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Behavior under Axial Load for Concrete Filled Steel Tubes

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***Abstract*—the concrete filled steel tubes are used very less due to lack of knowledge and less availability of proper codes. In this study attempt has been made to study the behavior of concrete filled steel tubes under axial load. Type of concrete used here is self-compacting concrete which is prepared using proper directions from EFNARRC guidelines. After the experimental work done the obtained results are later compared with the theoretical results obtained by international codes i.e., EC4, ACI-318-1999, ASCI-2005.**

I. INTRODUCTION

The structural behavior of CFST elements is very much affected by difference in poison's ratio of steel tube and concrete core. At the initial stages of loading poison's ratio of concrete is less than that of steel, hence steel tube will have no confining effect on core of concrete. As strain increases lateral expansion of concrete will be more than that steel tube at this stage concrete core will be tri axially stressed whereas steel tube will be bi axially stressed. As the steel tube will be at biaxial stress it cannot withstand the normal yield stress leading to transfer of load from steel tube to concrete core. At the first stage steel takes maximum load until it transfers its yield stress to the concrete core. The steel tube will exhibit gradual decrease in load sharing until the concrete reach its maximum compressive strength, after this stage there will be load redistribution where load will be transferred from concrete core back to steel tube, at this stage steel will be having hardening behavior with having almost same uniaxial stress-strain hardening relationship.

In order to study more about CFST structures experimental work is done for study of behavior of composite structures along with analytical work. Concrete filled steel tubes CFST are tested under axial load to failure, totally 30 specimens were tested where 15 steel tubes were filled with concrete remaining 15 were empty steel tubes. This was done for comparison of test results of CFST columns with empty steel tubes which were normally used in steel structure constructions. And along with this test results obtained are also compared with the theoretical results obtained from various codes like ACI, LRFD, and AISC.

Analytical work is also done using ANSYS software for study about deflection pattern and load distribution in tubes. The ultimate load carrying capacity obtained from the results of experiments is compared. At Last conclusions were made based on results obtained and also need of future work is also provided.

II. LITERATURE REVIEW

1. Stephen P. Schneider, Donald r. Kramer and Douglas l. Sarkkinen (2004):

In this experimental study the design and construction of joint which consists of wide steel flange which penetrates through concrete filled steel tubes two examples were considered one which includes connection of joints in the field other includes shop fabrication of critical joints. The stiffness and the strength of CFST columns are compared with ACI-318 and AISC-1994. Each method produces somewhat difference in strength but stiffness variation is most significant hence, one proper method for joint configuration is done. This method concluded that steel girder passing through CFT core will sustain large seismic events, this connection detail is more reasonable, economical and constructible. Joint equilibrium requires load distribution between steel tube and concrete core, it mainly depends on geometry of CFT and wide flange provided. For further research, it is required to identify true behavior of CFT elements, compression capacity of concrete core, stress distribution, axial load accuracy, joint equilibrium and flexural stiffness.

2. Anil kumar patidar (2012):

In this research the advantages of CFST over conventional concrete structural member made of steel reinforcement. Using ANSYS software FEA modeling is done to investigate load versus lateral deflection of composite sections. The effect of strength of in

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filledconcrete and thickness of steel tube is examined. Different sizes of steel tubes with different thickness are used along with various grades of concrete which involves various D/t ratio. As a result FEM model shows deformation resistance when concrete is used as infill material and deformation decreases as the grade of concrete increases, hollow steel tube deform more compared to infill steel tube

3. Norwati jamaluddin:

This research describes behavior of elliptical CFST columns under axial loading. 27 specimens were tested with variation of parameters like slenderness ratio, consideration of aspect ratio and uni axial compressive strength of concrete infill. Buckling tests on elliptical CFST columns were done. As there is no standard design code for this type of element normal EC 4 Eurocode and American specifications are considered as they are all provided for circular, square and rectangular columns proper guidelines were not available. The main aim of this research was to provide design guidelines for elliptical CFST columns in construction industry.

1.2 Materials used:

Following materials were used for the present study;

i. Cement.

ii. Aggregates.
   - Fine aggregate- sand
   - Coarse aggregate- 12mm crushed stone aggregates.

iii. Mineral admixture.
   - GGBS

iv. Chemical admixture.
   - Masterglenium SKY 8233

v. Mild Steel tubes

III. METHODOLOGY

1) **Procurement** of the material required for the intended study on concrete filled steel tubes.
2) Determination of **Physical properties** of materials.
3) Cutting of steel tubes for required sizes and giving proper finishing.
4) Development of proper mix design for Self Compacting concrete.
5) Consideringproper water cement ratio**,** cementwas mixed along with fine and coarse aggregates, GGBS is also mixed with cement and superplasticizer was added in water.
6) Slump-flow test was conducted on fresh Self compacting concrete for**flow ability** requirement of SCC.
7) Standard specimens were prepared by filling the steel tubes of different sizes for preparing **concrete filled steel tubes** using SCC made of coarse aggregate of 50% and fine aggregate of 40% of total volume of mortar, along with cement and filler material(GGBS) along with 2% of chemical admixture.
8) The cast specimens were placed in room temperature for about 28 days whose top and base surfaces which is the only exposure surface of specimen are covered with plastic bags in order to cure the specimen by method of **vapor curing (self curing)** technique.
9) After 28 days covering is removed and top and bottom surface are provided with proper finishing with the help of sand paper in order to provide flat surface for testing.
10) Later these specimens were tested for compressive strength by providing axial load using Universal Testing Machine and critical loads and strain values are recorded.
11) Graph is plotted with **strain v/s strain.**
12) Later the obtained critical loads are compared with the theoretical values obtained by American, Europe and Australian codes.
13) Deflection patterns are observed in the FEM based software ANSYS.
14) Results and conclusion are provided along with suggestion about future work.

A. Types of failure observed:

Failure patterns of empty steel tubes are,

1. Failure due to buckling
2. Failure due to compressive strength by ring formation at top and bottom.
3. Failure due to ring formations at the center of steel tube.
4. Failure due to splitting of tubes at the joints.

Failure patterns of CFS tubes are,

1. Failure due to crushing of concrete resulting in buckling of steel tube
2. Failure due to bending
3. Failure due to ring formations at the bottom
4. Failure due to ring/rings formation at the center of tube.

B. Results and discussion:

Table -1: Results of slump flow test of SCC

The slump flow test is done for checking the flow ability of prepared mix in order to get proper flow of concrete when poured inside steel tubes.

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Trial	Flow (mm)	T_{600} (sec)
Trial 1	610	4.2
Trial 2	615	4.4
Trial 3	608	3.9

Table -2: Compresivve Strength Of Self Compacting Concrete:-

Compressive strength of scc was determined at the beginning by compressive test of cube of size 150x150x150mm under utm. after obtaining compressive strength of concrete the axial load is applied on concrete filled steel tubes determination of compressive strength of cfs tubes of different dimensions, and also the comparison with the theoretical values obtained from codes are also provided in the table.

Grade	sample	time	Compressive strength
M25	Sample 1	28 days	33mpa
	Sample 2	28 days	34mpa

table -3: Average results of compressive test on hollow sections:

sample	Length (mm)	Diameter (mm)	Thickness (mm)	Ultimate load (kN)
Sample 1	500	48	3	145
Sample 2	500	64	3	239
Sample 3	500	76	2	250
Sample 4	500	86	3	272
Sample 5	500	96	3	315

Stress v/s strain graph of hollow steel tube:

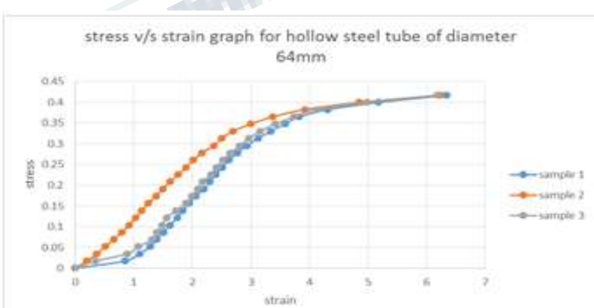
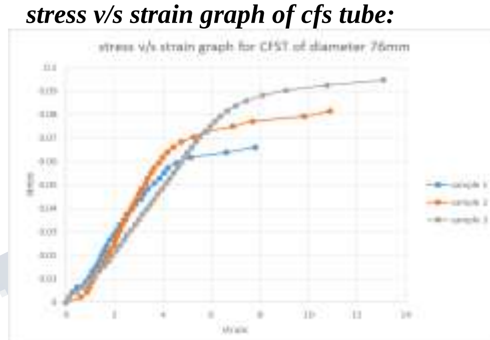


Table -4: Average results of compressive test on concrete filled steel tubes:

Sample	Ultimate Load	Stress	Strain	Theoretical		
				EC-4	ACI-318-1999	AISC-2005
Sample 1	200	0.102	0.01	140.6	135.4	97.5
sample 2	315	0.097	0.022	209.7	199.8	149.7
Sample 3	378	0.083	0.03	218.1	202.7	163.1
Sample 4	492	0.084	0.022	321.2	302.3	231.2
Sample 5	610	0.085	0.03	378.2	354.3	274.2

stress v/s strain graph of cfs tube:



V. CONCLUSION

the objective of this investigation is to obtain the accuracy of the codal design approach for prediction of load carrying under axial load and to appreciate the failure patterns obtained. The theoretical results were obtained by ec4, aci-2005, aisc318-1999, and linear analysis was made by fem software ansys to get stress distribution and deflection patterns. the test results were compared with theoretical results. Some conclusions were made by considering the above done investigation.

1. The theoretical capacity of cfst sections obtained using above equations denoted that increase in d/t ratio increases the capacity, which is due to increased confinement pressure when only diameter is increased, but increase in d/t ratio reduces the capacity of section because of reduction in cross section when thickness alone is reduced with constant diameter.

2. The strength of concrete core highly influences the theoretical section capacity of cfst columns. High strength concrete provides high strength.

3. The confining effect of steel tube on concrete core and restraining effect of concrete core on local buckling is the major observation to be done in this experimental work.

4. The bond strength has very less influence on compressive strength because there is no slip possible between concrete filled and steel tube under axial compression.

5. Normally the confinement effect increases the concrete resistance but decreases the axial resistance of steel tube hence high strength concrete is preferred more in place of normal concrete.

scope of future work:

1. The major work that can be improvised in future is the proper provision of code for composite members in construction industry, which will lead to major usage of composite construction in India.

2. For fem analysis various other softwares can also be used.

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