EXPERIMENTAL STUDY ON CONCRETE FILLED, UNPLASTICISED POLY VINYL CHLORIDE (UPVC) TUBES

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ABSTRACT-

In the present study, unplasticised poly vinyl chloride (UPVC) tubes filled with concrete are axially loaded until failure of the specimen to investigate their load carrying capacity. Total eighteen specimens of UPVC tubes of diameter 150mm, thickness 7.11mm with effective lengths of 500mm, 600mm, and 700mm were cast. M_{20} grade of concrete of two different mixes having two different sizes of coarse aggregate 6.3mm and 10mm was filled inside the tubes for casting of UPVC concrete filled tube (CFT) column specimens. The column specimens were tested for axial loading in the UTM machine of capacity 1000kN. Their load-displacement curves and stress-strain curves were recorded. All the columns fail by local buckling. As the length increases the strength was increased and it was higher for the mix which have 6.3mm size of coarse aggregate compared to 10mm size of coarse aggregate. It was found that about 1.6% increases in compressive strength of UPVC CFT columns experimentally when compared with theoretical value.

Keywords - M_{20}, Strength, UPVC , CFTC

I. INTRODUCTION

Columns occupy a vital place in the structural system. Weakness or failure of a column destabilizes the entire structure. Strength & ductility of steel columns need to be ensured through adequate strengthening, repair & rehabilitation techniques to maintain adequate structural performance. Columns are considered as critical members in moment-resisting structural systems. Their failure may lead to a partial or even a total collapse of the whole structure. Therefore, it is important to improve the ductile deformation capacity and energy dissipation capacity of columns so that the entire structure can endure severe ground motions and dissipate a considerable amount of seismic energy.

Recently, composite columns are finding a lot of usage for seismic resistance. In order to prevent shear failure of RC column resulting in storey collapse of building, it is necessary to make ductility of columns larger.

Concrete filled tubular columns have been increasingly used in many modern structures, such as dwelling houses, tall buildings. There has been significant research conducted on the investigation of behavior and performance of Concrete Filled Steel Tubes (CFST) under axial loading and combined axial and bending while little work has been done on concrete filled unplasticised poly vinyl chloride tubes as columns. UPVC pipes are readily available in market and it is cheaper than steel tubes and also provides durability, reliability and integrity of the housing/building. These tubes can be used as formwork during construction and their after as an integral part of column.

II. EXPERIMENTAL INVESTIGATION

2.1 Preparation of Specimens

M_{20} grade of concrete was used to fill the tubes for the casting of UPVC CFT column specimens. The different mixes for two types of coarse aggregates 6.3mm and 10mm were used to investigate there load carrying capacity in UPVC CFT columns. The eighteen UPVC Tubes, nine tubes for 6.3mm size coarse aggregate and another nine tubes for 10mm size coarse aggregate were casted. To prepare the specimens, UPVC tubes having different geometric dimensions with pressure holding capacity of 0.6 MPa were procured from market. External diameter and thickness of pipes were checked as per tolerances given in ASTM-D 1785. Eighteen tubes with inner diameter 150mm and thickness 7.11 of 500mm, 600mm and 700mm length were cut. The UPVC tubes were properly cut and finished in such a way that both the ends were horizontal, parallel to each other and exactly perpendicular to cylindrical surface. The Table 1 gives the data of selected UPVC tubes. The freshly prepared concrete was placed in three layers and vibrated and compacted in each layer properly. The Polyethylene sheet was tightly fixed in the bottom of the UPVC CFTs so that spilling water does not occur. The concrete mix was then poured into the UPVC tube to obtain the concrete filled tubular column specimen.

2.2 Test Instruments

The tests were conducted using a 1000kN capacity Universal Testing Machine which is digitally operated. The load-displacement and stress-stain curves were recorded by the machine automatically. The bearing surface of the testing machine and the bearing plates were wiped clean and any loose sand or other material removed from the surface of the specimen. Which were to be in contact with the bearing plates. The specimen was placed between the bearing plates in such a manner that the upper bearing plate was directly in line with the lower plate and the bearing plates extend at least 25mm from each end of the specimen. Care was taken to ensure that truly axial load was transformed to each of the columns as shown in Fig. 6 & 7.

3.3 RESULTS AND DISCUSSIONS

3.3.1 Theoretical Results

The total load carried by the concrete filled UPVC tubes were calculated by considering both the load carried by tube and concrete. The corresponding results obtained for 6.3mm and 10mm aggregate size of coarse aggregate mixes of grade M_{20} with length variation from 500mm, 600mm and 700mm of constant diameter 150mm is given in Table 2. The load calculation is as follows:

$$P = P_p + P_c,$$
$$P = (A_p * f_p) + (A_c * f_c)$$
$$P = (L * t * f_p) + (((\pi / 4) * d^2) * f_c)$$

Where P = total load,

P_p = load carried by UPVC tube,

P_c = load carried by concrete,

A_p, A_c = corresponding area of UPVC tube and concrete core,

L, t = length and thickness of UPVC tubes,

d = diameter of the concrete core,

f_p and f_c = design stress of UPVC tube and concrete core.

f_p=13.79 N/mm^2 for UPVC tube of ASTM D- 1785 (designation PVC 1120 / 2120).

f_c= 20 N/mm^2 for concrete core.

t = 7.11mm

L = 500,600 and 700 mm,

d = 150 mm

3.3.2 Experimental results

Behaviour of the UPVC CFT's columns has been studied with respect to displacement characteristics in the axial direction. The load carrying capacity due to the UPVC confinement effect was analyzed. M_{20} grade of concrete with two types of aggregates 6.3mm, 10mm sizes of aggregates and their effect on UPVC CFT columns for length variations 500mm, 600mm and 700mm with constant diameter 150mmspecimens were tested. The table 2 represents the Comparison between the Strength Parameters of 6.3mm and 10mm aggregates on CFTC UPVC Tubes. The table 3 shows that the smaller aggregate will give higher compressive strength.

In the Fig.1 the load vs displacement is plotted for M_{20} grade of concrete with 6mm and 10mm size of coarse aggregates for length varied from 500 to 700mm and the following points are observed:

Likewise 10CFTC600 fails at an early stage than 6.3CFTC600. Correspondingly 10CFTC500 fails at an early stage than 6.3CFTC500 but it is hard to tell at what exact point the concrete fails, because of the early failure of concrete bulging is very high in 10mm aggregate specimens compared to 6.3mm aggregate specimens due to this reason the displacement is very high. From the graph shown in Fig.1 it can be concluded that 6.3mm aggregate carry maximum load than the 10mm aggregate compared with corresponding length.

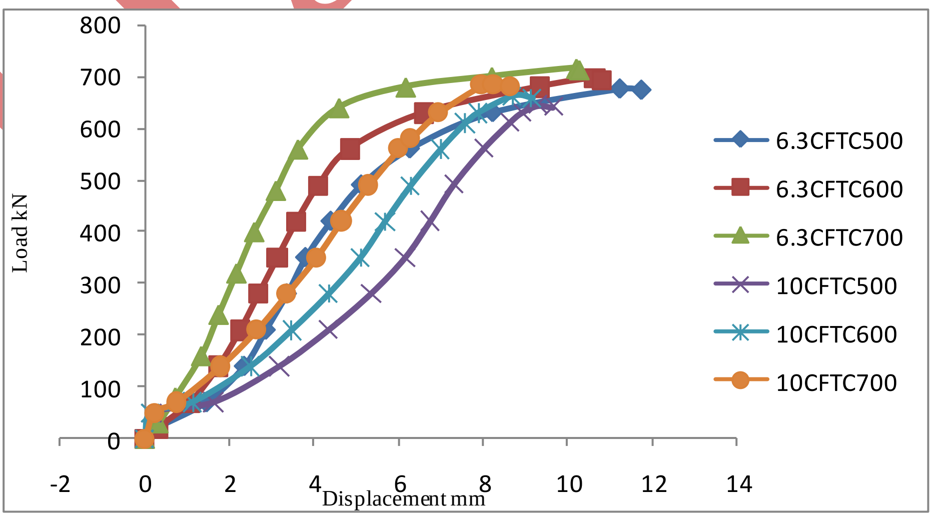

Fig 1: comparison for 6.3CFTC500, 6.3CFTC600, 6.3CFTC700 and 10CFTC500, 10CFTC600, 10CFTC700

6.3CFTC500, 6.3CFTC600 and 6.3CFTC700 and also the 10CFTC500, 10CFTC600 and 10CFTC700 behave linearly until failure because composite of the concrete filled UPVC tube action. Initially 6.3CFTC700, the concrete fails in the concrete filled UPVC tube at maximum load which causes larger displacement after failure than the 10CFTC700.

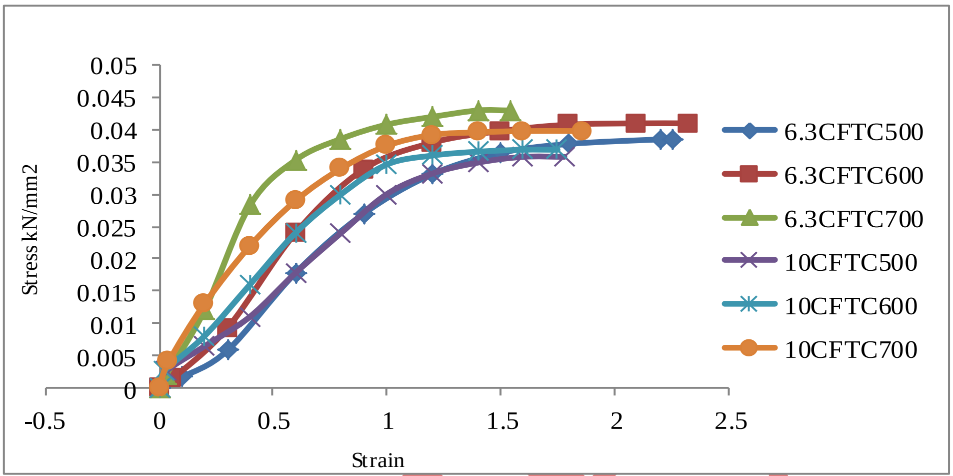

Fig 2: comparison for 6.3CFTC500, 6.3CFTC600, 6.3CFTC700 AND 10CFTC500, 10CFTC600, 10CFTC700

Fig. 2 shows stress-strain curves for the confinement mechanisms of 6.3mm and 10mm aggregate CFT columns of length 500mm, 600mm, and 700mm. It can be seen from the figure that 700mm length specimen of 6.3mm aggregate provides larger strength capacity than 700mm length specimens of 10mm aggregate. Correspondingly 6.3CFTC500, 6.3CFTC600 has larger strength capacity than 10CFTC600 and 10CFTC700 specimens. It can be observed that strength capacity increases as the length increases.

Note: 6.3CFTC and10CFTC refers to concrete filled tubular column with 6.3mm and10mm size of coarse aggregates, length of the column is 500 and so on.

3.3.3 Comparison between Theoretical and Experimental Results

The experimentally obtained value is compared with theoretical value. It was found that about 1.6% increase in load carrying capacity by CFTC UPVC tubes experimentally than the theoretical value. The table 4 gives the corresponding increase of load carrying capacity of specimens by experimentally.

III. FIGURES AND TABLES

Table 1: Details of UPVC Tubes

Sl.No	Length(L) mm	Inner diameter(mm)	Outer diameter(mm)	Thickness(t) (mm)	L/D ratio	D/t ratio
1	500	150	157.11	7.11	3.18	22.09
2	600	150	157.11	7.11	3.81	22.09
3	700	150	157.11	7.11	4.45	22.09

Table 2: Theoretical results

Sl. No	Length (mm)	Total load
1	500	402.45
2	600	412.25
3	700	422.06

Table 3: Comparison between the Strength Parameters of 6.3mm and 10mm aggregate on CFTC UPVC Tubes

Sl. No	Specimen	Average Maximum load (kN)	Average Maximum displacement (mm)
1	6.3CFTC500	675.4	11.24
2	6.3CFTC600	696.5	10.61
3	6.3CFTC700	716.2	10.71
4	10CFTC500	644.2	9.29
5	10CFTC600	661.7	8.7
6	10CFTC700	682.7	8.24

Table 4: Comparison between Theoretical and Experimental results

Sl. No	Specimen	Theoretical Value	Experimental Value	% Increase in capacity
1	6.3CFTC500	402.45	675.4	1.678%
2	6.3CFTC600	412.25	696.5	1.689%
3	6.3CFTC700	422.06	716.2	1.696%
4	10CFTC500	402.45	644.2	1.6%
5	10CFTC600	412.25	661.7	1.605%
6	10CFTC700	422.06	682.7	1.617%

Fig 3: ASTM-D 1785 UPVC tubes of length 500, 600, 700mm having 150mm diameter

Fig 4:casting of CFT UPVC Tubes

Fig 5:Water Curing by Ponding at the Top and Gunny Bags at the Bottom of Specimen

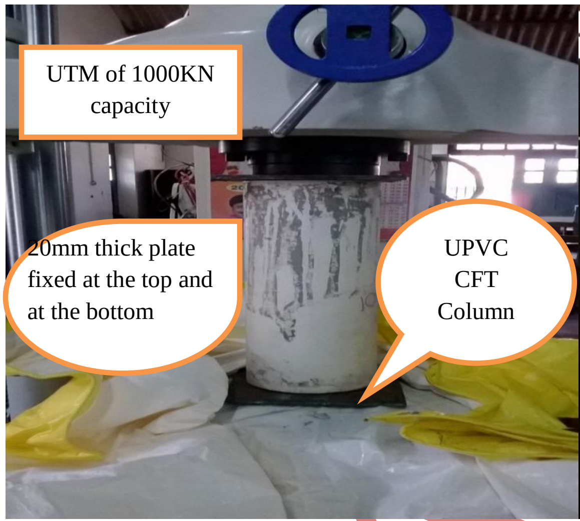

Fig 6: typical arrangement for loading using UTM

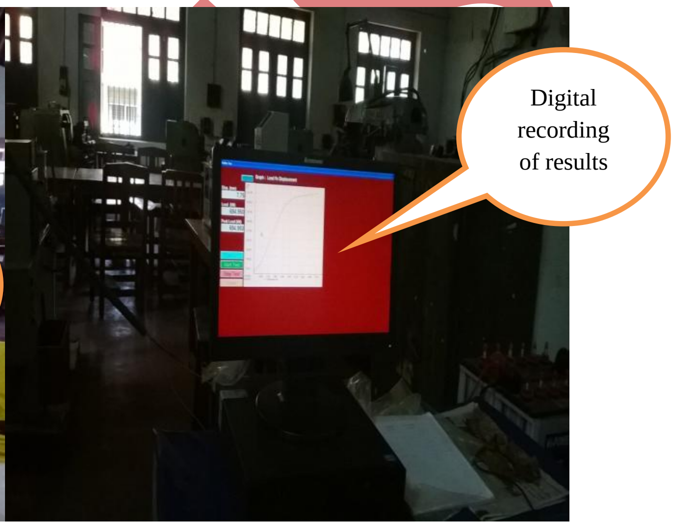

Fig 7: UTM with digital recording system of loading

Fig 8: increase in diameter (after testing)

Fig 9: decrease in length (after testing)

IV. CONCLUSION

1. Confinement of concrete columns with UPVC tubes improves their compressive strength. The improvement in strength is dependent on the concrete strength and geometrical properties of the tubes.
2. As the Length increases, the ultimate axial strength of the column increases.
3. Higher compressive strength of UPVC column can be obtained by using smaller coarse aggregates. It was concluded by conducting experiment with two types of i.e., 6.3mm and 10mm size of coarse aggregates.
4. The higher compressive strength is obtained with 6.3mm aggregate compared to 10mm size of coarse aggregate.
5. Local buckling is less due UPVC confinement.
6. The corresponding experimental result is compared with the theoretical results. The experimental result is about 1.6% greater than theoretical result.
7. The failure pattern can be seen by local buckling. i.e., Decrease in length and increase in diameter. About 5mm decrease in length and 3mm increase in diameter (Fig. 8 & 9). The UPVC CFTC was not completely failed till 11mm of compression in displacement. From it was concluded that UPVC CFTC absorbs considerable energy also.

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REFERENCE CODE OF PRACTICE

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- IS: 10262-2009 Recommended guidelines for concrete.
- IS: 383-1970 Indian Standard Specification for Coarse and Fine aggregates from natural sources for concrete.