EXPERIMENTAL INVESTIGATION ON PVC ENCASED COLUMNS

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Abstract

In the present study, poly vinyl chloride (PVC) tubes filled with concrete are axially loaded until failure of the specimen to investigate their load carrying capacity. Total eighteen specimens of PVC tubes of diameter 150 mm with effective lengths of 500 mm, 600 mm, and 700mm were cast. M_{20} *grade of concrete of two different mixes having two different sizes of aggregate 6.3mm and 10mm was filled inside the tubes for casting of PVC concrete filled tube (CFT) column specimens. The column specimens were tested for axial loading in the UTM machine of capacity 100 tons. Their load-displacement curves and stress-strain curves were recorded. Theoretical and experimental results were compared and tabulated and it was found to be 1.36% & 35.55 % for 6.3 mm size and 11.28% & 27.46% for 10 mm size of aggregates as conservative side as increased with compressive strength of PVC Concrete Filled Tube Columns experimentally and catalogue results when compared with theoretical results.*

Keywords: *PVC Pipe, CFTC, M20, Strength.*

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I. INTRODUCTION

Plastic have exceptional properties which make these materials attractive for different structural applications. Some of these properties include high resistance to severe environmental attacks, electromagnetic transparency, and high strength to weight ratios. Due to these properties there is a great demand for structures such as piling, poles highway overhand signs and bridge substructures to be made of materials that are more durable in comparison to traditional materials and system.

PVC is extensively used in the building industry as a low-maintenance material, particularly in Ireland, the United Kingdom, and in the United States. In the USA it is known as vinyl, or vinyl siding. The material comes in a range of colours and finishes, including a photo-effect wood finish, and is used as a substitute for painted wood, mostly for window frames and sills when installing double glazing in new buildings, or to replace older single-glazed windows. Other uses include fascia, and siding or weatherboarding. This material has almost entirely replaced the use of cast iron for plumbing and drainage, being used for waste pipes, drainpipes, gutters and downspouts. PVC is known as having strong resistance against chemicals, sunlight, and oxidation from water.

If structural CFT Columns can be developed from PVC Tubes, which is locally available in abundance, it would be a milestone achievement for the local construction industries. Therefore, the main objective of this research is to determine the feasibility of using PVC Tubes for CFT Columns when it is axially loaded to investigate their load carrying capacity and associated ductility. The objectives are briefly summarized below:

- To study the PVC Tubes subjected to axial loading by considering Length.
- To study the influence of concrete strength by using two different sizes of coarse aggregate 6.3mm and 10 mm using design mix method as per IS:10262-1982.
- To study the strength and confinement of concrete filled PVC pipes.

2. MATERIALS AND METHODOLOGY

MATERIALS USED

PVC Pipes,Cement, Fine aggregate, Coarse aggregate & water as shown in Plate(1)& (2)

Plate (1) PVC Tube Plate(2) Concrete Filled PVC Tube

Mix Design

Step 1: Target Mean Strength for M_{20} Grade Concrete

$f''_{ck} = f_{ck} + 1.65s$

$f'_{ck} = 20 + 1.65*4.6 = 27.59$ N/ mm^2

Step 2: Determination of cement content

Water cement ratio = 0.48

Water = 220.48

Cement = 220.48 / 0.48 =459.38 kg/m^3

Step 3: Determination of coarse and fine aggregate content

$V = [W + (C/S_o) + (1/p)(f_a/Sf_a)] * (1/1000)$, and

$V = [W + (C/S_o) + (1/1\text{-}p)(c_a/Sc_a)] * (1/1000)$

$V = [W + (C/S_o) + (1/p)(f_a/Sf_a)] * (1/1000)$

$0.97 = [220.48 + (459.33/3.06) + (1/0.38)(f_a)] * (1/1000)$

$f_a = 603.60$ $c_a = 1003.41$

Cement	Fine aggregate	Coarse aggregate	Water
459.33	603.60	1003.41	220.48
1	1.31	2.18	0.48

Table (a). Mix proportion

3. EXPERIMENTAL PROGRAM

M_{20} grade of concrete was used to fill the tubes for the casting of PVC 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 PVC CFT columns. The eighteen PVC Tubes, nine tubes for 6.3mm size coarse aggregate and another nine tubes for 10mm size coarse aggregate were casted. To prepare the specimens, PVC 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 150 mm and thickness 7.11 of 500 mm, 600 mm and 700 mm length were cut. The PVC 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(b) gives the data of selected PVC 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 PVC tube to obtain the concrete filled tubular column specimen

It includes several steps they are:-

1 Trial Mix Preparation
2 Mixing of Concrete
3 Basic Test Procedures on Materials
3.1 Slump Test
3.2 Compaction Factor Test
4 Casting and Testing of Cubes
4.1 Curing of Cubes
4.2 Checking Compressive Strength of Cubes
5 Casting of Specimens
5.1 Curing of Specimens
5.2 Checking Compressive Strength of Specimens

Detailed description of the experimental setup as shown in Plate (3) & (4) and the mix proportion and the basic tests for the two different mix proportions of 6.3mm, 10mm size coarse aggregates has been carried out. Compaction factor, slump value was found out. Finally for good mix proportion cubes were casted and cured. Corresponding 7days and 28days compressive strength for 6.3mm, 10mm size coarse aggregate mixes has been presented.

Plate (3): Experimental Setup

Plate (4): PVC pipe Test

Table (b): Details of PVC 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

IV. RESULTS AND DISCUSSIONS

Theoretical Result

The total load carried by the concrete filled PVC tubes is calculated by considering both the load carried by tube and concrete. The load calculation is as follows:

P = Pp + Pc,

$P = (Ap * fp) + (Ac * fc)$

$P = (L * t * fp) + (((\pi / 4) * d^2) * fc)$

Table (c). Theoretical Results

Sl. No.	Length (mm)	Stress based on catalogue ($13.79\ N/mm^2$)	Stress based on experimental work ($65.88\ N/mm^2$)
		Total Load(kN)	
1	500	402.45	587.63
2	600	412.25	634.47
3	700	422.06	681.31

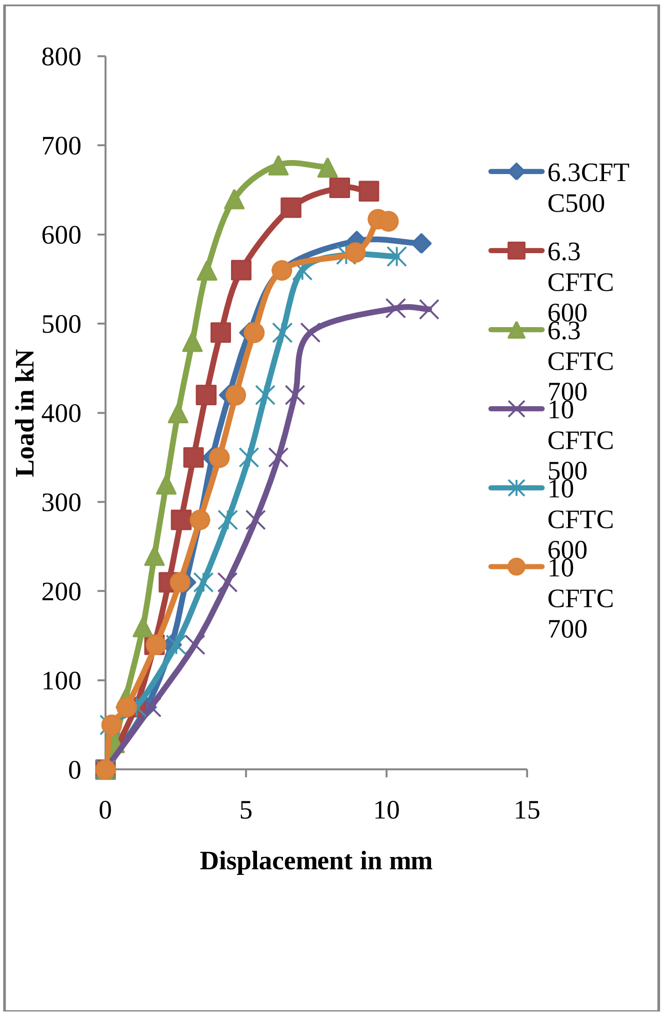
6. COMPARISON BETWEEN THE STRENGTH PARAMETERS OF 6.3MM AND 10MM SIZE OF AGGREGATE ON CFTC PVC TUBES

In this experimental work it was proved that the smaller aggregate will give higher compressive strength. The following table will give the corresponding compressive strength parameters of 6.3mm and 10mm aggregate on CFTC PVC tubes of L/D ratio 3.33, 4 and 4.67.

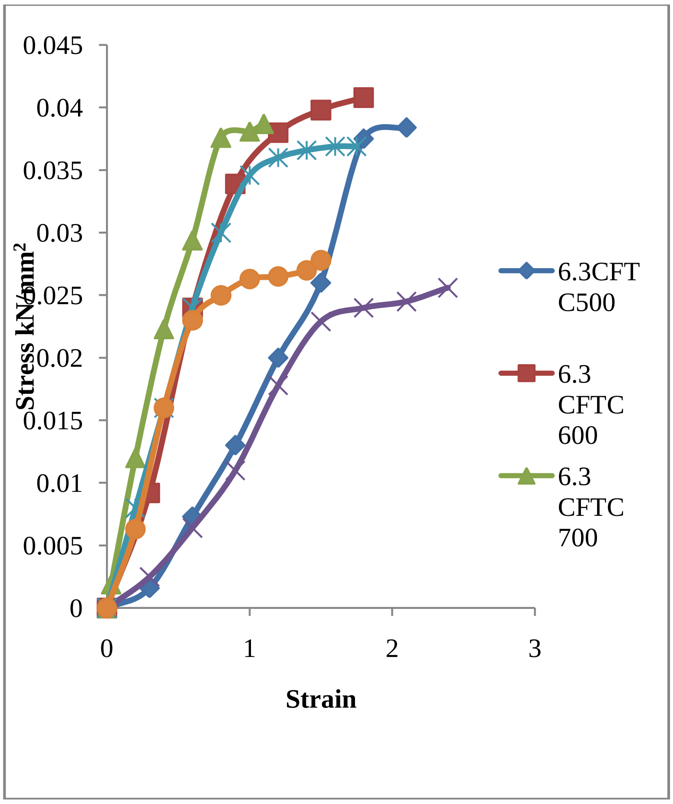
Table (d). Comparison between the Strength Parameters of 6.3mm and 10mm Aggregate on CFTC PVC Tubes

SL.NO	SPECIMEN	AVERAGE MAXIMUM LOAD (KN)	AVERAGE MAXIMUM DISPLACEMENT (MM)
1	6.3CFTC500	592.73	11.24
2	6.3CFTC600	652.31	9.37
3	6.3CFTC700	677.98	7.9
4	10CFTC500	517.19	11.51
5	10CFTC600	577.33	10.36
6	10CFTC700	617.3	10.07

In the Fig(a) the load v/s displacement is plotted for M_{20} grade of concrete with 6.3mm and 10mm size of coarse aggregates for length varied from 500 to 700mm and the following points are observed



Fig(a). Load v/s Displacement Comparison for 6.3CFTC500, 6.3CFTC600, 6.3CFTC700 and 10CFTC500, 10CFTC600, 10CFTC700



Fig(b). Stress v/s Strain Comparison for 6.3CFTC500,

6.3 CFTC600, 6.3CFTC700 and 10CFTC500, 10CFTC600, 10CFTC700

Fig (b) shows stress-strain curves for the confinement mechanisms of 6.3mm and 10mm aggregate CFT columns of length 500mm, 600mm, and 700mm.

6.4 Comparison Between Theoretical And Experimental Results

The experimentally obtained value is compared with theoretical value. The following table gives the corresponding increase of load carrying capacity of specimens by experimentally.

Here we observed that the experimental results were about 35.55% greater than the theoretical results for the concrete columns which is prepared by using 6.3mm size of aggregates(stress value i.e., fp=13.79N/mm^2) and also It has been observed that the experimental results were about 27.46% greater than the theoretical results for the concrete columns which is prepared by using 10mm coarse aggregates(stress value i.e., fp=13.79N/mm^2). The strength obtained was greater for 6.3mm size aggregate compared to 10mm size of aggregate for PVC CFT columns (stress value i.e., fp=13.79N/mm^2). Similarly observed experimental results were about 1.36% and 11.28% greater than the theoretical results for the concrete columns which is prepared by using 6.3mm and 10 mm size of aggregates respectively(stress value i.e., fp=65.88N/mm^2). Plate (5) & (6) shows that the failure of PVC tubes

Table (d) Comparison between Theoretical and Experimental results

Sl. No.	Specimen	Theoretical values		Experimental values	Increase of load in %	
		Stress Based on Catalogue	Stress Based Expt. Work			
		Load in kN		Load in kN	As per Catalogue	As per Expt.
1	6.3CFTC500	402.45	587.63	592.73	32.10	0.86
2	6.3CFTC600	412.25	634.47	652.31	36.80	2.73
3	6.3CFTC700	422.06	681.31	677.98	37.75	0.49
4	10CFTC500	402.45	587.63	517.19	22.18	13.61
5	10CFTC600	412.25	634.47	577.33	28.59	9.89
6	10CFTC700	422.06	681.31	617.30	31.62	10.36

Plate(5) FailureofPVCTube
Plate(6) IncreaseinDiameter(AfterExpt) Decrease in Length (After Expt)

7. CONCLUSION

- Confinement of concrete columns with PVC tubes improves their compressive strength. The improvement in strength is dependent on the concrete strength and geometrical properties of the tubes.
- As the Length increases, the ultimate axial strength of the column increases.
- The corresponding experimental result is compared with the theoretical results. The experimental result is about 35.55% and 27.46% greater than theoretical result for the concrete columns which is prepared by using 6.3mm and 10 mm coarse aggregates respectively(stress value i.e., $fp=13.79N/mm^2$).
- Similarly observed experimental results were about 1.36% and 11.28% greater than the theoretical results for the concrete columns which is prepared by using 6.3mm and 10 mm size of aggregates respectively(stress value i.e., $fp=65.88N/mm^2$).
- 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. The PVC CFTC was not completely failed till 10 mm of compression in displacement. From it was concluded that PVC CFTC absorbs considerable energy also.

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REFERENCE CODE OF PRACTICE

- IS:456-2000 Plain and reinforced concrete code of practice.
- IS:10262-1982 Recommended guidelines for concrete.
- IS:10262-2009 Recommended guidelines for concrete.
- IS:383-1970 Indian Standard Specification for Coarse and Fine aggregates from natural sources for concrete.