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# EXPERIMENTAL STUDY ON CONFINEMENT EFFECT OF CONCRETE FILLED IN PVC-FRP COLUMN

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**Abstract –** *The main objective of this paper was to experimentally investigate behavior of different column specimens confined with PVC to conventional column. The different columns specimens are PVC-FRP column, PVC-FRP column with wire mesh, PVC column with wire mesh were used for the study. PVC tubes of 2 different thicknesses of 3.7m and 5.4mm were used. The variables included in the paper were concrete compressive strength, PVC tube thickness and slenderness ratio. The test results indicated that the PVC-FRP column with wire mesh shows more strength capacity compared to other columns. It was found that the compressive strength of PVC-FRP column with wire mesh of 3.7mm thickness was increased by 25.84%, 4.98%& 10.52%compared to conventional column, PVC –FRP Column, PVC column with wire mesh for the height of 300mm. The compressive strength of PVC-FRP column with wire mesh of 5.4mm thickness was increased by 39.49%, 3.47%&8.53% compared to conventional column, PVC –FRP column, PVC with wire mesh column for the height of 300mm.*

***Key Words*: PVC-FRP tube, wire mesh, compressive strength, tube thickness, slenderness ratio etc.**

## 1. INTRODUCTION

In building construction, the complete benefits of a structure depends on certain important factors such as strength, durability and workability. These properties depend on the structural materials used in the construction and no single material alone is possible for the same requirements which resulted in the usage of composite structure. When the longitudinal reinforcement is in the form of structural steel section or pipe with or without longitudinal bars, it is called as a composite column. The advantages of composite columns are increased strength for a given cross sectional dimension increased stiffness, leading to reduced slenderness and increased buckling resistance, corrosion protection in encased columns and significant economic advantages over either pure structural steel or reinforced concrete alternatives. PVC confined concrete column is effective in load carrying capacity Incorporation of FRP (Fiber reinforced polymer) can improve load carrying capacity and hence prevents local bulging of PVC. Fibre-reinforced polymer (FRP) also Fibre-reinforced plastic is a composite material made of a polymer matrix reinforced with fibres. FRP composites are lightweight, no-corrosive, exhibit high specific strength and specific stiffness are easily constructed and can be tailored to satisfy performance requirements. Due to these advantageous characteristics, FRP composites have been included in new construction and rehabilitation of structures through its use as reinforcement in concrete, bridge decks, modular structures, formwork, and external reinforcement for strengthening and seismic upgrade. The system of new column consists of concrete confined within PVC tube reinforced with fiber reinforced polymer and wire mesh is provided as lining inside the PVC.

The experiment was conducted to investigate the strength of PVC-FRP column with wire mesh with PVC-FRP Column and PVC column providing wire mesh as lining inside PVC without FRP.

### 1.1 OBJECTIVE

- To construct economical PVC-FRP column with wire mesh.
- To experimentally investigate the behavior of PVC confined columns to conventional column.
- To analyze the effect of confinement in load carrying capacity of column.
- To analyze the strength characteristics with thickness of pipe, slenderness ratio.
- To produce load-deflection curve.

## 2. MATERIALS AND PROPERTIES

*1) Cement*

Ordinary Portland Cement (OPC) of 53 grade was used.

**Table 1**: Properties of cement

| Physical properties | Results |
|---|---|
| Fineness | 1.76 |
| Standard consistency | 32% |
| Initial setting time | >1 Hour |
| Soundness test | 1 |
| Specific gravity | 3.15 |

*2) Fine aggregate and Coarse aggregate*

MSand or manufacturer sand was used as fine aggregate and Msand belongs to zone 2. Crushed stone with maximum size of 20mm was used as coarse aggregate.

**Table 2:** Properties of aggregates

| Physical properties | Results | |
|---|---|---|
| | Fine aggregate | Coarse aggregate |
| Bulk density | 1.69 | 1.746 |
| Specific gravity | 2.47 | 2.97 |
| Void ratio | .475 | .679 |
| Porosity | .322 | .404 |
| Fineness modulus | 2.88 | 4.64 |

*3) PVC*

Two different thickness pipes of heights 300mm and 500mm was used. These pipes are manufactured in accordance with IS 4985:2000. The properties of PVC is given in table 3.

**Table 3**: Properties of PVC

| Gauge of pipe | Class of pipe (IS4985:2000) | Dimensions | | Density |
|---|---|---|---|---|
| | | Outer Dia(mm) | Wall Thickness | |
| 4 | II | 160 | 3.7 | 1.45 |
| 6 | III | 160 | 5.4 | 1.45 |

*4) Carbon fiber FRP composites*

Carbon fiber FRP composites with thickness of 0.165mm having an ultimate tensile strength of 4410 were used.

*5) Resin*

Araldite AW 106 and Hardener HV 953 IN were used as epoxy resin with an ultimate tensile strength of 34.80 N/mm2 (ASTM D638), flexural modulus 3377 N/mm2 (ASTM D790), flexural strength 32.0 N/mm2 (ASTM D790), elastic modulus of 1500 N/mm2 (ASTM D638), density 1.35 g/cc (IS4456).

*6) Wire mesh*

Steel wire mesh of 1mm thickness were used as lining inside PVC for extra confinement to the structure.

*7) Admixture*

CERAPLAST 300 was used as admixture in the project.

## 2. SPECIMEN PREPARATION

The conventional column of 150mm X 300mm (C1) and 150mm X 500mm (C2) of M40 concrete were casted. The grooves of 5mm width and 2mm depth were made on the surfaces of PVC using lathe and grooves were cleaned. Epoxy was mixed according to the specifications provided by the manufacturer. Then the epoxy was applied to the grooves and FRP sheets wrapped manually on these grooves and one more layer of epoxy was applied on the surface of FRP sheets and kept for 24hrs.This procedure was done for both the thickness and for the both heights of PVC. Concrete was placed to the above PVC –FRP tube to prepare PVC-FRP column (Z2, Z2*, X2, X2*). A wire mesh was provided additionally to PVC–FRP tube as a lining inside PVC, then concrete was placed (Z3, Z3*, X3, X3*).Another column was prepared by placing concrete to the PVC with wire mesh as a lining inside PVC (Z4, Z4*, X4, X4*).

**Fig 1**.PVC-FRP tubes.

**Fig 2.**PVC-FRP with wire mesh as lining inside PVC.

## 3. TESTING

The specimens were tested using Universal Testing Machine of 2000KN capacity to determine the load carrying capacity at the age of 28days, a dial gauge was placed to determine the vertical deflections.


**Fig 3.**Experimental setup

## 4. RESULTS AND DISCUSSIONS

### A.compressive strength

The ultimate load and corresponding deflection for all column specimens are shown in Chart 1, chart 2, chart 3, and chart 4.The ultimate load of PVC-FRP column with wire mesh column was high compared to other column specimens. The compressive strength of PVC-FRP column with wire mesh of 3.7mm thickness (Z3) was 4.98% more than PVC-FRP column (Z2) that is, 10.52% more than PVC column with wire mesh (Z4) and 25.84%more than conventional columns for same height of 300mm. PVC column with wire mesh (Z4 & X4) undergoes more deflection compared to other column specimens.

The compressive strength of PVC-FRP column with wire mesh of 5.4mm thickness (X3) was 3.47% more than PVC-FRP column (X2) that is, 8.53% more than PVC column with wire mesh (X4) and 39.49%more than conventional columns for same height of 300mm.

### B.Effect of thickness

The compressive strength was high for column specimens of PVC with 5.4mm thickness than the column specimens of PVC with 3.7mm thickness. PVC column with 5.4 mm thickness undergoes more deflection than column with 3.7mm thickness. There was an increase in compressive strength of 12.46%, 10.84% & 12.87% for PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 5.4mm thickness (X2,X3&X4)respectively compared to PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 3.7mm thickness (Z2,Z3&Z4).

### C.Effect of slenderness ratio

As the column length increases, the strength of specimen deceased with more deflection. The compressive strength was found decreased 8.37%, 2.55%, 3.71% &4.11% for conventional column, PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 500mm height (C2, Z2*, Z3*&Z4*) compared to conventional column, PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 300 mm height (C1, Z2, Z3&Z4) respectively for 3.7mm thickness. The compressive strength was found decreased 3.62%, 2.3% &1.3% for PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 500mm height (X2*,X3*&X4* )compared to PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 300mm height (X2,X3&X4 )respectively for 5.4mm thickness.

The region at the mid height of column was free to expand laterally and this caused excessive cracking of concrete which leads to failure of columns. Also this reduction be attributed to that with an increase in the slenderness ratio, lateral buckling may occur which causes some bending to develop causing failure at loads less than the failure of short columns.

**Table 4:** Compressive strength of column specimens

| Sl.no | Specimens | Compressive strength (KN/MM2) | Deflections (MM) |
|---|---|---|---|
| 1 | C1 | 36.49 | 3.6 |
| 2 | Z2 | 43.74 | 3.9 |
| 3 | Z3 | 45.92 | 3.65 |
| 4 | Z4 | 41.55 | 4.25 |
| 5 | X2 | 49.19 | 4.2 |
| 6 | X3 | 50.9 | 3.9 |
| 7 | X4 | 46.9 | 4.5 |
| 8 | C2 | 33.67 | 4 |
| 9 | Z2* | 42.65 | 4.2 |
| 10 | Z3* | 44.28 | 3.92 |
| 11 | Z4* | 39.91 | 4.45 |
| 12 | X2* | 47.47 | 4.4 |
| 13 | X3* | 49.76 | 4.2 |
| 14 | X4* | 46.3 | 4.7 |

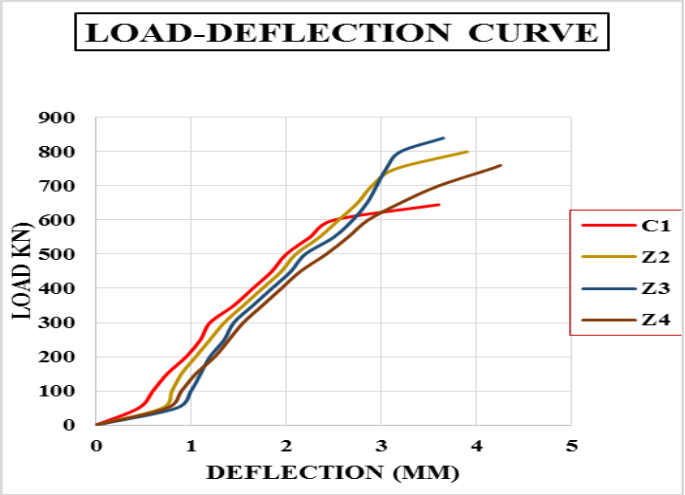


**Chart 1** .Load deflection curve of PVC with 3.7mm thickness for 300mm height.

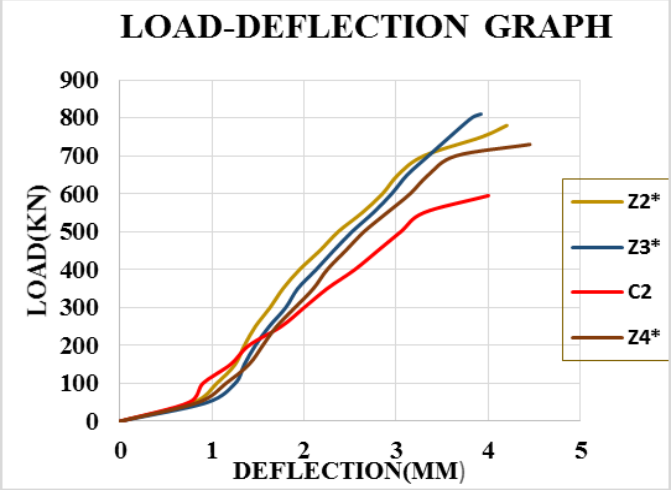


**Chart 2.** Load deflection curve of PVC with 3.7mm thickness for 500mm height

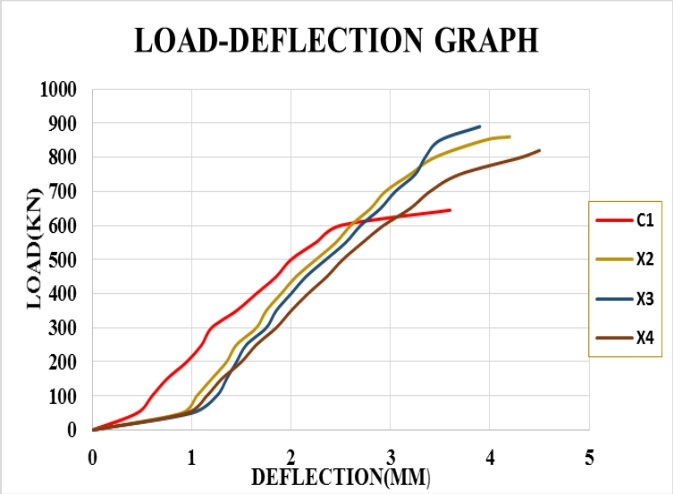


**Chart 3.** Load deflection curve of PVC with 5.4mm thickness for 300mm height

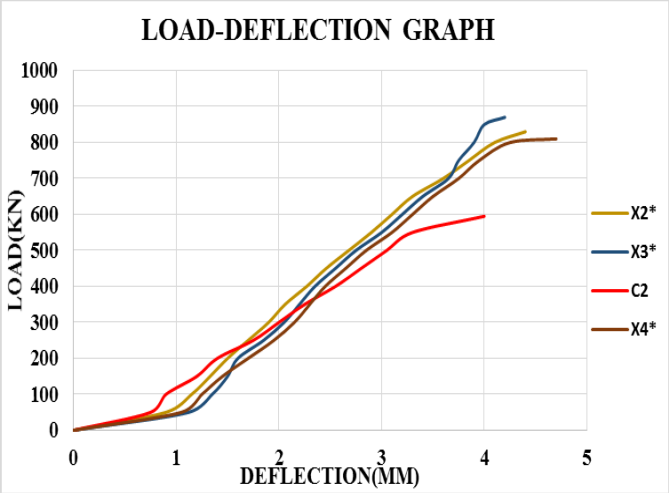


**Chart 4.** Load deflection curve of PVC with 5.4mm thickness for 500mm height

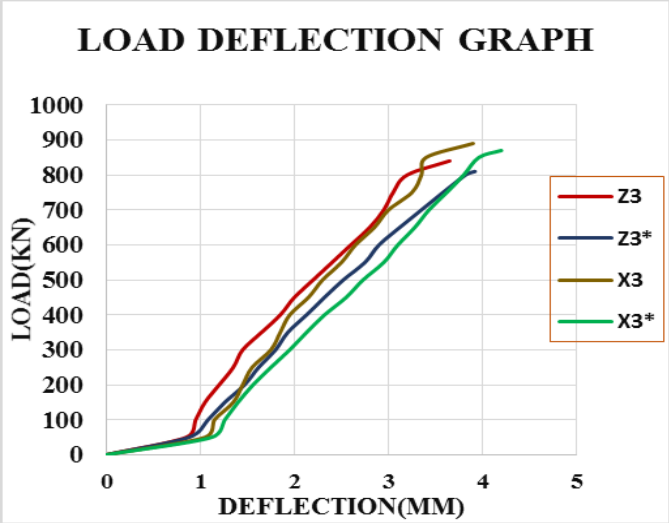


**Chart 5.**Load deflection curve for the both the thickness and height of PVC

## 5. CONCLUSION

- Out of all column specimens, the compressive strength was found increased for PVC –FRP column with wire mesh for both the thickness of PVC.
- The compressive strength of PVC-FRP column with wire mesh was found to be increased 25.84%, 4.98% & 10.52% compared to conventional column, PVC-FRP column and PVC column with wire mesh respectively for the PVC with 3.7mm thickness of 300mm height.
- The compressive strength of PVC-FRP column with wire mesh was found to be increased 31.51%, 3.82% & 10.94% compared to conventional column, PVC-FRP column and PVC column with wire mesh respectively for the PVC with 3.7mm thickness of 500mm height.
- The compressive strength of PVC-FRP column with wire mesh was found to be increased 39.49%, 3.47% & 8.53% compared to conventional column, PVC-FRP column and PVC column with wire mesh respectively for the PVC with 5.4mm thickness of 300mm height.
- The compressive strength of PVC-FRP column with wire mesh was found to be increased 47.78%, 4.82% & 7.47% compared to conventional column, PVC-FRP column and PVC column with wire mesh respectively for the PVC with 5.4mm thickness of 500mm height.
- PVC with 5.4mm thickness undergoes more deflection and strength compared to PVC with 3.7mm thickness.
- There was an increase in compressive strength of 12.46%, 10.84% & 12.87% for PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 5.4mm thickness (X2,X3&X4)respectively compared to PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 3.7mm thickness (Z2,Z3&Z4).
- There was an increase in compressive strength of 11.3%, 12.37% & 16.01% for PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 5.4mm thickness

(X2*,X3*&X4*)respectively compared to PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 3.7mm thickness (Z2*,Z3*&Z4*).

- As the column length increases, the strength of specimen deceased with more deflection.
- The compressive strength was found decreased 8.37%, 2.55%, 3.71% &4.11% for conventional column, PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 500mm height (C2, Z2*, Z3*&Z4*) compared to conventional column, PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 300 mm height (C1, Z2, Z3&Z4) respectively for 3.7mm thickness.
- The compressive strength was found decreased 3.62%, 2.3% &1.3% for PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 500mm height (X2*,X3*&X4* )compared to PVC-FRP column, PVC-FRP column with wire mesh and PVC column with wire mesh of 300mm height (X2,X3&X4 )respectively for 5.4mm thickness.
- The ultimate strength of columns decreased with increase in heights, the reason for the failure of these columns was due to crushing of materials for 300mm column but combined effect of crushing with lateral expansion of column results in the failure of 500mm columns

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