International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 7
July 2017

Investigations in behaviour of Concrete Filled Steel Tubular Columns

P. Prasanna Kumari
Research Scholar, Bangalore University, Bangalore, India

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 composite structures using steel and concrete leading to the invention of CFST columns (Concrete Filled Steel Tubular Columns). CFST is a 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 with flutes on the surface area, named as CFSFC. (Concrete Filled Steel Fluted Columns). This paper presents research trends about the investigations on behaviour of concrete filled steel tube columns by various researchers.

KEYWORDS

CFST, parametric study, composite columns, confinement, high rise buildings, Strength, Stiffness, buckling

INTRODUCTION

Concrete Filled Steel Tubular (CFST) columns are first used in multi-storied buildings. They are advantageous compared to conventional concrete structural members and are extensively used in seismic zones involving 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 outer 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 paper presents the investigations done on behaviour of concrete filled steel tube columns by various researchers.

RESEARCH.

In 1997, 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 using concrete of grades 50, 80, and 120, resulted increased buckling strength [1].The capacity of a short, thick-walled circular steel tube filled with medium strength concrete was determined using ACI 318 [2] and EC4 [3].

Later in 2000, tests conducted on double skinned CFST, taking the parameters, diameter to thickness ratio and the hollowness ratio for an effective length of 1100 mm. 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 [4].

In 2001, experiments were conducted with a B/t ratio on local & Post local buckling of hollow CFST box sections using M 20 grade concrete. The tests for the hollow sections are significantly greater than the yield slenderness limits designated in international design codes. [5]

Experiments were conducted in 2001, on the effects of cross section shapes, width to thickness ratios ranging from 40 to 150, and stiffening arrangements on the ultimate strength, stiffness and ductility of CFT columns. Width to thickness ratio or diameter to thickness ratio of 40, 70, and 150, of circular cross section and square cross section were tested. Results have shown that there was a significant enhancement in the ultimate strength and ductility of square CFT columns [6].

Experiments on 20 high strength concrete short columns with a length to diameter ratio of 3.5, resulted in the improvement in mechanical properties and compressive strength of the composite unit [7].

In 2004, research was done to study the Cyclic inelastic flexural behaviour of CFT beams made of cold formed circular hollow sections using normal concrete. Deformation ductility demand was determined to drive new ductile section slenderness limits suitable for seismic design. [8]

Experiments conducted in 2006 on different no. of concrete core layers, in various loading stages, have shown that multi-layered elements resist greater loads [9].

In 2007, tests were performed on specimens made of normal concrete and self-compacting concrete to study the behaviour of stub columns in confinement. It has been proven that an increase in ultimate capacity using high strength concrete and residual capacity after failure is almost constant [10].

In 2008, experiments were performed on the behaviour of axially loaded hollow steel columns with concrete infill consisting of fibers, rubber, granite, and debris. It was found that the use of other aggregates influenced the strength of concrete. The Double Skinned Concrete Filled Tubular 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 [11].

In 2009, research on study the buckling of slender composite concrete-filled steel columns was conducted. Circular and rectangular hollow section stub and long columns filled with concrete, with or without applied moments at the ends of specimen were considered for the experiments. The results obtained on the load bearing capacity for circular CFST columns correspond with the calculated values based on methods presented by Euro code 4.The analysis demonstrated that preloading of concrete-filled hollow section members does not influence the load bearing capacity by Euro code 4. [12].

In 2011, tests have been conducted on specimens having a slenderness 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. The parameters chosen were geometry of the specimen, slenderness ratio, and longitudinal reinforcement. Results have shown that the load resistance was better in rectangular fluted columns as compared to the triangular fluted columns [13].

In (2012), experimental and numerical research was carried out 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 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. [14]

Finite Element Analysis was performed on CFST columns under axial loading for circular and square cross sections with varying Grades of concrete, 30, 50, 70 and 90 N/mm2. 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 [15].

In 2014, experiments were conducted on specimens to study the peak load, axial compressive load versus axial deflection behaviour and failure modes for both hollow and CFT specimens. M30 (25% of coarse aggregate is replaced by recycled aggregate.) The results showed that the axial compressive strength of CFTs increases up to 2 to 5 times that of hollow sections due to confinement effect of concrete core on steel tubes and estimation of axial compressive strength using all methods is conservative. All bare steel columns failed by local buckling whereas CFT columns failed by local buckling accompanied by concrete crushing (similar to Schneider, 1998). It was observed that the local buckling of steel tube was delayed due to concrete filling in CFT column specimens.

The maximum axial deflection occurred for CFT column of least D/t ratio (33.3). The axial compressive strength of CFT columns was increasing with increase in % steel contribution and decrease in diameter to thickness ratio. The design equations are modified using the effective steel and concrete stress-strain relationships developed and verified by the authors in a previous research. [16]

The ultimate axial load carrying capacity of CFST column is investigated by changing diameter-to thickness (D/t) ratio, steel grade and concrete grade. Results shows that the ultimate load capacity decreases by increase in D/t ratio but increases by increase in steel grade and concrete grade. [17]

In this study, test on hollow columns filled with timber were carried out to investigation the actual behavior and the load bearing capacity of such columns. Circular sections were chosen for the experimental procedure. The timber filled was found to significantly improve the capacity by preventing local inward buckling. Several tests were conducted on different specimens and the impact of each material was studied on the structural behavior of these members under axial compression for comparison purpose between the loads and the lateral displacements. The results showed that using timber filling instead of concrete filling will reduce the weight of columns. At the same time, a high load bearing capacity is achieved. [18]

CONCLUSION

This paper highlights the research done on 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 the various advantages of CFST against conventional reinforced cement columns. According to literature, major experimental work is done on CFST. Numerical study to check the parameters which affect the ultimate strength is also necessary. Extensive research need to be done according to the loading and different regions with varied geometry to check the improvement in the strength.

REFERENCES

[1] Oshea and Bridge. 1997. Local buckling of thin-Walled circular steel sections with or without internal restraint, Journal of Constructional Steel Research, vol. 41, issues 2-3, Feb-March 1997 pp. 137-157.

[2] ACI, Buildings code requirements for structural concrete (ACI-318-99). Detroit (M) American Concrete Institute (ACI), 1999.

[3] Eurocode 4. 1994. Design of composite steel and concrete structures, Part 1.1, General rules and rules for buildings. Eurocode 4. 2004. Design of composite steel and concrete structures, Part1-1: General rules—structural rules for buildings. Brussels: EN1994-1-1, CEN

[4] Lin and Tsai. 2000. Mechanical behaviour of double skinned composite steel tubular columns‖, National Centre for Research on Earthquake Engineering, Taipei, Taiwan.

[5] Brian Uy. 2001. Local and post-local buckling of fabricated steel and composite cross sections‖, journal of Structural Engineering, ASCE, Vol. 127, no.6, pp 666-677

[6] Huang CS. 2001. Axial Load Behavior of Stiffened Concrete-Filled Steel Columns‖, Journal of Structural Engineering, September 2002

[7] Kefeng Tan. 2003. Mechanical properties of High Strength Concrete Filled Steel Tubular Columns Part-I Concentrically loaded‖, ACI journal April 2003.

[8] Mohamed Elchalakani, Xiao-Ling Zhao, Raphael Grzebieta. 2004. Concrete filled steel circular tubes subjected to constant amplitude cyclic pure bending‖, ENGINEERING STRUCTURES 26 (2004), pp 2125- 2135.

[9] Artiomas and Audronis. 2006. Behaviour of hollow concrete-filled steel tubular composite elements‖. Journal of Civil Engineering and Management http:/www.jcem.vgtu.lt 2007, vol. xiii, no 2, 131–141.

[10] Zhi Wua. 2007. Experimental behaviour of circular concrete filled steel tube stub columns‖, Journal of Constructional Steel Research 63, pp. 165-174.

[11] Mohnaraj and Kandasamy. 2011. Study on concrete using waste materials by partial replacement of aggregates to reduce global warming gases‖, Indian Journal of Science and Technology, Vol. 4 issue 3, March 2011. ISSN: 0974-6846

[12] C. Douglas Goode, Artiomas Kuranovas, Audronis Kazimieras Kvedaras. 2009. Buckling of slender composite concrete-filled steel columns.

[13] Dr. B.R. Niranjan and Dr. Erremma. 2012. Experimental Investigation on Reinforced Concrete Filled Steel Rectangular Fluted Columns, International Journal of Scientific & Engineering Research, Volume 3, Issue 11, November.

[14] Vipulkumar Ishvarbhai Patel, Qing Quan Liang and Muhammad N S Hadi. (2012). High Strength thin-walled rectangular concrete-filled steel tubular slender beam columns, Part II: Behavior, Journal of Constructional Steel Research, Vol. 70, March, pp. 368-376.

[15] Darshika K Shah, M.D.Vakil, and M.N.Patel. (2014). Parametric study of Concrete filled steel tube column, IJEDR, Vol.2, Issue 2, ISSN: 2321-9939.

[16] N.Umamaheswari and S. Arul Jayachandran. 2014. IJETAE ISSN 2250-2459, Volume 4, Issue 5, May 2014, ISO 9001:2008 Certified Journal

[17] Raghabendra Yadav, Baochun Chen. 2017. Parametric Study on the Axial Behaviour of Concrete Filled Steel Tube (CFST) Columns. American Journal of Construction and Building Materials. Vol. 2, No. 1, 2017, pp. 21-25. doi: 10.11648/j.ajcbm.20170201.13

[18] Gowri P , Shanmugavalli B. 2017. Experimental Investigation on the Buckling Behaviour of Timber Filled Steel Tubular Column, IJIRSET, Vol. 6, Issue 5, May 2017