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Research Article

CONFINEMENT OF REINFORCED CONCRETE COLUMN WITH UPVC

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A R T I C L E I N F O

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A B S T R A C T

Existing construction technology has not delivered the reliability needed. The rapid deterioration of infrastructure, especially those constructed in severe environments such as bridge piles, has increased the demand for advanced measures in building and bridge substructures. It is necessary to strengthen the concrete columns to increase their load carrying capacity. The cost of formwork was about 40% of the cost of concrete works, the rest being accounted for by labour and the cost of materials. Eliminating or reducing this formwork in construction can significantly reduce the cost of construction. The use of plastic tubes will act as a confinement material as well as a permanent formwork and this will eliminate the need for temporary formwork. Steel and FRP tubes have been widely researched on and used to confine concrete in CFT columns systems. However steel is prone to corrosion, weathering, and chemical attacks especially when used in severe environments such as under-sea piling. According to the specification the casting of short column was carried out. Then the specimen is cured for28 days and on 28th the axial compression testing of short column on load testing machine which has capacity of 15000 kN.

INTRODUCTION

Governments in various countries are now investing heavily to develop unique high- performance construction materials and systems. Special interest is being directed towards advanced composite materials and systems. An example of advancement into these types of new composite systems is the concrete-filled steel tube (CFST) column systems. CFSTs have been used for years as piles and columns and extensive research has been established in this area of advanced composite construction materials. However, CFSTs have the problem of corrosion of steel tubes as well as reduced confinement effectiveness at low levels of loading if the tube is also loaded in the axial direction. This is due to the fact that Poisson's ratio of concrete at low levels of loading is smaller than the value for steel. It is observed that the differential radial expansion of steel tube and concrete, at low levels of loading, results in partial separation between the two materials. This separation leads to a premature buckling of the tube. Thus, effective confinement will only be achieved at higher loading when concrete begins to crack as it expands faster than the steel tube and becomes well confined.

An alternative to CFSTs is FRP composites which have been used as precast piles, girders, and pier. As opposed to steel CFTs, Poisson's ratio of FRP tubes can be controlled through selected design of the laminate structure to providemore confinement effect. The confining pressure provided by steel tubes is limited to a constant value once the tube yields, whereas FRP tubes provide a continuously increasing confining pressure, which adds to both the ultimate confined strength and ductility. However, with the high cost of advanced FRP composite materials, an alternative to the advanced composite materials tubing is the commercially available UPVC plastic pipes. UPVC are the pipes made of unplasticized polyvinyl chloride, which are easily obtained in various diameters.However, due to the high cost of advanced composite materials, the use of these materials in composite columns in light construction is not recommended. Another alternative to the advanced composite materials tubing would be the commercially available unplasticized polyvinyl chloride (UPVC) pipes. The strength, ductility and energy absorption capacity of new concrete columns can be enhanced by providing external confinement by employing UPVC pipe. The tubes in composite construction will be used as formwork during construction and thereafter as an integral part of the column.

Walter O. Oyawa *et al.* (2015), studied collapse of buildings during construction largely depends on the quality of in-situ concrete and poor workmanship. The situation is further compounded by rapid deterioration of infrastructure it is necessary that measures be taken to develop enhanced structural materials and systems. study clearly demonstrate the effectiveness of plastic tubes as a confining medium for infill concrete, gives enhanced composite interaction between the plastic tube and infill concrete medium. It was determined that

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compressive strength of the composite column specimens increased with increase in grade of concrete while the same decreased with increased column height [01]. Research done by Andrew Wheeler and Russell Bridge (2007), the concrete filled steel tubes are efficient members in structural applications including bridges, buildings and piled foundations and their use in the building industry is increasing. Mainly use has been in axial applications, design methodology based on theory and tests of columns under loads applied axially or at relatively small eccentricities. Researches for the behaviour of CFTs subjected to large eccentricities or loading in pure flexure have been conducted [02]. Work done by Ata El-kareim Shoeib Soliman (2011), the behavior of concrete columns confined by means of proper plastic tube is investigated including failure mechanisms and subsequently their failure mode with model for calculation of the column capacity. Plastic pipes is used in a wide variety of industries including, building and construction, automotive, consumer goods, lawn and garden, windows and doors, furniture, plumbing and electrical. One of the most widely used materials for these products is polyvinyl chloride commonly known as PVC [03]. Experimental investigation done by B. R. Niranjan and Eramma H. (2014), the behaviour of CFST columns to develop composite columns. Emphasis has been given to, shape of the column, L/D ratio, type of failure of the members depending upon the shape and boundary condition of the column. Study has been made both on experimental and analytical investigations. The reduction of the steel tube thickness in thin-walled CFST columns has the potential to significantly reduce construction costs [04]. Abhale *et al.* (2016), studied poly vinyl chloride (PVC) tubes filled with concrete are axially loaded until failure of the specimen to investigate their load carrying capacity. The main advantage in the interaction between PVC tube and concrete is, local buckling and PVC tube delayed by restraint of concrete and strength of concrete is increased by the confining effect of PVC tube. [05]. In research done by N. Gopi and B. Sujitha (2017), the plastics are having low bonding with concrete so, to increase the bonding strength by forming of scratches on plastic pipes. It may increase bonding strength compare with actual strength of bonding the specimen tested for axial loading on the universal testing machine. The improvement in strength is dependent on the concrete strength and geometrical properties of the tubes.

Higher compressive strength of UPVC confined column can be obtained by using smaller coarse aggregates [06]. Work done by Amir Mirmiran and Mohsen Shahawy (1997), the behavior of concrete columns confined by fiber composite. It is generally recognized that hybrid construction can result in a more efficient structural system. Their benefits include high stiffness and strength, large energy absorption, and enhanced ductility and stability. The tube interacts with the core in three ways: (1) it confines the core, thereby enhancing its compressive strength and ductility; (2) it provides additional shear strength for the core; and (3) depending on its bond strength with concrete and its stiffness in the axial direction, it develops some level of composite action, thereby also enhancing the flexural strength of concrete. The core, in return, prevents buckling of the tube. Exterior use of steel tubes in corrosive environments may prove costly. External confinement of concrete by means of high-strength fiber composites can significantly enhance its strength and ductility as well as result in large energy absorption capacity [07].

Experimental Work

MATERIALS

Cement used in mix was as per requirement of IS 12269- 2013. Coarse aggregate and fine aggregate are used as per requirement of IS 383-1970. UPVC pipe of height 650 mm and thickness 5 mm with internal and external diameter 190 mm and 200 mm respectively was procured for confinement of short column.

Table I Technical details of UPVC

Properties	Value	Units
Density	1.36	g/cm^3
Water absorption	0.1	%
Tensile stress	55	N/mm^2
Compressive strength	7	N/mm^2
Melting temperature	80	^{o} C

Fig 1 Cross-section of UPVC

UPVC Pipe

UPVC pipe do not corrode and are unaffected by acids, alkalis. They are light in weight and easy to handle as its weight is only 1/5 the weight of equivalent cast iron pipe and 1/3 the weight of equivalent cement pipe. This pipe is self-extinguishing and does not support combustion. It is flexible and resistant to breakage. Also, UPVC pipe has long life as its safe life estimated 80 to 100 years. UPVC pipes have effect of pressure and temperature due to which expansion and contraction is occurred. It's another limitation to hot and very strong acids are cause harm to pipes. Its cutting and threading limits its use in high pressure and temperatureapplication.

Concrete Mix Design

Concrete mix of M30 grade with proportion 1: 1.30: 2.78 was designed as per IS 10262-2009. Three specimens of concrete as per designed were tested for compressive strength after 28 days of curing.

RESULTS

Total twelve number specimens were cast then testing of column was done on load testing machine by applying the axial load on a column of height of 650 mm and circular C/s of diameter 200 mm were cast. In this investigation six specimen of confined with UPVC and six specimens without confinement with circular and spiral lateral reinforcement.

Table II Compressive Strength of UPVC confined column

Sr.No.	Specimen Type	Avg. Compressive strength (N/mm^2)	Max Deformation (mm)
1	UC	20	13.25
2	CC	31.78	15.80
3	US	22.73	13.65
4	CS	34.49	17.75

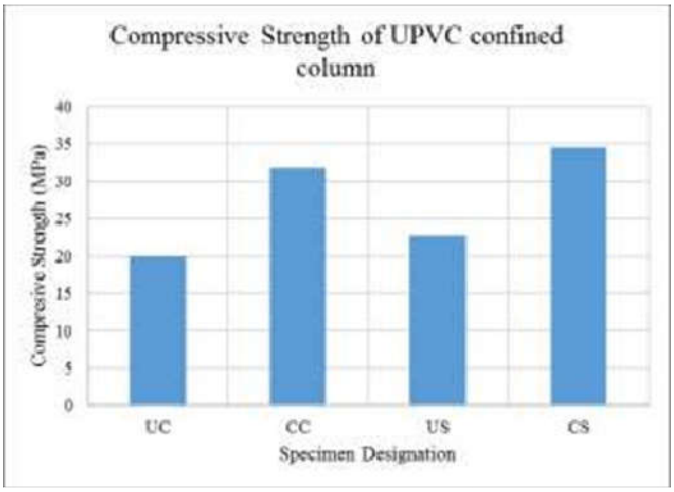

Fig II Compressive Strength of UPVC confined column

Average increase in load carrying capacity of specimen having confinement and spiral lateral ties is 51.73% in comparison with conventional RCC short column. Average increase in load carrying capacity of specimen having confinement and circular lateral ties is 58.90% in comparison with conventional RCC short column. Average increase in deformation of specimen havingconfinementand a spiral lateral tie is 30.03% in comparison with conventional RCC short column. Average increase in deformation of specimen having confinement and circular lateral ties is 19.24% in comparison with conventional RCC short column.

Validation

The deformation of UPVC confined short column having spiral and circular lateral reinforcement validate using ANSYS software. Table III shows validation for the observed experimental results of the UPVC confined short column using ANSYS software.

Table III Comparison of deformation of UPVC confined column

Sr.No.	Specimen Type	Experimental Deformation (mm)	ANSYS Software Deformation (mm)
1	UC	13.25	12.01
2	CC	15.80	13.00
3	US	13.65	15.01
4	CS	17.75	17.02

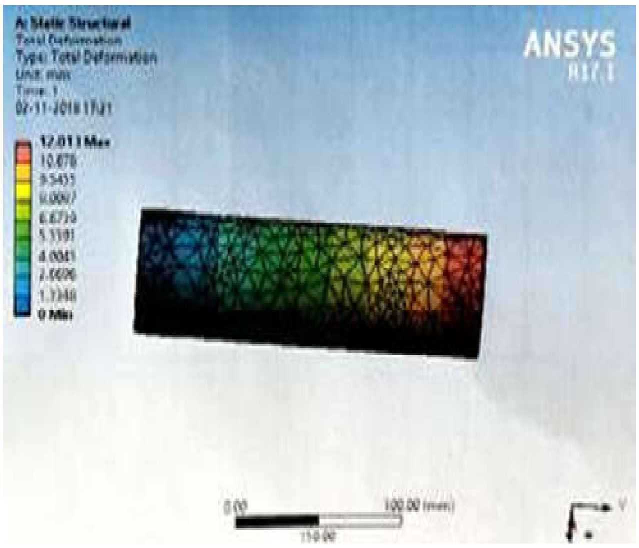

Fig 2 Deformation of UC specimen

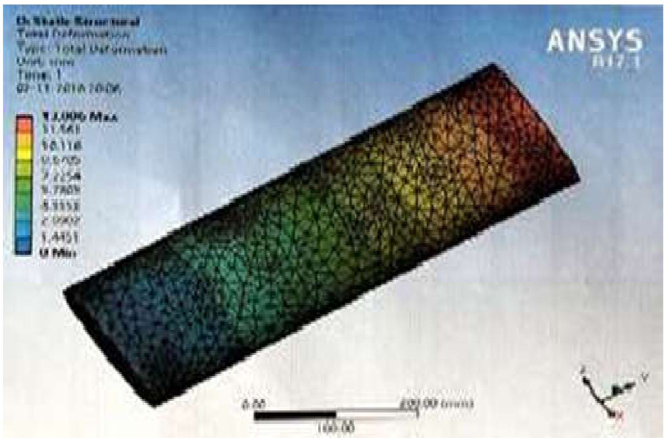

Fig 3 Deformation of CC specimen

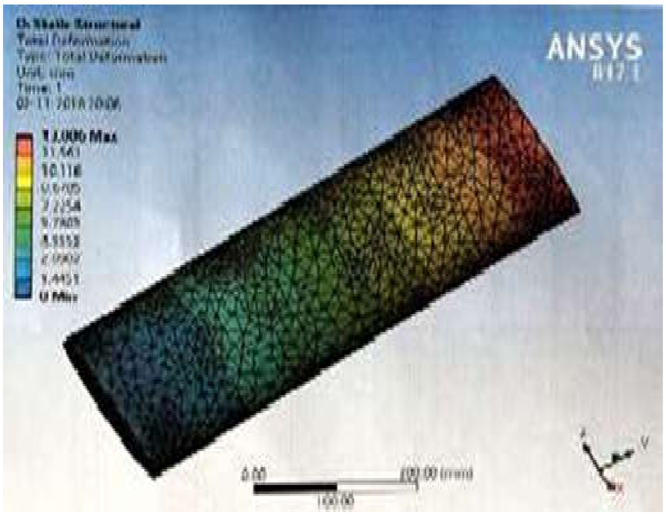

Fig 4 Deformation of US specimen

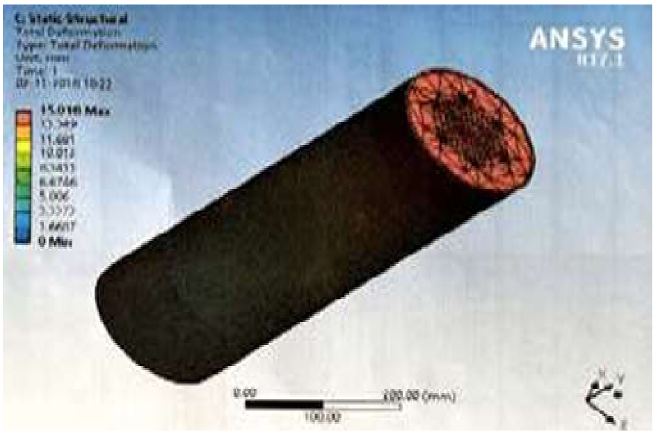

Fig 5 Deformation of CS specimen

CONCLUSION

Total twelve specimens of which six short columns with circular lateral reinforcement with and without confinement.six short columns with spiral lateral reinforcement with and without confinement were casted for experimental study and results obtained were discussed above and conclusions from the results are stated –

1. Average compressive strength of 31.78 MPa for the short column specimen confined with UPVC pipe having circular lateral reinforcement (CC) as compared to control specimen which is 20.00 MPa (UC).
2. Average compressive strength of 34.49 MPa for the short column specimen confined with UPVC pipe having spiral lateral reinforcement (CS) as compared to control specimen which is 22.73 MPa (US).
3. Maximum deformation of 15.80 mm for the short column specimen confined with UPVC pipe having circular lateral reinforcement (CC) as compared to control specimen which is 13.25 mm (UC).
4. Maximum deformation of 17.75 mm for the short column specimen confined with UPVC pipe having spiral lateral reinforcement (CS) as compared to control specimen which is 13.65 mm (US).

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