Assessment of Concrete Cylinders Confined with HDPE, PVC & UPVC Tubes

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Abstract—This project presents an experimental study on the behavior of circular concrete cylinders confined by High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC) and Unplasticized Poly Vinyl Chloride (UPVC) tubes under axial loading. A total of 12 specimens were prepared and tested under axial loading. The main parameters varied in the tests were strengthening ratio and strengthening approach of HDPE, PVC and UPVC. The performance, such as failure modes and ultimate bearing capacity, was investigated in details. The results show that this kind of confined columns obviously improves the ultimate bearing capacity, and failure modes.

Index Terms— High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC) and Unplasticized Poly Vinyl Chloride (UPVC)

1. INTRODUCTION

Strengthening or repairing of deteriorating concrete columns has now become one of the areas of study in construction industry across the world. One of the deficiencies in concrete columns is the lack of lateral confinement and low energy absorption capacity. Researchers are working on the techniques by which such deficiencies can be minimized during construction stage. The strength, ductility and energy absorption capacity of new concrete columns during construction can be enhanced by providing external confinement by employing HDPE, PVC and UPVC tubes. These tubes can be used as formwork there after during construction and as an integral part of column. There are a number of confinement materials to be used for confining concrete columns. Structural steel tubes are extensively studied for such purpose in past two decades. Fibre reinforced polymer composite tubes are used for confinement of concrete by many researchers with performing experimental studies.

A very few studies are available in which PVC tubes are used for confinement of concrete column specimens. In view of these facts, the present study has tried to strengthen the concrete column by using the UPVC, HDPE & PVC tube as outer confining layer in order to increase the load carrying capacity, ductility and durability of the column and compare with the conventional concrete. In order to evaluate the behaviour of the proposed UPVC, PVC and HDPE tube columns more objectively and thoroughly, an experimental study is performed. The test results are presented and discussed its strength point of view.

Since use of UPVC for confinement of concrete is relatively new and theoretical work available in this area is very limited.

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2. BACKGROUND

Pramod (2010) studied in Increase and decrease in strength of concrete core due to confinement and slenderness ratio respectively. Polyethylene copolymer coatings have been used of the protection of external surface of onshore no offline pipeline. All specimens exhibited a good ductility and still retained the integrity. Core concrete is damaged by shear stress in one direction due to weak confinement effect of the tube. The shear crack direction can be judged by the appearance of the specimen. To avoid the shear failure of the specimens, the diameter to wall thickness ratio (D/t ratio) of the tube should be taken sufficiently lower.

DiatoNiu (2010) investigated that the design of PVC-FRP confined concrete members requires accurate evaluation of the performance enhancement due to the confinement provided by PVC-FRP tube. The comparison between experimental and numerical shows that the model provides satisfactory predictions of the stress-strain response of the column.

Li Ning investigated that the lateral confining effect has an important influence on the failure mode of BFRP-PVC specimens. The failure mode of core concrete tends to shear failure with the increasing lateral confining effect. The Hoop Strain and axial strain of PVC increase with the load increasing, the hoop strain increase slowly and the axial strain increases rapidly, but the hoop strain to axial strain ratio increases, which indicates the lateral confining effect increasing. Columns, concrete confined by BFRP-PVC tube, has good ultimate bearing capacity and ductility owing to the confining by BFRP-PVC tubes.

3. OBJECTIVES

This work proposes a new kind of composite column, which is obtained by filling HDPE, PVC and UPVC tubes with concrete.

To improve the compressive strength and ductility by confinement of concrete column with HDPE, PVC and UPVC tubes.

To improvement the strength and ductility depend upon the concrete strength and geometrical properties of the tubes.

4. Materials Used

4.1 Cement

Ordinary Portland Cement of 53 Grade was used in this study. Having Standard Consistency 32 %, Initial Setting Time 25 minutes, Specific Gravity 3.15 and Fineness Modulus 6 %.

4.2 Sand

Locally available river sand of size passing through 4.75 mm sieve and having specific gravity 2.6 was used in this study.

4.3 Coarse Aggregate

Locally available coarse aggregate of size passing 20mm and retain in a 12.5mm sieve and well graded such that voids do not exceed 42% was used in this study.

4.4 Water

Portable water was used for mixing of concrete.

4.5 PVC

PVC has high hardness and mechanical properties. The mechanical properties increase the molecular weight increasing, but decrease the temperature increasing. PVC's relatively low cost, biological and chemical resistance and workability have resulted in it being used for a wide variety of applications.

4.6 UPVC

Unplasticized polyvinyl chloride is extensively used in the building industry as a low-maintenance material; the material comes in a range of colours and finishes, including a photo-effect wood finish.

4.7 HDPE

High Density Polyethylene (HDPE) is a versatile plastic that has many practical uses, not the least of which is for the fabrication of pipe. The number one characteristic that sets HDPE apart from other pipe types is that it can be made to be flexible. Geometrical properties of HDPE, PVC and UPVC Tubes is given in Table I

TABLE I

GEOMETRICAL PROPERTIES OF HDPE, PVC AND UPVC TUBES

SL No	Specimen	Mean Tk. (t) mm	Inner Dia. (d) mm	Outer Dia. (D) mm	C/S Area (mm^2)	D/t Ratio	L/D Ratio	Length (L) mm
1	HDPE	7	100	114	2353	16.29	2.63	300
2	PVC	3.5	105	112	1193	32	2.68	300
3	UPVC	7	100	114	2353	16.29	2.63	300

5. Experimental Methodology

The methodology adopted to achieve the objective is as shown in Fig 3 and Fig 1 and 2 shows UPVC and HDPE confined concrete specimen.

Fig 1 UPVC Confined Concrete Specimen

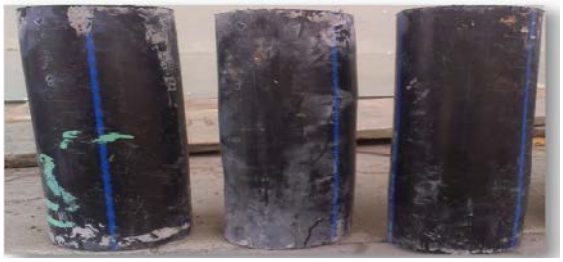

Fig 2 HDPE Confined Concrete Specimen

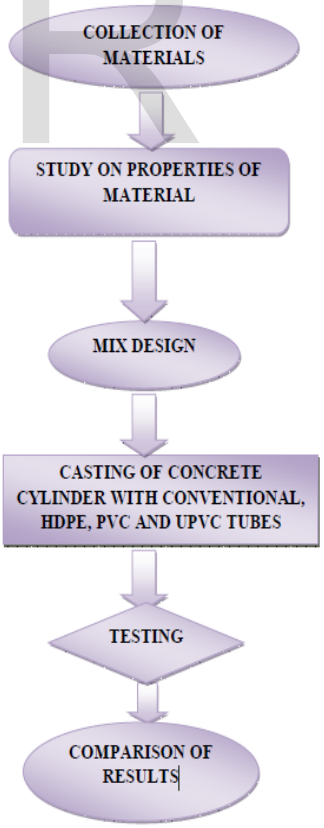

Fig 3 Methodology

6. RESULTS

6.1 Slump Test

Mix proportion considered in this study was 1:1.46:2.94 with w/c ratio 0.50. Slump value got was 120mm that is with nature of collapse is true slump.

6.2 Compaction Factor Test

Mix proportion considered in this study was 1:1.46:2.94 with w/c ratio 0.50. Compaction factor obtained was 0.896 that is with nature of collapse is true slump.

6.3 Compressive Strength

Compressive strength of concrete is one of the methods to measure the quality of the concrete. This test was carried out in digital compression testing machine. Cubes are tested for compressive strength with rate of loading of 2.3kN/sec. Compression strength tests were conducted on three cubes 28 days.

TABLE II

COMPRESSION STRENGTH OF CONVENTIONAL CONCRETE

Test Samples	Compressive Strength (N/mm²)
1	28.98
2	28.36
3	29.60

From Table II it is clear that compression strength of conventional concrete is about 28.98 kN/mm². These test results were obtained after 28 days of curing which obeys IS specification.

Fig 4 Compression strength test of concrete specimen confined with HDPE and UPVC Pipe.

TABLE III

COMPRESSION STRENGTH OF CONCRETE CONFINED WITH HDPE TUBE

Test Samples	Compressive Strength (N/mm²)
1	32.06
2	29.60
3	30.83

From Table III it is clear that compression strength of concrete Confined with HDPE Tube is about 30.83 kN/mm². These test results were obtained after 28 days of curing which obeys IS specification

TABLE IV

COMPRESSION STRENGTH OF CONCRETE CONFINED WITH PVC TUBE

Test Samples	Compressive Strength (N/mm²)
1	37
2	35.15
3	35.77

From Table IV it is clear that compression strength of concrete Confined with PVC Tube is about 35.97 kN/mm². These test results were obtained after 28 days of curing which obeys IS specification

TABLE V

COMPRESSION STRENGTH OF CONCRETE CONFINED WITH UPVC TUBE

Test Samples	Compressive Strength (N/mm²)
1	47.73
2	51.55
3	44.46

From Table V it is clear that compression strength of concrete Confined with UPVC Tube is about 47.93 kN/mm². These test results were obtained after 28 days of curing which obeys IS specification

- Comparison of compression test results of conventional concrete with concrete cylinder confined with HDPE pipes.

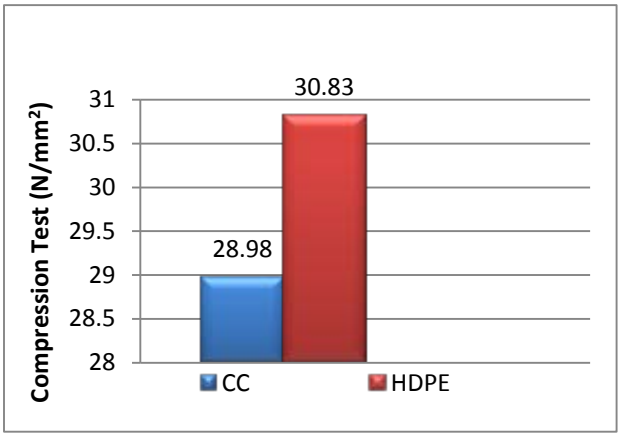

Chart 1: Comparison of compression test results of conventional concrete with concrete cylinder confined with HDPE pipes.

While comparing the compressive strength of conventional concrete with HDPE confined concrete it is clear that

Compressive strength of HDPE confined concrete is 6% more than that of conventional concrete cylinder.

- Comparison of compression test results of conventional concrete with concrete cylinder confined with PVC pipes.

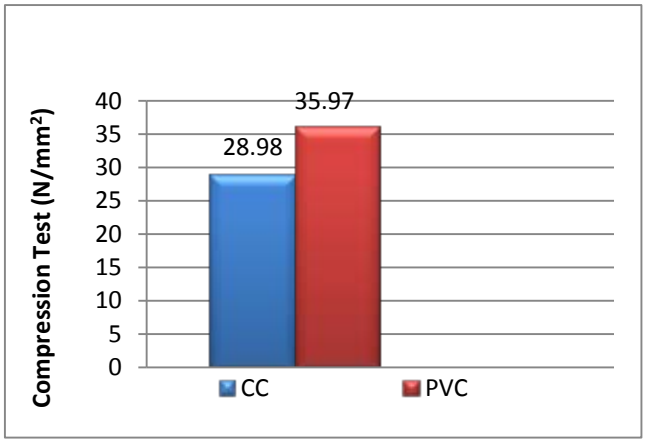

Chart 2: Comparison of compression test results of conventional concrete with concrete cylinder confined with PVC Pipes

Fig 5 Failure of HDPE and PVC Confined Concrete specimen

Fig 6 Failure of HDPE and PVC Confined Concrete specimen

While comparing the compressive strength of conventional concrete with PVC confined concrete it is clear that Compressive strength of PVC confined concrete is 19.43% more than that of conventional concrete cylinder.

- Comparison of compression test results of conventional concrete with concrete cylinder confined with UPVC pipes

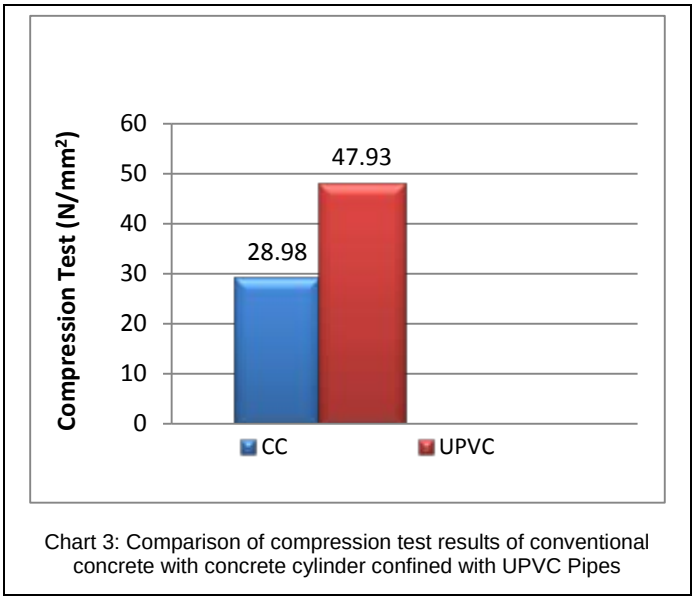

Chart 3: Comparison of compression test results of conventional concrete with concrete cylinder confined with UPVC Pipes

While comparing the compressive strength of conventional concrete with UPVC confined concrete it is clear that Compressive strength of UPVC confined concrete is 39.54% more than that of conventional concrete cylinder.

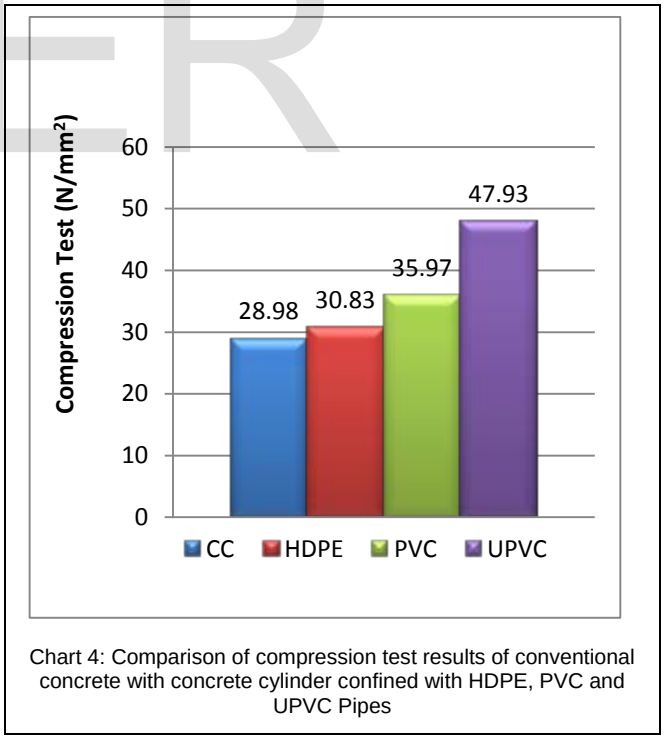

Chart 4: Comparison of compression test results of conventional concrete with concrete cylinder confined with HDPE, PVC and UPVC Pipes

Confinement effect of HDPE, PVC and UPVC increased 6%, 19.43% and 39.54% respectively with compare to conventional concrete and UPVC is increased 35.68% and 25.00% when compared to HDPE and PVC respectively.

7. CONCLUSION

- Confinement of concrete column with HDPE, PVC and UPVC tubes improve their compressive strength and ductility.
- Depend upon the concrete strength and geometrical properties of the tubes the improvement in strength and ductility.
- Confinement effect of HDPE, PVC increased with conventional concrete and UPVC is increased with compare to HDPE and PVC.
- Failure pattern of all the concrete filled with PVC tube is brittle type failure.
- HDPE and UPVC tubes failure pattern is shear type failure.
- Use of HDPE, PVC and UPVC pipes in confinement of concrete will help to achieve good compressive strength and also helps in the penetration and corrosion control in concrete.

8. REFERENCES

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