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# A Comprehensive Survey of Structural Applications for Concrete-Filled Steel Tubes

Pawar Praveen[1,*], P. Poluraju[2]

**_Abstract_**

*A composite section made from a hollow steel tube after concrete has been poured inside of it is known as Concrete filled steel tube. CFT is a high-performance component that combines the impact of steel confinement with the design freedom of concrete. It resists applied stress by fusing concrete and steel. The interaction of steel tubes and concrete gives CFST its strength, and as a result, it has become more and more well-liked in recent years. The current study intends to conduct a thorough evaluation of the existing literature on CFST under various loads, variable steel tube thickness, altering grade of concrete infill, as well as various boundary circumstances. The load bearing capacity, applied load vs. deflection response, normalisation of applied load vs. deflection response, moment vs. rotation response, stiffness degradation, energy dissipation, and confinement effect will all be used to evaluate the behaviour of the composite column. After carefully examining the literature, it is determined that CCFST has an excellent load-carrying capability. As the concrete grade which is going to fill inside the steel tube increases as well as steel tube thickness increases, the confinement effect decreases, and hence load-carrying capacity declination takes place. Concrete-filled steel tubes' load carrying capacity is also influenced by the boundary condition.*

**Keywords:** CFST, Grade of infill concrete, Thickness of steel tube, Compression behavior, Ultimate Capacity

## INTRODUCTION

In many modern structures, CFST columns have been significantly used in arch bridges, dwelling houses, and tall buildings [1]. Composite steel tube columns outperform bare steel or reinforced concrete structural components in terms of structural performance and steel hollow sections serve as concrete reinforcement [2]. Strength, ductility, and stiffness are all important attributes governed by steel-concrete composite members. CFT columns have generally shown excellent load-carrying capacity, ductility, and energy absorption capacity. CFSTs are a low-cost column type in which the overall axial load is supported by concrete rather than steel [3]. Pouring concrete in column steel tube serves as a mould, which lowers the overall cost of construction. Because of the steel tube, there is no requirement for extra reinforcement which take care of longitudinal & lateral reinforcement for the concrete core. The confinement effect leads to a triaxial stress condition behavior in the concrete core, preventing the hollow steel section wall from bowing inward. For many decades, researchers have been conducting experiments on concrete-filled steel tubes. According to experimental studies conducted in the available review, the main parameters influencing the behavior and strength of CFST are geometrical parameters like (D/t) ratio, slenderness, and geometry of the column [4]. The lack of knowledge about CFTs' behavior is a major barrier to their widespread usage. The study and design of CFST are complicated by several

***Author for Correspondence**

Pawar Praveen
1Research Scholar, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur, India
2Professor, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur, India

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issues [5]. Even though CFST columns are ideal for all tall structures in seismically active places, Due to a lack of knowledge about the true strength and elastoplastic behavior of CFST members, their application has been limited. [6]. Despite the fact that CFT columns are becoming more widespread, concrete core confinement remains a mystery [7]. Many scholars have explored the phenomena of local buckling of axially loaded thin-walled steel tubes does not occur if the steel and concrete are sufficiently bonded [8].

### Behaviour of Axially Loaded CFT columns

The axially loaded column behavior under compression (concentrically or eccentrically) can be divided into two categories. Cross-section strength governs the column with a smaller L/D ratio (short columns). When the concrete and steel both achieve their strength properties, i.e., when the concrete crushes and the steel yields, these sorts of columns reach their maximum capacity. This sort of column will be unaffected by eccentric loads. Long (slender) or intermediate columns with a larger L/D ratio exhibit the second type of behavior. Stability governs these columns, and they fail to owe to column buckling, which can be elastic or inelastic.

#### *CFT Columns*

The general behavior of short columns is in focus, when a short column is subjected to a concentric axial load, both steel and concrete begin to flex longitudinally (assuming the weight is delivered equally over both materials). Steel has a higher Poisson's ratio than concrete at these starting stresses. As a result, the steel has a greater lateral expansion and there is an interaction between the two elements. During the loading stage, the concrete and steel can support their weight. As a result, the steel tube longitudinal tension is roughly constant. On another hand, the general behavior of long CFT columns particularly, Slenderness, rather than strength, will determine the eventual load-carrying capability if it is adequately stable. Overall column buckling will occur before stresses are big enough to allow for substantial volumetric expansion of the concrete. As a result, there is minimal concrete confinement for total buckling failures and consequently no further strength increase. Many scholars think that a slenderness ratio (L/D) of 15 is ideal. In general, denotes an approximate distinction between short and long column behavior.

#### *Axially Loaded CFT Columns' Stiffness*

The concrete core and the interplay between the two components complicate the stiffness of concrete-filled steel tubes. Steel components have well-known moments of inertia, moduli of elasticity, and effective areas for tensile loading. However, due to the inhomogeneity of concrete, these qualities are hard to forecast. As illustrated in Figure 1, they vary based on the strength of concrete, frequency of tensile cracking, and long-term influence due to load among other factors.

## REVIEW OF LITERATURE

Since 1957, A lot of research has been carried out to look at what is happening to the structural performance of CFT columns under concentric, eccentric, and seismic stresses. The effect of cross-sectional shape, wall thickness, and material properties on CFT column performance has been investigated. These works represent a study strategy for circular polymer-filled columns built of steel and various grades of concrete infills with constant length, diameter, and wall thickness. Some of the major research studies have been discussed in the following subsequent sections.

### Experimental Behavior of CFST Under Axial Compression

Alifujiang et al. [9] conducted a study comparing reinforced concrete-filled tubular steel (RCFT) columns through experimental and numerical analysis. They proposed an evaluation equation for the axial compressive strength of RCFT columns. Lu et al. [10] focused on the relationship between bending moment, axial force, and curvature (M-N-$\phi$) in compressed CFST eccentric columns. They developed a method to predict the ultimate strength of axially crushed columns with initial flaws. Jamaluddin et al. [11] conducted experiments to analyze the impact of member shape, component material qualities, and infill concrete strengths on the structural response of elliptic concrete-filled

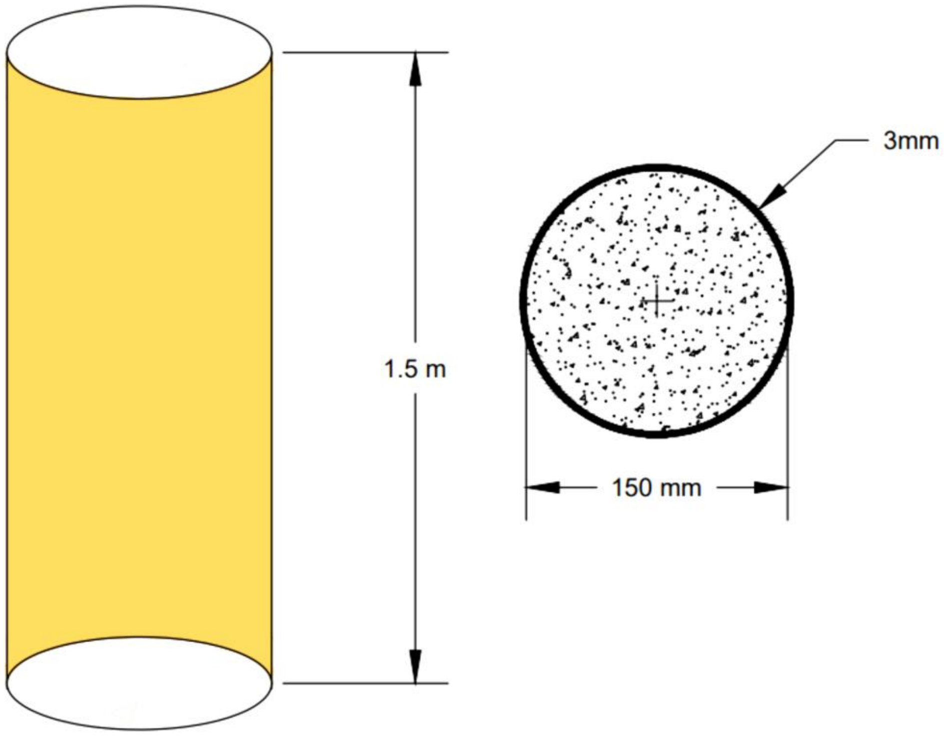

**Figure 1.** Showing steel tube and Top View of concrete filled steel tube.

tube columns. They also investigated existing design requirements for CFST sections. Moon et al. [12] discussed the use of CFST in deep foundation columns, piers, and caissons, emphasizing the need to understand the bending behavior of CFST members and the importance of advanced numerical models for design. Theodoros et al. [13] proposed a technique for predicting permanent deformations using observable experimental and theoretical elastic responses of constrained concrete. They developed a model that accurately accounted for material softening and hardening reactions. Song et al. [14] recommended a slenderness ratio of 40 and the use of three-layer CFRP-confined slender RPCFST columns for engineering applications. They highlighted the benefits of CFRP confinement in increasing column ductility and bearing capacity. Georgios et al. [15] examined CFT column strengths and compared them to values expected by different codes. They found that Eurocode 4 provided the most accurate calculations, particularly for higher-grade concrete. Manoj et al. [16] investigated the influence of varying wall thickness on axially loaded rectangular CFT columns. They used Taguchi's method and linear regression models to predict column strengths and compared them to design codes. Qiyun et al. [17] explored the use of axial compression stainless-carbon steel tube concrete-filled stub columns. They found that varying the thickness of the carbon steel tube significantly improved the ultimate and residual strength of the columns. Jie et al. [18] used crushed bricks as coarse aggregates in recycled aggregate concrete-filled steel tubes (RACFST). They found that the compressive resistance was minimally affected, and they provided design recommendations and stress-strain equaftabletions. Na et al. [19] studied the influence of concrete fiber, steel fiber volumes, and steel tube thickness on CFST column performance. They observed that concrete self-stress and steel fibers affected ultimate load and post-peak performance. Hongo et al. [20] examined tubed SRC stub columns under axial compressive stress. They studied circular and square tubed SRC columns, investigating factors like steel tube dimensions and tube/concrete bonding. They found that tubed SRC stub columns with the same steel ratio had higher axial-load capacity.

Table 1 illustrate the studies related to CFST columns, including their behavior under axial compression, strength prediction, the influence of various factors, and the development of predictive models. These studies contribute valuable insights to the field of structural engineering and provide recommendations for designing and analyzing CFST columns.

**Table 1.** Showing the summary of experimental study.

| S.N. | Author | Summary of Experimental Study |
|---|---|---|
| 1. | Alifujiang et al. [9] | Comparative study of reinforced concrete-filled tubular steel (RCFT) columns through parametric analysis and equation for axial compressive strength. |
| 2. | Lu et al. [10] | Analysis of the relationship between bending moment–axial force–curvature (M–N–ϕ) in SCFT eccentrically columns and a method for forecasting ultimate strength. |
| 3. | Jamaluddin et al. [11] | Investigation of axial compressive stress on elliptic concrete-filled tube columns, considering member shape and material qualities. |
| 4. | Moon et al. [12] | Exploration of the bending behavior of CFST members for deep foundation applications and the need for advanced numerical models. |
| 5. | Theodoros et al. [13] | Development of a Drucker Prager model for predicting permanent deformations in concrete and comparisons with experimental data. |
| 6. | Song et al. [14] | Introduction of CFRP-confined slender RPCFST columns and their impact on column ductility and bearing capacity. |
| 7. | Georgios et al. [15] | Examination of CFT column strengths, comparisons with international codes, and the influence of shrinkage on higher-grade concrete. |
| 8. | Manoj et al. [16] | Investigation of the influence of varying wall thickness on axial shortening and ultimate axial load in rectangular CFT, with design code comparisons. |
| 9. | Qiyun et al. [17] | Exploration of axial compression stainless-carbon steel tube concrete-filled stub columns, varying tube thickness, concrete grade, and code assessments. |
| 10. | Jie et al. [18] | Use of crushed bricks as coarse aggregates in axially loaded recycled aggregate concrete-filled steel tubes (RACFST) and model equations. |
| 11. | Na et al. [19] | Study of early self-stress in steel and compressive performance of CFST columns with concrete fiber, including axial load-axial shortening curve and formulas. |
| 12. | Hongo et al. [20] | Experimental and mathematical analysis of tubed SRC stub columns, including mode of failure, axial-load performance, and equations for axial load strength. |

Dalin et al. [21] conducted a study on rectangular CFST stub columns subjected to concentric compression. They tested 26 specimens with varying cross-sectional aspect ratios and material strengths. The results showed that all specimens exhibited favorable ductility performance. When comparing axial load capacity with design regulations, AISC and ACI provided safe estimates, while EC4 overestimated the ultimate capacity for mild steel and high-strength concrete. They also developed a fiber model that accurately predicted the nonlinear response of high-strength rectangular CFST stub columns after calibration. Subhan et al. [22] conducted experiments on CFST columns using GGBFS (Ground Granulated Blast Furnace Slag) concrete. They found that CFSTs with GGBFS concrete had higher axial capacities than control concrete CFSTs. The axial capacity increased with the compressive strength of the concrete mixtures. They compared the results with various code provisions and found that ACI 318 was the most conservative in estimating the axial capacities of GGBFS concrete CFST columns. Manojkumar et al. [23] studied the impact of various parameters, including steel tube diameter, thickness, length, concrete strength, and tube length, on the ultimate axial load and axial shortening of circular CFST columns. They conducted experiments on 243 circular CFST samples and evaluated the predictions using design codes such as EC4-1994 and AISC-LRFD-2005. Jiepeng et al. [24] conducted experiments on circular, thin-walled steel tubes filled with high-strength concrete. They investigated the effects of axial compression on concrete compressive strength and steel tube dimensions. They found that the loading pattern did not significantly affect concrete strength or stiffness, but specimens became more brittle as the concrete grade increased. They also analyzed the stress and strain states of the steel tube and concrete interaction. Helmut et al. [25] focused on the ductility of thin-walled steel tubes surrounded by high-strength concrete. They conducted experiments with different axial and cyclic loadings on concrete samples with varying compressive strengths. They compared the test results with design models used in building code standards to assess ductility. Jiepeng et al. [26] performed analytical and experimental research on axially compressed tubed RC (Reinforced Concrete) stub columns. They evaluated the mode of failure and axial load strength of circular and square tubed RC columns. They also investigated the impact of tube height to diameter/width ratio on tubed RC columns' performance and conducted elastic-plastic analysis using steel tubes. Kenji et al. [27] conducted a comprehensive study on the concrete-filled steel tubular (CFT) column system as part of the US-Japan Cooperative Earthquake Research Program. They cast and tested 114 samples with different characteristics such as cross-section, tensile strength, tube dimensions, and concrete grade. They used the collected data to develop CFT column design methods for both circular and square sections.

Wang et al. [28] investigated a novel building component known as ice-filled steel tubes (IFT). They performed experiments on circular IFT stub columns under axial compression, considering the steel tube's diameter-to-thickness ratio. The results showed that the steel tube's presence improved the ductility of ice columns by inhibiting crack formation. Jie et al. [29] conducted failure tests on columns and beams filled with recycled aggregate concrete (RACFST). They found that the compressive load of the columns decreased slightly with increasing RCA (Recycled Concrete Aggregate) substitution. However, the structural impact on load capacity and stiffness due to RCA substitution was minimal. The study supported the use of RACFST in structural engineering and compared the results with CFST design provisions. Dub et al. [30] examined the susceptibility of high-strength steel members to local buckling and the role of rectangular CFST columns in preventing inward buckling. They conducted experimental tests on rectangular CFST columns made of high-strength steel and evaluated different design codes. The study suggested design recommendations for width-to-thickness (h/t) ratios to account for the effects of different aspect ratios in rectangular CFST columns.

Table 2 Summarizes these research studies contribute valuable insights into the behavior and performance of CFST columns, considering factors such as material properties, dimensions, and loading conditions. The findings have practical implications for structural engineering design and provide guidance on code compliance and ductility improvement.

Concrete-Filled Steel Tubular (CFST) columns are essential structural elements in civil engineering, offering significant advantages in terms of strength and durability. A comprehensive review of recent research in this field reveals various studies focusing on different aspects of CFST columns, including material properties, behavior under axial and lateral loads, innovative configurations, and structural performance. This overview summarizes key findings and insights from these studies, providing a comprehensive understanding of the state of CFST column research.

### *Material Properties and Behavior*

Lu et al. [31] investigated Steel Fiber Reinforced Self-Compacting (FRSCCFST) and Self-Stressing Concrete-Filled Steel Tube (FSSCFST) specimens in bending. Their study revealed that self-stress and steel fibers had a positive effect on flexural capacity and rigidity in CFST specimens. Zhang et al. [32] explored the impact of concrete strength on CFST specimen failure patterns. They proposed one-dimensional nonlinear stress-strain models to predict the performance of high-grade concrete-filled Rectangular Hollow Section (RHS) tubes, with accurate numerical and experimental validation. Chang et al. [33] conducted compressive tests on notched steel tubes to study the effects of material faults on CFST column mechanical performance. They proposed an empirical equation for predicting column strength based on experimental data. Ding et al. [34] investigated CFRP-confined concrete-filled circular steel tube stub columns, studying the impact of CFRP layers on the mechanical properties. They developed a simplified formula for the ultimate capacity of CFRP-confined CFT stub columns. Artiomas et al. [35] studied composite elements, including concrete-filled steel tubes, and evaluated various design approaches and philosophies. Their research highlighted the need for design guidelines for hollow CFST elements. Ehab et al. [36] conducted a parametric analysis to examine the effects of concrete strengths and cross-section geometries on circular stub columns made of compacted steel tubes filled with concrete. They found that European norms were frequently unconservative in their design. Minsheng et al. [37] evaluated the performance and bond strength of CFST columns filled with manufactured sand through push-out tests. Their study provided insights into bond strength variation with parameters like sand type and diameter-to-thickness ratio.

**Table 2.** Key findings of experiment carried against code referred.

| S.N. | Author | Experimental Parameters | Key Findings and Results | Design Codes and Comparisons | Additional Notes |
|---|---|---|---|---|---|
| 1 | Dalin et al. [21] | Cross-sectional aspect ratio, material strengths | Favorable ductility performance. Comparison of axial load capacity with AISC, ACI, EC4. | AISC and ACI provide safe estimates. EC4 overestimates ultimate capacity for mild steel and high-strength concrete. | Fiber model predicts nonlinear response accurately. |
| 2 | Subhan et al. [22] | GGBFS concrete, compressive strength, axial capacity, code provisions | GGBFS concrete CFSTs have higher axial capacities. Comparison with ACI 318, AIJ, EC4, DL/T. | ACI 318 is most conservative. EC4 and DL/T provide accurate estimates. Cost and embodied energy comparisons. | Evaluation based on various concrete types. |
| 3 | Manojkumar et al. [23] | Steel tube parameters, concrete strength | Influence of parameters on axial load and shortening. Use of EC4-1994 and AISC-LRFD-2005 for predictions. | Analysis of variance identifies influential parameters. Evaluation of predicted column strengths. | Examination of circular CFT samples. |
| 4 | Jiepeng et al. [24] | Steel tube diameter, axial compression, concrete strength | Study on axial stress-strain performance. Effect of concrete grade on specimen behavior. | Loading pattern impact on concrete's strength and stiffness. Stress condition variation with tube height. | Examination of thin-walled steel tubes. |
| 5 | Helmut et al. [25] | Diameter of specimens, concrete compressive strength | Focus on ductility. Comparison with code standards. | Diameter of specimens and concrete strength considered. | Testing of thin-walled steel tubes. |
| 6 | Jiepeng et al. [26] | Tubed RC columns, parameters, binding, friction | Investigation of axially compressed tubed RC columns. | Impact of tube parameters and binding/friction on column performance. | Use of elastic-plastic analysis with steel tubes. |
| 7 | Kenji et al. [27] | CFT column system, cross-section, tensile strength | Study on CFT column system. Gathering test data for design methods. | Establishment of CFT column system design technique. | |
| 8 | Wang et al. [28] | Ice-filled steel tube (IFT), D/t ratio | Experimental study on circular IFT stub columns. | Steel tube's effect on ice cracks, bearing capacity, and ductility. | Introduction of ice-filled steel tube concept. |
| 9 | Jie et al. [29] | Recycled aggregate concrete, column tests | Structural application of recycled aggregate concrete in steel tube members. | Impact of RCA substitution on load capacity and stiffness. Comparison with design provisions. | Support for the use of RACFST in structural engineering. |
| 10 | Dub et al. [30] | High-strength steel, rectangular CFT columns | Experimental examination of rectangular CFT columns made of high-strength steel. | Evaluation of design codes (EC4, AISC 360, GB50936) for high aspect ratio. Proposed design recommendations for h/t ratio. | Focus on high-strength steel and aspect ratio. |

### *Innovative Configurations*

Jing et al. [38] proposed a bamboo plywood and steel-tube dual-confined stone dust concrete composite column. Their study explored the failure modes and behavior of this innovative configuration under compression, highlighting the adhesive cracking failure as the dominant mode. Ding et al. [39] conducted axial compression experiments on octagonal CFST stub columns, examining the influence of concrete strength and steel ratio on mechanical behavior. They also provided a formula for calculating the final bearing capacity of octagonal CFST stub columns. Zhang et al. [40] investigated the compressive performance of Steel Ring Confined CFST (SRCFT) stub columns using experimental and computational techniques. They developed a new simplified formula for evaluating SRCFT stub column ultimate bearing capacity. Wang et al. [41] studied carbon FRP (CFRP) confined STCC stub columns, focusing on their axial compressive performance. They successfully predicted the ultimate axial bearing capacity using mathematical analysis.

### *Size Effect and Shear Behavior*

Liu et al. [42] analyzed the shear behavior of short square CFST columns, highlighting the transition from brittle shear failure to ductile bending failure with increased shear-span ratio. Wang et al. [43] assessed the impact of size and steel ratio on short CFST columns' axial compression resistance. They introduced a reduction coefficient to account for the size effect, emphasizing the confinement effect's significance in mitigating size-related issues.

### *Experimental Testing and Model Development*

Xu et al. [44] utilized gray relational assessment and neural networks to evaluate the structural performance of CFST columns filled with recycled aggregate concrete. Their study demonstrated the effectiveness of machine learning techniques in predicting load-carrying capacity. Ding et al. [45] assessed the reliability of bearing capacity formulas for CFST columns under axial compression. They used Monte Carlo Simulation (MCS) to explore the dependability index under various conditions, including different cross-sections, concrete strengths, and load ratios. Serkan et al. [46] examined concrete-filled stainless steel tubular composite columns and compared the load-deflection curves of plain and steel fiber-reinforced concrete-filled stainless steel tube composite columns. Their theoretical approach estimated strength and functional parameters. Alexandra et al. [47] proposed a method to calculate the minimum fiber angle for filament-wrapped FRP tubes in CFSTs. They verified their approach experimentally, providing valuable insights into the design of FRP-confined CFSTs.

Table 3 illustrates recent research on Concrete-Filled Steel Tubular (CFST) columns covers a wide range of topics, including material properties, innovative configurations, size effects, shear behavior, and the development of prediction models. These studies contribute to a better understanding of CFST columns' behavior and offer valuable insights for their design and application in civil engineering. Researchers continue to explore new avenues to enhance the performance and reliability of CFST structures, making them a vital component in modern construction.

### *Numerical Study Behavior of CFST Under Axial Compression*

Qing et al. [48]: This study utilized finite element analysis (FEA) to analyze the behavior of steel tube confined concrete (STCC) stub columns under axial compression. The FEA model provided accurate predictions of ultimate strength and load versus deformation curves. The interaction between the steel tube and concrete core was studied, and reduced equations were suggested based on parametric analysis. Stephen et al. [49]: The behavior of small steel tubes filled with concrete under concentric loading was studied experimentally and analytically. The study focused on how steel tube and wall thickness influenced the ultimate strength of composite columns. It was found that current design criteria for concrete-filled steel tube columns are suitable for predicting yield load under most conditions. Chengliang et al. [50]: This research explored the use of CFST columns with high-strength steel (HSS) to improve structural performance while reducing weight. The study considered parameters such as concrete strength and loading eccentricity ratio. The experimental program involved creating CFHST specimens with high-performance Q460 structural steel. Computational models were developed and validated for predicting the capacity of CFHST columns. Xuhong et al. [51]: The study focused on TRC columns, a type of CFST column where the outer steel tube does not extend into the beam-column connection. Finite element models were used to predict the behavior of these connections under axial compression. The research also proposed a theoretical approach to determine the axial bearing capacity of connections in TRC columns. Lin et al. [52]: This study

**Table 3.** Findings show case against the approach utilised.

| S.N. | Author | Key Finding | Approach Used |
|---|---|---|---|
| 1 | Lu et al. [31] | Steel fibers' self-stress had no effect on the mode of failure of CFST specimens. | Not specified |
| 2 | Zhang et al. [32] | Proposed One-Dimensional nonlinear stress-strain models for high-strength concrete-filled RHS tubes. | Numerical separation approach |
| 3 | Chang et al. [33] | Notched concrete-filled steel tube stub columns have different failure processes due to notches. | Not specified |
| 4 | Ding et al. [34] | Developed a simplified formula for the ultimate capacity of CFRP-confined CFT stub columns. | FORTRAN software |
| 5 | Artiomas et al. [35] | Studied complex stress states of hollow CFST elements like compressed stub structural members. | Not specified |
| 6 | Ehab et al. [36] | European norms are frequently unconservative for CFST columns. | Not specified |
| 7 | Minsheng et al. [37] | MSCFT columns have higher bond strength than CFT columns. | Not specified |
| 8 | Jing et al. [38] | Bamboo plywood and steel-tube dual-confined stone dust concrete composite column (BS- DCC) studied. | Not specified |
| 9 | Ding et al. [39] | Developed a formula for calculating the final bearing capacity of an octagonal CFT stub column. | 3D finite element modeling |
| 10 | Zhang et al. [40] | SRCFT stub columns were more ductile than CFT stub columns. | Computational techniques |
| 11 | Zhao et al. [53] | Proposed a more efficient method for calculating the compressive strength of HCCFSTs. | Not specified |
| 12 | Dundu [54] | South African and Eurocode codes were found to be conservative in some tests on CFST columns. | Not specified |
| 13 | Elchalakani et al. [55] | Proposed new slenderness ranges for CFT ultimate moment capacity. | Not specified |
| 14 | Yang et al. [56] | Developed a model for calculating the load-carrying capacity of CFT columns. | Von Mises yield criterion |
| 15 | Xu et al. [57] | Evaluated the seismic response of different column-foundation connections for CFST columns. | Experiments and finite element model |
| 16 | Martin et al. [58] | Presented design methodologies for thin-walled circular CFST under various loading conditions. | Experimental testing |
| 17 | Tao et al. [59] | Compared AS 5100 with other international design codes for CFST members. | Experimental samples and databases |
| 18 | Lin et al. [60] | Explored recent advances in CFST members and their usage in Chinese projects. | Not specified |
| 19 | Dilrukshie et al. [61] | Developed an approach to address axial shortening in high-rise buildings with composite CFTs. | Experimental data validation |
| 20 | Dong et al. [62] | Studied the effects of external confinement on CFST structural performance. | Parametric investigation |
| 21 | Zhang et al. [63] | Loading CFST columns at an early age can increase their long-term load-bearing capability. | Early age loading experiments |
| 22 | Wang et al. [41] | Developed an ultimate axial bearing capacity prediction model for CFRP-STCC stub columns. | Experimental investigation |
| 23 | Xu et al. [44] | Used Gray relational assessment and BP neural networks to evaluate structural performance of RACFSTs. | Gray relational assessment, BP neural networks |
| 24 | Ding et al. [45] | Evaluated the reliability of CFST bearing capacity formula under axial compression using MCS. | Monte Carlo Simulation |
| 25 | Serkan et al. [46] | Studied concrete-filled stainless steel tubular composite columns and compared them with unreinforced concrete columns. | Theoretical and experimental research |
| 26 | Liu et al. [42] | Investigated the failure modes and ductility of square CFST columns under different conditions. | Mesoscale modeling |
| 27 | Wang et al. [43] | Assessed the axial compression resistance of short columns with varying diameters and steel ratios. | Experimental testing |
| 28 | Alexandra et al. [47] | Determined the minimum fiber angle for filament wrapped FRP tubes used in CFFTs. | Not specified |

examined the behavior of CFST stub columns subjected to axial localized compression. Parameters included different cross-sectional shapes, local compression area ratios, and endplate thicknesses. The results showed good agreement between experimental and model findings. Reddy et al. [64]: Experimental and computational evaluations compared the structural behavior of RCC and CFST stub columns. CFST columns exhibited significantly higher axial capacity than RCC columns. The study considered factors such as steel tube thickness, concrete cube strength, and steel percentage. Hassanein et al. [65]: The research focused on short columns with double-skinned steel tubing filled with concrete. A new design formula was proposed for estimating the compressive strength of CFDST columns, providing more accurate predictions than existing design rules. Gupta et al. [66]: This study investigated the influence of steel tube diameter, diameter-to-thickness ratio, concrete grade, and fly ash volume on the capacity of CFST columns. A non-linear finite element model was developed to analyze CFST behavior. He et al. [67]: Experimental and theoretical tests assessed the structural performance of circular concrete-filled stainless-steel tube (CFSST) stub columns under axial partial compression. The study considered factors like partial compression area ratio and confinement factor and proposed a novel design technique for CFSST stub columns. Farid et al. [68]: The compressive behavior of circular CFSTs was studied experimentally with different concrete strengths and tube dimensions. The results indicated that existing design codes tended to underestimate axial capacities with significant changes in the D/t ratio. Gunawardena et al. [69]: Finite element analysis (FEA) was performed on CF-SWSST columns using ABAQUS software. The FEM predictions matched experimental results for globally flexural deformed states, but not local buckling patterns. Variations in bending stiffness and strain were qualitatively represented by the FEM.

Table 4 collectively provide valuable insights into the behavior and design considerations of concrete-filled steel tube columns, considering various parameters like material properties, geometry, and loading conditions. The research findings contribute to improving the accuracy of design guidelines and understanding the performance of CFST columns in different applications

**Table 4.** Summary of existing constitutive models for concrete filled steel tube.

| S.N. | Author | Key Finding | Mathematical Model Used |
|---|---|---|---|
| 1 | Qing et al. [48] | FEA model used to analyze STCC stub columns under axial compression. | Finite Element Analysis (FEA) |
| 2 | Stephen et al. [49] | Steel tube and wall thickness affect the ultimate strength of composite columns. | Experimental and Analytical Methods |
| 3 | Chengliang et al. [50] | High-strength steel (HSS) in CFST can improve structural performance. | Computational Model and Experimental |
| 4 | Xuhong et al. [51] | Behavior of TRC columns with steel tube discontinuity in beam-column connections. | Finite Element Model |
| 5 | Lin et al. [52] | Behavior of CFST stub columns with different parameters like section type and endplate thickness. | Finite Element Analysis (FEA) |
| 6 | Reddy et al. [64] | CFST stub columns have higher axial capacity than RCC stub columns. | Finite Element Analysis (FEA) and Experiments |
| 7 | Hassanein et al. [65] | Proposed a new design formula for CFDST columns. | Theoretical Modeling and Design Formula |
| 8 | Gupta et al. [66] | Investigated the influence of steel tube parameters and concrete grade on CFST columns. | Finite Element Analysis (FEA) and Experiments |
| 9 | He et al. [67] | Developed a novel design technique for CFSST stub columns. | Finite Element Modeling and Experimental |
| 10 | Farid et al. [68] | D/t ratio significantly influences the compressive behavior of CFSTs. | Experiments and Theoretical Comparisons |
| 11 | Gunawardena et al. [69] | FEM predictions less conservative than other models for CF-SWSST column tests. | Finite Element Analysis (FEA) |

## CONCLUSIONS

This paper mainly focuses on studies and research done on Concrete filled steel tubes. Nowadays, much research is going on designing aspects of CFST and behavior in different loading conditions. The following conclusions have been drawn:

1. Many research works on the behavior of CFST have been undertaken based on its varied cross-sections, such as Rectangular and Circular, which are frequently employed in the design industry.
2. A literature assessment indicates that CFST columns have strong seismic event-resistant structural properties such as ductility, high strength, and tremendous energy absorption capacity.
3. These parts demonstrate how CFST responds to axial concentric and eccentric loads, its fire characteristics, and its benefits over RC columns.
4. As per literature, the majority of the work done on CFST is experimental; nevertheless, numerical research is needed to examine the factors that determine the final strength.
5. Because there hasn't been much research on the effect of a CFST cross-section, a substantial effort may be done to pick optimal cross-sections based on stress and region.
6. Because the Indian standard does not specify the Composite column, more study in that area is required.
7. Based on a study of the investigations conducted by various researchers, It is feasible to conclude that when the D/t ratio of concrete-filled steel tube section increases, compressive strength drops as confinement reduces.

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