IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 14, Issue 4 Ver. IV (Jul. - Aug. 2017), PP 01-04
www.iosrjournals.org

A Review on Developments in Concrete Filled Steel Tubular Columns (CFST)

[*]Kunal R. Harale[#1], Snehal P. Kitture[*2]
[#]Department of Civil Engineering, Sinhgad Academy of Engineering, Pune, Maharashtra.
[*] Department of Civil Engineering, Sinhgad Academy of Engineering, Pune, Maharashtra.
Corresponding Author: Kunal R. Harale

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 Concrete Filled Steel Tubular Columns (CFST). Concrete Filled Steel Tube (CFST) is the composite section formed by filling concrete into a hollow steel tube. Extensive work carried out on CFST in past years have indicated that the CFST sections possess high ductility, strength and stiffness properties. This Paper presents a review about the investigations done on behaviour of concrete filled steel tube columns by various researchers with relevance to the strength of various cross sectional areas, addition of FRPs and recycled materials and corresponding changes in strengths and its advantages over RC structures.*

Keywords: *CFST, FRP composites, Recycled coarse aggregates, Square and Circular CFST.*

Date of Submission: 04-07-2017 Date of acceptance: 26-07-2017

I. Introduction

Concrete filled steel tubes (CFST) are a type of composite members which consists of hollow steel tube section with high strength concrete core filled inside it. Concrete filled steel tubular (CFST) members utilize the advantages of both steel and concrete. It has the structural stiffness and integrity of a cast-on-site reinforced concrete building, and the ease of handling and erection of a structural steelwork. The inherent buckling problem related to thin-walled steel tubes is either prevented or delayed due to the presence of the concrete core. Furthermore, the performance of the concrete in-fill is improved due to confinement effect exerted by the steel shell. The distribution of materials in the cross section also makes the system very efficient in term of its structural performance. The steel lies at the outer perimeter where it performs most effectively in tension and bending. The concrete core gives greater contribution to resisting axial compression.The inner concrete core also plays an important part in delaying the inward buckling of steel tubes. One of the many developments in the previous years was the use of Recycled Aggregate Concrete (RAC), in which broken pieces of waste concrete are used as aggregates[1].

One of the few drawbacks of Concrete filled steel tubular members is that they get deteriorated due to the environmental effects like corrosion and ageing. The external strengthening by using fibre reinforced polymer (FRP) material[2] is emerging as a new trend in enhancing the structural performance of CFST members to counteract the drawbacks in the past rehabilitation work. Recent years FRP is becoming a popular material for rehabilitation due to its superior material properties like: corrosion and weather resistance, high mechanical strength, less weight, ease of handling, good fatigue resistance and ductility. One of the many reasons that cause the failure of multi-storey or high rise RCC buildings is due to earthquake forces. To resist such large forces the buildings require bulky columns which further cause reduction in the functional area. To overcome such problem, use of Concrete Filled Steel Tube (CFST) columns for high rise RCC buildings becomes better option[4]. CFST member has variety of applications such as columns supporting platforms in offshore structures, roofs of oil storage tanks, large industrial workshops and tall structures, bridges and open-air overhead travelling cranes and also used as piles in foundation.

1.1 Advantages 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 the stiffness and ultimate strength of CFST columns which makes them very suitable for columns 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.

[6] 2) CFST columns provide large savings in cost by increasing the floor area by a reduction in the required size of columns. This aspect is

[7] 3) Significant in the design of tall buildings in cities where the cost of land is extremely high.

[8] 4) The steel tube serves as a formwork for casting while the concrete reduces the construction cost.

[9] 5) The tube acts as a longitudinal and lateral reinforcement for the concrete core and no other reinforcement is needed

II. Literature Review

In 2006, You-Fu Yang et. al conducted a series of tests on CFSTs of circular and square cross sections which were filled with normal concrete and recycled aggregate concrete and their respective results were compared. The main parameters that were varied in the tests were, tube shape (circular or square), concrete type (normal concrete or recycled aggregate concrete) and load eccentricity ratio. From the tests it was concluded that the ultimate capacities of such composite columns decreased with the increase in load eccentricity ratio. The ultimate capacities of CFSTs having recycled aggregates were slightly lesser but comparable, than the ones that were made up of using normal concrete.

In 2011, Fuyun Huang et. al studied a series of comparative experiments that were aimed at structural performance of concrete filled circular steel tube columns subject to four concentric loading schemes.The loads were applied on the entire section (LT-A), the concrete core only (LT-B), the steel tube only (LT-C), or on the entire section with two different preloading ratios (LT-D1 and -D2). For a complete comparison, three empty steel tubes were also tested (LT-E).The test results showed that the confinement effect is significant in short CFST columns, hence strengthening the columns. The LT-B loading has the most significant confinement. Compared with the LT-A, -B, and -D loading schemes, the LT-C loading exhibits least load resistance and therefore should be avoided as a mandatory requirement in construction.

In 2015, P.Kiruthika et. al studied the behaviour of FRP strengthened slender circular CFST members under compression. The unidirectional carbon fibre called MBrace 240, fabricated by BASF India Inc was used in this study. Longitudinal wrapping of unidirectional CFRP strips over CFST columns was put forth in this research work. The performance was observed and discussed in terms of failure modes, axial load Vs lateral deformation and load carrying capacity. The axial compressive behaviour of CFRP strengthened CFST columns was enhanced both in terms of strength and stiffness, by reducing the lateral deformation and increasing the load carrying capacity when compared to unstrengthen CFST column.

In 2016, Shilpa Sara Kurian et al. studied the load deformation characteristics of composite columns critically, numerical finite element analysis using software package ANSYS[1]. The deformation of circular and square cross sectional areas of CFSTs were compared and also, the specimens were tested by varying the grade of concrete and respective deformations were noted. It was found that, deformation in a circular CFST column is less than deformation in Square CFST columns due to better confining effect. The comparative results of the test conducted are as shown in Fig. Ⅰ. The effect of variation of grade of concrete was such thatthe deformation of the column decreases by 10-15 percent with increasing grade of concrete.

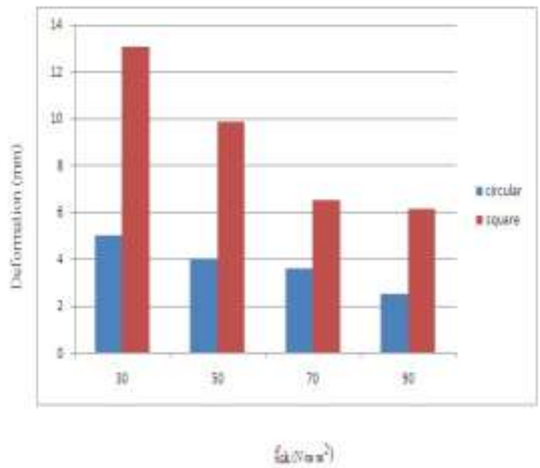

Fig. Ⅰ Deformation for Different Grades of Concrete

In 2016, Vishal V. Gore et al studied the seismic behaviour of a RCC multi-storeyed building provided with RCC and CFST columns and compared them using ETABS 15.0 software. The results of study indicate that the building with CFST columns performs better against seismic forces. It was also observed that there was a 40% reduction in the cross-sectional area used by CFST columns. There was also a considerable amount of reduction in the base shear values and in the lateral displacements of buildings (as shown in Fig Ⅱ) with a reduction of nearly 18% of the buildings dead weight which proves to be useful in case of seismic studies.

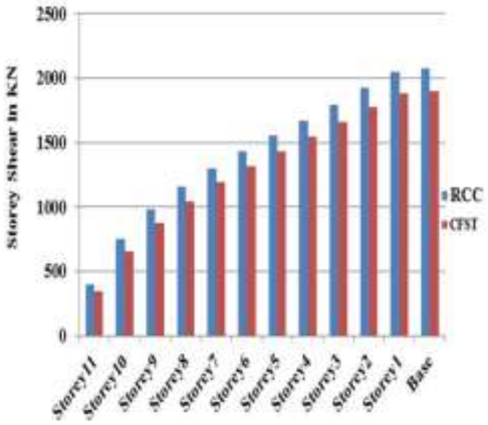

Fig Ⅱ. Comparison of lateral displacement of building in X-Dir

III. Methodology

In producing RAC, by You-Fu Yang et. al [1], in place of natural coarse aggregate (NCA), portions of 25% and 50% recycled coarse aggregate (RCA) were added as coarse aggregate. RCA were obtained by crushing waste concrete, which was taken from failure CFST specimens.The compressive cube strength of the waste concrete was about 50 MPa. All specimens were cast from one batch of concrete.Several150 mm cubes and 150mm×300mm prisms were also cast from the concrete and cured. A total of 30 composite columns, including 24 RACFST columns and 6 corresponding normal CFST columns were tested. In order to investigate the influence of different loading conditions on the ultimate strength of CFST columns [2], a total of 15 CFST specimens and 3 empty steel tubes were fabricated and tested. The steel tubes were welded from Grade Q345 (GB 50017, 2003) steel plates. The outer diameter of the tubes was 108 mm; the tube wall thickness was 4 mm. They were carefully cut and machined to three lengths of short (324 mm), intermediate (1296 mm) and long (1944 mm), so that the two ends were parallel to each other and normal to the longitudinal axis.The tests were carried out in a 5000kN capacity hydraulic compression machine.

For the research work based on the FRP CFST [3], the mild steel tube of 1.5m height was cut out from 6m length steel tube with the circular cross section of 42.4mm diameter and 3.2mm thickness. Here the CFRP strips were used to complement the strength of steel tubes and the tubes were filled with normal strength concrete. Six specimens were tested under axial compression to optimize the need of CFRP strips in view of width, spacing and number of layers. The following designation was used to identify the specimens: CS, CF-200-60-1, CF-200-60-2, CF-200-60-3, CF-300-100-1, CF-300100-2 and CF-300-100-3. For example, the CF-200-60-1 specifies that carbon fibre strip having a width of 200mm and spacing of 60mm with one layer. CS specifies control specimen. All the specimens were tested under axial compression in a column tester of 2000kN capacity.

While conducting the research work by Shilpa Sara Kurian et al. [4] ANSYS software was used. Finite element method is considered to be the best tool for analyzing the structures. Recently, many software's use this method for analyzing and designing. In Ansys Workbench, analyses are built as systems, which can be combined into a project. The project is driven by a schematic workflow that manages the connections between the systems. The seismic analysis and design of G+10 storied RCC building provided with RCC and CFST [5] columns has been carried out as per code IS: 18932002 using ETABS 2015 software. Loadings on building are considered as per code IS 875: 1987 Part I, Part II,Part III and Part V.

IV. Conclusion

This paper highlights the developments made in concrete filled steel tubular columns and the strength variations due to change in either the grade of concrete or in the cross-sectional area of the tubular columns. It also focuses on the various advantages of CFSTs over the traditional RC columns in terms of various aspects like dead load, usable area and displacements. In recent years, there has been a trend towards the development of advanced analysis methods suitable for design of CFST columns.

Based on the various research work performed it can be said that circular columns should be preferred over square shaped CFSTs and for further strengthening of the columns, introduction of FRPs is suggested. Recycled aggregate concrete can also be used but it should be noted that even though it is eco-friendly, the strength provided by these columns is not same as that of the normal concrete CFSTs and should be avoided for high rise and structures of greater significance.

References

[1] You-Fu Yanga, Lin-Hai Hanb,c,∗ (2006) "Experimental behaviour of recycled aggregate concrete filled steel tubular columns", Journal of Constructional Steel Research- Steel Research 62 (2006) 1310–1324

[2] Fuyun Huang, Xinmeng Yu and Baochun Chen (2011) "The structural performance of axially loaded CFST columns under various loading conditions" Steel and Composite Structures, Vol. 13, No. 5 (2012) 451-471

[3] P.Kiruthika1*,S.Balasubramanian2,M.C.Sundarraja3,J.Jegan4 (2015)"Strengthening of Concrete Filled Steel Tubular Columns using FRP Composites", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4 Issue 4, April 2015.

[4] Shilpa Sara Kurian1, Dinu Paulose2, Sreepriya mohan3(2016) "Study On Concrete Filled Steel Tube", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, PP 25-33

[5] Vishal V. Gore1, Popat D. Kumbhar2 (2016)- Comparative Behavioural Study of Multi Storied Building Provided with RCC and Concrete Filled Steel Tube Columns- Proceedings of the 2nd National Conference for Engineering Post Graduate Students, RIT NConPG-16

Kunal R. Harale. "A Review on Developments in Concrete Filled Steel Tubular Columns (CFST)." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 14.4 (2017): 01-04.