Fire Exposure Behavior of CFST Column

Kamaljit Singh, Khushpreet Singh, Aditiya Kumar Tiwary

Abstract: From the past numerous years Concrete Filled Steel Tubes (CFST) segments are progressively utilized in the structures on account of their high burden bearing limit. In CFST sections the solid is encased in a steel tube that gives formwork to solid which aides in continuing the nearby clasping of the steel. Additionally, composite sections will add more solidness to the structure when contrasted with the ordinary segments. This paper displays the Fire Exposure Behavior of CFST sections and the temperature in the diesel heater is pursued by the ISO-834 standard flame bend. The example was chilled off for 24 hours at room temperature in the wake of warming. During the cooling period of the example the weakening of solid happens. At long last, the quality estimation of CFST sections is tried under Universal Testing Machine (UTM). The examination centers around the quality properties of the roundabout CFST sections in the wake of being presented to a very controlled temperature in the diesel heater.

Index Terms:Temperature, CFST columns, Universal Testing Machine, Stiffness.

I. INTRODUCTION

The use of CFST (Concrete Filled Steel Tubes) is expanding nowadays in the entire world. These are made of the composite materials for example Steel and Concrete which accomplishes more solidarity to the structure. These sections are most broadly utilized as new innovation in the tall structures and it turned out to be critical to acquire information to limit the harm that happens after the structure is liable to fire with the goal that the harm can be limited. In any case, from the past numerous years, there are many research thinks about on the exhibition of the CFST sections enduring an onslaught conditions. In any case, in this paper, the quality parameter of 12 roundabout CFST segments is checked in the wake of presenting them to the diverse flame conditions. The example was presented to the flame as per the ISO 834 standard flame bend. The example was exposed to stack under Universal Testing Machine in the wake of being warmed in the diesel heater and chilled off at room temperature for 24 hours. Subsequent to being presented to the flame, there is lost bond among steel and solid material of these sections. In the wake of giving the stacking to the example it is noticed that the parameters like neighborhood clasping, cross-area measurement, thinness proportion, and so on have much affected the CFST sections. In addition, it is additionally noticed that these flame harmed sections flopped in an extremely bendable way. The compressive quality of the CFST sections will in general diminishing rather than regular CFST segments. This paper gives diverse test information identifying with the quality of the CFST sections subsequent to presenting these examples to the flame.

The primary target of this paper is to decide the quality parameter of the CFST segments by breaking down the conduct of these examples by keeping up its H/D and H/T proportion, greatest burden twisting is likewise completed under a higher level of temperature from 600 °C to 1000 °C. Likewise, the example of disappointment of these segments is recognized.

A.Review Stage

Yang et al. (2010) The investigation of the conduct of cement filled steel cylindrical (CFST) sections during the whole phase of flame introduction are done in this paper. The numerical outcomes demonstrated that the encompassing temperature stacking and warming and cooling history effect sly affected the cooling and post-fire conduct of CFT segments. Three parameters, including load proportion, slimness, and cross-segment measurement, were distinguished to have the most effect on post-fire remaining quality as opposed to warming time connection.

Martin Neuenschwander, et al. (2009) The basic flame conduct of composite CFST segments by methods for cutting edge numerical models is done in this paper to accomplish a comprehension of the fundamental thermo-mechanical conduct which is seen in expensive full-scale fire tests, and in the long run, to halfway supplant them. To join the unpredictable alignment information, the Finite Element Method is utilized.

JingsiHuoa et al. (2010) The test conduct of 8 CFST sections were resolved under cyclic stacking after presentation to fire under pivotal stacking. The examples were warmed with an electric heater and chilled off at room temperature with keeping pivotal burden consistent. At the season of warming, the two segments were found to have neighborhood clasping and three segments have endured steel weld burst during flame presentation. It is noticed that the post-fire flexibility with preload had no decay of CFST and the pivotal burden level had no effect on the quality of flame harm CFT sections.

II. MATERIAL

Grade of concrete used is M30 The material used for the concrete mix as: Coarse aggregates having size 10mm and 20mm used. Fine aggregates passing through 4.75mm sieve is used. Portland Pozzolana cement was used.

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III. EXPERIMENTAL PROGRAM

A total of 16 CFST columns were cast. Out of which 12 CFST columns were cast to check the behavior of CFST columns under different temperature conditions i.e. 600 °C, 800 °C, 1000 °C and other 4 CFST columns were cast to check the behavior under controlled temperature i.e. conventional one. The specifications of the specimen are as under:

Table 1

S no.	Specimen	Grade of steel (fy)
1.	$CD_{100/T4}$	285 N/mm2
2.	$CD_{100/T5}$	285 N/mm2
3.	$CD_{150/T4}$	385 N/mm2
4.	$CD_{150/T5}$	385 N/mm2

Where,

$CD_{100/T4}$ is the CFST column having diameter of 100mm and thickness of steel tube is 4mm respectively.

$CD_{100/T5}$ is the CFST column having diameter of 100mm and thickness of steel tube is 5mm respectively.

$CD_{150/T4}$ is the CFST column having diameter of 150mm and thickness of steel tube is 4mm respectively.

$CD_{150/T5}$ is the CFST column having diameter of 150mm and thickness of steel tube is 5mm respectively.

3.1 Material Specifications:

Grade of concrete used is M30

The material used for the concrete mix as:

Coarse aggregates having size 10mm and 20mm used.

Fine aggregates passing through 4.75mm sieve is used.

Portland Pozzolana cement was used.

3.2 Specimen preparation:

Mix design of the M30 concrete is used as per the IS 10262:2009, IS 456:2000. Curing for all the samples is done for 28 days only. Once the concrete mix of M30 is made, it is poured into the steel tubes having different diameters and different thicknesses respectively.

3.3 Exposure to heat:

The heat treatment to the 12 CFST columns was done at 600 °C, 800 °C and 1000 °C is carried out and then these specimens were cooled down at room temperature for 24 hours.

Figure 1 Sample temperature at 1000 °C

Figure 2

All the 12 CFST columns exposed to fire to all sides and overall height of CFST columns with the help of diesel furnace.

IV. METHODOLOGY- RESEARCH PROCESS

4.1 Graphs:

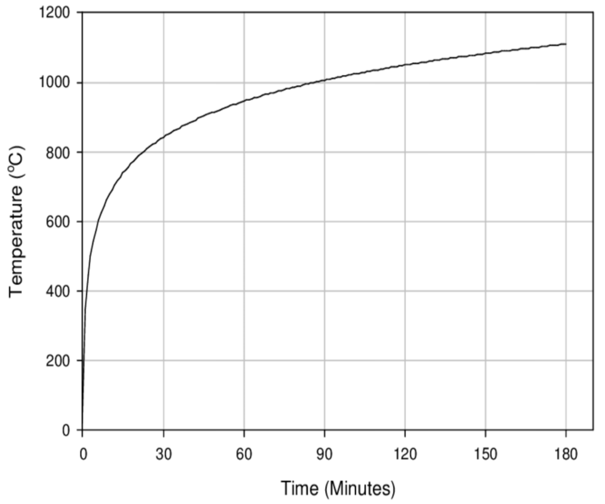

Figure 3 STANADRD FIRE CURVE ISO 834

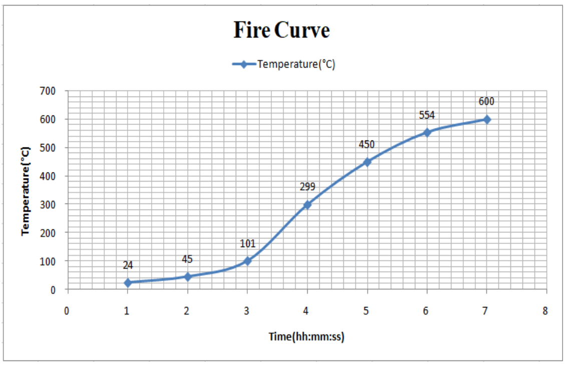

Figure 4 Applied temperature 600 °C

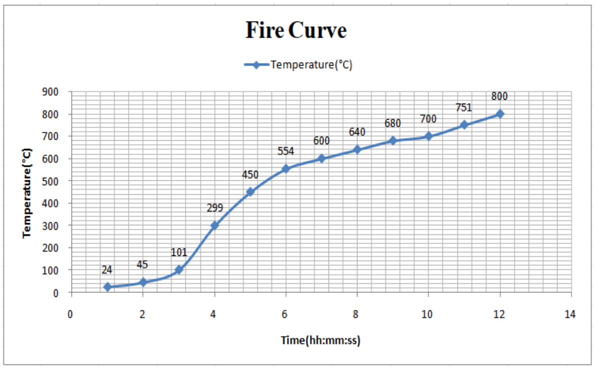

Figure 5 Applied temperature 800 °C

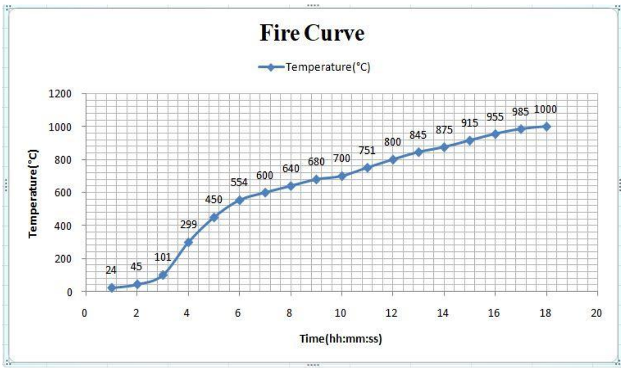

Figure 6 Applied temperature 1000 °C

II. TESTS PERFORM DURING THE RESEARCH

Following are the tests performed to determine the strength parameter of the CFST columns:

1. Compressive strength test.
2. Ultrasonic Pulse Velocity test.
3. Failure criteria.

1. Compressive strength test: Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates.

$$Compressive\ strength = \frac{L}{A} \dots \dots (i)$$

Where,
L= Load
A= Area
Compressive strength test is conducted on Universal Testing Machine (UTM):

Figure 7: Universal Testing Machine

Compressive strength test results of conventional columns as well as heat treated CFST columns are as under:

5.1.1 Conventional results:

Table 2

S no.	Specimen	Grade of steel (N/mm^2)	Compressive value (KN)
1.	$C_{D150,T5}$	385	1705
2.	$C_{D150,T4}$	385	1680
3.	$C_{D100,T5}$	285	773
4.	$C_{D100,T4}$	285	743

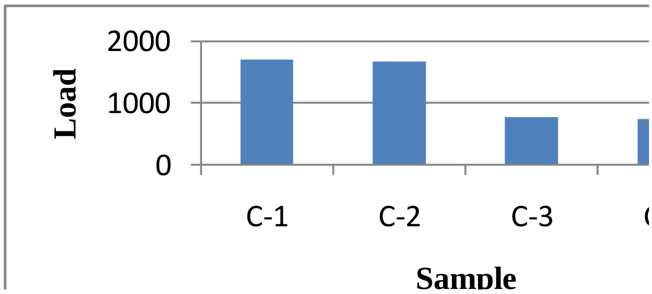

Figure 8: Maximum load carrying capacity of conventional CFST columns

5.1.2 Results after heat treatment:

For temperature 600 °C:

Table 3

S no.	Specimen	Grade of steel (N/mm2)	Compressive value
1.	$C_{D150,T5}$	385	1432.20
2.	$C_{D150,T4}$	385	1377.60
3.	$C_{D100,T5}$	285	983.84
4.	$C_{D100,T4}$	285	957.97

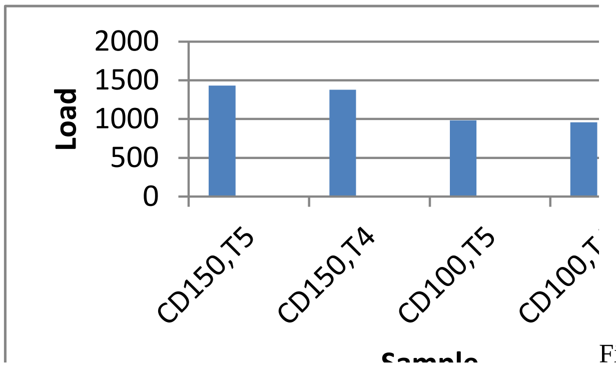

Figure 9: Maximum load carrying capacity of heated CFST columns at 600 °C

For temperature 800 °C:

Table 4

S no.	Specimen	Grade of steel (N/mm^2)	Compressive value (KN)
1.	$C_{D150,T5}$	385	1406.63
2.	$C_{D150,T4}$	385	1273.4
3.	$C_{D100,T5}$	285	861.55
4.	$C_{D100,T4}$	285	828.99

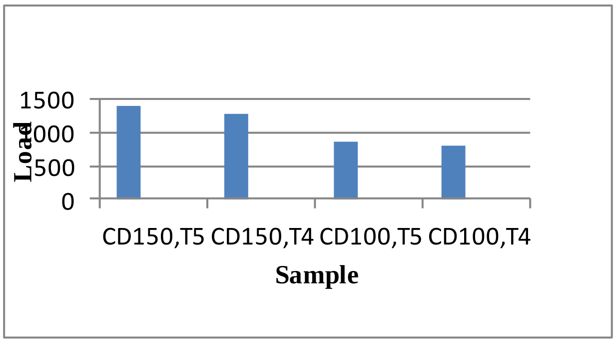

Figure 10: Maximum load carrying capacity of heated CFST columns at 800 °C

For temperature 1000 °C:

Table 5

S no.	Specimen	Grade of steel (N/mm^2)	Compressive value (KN)
1.	$C_{D150,T5}$	385	865.2
2.	$C_{D150,T4}$	385	773.66
3.	$C_{D100,T5}$	285	721.36
4.	$C_{D100,T4}$	285	680.96

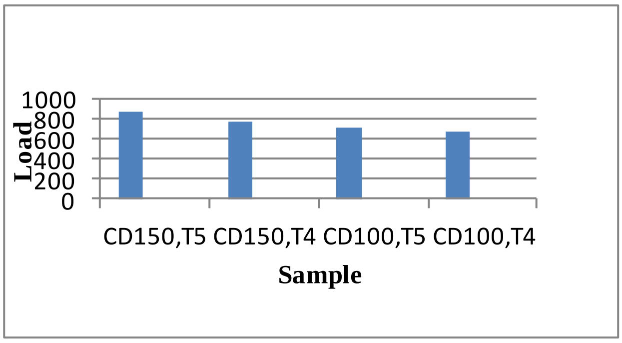

Figure 11: Maximum load carrying capacity of heated CFST columns at 1000 °C

2. *Ultrasonic pulse velocity test:*

It is a non-destructive test which is generally used to check the quality of the concrete by determining the velocity of ultrasonic pulse passing through the concrete. Higher velocity indicates the concrete is in good condition and lower velocity indicates the presence of cracks and voids in the concrete.

$$\text{Pulse Velocity i.e. } V = \frac{L}{T} \ldots\ldots\ldots\ldots(ii)$$

Where,
L= Path length
T= Travel time

Figure 12: Ultrasonic Pulse Velocity test

According to IS13311 (Part 1):1992, Quality of the concrete is determine by the table 6:

Table 6

Pulse velocity (Km/sec)	Quality of concrete
Above 4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
Below 3.0	Poor concrete

By Ultrasonic Pulse Velocity test we can determine:
a) Strength
b) Cracks
c) Durability
d) Internal flaws

Conventional results:

Table 7

S no.	Specimen	Grade of Concrete	Pulse velocity (V=L/T) (Km/sec)
1.	$C_{D150,T5}$	M30	3.2
2.	$C_{D150,T4}$	M30	3.6
3.	$C_{D100,T5}$	M30	3.5
4.	$C_{D100,T4}$	M30	3.1

Results after heat treatment:

For temperature 600 °C:

Table 8

S no.	Specimen	Grade of Concrete	Pulse velocity (V=L/T) (Km/sec)
1.	$C_{D150,T5}$	M30	2.0
2.	$C_{D150,T4}$	M30	2.9
3.	$C_{D100,T5}$	M30	1.1
4.	$C_{D100,T4}$	M30	1.7

For temperature 800 °C:

Table 9

S no.	Specimen	Grade of Concrete	Pulse velocity (V=L/T) (Km/sec)
1.	$C_{D150,T5}$	M30	1.8
2.	$C_{D150,T4}$	M30	1.5
3.	$C_{D100,T5}$	M30	1.0
4.	$C_{D100,T4}$	M30	1.1

For temperature 1000 °C:

Table 10

S no.	Specimen	Grade of Concrete	Pulse velocity (V=L/T) (Km/sec)
1.	$C_{D150,T5}$	M30	0.8
2.	$C_{D150,T4}$	M30	0.9
3.	$C_{D100,T5}$	M30	0.8
4.	$C_{D100,T4}$	M30	0.7

3. *Failure criteria:*

A failure criterion is that in which solid material fails under extreme loads. Depending upon the conditions like temperature, loading rate it is classified into brittle (fracture) or ductile (yield) failure.

In this paper the CFST columns fails in ductile failure. In heat treated samples pre-mature failure of the specimen is determine, local buckling is observed at the top end of the specimen in fixed end conditions.

VI. OVERALL PERFORMANCE ANALYSIS

6.1 Compressive strength results of Conventional as well as of heated samples are as under:

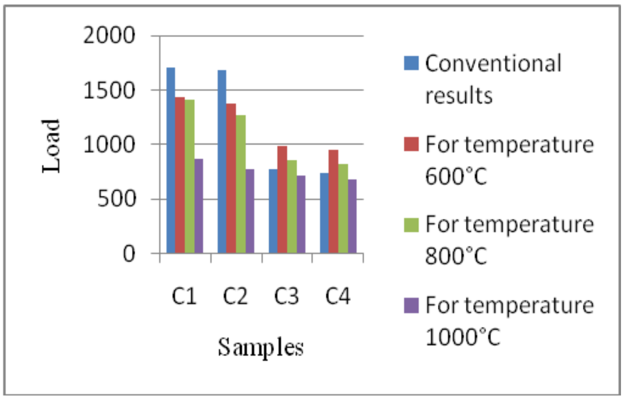

Figure 13: Comparison of Conventional and after fire treatment results

6.2 Ultrasonic Pulse Velocity results of Conventional as well as of heated samples are as under:

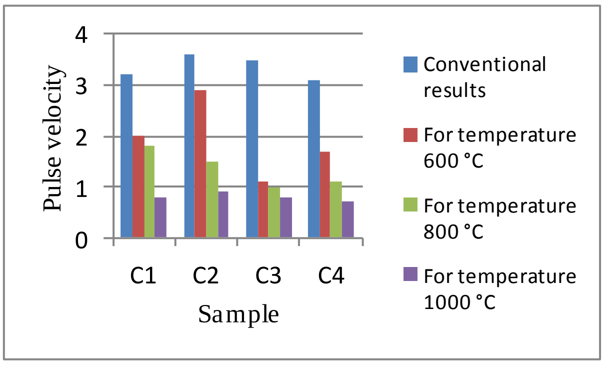

Figure 14: Comparison of results of UPV test

VII. CONCLUSION

Based on the results presented in this paper, the following conclusion may be drawn are as under:

1. The steel tubes having more diameter and more thickness sustain more load which results in gaining more compressive strength, ductility of CFST columns.
2. CFST columns having different H/D and H/T ratio at high-temperature affect the strength.
3. Deterioration of composite columns on heated samples is noted. Moreover, it is found that in heated samples there is loss of bond between the steel pipe and concrete.
4. It is found that the local buckling of the composite columns take place in both end fixed condition by providing axial loading to the heated samples.
5. UPV test values determine the concrete obtain after fire treatment is very poor in condition which means the quality of the concrete is very poor or there may be presence of internal flaws, cracks.

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