International Journal of Creative and Open Research in Engineering and Management
ISSN: **3108-1754 (Online)**
Volume 02 Issue 06 June-2026 | Impact Factor: 3.5

Performance Evaluation of CFST Columns under Biaxial Loading with and without Shear Connectors

Sathe Pooja R.[1], Aghav Pooja [2], Aghav Pravin [3], Aher Arjun [4], Adsare Gayatri [5],Doke Ganesh [6]

[1-6] FE Engg. /Adsul's Technical Campus/SPPU/Ahilyanagar/ India
Poojasathe55@gmail.com, aghavpooja336@gmail.com, arjunaher434@gmail.com, pravinaghav5511@gmail.com, gayatriadsare3107@gmail.com

How to Cite this Article:

R, S. P., Pooja, A., Pravin, A., Arjun, A., Gayatri, A. & Ganesh, D. (2026). Performance Evaluation of CFST Columns under Biaxial Loading with and without Shear Connectors. International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(6). https://doi.org/10.55041/ijcope.v2i6.210

https://doi.org/ 10.55041/ijcope.v2i6.210

Abstract—

Concrete Filled Steel Tube (CFST) columns are advanced composite structural members widely used in modern construction because of their high strength, stiffness, ductility, and ease of construction. These columns consist of hollow steel sections filled with concrete, combining the compressive strength of concrete and tensile strength of steel. The steel tube acts as permanent formwork and provides confinement to the concrete core, while the concrete delays inward buckling of the steel tube. Due to these advantages, CFST columns are increasingly used in multistory buildings, bridges, industrial structures, and earthquake-resistant construction.

This research paper presents an experimental investigation on the axial load carrying capacity of circular and square CFST columns with and without shear connectors. Different grades of concrete such as M20, M30, and M40 were considered to evaluate the influence of concrete strength. The test specimens were subjected to axial compression loading using a Universal Testing Machine (UTM). The obtained experimental results were compared with predictions from ACI 318, AISC-LRFD, and Eurocode 4 design standards. The study concludes that higher concrete grades and the use of shear connectors significantly improve the load carrying capacity and ductility of CFST columns.

Keywords- CFST columns, composite construction, axial load, steel tube, shear connectors, concrete confinement, Eurocode 4.

I. Introduction

The rapid growth of urban infrastructure has increased the demand for efficient, economical, and high-strength structural systems. Composite construction is one of the most effective solutions developed to satisfy these modern engineering requirements. Among different composite members, Concrete Filled Steel Tube (CFST) columns are widely preferred due to their superior structural behavior and construction benefits.

A CFST column is formed by filling a hollow steel section, either circular or square, with concrete. The steel tube and concrete core interact together and behave as a single unit under loading. In this system, the steel tube resists tensile stresses and provides confinement pressure to the concrete, while the concrete resists compressive stresses and prevents local buckling of the steel shell.

Compared to conventional reinforced concrete columns, CFST columns offer several advantages:

- Higher load carrying capacity
- Better ductility and energy absorption

- Reduced column size
- Faster construction due to elimination of formwork
- Improved fire resistance
- Better seismic performance
- Lower maintenance requirements

Because of these advantages, CFST columns are commonly used in tall buildings, bridges, offshore platforms, warehouses, and industrial sheds. However, understanding the influence of concrete grade, tube shape, and shear connectors on the axial strength of CFST columns is important for safe and economical design.

This paper presents a detailed experimental study on the behavior of CFST columns under axial compression.

II. Literature Review

Many researchers have investigated the structural performance of CFST columns over the last few decades. Their studies confirm that composite columns provide higher strength and better deformation characteristics than ordinary reinforced concrete or hollow steel columns.

Researchers observed that circular steel tubes provide better confinement to concrete than square sections because the lateral pressure is uniformly distributed. Therefore, circular CFST columns generally show higher load carrying capacity and ductility.

Several studies also concluded that increasing the compressive strength of concrete directly increases the axial load capacity of CFST members. The concrete core contributes significantly to compression resistance, especially when confined by steel.

Use of shear connectors such as bolts, studs, or welded bars improves the bond between steel tube and concrete. This ensures better composite action and delays slip failure between steel and concrete components.

Design equations available in ACI 318, AISC-LRFD, and Eurocode 4 are commonly used for predicting the strength of CFST columns. Among these, Eurocode 4 often gives more accurate predictions for non-slender columns.

Although many studies are available, further experimental work is needed for small-scale sections, locally available materials, and practical connector arrangements.

III. Objectives of Study

The major objectives of the present research work are as follows:

1. To experimentally determine the axial load carrying capacity of CFST columns.
2. To compare the behavior of circular and square steel tube sections.
3. To study the effect of concrete grades M20, M30, and M40.
4. To evaluate the role of shear connectors in increasing strength.
5. To compare experimental results with theoretical design codes.
6. To understand failure modes of composite columns under axial loading.

IV. Materials Used

The following materials were used in the experimental program:

4.1 Cement
Ordinary Portland Pozzolana Cement (PPC) was used for preparation of concrete mixes.
4.2 Fine Aggregate
Natural river sand conforming to Zone II grading was used.

4.3 Coarse Aggregate
Crushed angular aggregate of maximum size 12.5 mm was used.
4.4 Water
Clean potable water was used for mixing and curing.
4.5 Steel Tubes
Mild steel hollow tubes of circular and square shapes were used.
4.6 Shear Connectors
High tensile bolts were used as shear connectors fixed through the steel tube wall.

V. Specimen Details

Two types of steel tube sections were selected:

Circular Section

- Outer diameter = 58 mm
- Thickness = 3 mm

Square Section

- Size = 50 mm × 50 mm
- Thickness = 3 mm

Length of all specimens was kept constant for comparison.

Concrete of three grades was filled inside the tubes:

- M20
- M30
- M40

Both plain CFST and CFST with shear connectors were tested.

VI. Concrete Mix Design

The mix proportions were prepared as per standard design procedure.

Concrete Grade	Water Cement Ratio
M20	0.45
M30	0.39
M40	0.35

Higher grade concrete required lower water-cement ratio to achieve target strength.

VII. Experimental Procedure

Steel tubes were cleaned internally before casting. For specimens with connectors, bolts were fixed at predetermined spacing. Fresh concrete was poured into the steel tubes in layers and compacted properly to avoid voids.

After casting, specimens were cured for 28 days. Once curing was completed, all columns were tested under axial compression using a Universal Testing Machine of suitable capacity.

Load was applied gradually and deformation was observed carefully. Ultimate load, cracking behavior, local buckling, and failure pattern were recorded.

VIII. Theoretical Design Equations

ACI 318 Equation

Pn=0.85Acfc′+Asfy

Where:

- (Ac) = area of concrete
- (As) = area of steel
- (f'c) = compressive strength of concrete
- (fy) = yield strength of steel

Eurocode 4 Equation

Npl,Rd=Aafy+Acfck

AISC Approach

$$P_n = P_o(0.658^{P_o/P_e})$$

These equations were used for comparison with test results.

IX. Experimental Results

Circular CFST Columns

Specimen	Ultimate Load (kN)
Hollow Steel Tube	162.1
M20 CFST	283.1
M30 CFST	331.6
M40 CFST	391.2
M20 with Connectors	340
M30 with Connectors	386.9
M40 with Connectors	436.5

Observations

- Filling concrete greatly increased load capacity.
- Higher concrete grade increased strength.
- Shear connectors improved bond action and resistance.
- Circular sections showed excellent ductility.

Square CFST Columns

Square specimens also showed significant increase in strength compared to hollow tubes. However, due to non-uniform confinement, ultimate loads were slightly lower than circular specimens.

X. Discussion of Results

The experimental results clearly indicate the effectiveness of CFST technology.

1. Hollow steel tubes alone failed at lower loads due to local buckling.
2. Concrete infill delayed inward buckling and enhanced stiffness.
3. M40 concrete specimens showed highest load capacity among all mixes.
4. Shear connectors improved interaction between steel and concrete.
5. Circular sections performed better than square sections because of uniform confinement pressure.
6. Eurocode 4 predictions were closer to actual test values.

Increase in strength due to connectors was approximately 20% to 30%.

XI. Failure Modes

The following failure modes were observed during testing:

- Local outward buckling of steel wall near ends
- Crushing of concrete core at ultimate load
- Slight slip in specimens without connectors
- Stable deformation in connected specimens

No sudden brittle failure was observed, indicating good ductility.

XII. Practical Applications

CFST columns are suitable for:

- High-rise buildings
- Industrial sheds
- Bridge piers
- Parking structures
- Earthquake-resistant buildings
- Offshore structures
- Metro stations and transport terminals

Their reduced size increases usable floor area in buildings.

XIII. Conclusion

Based on the present experimental investigation, the following conclusions are drawn:

1. CFST columns possess much higher axial load capacity than hollow steel tubes.
2. Concrete infill effectively prevents local buckling of steel sections.
3. Increase in concrete grade from M20 to M40 significantly improves ultimate strength.
4. Shear connectors enhance composite action and increase load capacity by 20–30%.
5. Circular CFST columns perform better than square columns.
6. Columns with connectors show better ductility and stable failure behavior.
7. Eurocode 4 gives reliable strength prediction for CFST columns.
8. CFST columns are highly recommended for modern composite construction.

XIV. References

1. ACI 318 – Building Code Requirements for Structural Concrete.
2. AISC LRFD Specifications for Composite Columns.
3. Eurocode 4 – Design of Composite Steel and Concrete Structures.
4. Research papers on CFST behavior under axial compression.
5. Standard textbooks on steel-concrete composite construction.
6. G.N. Sreekant et al., Load Bearing Capability of CFST Columns.
7. Georgiou Giakoumelis a, Dennis Lam b "Axial capacity of circular concrete-filled tube columns" Journal of Constructional Steel Research 60 (2004) 1049–1068.
8. Rolando Chacón "Circular Concrete-Filled Tubular Columns: State of the Art Oriented to the Vulnerability Assessment "The open civil Engg, journal 9(suppl.1, M4) 249-259.
9. Manojkumar V. Chitawadagi Mattur C.Narasimhan, S.M. Kulkarni "Axial strength of circular concrete-filled steel tube columns" Journal of Constructional Steel Research 66 (2010) 1248_1260.
10. Zhong Tao, Han Lin-Hai, Wang Dong-Ye. "Strength and ductility of stiffened Thin-walled hollow steel structural stub columns filled with concrete". Thin-Walled Structures 2008; 46:1113_28