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Experimental Study on Steel Concrete Composite Column

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ABSTRACT

Steel-concrete composite columns are used widely in modern buildings. Structural steel shapes and tubes can be used with concrete to produce structural components. The performance of such composite systems is better than the sum of responses of the parts taken separately. In a concrete-filled steel tube caisson, for example, the steel casing resists flexural tension efficiently while confining the concrete core as the core resists axial compression, whereas it also stabilizes the steel casing. Concrete encasement of structural steel shapes can provide lateral stability to the steel shape, restraining local buckling as well as reducing the slenderness ratio below that of the steel shape alone. Concrete encasement serves as insulation for fire and shock loading. Extensive research on steel concrete composite columns in which structural steel sections are encased in concrete have been carried out. In-filled composite columns, however have received limited attention compared to encased columns. This Paper presents a review about the investigation done on behavior of concrete filled steel tube columns by various researchers with reference to various codal provisions. The study about the behavior and the characteristics of Concrete filled steel tubes (CFST) is the prime need. Ultimate strength, ductility and stiffness of columns are determined in comparison with RC column.

Keywords: Concrete filled steel tubes(CFST)

1. INTRODUCTION

With the increasing use of composite construction worldwide, there is a growing interest in utilizing Concrete - Filled Tubes (CFTs) as a primary column member. The interest develops from the fact that properties of steel and concrete in the CFTs are fully utilized, so that the strength, stiffness and ductility of the structures constructed from CFTs can be enhanced simultaneously. Since the function of longitudinal reinforcement and transverse confinement can be acquired due to presence of the steel tubes, the traditional longitudinal and transverse reinforcement may be eliminated. This type of column also maintains sufficient ductility when high strength concrete is used. CFT columns can replace conventional structural columns like reinforced concrete, structural steel with reinforced concrete and structural steel alone with enhanced performance and at the same time reducing costs to a minimum. It is especially useful in high-rise buildings where high strength is required and flexibility of open space is desired for a maximum range of applications.

2. OBJECTIVE

- To make a comparison between RC column and concrete-filled steel columns.
- To study the characteristics such as ultimate strength, stiffness and ductility of a composite column.

3. MATERIAL SPECIFICATION

CEMENT:

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Table 3.1 Properties of cement

Type of cement	Specific gravity	Initial setting time
OPC-53 grade	3.15	30 minutes

COARSE AGGREGATE

Table 3.2. Properties of coarse aggregate

Size of aggregate	Specific gravity	Fineness
Passing through 20mm sieve	2.70	1.5

FINE AGGREGATE

Table 3.3. Properties of fine aggregate

Size of aggregate	Specific gravity	Zone
Passing through 4.75mm sieve	2.64	II

MIX PROPORTION

Table 3.4. Mix proportion of M30 grade concrete

Cement	Fine aggregate	Coarse aggregate	Water content
1	1.48	2.47	0.44

4. PREPARATION OF SPECIMEN

Six specimens were tested under concentric axial load. Three of them were concrete infilled steel columns and the other three were conventional RC columns of M30 grade. Fig.4.1 shows the cross section of the welded square tube, where B and D are the width and the depth of the square steel tube respectively and t is steel wall thickness.

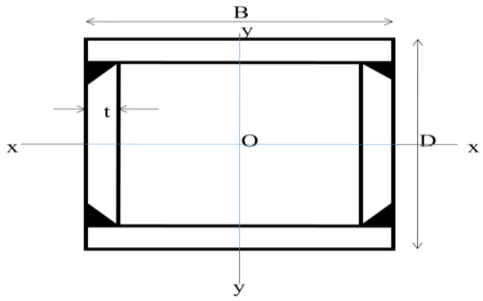

Fig 4.1. Cross section of steel column

The dimensions of the composite column cross sections and other specifications of the columns were given in Table 4.1 where, L was the length of the specimen. Three reinforced columns of same size were cast. The dimensions of RC columns were given in table 4.2. The reinforcement details of RC column were given in figure 4.3.

Fig 4.2. Steel column with wire mesh welded inside

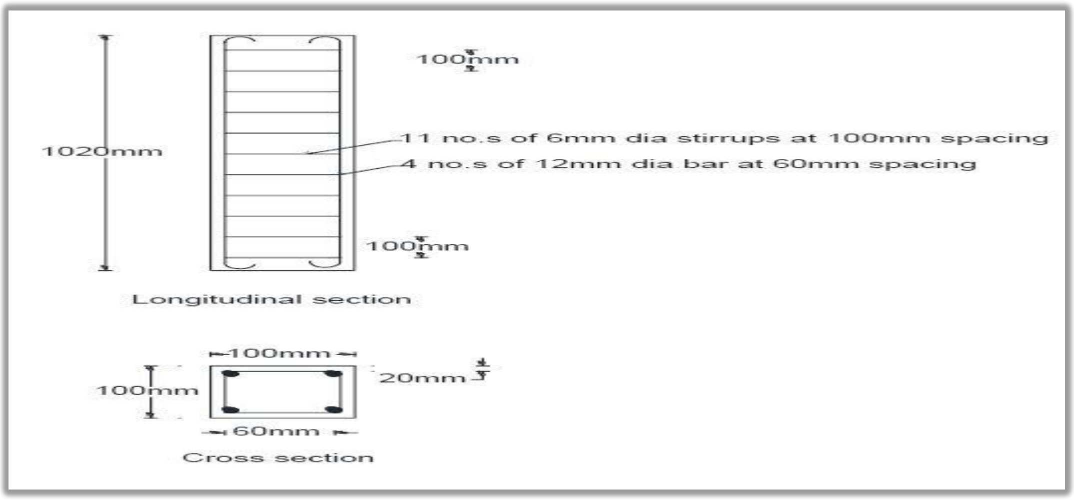

Fig 4.3. Reinforcement details of RC column

5. TEST ON CONCRETE

To find the properties of M30 grade concrete, compressive strength test was done. Test on compressive strength was conducted on cubes of size 150mm x 150mm x 150mm after 28 days of moist curing as shown in Fig.5.1. The results of compressive strength of cube were as given in Table 5.1.

Table.5.1. Results of compressive strength on concrete cube

COLUMN	COMPRESSIVE STRENGTH (MPa)	AVERAGE COMPRESSIVE STRENGTH (MPa)
RC-1	35.5	35.67
RC-2	36	
RC-3	35.5	

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Fig.5.1. Compressive strength test on concrete cube

6. TESTS ON COLUMN

Columns were tested in a loading frame of capacity 1000kN. The test setup is shown in fig.6.1. Two LVDTs were used for measuring deflection and bending. Ultimate strength, stiffness and ductility were measured for all six columns.

Fig 6.1. Test setup

Fig.6.2. Failure patterns of composite columns

From the failure patterns of steel concrete composite columns it was clear that the failure only at the joints of steel sheets. Since the steel column was made up of steel sheets welded together, the failure occurred at these joints. The failure of the column was mainly due to tearing of steel joints. If the composite were from a single sheet or it was a fabricated one, it will surely take more strength than now obtained results.

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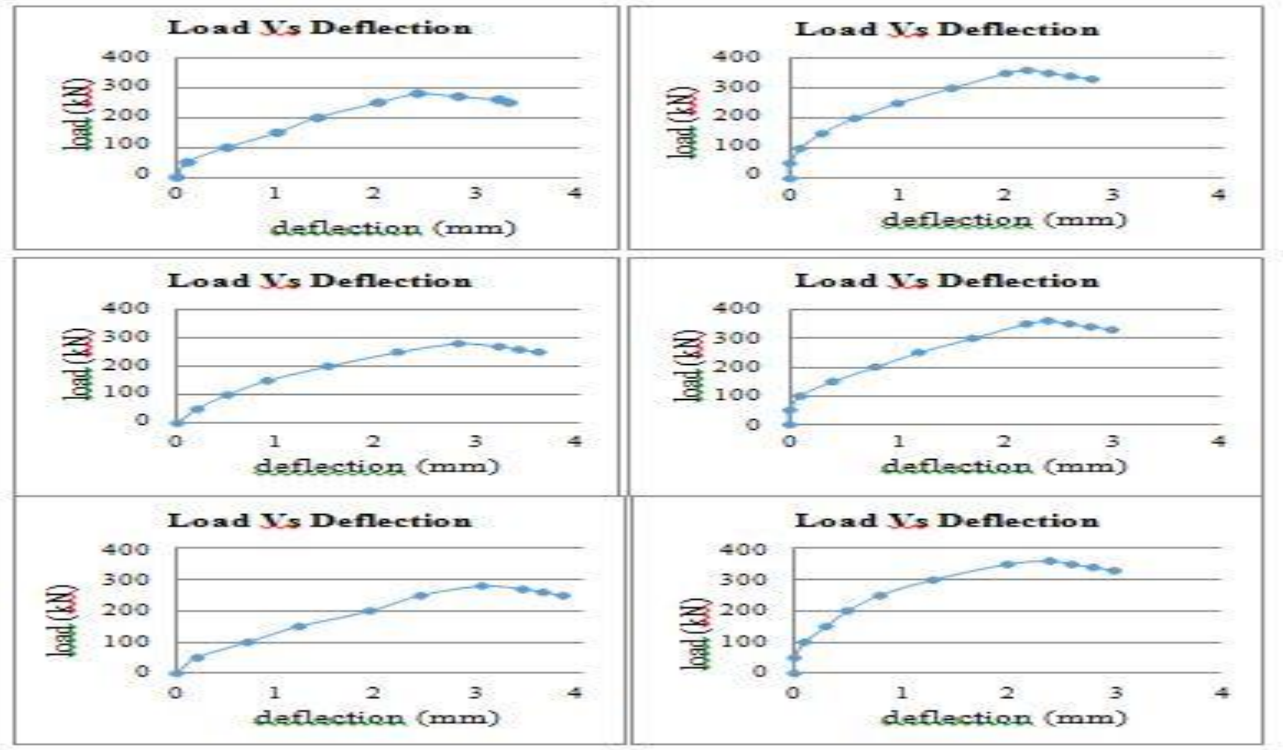

Fig 6.3. Comparison between RC column and composite column

From the experiments done on composite columns ultimate strength, ductility factor, and stiffness were calculated.

7.ULTIMATESTRENGTH

Table 7.1.Ultimate strength

Column type	Calculated ultimate strength(kN)	Observed ultimate strength(kN)
RC-1	240.35	280.5
RC-2	240.35	272.45
RC-3	240.35	288.52
SC-1	340.4	363.66
SC-2	340.4	372.34
SC-3	340.4	375.23

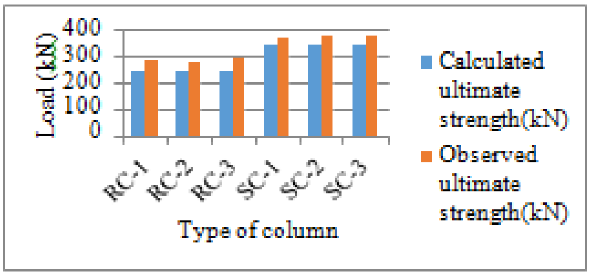

Fig.7.1. Ultimate strength test results

Ultimate strength is the highest stress at which a material can withstand before breaking. Ultimate strength was observed for all six columns. The observed values as well as calculated values were shown in table 7.2. From table it was clear that steel concrete composite columns have more ultimate strength than conventional RC columns.

8. DUCTILITY FACTOR

Ductility is the ability of a material to undergo plastic deformation without breaking. Ductility factor is the ratio of ultimate strength to first crack load. The ductility factors calculated were tabulated in table 8.1. From table it was clear that the ductility of steel concrete composite columns were greater than that of RC columns.

Table 8.1. Ductility factor

Type of column	Ductility factor
RC-1	3.73
RC-2	3.29
RC-3	2.54
SC-1	4.23
SC-2	3.79
SC-3	4.5

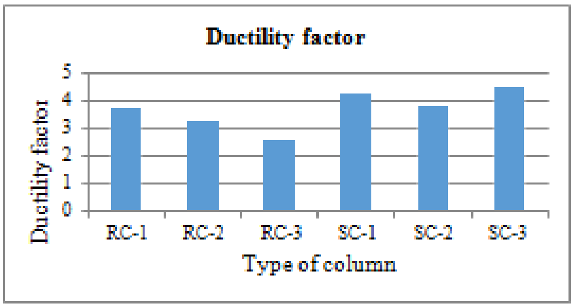

Fig.8.1. Ductility factor

9.STIFFNESS

Stiffness is the resistance of a material to deflection. It is the resistance offered to bending or buckling. Stiffness was calculated for all six columns and tabulated in table 9.1. Here also composite columns showed better results.

Table 9.1 .Stiffness

Type of column	Stiffness
RC-1	55.56
RC-2	83.33
RC-3	60
SC-1	125
SC-2	120
SC-3	166.67

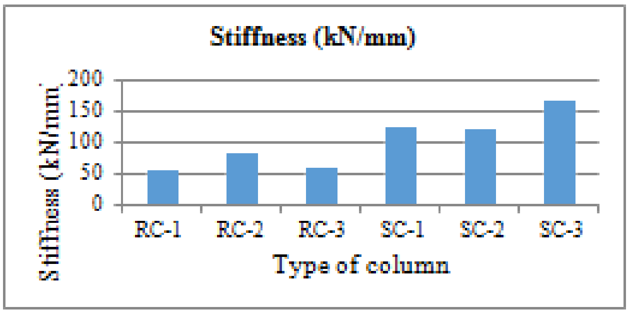

Fig.9.1. Stiffness

10. CONCLUSION AND SCOPE FOR FUTURE STUDY

The experimental study was done based on the previous experiments and the researches in this area. Following conclusions were obtained from the tests.

• While compared with same size of RC columns, steel concrete composite columns showed significant increase in ultimate strength.

• Steel concrete composite columns showed better results in ductility, stiffness and ultimate strength.

• Since it is very ductile, it will show high resistance to vibrations caused due to earthquakes.

• Columns tested under axial loading showed that the increase of the concrete strength has a positive effect on the load carrying capacity of concrete-filled steel tubes.

• Apart from the strength aspects, steel concrete composite columns have many other advantages such as it eliminates the need for formwork and reinforcement, spalling is controlled, rapid construction can be done etc.

• Can be used in High rise building

Steel concrete composite columns are becoming more and more popular nowadays. In future we can expect studies on long columns with better qualities in terms of strength, ductility, stiffness etc. Fire resistance can be improved in concrete infilled steel columns.

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