# Review: Concrete Filled Steel Tubular Columns

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## ABSTRACT

The development of high rise buildings and the need to provide more rigid structural systems to sustain severe lateral loads due to seismic and wind conditions lead to the necessity for mixed steel and concrete systems. This leads to the invention of CFST (Concrete Filled Steel Tubular Columns). CFST is component with good performance resulting from the confinement effect of steel with concrete core and design versatility. Research has been carried out for triangular, rectangular, circular column sections of CFST and also with flutes on the surface area, named as CFSFC. (Concrete Filled Steel Fluted Columns). This Paper presents a review about the investigations done on behaviour of concrete filled steel tube columns by various researchers.

**Keywords:** CFST, parametric study, composite columns, FEA analysis, SCC, high rise buildings, Strength

## 1. INTRODUCTION

CFST columns are first used in Japan in multi-storied buildings. They have many advantages compared to conventional concrete structural members and are extensively used in seismic zones involving very large applied moments. In framed structures CFST columns are used as beams, columns and girders. The steel tube serves as a formwork for casting while the concrete reduces the construction cost. The tube acts as a longitudinal and lateral reinforcement for the concrete core and no other reinforcement is needed. Further it enhances the core's strength and ductility. The concrete core delays bending and buckling of the steel tube and steel tube prevents the concrete from spalling. This significant feature made CFST columns, suitable for tall buildings in high seismic regions. The composite column is a structural element with proven behaviour of its constituent materials, including high cross-sectional stiffness, high compressive strength, and fire resistance of the concrete and large ductility, high tensile resistance, high strength-to-stiffness ratio, and lightweight construction associated with steel.

CFST columns provide large savings in cost by increasing the floor area by a reduction in the required size of columns. This aspect is significant in the design of tall buildings in cities where the cost of land is extremely high. The typical cross-sections are as shown in Fig.1 [16].

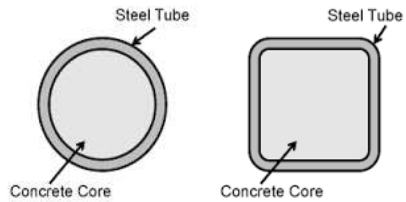


**Fig.1.[16]**

## 2. RESEARCH

Research work is going on all over the world, and following investigations were observed.

**2.1**. Oshea and Bridge [1] (1997) had conducted research on thin wall steel tube with concrete infill taking the parameters as diameter to thickness ratio ranging from 55-200 and length to diameter ratio as 3.5. Concrete of grades 50, 80 and 120 MPa were used and the results had shown an improvement in the buckling strength. The experiments were performed in four series of tests. In the first series of the experimental study, the local buckling behaviour of short thin-walled circular tube members was investigated. Both unfilled and concrete-filled confinement on the cross section strength. Design methodologies were developed for thin-walled concrete filled steel tubes. The capacity of a short, thick-walled circular steel tube filled with medium strength concrete was determined using ACI 318 (1989) [2] and EC4 (1992) [3].

**2.2.** Later, in 2000, Lin and Tsai [4] performed research on 18 specimens for double skinned CFST, taking the parameters, diameter to thickness ratio and the hollowness ratio for an effective length of 1100 mm. Results have shown that steel tube can improve the confinement of the concrete, and concrete infill can delay the occurrence of local buckling of steel tube.

**2.3.** In 2001, Brian Uy [5] had conducted the research with a width to thickness ratio on local and post local buckling of hollow CFST box sections using M 20 grade concrete. The tests for the hollow sections were significantly greater than the yield slenderness limits designated in international design codes.

**2.4.** Huang CS [6](2001), had conducted on the effects of cross section shapes, width to thickness ratios and stiffening arrangements on the ultimate strength, stiffness and ductility of CFT columns. He had conducted experiments with width to thickness ratio ranging from 40 to 150. 5 specimens were taken with width to thickness ratio or diameter to thickness ratio of 40, 8 specimens with 70, 4 no. with 150, 3 specimens of circular cross section and 14 no. of square cross section were tested. Results had shown that there was a significant enhancement in the ultimate strength and ductility of square CFT columns.

Further advancements in the research were conducted in 2003, by Kefang Tan [7] by performing experiments on 20 high strength concrete short columns with a length to diameter ratio of 3.5. Improvement in mechanical properties and compressive strength of the composite unit were observed.

**2.5.** Later, in 2004, Mohammad et.al [8] had performed research on specimens made of normal concrete. The study was on Cyclic inelastic flexural behaviour of CFT (Concrete Filled Tubular) beams made of cold formed circular hollow sections. Deformation ductility demand was determined to drive new ductile section slenderness limits suitable for seismic design.

specimens were tested. In series 2, two groups of thin-walled square box specimens were tested. The third series of experiments were performed to investigate the effect of confinement on the cross section strength. The fourth

**2.6**. In 2006, Artiomas and Audronis [9] had conducted different no. of concrete core layers, to study the behaviour of composite steel concrete elements in various loading stages. Results have shown that multi-layered elements resist greater loads, but they will have better characteristics such as modulus of Elasticity, density etc.

**2.7**. In 2007, Zhi-Wu [10] performed tests on 17 specimens made of normal concrete and self-compacting concrete to study the behaviour of stub columns in confinement. Results have shown an increase in ultimate capacity using high strength concrete and residual capacity after failure is almost constant.

**2.8.** In 2008, Mohnaraj and Kandasamy [11] had studied for an L/r ratio of 28.5, the behaviour of axially loaded hollow steel columns with concrete infill. Fibres, rubber, granite, debris are used in concrete. The strength, stiffness, ductility and failure mode were discussed and found that the use of other aggregates influenced the strength of concrete. Eight double skinned concrete filled steel tubular (DSCFT) beam columns of concentrically placed circular sections filled with SCC were tested. Testing of specimens investigated the behaviour on load deflection, confinement effect, and the strength of the columns. The experimental observations were displayed by load-deflection curves. Various significant characteristics such as strength, stiffness, ductility and failure mode were discussed. The predicted load versus deformation relationships were in good agreement with beam-column test results. The DSCFT columns in-filled with SCC showed good strength and ductility. Modified equations were suggested to find the ultimate compressive strength of DSCFT columns filled with SCC.

**2.9.** In 2009, C. Douglas Goode Artiomas Kuranovas, Audronis Kazimieras Kvedaras, [12] had conducted research on study the buckling of slender composite concrete-filled steel columns. The experimental results were compared with the predicted results of the load-bearing capacity of calculations of slender elements according to the methods suggested by Eurocode 4. Circular and rectangular hollow section stub and long columns fully filled with concrete, which were with or without applied moments at the ends of specimen. During the results obtained in the result of the tests on the load bearing capacity for circular concrete-filled steel tubular columns correspond with the calculated values based on methods presented by Eurocode 4. The experimental values of load bearing capacity for members of concrete-filled rectangular hollow sections agree very well with the theoretical values where the concrete cylinder strength is below 75 N/mm$^2$. The analysis demonstrated that preloading of concrete-filled hollow section members does not influence the load bearing capacity.

**2.10**. In 2011, Dr.B.R. Niranjan and Dr.Erremma [13] had conducted experiments on 13 specimens having a length of 2.5m and length to diameter ratio, ranging 15,20,25 filled with M20 grade of SCC. The cross section was modified by providing flutes on the steel tube which increases the moment of inertia by 17 % to 40 % for rectangular flutes and 9 to 23% for triangular flutes. The parametrics chosen for the research were geometry of the specimen, (triangular fluted and rectangular fluted), length to diameter ratios and longitudinal reinforcement. It was observed that the load resistance was better in rectangular fluted columns as compared to the triangular fluted columns by 1.31 %, 1.05 % and 9.92% for length to diameter ratio of 15, 20 and 25 respectively. The moment of inertia gets increased by about 17% to 40% for rectangular fluted columns and 9% to 23% for triangular fluted columns.

**2.11**. Vipulkumar Ishvarbhai Patel (2012) [14] carried out experimental and numerical research on full scale high strength thin-walled rectangular steel slender tubes filled with high strength concrete. Experimental ultimate strengths and load deflection responses of CFST slender beam columns were tested by independent researchers and used to verify the accuracy of the numerical model. The verified numerical model was then utilized to investigate the effects of local buckling, column slenderness ratio, and depth-to-thickness ratio, loading eccentricity ratio, concrete compressive strengths and steel yield strengths on the behaviour of high strength thin walled CFST slender beam-columns.

**2.12.** Darshika, Vakil and Patel [15] had performed Finite Element Analysis using ANSYS software on CFST columns under axial loading for circular and square cross sections with varying Grades of concrete, 30, 50, 70 and 90 N/mm$^2$. It is concluded that the deformation of the column is decreasing 10% to15% with the increase in the grade of concrete. It is also found that the circular section leads to better confinement than the square section.

## 3. CONCLUSION

This paper highlights the behaviour of CFST columns under axial loads with various parameters such as length to diameter ratio, diameter to thickness, end conditions, fill material, geometrical shapes etc., and also the various advantages of CFST against conventional Reinforced Columns.

According to literature major work is done on CFST is experimental. Still, there is a need for numerical study to check the parameters which affect the ultimate strength. Also since the effect of cross section has a significant role in improving the strength, extensive research need to be done according to the loading and different regions.

Also, as Bureau of Indian standard code has not given any specification about Composite concrete filled steel columns, there is further research in that field is needed to incorporate codal provisions.

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