IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Analysis Of Load Carrying Capacity Of CFST With Or Without Shear Connectors

[1] Mandar Golhar, [2] Prof V.M. Saptate

[1] Mtech Scholar, GHRU, Amravati

[2] Assistant professor, GHRU, Amravati

Abstract

Composite Columns are constructed using various combination of structural steel and concrete in and attempt to utilize the beneficial properties of each material mainly tree types composite columns has been widely applied to industrial building that required large size columns and fast construction are use in rise building construction. Experimental study on the behavior of concrete filled steel tubular columns (CFST) axially loaded in compression to failure. Shear connector of nominal diameter 6 mm and a length of 80.3 mm. The bolt holes in the pipes were used of one mm oversized to facilitate erection adjustments. The results show that the use of high strength infill concrete is much more effective to get extra strength with same size of CFST column and use of shear connector increases the strength of column with the same size of column dimensions give a D/T ratio of 19.33(circular) and 16.66(square) to avoid local buckling effect. The experimental analysis of the data was done using the Regression analysis and an equation was developed in order to correlate the strength between shear and non-shear component of the Composite member. The developed equation can thus predict the behavior of the column without actual testing.

Keywords: Regression analysis, CFST, Shear connector

Introduction

A steel-concrete composite column is a compression member, comprising either a concrete encased hot-rolled steel section or a concrete filled tubular section of hot-rolled steel and is generally used as a load-bearing member in a composite framed structure. In a composite column both the steel and concrete would resist the external loading by interacting together by bond and friction. . There is quite a vertical spread of construction activity carried out simultaneously at any one time, with numerous trades working simultaneously (G.N.Sreekanth 2017). The application of CFST in tall buildings, only partial columns of building adopted in early days, then gieater part of Columns adopted, then all of the columns adopted. This process was very short, only a little more than 10 years. The highest tall building adopted CFST is Shenzhen SEG Plaza building completed in 1999. It is the highest one in China and abroad. There is no staying area for construction. It made the construction rather difficult. There are a lot of new technology and experiences in design, fabrication and construction of this building. It offers a good example of the adoption of CFST columns in super tall buildings. It also promotes the development of CFST structures in our country to a higher level. CFT composite columns can be introduced in various forms. The hollow steel tubes can be filled with various types of concrete and strength, whilst the columns can be erected with various shapes of hollow steel sections. The most common types of composite columns; namely steel-encased concrete column, concrete-filled circular hollow section (CHS), concrete-filled square (SHS), or rectangular hollow section (RHS),pentagon hollow section(PHS),elliptical hollow section(ENS). The steel-encased column comprises I or H steel cross-section placed within a traditional reinforced concrete or plain concrete. This structure is the earliest type of composite cross-section. A CFST column, on the other hand, is simply constructed by filling concrete into the hollow section, which is used as a casting mould to the concrete. The orientation of the steel and concrete member in the CFT column cross-section has a significant role in terms of enhancing the strength and stiffness of the structure. The steel section is located at the outer perimeter, where it performs most effectively in tension and bending moment. (Manoj Kumar V-2010).

Literature Review

P. K.Gupta and S.K.Katariya (2004) Present study deals with concrete filled square and rectangular steel tube structural elements subjected to bending. The square section (176.77mm x 176.77mm) and rectangular section (125 mm x 250 mm) are selected in such a way to have equal concrete and steel sectional area. Steel tubes having ultimate strength 400, 480 and560MPa are filled with concrete having cylinder compressive strength 30, 50, 70 and lOOMPa. Behavior of specimens was studied by fiber element analysis computer code developed in Oracle database. The efficiency and accuracy of the developed computer code are demonstrated through comparisons between computer code results and experimental results. It was found that increment in concrete strength from 30 to 50MPa, 70 and 100114Pa resulted to increase in the moment capacity of CFST beams by4, 7 and 11%for square section and 5, 10 and 15%for rectangular section, respectively. The moment capacity of CFST beams increases by 17-18 % and 34-36 % when steel tube strength was increased by 20 and 40 %, respectively.

Martin D. O'Shea et.al. (2006) In this paper several design methods have been developed that can be used to conservatively estimate the strength of circular thin-walled concrete filled steel tubes under different loading conditions. The loading conditions examined include axial loading of the steel only, axial loading of the concrete only, and simultaneous loading of the concrete and steel both axially and at small eccentricities. Recent tests on circular concrete filled steel tubes have been used to calibrate and validate the proposed design methods. The test specimens were short with a length-to-diameter ratio of 3.5 and a diameter thickness ratio between 60 and 220.The internal concrete had nominal unconfined cylinder strengths of 50, 80, and 120MPa. The bond (or lack of) between the steel and internal concrete was critical in determining the formation of a local buckle.

Manojkumar V. Chitawadagi et.al. (2008)This paper presents the effect of changes in diameter of the steel tube (D), wall thickness of the steel tube (t), strength of in-fill concrete (fcu), and length of the tube (L) on ultimate axial load (Pu) and axial shortening at the ultimate point of circular Concrete Filled steel Tubes (CFST). Taguchi's approach with an L9 orthogonal array is used to reduce the number of experiments. With the help of initial experiments, linear regressiori models are developed to predict the axial load and the axial shortening at the ultimate point. A total of 243 circular CFST samples are tested.to verify the accuracy of these models at three factors with three levels. The experimental results are analyzed using Analysis Of Variance to investigate the most influencing factor on strength and axial shortening of CFST samples.

Materials and methods

Material properties consist of properties of all the materials required for the work is described in this section.

Cement:

After reviewing all above requirements Ultratech Portland Pozzolona Cement (PPC) cement is used be throughout the experimental work. Cement is tested in laboratory and is tabulated under **table 1** :

Table 1: Properties of Cement

Sr. No	Description of Test	Results
01	Fineness of cement(residue on IS sieve No.9)	2%
02	Specific gravity	3.15
03	Standard consistency of cement	29%
04	Setting time of cement a) Initial setting time b)Final setting time	 86 minutes 586 minutes
05	Soundness test of cement (with Le-chatelier'smould)	3mm
06	Compressive strength of cement: a)7 days b) 28 days	 37 N/nm^2 53N/nm^2

Mix Design

The mix design for the test is represented under **Table 2.**

Table 2: Mix proportion of M20

Aggregates/Admixtures	Units	M20
Ordinary Portland Cement	Kg/m^3	347
Water	Lit	156.54
Fine aggregate	Kg	1214.10
Coarse aggregate	Kg	776.25
Chemical admixture	Lit.	6.95
Water cement ratio		0.45

DxB	Thickness	Area	Moment of Inertia	Radius of gyration	Elastic modules	Fy	Fu	Poisson's Ratio
mm	mm	mm^2	mm^2	mm	N/ mm^2	Mpa	Mpa	
50x50	3	2500	$16.91x10^4$	19	$2x10^5$	210	330	0.3

Schedule of Testing

Cube molds of 150x150x150 mm and cylinder molds of 150mm diameter and 300mm in height will be used for casting the specimen for compressive strength.

Table 3: Test Specimen

Sr. No.	Sample Type	Sample	Testing of specimen			No. of specimen
			At 3 days	At 7 days	At 28 days	
1.	Cube	PCC	3	3	3	9

Steel Properties

The properties of the steel to be used in CFST in described in the Table 4.

Circular Tube properties

Strength Properties of circular steel tubes is tabulated under **table 5.**

Table 5: Circular tube properties

Diam. (outer)	Thickness	Area	Moment of Inertia	Elastic modules	Fy	Fu	Poisson's Ratio
mm	**mm**	**mm^2**	**mm^2**	**N/ mm^2**	**Mpa**	**Mpa**	
58	**3**	**2642.07**	**196.589×10^3**	**2×10^5**	**210**	**330**	**0.3**

CFST Casting

All specimens consisted of a small part of a circular and square steel section fabricated from rolled flat plate. The outer diameter of circular steel tube was chosen equal to 58mm while the thickness was 3 mm. The dimensions of square steel specimen is 50X5Omm and thickness is 3mm.The chosen dimensions give a D/T ratio of 19.33(circular) and 16.66(square) to avoid local buckling effect. Specimen height was taken 800 mm to be in the range of 3D< H <20 ry (where ry is the minimal radius of gyration of the composite section) to avoid the overall buckling.

Table 7: Details of CFST specimens

Group Series	**Column**	**No. of tests**	**Column height(mm)**	**Filling with concrete**	**Load application**	**Shear connector Diameter(mm)**	**Shear Connector using**
I	C11,C12,C13 S11,S12,S13	1	800	N.A.	Steel	6	N.A.
II	C21,C22,C.23 S21,S22,S23	1	800	N.A.	Steel	6	Yes
III	C31,C32,C33 S31,S32,S33	1	800	M20	Steel+ concrete	N.A.	N.A.
IV	C41,C42,C43 S41,S42,S43	1	800	M20	Steel+ concrete	6	Yes

Results

All the result obtained from experiments and from codal provision are stated below. The square and circular column provides different failure loads for different condition of shear connector and without shear connector as given in the **Table 8 and 9**:

Table 8: Failure load for circular specimen

Specimen type	**Expt.Load (KN)**		**Failure LOAD (KN)**
	Without SC	SC	Without SC
CFST M20	283.1	240	144.95

Table 9: Failure load for square specimen

Specimen type	**Expt.Load (KN)**		**Failure LOAD (KN)**
	Without SC	SC	Without SC
CFST M20	276.2	344.1	145.41

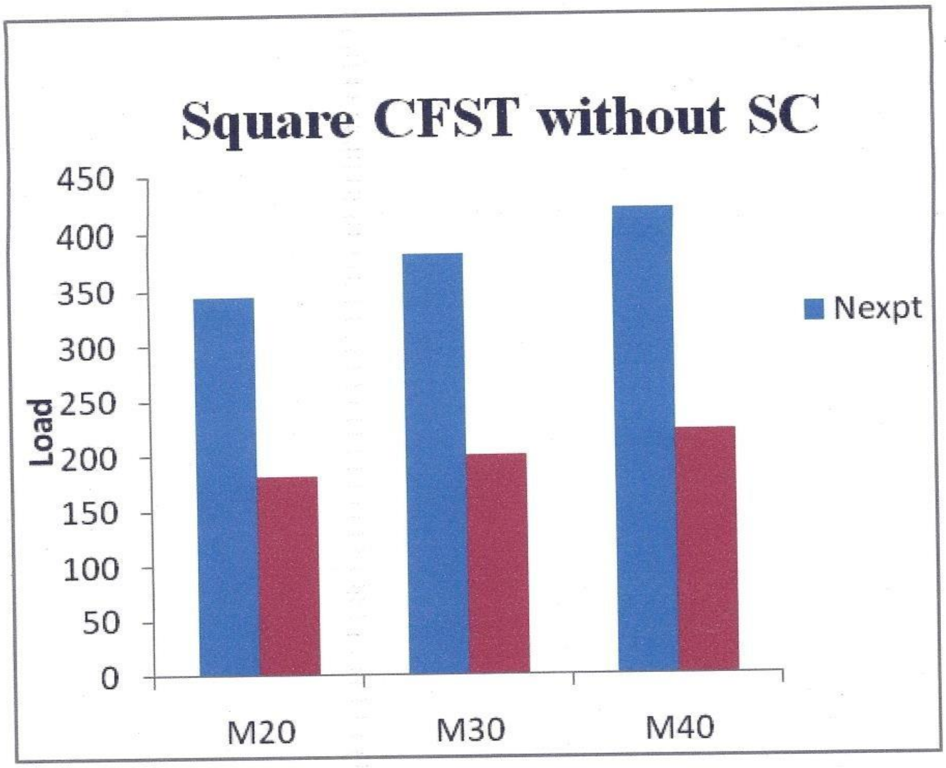

Fig 1: Comparison of load capacity of circular CFST with SC by Expt. And Codes

The test specimens show that, adding of shear connectors inside the columns increased the load carrying capacity of column so that the use of shear connector can help to increase the strength of column with the same size of column.

Conclusion

The R^2 factor was 0.81 which is term as moderate correlation and therefore a linear equation can be developed. The presence of shear connectors increases the strength and such enhancement in strength reaches up to 25% to 30% in specimens of groups. In both circular and square columns it is seen that, the axial load carrying capacity of column increases as the strength of concrete increases. From above result it is concluded that use of high strength infill concrete is much more effective to get extra strength with same size of CFST column.

Test specimens show that, adding of shear connectors inside the columns increased the load carrying capacity of column so that the use of shear connector can help to increase the strength of column with the same size of column.

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