

Comparative Analysis of RCC and Steel Frame Structure Using STAAD PRO

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Abstract: *This project presents a comparative analysis of RCC and Steel frame structures for a G+3 building using STAAD.Pro software. Both structural systems are analyzed under identical dead load, live load, wind load, and seismic load conditions as per Indian Standard codes. The study compares important parameters such as bending moment, axial force, displacement, structural weight, construction time, and overall cost. The analysis shows that RCC structures are economical and suitable for low-rise buildings due to their durability and stiffness, whereas Steel structures provide faster construction, reduced self-weight, and better seismic performance because of their ductility. The study helps in selecting an efficient structural system based on safety, economy, and construction requirements.*

Keywords: RCC Structure, Steel Structure, STAAD.Pro, Structural Analysis, Seismic Load, Deflection, Cost Comparison, G+3 Building, IS Codes, Structural Performance.

I. INTRODUCTION

Reinforced Cement Concrete (RCC) and Steel frame structures are widely used structural systems in modern civil engineering due to their strength, durability, and structural efficiency. The selection of a suitable structural system plays an important role in ensuring safety, economy, and construction speed for residential and commercial buildings [1]. RCC structures are commonly preferred for low- and medium-rise buildings because of their rigidity, fire resistance, and lower maintenance requirements [2]. In contrast, Steel structures provide a high strength-to-weight ratio, flexibility, and faster construction through prefabrication techniques [3].

With rapid urbanization and increasing demand for multi-storey buildings, it has become necessary to compare the performance of RCC and Steel structures under different loading conditions such as dead load, live load, wind load, and seismic load [4]. Structural analysis software like STAAD.Pro helps engineers accurately evaluate parameters including bending moment, shear force, displacement, and In seismic-prone regions, steel structures are often considered advantageous because of their ductility and reduced self-weight, while RCC structures provide greater stiffness and durability [6]. Economic considerations such as material cost, labor requirement, and construction time also influence the selection of the structural system [7]. RCC construction generally requires more curing time and formwork, whereas steel structures allow rapid erection and easy future modification [8].

This project focuses on the comparative analysis of RCC and Steel frame structures for a G+3 building using STAAD.Pro software. The study aims to evaluate structural behavior, cost efficiency, construction practicality, and seismic performance according to Indian Standard codes [9]. The findings of this study will help engineers and designers select the most suitable structural system based on project requirements and performance criteria [10].

II. PROBLEM STATEMENT

In modern construction practices, the selection of an appropriate structural system is a major challenge for engineers and designers because both Reinforced Cement Concrete (RCC) and Steel structures possess different structural and economic characteristics. RCC structures are widely used due to their durability, stiffness, fire resistance, and lower initial construction cost, while Steel structures are preferred for their lightweight nature, high strength-to-weight ratio, ductility, and faster construction process. However, there is no universal solution suitable for every type of building, as



the performance of each structural system depends on factors such as load conditions, seismic behavior, construction time, material availability, maintenance requirements, and overall project cost. For low- and medium-rise buildings like G+3 structures, it becomes essential to identify which system provides better structural efficiency, safety, and economy under identical loading and environmental conditions. In many cases, improper selection of the structural system may lead to increased construction cost, excessive structural weight, poor seismic response, longer project duration, and maintenance difficulties.

III. OBJECTIVES

- To design and model a G+3 building in RCC and Steel frame structures using STAAD.Pro software.
- To analyze and compare structural parameters such as bending moment, shear force, axial load, and displacement.
- To evaluate the seismic and wind performance of RCC and Steel structures as per Indian Standard codes.
- To compare the construction cost, material quantity, and construction time of both structural systems.
- To determine the most economical, safe, and structurally efficient system for G+3 buildings.

IV. LITERATURE SURVEY

S. Ramamrutham (2015) presented detailed concepts of Reinforced Cement Concrete structures in his work on RCC design and analysis. He explained that RCC structures provide excellent compressive strength, rigidity, fire resistance, and durability, making them suitable for residential and medium-rise buildings. His study highlighted that RCC structures are economical and require less maintenance over time. However, RCC construction involves higher self-weight and longer construction duration because of curing and formwork requirements.

N. Subramanian (2016) discussed the behavior and design of steel structures under various loading conditions in his research on steel design. He emphasized that steel structures possess a high strength-to-weight ratio, ductility, and flexibility, which improve structural performance under wind and seismic loads. The study concluded that steel structures are highly suitable for industrial and high-rise buildings due to faster construction and ease of expansion. However, steel structures require corrosion protection and involve higher initial material costs.

B.C. Punmia et al. (2017) conducted a comparative study on RCC and Steel frame structures focusing on construction cost and execution time. Their findings showed that RCC structures are cost-effective in terms of material availability, whereas steel structures significantly reduce construction time because of prefabrication and easy assembly techniques. The research also highlighted that the choice of structural system depends on project scale, labor availability, and functional requirements.

S.K. Duggal (2018) analyzed the seismic behavior of RCC and Steel structures using limit state design principles. His study demonstrated that steel structures perform better during earthquakes because of their lightweight nature and high ductility, which helps in absorbing seismic energy effectively. In comparison, RCC structures experience larger seismic forces due to higher dead load and may develop cracks if not properly designed for ductility.

P.C. Varghese (2019) studied the structural performance of RCC buildings under combined loading conditions. He observed that RCC structures offer better stiffness, sound insulation, and durability in environmental conditions. However, the higher self-weight of RCC structures increases foundation loads and base shear. The research concluded that steel structures are structurally more efficient for taller and lightweight construction projects.

International Journal of Engineering Research – IJER (2020) published a comparative analysis of RCC and Steel structures using STAAD.Pro software. The study reported that steel structures showed lower structural weight and reduced displacement compared to RCC structures under identical loading conditions. The researchers concluded that steel structures are more effective in seismic regions, while RCC structures remain economical for low-rise buildings.

S. Karthikeyan and G. Suresh (2021) carried out seismic analysis of RCC and Steel frame buildings using STAAD.Pro. Their study revealed that steel structures provide better lateral load resistance and lower storey drift due to



their flexibility and ductility. RCC structures, however, demonstrated higher stiffness and damping characteristics. The authors suggested that steel is more suitable for high seismic zones and tall buildings.

Comparison Table

Author & Year	Method Used	Advantages	Limitations
S. Ramamrutham (2015)	RCC structural analysis and design concepts	Economical, durable, fire resistant	Higher self-weight and slow construction
N. Subramanian (2016)	Steel structure design and analysis	High strength-to-weight ratio, fast construction	Corrosion and higher initial cost
B.C. Punmia et al. (2017)	Comparative study of RCC and Steel frames	Cost-effective RCC, faster steel erection	RCC requires curing; steel needs maintenance
S.K. Duggal (2018)	Seismic analysis using limit state design	Better seismic performance in steel structures	RCC may develop cracks during earthquakes
P.C. Varghese (2019)	RCC behavior under combined loads	High stiffness and durability	Increased foundation load due to heavy weight
IJER (2020)	STAAD.Pro comparative analysis	Lower displacement and weight in steel	Higher steel material cost
S. Karthikeyan & G. Suresh (2021)	Seismic performance comparison using STAAD.Pro	Better lateral resistance in steel	RCC less flexible under seismic loads
A. Patel & R. Singh (2022)	Cost and time comparison of G+3 structures	Faster construction using steel	RCC construction takes longer time

IV. WORKING OF SYSTEM

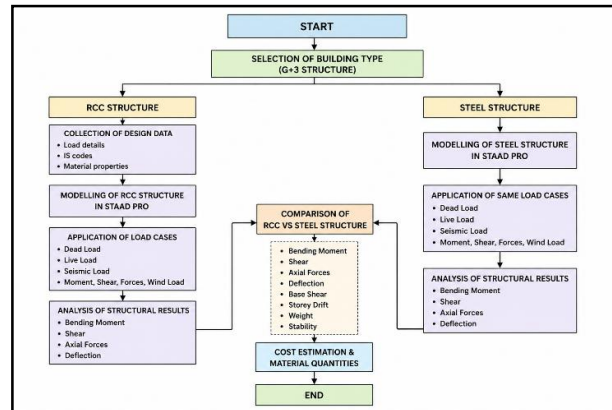


Fig 1: Design of the system

1. Selection of Building Type

The process begins with the selection of a G+3 building structure for comparative analysis. Both RCC and Steel frame models are considered with identical geometry, dimensions, and loading conditions to ensure accurate comparison.

2. Collection of Design Data

All required structural data such as building dimensions, load details, material properties, and Indian Standard codes are collected. This includes dead load, live load, wind load, and seismic load parameters as per IS 456, IS 800, IS 875, and IS 1893 codes.



3. Modeling of RCC Structure in STAAD.Pro

The RCC frame structure is modeled in STAAD.Pro by defining beam sizes, column sizes, slab thickness, support conditions, and material properties. The RCC model is designed according to reinforced concrete design standards.

4. Modeling of Steel Structure in STAAD.Pro

A separate Steel frame model is created using steel beam and column sections such as ISMB and ISHB sections. The steel structure is modeled with the same building geometry and loading conditions for fair comparison.

5. Application of Load Cases

Different load cases including dead load, live load, wind load, and seismic load are applied to both RCC and Steel structures. Load combinations are generated according to Indian Standard code requirements to evaluate structural safety under critical conditions.

6. Structural Analysis

STAAD.Pro performs structural analysis for both models to calculate bending moment, shear force, axial force, displacement, storey drift, and support reactions. The software analyzes how each structure behaves under various loading conditions.

7. Comparison of RCC and Steel Structures

The obtained results from both structures are compared based on structural performance, weight, deflection, seismic response, stability, and load-carrying capacity. This comparison helps in identifying the advantages and limitations of each structural system.

8. Cost Estimation and Material Quantity Analysis

Material quantities such as concrete, reinforcement, and steel sections are estimated. The overall construction cost, labor requirement, and construction time for RCC and Steel structures are compared to determine economic feasibility.

9. Final Conclusion

Based on the analysis results, the most suitable structural system is identified for G+3 buildings considering safety, economy, construction speed, durability, and seismic performance.

V. SYSTEM DESIGN

1. System Overview:

The system design for the project “Comparative Analysis of RCC and Steel Frame Structure Using STAAD.Pro” is developed to analyze and compare the structural behavior of RCC and Steel frame buildings under identical loading conditions. The complete design process includes structural modeling, load application, analysis, and comparison of results using STAAD.Pro software.

1. Building Configuration

The proposed structure is a G+3 framed building designed for comparative analysis. Both RCC and Steel models are developed with the same architectural dimensions and support conditions to ensure accurate comparison.

- Architectural Plan Dimensions: 8.67 m × 13.19 m
- Storey Height: 3 m
- Total Height: 12 m (G+3)
- Support Condition: Fixed Supports



2. RCC Structural Model

The RCC frame structure is designed using reinforced concrete members. The dimensions of beams, columns, and slabs are assigned according to structural requirements and IS 456:2000 guidelines.

- **RCC Member Details**
- Beam Size: 230 × 450 mm
- Column Size: 300 × 500 mm
- Slab Thickness: 150 mm

The RCC model provides higher stiffness and durability, making it suitable for residential and low-rise buildings.

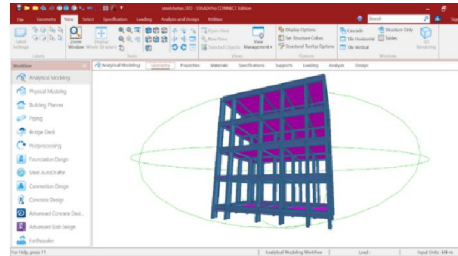


Figure 1: RCC Structural Model in STAAD.Pro

The figure shows the 3D analytical model of the RCC structure created in STAAD.Pro software for structural analysis and load evaluation.

3. Steel Structural Model

The Steel frame structure is modeled using standard ISMB steel sections. The model is developed with identical geometry and loading conditions for proper comparison with the RCC structure.

Steel Member Details

Beams: ISMB Sections

Columns: ISMB Sections

Steel structures provide lightweight construction, higher ductility, and faster construction speed.

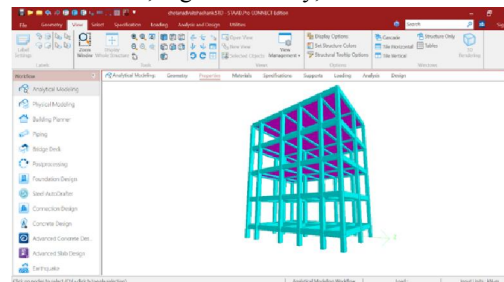


Figure 2: Steel Structural Model in STAAD.Pro

The figure illustrates the analytical steel frame model developed in STAAD.Pro for structural analysis under various loading conditions.

4. Load Application

Different structural loads are applied to both RCC and Steel structures according to IS 875 and IS 1893 standards.

- **Dead Load**
Dead load includes permanent structural loads acting on the building:
- Self-weight of structure (automatically generated in STAAD.Pro)
- Wall load



- Floor finish load
- **Live Load**
Live load represents movable and occupancy loads:
- Residential live load: 2–3 kN/m²

5. Load Combinations

Load combinations are applied to evaluate structural safety under critical loading conditions.

- 1.5 DL + 1.5 LL
- 1.2 DL + 1.2 LL
- 1.5 DL
- 0.9 DL

These combinations help in determining maximum bending moment, shear force, axial force, and displacement.

6. Structural Analysis

STAAD.Pro software is used to perform detailed structural analysis for both RCC and Steel models. The software calculates:

- Bending Moment
- Shear Force
- Axial Force
- Deflection
- Storey Drift
- Support Reactions

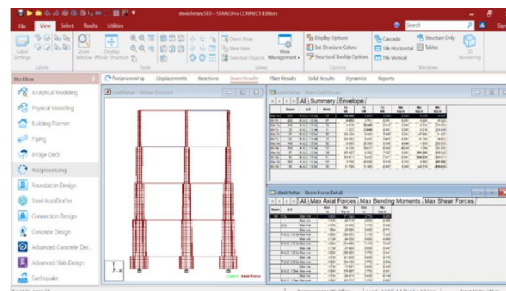


Figure 3: Structural Analysis Results

The figure presents beam force and axial force results obtained from STAAD.Pro after structural analysis.

7. Section Property Assignment

Structural properties and material specifications are assigned in STAAD.Pro for beams, columns, and slabs to define the behavior of structural members during analysis.



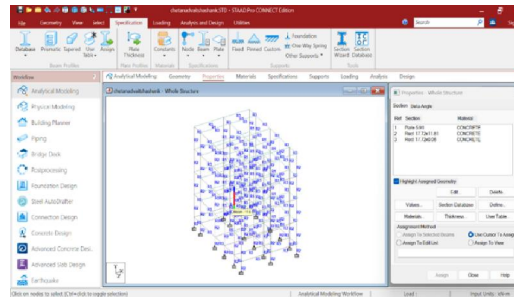


Figure 4: Section Property Assignment in STAAD.Pro

The figure shows the assignment of RCC and Steel section properties within the STAAD.Pro environment.

8. Comparative Structural Evaluation

After analysis, the performance of RCC and Steel structures is compared based on:

- Structural Strength
- Weight
- Deflection
- Construction Time
- Cost Estimation
- Seismic Performance

The final comparison helps in identifying the most suitable structural system for G+3 buildings based on economy, safety, and structural efficiency.

VI. RESULTS

The structural analysis of RCC and Steel frame structures was successfully carried out using STAAD.Pro software under identical loading and support conditions. The analysis included dead load, live load, and load combinations as per Indian Standard codes. From the obtained results, both structures were found to be structurally safe and stable for the proposed G+3 building. The RCC structure showed higher stiffness and comparatively lower deformation due to the rigid nature of reinforced concrete members. However, the self-weight of the RCC structure was significantly higher, resulting in larger axial forces and increased foundation loading.

The Steel frame structure demonstrated better overall structural efficiency because of its lightweight characteristics and high strength-to-weight ratio. The maximum displacement observed in the steel structure was lower than the RCC structure, indicating improved flexibility and seismic behavior. Steel members also experienced lower axial forces because of reduced dead load. The analysis results further showed that steel construction offers faster execution and easier modification compared to RCC structures. On the other hand, RCC structures were found to be more economical for residential and low-rise applications because of lower material cost and higher durability.

VII. CONCLUSION

The comparative analysis of RCC and Steel frame structures using STAAD.Pro concluded that both structural systems are safe and suitable for the proposed G+3 building under the applied loading conditions. The study showed that RCC structures provide greater stiffness, durability, fire resistance, and cost effectiveness, making them suitable for residential and low-rise buildings. However, RCC structures have higher self-weight and require more construction time because of curing and formwork processes.

Steel structures, on the other hand, demonstrated better structural efficiency due to their lightweight nature, higher strength-to-weight ratio, and ductility. The steel frame showed lower displacement, reduced axial force, and improved



seismic performance compared to the RCC structure. In addition, steel construction offers faster erection, easy modification, and reduced overall project duration through prefabrication techniques.

VIII. FUTURE SCOPE

The present study can be further extended by analyzing high-rise buildings with greater numbers of storeys to evaluate the performance of RCC and Steel structures under increased loading conditions. Advanced structural systems such as composite structures, tubular structures, and pre-engineered buildings can also be included for better comparative analysis. Future work may involve dynamic analysis using response spectrum and time history methods to obtain more accurate seismic behavior of structures in different seismic zones.

The project can also be improved by considering additional factors such as soil-structure interaction, foundation analysis, wind tunnel effects, and sustainability assessment. Modern construction materials like high-strength concrete and advanced steel sections may be studied to enhance structural efficiency and reduce overall cost.

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