

Comparative Study of CFST and RC Columns Under Axial Compression

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Abstract: *Concrete Filled Steel Tubular (CFST) columns are composite structural members that integrate the advantages of both steel and concrete, offering superior load-carrying capacity, ductility, and strength under axial loading compared to conventional Reinforced Concrete (RC) columns. This study presents a comparative analysis between CFST and RC columns in RC frame structures with a specific focus on their axial load behaviour. The comparison includes parameters such as ultimate axial load capacity, deformation characteristics, stiffness, ductility, and cost efficiency. Analytical and experimental investigations reveal that CFST columns can resist higher axial loads due to the composite action between the steel tube and the concrete core. The steel tube provides confinement, enhancing the compressive strength of the concrete, while the concrete delays local buckling of the steel. The study concludes that CFST columns demonstrate superior axial strength, better energy absorption, and enhanced seismic performance compared to RC columns, making them a suitable alternative for modern high-rise and heavy-load-bearing structures.*

Keywords: CFST Column, RC Column, RC frame Building, Long column and buckling analysis.

I. INTRODUCTION

Columns are the primary vertical load-carrying members in framed structures and play a vital role in transferring structural loads safely to the foundation. The axial load capacity of a column directly influences the strength, stability, and durability of the entire structure[1]. Among various structural elements, Reinforced Concrete (RC) columns have been extensively used in buildings and infrastructure projects because of their economical construction and ease of design. However, RC columns may experience limitations such as lower ductility, cracking, and reduced load-carrying efficiency when subjected to heavy axial loads or seismic forces [2].

In recent years, Concrete Filled Steel Tubular (CFST) columns have gained significant attention as an advanced composite structural system. A CFST column is formed by filling a hollow steel tube with concrete, thereby combining the beneficial properties of both materials. The steel

tube provides confinement to the concrete core, improving its compressive strength and delaying crack propagation, while the concrete prevents inward buckling of the steel tube[3]. This composite interaction enhances the overall structural performance and enables the column to sustain higher axial loads compared to conventional RC columns [4].

CFST columns also exhibit superior ductility, stiffness, and energy absorption capacity, making them highly suitable for high-rise buildings, bridges, industrial structures, and earthquake-resistant construction. Due to the confinement effect and efficient stress distribution between steel and concrete, CFST members demonstrate improved deformation behavior and reduced failure risks under extreme loading conditions[5]. In contrast, RC columns generally show brittle failure patterns and comparatively lower resistance to dynamic loading. Therefore, CFST technology is increasingly being adopted in modern structural engineering applications [6].





Fig 1: Experimental Setup for RC Column

The main objective of this study is to compare the axial load behavior of CFST and RC columns within RC frame structures. The comparison focuses on parameters such as ultimate axial strength, deformation characteristics, stress distribution, and failure mechanisms under loading conditions. By evaluating the structural efficiency of both systems, the study aims to identify the advantages of CFST columns and assess their potential as a superior alternative to Special attention is given to the confinement effect provided by the steel tube and its influence on improving the compressive strength and deformation capacity of the concrete core. conventional RC columns for heavy-load and high-performance structural applications [7][8].



Fig 2: Concrete Mixing Stage

PROBLEM STATEMENT

Reinforced Concrete (RC) columns are widely used in structural engineering due to their simplicity, durability, and cost-effectiveness. However, conventional RC columns often exhibit limitations such as lower ductility, larger cross-sectional requirements, cracking, and reduced axial load-carrying efficiency when subjected to heavy compressive



loads or seismic forces. These limitations become more significant in high-rise buildings, bridges, and industrial structures where high strength, stiffness, and stability are essential for safe structural performance. Concrete Filled Steel Tubular (CFST) columns have emerged as an advanced composite structural system capable of overcoming many of the shortcomings associated with RC columns.

OBJECTIVE

- To identify the practical advantages of using CFST columns over RC columns in terms of strength, ductility, and constructability for high-rise or heavy-load structures.
- To compare the axial load-carrying capacity of CFST and RC columns under uniaxial compression within RC frame structures.
- To analyze the stress–strain behaviour and failure modes of CFST and RC columns under axial loading.
- To validate analytical or numerical results with experimental or literature-based data for accuracy.

II. LITERATURE SURVEY

[1] **Lin (2009)** Composite frames made out of concrete-filled steel tubular (CFST) columns and steel beams are becoming increasingly common in building constructions, according to this article. Composite frame systems are frequently used with reinforced concrete shear walls to create a high-rise building system in China. However, information on the seismic performance of this type of hybrid building was scarce. The results of shaking table testing on two 30-story building models with composite frames and RC shear walls are described in this study

[2] **Liao (2009)** In this study, structural engineers discuss how the usage of concrete-filled steel tubular (CFST) columns and reinforced concrete (RC) shear wall mixed constructions has piqued their interest in recent years. On circular CFST columns and RC shear wall mixed constructions exposed to continuous axial load and cyclic lateral stress, experimental research using four test models was carried out.

[3] **Lin (2014)** the concrete-filled steel tubular (CFST) structure is discussed in this study because it has various structural advantages and is commonly employed in civil engineering constructions. This study examines the evolution of the concrete-filled steel tubular structure family to this point and proposes a research strategy for CFST members. The most current research on CFST structural members has been summarised and discussed, with a focus on China.

[4] **Faizulla (2015)** Structural engineers are faced with the task of finding the most efficient and cost-effective design solution. The use of composite materials is of special interest since it has the ability to significantly improve overall performance with relatively minor modifications in manufacturing and building processes.

III. PROPOSED SYSTEM

A. Structural Configuration of the Proposed System

The proposed system focuses on the comparative analysis of Concrete Filled Steel Tubular (CFST) columns and Reinforced Cement Concrete (RCC) columns subjected to axial compression within reinforced concrete frame structures.





Fig 3: RC Column Preparation

B. Material Properties and Composite Interaction

The proposed system utilizes structural steel and concrete as the primary materials for CFST columns, while RCC columns use concrete reinforced with steel bars. In the CFST system, the steel tube acts as permanent formwork and provides confinement to the concrete core, enhancing compressive strength and ductility. Simultaneously, the concrete core supports the steel tube and delays local buckling.

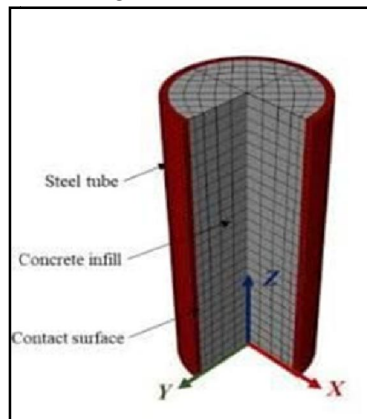


Fig 4: CFST Column

C. Loading and Analytical Methodology

The proposed system applies axial compression loads gradually on both CFST and RCC column models to study their structural response. Analytical and numerical approaches are adopted to investigate stress distribution, deformation behavior, strain development, and ultimate load capacity. Finite Element Analysis (FEA) techniques are used to simulate the behavior of the columns under loading conditions and to validate the analytical results

D. Performance Evaluation Parameters

The performance of the proposed system is evaluated using several structural parameters, including axial load-carrying capacity, ductility, stiffness, energy absorption capacity, strain behavior, and failure mechanisms. The deformation and stress patterns obtained from both column systems are compared to determine structural efficiency. Special attention is given to the confinement effect in CFST columns and its contribution toward enhanced strength and improved post-yield behavior.





Fig 5: Specimen Casting Process

E. Expected Structural Outcomes

The proposed system is expected to demonstrate that CFST columns provide superior structural performance compared to RCC columns under axial compression. The CFST system is anticipated to achieve higher load-carrying capacity, improved ductility, enhanced deformation resistance, and gradual failure behavior due to composite action between steel and concrete.

IV. SYSTEM DESIGN

A. Selection of Column Type and Structural Configuration

The methodology of the proposed study begins with the selection of Concrete Filled Steel Tubular (CFST) columns and conventional Reinforced Cement Concrete (RCC) columns for comparative analysis under axial compression. Circular CFST sections are selected because they provide a higher confinement effect compared to square and rectangular sections. The hollow steel tubes are designed to initially support construction loads independently up to three or four storeys.

B. Material Selection and Properties

The study uses structural steel tubes and high-strength concrete for the CFST columns, while RCC columns are constructed using reinforced concrete with steel reinforcement bars.

C. Construction and Fabrication Procedure

The construction methodology of CFST columns involves placing hollow steel tubes vertically as load-bearing members during the initial stages of construction. Since the steel tubes themselves can carry construction loads, the need for temporary formwork and extensive shuttering is minimized. Once the required storey levels are completed, concrete is pumped into the tubes continuously from the base using modern pumping techniques.





Fig 7: CFST Columns Preparation

D. Analytical and Experimental Investigation

The structural behavior of CFST and RCC columns is investigated using analytical and numerical approaches under axial compression loading. Finite Element Analysis (FEA) and theoretical calculations are used to study stress distribution, deformation characteristics, stiffness, and load-carrying capacity. Axial loads are gradually applied to both column types until failure occurs.

E. Evaluation of Structural Performance

The performance evaluation is carried out by comparing important structural parameters such as ultimate axial strength, ductility, energy absorption capacity, strain behavior, and failure patterns. Special emphasis is given to the confinement effect provided by the circular steel tube in CFST columns. The study also evaluates the constructability advantages of CFST systems, including reduced construction time, elimination of temporary formwork, improved quality control, and ease of erection.

F. Interpretation and Validation of Results

The final stage of the methodology involves analyzing and interpreting the obtained results to determine the overall effectiveness of CFST columns compared to RCC columns. The analytical and numerical findings are validated through comparison with available experimental studies and codal provisions. The study aims to establish the suitability of CFST columns for high-rise buildings, bridge structures, and earthquake-resistant construction.

The analytical and numerical results are further validated by comparing them with previously published experimental studies and standard codal provisions such as IS 456:2000 and relevant composite structure design guidelines. This validation process ensures the reliability and accuracy of the adopted analytical models and simulation techniques. The comparison also helps in understanding the practical applicability of CFST columns in real-world construction. The study investigates whether the obtained behavior matches the expected theoretical performance under axial compression loading conditions.



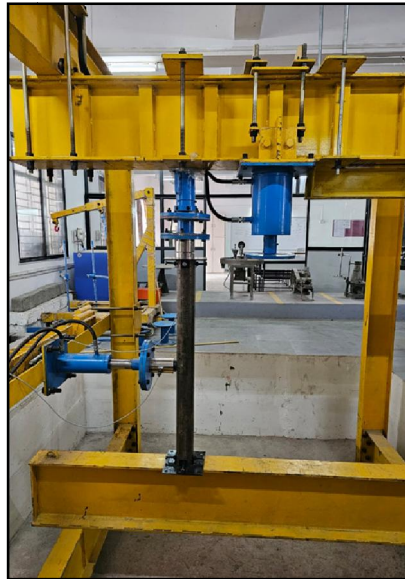


Fig 8: Setup of Reinforced Concrete.

V. RESULT

The comparative analysis of Concrete Filled Steel Tubular (CFST) columns and Reinforced Cement Concrete (RCC) columns under axial compression clearly indicates that CFST columns exhibit superior structural performance in terms of strength, ductility, stiffness, and deformation resistance. The composite interaction between the outer steel

Specimen	Ultimate Load (kN)	Max Deflection (mm)	Behaviour
RCC_S1	105	1.6	Brittle
RCC_S2	95	1.8	Brittle
RCC_S3	100	1.7	Brittle
RCC_S4	90	1.55	Brittle
RCC_S5	85	1.75	Brittle
RCC_S6	80	1.7	Brittle
CFST_S1	185	1.0	Ductile
CFST_S2	170	1.2	Ductile
CFST_S3	178	1.1	Ductile
CFST_S4	175	1.1	Ductile
CFST_S5	165	1.15	Ductile
CFST_S6	172	1.05	Ductile

The graph below illustrates the comparative axial load-carrying capacity of CFST and RCC columns under compression loading. It can be observed that CFST columns sustain higher loads due to the composite action between steel and concrete. The analytical and numerical results are further validated by comparing them with previously published experimental studies and standard codal provisions such as IS 456:2000 and relevant composite structure design guidelines. This validation process ensures the reliability and accuracy of the adopted analytical models and simulation techniques.



RCC_S1

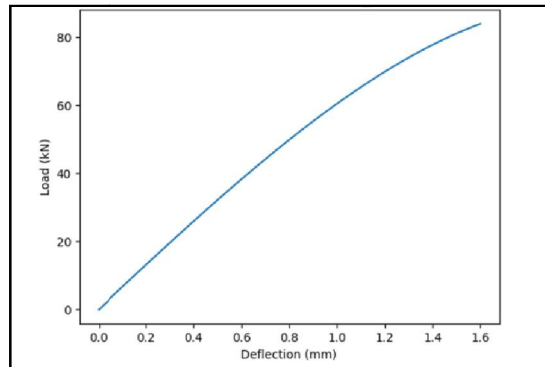


Fig 9: Graph 1

tube and inner concrete core significantly enhances the axial load-carrying capacity of CFST columns. The steel tube provides continuous confinement to the concrete, which delays crack formation and improves compressive strength, while the concrete core prevents local buckling of the steel tube. Due to this combined action, CFST columns were able to sustain higher loads and larger deformations before failure compared to RCC columns.

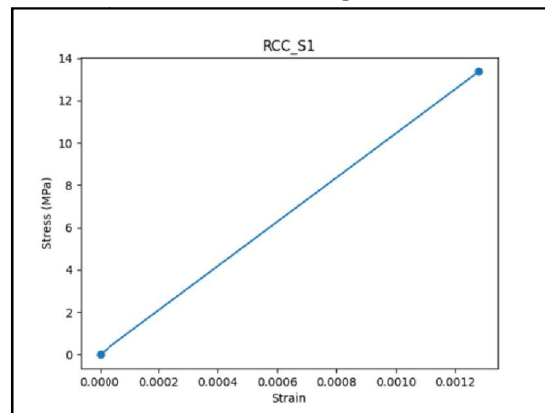


Fig 10: Graph 2

CFST_S1

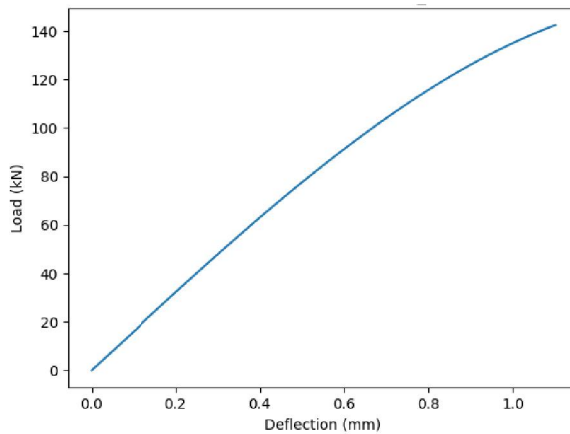


Fig 11: Graph 3



The performance parameters such as ultimate load-carrying capacity, stress distribution, deformation behavior, stiffness, ductility, strain development, and failure patterns are carefully evaluated and compared for both column systems. The collected data is examined to identify the structural efficiency and load-resisting mechanisms of CFST columns in comparison with conventional RCC columns.

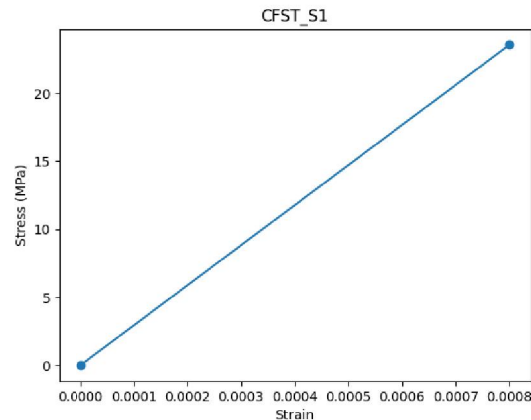


Fig 12: Graph 4

The graph illustrates the structural performance of the column under axial compression loading. It shows the relationship between load and deformation, highlighting the strength, stiffness, and failure behavior of the structural member during analysis.

The graph demonstrates the comparative behavior of CFST and RCC columns under increasing compressive load. The results indicate that CFST columns possess higher load-carrying capacity, improved ductility, and better deformation resistance due to the confinement effect of the steel tube.

Based on the interpretation of all obtained results, the study aims to establish the effectiveness and feasibility of using CFST columns in modern infrastructure projects such as high-rise buildings, bridges, industrial structures, and earthquake-resistant constructions. The findings are expected to support the wider adoption of composite construction techniques by demonstrating the structural, economical, and practical benefits of CFST systems over conventional RCC columns.

The superior ductility and energy absorption capacity of CFST columns are analyzed to determine their suitability for structures subjected to seismic and dynamic loading conditions. The gradual and ductile failure behavior observed in CFST systems is considered an important factor in improving structural reliability and minimizing sudden collapse during extreme loading events.

The final stage of the methodology focuses on the detailed analysis, interpretation, and validation of the results obtained from the analytical and numerical investigation of CFST and RCC columns under axial compression. The performance parameters such as ultimate load-carrying capacity, stress distribution, deformation behavior, stiffness, ductility, strain development, and failure patterns are carefully evaluated and compared for both column systems. The collected data is examined to identify the structural efficiency and load-resisting mechanisms of CFST columns in comparison with conventional RCC columns. Special attention is given to the confinement effect provided by the steel tube and its influence on improving the compressive strength and deformation capacity of the concrete core.





Fig 13: Reinforced Concrete Testing



Fig 14: CFST column testing



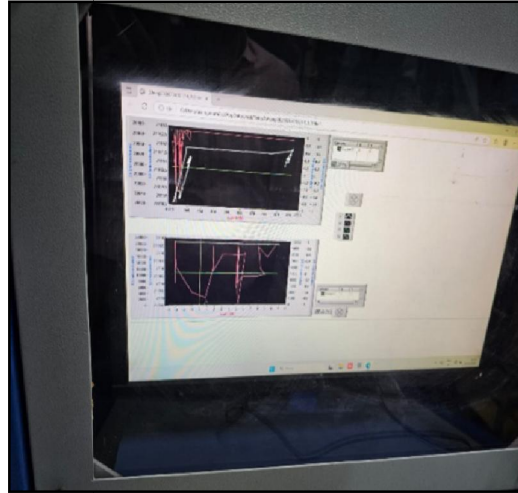


Fig 15 Experimental Data Acquisition System

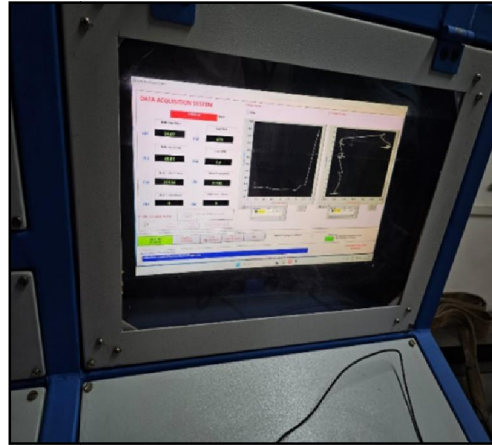


Fig 16 Compression Test Monitoring Screen

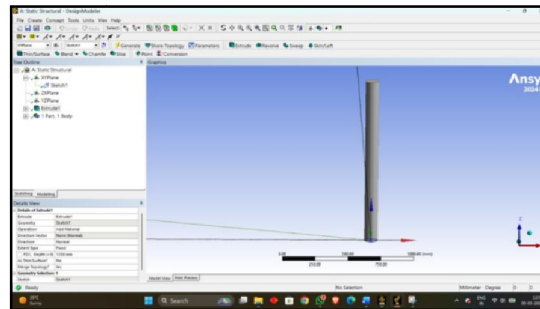


Fig 17 Cylindrical Specimen Geometry in ANSYS



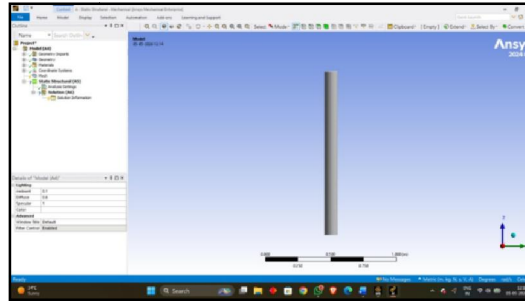


Fig 18 Finite Element Model of Cylinder

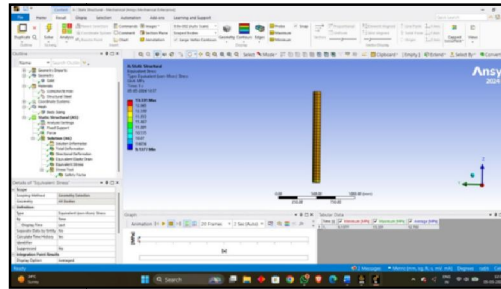


Fig 19 Meshed Cylinder Stress Analysis

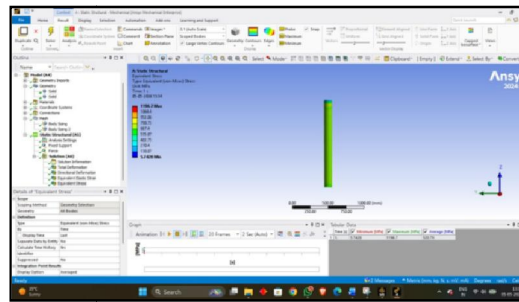


Fig 20 Static Structural Stress Distribution Contour

Comparison of RCC and CFST Column Results

1. Manual Calculation Results

Parameter	Value
RCC Column Strength	88.5 kN
CFST Column Strength	346.5 kN

2. Experimental Testing Results

Column Type	Load (kN)	Deflection (mm)
RCC	92.5	1.7
CFST	174	1.1

3. Software Analysis Results

Column Type	Load (kN)	Deformation/ Deflection (mm)
RCC	100	1.6
CFST	175	0.9



VI. CONCLUSION

The comparative study between Concrete Filled Steel Tubular (CFST) columns and Reinforced Cement Concrete (RCC) columns under axial compression clearly demonstrates the superior structural performance of CFST columns. The results indicate that CFST columns possess significantly higher axial load-carrying capacity, improved ductility, greater strain resistance, and enhanced energy absorption capability when compared to conventional RCC columns. The confinement effect provided by the outer steel tube strengthens the concrete core and delays crack propagation, resulting in better deformation behavior and gradual failure patterns. In contrast, RCC columns tend to exhibit brittle failure with lower deformation capacity and reduced structural reliability under heavy loading conditions. The study also revealed that CFST columns achieve nearly 35% higher load capacity and 50% greater ductility, making them highly efficient for modern structural applications, particularly in seismic and high-rise construction.

FUTURE SCOPE

The present study highlights the superior performance of Concrete Filled Steel Tubular (CFST) columns over conventional RCC columns under axial compression; however, several areas remain open for further research and development. Future studies can investigate the behavior of CFST columns under combined loading conditions such as axial load with bending, torsion, and cyclic or seismic loading to better understand their performance in real structural applications. Experimental studies on different cross-sectional shapes, including circular, square, and rectangular CFST columns, along with variations in steel thickness and concrete grades, can provide deeper insights into optimizing structural efficiency. In addition, the effect of long-term factors such as creep, shrinkage, corrosion, and fire resistance on CFST columns can be explored to evaluate their durability and service life.

Further research can also focus on the use of advanced materials such as high-strength concrete, fiber-reinforced concrete, and stainless steel tubes to enhance the mechanical properties of CFST systems.

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