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COMPARATIVE ANALYSIS OF HIGH-RISE STEEL-CONCRETE COMPOSITE AND RCC FRAMED STRUCTURES USING ETABS

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Abstract: The growing demand for structurally efficient and economically viable construction systems has led to a significant increase in the adoption of steel-concrete composite technology in modern civil engineering practice. Composite structures leverage the complementary mechanical properties of structural steel and reinforced concrete, wherein the steel component provides high tensile strength and ductility while concrete contributes compressive strength and lateral stiffness. In the present study, a comprehensive comparative analysis and design of a G+15 commercial building (plan dimension 20 m x 20 m, total height 45 m) situated in Pune, Maharashtra, has been undertaken for both conventional Reinforced Cement Concrete (RCC) and steel-concrete composite structural systems using ETABS 2018 software. Both systems were modelled under identical loading and boundary conditions in Seismic Zone III as per IS 1893:2016 and analysed using the Equivalent Static Analysis method. Key structural performance parameters, including storey displacement, storey drift, storey shear, bending moment, shear force, axial force, and self-weight, were systematically evaluated and compared. The analytical results demonstrate that the composite structural system exhibits superior performance in terms of reduced lateral displacement (24.40% lower), lower storey shear demand (18.53% lower), reduced axial force in columns (7.6% lower), and substantially reduced self-weight (35.91% lower) relative to the RCC structure. A construction cost analysis further confirms that the composite structure is 6.22% more economical than the equivalent RCC structure. It is concluded that steel-concrete composite structures are structurally more efficient, economically advantageous, and technically superior compared to conventional RCC framed systems for high-rise commercial buildings in seismically active regions.

Index Terms - Steel-Concrete Composite Structure, Reinforced Cement Concrete (RCC), ETABS 2018, Seismic Analysis, Equivalent Static Method, Storey Displacement, Storey Drift, IS 1893:2016, Structural Performance, Construction Economy.

I. INTRODUCTION

The rapid pace of urbanization and industrial expansion in the contemporary era has generated an ever-increasing demand for high-rise and multi-storey building construction. Conventional Reinforced Cement Concrete (RCC) structures have historically dominated the construction industry owing to their durability, structural robustness, and relative ease of execution. However, RCC structural systems are inherently characterized by high self-weight, larger member cross-sections, and extended construction durations, which collectively limit their suitability for modern tall buildings and fast-track project schedules.

Steel-concrete composite construction has emerged as a structurally efficient and economically viable alternative. In composite systems, structural steel sections and concrete components interact through shear connectors to achieve enhanced load-carrying capacity, stiffness, and ductility. The synergistic combination of these two materials yields a structural system that is lighter, stronger, and more cost-effective than conventional RCC alternatives [1].

Despite the proven advantages of composite construction in international practice, RCC continues to dominate in India largely due to long-established design familiarity. The present study undertakes a systematic comparative analysis of both structural systems for a G+15 commercial building using ETABS 2018 software, with the objective of quantifying performance differences and identifying the structurally superior and economically preferable solution for modern multi-storey commercial construction in seismically active regions.

II. LITERATURE REVIEW

Panchal and Marathe (2011) conducted a comparative study of RCC, steel, and composite G+30 storey buildings using ETABS and concluded that composite construction is more economical and efficient for high-rise structures [6]. Shah and Pajgade (2013) demonstrated that composite structures exhibit lower dead load, higher ductility, and improved seismic performance compared to RCC systems [5]. Wagh and Waghe (2014) used STAAD-Pro to compare RCC and composite commercial buildings and found composite systems progressively more economical as building height increases [4].

Patil and Suryanarayana (2015) established that composite systems provide better lateral stiffness and improved seismic response for G+15 buildings [21]. Aainawala (2016) demonstrated that composite beams and columns require smaller section sizes, resulting in greater usable floor area and lower dead load [16]. Bhoir and Bagade (2016) confirmed superior ductility and energy dissipation capacity of composite frames through pushover analysis [19]. Malakar and Bedi (2020) and Hegde et al. (2020) independently confirmed through ETABS-based analyses that composite structures consistently outperform RCC in terms of displacement, drift, storey shear, and construction economy [14],[8].

Research Gap: A notable gap exists in the simultaneous comparison of all key structural performance parameters for G+15 commercial buildings in Seismic Zone III under Indian Standard code provisions using ETABS 2018. The present study specifically addresses this gap.

III. PROBLEM STATEMENT AND OBJECTIVES

The structure considered in the present study is a G+15 commercial building situated in Pune, Maharashtra. The building has a uniform plan dimension of 20 m x 20 m and a total structural height of 45 m, with a uniform storey height of 3 m. The same building geometry is evaluated under identical loading conditions for both RCC and composite structural configurations. The objectives of the study are as follows:

To analyse and compare the structural behaviour and design of steel-concrete composite and conventional RCC framed structures for a G+15 multi-storey commercial building.

To compare structural performance parameters including storey displacement, storey drift, storey shear, axial force, bending moment, shear force, and self-weight between both structural systems.

To evaluate the cost-effectiveness of composite construction relative to conventional RCC construction.

To identify the structurally superior and economically preferable solution for multi-storey commercial buildings in seismically active regions.

IV. STRUCTURAL DATA AND METHODOLOGY

A. Structural Data

The structural data adopted for modelling both the RCC and composite systems are presented in Table 1. Three-dimensional finite element models were developed in ETABS 2018 with accurate member geometries, material properties, load assignments, and boundary conditions. Dead load and live load were applied as per IS 875 (Parts I and II). Seismic loading was applied per IS 1893:2016 using the Equivalent Static Analysis method. The same load patterns and combinations were applied to both models.

Table 1: Structural Data for RCC and Composite Systems

Parameter	RCC Structure	Composite Structure
Plan Dimension	20 m x 20 m	20 m x 20 m
Total Height	45 m (G+15)	45 m (G+15)
Storey Height	3 m	3 m
Beam Size	300 x 500 mm	ISMB 450
Column Size	500 x 500 mm	500 x 500 mm + ISMB 450 encased
Slab Thickness	150 mm RCC	150 mm Composite Deck
Grade of Concrete	M30	M30
Grade of Steel (Structural)	Fe415	Fe250
Seismic Zone	Zone III (IS 1893:2016)	Zone III (IS 1893:2016)
Importance Factor	1.0	1.0
Response Reduction Factor (R)	5	5
Soil Type	Medium Soil	Medium Soil
Damping Ratio	5%	5%
Live Load (all floors)	3 kN/m2	3 kN/m2
Floor Finish Load	1 kN/m2	1 kN/m2
Wind Speed	39 m/s	39 m/s

B. Analysis Methodology

The Equivalent Static Analysis (ESA) method as prescribed in IS 1893 (Part 1): 2016 was adopted for seismic analysis. The design base shear was computed using the expression Vb = Ah x W, where Vb is the design base shear, Ah is the design horizontal seismic coefficient, and W is the seismic weight of the building. The design horizontal seismic coefficient was determined as Ah = (Z/2) x (I/R) x (Sa/g), with Z = 0.16 (Zone III), I = 1.0, R = 5, and Sa/g obtained from the IS 1893:2016 spectrum for medium soil. For the RCC structure, members were designed per IS 456:2000 and IS 13920:2016. For the composite structure, composite beams were designed per AISC 360-10 and encased composite columns per AISC 360-10.

V. RESULTS AND DISCUSSION

A. Storey Displacement

Table 2 presents the maximum storey displacements for both structural systems under earthquake loading in the EQX direction. The composite structure exhibits a maximum storey displacement of 13.56 mm at Storey 15, compared to 17.33 mm for the RCC structure — a reduction of 24.40%. This improvement is directly attributable to the higher lateral stiffness of composite columns and the composite action of beams and slabs, which together reduce lateral deflection under seismic loading [2].

Table 2: Storey Displacement Comparison (mm)

Storey	RCC EQX	RCC EQY	Comp. EQX	Comp. EQY
15	17.33	17.33	13.56	13.94
12	15.54	15.54	12.35	12.72
9	12.22	12.22	10.10	10.42
6	8.04	8.04	7.24	7.50
3	3.53	3.53	4.12	4.33
1	0.73	0.73	1.79	1.97

B. Storey Drift

The RCC structure exhibits a maximum storey drift of 0.000599 (at Storey 1), while the composite structure records a maximum of 0.000503 (at Storey 5), representing a 17.42% reduction. Both values remain well within the IS 1893:2016 permissible limit of 0.004, confirming the serviceability adequacy of both systems. The reduced drift in the composite system reflects its superior inter-storey deformation control under seismic loading.

Table 3: Storey Drift Comparison (Unitless)

Storey	RCC EQX	RCC EQY	Comp. EQX	Comp. EQY
15	0.000090	0.000088	0.000134	0.000134
10	0.000280	0.000286	0.000411	0.000411
5	0.000346	0.000353	0.000503	0.000503
3	0.000364	0.000368	0.000491	0.000491
1	0.000599	0.000658	0.000246	0.000246

C. Storey Shear

The RCC structure generates a base storey shear of 564.24 kN in EQX, while the composite structure generates 468.52 kN — a reduction of 18.53%. This reduction is a direct consequence of the lower self-weight of the composite system. As per IS 1893:2016, design seismic forces are proportional to the seismic weight; the significantly lower dead load of the composite system therefore directly reduces the storey shear demand at all floor levels [3].

Table 4: Base Storey Shear Comparison (kN)

Model	EQX (kN)	EQY (kN)	Reduction
RCC	564.24	564.24	-
Composite	468.52	453.07	18.53% lower

D. Bending Moment and Shear Force

Bending moment and shear force demands were extracted from representative beam B31 at Storey 5. As presented in Table 5, the RCC beam exhibits a bending moment of 24.43 kN-m and a shear force of 51.10 kN, while the composite beam records 23.40 kN-m and 45.42 kN respectively. The reduction in shear force (11.12%) directly reduces transverse reinforcement demand and improves the shear performance of the structural member.

Table 5: Bending Moment and Shear Force - Beam B31 at Storey 5

Member	Bending Moment (kN-m)	Shear Force (kN)
RCC Beam	24.43	51.10
Composite Beam	23.40	45.42

E. Axial Force in Columns

The axial force demands were compared for Column C1 at Storey 13. The RCC column carries an axial force of 588.16 kN, compared to 543.42 kN for the composite column — a reduction of 7.6%. The reduced axial demand is attributable to the lower gravity-induced dead load of the composite system and has direct implications for column section sizing, rebar requirement, and foundation design economy.

F. Self-Weight and Material Quantities

The total self-weight of the RCC structure is 44,086.97 kN, compared to 30,663.06 kN for the composite structure — a reduction of 35.91%. This is the primary driver of all performance improvements noted above. Table 6 presents the material quantities and construction cost comparison for both structural systems.

Table 6: Material Quantities and Construction Cost Comparison

Parameter	RCC Structure	Composite Structure	Change
Concrete Volume (m3)	2,331	1,305	-44.0%
Reinforcement (Ton)	375.93	51.18	-86.4%
Structural Steel (Ton)	-	412.37	-
Self-Weight (kN)	44,086.97	30,663.06	-35.91%
Total Construction Cost (INR)	Rs. 3,33,99,490	Rs. 3,13,82,760	-6.22%

Table 7: Summary of Comparative Structural Performance

Parameter	RCC	Composite	Improvement
Max. Storey Displacement (mm)	17.33	13.56	24.40% reduction
Max. Storey Drift (unitless)	0.000599	0.000503	17.42% reduction
Base Storey Shear - EQX (kN)	564.24	468.52	18.53% reduction
Beam Bending Moment (kN-m)	24.43	23.40	4.22% reduction
Beam Shear Force (kN)	51.10	45.42	11.12% reduction
Column Axial Force (kN)	588.16	543.42	7.6% reduction
Total Self-Weight (kN)	44,086.97	30,663.06	35.91% reduction
Construction Cost (INR)	Rs. 3.34 Crore	Rs. 3.14 Crore	6.22% reduction

VI. CONCLUSIONS

The steel-concrete composite structure exhibits a maximum storey displacement of 13.56 mm, which is 24.40% lower than the RCC structure (17.33 mm), confirming superior lateral stiffness of the composite system under seismic loading.

The maximum storey drift of the composite structure (0.000503) is 17.42% lower than that of the RCC structure (0.000599). Both values satisfy the IS 1893:2016 permissible limit of 0.004.

The base storey shear of the composite structure (468.52 kN) is 18.53% lower than that of the RCC structure (564.24 kN), directly reflecting the reduced seismic mass of the composite system.

Beam bending moment and shear force demands are lower in the composite system by 4.22% and 11.12% respectively, reducing both longitudinal and transverse reinforcement requirements.

Column axial force in the composite system is 7.6% lower than in the RCC system, with consequent reductions in column section demands and foundation loads.

The total self-weight of the composite structure (30,663.06 kN) is 35.91% lower than the RCC structure (44,086.97 kN), which is the primary driver of all the above performance improvements.

The composite structure is 6.22% more economical in terms of total construction cost. When reduced construction time and lower foundation costs are additionally considered, the economic advantage of the composite system is further amplified.

Overall, steel-concrete composite structures are structurally more efficient, economically advantageous, and technically superior compared to conventional RCC framed systems for high-rise commercial buildings in seismically active regions of India.

REFERENCES

[1] Panchal D.R. and Marathe P.M. (2011). Comparative Study of R.C.C, Steel and Composite (G+30 Storey) Building. Int. Conf. on Current Trends in Technology, Vol. 4, Issue 3, pp. 284-289.

[2] Shah A.N. and Pajgade P.S. (2013). Comparison of R.C.C. and Composite Multistoried Buildings. IJERA, Vol. 3, Issue 2, pp. 534-539.

[3] Panchal D.R. (2014). New Techniques of Analysis and Design of Composite Steel-Concrete Structures. IJERT, Vol. 3, Issue 3, pp. 639-643.

[4] Wagh S.A. and Waghe U.P. (2014). Comparative Study of R.C.C and Steel Concrete Composite Structures. IJERA, Vol. 4, Issue 4, pp. 369-376.

[5] Tedia A. and Maru S. (2014). Cost, Analysis and Design of Steel-Concrete Composite Structure RCC Structure. IOSR-JMCE, Vol. 11, Issue 1, pp. 54-59.

[6] Patil U.P. and Suryanarayana M. (2015). Analysis of G+15 RCC and Composite Structure having a Soft Storey. IRJET, Vol. 2, Issue 3, pp. 59-64.

[7] Aainawala M.S. (2016). Behaviour of G+15 R.C.C. and Composite Structure. Int. J. of Innovative and Emerging Research in Engineering, Vol. 3, pp. 402-407.

[8] Bhoir R.R. and Bagade M. (2016). Analysis and Design of Composite Structure and Its Comparison With RCC Structure. IJARSET, Vol. 3, Issue 7, pp. 2371-2378.

[9] Malakar S. and Bedi K. (2020). A Review on Comparison Between RCC And Composite Materials In Multi Storey Building. IJSRET, Vol. 6, Issue 4, pp. 2102-2107.

[10] Hegde R. et al. (2020). Parametric Study of RCC, Steel and Composite Structures under Seismic Loading. IRJET, Vol. 7, Issue 2, pp. 2658-2661.

[11] Sharma P.K. et al. (2021). Seismic Performance of Steel Concrete Composite Structures using ETABS.

[12] Patil S.R. et al. (2021). Comparative Analysis of RCC and Composite Multistorey Building Using ETABS.

[13] Deshmukh R. et al. (2022). Comparative Study of High-Rise RCC and Composite Buildings. ETABS-based Internal Study.

[14] Reddy V.M. et al. (2023). Seismic Analysis of RCC and Composite Buildings using Response Spectrum Analysis. ETABS-based Study.

[15] IS 456:2000. Plain and Reinforced Concrete - Code of Practice (Fourth Revision). Bureau of Indian Standards, New Delhi.

[16] IS 875 Parts I, II, III (1987). Code of Practice for Design Loads for Buildings and Structures. Bureau of Indian Standards, New Delhi.

[17] IS 1893 (Part 1): 2016. Criteria for Earthquake Resistant Design of Structures. Bureau of Indian Standards, New Delhi.

[18] IS 11384:1985. Code of Practice for Design of Composite Structure. Bureau of Indian Standards, New Delhi.

[19] IS 13920:2016. Ductile Design and Detailing of Reinforced Concrete Structures. Bureau of Indian Standards, New Delhi.

[20] AISC 360-10 (2010). Specification for Structural Steel Buildings. American Institute of Steel Construction, Chicago, USA.