STRENGTH OF CONCRETE FILLED STEEL TUBES WITH SHEAR CONNECTOR

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ABSTRACT

An experimental research gives the performance of short concrete filled steel tubular columns (CFST) axially loaded in compression to failure .Total 48 specimens (24 circular and 24 square specimens) with different concrete grade from M20 to M40 with and without shear connector (SC) were tested to find out the load capacity. High strength bolts (10.9) with smooth shank were used as shear connector. The shear connectors were bolted with nominal diameter of 6 mm and a length of 80.3 mm. The bolt holes in the pipes were one mm oversized to promote erection adjustment. The results show that the adoption of shear connector enhances the strength of column with the same size of column dimensions and use of high strength infill concrete is also effective to get extra strength with same size of CFST column. CFST columns gives a D/T (Diameter to thickness) ratio of 19.33(circular) and 16.66(square) to prevent local buckling effect.24 specimens (12 circular and 12 square) of the concrete filled columns are provided with shear connectors.

Keywords: Axial Load, CFST, Concrete Grade, Deflection, Shear Connectors (SC)

I. INTRODUCTION

Concrete filled steel tubular (CFST) members utilize the advantages of both steel and concrete. They comprise of a steel hollow section of circular, square and rectangular shape filled with plain or reinforced concrete. They are widely used in high-rise and multi-storey buildings as columns and beam-columns, and as beams in low-rise industrial buildings where a strong and efficient structural system is required.

There are a number of distinct advantages related to such structural systems in both terms of structural performance and construction sequence. 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. It also provides the greatest stiffness as the material lies furthest from the centroid. This, combined with the steel's much greater modulus of elasticity, provides the greatest contribution to the moment of inertia. The concrete core gives the greater contribution to resisting axial compression.

Concrete-Filled steel Tubular (CFST) columns have been increasingly used in many modern structures, such as dwelling houses, tall buildings, and arch bridges. The composite tubular column shows better structural performance than that of bare steel or re-inforced concrete structural members. Steel hollow sections act as reinforcement for the concrete. Steel concrete composite members have advantageous qualities such as sufficient strength, ductility and stiffness. Generally, CFST columns have demonstrated sufficient load capacity, ductility and energy absorption capacity. Concrete filled steel tubes are an economical column type, as the majority of the axial load is resisted by the concrete, which is less expensive than steel. The steel tube serves as the formwork forecasting the concrete, which reduces the construction cost. No other reinforcement is needed since the tube acts as longitudinal and lateral reinforcement for the concrete core. The confining effect causes the core concrete to behave in a triaxial stress state while the core concrete prevents the wall of the steel hollow section from buckling inward.

II. METHODOLOGY

i) Experimental setup:

A set of twenty four circular and twenty four square hollow steel short columns sections filled with concrete were loaded to failure. The tests were conducted at the laboratory of Amrutvahini College of Engg. Sangamner. 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 50X50mm 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. In 12 circular and 12 square specimens holes were drilled in the shell to allow fixation of the shear connectors. High strength bolts (10.9) with smooth shank were used as shear connectors with nominal diameter of 6 mm and a length of 80.3 mm. The bolt holes in the pipes were one mm oversized to facilitate erection adjustments.

The tests were divided into eight groups I, II, III, IV, V, VI, VII, &VIII. One steel specimen of circular and square section was tested unfilled. The test specimens are shown in fig.1 and the summary of all specimens is shown in table 1 Specimens of each circular and square steel section were provided with shear connectors with the arrangement of shear connector at 100mm from top and bottom and 150mm from first shear connector. The arrangement of shear connector is shown in Fig1 and fig.2 The studied parameters were the different grade of concrete filled steel tube with and without shear connector. All other parameters such as column size, column height, shell thickness, connectors section, and steel were not changed. For each group testing three specimens were tested and the average value of load carrying capacity is taken for further studies. First group consisted of six specimens of steel pipe without any concrete filling and without shear connector. . This group includes three circular specimens named as C11, C12, C13 and three square specimens S11, S12, S13. The second group of specimens consisted of circular and square sections with shear connector without concrete filling and loaded through the steel shell. This group included three circular specimens C21, C22 and C23and square specimens S21, S22andS23.

There are no differences among these columns in the shear connector's distribution. The arrangement of shear connector is that the shear connector is provided at 100mm from top and bottom and 150mm from first shear connector. Details of the specimen's geometry and shear connectors distribution is shown in Fig.1 and fig.2

TABLE1. Details of CFST specimens

Group	Column	No. of test	Column height (mm)	Filling with conc.	Load application	Shear connector Diameter (mm)	Shear connector
I	C11,C12,C13 S11,S12,S13	1	800	N.A.	Steel	6	N.A.
II	C21,C22,C23 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
V	C51,C52,C53 S51,S52,S53	1	800	M30	Steel+ concrete	N.A	N.A
VI	C61,C62,C63 S61,S62,S63	1	800	M30	Steel+ concrete	6	Yes
VII	C71,C72,C73 S71,S72,S71	1	800	M40	Steel+ concrete	N.A.	N.A.
VIII	C81,C82,C83 S81,S82,S83	1	800	M40	Steel+ concrete	6	Yes

The third group of specimens consisted of sections filled with concrete grade M20 without shear connector and loaded. This group included three circular specimens C31, C32, C33 and square specimens S31,

S32 and S33 .Group IV specimens consisted of circular and square sections filled with concrete grade M20 having shear connectors distributed in the pattern as stated above this group included three circular specimens C41, C42, C43 and three square specimensS41,S42 and S43.V

and VII groups are same as like third group but the only difference is of concrete grade M30 & M40. V group included the specimens C51, C52,C53 and S51, S52, S53. VII group included specimens C71, C72, C73 and S71, S72, S73. sixth and eighth groups are same like IV group but only difference is of concrete grade M30 & M40. VI group

includes six specimens C61, C62, C63 and S61, S62, S63. VIII group included specimens C81, C82, C83 and S81, S82, S83.

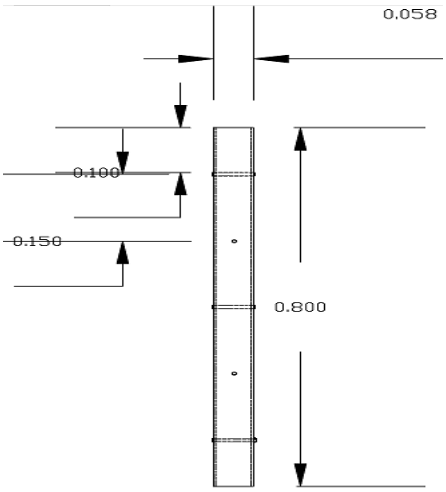

Fig..1 Test specimens of CFST **Fig. 2 Arrangement of shear connector**

ii) Test setup:

An universal testing machine with a maximum compressive load capacity of 1000 KN was used to test the specimens as shown in Fig.3. The specimens were placed between the base and the head of the universal testing machine and centered with the applied load axis to ensure concentric axial compression loading. The load was applied gradually.

The load application was continued till specimen failure. A 1000 KN load cell was attached to the machine head to measure the load during testing. All the instrumentations were connected to a data acquisition system to record different measurements with a rate of 2 readings per second.

Fig.3 Test set up for CFST testing

IV.RESULTS AND DISCUSSIONS:

All the results obtained from experiments are stated below.

i) **Experimental results:**

A) Table 2. Circular CFST specimens

Specimen type	Load(KN)		Deflection(mm)	
	Without SC	SC	Without SC	SC
Hollow steel tube	162.1	221.1	3.8	5.8
CFST M20	283.1	340	8.4	8.9
CFST M30	331.6	386.9	7.3	7.8
CFST M40	391.2	436.5	8.1	9

B)Table 3.Square CFST specimens

Specimen type	Load(KN)		Deflection(mm)	
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ii) Discussions:

1) The fig.no.5 shows the results of axial load carrying capacity of group I and groupII. The average value of load carrying capacity is taken for studies.

2) The fig.no.6 shows the results of axial load capacity of groupIII to groupIV.The Average value of load carrying capacity of each group is taken for studies and graph shows the selected values.

1) 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 the same size of CFST column.

2) The test specimens show that, adding of shear connectors inside the columns increased the load carrying capacity of column.

8) The high strength of concrete in CFST can be achieved with shear connector with appropriate spacing and material properties.

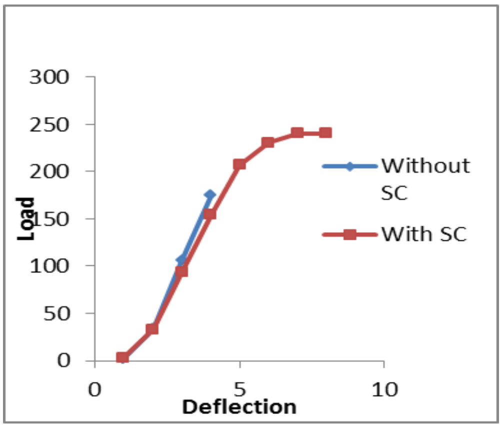

Fig..4 Load and deflection of hollow square column With SC and Without SC

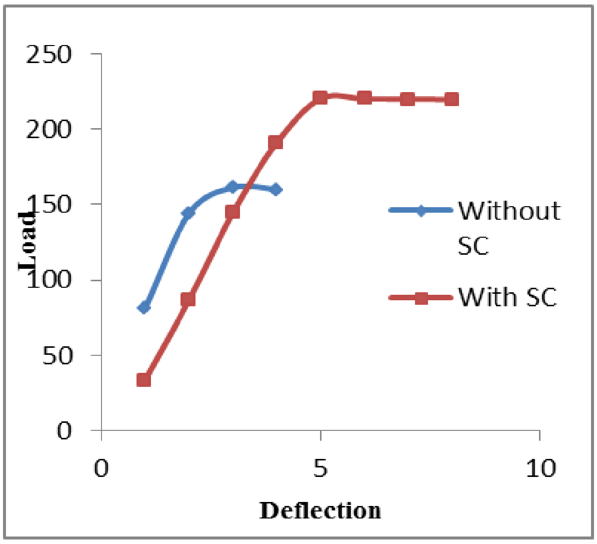

Fig.5 Load and deflection of hollow circular column With SC and without SC

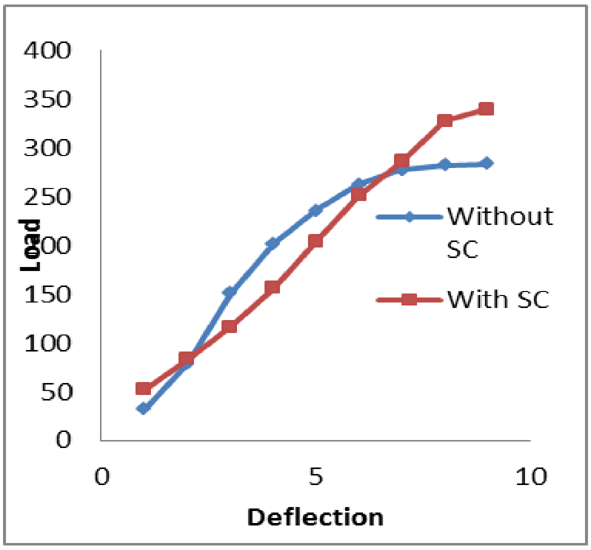

Fig.6 Load and deflection of M20 grade circular CFST With SC and without SC

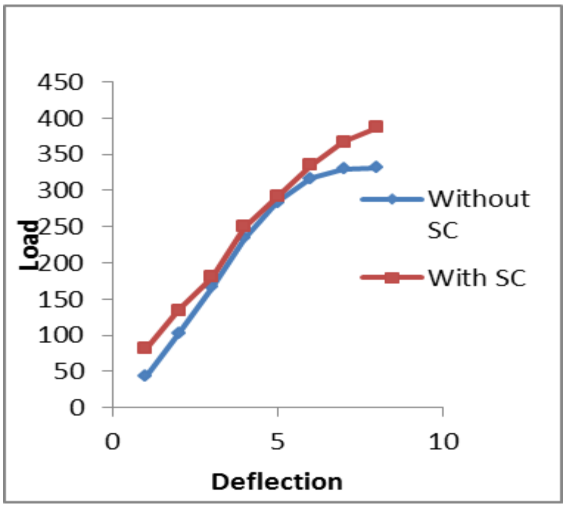

Fig.7 Load and deflection of M30 grade circular CFST With SC and without SC

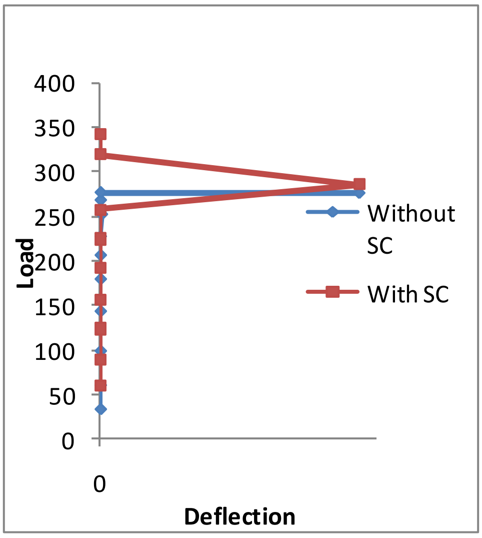

Fig.8 Load and deflection of M20 grade square CFST With SC and without SC

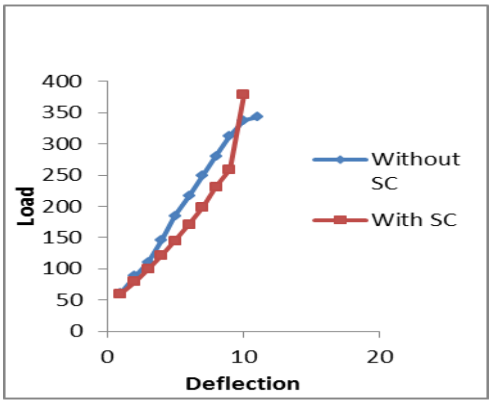

Fig.9 Load and deflection of M30 grade square CFST with SC and without SC

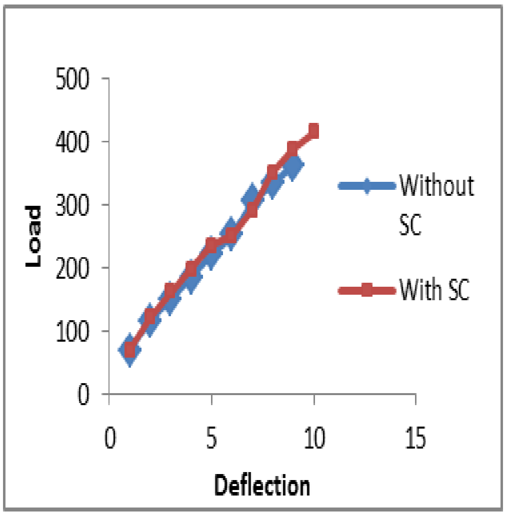

Fig.10 Load and deflection of M40 grade square CFST with SC and without SC

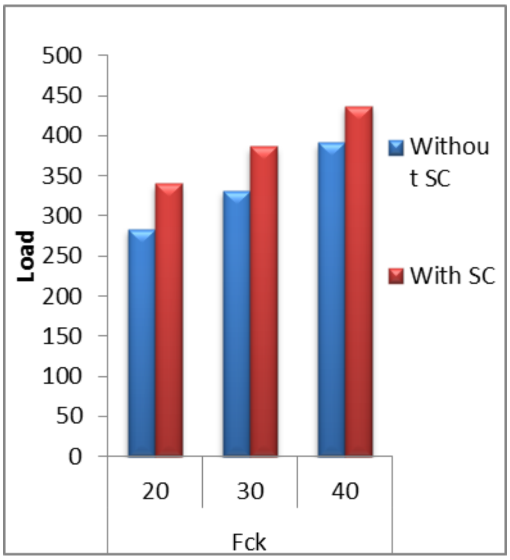

Fig.11 Axial load of M20, M30, M40 grade circular CFST with SC and without SC

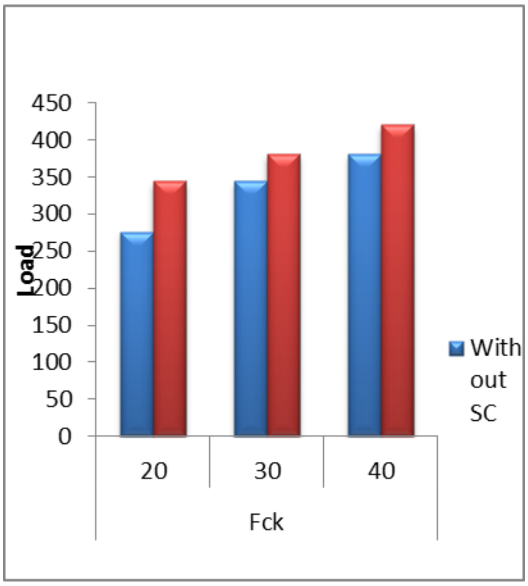

Fig.12 Axial load of M20, M30, M40 grade square CFST with SC and without SC

V.CONCLUSION

From the extensive study of CFST and the experimentation carried out following conclusions were made

1) Comparing the graphs from fig.4 to 9 it is concluded that the presence of shear connectors increases the strength and such enhancement in strength reaches up to 25% to 30% in specimens of groups II, IV, VI and VIII respectively.

2) The deflection is increased as shear connector is provided. That is due to shear connector CFST behaves more ductile.

3) It is observed from graph 11 and 12 that as the strength of concrete is increased the strength of the CFST specimens also increased. The enhancement of the strength of CFST is in percentage of 16 to 18%.

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