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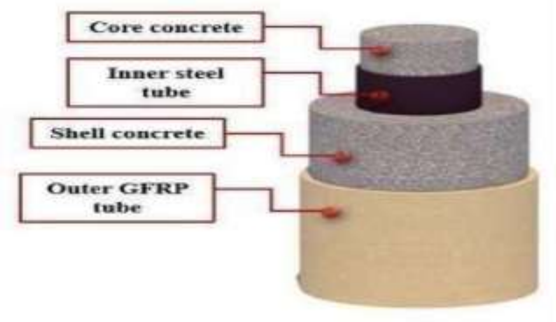
Behaviour Of Double Tube Columns Filled Withdifferent Types Of Concrete

Mansoor Zahir[1], Dr.Mahendra Kumar Singar[2], Dr.Ravi Kant Pareek[3]
[1]Department of Civil Engineering (Structure Engineering) Vivekananda Global University, Jaipur, India
mansoorzahir55@gmail.com
[2]Department of Civil Engineering (Structure Engineering) Vivekananda Global University, Jaipur, India

Abstract
The composite steel-concrete structure has gained popularity as a contemporary construction solution with its enhanced strength, rapid construction, and light weight. Nevertheless, the concrete-filled double steel skin tube section (CFDSTS) columns suffer from corrosion under severe environments, particularly for offshore oil platforms. Consequently, a concrete-filled double circular tube section (CFDTS) model was developed an outer Glass FRP tube, an inner steel tube.so compressive strength of various materials employed for concrete filling of hollow sections, i.e., normal concrete, special concrete where fine aggregates were partially replaced by ferro-chrome slag, and fiber-reinforced special concrete with crimped steel fibers, was tested through the research work. The findings indicated that both special and fiber-reinforced special concrete exhibited much higher compressive strengths compared to the normal concrete.
The research moreover explored compressive loads of various types of CFDTS columns at 28 days of curing.
The findings indicated that Type 1 CFDTS column recorded the highest compressive strength in comparison to Type 2 and Type 3 columns. The research found that the results add to the existing literature in the area and can guide future studies and innovation of more efficient and sustainable products. The CFDTS model with external FRP confinement is a viable option for new construction in rust-corrosive areas, as it gives lateral confinement, formwork, and an impermeable barrier against rust-promoting elements.
Keywords: *CFDTS (Concrete-Filled Double Tube Section), Compressive Strength, Ferro-chrome Slag Concreter FRP Confinement, Corrosion Resistance*

INTRODUCTION
In contemporary construction, composite steel–concrete systems have become widely used due to their ability to integrate the strengths of both materials. Steel offers rapid construction, high load-bearing capacity, and reduced weight, while concrete contributes mass, stiffness, damping, and cost-effectiveness. One notable development in this domain is the concrete-filled double steel skin tube section (CFDSTS), where dual steel tubes are filled with either conventional or modified concrete.
But these CFDSTS columns are seen as a disadvantage for offshore oil platform columns as they are prone to corrosion when subjected to these harsh environments. To address this issue, this study proposes a hybrid concrete-filled double circular tube section (CFDTS) design, featuring an inner steel tube enclosed by an outer glass fiber-reinforced polymer (GFRP) tube. This configuration is tested with three types of concrete infill: ordinary concrete, special concrete with 40% fine aggregate replaced by ferro-chrome slag, and fiber-reinforced special concrete incorporating 2% crimped steel fibers with an aspect ratio of 60.
The hybrid CFDTS specimen consists of concrete filling the annular space between the inner steel and outer FRP tubes, effectively combining multiple benefits. FRP confinement has gained popularity in recent years for its excellent durability, high tensile strength-to-weight ratio, and corrosion resistance, especially in harsh environmental conditions. FRP can be applied in the form of sheets or tubes and has been extensively studied for strengthening and retrofitting deteriorating reinforced concrete structures. However, such strengthening interventions can be costly. Consequently, research has focused on designing systems that inherently resist deterioration over their service life. In rust-prone environments, concrete confined within FRP tubes (CFFT) has emerged as a promising solution, serving as both formwork and lateral confinement while providing an impermeable barrier against corrosive agents. Figure 1 illustrates the proposed CFDTS column with its outer GFRP and inner steel tube components.

Figure 1 Concrete filled double tube sectional (CFDTS) column with outer GFRP and inner steel tube.



Problem Statement:

Concrete-filled double tube section (CFDTS) columns are used in tall buildings and offshore structures to support substantial loads. For CFDTS columns to serve as effective alternatives to conventional CFST (Concrete-Filled Steel Tube) and CFFT (Concrete-Filled FRP Tube) systems, their structural behavior and performance under axial loading must be thoroughly investigated.

Offshore oil platforms often utilize CFFT columns because of their lightweight nature, high strength, and excellent corrosion resistance. To evaluate whether CFDTS columns can offer comparable or superior performance in such corosive environments, it is essential to study their load-bearing characteristics and overall structural behavior.

The CFDTS design features two concentric tubes—an inner steel tube and an outer FRP tube—both filled with concrete. Investigating the axial compression performance of these columns is critical to validating their suitability for use in demanding applications.

Objectives:

- Examine how varied concrete types influence CFDTS column strength.
- Analyze their structural performance when subjected to axial forces.
- Identify suitable designs for use in challenging environmental conditions.

METHODOLOGY

Our project consists of casting and testing of 3 types of circular CFDTS columns under axial load. For each type of CFDTS column, 3 specimens were casted, average strength of 3 specimens were considered as strength of such type. Prior to the casting of CFDTS columns, different types of concretes were tested by casting cube specimens of size 15cmx15cmx15cm at the time of 7, 28 days of curing. Normal concrete, Special concrete (partial replacement of fine aggregate with ferro-chrome slag by 40 %) and Fiber- reinforced special concrete (addition of 2% of fibers to special concrete). Following tabular forms gives the complete experimental analysis conducted during project work.

REPORT ON PRESENT INVESTIGATION:

Fineness Test:

First off, you'll want to measure out about 100 grams of cement—make sure you get it as close to 0.01 grams as you can. Then, you put that cement on a 90-micron sieve. After that, you'll need to shake things up a bit—literally. You can swirl it, move it in a planetary motion, or go for a linear movement. The key here is to keep going until you don't see any more fine particles getting through. Once you've done that, weigh what's left on the sieve. Finally, you'll express that weight as a percentage of what you started with, rounding to the nearest 0.1 percent.

Fineness = (Wt. of cement retained on 90μ/total wt. cement taken) x 100

= (3/100) x 100 = 3% < 10%

Standard Consistency Test:

you will need to weigh out around 400 grams of cement. And then, mix that with a specific amount of water do not forget to measure that too, you will want to get all this sorted in about 3 to 5 minutes. Once you have got your mix just right, fill the Vicat Mould with the cement paste and smooth it out with a trowel. Alright, so what you want to do next is gently lower the plunger, making sure it's just skimming the surface of the cement. Now, take a deep breath, let go of the plunger, and watch it sink into the paste. Oh, and make sure to jot down the reading on the gauge. You will probably need to go through this whole process a few times until you hit that sweet spot of 5 to 7mm from the bottom of the Mould. Weight of sample = 400 gm

Initial and Final Setting Time Test:

So, when we talk about initial setting time, we're really looking at the period that kicks off right after you mix water with cement. This phase lasts until that tiny 1mm square needle can no longer push through the cement paste in the Vicat's mold. We're talking about around 5 to 7mm from the bottom, give or take. Now, shifting gears to final setting time this is when that same needle mark on the paste, but the thicker 5mm part, it doesn't leave any impression at all. The amount water tested for initial and final setting time is = (0.85P/100) x weight of cement taken for test.

Specific Gravity:

First off, you take your empty density bottle and weight it. We'll call that mass (m1) in grams. fill about a third of the bottle with your cement and weigh it again. That gives you mass (m2). After that, just fill the rest of the bottle with kerosene and note that weight down — we'll label that one mass (m3). dump everything out and then refill the bottle all the way with kerosene. Finally, do one last weight-in; that'll be your mass (m4).

Specific gravity at room temperature is given as (G2 is taken as 0.8 for kerosene)

Cement:

So, let's talk about Ordinary Portland Cement. In India, you'll typically find it in three main grades: Grade-53, Grade-43, and Grade-33. So, they create it by heating limestone and some other siliceous materials to a blazing 1400 degrees Celsius. After that, they grind it all up with gypsum. As for its uses, OPC is versatile — it finds its way into pre-stressed concrete, dry-lean mixes, and even ready-mixed concrete for general construction purposes. the findings from these tests can be found in table 1.

Table 1 Test results of cement

Test	Results
Fineness Test	Fineness = 3 %
Standard Consistency Test	P = 31 %
Initial and Final setting time Test	Initial setting time = 32 minutes Final setting time = 390 minutes
Specific Gravity	G = 3.15

Fine Aggregate:

it's any material that's smaller than 4.75 mm – that's the standard according to the IS sieve. Think of it as the glue that keeps everything together, filling all those little gaps between the coarse aggregate and the cement. In our research, we decided to explore natural river sand and even some ceramic waste as options. the findings from these tests can be found in table 2.

Ferro-chrome slag:

This is a grain-like material with good strength and physical properties, which makes it useful in concrete. It's becoming more common as a substitute for normal sand or crushed stone. It's better for the environment because it reuses waste that would just be thrown away. It also makes concrete stronger and lasts longer thanks to its density and chemical behavior. Plus, it often costs less than regular fine aggregates.

Table 2 Test results of fine aggregate

Test	Results for Sand	Results for Ferro-chrome slag
Fineness Test	Fineness Modulus = 2.88	Fineness Modulus = 2.4
Specific Gravity	G = 2.65	G = 4.06

Coarse Aggregate:

it's really the backbone of concrete. When we mention the stuff that gets caught on a sieve measuring 4.75 mm, that's exactly what we're talking about. Typically, folks go for crushed stone or gravel, and they really should meet the standards outlined in IS 383-1970. the findings from these tests can be found in table 3.

Table 3 Test results of coarse aggregate

Test	Results
Fineness Test	Fineness Modulus = 6.60
Specific Gravity	G = 2.75

Fabrication of Glass Fiber Reinforced Polymer (GFRP) Tubes:

1. cut some woven roving mats to fit your mold and weigh them as well.
2. Next, mix up a thermosetting polymer in liquid form.
3. apply wax to the mold surface, it really helps keep the polymer from sticking later.
4. After that, go ahead and lay down your first layer of reinforcement in the mold.
5. Then, pour your polymer and resin mix over that layer. Grab a roller and gently press down.
6. Keep layering — polymer and reinforcement — until you've got about six layers,more or less.
7. Figure 2 illustrates the proposed application of GFRP sheet

Figure 2 Application of GFRP sheet

Concrete Mix Design for M25 Grade Concrete:

Data for mix design:

When you're putting together a concrete mix, there are a few important things you should get straight:

a) First things first, you need to figure out the characteristic compressive strength. In simpler terms, this means you must decide how strong you want your mix to be. Ideally, only about 5% of your test results should dip below this level after 28 days—this is what we call fck.

b) Then, let's talk about workability. How easy should it be to handle this mix? It's key for whatever application you have in mind.

c) Don't forget about the water-cement ratio and the minimum cement content. These factors are crucial for making sure your mix stands up to the test of time. There are some guidelines out there, like IS: 456.2000, which can help you out.

d) And lastly, you'll want to decide on the type of aggregate and its maximum size. This choice can really influence everything—strength, finish

Target strength for mix design:

To avoid having too many tests results dip below the characteristic strength, we've got to create a concrete mix with a slightly higher target average compressive strength. Let's call this new strength fck1. First, we need to think about quality control. We can gauge this with something called standard deviation. And then, there's the matter of how many tests results we're willing to accept that fall short of that characteristic strength, fck. Honestly, getting this relationship right is crucial.

fck 1 = fck + 1.65 x s. or fck 1 = fck + X, whatever is higher.

where fck 1 = target average compressive strength at 28 days, fck = Characteristic compressive strength at 28 days.

s = Standard deviation,

X = factor based on the grade of concrete.

Selection of water-cement ratio:

when you really get into the concrete game, it becomes pretty clear that not all cements and aggregates are created equal. Seriously, they come in a bunch of different sizes, textures, and shapes. These differences can have a big effect on compressive strength, even if we keep that free water- cement ratio constant. So, honestly, it makes total sense to look into how strength relates to that water-cement ratio, especially with the exact materials we plan to use. if we don't have that specific data at our fingertips right now, we can kick things off with a rough free water-

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cement ratio (by mass) that aligns with our target strength at 28 days. And if you're interested, you should totally check out the guidelines in IS: 10262-2019. They really break down the water-cement ratio and how it connects to that all-important 28-day compressive strength. the results of the testing (see Table 4).

Table 4 **Data for M25 Grade Concrete Mix Design**

Typof concrete	**Ceme nt (kg/ m3)**	**Fine aggregeate (kg/m3)**	**Coarse aggregate (kg/m3)**	**% Ferro chrome slag replacement**	**Ferro chrome slag(kg /m3)**	**%Crimped steel fibers**	**Steel fibers (kg/m)**
Normal	372	690.802	1169.63	--	--	--	--
Special	372	414.48	1169.63	40 %	276.32	--	--
Fiber reinforce special	372	414.48	1169.63	40 %	276.32	2 %	7.44

Preparation of Specimen:

Mixing:

Alright, let's talk about mixing those ingredients. Usually, we grab a machine for this. First things first, you'll want to combine the cement and fine aggregate while it's all dry. Make sure you really get in there and blend it well; you want to see that nice, even color all the way through.

Once that's done, it's time to throw in the coarse aggregate. Give it another good mix to make sure everything's nicely distributed.

Now, here's where it gets crucial—you've got to add water. Seriously, don't skip this step, mix it all up again until the concrete looks smooth and uniform. It's all about that final blend, making sure everything comes together nicely at the end.

Compressive strength of cube specimens:

the machine we used for testing its a microprocessor-based compression tester. the pressure was increased slowly at first then built up steadily close to 140 kgcm per minute. we continued applying the load until the cube broke the highest load just before failure was recorded. the outcome of this test is shown in table 5 figure 3 shows the actual setup used to carry out the cube compression test.

Table 5

Average compressive strength of cube specimens

Description	**Average 7 days strength (M Pa)**	**% Increase in strength with respect to normal concrete**	**Average 28 days strength (M Pa)**	**% Increase in strength with respect to normal concrete**
Normal concrete	19.25	---	32.71	---
Special concrete	23.11	20 %	44.22	35.20 %
Fiber reinforced special concrete	26.11	35.63 %	46.13	41.02 %

Figure 3 Experimental setup for compression test of cube specimen

Compressive strength of CFDTS specimens:

we're looking into the compressive load versus deformation of our specimens both laterally and longitudinally. This is all about understanding how well those CFDTS specimens hold up, especially when we mix different types of concrete in their core and shell areas. we hooked up two strain gauges and added four digital dial gauges — two for lateral measurement and the other two for the longitudinal side, all precise to 0.01 mm. We used a hefty compression testing machine with a capacity of 300 tons to put these specimens through their paces. First, we preloaded each specimen to 10 tons, to keep everything steady and avoid any movement between the specimen and the machine's loading head. After that, we cranked up the load gradually at a rate of 5 kN/s until we hit failure. the outcome of this test is shown in table 5 figure 3 shows the actual setup used to carry out the Experimental setup.

Figure 4 Experimental setup for compression test of CFDTS columns

Table 6 Average compressive load of CFDTS specimens

Description	Average load of CFDTS specimens (kN)
Compressive strength of CFDTS specimens filled by normal concrete in core portion and fibre reinforced special concrete in shell portion (Type 1)	937.27
Compressive strength of CFDTS specimens filled by normal concrete in core portion and special concrete in shell portion (Type 2)	873.38
Compressive strength of CFDTS specimens filled by fibre reinforced special concrete in core portion and normal concrete in shell portion (Type 3)	847.30

SUMMARY AND CONCLUSION

we've uncovered some pretty interesting findings that really help answer the research questions we started with. The study has given us a closer look at different elements of the project — from the strengths and weaknesses of the methods we used to how effective the materials and techniques turned out to be. Plus, we've thought about how these findings could be applied in future studies or real-world scenarios. Here's a quick summary of what we found:

- First off, the compressive strength of our special concrete is significantly better about 20% more at 7 days and 35.20% more at 28 days compared to regular concrete.
- Then, when we look at the fiber-reinforced special concrete, it's even stronger 35.63% more at 7 days and 41.02% more at 28 days than normal concrete.
- Interestingly, that same fiber-reinforced concrete is also stronger than the special concrete by 12.98% at 7 days

and 4.32% at 28 days.

- Now, if we check out the Type 1 and Type 2 CFDTS columns after 28 days of curing, Type 1 had a boost in strength, about 7.31% more than Type 2.
- And between Type 1 and Type 3 CFDTS columns, Type 1 was even better 10.61% stronger after those 28 days.
- Lastly, comparing Type 2 and Type 3 CFDTS columns, Type 2 had 3.07% more strength after the same curing time.
- All in all, this project has added some valuable insight into the field and opened up new avenues for further research. I mean, the findings we've gathered here could really guide future studies and help in creating more effective, sustainable solutions down the line.

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