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Performance of Composite Concrete-Filled Plastic Tubular Stub Columns Under Axial Compressive Loads

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ABSTRACT

The development of Concrete Filled Plastic Tube (CFPT) Stub Columns, is commonly used in the areas where the concrete structures interact with marine and saline environments, compared to regular concrete columns. CFPT and Composite CFPT stub column samples were prepared to investigate their behaviour under certain loading conditions. The main objective of this study was to conduct an experimental investigation to observe the effect of using CFPT with and without additional of fibers on the final strength of the concrete columns. In order to achieve this target, three types of loading conditions were applied, including separate load on the concrete, combined load on the concrete and the plastic tube and combined load of composite concrete and plastic tube simultaneously. Comparing and Adding 2% of two different artificial fibers in CFPT columns which are Steel and Polymer fibers. The study revealed a significant improvement in the compressive strength of CFPT Composite CFPT columns with 110 diameters. Overall results show that the use of CFPT columns provides better mechanical performance compared to ordinary concrete columns. An evaluation of using the available calculation methods to predict the load-carrying capacities of CFPT. The study suggested the use of CFPT columns in situations where common concrete may cause significant issues related to its deterioration and disintegration in response to severe weather conditions.

Keywords: *Concrete, Plastic, CFPT, Composites, Columns, Compressive*

1. INTRODUCTION

Year-long experience in countries such as the USA, Europe, and Japan attests to the seriously deteriorating infrastructure and the inability to guarantee protection against natural disasters. In India, there have been numerous instances of buildings collapse both during construction and after they were occupied. Governments are currently investing a significant sum of money in collaborative ventures with the business sector in order to create novel, high-performance building materials and systems, with a focus on state-of-the-art composite materials and systems. The CFT column systems are one instance of the developments in these novel composite systems. Furthermore, there is a greater need than ever for the updating and repair of existing concrete columns in building and bridge substructures due to the rapid deterioration of infrastructure, especially those built in severe locations like bridge piles. In order to improve seismic performance, the deteriorated and damaged concrete columns must be strengthened to increase their bearing capacity. For a considerable amount of time, reinforced or unreinforced concrete has been encased in steel tubes to form composite columns, which have demonstrated remarkable results in building construction. Numerous writers have investigated the behavior of concrete-filled steel columns and their ultimate compressive strength through theoretical and experimental studies. (These comprise Uy, B., 2000; Faruqi et al., 2000; O'shea et al., 2000; Campione et al., 2000, among many more). Better building materials should have better mechanical qualities, a longer shelf life, and a more affordable price. One of the newest innovations in the building business is the concrete filled tube (CFT) column. Numerous materials have been investigated and utilized as confinement tubes in these columns, including steel and fiber-reinforced polymer (FRP). To understand the behavior of FRP and CFST composite columns, a lot of study has been done in the last few decades.

2. LITERATURE REVIEW

Numerous investigations came to the conclusion that the ultimate compressive strength, ductility, and other mechanical characteristics of CFT columns may be improved by encasing concrete columns in plastic tubes. Usha and Eramma (2014) investigated the effects of axial loads on 150 mm-diameter, 7.11 mm-thick CFPT columns. The specimens had effective lengths of 500, 600, and 700 mm.

Prion and Boehme (1994) several approaches were used to test concrete-filled circular steel tubes. They claimed that the confinement effect is noticeable when the slenderness ratio, L/D, is less than 15. In this case, L and D represent the height and diameter of the column, respectively. For short columns (L/D < 15), the mode of failure was shear failure of the concrete core. For the goal of concrete confinement, structural steel tubes have been extensively studied throughout the last 20 years. A substantial amount of literature has been written as a result, including pieces by Gupta et al. (2007) and Oliveira et al. (2009).

Mirmiran and Shahawy (1995); (A concrete-filled fiber-reinforced polymer tube (CFFT), which functions as the concrete's corrosion-resistant casing, hoop and longitudinal reinforcement, and formwork, was detailed in US Patent 5,599,599. It is essentially a FRP tube filled with concrete that has been wrapped like a filament. This concrete-filled FRP tube (CFFT) is comparable to the concrete-filled steel tube (CFST). It was advised to employ the CFFT for bridge columns as well as pile splicing.

Kargahi (1995) investigated the strength of CFFT under uniaxial compression. Three 150 x 300 mm plain concrete cylinders and nine CFFTs were among the twelve circular specimens that were tested in total. Filaments were used to wind the E-glass/polyester tubes, with a winding angle of ±75° with respect to the longitudinal axis of the tube. Three different tube thicknesses were found. It was reported that the strength of the concrete was 2.5–3.5 times greater than its unconfined strength. He also performed several split-cylinder tests to investigate potential ways to increase the tensile strength of the FRP-confined concrete. It was found that the FRP tube improves the behavior of the concrete section under tension by encapsulating the fractured concrete instead of restricting it.

The bond effect was investigated by **Mastrapa (1997)**. He looked at thirty-two distinct 150 x 300 mm composite cylinders; half of these had S-glass fabric wrapped in one, three, five, or seven layers; the other half had tubes filled with the same batch of concrete that had the same number of layers and the same wrapping method. There were two test series run. In Series 2, the jacket was built as a continuous wrap of fabric with an overlap of around 32% of the cylinder's perimeter. In Series 1, multi-layer jackets were formed layer by layer with a splice approximately 17% of the cylinder's perimeter. It was found that construction bond had no appreciable effect on axially loaded confined concrete.

Pico (1997) A total of 9 Nos. were investigated. Using concretefilled FRP tubes 150 mm by 150 mm by 300 mm under axial compression,the effects of the CFFT's cross section were investigated. The FRP tube and the concrete core were not connected. The strength increased slightly and was independent of the jacket's thickness. It was shown that the corner radius multiplied by the confining pressure functioned as themain confinement control parameter.

El Echary (1997) evaluated the effects of the length-to-diameter (L/D) and diameter-to-thickness (D/t) ratios on the behavior of the CFFT.Twenty-four circular CFFTs (Dinner=145mm) with three different tube thicknesses (6, 10, and 14layers) and four different lengths (300, 450, 600, and 750 mm) were tested. There was no evidence of buckling during the tests. An analysis of the test results revealed that the largest eccentricity was found to be within10-12% of the section width.No appreciable decrease of strength was observed. The effects of thinness were found to be negligible up to a 5:1 ratio L/D.

WalterO. Oyawa conducted an investigation using experimentation. Composite concrete filled plastic tubes: structural response under compression. The study's conclusion that UPVC is useful for confining concrete is supported by the confined concrete's higher compressive strength when compared to unconfined concrete. Circular columns that are confined exhibit a notable enhancement in strength, which, depending on the degree of confinement, can reach 3.65 times the unconfined strength values.

Kurt C. E. (1978) suggested using concrete-filled PVC plastic pipes, which are easily found on the market. According to theoretical research, there was an interaction between the concrete core and the plastic pipe, which strengthened the concrete core. The structural performance of the plastic pipe under column loading was similar to spiral reinforcement. The plastic pipe increased the strength of the concrete core by approximately 3.2 times the pipe break pressure. Plastic-encased concrete showed a 45° shear failure for a slenderness ratio of less than 20 in both the concrete core and the plastic pipe due to the combination of axial compression and hoop tension in the pipe. Kurt used a flimsy plastic material, therefore the concrete's strength increased only somewhat. However, his preliminary research indicated that PVC pipes filled with concrete would make a workable column system for lightweight construction.

Gupta (2013) evaluated 140, 160, and 200 mm-long UPVC pipes that were filled with concrete. Furthermore, he put three different grades of concrete mixes—M20, M25, and M40—into the tubes. Based on his research, he concluded that the ductility and compressive strength of concrete columns are increased when UPVC tubes are added. How much strength and ductility can be enhanced depends on the strength of the concrete and the geometric properties of the tubes. The confinement impact of UPVC was comparable to that of earlier models in that all specimens experienced shear type failures, with results varying by up to ±6% according to published literature. The post-peak behavior of the load-compression curve is largely dependent on the compressive strength of the concrete. The absolute size of the slope of the curve increases as concrete strength increases due to its increased brittleness. The slope of the first part of the bends lowers as the concrete's grade does. The tube diameter/thickness ratio governs the post-peak behavior of the curve; a decrease in this ratio causes the absolute value of the slope of the curve to reduce. However, the research did not investigate the consequences of altering the slenderness (height-to-diameter) ratio because all of his columns had a set height of 500mm.

The results of the investigation showed that, as sample length increased, the local buckling effect was responsible for all column failures. Furthermore, a comparison of the real data and theoretical calculations showed a 1.6% increase in the section comparative capacity of the CFPT columns above the theoretical value. The goal of a different experimental investigation was to examine how CFPT Stub columns would compress under axial compressive loads that are concentric. In their experiment, they employed a variety of CFPT forms with various concrete design strengths. The findings demonstrated that the compressive strength of the column specimens rose with concrete strength and fell with column height. The findings demonstrated that the compressive strength of the column specimens rose with concrete strength and fell with column height. Furthermore, when PVC was added, the samples' ultimate strength was 1.18 to 3.65 times higher than their unconfined strength. Gupta reached similar conclusions as well. When comparing the projected values with the experimental load capacity of CFPT samples, it is discovered that the expected values (derived from developed models accessible in the literature) are within ±6% of the experimental capacities. Soliman (2011) conducted an experimental investigation to examine the behavior of CFPT long columns. The investigation's findings demonstrated that the usage of plastic tubes as confinement materials had a major impact on how concrete columns failed. The study also found that when the slenderness ratio dropped, the tested long CFPT columns' rigidity rose. In this investigation, concrete, concrete with plastic tubes, and empty plastic tubes were subjected to an axial load. Additionally, look into how these samples, which vary in length and diameter, respond to full and partial axial compression loads. Lastly, consider if the load-carrying capacity of CFPTs can be predicted using the existing computer techniques.

3. OBJECTIVE OF CURRENT STUDY

Examining the structural behavior of CFPT stub columns under axial compressive loads is the study's main objective. The purpose of the study is to gain a better understanding of how the load-bearing capacity, failure modes, and overall stability of the columns are impacted by the interaction between the concrete core and the plastic outer tube.

1) To create various concrete mix classes by including steel and polyester artificial fibers for M25 garde.

2) To compare the effects of concrete on the composite stub columns' strength and ductility properties.

3) To assess how concrete columns are affected by plastic tube confinement.

4) Compare the load capabilities of the composite columns to the sum of the capacities of the individual components to get the final load capacity of the composite section.

5) To determine the axial deformations, axial stress, and axial and radial strains of the composite concrete stub columns made of different composite materials.

4. MATERIALS AND METHODOLOGY

The technique for this study is intended to systematically assess the structural performance of CFPT stub columns and adding 2.5% of two different types artificial fibers under axial compressive loads. This method combines experimental testing and analytical methodologies to better understand how composite columns react under compressive stresses.

Given the novel usage of plastic as a structural element, the technique focuses on both the preparation and testing phases, ensuring that all variables are properly controlled and measured. The major purpose is to evaluate the load-bearing capacity, deformation properties, and overall failure modes of the CFPT columns, which will provide information on their appropriateness for various building applications.

During the experimentation phase, exact requirements are followed in the fabrication of the composite columns, including the choice of suitable plastic tubes and concrete mixtures. Axial compression tests will be performed on each column in order to gather information on failure patterns, ultimate load capacity, and load-deformation behavior.

To make sure that the testing protocols follow accepted principles in structural engineering, the process also entails a careful examination of the body of current literature and standards. Through a combination of theoretical research and practical experience, this methodology seeks to offer a thorough understanding of the behavior of CFPT columns under axial loads, which will ultimately aid in the creation of more sustainable and effective building materials.

4.1 Research Design

First, the mechanical parameters of the main materials utilized in the research were determined. Next, a series of UPVC-confined concrete columns were tested under monotonically rising concentric axial compressive loads. The experiments were carried out in a laboratory setting**.**

4.2 Materials

In order to add artificial fibers to UPVC-Concrete Columns, the following materials are needed: cement, water, UPVC pipes, steel fiber, polymer fiber, and fine and coarse aggregate.

4.2.1 Cement

One common building material that is used extensively in construction projects is cement. There are several types of cement on the market, and because each has unique qualities, it is employed in specific situations. Fly ash-based Portland Pozzolana Cement is utilized. When creating concrete, this cement is employed as a binding agent. Table 4.1 below lists its characteristics derived from testing carried out in accordance with the BIS codes.

4.2.2 Fine Aggregates

The aggregate that goes through the IS 4.75 mm screen might be referred to as fine aggregate. In concrete, fine aggregate is commonly used as a filler. In this project, river sand served as the fine aggregate. Sand also known as fine aggregate, is key to concrete's makeup. It fills gaps between bigger aggregates and cement bits making concrete denser and stronger. The sand must meet certain standards to ensure the concrete works well when wet and after it hardens.

4.2.3 Coarse Aggregates

Rubble is one of the most basic crusher products and can also be obtained from crushing boulders whereas it is not a natural aggregate. Granular materials that can be categorized into aggregate include sand, gravel, crushed stone, and iron blast furnace slag. Frequently, aggregates are classified into different groups based on how fine it is or how large a specific particle is, such as is the case here. The Concrete Institute defines coarse aggregates as particles larger than 4.75 mm in size. It is evident that big pieces of aggregate and smaller particles are not the same in that smaller particles give a larger surface area per unit particle compared to bigger chunks. Coarse aggregate means that portion of the aggregate that passes a 20 mm sieve but is retained on a 4.75 mm sieve. Generally, where it covers a ratio for aggregates, coarse aggregate is a material for crushing. For this construction work, coarse aggregate was sourced from the river. Shear specific gravity of fine aggregate typically ranges in the values of 2.4 to 2.7.

4.2.4 Upvc Pipes

UPVC pipe filled with concrete Unplasticized Polyvinyl Chloride (Unplasticized Polyvinyl Chloride) is gaining popularity in construction and infrastructure due to its combination of strength, durability and cost-effectiveness. UPVC is a rigid form of PVC that does not plasticize. It is known for its corrosion resistance, light weight and ease of installation. When filled with concrete These pipes will have increased strength. The Dimensions of UPVC pipes are 300mm height 100mm dia and 3mm thickness.

The concept of filling UPVC pipes with concrete is widely used in civil engineering to increase their load bearing capacity. The concrete middle reinforces the pipe, making it capable of resist greater external weight. Whilst the UPVC exterior presents corrosion resistance. Chemical balance and protection from environmental factors. This combination outcomes in a durable and value-powerful answer that calls for much less protection as compared to conventional metallic pipe.

Concrete filled UPVC pipes are commonly used in foundations, retaining walls and bridge supports. Where both strength and durability are important, the UPVC cover acts as a permanent formwork. Protects concrete from external damage and weathering. The combined action of the concrete core and UPVC shell allows the structure to carry more weight. This makes it an ideal choice for modern infrastructure projects.

4.2.5 Steel Fiber

Steel fibers are small, discrete portions of steel which are used as a reinforcement cloth in concrete to decorate its mechanical homes. They are normally made from carbon or stainless-steel and come in various shapes, sizes, and lengths. Steel fibers are widely used in production to enhance the tensile power, ductility, and crack resistance of concrete, making it extra durable and much less at risk of brittle failure. When added to concrete, steel fibers distribute stresses extra lightly throughout the material, preventing the formation of huge cracks below load.

4.2.6 *Polymer* ***Fiber***

Polymer fibers are synthetic substances made from numerous polymers, along with polypropylene, polyester, and nylon.

They are durable and feature exceptional chemical resistance. These fibers are consequently extensively utilized in textile manufacturing, engineering and other industries. Polymer fibers in production are consequently particularly precious while blended with concrete or mortar to decorate their homes. These fibers can be produced in various forms such as monofilaments, fibers and meshes. It depends on the usage and intended use.

4.3 Preparation and Mixing of Concrete

To boom workability, air-entrained concrete under slight exposure occasions was used inside the concrete mix design. The maximum mixture size of 25 mm and the water/cement ratio of 0.45 were used to achieve the supposed workability of slump 28 mm–30 mm. The blend design yielded a 1:1:2 blend ratio, which was utilized within the guide production of one hundred fifty mm length used for break up tensile testing and compressive power trying out. Materials training, mixing, and sampling have been completed. **Mixing concrete:** The methodology for the mixing process is as follows.

• Each material is produced and weighed according to the mix design proportions.

• Sprinkle a small amount of water on the floor before the mixture starts to get wet.

• Mix the ingredients into a fine aggregate.

• The microaggregates and aggregates are thoroughly combined for several minutes.

• Then the aggregate is mixed with cement.

• Slowly add water to the dry mixture, stirring constantly.

• After mixing for 2-3 minutes, prepare the concrete mix for pouring into the mold.

5. RESULTS AND DISCUSSIONS

Concrete’s compressive strength is its most crucial feature. The other properties of concrete may be evaluated using its compressive strength as a basis. As a consequence, the column stubs compressive strength of the concrete mixes was evaluated and the findings were repeated after 28 days to validate the objective’s strength. There is evidence to suggest that as the percentage of individual fibers added the growth increases.

Column stub specimens were compressed, and the ultimate compression strength was determined by measuring the failure load on the compression testing apparatus. For each category, the average values of the specimens at 28 days old are tabulated.

6. CONCLUSIONS

Concrete-filled plastic pipe columns are a new approach to construction. It combines the flexibility and friction properties of plastic with the strength of concrete. In this study, a CPT column was tested against a conventional M25 grade concrete column to evaluate its performance under axial compression.

In addition, the effect of including 2% steel fibers and polymer fibers in the mix was evaluated. concrete to determine how these fibers affect the overall performance of the CPT column.

Concrete can be effectively contained by plastic pipes, as seen by the higher compressive stress. The confinement of circular columns results in a significant increase in strength, which can reach 1.18 to 2.29 times the unconfined strength values, depending on the degree of confinement. It was clear that confinement effectiveness depended on concrete strength, with the former decreasing as concrete strength increased because high strength concrete exhibits brittle behavior.

REFERENCES

[1] U.M. Sulthana, S.A. Jayachandran Axial compression behaviour of long concrete filled double skinned steel tubular columns Structures, 9 (2017), pp. 157-164

[2] M.F. Hassanein, M. Elchalakani, A. Karrech, et al. Behaviour of concrete-filled double-skin short columns under compression through finite element modelling: SHS outer and SHS inner tubes Structures, 14 (2018), pp. 358-375

[3] Gupta, (2013):“Confinement of concrete columns with Unplasticized Poly-vinyl chloride tubes.” International Journal of Advanced Structural Engineering, Aug 2013. Available online at http://www.advancedstructeng.com/content/5/1/19

[4] Hamdy Mohamed & Radhouane Masmoudi, (2009). “Behavior of FRP tubes-encased concrete columns under concentric and eccentric loads”. COMPOSITES & POLYCON 2009, American Composites Manufacturers Association, January 15-17, 2009 Tampa, FL USA.

[5] Hamdy Mohamed & Radhouane Masmoudi, (2009). “Behavior of the concrete filled FRP tube columns under

eccentric load" Structural Composites for Infrastructure Applications, Hurghada, Egypt

[6] Iskander, M., & Hassan, M. (1998). "State of the practice review in FRP composite piling." Journal of Composites for Construction, ASCE, 2(3), 116-120.

[7] Mirmiran, A., Shahawy, M., & Samaan, M. (1999). "Strength and ductility of hybrid FRP concrete beam-columns." Journal of Structural Engineering, ASCE, 125(10), 1085-1093.

[8] M Marzouck & K. Sennah, (2002). Concrete-filled PVC tubes as compression members: Composite Materials in Concrete Construction. Proceedings of the international congress "challenges of concrete construction" pp. 31-38

[9] Lam D., Gardner L. & Burdett M. (2008). Behavior of concrete filled stainless steel elliptical hollow sections. Proceeding of the Second International Symposium on Innovative Design of Steel Structures. 5 December, 2008, Hong Kong.

[10] Lampo R. et al. (1998). "Development and demonstration of FRP composite fender, load-bearing and sheet piling systems", USACERL Technical Report 98/123.

[11] Mander, J.B., M. J. N. Priestley & R. Park. 1988. "Theoretical Stress-Strain Model for Confined Concrete," Journal of Structural Engineering, ASCE, 114:1804-1823.

[12] L.H. Han, G.H. Yao, X.L. Zhao Tests and calculations for hollow structural steel (HSS) stub columns filled with self-consolidating concrete (SCC) J. Constr. Steel Res., 61 (9) (2005), pp. 1241-1269.

[13] Han L.-H., Liu W., and Yang Y.-F., Behaviour of concrete-filled steel tubular stub columns subjected to axially local compression, Journal of Constructional Steel Research. (2008) 64, no. 4, 377–387, https://doi.org/10.1016/j.jcsr.2007.10.002, 2-s2.0-39749131169.

[14] D. Santarosa, A. Campos Filho, A.J. Beber and J. L. Campagnolo, (2001) "Concrete columns confined with CFRP sheets." FRP Composites in Civil Engineering; Proceedings of the International Conference on FRP Composites in Civil Engineering, Vol 1, December 2001, Hong Kong, China.

[15] Daniali, S., (1992) "Investigation of the behavior of reinforced plastic columns with concrete core." Proc., ASCE 1992 Material Congress, 666-676

[16] De Lorenzis, L. and Tepfers, R. (2001). "A Comparative Study of Models on Confinement of Concrete Cylinders with FRP Composites." Division of Building Technology, Work No.46, p.81, Publication:01:04, Chalmers University of Technology, Sweden .

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