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COMPARISON OF ULTIMATE LOAD OF CONCRETE FILLED TRIPLE SKIN TUBE WITH OUTER SQUARE STEEL AND INNER CIRCULAR UPVCS (CTTSSCU) WITH SQUARE CFDSTS

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Abstract: This experimental paper is about the comparison of ultimate loads of CTTSSCU with conventional CFDSTs with different inner tubes. A Concrete Filled Double Skin Tube (CFDST) column consists of 2 tubes: One is outer and the other is inner with space between them is filled with concrete. Square outer tubes and inner tubes of circular, square cross section and one specimen of no inner tube are used. Concrete filled Triple skin Tube with outer Square Steel and inner Circular UPVCs (CTTSSCU) consist of outer square steel tube & two inner UPVCs (Un-plasticized Poly Vinyl Chloride) of different diameters. The space between all the three tubes are filled with concrete and inner core is left hollow.

Index Terms **– CFDST, Concrete Filled Steel Tube, Ultimate Load, Triple Skin Tube, Double Skin Tube, Concrete Column, UPVC, Un-plasticized Poly Vinyl Chloride**

1.INTRODUCTION

Concrete Filled Double Skin Tubes (CFDSTs) are of good technology used widely in many countries, but it is still new in India. Many peoples in India don't know about it and they follow only the old type of column construction consist of reinforcements. Here there is no reinforcement and concrete is covered at it's outer and inner perimeters using steel. The inner hollow portion can be used for carrying conduit pipes, duct, etc. and thereby saving area. The Concrete filled Triple Skin Tube with outer Square Steel and inner Circular UPVCs (CTTSSCU) columns has got total three tubes and 3 materials namely: Concrete, steel and UPVC. So the compressive strength of concrete, tensile capacity of steel and stiffness, stiffness and fire resistance of UPVCs are utilized here. So here the ultimate compressive strength of CTTSSCU specimen is compared with normal CFDSTs.

1.1 Objective of The Project

- To compare the ultimate loading capacity of CTTSSCU specimen with normal square CFDST specimen
- To find out the ultimate load of failure values and deformation pattern by experiment
- To check whether we can use UPVCs instead of steel tubes as inner tubes in CFDSTs

2. EXPERIMENTAL INVESTIGATION

2.1 Specimen Details

Total 10 columns with different design specifications are to be tested under compression. G. I. square tubes of 7 cm width, 1.5 mm thick and 60 cm height, UPVC tubes of 1.905cm or 0.75 inch and 3.81cm or 1.5 inch diameter and 60 cm height and G. I. tubes of 1.905cm and 3.81cm diameter and 60 cm height are used in this experiment study. 4 types of specimens are tested here and they are normal CFDST with outer square G. I. tube and inner circular G. I. tube, inner square G. I. tube, inner circular hollow with no inner tube and concrete filled triple skin tube with outer square steel and inner circular UPVCs which are designated as ICCFDST, ISCFDST, ICHCFDST and CTTSSCU respectively. The cross-sectional details of the main specimen and control specimens are given in Figure 1 and Detailed specimen specifications are shown in table 1.

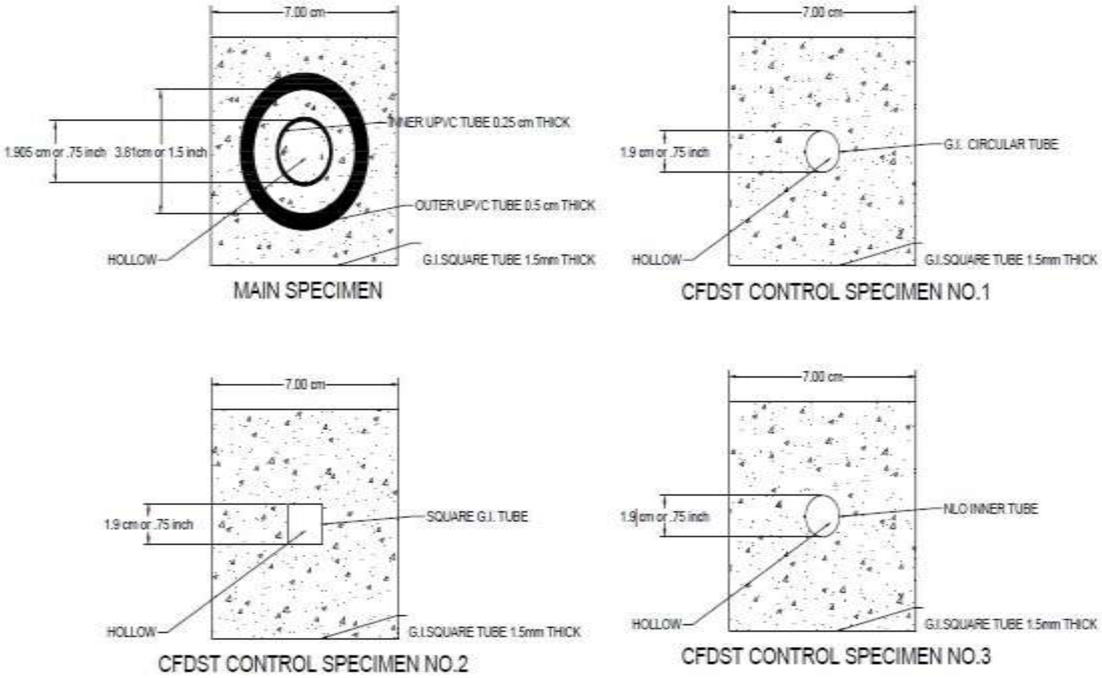

Fig-1: Cross-Section of Specimens

Table -1: Specifications of the specimens

Designation	Outer Square G.I. Tube Width (mm)	Thickness (mm)	Larger Inner Tube Material	Diameter or width	Smaller Inner Tube Material	Diameter or Width	Length (mm)
CTTSSCU 1	70	1.5	UPVC	38.1	UPVC	19.05	600
CTTSSCU 2	70	1.5	UPVC	38.1	UPVC	19.05	600
CTTSSCU 3	70	1.5	UPVC	38.1	UPVC	19.05	600
ICCFDST 1	70	1.5	NIL	NIL	UPVC	19.05	600
ICCFDST 2	70	1.5	NIL	NIL	UPVC	19.05	600
ICCFDST 3	70	1.5	NIL	NIL	UPVC	19.05	600
ISCFDST 1	70	1.5	NIL	NIL	UPVC	19.05	600
ISCFDST 2	70	1.5	NIL	NIL	UPVC	19.05	600
ISCFDST 3	70	1.5	NIL	NIL	UPVC	19.05	600
ICHCFDST	70	1.5	NIL	NIL	HOLLOW	19.05	600

2.2 Material Used

The materials used for the preparation of the various specimens are G. I. tubes, M-Sand as fine aggregate, 12.5 mm crushed stones as coarse aggregate, 53 grade OPC cement as the binding material, U-PVC tubes of diameters 1.905 cm or 0.75 inch and 3.81 cm or 1.5-inch, G. I. square tubes of width 1.905 cm, G. I. circular tubes of diameter 1.905cm. The pictures of G.I. tubes and UPVCs are shown in Figure 2 and Figure 3.


Fig-2: G.I. Square Tube **Fig-3:** UPVC Tubes

2.3 Preparation of Specimen

The outer square G. I. tube is made by cutting, bending and welding of G. I. sheets. The G. I. square and circular tubes and UPVCs are cut into the required length. The required quantities of cement, fine aggregate, coarse aggregate and water were taken for the filling of the specimens. Fine aggregate, coarse aggregate, cement are mixed well and water was added stage by stage to make the required M20 mix.

Fig -4: Cutting of UPVC Tubes

2.3.1 Casting of Specimens

The interior of G.I. tubes and UPVCs are well cleaned thoroughly to remove dust and loose debris. The ends of the tubes were leveled using spirit level. The outer square tube and other inner UPVCs are placed and fixed with the help of one persona and the filling was done by another person. The mixed concrete is poured in layer by layer and more than 25 blows are given to each layer for better confinement. A plastic sheet is also placed beneath the specimen to catch the leakage of slurry. Then the top surface is leveled using trowel. The specimens during casting is shown in Figure 5.

Fig -5: Casting of Specimens

2.3.2 Curing of Specimens

After 24 hours, the casted specimens were water cured for a period of 28 days. The specimens during curing is shown in figure 6.

Fig -6: Curing of Specimens

2.4 Test Setup

The test set up consist of Universal Testing Machine of 1000 kN capacity. The test specimens are placed approximately at the center of the Compression Testing Machine's end bearing plates to apply the axial compression correctly. Axial load was applied to the column and the axial deformation corresponding to the load was measured. Then the load is applied to find the ultimate load of failure. The axial deformations and ultimate loads were noted. The test setup is shown in figure 7.

Fig -7: Test Setup

3 TEST RESULTS

Various results were obtained from the axial compression test of the concrete filled triple skin tube with outer square steel and inner circular UPVCs. The results include load deflection behavior and ultimate load carrying capacity.

3.1 TEST RESULT OF ICCFDST SPECIMENS

This control specimen has got inner circular G.I. tubes and it is found that this specimen has more ultimate load carrying capacity than ISCFDST and ICHCFDST. The maximum ultimate load attained by these specimens is 220.7 kN.

Fig -8: ICCFDST Specimen Before Loading **Fig -9**: ICCFDST Specimen After Loading

3.2 TEST RESULT OF ISCFDST SPECIMENS

This control specimen has got inner square G.I. tubes and it is found that this specimen has less ultimate load carrying capacity than main specimen and ICCFDST but more load carrying capacity than hollow specimen. The maximum ultimate load attained by these specimens is 210.9 kN.


Fig -10: ISCFDST Specimen Before Loading **Fig -11**: ISCFDST Specimen After Loading

3.3 TEST RESULT OF ICHCFDST SPECIMENS

This control specimen has got outer square G.I. tubes and no inner tube and there is hollow space. It is found that this specimen has less ultimate load carrying capacity than main specimen and all other control specimens. The maximum ultimate load attained by these specimens is 137.4 kN.


Fig -11: ICHCFDST Specimen Before Loading **Fig -12**: ICHCFDST Specimen After Loading

3.4 TEST RESULT OF CTTSSCU SPECIMENS

This specimen has got outer square G.I. tubes and two inner circular UPVCs and it is found that this specimen has more ultimate load carrying capacity than all other control specimens. The maximum ultimate load attained by these specimens is 240.4 kN.

In the initial stages of axial loading of the CTTSSCU specimens, both G.I. tube and infill concrete and UPVC tubes deform longitudinally and no significant changes in the appearance of the specimens. After that in one UPVC specimen there was outer steel tube deformation in the top end. Then further increasing the loads, there is lateral deformation of outer tubes and crushing of concrete at a particular load then also it carries some more load before failure. The final buckling is observed normally at just below the mid height of the specimen. In all specimens an initial buckling load and final ultimate buckling load is obtained. No inward buckling is observed in both outer and inner tubes.


Fig -13: CTTSSCU Specimen Before Loading **Fig -14**: CTTSSCU Specimen After Loading

3.4.1 Behavior of UPVC on loading

No cracking and buckling occurred in the UPVC. As load applied the steel buckles, concrete crushes and UPVC bends and after ultimate load when loading is stopped the UPVC comes to it's initial position. That is no damage is occurred to the UPVC during loading.

4 COMPARISON OF ULTIMATE LOADS

The maximum average load taken by ICCFDST, ISCFDST, ICHCFDST and CTTSSCU are given in table 2.

Table -2: Ultimate Average Loads of specimens

Specimens	**Ultimate Load (kN)**
ICCFDST	214.2
ISCFDST	204.37
ICHCFDST	137.4
CTTSSCU	235.5

From the above table, it can be seen that the main specimen has got more ultimate load carrying capacity than all control specimens. The maximum load carrying capabilities of all the columns are plotted and compared with the main specimens and it is shown in chart 1 below.

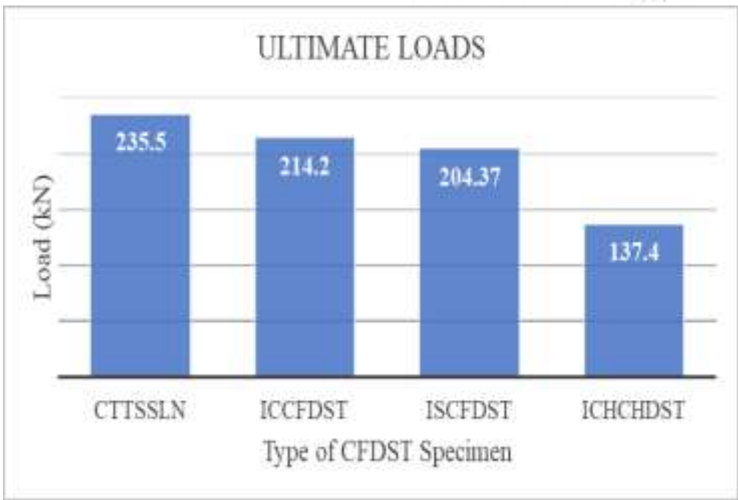

Chart -1: Comparison of Ultimate Loads of Different specimens

4.1 LOAD DEFORMATION CURVE

The behaviour of various specimens can be observed by plotting the load deformation curve. Chart 2 shows the load deformation curves of the control specimens and main specimen.

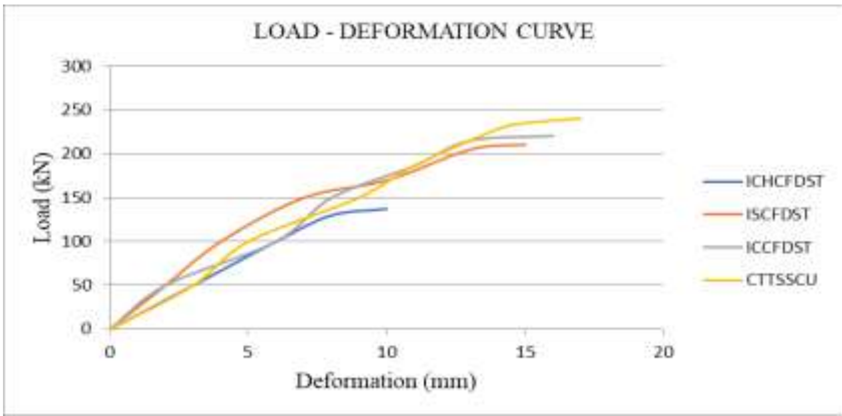

Chart -2: Load Deformation Curves of Four Types of Specimens

From the above chart it is clear that the CTTSSCU specimen has got more load carrying capacity and ductility than other three control specimens.

5. CONCLUSIONS

Mainly in my work the behavior and ultimate load carrying capacities of CTTSSCU column specimens were compared experimentally under axial compression loading with ICCFDST, ISCFDST and ICHCFDST specimens.

From the experimental study it is found that the load carrying capacity of CTTSSCU specimen is more than that of conventional square CFDST columns. So this CTTSSCU specimens provides better strength and durability also. The use of UPVC is cost effective than using steel tubes and it is corrosion resistant and rigid also. While testing the main specimen there occurred an initial failure and deformation mainly at the top and bottom end of the specimen which is like elephant foot buckling. But after that also it carried more load before ultimate failure which indicates it's improved ductility properties. The bonding between surface roughened UPVC and concrete is also found to be good and there were no buckling or cracking of UPVC used while there were buckling and cracking of steel tubes used. The no inner tube specimen has got least strength when compared with all specimens and this may be due to the lack of confinement.

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