Experimental Behavior of Concrete filled Steel Tube (CFST) Column

Mr.S.S.Bargaje  
P.G. Student  
PREC,Loni  
bargajess91@gmail.com

Prof.V.R. Rathi  
P.G.Coordinator at  
PREC,Loni  
vrathin@gmail.com

ABSTRACT
In this paper, a series of test were carried out on, different CFST long column such as CFST stiffened with shear connector, CFST filled with different fiber i.e. Steel, carbon, polypropylene reinforced concrete, Concrete filled Double steel tube Column (CFDST) filled with normal concrete to explore their performance under axial compression. Empty steel hollow tube also tested for comparison. Total forty two specimens were tested. The test results showed that addition of concrete to hollow steel tube enhances load carrying capacity and stiffness greatly. In case of CFST with shear connector, it is found that lower shear connector spacing gives higher load carrying capacity. In case of CFST in-filled with fiber reinforced concrete, CFST filled with Carbon fiber reinforced concrete gives satisfactory result and polypropylene fiber affect workability of concrete.

Keywords
CFST column, Uniaxial compression, Stiffness, composite column, Shear connectors

1. INTRODUCTION
Concrete filled steel tubular (CFST) members utilize the advantages of both steel and concrete. The steel tube supports axial load, confines concrete core, and eliminates the need for permanent formwork. The concrete core sustains the axial load and prevents or delays local buckling of the steel tube. They are widely used in high-rise and multistory buildings as columns and beam-columns. The main parameters affecting the behavior and strength of concrete-filled columns are: the geometrical parameters, such as the slenderness, the diameter to wall thickness (D/t) ratio and the initial geometry of the column, and the mechanical parameters, such as the strength of the steel and concrete.

The bond between steel and concrete in CFST column always remain a point of uncertainty, so to enhance bond between steel and concrete in CFST column, it is of great interest to use of mechanical shear connectors at the interface between the concrete core and the steel tube.

In case of construction of high rise building requires column of higher load carrying capacity but of optimum C/S area, so to match this requirement it is very beneficial to add extra inner tube of small diameter in CFST column thereby increasing load carrying capacity.

Adding fibers into in-filled plain concrete in CFST proved to be an effective method of eliminating its inherent brittleness. The fibers bridge the cracks in the concrete and transfer the applied load to the matrix, thus fiber reinforced concrete has better post-crack behavior than plain concrete. Addition of fiber leads to significant improvement of the ductility and the energy dissipation capacity of CFST columns. When sufficient ductility is required then addition of fiber in in-filled concrete is always better than use of thicker tube in CFST column

2. ADVANTAGES OF CFST STRUCTURE
1. The occurrence of the local buckling of the steel tube is delayed, and the strength deterioration after the local buckling is moderated, both due to the restraining effect of concrete.
2. The steel ratio in the CFT cross section is much larger than those in the reinforced concrete and concrete-encased steel cross sections.
3. The steel tube serves as a form for casting concrete; no other reinforcement is needed since the tube acts as longitudinal and lateral reinforcement for the concrete core.
4. Concrete improves the fire resistance performance, and the amount of fireproof material can be reduced or its use can be omitted.

3. MATERIAL PROPERTIES
In this particular project normal grade concrete i.e. M25 is used.mix design is done as per IS 10262 as well as cube and cylinders were casted and tested at the end of 28 day. Steel tube of Nominal bore 50mm and thickness of 1.6mm is used in addition to this steel tube of nominal bore 25mm is also used for extra inner tube. Three different fibers are used in this project namely,

a) Carbon fiber- it is of chopped type length 5-6mm and tensile Strength 3450 MPa.
b) Steel Fiber-hook end type length 30mm and tensile strength 1060 MPa.
c) Polypropylene Fiber- Monofilament type, length 6.20mm and tensile strength 308 MPa
4.EXPERIMENTAL PROGRAMME

4.1 Test Specimen

A series of forty three hollow steel long columns sections filled with concrete were loaded for uniaxial compression. The tests were conducted at the laboratory of testing of material of Amrutvahini college of Engineering, Sangamer. All specimens consist of Circular mild steel pipe. The outer diameter of pipes was chosen equal to 58mm while the thickness was 1.6 mm. The chosen dimensions give a D/T ratio of 36.25. Specimen height was taken 800 mm to make the section long column (for long column L/r > 40 where r = 0.25D). Bolt of 8mm diameter and 85mm length used as a shear connector. There are four types of CFST columns are studied so that is categorized under four major groups details are given in Table 1.

Studied parameters were shear connector spacing, type of infilled concrete, effect of extra inner tube, effect of type and percentage of fiber in in-filled concrete. All other parameters such as pipe diameter, thickness, concrete grade, height of section remain unchanged.

All specimens filled with M25 grade concrete in four layer with proper compaction by tamping rod after filling top of section was covered with thick plastic fig1 sheet for 28 days.

![Fig 1: Casting of CFST column section](image1.png)

4.2 Test Setup

All columns were tested under universal testing machine. The load was applied by using Universal Testing Machine of capacity 1000 kN. The columns were tested under uniaxial compressive loading. Load was applied at an increment of 5kN. Deflection was recorded for each load increment. All specimens were loaded up to reversal of load. In addition to this two strain gauges of length 5mm, gauge resistance 320Ω were attached at mid height of column and two dial gauges also attached to measure mid height buckling see fig 3.

![Fig 2 Failure mode](image2.png)

![Fig 3 Test To Set Up](image3.png)
<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>CFST Type</th>
<th>No. of specimen testing at 28 days</th>
<th>Total no. of specimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hollow Section (HS)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>Controlled CFST</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>CFST with shear connector -d</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>CFST with shear connector -2d</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>CFST with shear connector -3d</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>CFDST with inner tube diameter 25mm</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>CFST filled with Steel Fiber Reinforced Concrete (SF) - 0.6%,0.9%,1.2%</td>
<td>3 for each percentage</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>CFST filled with Polypropylene Fiber Reinforced Concrete (PF) - 0.6%,0.9%,1.2%</td>
<td>3 for each percentage</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>CFST filled with Carbon Fiber Reinforced Concrete (CF)- 0.6%,0.9%,1.2%</td>
<td>3 for each percentage</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Total no. of specimen</td>
<td>43</td>
<td></td>
</tr>
</tbody>
</table>

5. RESULT AND DISCUSSION

5.1 Load and Vertical deflection behavior

In case of group III, CFST in-filled with carbon fiber reinforced concrete takes higher load and deflection than other column of the same group due to high tensile strength of carbon fiber. CFST with extra inner tube took highest load than other column of all groups.

<table>
<thead>
<tr>
<th>Load (kN)</th>
<th>CS</th>
<th>HS</th>
</tr>
</thead>
<tbody>
<tr>
<td>172.22</td>
<td>194.78</td>
<td></td>
</tr>
<tr>
<td>101.7</td>
<td>186.85</td>
<td></td>
</tr>
<tr>
<td>182.81</td>
<td>182.81</td>
<td></td>
</tr>
</tbody>
</table>

Fig 4: Comparison of load taken by group I

![Fig 4: Comparison of load taken by group I](image)

Fig 5: Comparison of load taken by group II with CS

![Fig 5: Comparison of load taken by group II with CS](image)

6. CONCLUSIONS

From the tested CFST thin-walled long columns subjected to axial loading, the following conclusions may be reached:

1. Filling of concrete in hollow steel tube increases load carrying capacity by 59.05%

2. The use of Shear connectors enhanced the load carrying capacity of CFST columns, the closer the shear connectors the higher the load carrying capacity. This is happened because of the fact that there is increase in amount of load transferred to the steel tube by increase in the number of shear connectors. Such increase in load carrying capacity was in the range of 6-13%.

3. Closer the shear connector spacing higher is the vertical deflection means column behaves more elastically.

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About Authors
Mr. Bargaje S.S., he received his BE from Amrutvahini College of Engineering and currently pursuing ME from Civil Engineering Department, Pravara Rural College of Engineering Loni India. His main area of interest is Composite column.

Mr. Rathi V.R. Received his M.E. in PREC Loni and currently working as Assistant Professor civil Engineering Department, Pravara Rural College of Engineering, Loni