A Review on Concrete Filled Steel Tubes Column

Conference Paper · December 2015

Milind V Mohod
Prof. Ram Meghe Institute of Technology & Research

Deepam Publication's ISSN 2395-6453 (Online)
International Journal of Research in Engineering, Science and Technologies (IJRESTs)
Civil Engineering

A Review on Concrete Filled Steel Tubes Column

Mustafa M Wagh *
PG Student,
Civil Engineering Department,
P.R.M.I.T&R Badnera,
Maharashtra, India
mus1441@gmail.com

Milind V Mohod
Assistant Professor,
Civil Engineering Department
P.R.M.I.T&R Badnera,
Maharashtra, India
milindmohod88@gmail.com

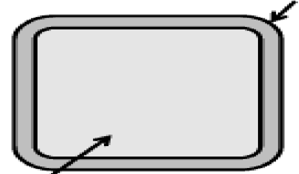
Abstract: Concrete filled steel tube is gaining more popularity now a days in construction area. Concrete filled steel tube is component with good performance resulting from the confinement effect of steel with concrete and design versatility. Concrete-filled steel tubes are gaining increasing prominence in a variety of engineering structures, with the principal cross-section shapes being square, rectangular and circular hollow sections. Columns are designed to resist the majority of axial force by concrete alone can be further economized by the use of thin walled steel tube. The study about the behavior and the characteristics of CFST columns is the prime need. This Paper present a review about the investigation done on behavior of concrete filled steel tube columns by various researchers with reference to various codal provisions.

Keywords:Composite column, RCFST , CCFST, Design codes, seismic behavior, Cross section

1.0 INTRODUCTION

Concrete filled steel tubes (CFST) are Structural member. CFST structure is atype of the composite steel-concrete structures used presently in civilengineering and consists of steel tube and concrete core inside it. In which hollow steel section is filled with high strength concrete. Combiningthe advantages of both hollow structural steel and concrete. Composite columns are structural members, which are subjected mainly to axial compressive forces and end moments. The general term 'composite column' refers to any compression member in which the steel element acts compositely with the concrete as shown in fig 1. so that both elements contribute to the strength.[8]

Rectangular concrete filled steel tubes (RCFST) and Circular concrete filled steel tubes (CCFST) are being used widely in realcivil engineering projects due to their excellent static and earthquakeresistant properties, such as high strength, high ductility and large energy absorption capacity. Concrete filled steel tubes (CFST) are also usedextensively in other modern civil engineering applications. When they areused as structural columns, especially in high-rise buildings, the compositemembers may be subjected to high shearing force as well as moments underwind or seismic actions. It may be noted here that mechanical andeconomical benefits can be achieved if CFST columns are constructedtaking advantages of high-strength materials. For example, high-strengthconcrete infill contributes greater damping and stiffness to CFST columnscompare to normal strength concrete. Moreover, high-strength CFSTcolumns require a smaller cross-section to withstand the load, which isappreciated by architects and building engineers. New developments, including the use of high strength concrete and the credit of the enhanced local buckling capacity of the steel has allowed much more economical designs to evolve. The main economy achieved by using high strength concrete in thin steel casings is that the structural steel cost is minimized and the majority of the load in compression is resisted by the high strength concrete .However, bare steel or reinforced concrete columns are still used more extensively than CFSTs due to the lack of knowledge and experience that Engineers have with CFST structural systems.[11]



* Corresponding Author

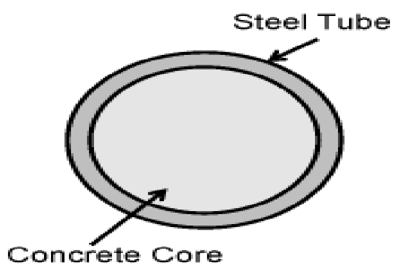


Fig.1: Schematic view of concrete filled steel tube column.

1.1 Advantage over Reinforced Concrete

1) The concrete infill is confined by the steel tube. This confinement effect increases the strength and ductility of the concrete core in steel tubes.

2) The concrete infill delays local buckling of the steel tube.

3) The combined capacity of the steel and concrete significantly increases thestiffness and ultimate strength of CFST columns which makes them very suitable forcolumns and other compressive members.

4) The steel tube serves as longitudinal reinforcement and permanent formwork for the concrete core, which results in rapid construction and significant saving in materials.

5) The steel tube can also support a considerable amount of construction and permanent loads prior to the pumping of wet concrete.

1.2 Review of Design Codes

Different design regulations were produced for various cross-sections of CFST structures. Different approaches and design philosophies have been adopted in different design codes (Xinbo et al. 2006). In China, there are circular CFST structure design regulation, square structure design regulation, rectangular structure design regulation, and circular hollow CFST structure design regulation. In these regulations, the design methods are different. In China and Japan, the standard for designing the composite columns is based on a simple method of superposition that uses the allowable stresses of the materials or then working stress method. ACI-318 adopts the traditional reinforced concrete approach. AS 3600-1994 also uses the concept of reinforced concrete design. The AISC-LRFD is based on the concept of structuralsteel. The Eurocode 4, being a dedicated code for composite construction, combines the design approach of both structural steelwork and reinforced concrete columns. Different limitations on the compressive strength ofconcrete, steel yield strength, diameter-to-thickness ratio, steel ratio and confining coefficient are prescribed in differentcodes.

1.3 Review on Behavior of Concrete filled steel Tube

Artiomas Kuranovas, Douglas Goode, Audronis Kazimieras Kvedaras, Shantong Zhong done analysis of 1303 specimens of CFST experimental data. Test results are compared with EC4 provided method for determining the load-bearing capacity of these composite elements. Several types of CFSTs were tested: both circular and rectangular cross-sections with solid and hollow concrete core with axial load applied without and with moment, with sustained load and preloading. For circular cross-section columns there is a good agreement between the test failure load and the EC4 calculation for both short and long columns with and without moment. For rectangular cross-section columns the agreement is good except when the concrete cylinder strength was greater than 75 MPa, when many tests failed below the strength predicted by EC4.

X.H. Dai et al The structural fire behaviour of a series of concrete filled steel tubular stub columns with four typical column sectional shapes in standard fire. The selected concrete filled steel tube stub columns are divided into three groups by equal section strength at ambient temperature, equal steel cross sectional areas and equal, concrete core cross sectional areas. The temperature distribution, critical temperature and fire exposing time etc. of selected composite columns are extracted by numerical simulations using commercial FE package ABAQUS. Based on the analysis and comparison of typical parameters, the effect of column sectional shapes on member temperature distribution and structural fire behavioris discussed.

Jerom Hajjar reported a review of the behavior of circular and rectangular concrete-filled steel tube beam-columns and braces, and particularly focused on their behaviour when subjected to cyclic seismic loading. He explained the monotonic behavior of CFTs subjected to axial, flexural, and torsional loading, summarizing the effects of CFT behaviour including creep, shrinkage, composite action and residual stresses

Lin-Hai Hana,ZhongTab,Guo-Huang Yaob had had used ABAQUS Programming in this paper for the analysis of CFST subjected to shear and constant axial compression. A comparison of results calculated using this model shows good agreement with the test results in general. The theoretical model was used to investigate the influence of important parameters that determine the ultimate shearing strength of the composite members. The parametric studies provide information for the development of formulae to calculate the ultimate strength of CFST members subjected to shear and constant axial compressionPreloading the steel tube before filling with concrete seems to have no effect on the strength. This paper also presents the stress distribution, confinement distribution and complete average longitudinal stress-strain curves for concrete-filled steel tubular elements

Dr. B.R Niranjan, Eramma had made an attempt to use this composite structural member as a column with a modification of flutes on the steel tube which enhances the aesthetics and development area of sheet by which the moment of inertia gets increased by about 17 to 40 % for rectangular flutes and 9 to 23 % for triangular flutes. Confining concrete by providing triangular and rectangular shape fluted steel tube has been investigated by a well planned experimental work on twenty six concrete filled steel fluted columns (CFSFC). The parameters chosen for the study are (i) Geometry of the specimen - Triangular fluted columns (TFC) and rectangular fluted columns (RFC) (ii) Different L/D ratios (size of the columns) (iii) Longitudinal reinforcement. Three series of specimens having different L/D ratios, 2500mm long have been tested with M20 grade of self compacting concrete (SCC). It is observed that the load resistance is better in rectangular fluted columns as compared to the triangular fluted columns by 1.31 %, 1.05 % and 9.92% respectively for L/D ratio of 15, 20 and 25. The moment of inertia gets increased by about17% to 40% for RFC and 9% to 23% for TFC.

Shams and Saadeghvaziri presented the state of the art for concrete-filled steel tubular (CFT) columns including experimental and analytical work. They discussed the general response of CFT columns and the use of steel jacketing. They also presented an overview of analytical work for CFTs, including a comparison between the different design codes.

Aritra Mandal conducted experimental study was conducted to understand the behavior of Short Concrete Filled Steel Tubular Columns (CSFT) under axial compression to failure. An analytical study was also done to compare with the experimental results. A total of 69 specimens (63 specimens were filled with concrete, 3 specimens were kept hollow and 3 specimens were only concrete) having different cross-sections were tested to investigate the load carrying capacity in particular and behavior as a whole

Keigo TSUDA1, Chiaki MATSUI2 AndEiji MINO conducted tests onthe concrete filled steel square and circular tubular columns.The test is composed of two Series. In Series I, columns are subjected to concentric and eccentric axial force at both ends. In Series II, columns are cantilever columns, and subjected to alternating horizontal load under constant vertical load. As a main experimental parameter, buckling length - section depth ratio of a column is selected. Strength and behavior are examined, and design methods for slender composite columns are investigated.

Spacone and El-Tawil presented a state of the art of nonlinear analysis of steel-concrete composite structures. The work was focussed on frame elements, section models and fibber models, with lumped and distributed inelasticity, as well as models with perfect and partial connections.

J. Zeghichea, K. Chaouib had conducted tests on 27 concrete-filled steel tubular columns and result are reported. The test parameters were the column slenderness, the load eccentricity covering axially and eccentrically loaded columns with single or double curvature bending and the compressive strength of the concrete core. The test results demonstrate the influence of these parameters on the strength and behaviour of concrete-filled steel tubular columns. A comparison of experimental failure loads with the predicted failure loads in accordance with the method described in Eurocode 4 Part 1.1 showed good agreement for axially and eccentrically loaded columns with single curvature bending whereas for columns with double curvature bending the Eurocode loads were higher and on the unsafe side. More tests are needed for the case of double curvature bending.

C. Douglas GoodeDennis Lam This paper compares concrete-filled steel tube columns and failure load with the prediction of Eurocode 4. The comparison with Eurocode 4 is discussed and shows that Eurocode 4 can be used with confidence and generally gives good agreement withtest results, the average Test/EC4 ratio for all tests being 1.11. The Eurocode 4 limitations onconcrete strength could be safely extended to concrete with a cylinder strength of 75 N/mm2 forcircular sections and 60 N/mm2 for rectangular sections.

P.K. Gupta, S.M. Sarda, M.S. Kumar have donean experimental and computational study on the behaviour of circular concentrically loaded concrete filled steel tube columns till failure. Eighty-one specimens were tested to investigate the effect of diameter and D/t ratio of a steel tube on the load carrying capacity of the concrete filled tubular columns. The effect of the grade of concrete and volume of flyash in concrete was also investigated. The effect of these parameters on the confinement of the concrete core was also studied. Diameter to wall thickness ratio between 25 < D/t < 39, and the length to tube diameter ratio of 3 < L/D < 8 was investigated. Strength results of Concrete Filled Tubular columns were compared with the corresponding findings of the available literature. Also a nonlinear finite element model was developed to study the load carrying mechanism of CFTs using the Finite Element code ANSYS. This model was validated by comparison of the experimental and computational results of load–deformation curves and their corresponding modes of collapse. From the experimental and computational study it was found that for both modes of collapse of concrete filled tubular columns at a given deflection the load carrying capacity decreases with the increase in % volume of flyash up to 20% but it again increases at 25% flyash volume in concrete.

Dennis Lam, EhabEllobod and Ben Young [2005]: The behavior and design of axially loaded concrete-filled steel tube circular stub columns were presented. The study was carried over a wide range of concrete cube strengths ranging from 30 to 110 MPa. The external diameter of the steel tube-to-thickness (D/t) ratio ranged from 15 to 80. An accurate finite element model was developed to carry out the study. Accurate nonlinear material models for concrete and steel tubes were used. The column strengths and load–axial shortening curves were evaluated. The results obtained from the FE analysis were verified against experimental results. An extensive parametric study was carried out to investigate the effects of different concrete strengths and cross-section geometries on the strength and behavior of concrete-filled compact steel tube circular stub columns. The column strengths predicted from the FE analysis were compared with the design strengths calculated using the American, Australian and European codes. Based on the results of the parametric study, it is found that the design strengths given by the American Specifications and Australian Standards are conservative, while those of the European Code are generally not much conservative.

Qing Quan Liang and Sam Fragomeni [2009]: Quin and Sam had presented accurate constitutive models for normal and high strength concrete confined by either normal or high strength circular steel tubes. A generic fiber element model that includes the proposed constitutive models of confined concrete was created for simulating the nonlinear inelastic behavior of circular CFST short columns under axial loading. The confinement effect provided by the steel tube with a concrete-filled steel tubular (CFST) short column increases the strength of the concrete core. The generic fiber element model developed was verified by comparisons of computational results with existing experimental data. Extensive parametric studies were conducted to inspect the accuracy of various confining pressure models and the effects of

1. The tube diameter-to-thickness ratio,
2. Concrete compressive strengths and
3. Steelyield strengths

On the fundamental behavior of circular CFST columns. A new design formula accounting for concrete confinement effects was also proposed for circular CFST columns.

It is demonstrated that the generic fiber element model and design formula adequately forecast the ultimate strength and behavior of axially loaded CFST columns and can be used in the design of normal and high strength CFST columns.

Paul J. Barr, Baochun Chen and ZhijingOu [2011]: An experimental and analytical investigation of concrete-filled steel tubular (CFST) laced columns was carried out. The columns consist of four concrete-filled steel tubes which are laced together. A total of 27 experimental tests was carried out to quantify the column failure mechanism at ultimate loads. The experiments were performed to obtain the load-deflection curves. Experimental results showed that the compression force in the longitudinal members dominated the failure mechanism in the CFST columns. The forces in the lacing members (diagonal and horizontal bracing) were found to be small. The experimental study was used to validate an analytical parametric study. The analytical study showed that increasing slenderness ratios and eccentricities reduced the ultimate load carrying capacity. On the basis of the analytical results, a new methodology for calculating the ultimate load-carrying capacity was proposed. The proposed methodology was compared with five different building codes like AISC, Eurocode4 and china codes (DL/T 5085-1999, JCJ 01-89, CECS 28:90) to quantify the accuracy.

Yu-Feng A, Lin-Hai Han and Xiao-Ling Zhao carried out test on the behavior of very slender, thin-walled concrete filled steel tubular (CFST) columns under axial compression was studied by the authors. A finite element analysis (FEA) was used to carry out the behaviour of compressive columns. Generally a good agreement was obtained between the predicted and calculated results. The FEA model was then used to perform analysis on very slender circular CFST columns. Parametric studies were conducted and the ultimate strengths from tested results and design codes were compared and discussed. The reliability analysis method was used to calibrate the existing design formulas given in DBJ/T13-512010, ANSI/AISC 360-05 and Eurocode 4.

Vipulkumar Ishvarbhai Patel (2012) carried out experimental and numericalresearch 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, concretecompressive strengths and steel yieldstrengths on the behavior of high strength thinwalledCFST slender beam-columns.

2.0 CONCLUSION

This paper focus on study and research done on Concrete filled steel tube. Now a days, many research is going on designing aspect of CFST and behavior in different loading condition. A wide range of research has been done on behavior of CFST according to its different cross section like rectangular and circular which are more popular in design field. From the review of literature its shows CFST columns provide excellent seismic event resistant structural properties such as high strength, high ductility and large energy absorption capacity.

These papers highlight the behavior of CFST under axial load concentric, eccentric, fire property of CFST and also discuss advantage of CFST against RC column. 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. As there is not such work done about effect of cross section of CFST an extensive work can be done for selecting appropriate cross section according to loading and different region. As Indian standard has not given any specification about Composite column there is further research in that field is needed.

Reference

[1] Eurocode 4 (2004), *Design of composite steel and concrete structures,*Part1-1:General rules—structural rules for buildings. Brussels: EN1994-1-1, CEN.

[2] American concrete Institute (ACI), Building code requirements for structural concrete (ACI 318-89) and commentary

[3] Shams M., Saadeghvaziri M.A., "State of the art of concrete-filled steel tubular columns", ACI Structural Journal 94 (5): 558-571 Sep-Oct 1997.

[4] Hajjar J.F., "Concrete-filled steel tube columns under earthquake loads", Prog. Struct. Engng Mater. 2: 72-81, 2000.

[5] Gourley, B.C., Tort, C., Hajjar, J.F., and Schiller, P.H., "A Synopsis of Studies of the Monotonic and Cyclic Behavior of Concrete-Filled Steel Tube Beam-Columns", Structural Engineering Report No. ST-01-4, Department of Civil Engineering, University of Minnesota, Minneapolis, Minnesota, Version 3.0, December, 263 pp., 2001.

[6] Spacone E., El-Tawil S., "Nonlinear analysis of steel-concrete composite structures: State of the art", Journal of Structural Engineering - ASCE 130 (2): 159-168 Feb 2004.

[7] C. Douglas GoodeDennis Lam., “CONCRETE - FILLED STEEL TUBE COLUMNS-TESTS COMPARED WITH EUROCODE 4”

[8] Darshika k. Shah, Merool D. Vakil, M.N.Patel," Behavior of Concrete Filled Steel Tube Column" 2014 IJEDR | Volume 2, Issue 1 | ISSN: 2321-9939

[9] Artiomas Kuranovas, Douglas Goode, Audronis Kazimieras Kvedaras, Shantong Zhong," Load-Bearing Capacity of Concrete-Filled Steel Columns" Journal of Civil Engineering And Management March 2009

[10] Keigo Tsuda, Chiaki Matsui and Eiji MINO.,"Strength And Behavior Of Slender Concrete Filled Steel Tubular Columns"

[11] Aritra Mandal.,"Concrete filled steel tube umder Axial Compression"

[12] Ehab Ellobody, Ben Young, Dennis Lam (2006). Behaviour of normal and high strength concrete-filled compact steel tube circular stub columns.*Journal of Constructional Steel Research, 62,706–71.*

[13] Qing Quan Liang, S. F. (2009). Nonlinear analysis of circular concrete-filled steel tubular short columns under axial loading. *Journal of Constructional Steel Research* , 2186-2196.

[14] Zhijing Ou, B. C. (2011). Experimental and Analytical Investigation of Concrete Filled Steel Tubular Columns. *JOURNAL OF STRUCTURAL ENGINEERING, 137*, 634-645

[15] Vipulkumar Ishvarbhai Patel, Qing Quan Liang and Muhammad N S Hadi (2012), "High strength thin-walled rectangular concrete filled steel tubular slender beamcolumns, PartI-Modeling", *Journal ofConstructional Steel Research*, Vol. 70, March, pp. 377-384.

[16] Dr. B.R Niranjan, Eramma. H.," Effect of Shape of Cross-section and Its Performance for Concrete Filled Steel Fluted Columns" International Journal of Modern Engineering Research (IJMER) Vol.3, Issue.2, March-April. 2013 pp-685-691

[17] X.H. Dai, D. Lam.," Shape effect on the behaviour of axially loaded concrete filled steel tubular stub columns at elevated temperature" Journal of constructional steel research 73(2012) 117-127

[18] Lin-Hai Hana,, Zhong Taob , Guo-Huang Yaob.," Behaviour of concrete-filled steel tubular members subjected to shear and constant axial compression" Thin-Walled Structures 46 (2008) 765–780

[19] J. Zeghichea, K. Chaouib.," An experimental behaviour of concrete-filled steel tubular columns" Journal of Constructional Steel Research 61 (2005) 53–66

[20] P.K. Gupta, S.M. Sarda, M.S. Kumar.," Experimental and computational study of concrete filled steel tubular columns under axial loads" Journal of Constructional Steel Research 63 (2007) 182–193

[21] Yu-Feng An, L.-H. H.-L. (2012). Behaviour and design calculations on very slender thin-walled CFST columns. *Thin-Walled Structures* , 161-175.

Author's Biography

Mr. Mustafa M Wagh obtained his B.E degree from Sant Gadge Baba Amravati University, Amravati. He is pursuing post-graduation in Structural Engineering from PRMIT&R, Badnera.

Mr.Milind V. Mohod is currently Assistant Professor at Prof. Ram Meghe Institute of Technology and Research, Badnera, Amravati. He obtained his BE degree from PRMIT&R,Badnera, SGBAU, Amravati University and M.Tech (Structural Engineering) from GCOE, Amravati. He has presented and published numerous research papers in several National confernces, International Conferences and Journals. His area of interest are related to Structural Dynamics, Earthquake Engineering, Plate Analysis, Finite Element Method. He has an experience of 4.5 years.