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COMPARATIVE BEHAVIOR OF CONCRETE FILLED STEEL TUBE, SAND FILLED STEEL TUBE, HOLLOW STEEL TUBE AND RCC COLUMN

Deeksha Chandrakar[1], Hemant Gupta[2], Yogita Malewar[3]

1 – PG Scholar; Deptt. of Civil Engineering, SISTec-R Bhopal(M.P.)
2 – Asst. Professor; Deptt. of Civil Engineering, SISTec-R Bhopal(M.P.)
3 – PG Scholar; Deptt. of Civil Engineering, SISTec-R Bhopal(M.P.)

Abstract – *Composite column consisting Concrete-filled steel tubes have become increasingly popular in structural application around the world composite Concrete-filled steel tubes are economic column type, the majority of axial load type is resisted by the concrete, which is less expensive than steel. Further, economic can be obtain by using high strength concrete with thin walled steel tubes using just sufficient steel to supports. the construction load prior to filling with concrete composite column consisting of Concrete-filled steel tubes of traditional concrete filled column, the problem of concrete cover spoiling can be avoided, furthermore, inward buckling of the steel is prevented by the steel core , thus increasing the stability and the strength. if the column as a system. the improved strength of the circular steel tubes filled with concrete is to the influence of bond strength between the steel tubes and concrete rather than lateral restrain and the strength of circular steel tubes can be significantly influence by local buckling. The local buckling has been considered by restricted the allowable diameter to thickness ratio.*
For compression member l/d < 50.
The main aim of this study was to increase the knowledge of structural behavior of composite column consisting of circular hallow steel section filled with concrete and to give practical information of the design purpose.
The main topic of insert were to study how the behavior of column was influenced by

- *The bond strength between the steel tubes and the concrete core.*
- *The increase concrete compressive strength due to confinement of steel.*
- *Compare of behavior of CFST concrete, sand filled steel tube and hollow steel tube. And*
- *Analysis of similar load for concrete filled steel tube with respect to RCC short column.*

In this thesis, Behavior of concrete filled steel tube is studied that can be used to conservatively estimate the strength of circular steel tube filled with concrete and reinforced concrete short column under axial loading. The loading positions examined include axial loading of the steel tubes, steel tube filled with sand and steel tube filled with concrete having simultaneous loading. Estimation of the economical section out of the tested specimens at same diameter and comparison of best result concrete filled steel tube with traditional R.C.C column.
In this report stapled practical reports to be done on lab. This reports ends with a set of conclusion and suggestion for future work.

Keywords *- Concrete Filled Steel Tube, Sand Filled Steel Tube, Hollow Steel Tube, Composite column.*

I. INTRODUCTION

1.1 Concrete Filled Steel Tube -

Composite columns consisting of Concrete-filled steel tubes have become increasing popular in structural applications around the world. These are used for their excellent earthquake resistance properties such as high strength, highly ductility and large energy absorption capacity. This type of structure can offer much other advantage such as:

- Increased speed of construction.
- Positive safety aspect.
- Functioning of steel tubes as both formwork & reinforcement for the concrete core.
- Possible use of simple standardized connections.

1.2 In order to achieve this, experimental analysis was use –

In this thesis checked the effect of sand filled steel tube for axially loaded column and hollow axially loaded steel tube for determining indusial behavior of steel tubes. The Concrete Filled Steel Tube (CFST) Structural System is a system based on filling steel tubes with high-strength concrete. It is one of the modifications to composite steel-concrete structures. CFST structure is a type of the composite steel-concrete structures used presently in civil engineering and consists of steel tube and concrete core inside it. Main advantages are the interaction between the steel tube and concrete: local buckling of the steel tube is delayed for presence of concrete and steel tubes provides sufficient confining effect to concrete. Concrete Filled Steel

Tubes are used in many structural applications including columns supported offshore platforms, roofs of storage tanks, bridge piers, piles, and columns in seismic zones.

1.3 Partial use of concrete filled steel tube -

The concrete filled steel tube is a composite material combined by the thin welled steel tube and the concrete filled into the steel tube. on one hand, the concrete in the tube improves the stability of the thin- walled steel tube in compression on the other hand the steel tube confines the filled concrete and the filled concrete is turn is in compression in three direction. Therefore the CFST has higher compression capacity and ductility. it is good for the application of high rise building and bridges.

Application of concrete filled steel tube joint two CFT by wide flange through the steel girder framing system and the roof having corrugated metal deck. Using CFST framed system increased efficiency of construction and reduced coast of building. The study mainly presents an experimental investigation of short concrete filled steel tube column under a concentric load.

II. STUDY OF THE BEHAVIOR OF CONCRETE FILLED STEEL TUBE COLUMNS

2.1 Concrete filled steel tube as composite members:

In this thesis, concrete – filled circular steel tubes mainly to compression will be discussed. The most common composite member of this kind around the world is a column used for seismic design of building. Additionally to steel tube acts as form work for the concrete during casting thus saving major construction cost.

2.2 Effect of lateral confining pressure on the stress-strain:

Concrete filled steel tube under concentric loading with Circular sections can developed effective hoop tension to a uniform distribution of lateral confining pressure.

2.3 Interaction between the concrete and the steel tube:

Load transfer mechanisms:

In the type of structure investigation in this study, concrete filled steel tube, it is of great practical and economics interest not to have any mechanical shear connection in the interface between the concrete core and the steel tube, hence the load has to be transferred in some way directly over the surface of the concrete core and the steel tube. They were together referred to as the load transfer mechanism and were defined as follows.

- Micro - interlocking between the concrete and the steel due to surface in regulation of the steel tube.
- Friction between the concrete core and the steel tube due to normal forces.
- Bending or curvature effect resulting from imposed loads must be compatible will hoop tension.

2.4 Behavior during loading:

In the initial concentric axial loading stages of the CFST column, both concrete infill and structural steel will deform longitudinally. The Poisson's ratio of the concrete infill (ranges between 0.15-0.25) is smaller than that of structural steel (roughly 0.28) at these initial strains. Thus, the lateral expansion of the confining tube is larger than the confined concrete. As a result, localized separation between the two composite materials takes place along the column.

In the second stage of loading where the confinement of the steel tube on the concrete is present, circumferential stresses are developed in the structural steel due to two factors:

- Longitudinal stresses from loading.
- Lateral pressure from concrete dilation.

2.5 Aspects which effect on the Strength and Behavior of the Concrete Filled Steel Tube -

- Confining action in circular concrete filled steel tube.
- Triaxial effects on the core.
- Biaxial effects on the shell
- Presence of lateral strain compatibility.
- Complete interaction of the core and the shell.
- Effects of methods of loading.
- Importance of Poisson's ration of concrete.
- Importance of volume dilation of core.
- Factors governing the service and ultimate load behavior.

2.6 Failure modes:

- Material properties
- Geometric configuration

The most dominant failure mode is the local buckling of the steel tube. When compared with the empty steel tube, the local buckling in the CFST column is delayed due to the presence of concrete infill. The concrete prevents the steel tube from buckling inward; instead it forces the tube to buckle in an outward mode

III. EXPERIMENTAL WORK

3.1 Experimental Program

The composite columns in this study analyzed by using the experimental program. The main topics of interact were the bond between the concrete core and the steel tube. The increase in the concrete compressive strength due to the confinement effect and the effect of various loads application. In order to study these phenomena three-dimensional model was established. When the stresses increase in the concrete and age steel. The material strong non linear behavior, inelastic staining occurs and the response of the material softens.

The experiment model of the long slender columns consists in total of three models.

- Hollow steel tube,
- Sand filled steel tube
- Concrete filled steel tube.

3.2 Model dimensions

- Outer diameter of the steel tube = 165 mm
- Inner diameter of the steel tube = 159 mm
- Thickness of the steel tube = 3 mm
- Length of the steel tube = 420 mm

Table 1: Details of Material Properties

S. No.	Material properties	Concrete	Steel	Loading plate thickness 20mm
1	Young's modulus	0.22×10^5 N/mm^2	2×10^5 N /mm^2	2×10^5 N /mm^2
2	Density of concrete	25 kN / m^3	78.5 kN / m^3	78.5 kN / m^3
3	Poisson's ratio	0.15	0.3	0.3
4	characteristic strength of concrete	20 N / mm^2	-	-
5	Coefficient of friction	-	0.2	0.2

3.3 Experimental work and materials used:

3.3.1 Cement: Cement is important binding material which is directly effect on strength of concrete. The cement used was Ordinary Portland Cement Grade 43 (OPC). The physical properties of cement:

- Setting time
- Soundness
- Fineness
- Strength

3.3.2 Aggregate: The nominal size of aggregate is taken as 20 mm. The crushed stone was used as coarse aggregate.

3.3.3Sand filled steel tube: Well graded dry sand used in sand filled steel tube for higher bearing capacity and low compression. Sand distribute load grain to grain. Steel tube cover protect explosion of sand. As per IS: 383:1970. In this thesis for experimental work zone II sand used in tube sand.

3.3.4 Proportioning: In this paper experimental work to be done in which used concrete filled steel tube for carrying higher load M20 concrete filled in the steel tube. Making M20 specified characteristic compressive strength of 150 mm cube at 28 days in concrete ratio of cement: sand: and aggregate 1:1.5:3 take with 0.45 water cement ratio and fill in mild steel tube

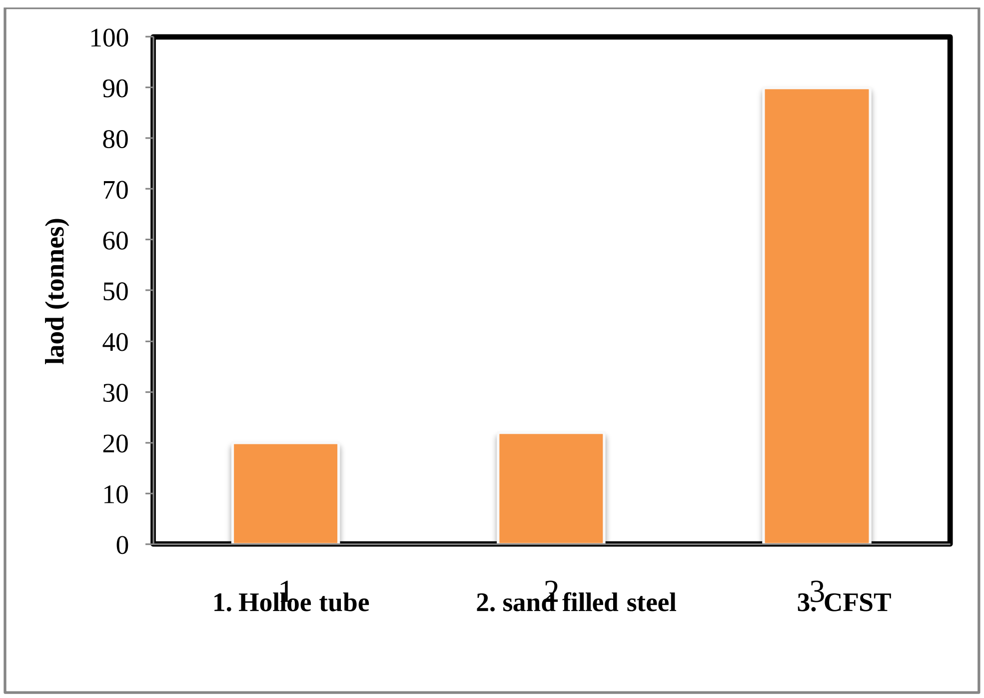
3.3.5 Properties of Mild steel tube: Properties of steel Mild steel are the least expensive of all steel and the most common steel used. Used in nearly every type of product created from steel, it is wieldable, very hard and, although it easily rusts, very durable. Containing a maximum of 0.20% carbon.

3.3.6 Testing Machine: The permissible error shall be not greater than ± 2 percent of the maximum load.

Table 2: Test Result of Experimental Program

S. No.	Experiment model	Carrying compression load
1	Hollow steel tube	20 tonnes
2	Sand filled steel tub	22 tonnes
3	Concrete filled steel tube	90 tonnes

Graph 1: Comparison of loads



IV. DESIGN DETAILS

4.1 Design Details of CFST Short Column:

- Grade of concrete = M20
- Grade of steel (mild steel) = 250
- Characteristic strength of concrete(f_{ck}) = 20 N/mm²
- Characteristic strength of steel (f_y) = 250 N/mm²
- Outer diameter of the steel tube (D_1) = 165 mm
- Inner diameter of the steel tube (D_2) = 159 mm
- Thickness of the steel tube = 3 mm
- Length of the steel tube = 420 mm
- Density of filled concrete = 25 kN/m^3
- Load carrying capacity by CFST (P) = 90Tonnes

4.2 Respectively Design Detail of RCC Short Column

- **Design constant data**
  - Length of short column (L) = 420 mm
  - Grade of concrete = M20
  - Grade of steel (mild steel) = 250
  - Density of concrete = 25 kN/m³
  - Characteristic strength of concrete(f_{ck}) = 20 N/mm²
  - Characteristic strength of steel (f_y) = 250 N/mm²
- **Design calculation data**
  - Axial load (P) = 900 kN
  - Load factor = 1.5
  - Factored load (P_u) = 1350 kN
  - Gross Area (A_g) = 140698 mm²
  - Diameter of circular short circular column (D) = 425 mm
  - Diameter and Nos. of bar **16 mm ϕ 7 Nos.**
  - Diameter lateral ties **8mm @ 250 mm c/c**

4.3 Advantages of CFST Columns over Reinforced Cement Column:

- Interface between steel tube and concrete: Local buckling of the steel circular section is delayed and the strength fall after the local buckling is moderated, both due to the preventive effect of the concrete. On the other hand, the strength of the concrete core is increased due to the confining effect provided by the steel tube, and the strength failure is not very severe, because concrete core is prevented by the tubular section. Drying shrinkage and creep value of the concrete are much smaller than in ordinary reinforced concrete.
- Cross-sectional properties: The steel ratio in the CFST cross section is much larger than in reinforced concrete and concrete-encased steel cross sections. The steel of the CFST column is well plasticized under bending because it is located most outside the section.
- Cost performance: Because of the merits listed above, better cost performance is obtained by replacing a steel structure with a CFST column.
- Ecology: The reduction in wood consuming needed for the formwork is environmentally advantageous.
- Construction efficiency: Labor for formwork and reinforcing longitudinal bars and lateral ties bars is omitted, and concrete costing is done by steel tube. This efficiency leads to a cleaner construction site and a reduction in construction cost and project length.
- The concrete infill is encased by the steel tubular section. The confinement effect increases the potency and ductility of the concrete core in steel tube.

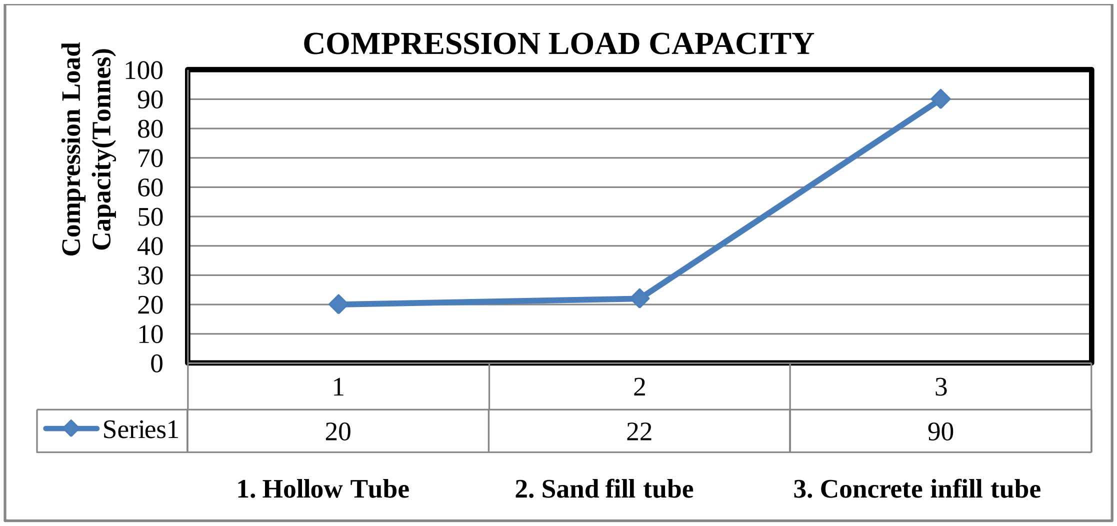
V. RESULTS AND DISCUSSIONS

5.1 Result Discussion: The obtained result is shown by table and graphical denotations.

Table - 3: Details of Test Specimens and Results

Specimens type	Diameter (mm)	Length (mm)	Thickness (mm)	L/D	Ultimate compression load
Concrete filled steel tube	165	420	3	2.54	90 tonnes
Sand filled steel tube	165	420	3	2.54	22 tonnes
Hollow steel tube	165	420	3	2.54	20 tonnes

Graph - 2: Load carrying in compression



5.2 Section Analysis of Reinforced Cement and Concrete Filled Steel Tube Column.

Table - 4 Data of Analysis

Constant design value	
Length of short column = 420 mm	
Load carrying capacity = 900 kN	
Characteristic strength of concrete(f_{ck}) = 20 N/mm²	
Characteristic strength of steel (f_y) = 250 N/mm²	
Density of concrete = 25 kN/m³	
CFST short column	**RCC short column**
D = 165 mm	D = 425 mm
Total wt of steel = 5 kg	Total wt of steel = 5.96 kg
Quantity of concrete in volume = 0. 0198	Quantity of concrete in volume = 0.148
Amount in Rupees = 484	Amount in Rupees = 893

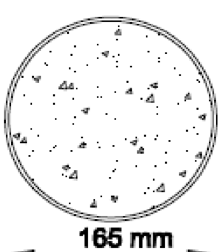


Fig - 1 CFST Short Column

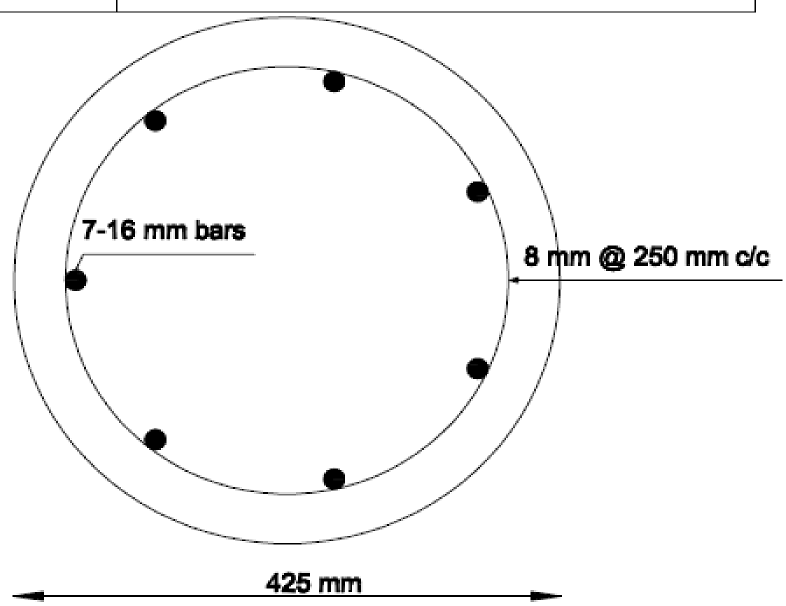


Fig - 2 RCC Short Column

5.3 Future Scope of Work

- It has been shown that the structural behaviors of the composite column can be greatly influenced by the how the load is applied to the column section. Hence the detailing of the connection to the column must be studied further in order to find simple standardized connections with good performance.
- The long- term effects, creep and shrinkage of the concrete are supposed to have smaller influence on the load bearing capacity for the capacity for the composite column consisting of a concrete filled steels tube than for ordinary reinforced concrete columns. How results for circular composite columns are scarce and more studies are needed.

VI. CONCLUSION

5.1 Conclusion

- Concrete filling increase the energy absorption especially for hollow steel sections. Even though the strength and behavior of concrete filled steel tubes have been studies by various models.
- Comparison by this paper concrete filled steel tube and reinforced cement concrete section concrete filled steel tubes more economical, durable and efficient for construction.
- Through this theory to predict the failure load in compression of concrete filled steel tube, sand filled steel tube and hollow steel tube.

5.2 The combined action of the Concrete filled steel tube show the higher compression load as compare to individual.

- The lateral confinement supplied by the concrete filled steels, progressively increases with the load level, and this is also continuously applied.
- Concrete filled steels shows large enhancement of the load carrying capacity and can sustain large strain and deformations.
- Lateral strain compatibility does not exist in concrete filled steel tubes for a good part of loading up to 50 % ultimate load
- Percentage of the load carried by the shell and the core are reversed from the services load stage to ultimate load stage.
- Major differences between reinforced concrete columns and the concrete filled steel tubes is that in the former, strain compatibility and the complete interaction between steel and concrete are present over the entire loading range, while in the latter, lateral strain compatibility and composite action.

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