildings. *Materials Today: Proceedings*, 46, 5310–5316.
- [12] Patel, H., & Shah, D. (2022). Performance evaluation of steel–concrete composite buildings under lateral loading. *Journal of Building Engineering*, 56, 104742.
- [13] Kumar, V., & Gupta, P. (2023). Comparative assessment of RCC and composite structures using finite element analysis. *Structures*, 52, 1468–1479.
- [14] Sharma, N., & Verma, R. (2023). Structural response of multi-storey buildings under seismic loading. *Asian Journal of Civil Engineering*, 24(8), 1187–1201.
- [15] Singh, M., & Kumar, S. (2024). Wind and seismic performance of composite frame buildings using STAAD.Pro. *Engineering Structures*, 306, 117612.
- [16] Patel, P., & Joshi, H. (2024). Comparative study of RCC and composite buildings under lateral loads. *Case Studies in Construction Materials*, 20, e03145.
- [17] Reddy, P., & Rao, K. (2025). Structural efficiency of composite multi-storey buildings subjected to wind and earthquake loading. *Journal of Constructional Steel Research*, 224, 109125.



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