COMPARATIVE STUDY OF CONCRETE FILLED STEEL TUBES AND R.C.C COLUMN UNDER AXIAL COMPRESSION

YASH VIJAYANAND TANDALE
Lecturer, Civil Engineering Depart.
Universal college of Engineering & Research (Polytechnic Shift II)
Sasewadi, Pune

SHUBHANGI ANMOL MESHRAM
Intern, Pune Municipal Corporation
Shivajinagar, Pune

ABSTRACT

The experimental study have been conducted to study the behaviour of self- compacting Concrete Filled Steel Tube CFST stub columns strengthened by Glass Faber Reinforced Polymer GFRP and CFST Columns strengthened by GFRP laminates A total of 42 stub columns under monotonic compression load were tested in order to discover the best configuration of the GFRP for confined column system, Fourteen specimens with circular cross-sections 50 mm Diameter and another Fourteen specimens with square cross-sections 70X70 mm. Fourteen specimens with Rectangular cross-sections 95X95X50 mm and having thickness of each specimen is 3 mm. The experimental results indicated that the use of GFRP laminates to strengthen the GFST has a significant effect on the overall behaviour of GFST such as enhancement on its strength. Also, the GFRP confinement delays local buckling of steel tube, prevents a sudden strength reduction caused by the local buckling of the steel tube. and increases lateral confinement of the concrete core. It is found that the best configuration of GFRP tubes system is transverse CFRP tube for circular hollow steel tube columns. Finally, from experimental investigation we have conducted that by using GFRP laminates strength has been increase consider ability for CFST columns and R.C.C columns.

Keywords
CEST GFRP. RCC

1.INTRODUCTION

In the Concrete Filled Steel Tube Structural System high-strength concrete is used for filling steel tubes. These members are ideally suited for all applications because of their effective usage of construction material. In this type of composite members, the advantages of both hollow structural steel and concrete is utilized. CFST having excellent static and earthquake resistant properties and due to which, they are being used widely in real civil engineering projects. Concrete filled steel tubes possess properties such as high strength, high ductility and large energy absorption capacity.

When these types of composite members are used as structural columns, especially in high-rise buildings, CFST may be subjected to high shearing force as well as moments due to wind or seismic actions. Therefore it is very important to study the behaviour of CFST columns in axial compression.

From many research studies it is observed that it gives mechanical and economic benefits when high strength concrete infill is used, which contributes greater damping and stiffness to CFST columns compare to normal strength concrete. Due to high strength concrete infill, CFST columns require a smaller cross section to withstand the load, which is appreciated by architects and building engineers. Local buckling is delayed due to interaction between concrete and steel tube and this is the main advantage of CFST, along with which steel tubes provided sufficient confining effect to concrete. The enhancement of CFST column in structural system is due to composite action between steel and concrete. The steel tube itself acts as longitudinal and transverse reinforcement. The shell also provides confining pressure to the concrete, which puts concrete under tri-axial state of stress, and concrete infill increase the stiffness of column, which prevents the inward buckling of steel tube, and increases the stability and the strength of column system, resulting in higher flexural strength. Therefore, tubes with thinner walls could reach the yielding strength before local buckling.

Under axial compression, the steel tube confines the concrete, therefore improves both axial load resistance and ductility of CFST members. Steel tubes were also used as permanent formwork and the well distributed reinforcement located at most efficient position. Due to large shear capacity of concrete filled steel tubular members, they predominantly fail in flexure in a ductile manner. Confinement effectiveness may bereduced to hit if rectangular or square tubes are filled up with high strength concrete but it provides advantage against flexure.

The advantage of CEST columns in construction is reduces the material and labour cost related with formwork and steel reinforcement. The concrete core can act to increase the siffness and compressive strength of the hollow steel tube and to delay local buckling The hollow steel tube acts as concrete reinforcement, resists bending moments and shear forces, and confines the concrete thereby increasing ductility.

Composite construction incorporates the adverse property of steel which has high tensile strength and ductility with the concrete having high compressive strength, excellent fire resistance and low cost. The composite construction is very often adopted in super high- rise building, long span bridges and roof structures owing to its high structural efficiency with large strength to weight ratio as well as large flexural rigidities against instability and serviceability problems. Among the composite members, the composite column is gaining importance because of its wide applications over bridge piers subjected to impact from traffic, column supporting storage tanks, columns in high rise buildings, railway decks. piles and offshore structures.

FRP

Fibre-reinforced plastic FRP also called fibre-reinforced polymer, or fibre-reinforced plastic is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass in fibreglass, carbon in carbon-fibre-reinforced polymer, aramid, or basalt. Rarely, other fibres such as paper, wood, or asbestos have been used. The polymer is usually an epoxy, vinyl ester, or polyester thermosetting plastic, though phenol formaldehyde resins are still in use. FRPs are commonly used in the aerospace, automotive, marine, and construction industries. They are commonly found in ballistic Armor as well.

A polymer is generally manufactured by step-growth polymerization or addition polymerization. When combined with various agents to enhance or in any way alter the material properties of polymers, the result is referred to as a plastic. Composite plastics refers to those types of plastics that result from bonding two or more homogeneous materials with different material properties to derive a final product with certain desired material and mechanical properties. Fibre-reinforced plastics are a category of composite plastics that specifically use fibre materials to mechanically enhance the strength and elasticity of plastics.

The original plastic material without fibre reinforcement is known as the matrix or binding agent. The matrix is a tough but relatively weak plastic that is reinforced by stronger stiffer reinforcing filaments or fibres. The extent that strength and elasticity are enhanced in a fibre-reinforced plastic depends on the mechanical properties of both the fibre and matrix, their volume relative to one another, and the fibre length and orientation within the matrix. Reinforcement of the matrix occurs by definition when the FRP material exhibits increased strength or elasticity relative to the strength and elasticity of the matrix alone.

Types of Fibre-reinforced polymers

Carbon-fibre-reinforced polymers

FRP can be applied to strengthen the beams, columns, and slabs of buildings and bridges. It is possible to increase the strength of structural members even after they have been severely damaged due to loading conditions. In the case of damaged reinforced concrete members, this would first require the repair of the member by removing loose debris and filling in cavities and cracks with mortar or epoxy resin. Once the member is repaired, strengthening can be achieved through wet, hand lay-up of impregnating the fibre sheets with epoxy resin then applying them to the cleaned and prepared surfaces of the member.

Two techniques are typically adopted for the strengthening of beams, relating to the strength enhancement desired: flexural strengthening or shear strengthening. In many cases it may be necessary to provide both strength enhancements. For the flexural strengthening of a beam, FRP sheets or plates are applied to the tension face of the member the bottom face for a simply supported member with applied top loading or gravity loading. Principal tensile fibres are oriented in the beam longitudinal axis, similar to its internal flexural steel reinforcement. This increases the beam strength and its stiffness load required to cause unit deflection, however decreases the deflection capacity and ductility.

For the shear strengthening of a beam, the FRP is applied on the web sides of a member with fibre-oriented transverse to the beam's longitudinal axis. Resisting of shear forces is achieved in a similar manner as internal steel stirrups, by bridging shear cracks that form under applied loading. FRP can be applied in several configurations, depending on the exposed faces of the member and the degree of strengthening desired, this includes side bonding, U-wraps U-jackets, and closed wraps complete wraps. Side bonding involves applying FRP to the sides of the beam only. It provides the least amount of shear strengthening due to failures caused by de-bonding from the concrete surface at the FRP free edges. For U-wraps, the FRP is applied continuously in a 'U' shape around the sides and bottom tension face of the beam. If all faces of a beam are accessible, the use of closed wraps is desirable as they provide the most strength enhancement. Closed wrapping involves applying FRP around the entire perimeter of the member, such that there are no free ends and the typical failure mode is rupture of the fibres. For all wrap configurations, the FRP can be applied along the length of the member as a continuous sheet or as discrete strips, having a predefined minimum width and spacing.

Glass Fibre Reinforced Polymer:

"Glass Fibre reinforced polymers" or GFRP normally alluded to just as fiberglass are a demonstrated and successful option that have various favourable circumstances over conventional reinforcement methods, giving structures a more drawn-out service life. It utilizes glass fibres of textile grade. Textile glass filaments are composed as mixes of Calcium Oxide CaO, Aluminium Oxiden A1203, Boron Trioxide B203, or Magnesium Oxide MgO in powder structure. Then heating of these mixtures are done by direct softening by considering temperature up to 1300 degrees Celsius, then utilization of dies is done to expel fibre of glass filament in different diameter measurement. These fibres are assembled into bigger strings by Roving methodology. Glass fibres is the most famous intends to reinforce plastic. Glass Fibre Reinforced Polymers are for all time impervious to chemical acids and alkaline bases; subsequently additional concrete cover, cathodic protection, and anti-shrink additives are not needed. GFRP essentially enhances the life span of engineering structures where corrosion is a major consideration.

Application and advantages

Glass Fibre is a gigantically flexible because of its light weight, inborn quality, inherent strength, climate safe completion and mixed bag of surface textures. The advancement of fibre-reinforced polymer for commercial utilization was widely examined in the 1930s. It was of noteworthy to the flying business. Amid World War II, fiberglass supplanted the moulded plywood utilized in airship. Its first fundamental non-military personnel application was, building of pontoons and game car bodies, recently its utilization was grown to the automotive and sports gear areas and in airship production. Glass Fibre is additionally utilized as a part of telecommunications industry for covering radio wires, in light of its low signal attenuation property and RF permeability. Different use incorporate sheet-structure electrical separators and structural components usually found in power industry items.

Advantages of GFRP
1. High Strength: The strength quality to weight ratio of GFRP is high.

2. Lightweight: GFRP contains very low weight per square foot that brings out speedier reestablishment, low auxiliary framing, and less transportation costs.
Resistance: Unaffected by acid fall. GFRP resists salty water, compounds, and most chemicals.
3. Consistence Construction: To frame a one piece watertight structure. Cupolas and Domes are rosined together,
Ready to Mould Complex Shapes: Any shape can or structure can be formed virtually.
4. Low Maintenance: Research demonstrate that even after 30 years there is no loss in laminate properties.
Durability: GFRP is highly durable just like Stromberg. And it can confront class 5 tropical storm Floyd with no harm.

Disadvantage of GFRP
1. Few material systems cost Very high.
2. Technology is still progressive towards it maturity.
3. The method for Fabrication is sophisticated for fibre-reinforced systems.
4. The service experience is limited.

Physical Properties of material
1. Characteristics - structural steel differs from concrete in its attributed compressive strength as well as tensile strength.

2. Strength - Having high strength, stiffness, toughness and ductile properties, structural steel is one of the most commonly used material in commercial and industrial building construction.
3. Constructability-Structural steel can be developed into nearly any shape, which are either bolted or welded together is construction. Structural steel can be erected as soon as the material are delivered on site, where as concrete must be cured at least 1-2 weeks after pouring before construction can continue, making steel a schedule friendly construction material.

FRP-FRP's using glass fibre are the predominant reinforcing fibre in all FRPs. E-glass is the most commonly used fibre. It has high electrical insulating properties, good heat resistance, and has the lowest cost. S-Glass fibres have higher heat resistance and about one-third higher tensile strength than E-glass. The specialty AR-glass fibre are resistant to the alkaline environment found in concrete but have much higher cost.

Hollow Tubular Structure

The hollow tubes alone were designed in such a way that they are capable of supporting the floor load up to three or four storey height. Once the upper floors were completed, the concrete was pumped into the tubes from the bottom. To facilitate easy pumping the tubes were continuous at the floor level. Modem pumping facility and high-performance concrete make pumping three or four storey readily achievable. Due to the simplicity of the construction sequence, the project can be completed in great pace. There are a wide variety of composite column types of varying cross-section, but the most commonly used and studied are concrete-filled steel tubes. A concrete-filled steel tubular CFST column is formed by filling a steel tube with concrete, It is well known that concrete-filled steel tubular CFST columns are currently being increasingly used in the construction of buildings, due to their excellent static and earthquake-resistant properties, such as high strength, high ductility, large energy absorption capacity, bending stiffness. fire performance along with favourable construction ability etc. Recently, the behaviour of the CFST columns has become of great interest to design engineers. infrastructure owners and researchers.

Problem Statement

The concrete filled steel tubular column plays an eminent role in the construction industry owing to its structural behaviour like large deformation and energy absorption capacity. But these members get deteriorated due to the environmental effects like corrosion and ageing. The external strengthening of using fibre reinforced polymer FRP material is emerging as a new trend in enhancing the structural performance of CFST members to counteract the drawbacks in using the past rehabilitation work. Strength and ductility gain in concrete is obtained by many confinement parameters e.g. compressive strength of concrete.

Objective

1. To design concrete Mix for M20, M30 grade.
2. To study concrete filled steel tubes CFST under axial compression loading.
3. Comparative study of concrete filled steel tubes with and without FRP.
4. Comparative study of concrete filled steel tubes with RCC column.

Scope of Experiment

This gives a brief introduction to behaviour of concrete filled steel tube column under axial compression. It includes the comparative parametric study of square, circular and rectangular column with varying grades of concrete M20, M30 for their load carrying capacity and deformation. We are focusing on FRP the best main advantage of FRP is that it reduces corrosion as compare to CFST columns.

Description of Experiment

The present experimental study, a total of Nine square section, Six circular section Ten rectangular are to be tested. These specimen were cast with circular shape, rectangular shape, square shape. The complete load-deflection behaviour and strength of column specimen were obtained and result were discussed in the study. In addition the column specimen were analysed on an experimental result.

Section	Sections		
	RCC Column	CFST Column	CFST with FRP
RECTANGULAR	95×50×300 mm	95×50×300 mm	95×50×300 mm
CIRCULAR	60 mm Dia.	60 mm Dia.	60 mm Dia.
SQUARE	70×70×300 mm	70×70×300 mm	70×70×300 mm

Table No. 1 Sizes of columns

2. Concrete Mixtures: -

The goal of concrete mixtures was to produce concrete specimen which will have minimum compressive strength of 20 MPa and 30MPa For acquiring mix design for this strength levels required materials were selected and there properties were found out.

3. Test on Specimens

3.1 Objective: Determining the aggregate crushing value of course aggregate.

3.2 Reference: IS. 2386 Part IV-1963, IS: 383-1976.

3.3 Theory: The aggregate crushing value gives a relative measure of die mitofon aggregate to crushing under a gradually applied compressive load. With aggregate of aggregate crushing value 30 or higher, the result may be anomalous, and in such cases the ten percent fines value should be determined instead.

3.4 Apparatus: A15-cm diameter open-ended steel cylinder, with plunger and bune plate of the general form and dimensions shown in Fig. A straight metal tamping rod. A balance of capacity 3 kg. readable and accurate to one gram, IS Sieves of sizes .12.5. 10 and 2 36 mm. For measuring the sample, cylindrical metal measure of sufficient rigidity to retain its form under rough usage and of the following internal dimensions: Diameter 11.5 cm and Height 18.0 cm.

3.5 Procedure**:**

1 The material for the standard test shall consist of aggregate passing a 125 mm IS Sieve and retained on a 10 mm 15 Sieve and shall be thoroughly separated on these sieves before testing.
2. The aggregate shall be tested in a surface-dry condition. If dried by heating. the period of drying shall not exceed four hours, the temperature shall be 100 to 110°C and the aggregate shall be cooled to the room temperature before testing.
3. The appropriate quantity may be found conveniently by filling the cylindrical measure in three layers of approximately equal depth, each layer being tamped 25 times with the rounded end of the tamping rod and finally levelled off, using the tamping rod as a straight-edge.
4. The weight of material comprising the test sample shall be determined (Weight A) and the same weight of sample shall be taken for the repeat test.
5. The apparatus, with the test sample and plunger in position, shall then be placed between the platens of the testing machine and loaded at as uniform a rate as possible so that the total load is reached in 10 minutes. The total load shall be 400 KN.
6. The load shall be released and the whole of the material removed from the cylinder and sieved on a 2.36mm IS sieve for the standard test. The fraction passing the sieve shall be weighed (Weight B).

4.Results

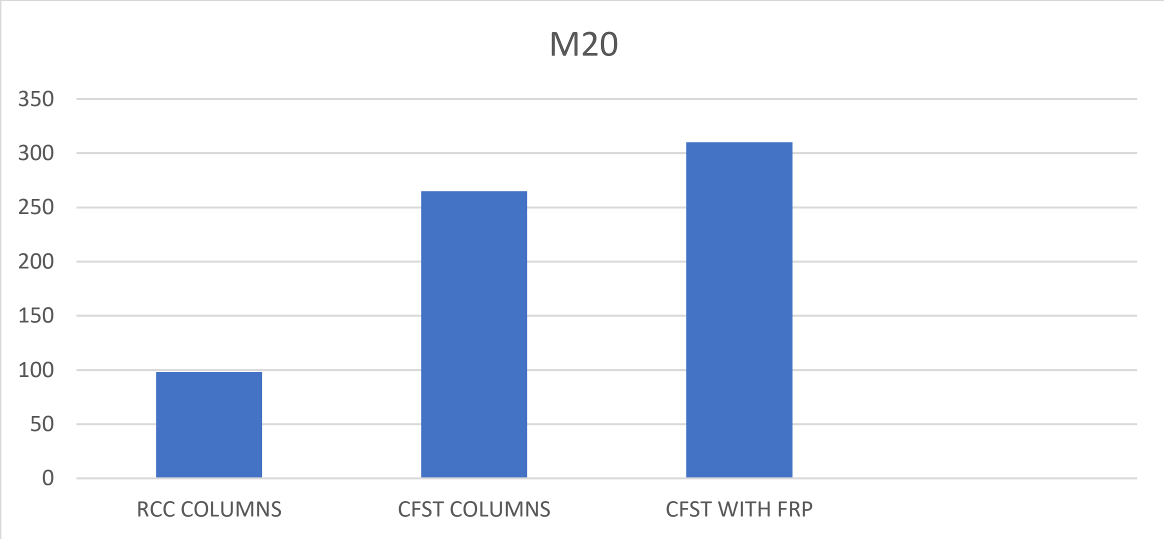
RECTANGULAR SPECIMENS

Specimen Shape: Rectangular
Specimen Type: RCC, CFST without FRP, CFST with FRP
Grade of Concrete: M20

Peak Load

Shape of Specimens	M20
RCC Column	103.30 KN
	82.55 KN
	92.00 KN
CFST Columns	256.70 KN
	267.80 KN
	273.10 KN
CFST with FRP	309.85 KN

Table No.2 Peak load of Rectangular Section M20



Graph No 1. Rectangular Section with M20

Observation- It is observed that the load carrying capacity of CFST column without FRP in increased by **96.66%** and with FRP it is increased by **107.95%**. as compared to RCC columns.

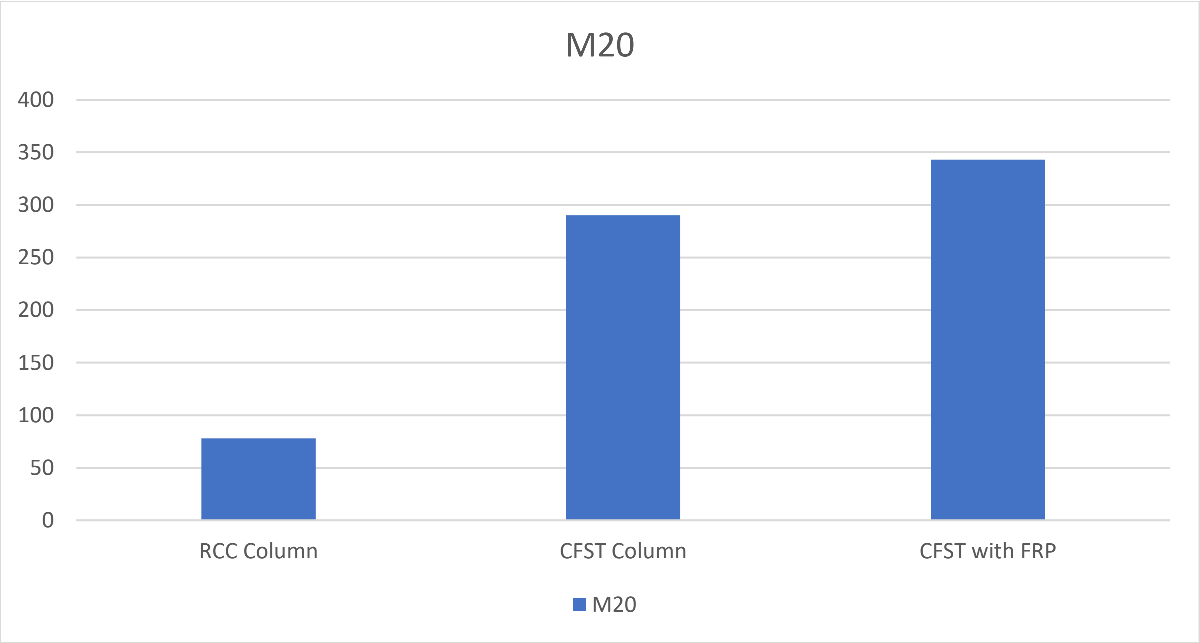
SQUARE SPECIMENS

Specimen Shape: Square
Specimen Type: RCC, CFST without FRP, CFST with FRP
Grade of Concrete: M20

Peak Load

Shape of specimens	M20
RCC column	77.30 KN
	85.13 KN
	105.10 KN
CFST Columns	283.95 KN
	289.10 KN
	295.10 KN
CFST with FRP	342.00 KN

Table No.3 Peak load of Square Section M20



Graph No 2. Square Section with M20

Observation- It is observed that the load carrying capacity of CFST column without FRP in increased by **105.77%** and with FRP it is increased by **117.27%**. as compared to RCC columns.

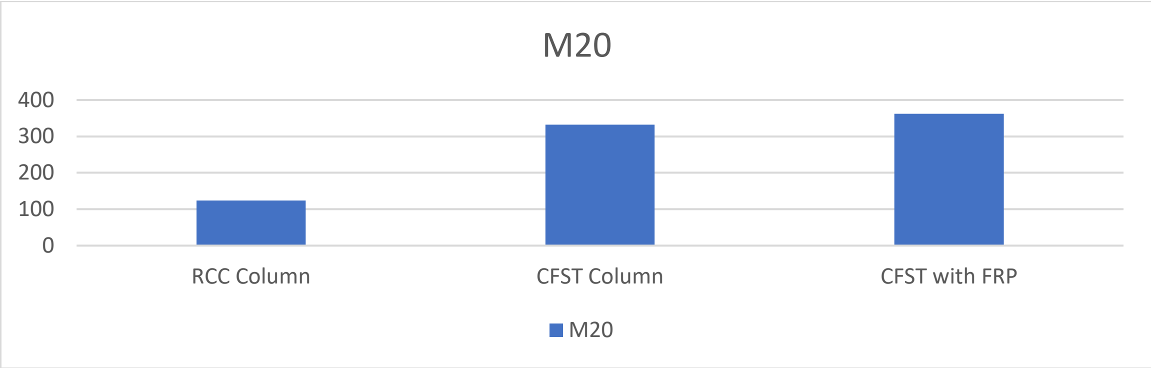
CIRCULAR SPECIMENS

Specimen Shape: Circular
Specimen Type: RCC, CFST without FRP, CFST with FRP
Grade of Concrete: M20

Peak Load

Shape of specimens	M20
RCC column	123.37 KN
	118.15 KN
	132.78 KN
CFST Columns	332.00 KN
	328.06 KN
	329.80 KN
CFST with FRP	362.18 KN

Table No.4 Peak load of Circular Section M20



Graph No 3. Circular Section with M20

Observation- It is observed that the load carrying capacity of CFST column without FRP in increased by **90.25%** and with FRP it is increased by **97.51%**. as compared to RCC columns.

4. Conclusion

1. It is observed that the load carrying capacity of M20 grade concrete Rectangular CFST column without FRP is increased by 96.66% and with FRP it is increased by 107.95% as compared to Rectangular RCC columns.
2. The load carrying capacity of M20 grade concrete Square CFST column without FRP is increased by 105.77% and with FRP it is increased by 117.27%.as compared to Square RCC columns.
3. The load carrying capacity of M20 grade concrete Circular CFST column without FRP is increased by 90.25% and with FRP it is increased by 97.51%.as compared to Circular RCC columns.

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