# An Experimental Study on Steel Wrapped Column Using Hybrid Concrete - An Overview

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***Abstract*— A Concrete-Filled Steel Tube (CFST) column comprises steel hollow section of circular or rectangular shape filled with plain or reinforced concrete. Steel confinement helps to reduce columns size and confined columns possess excellent earthquake-resistance and fire resistance properties. M30 design mix concrete amalgamated an hybrid fibre reinforced concrete which is used as an in-fill material for CFST columns. The test parameters are the amount of steel and fibre reinforcement, percentage of steel confinement, axial strain and the compressive strength of the concrete core. This mini project aims on experimental study on hybrid fibre reinforced Concrete Filled Steel Tube (CFST) short columns axially loaded in compression to failure.**

***Keywords*— *CFST column, Hybrid Fibre Reinforced Concrete, Steel Fibre Reinforced Concrete, Siliconized Plastic Polypropylene Fibre Reinforced Concrete. Introduction***

## I. INTRODUCTION

### *A. Cocrete filled Steel Tube Columns*

A Concrete-Filled Steel Tube (CFST) column comprises steel hollow section of circular or rectangular shape filled with plain or reinforced concrete. Steel columns have high tensile strength and ductility. Concrete columns have high compressive strength and stiffness. Composite columns combine steel and concrete, resulting in a column that has the beneficial qualities of both materials. Steel tube can be used, which acts as longitudinal and lateral reinforcement for the concrete core. Steel at the outer perimeter performs most effectively in tension and in resisting bending moment and also used as permanent formwork. CFSTs are used in buildings to avoid large size columns, supporting platform of offshore structures, roofs of storage tanks, bridge piers, and column in seismic zones. Concrete-filled steel tube (CFST) columns possess excellent earthquake-resistant properties such as high strength, high ductility, and large energy absorption capacity.

### *B. Hybrid Fibre Reinforced Concrete*

The Concrete made with cement, sand coarse aggregate and water is a kind of most commonly used construction material. These materials have inherently brittle nature and have some significant disadvantages such as poor deformability and weak crack resistance in the practical usage. Also their tensile strength and flexural strength is relatively low compared to their compressive strength. Fibre reinforced concrete (FRC) is a composite material consisting of cement, sand, coarse aggregate, water and short discrete fibres that are uniformly distributed and randomly oriented which increases its structural integrity. Fibres are used generally to improve the strength, ductility, post-cracking resistance, toughness etc. Various types of fibres such as metallic (steel) and non-metallic (siliconized plastic, siliconized plastic polypropylene, glass, carbon etc.) fibres were incorporated in plain concrete, each of which imparts varying properties to the concrete. The character of FRC changes with varying concretes, fibre materials, geometries, distribution, orientation, and densities of fibres used.

The addition of Non- metallic fibres in concrete improve its properties in fresh state and are effective in controlling the propagation of micro cracks in plastic state. There is no fibre which can improve all the desired properties of concrete in its fresh and hardened state. Hence to improve the desired properties of concrete the combination of two or more types of fibres is required and the composite is known as Hybrid Fibre Reinforced Concrete (HFRC).HFRC is used as an in-fill material, as it has greater flexural strength and tensile strength than plain concrete.

In a hybrid, two or more different types of fibres are rationally combined to produce a composite that derives benefits from each of the individual fibres and exhibits a synergistic response. The hybrid combination of metallic and non-metallic fibres can offer potential advantages in improving concrete properties as well as reducing the overall cost of concrete production. Combination of Steel Fibre Reinforced Concrete (SFRC) and Siliconized plastic Polypropylene Fibre Reinforced Concrete are the types of fibre reinforced concrete used in this study having wide range of advantages. Hence the combination of steel fibres and polypropylene fibres is used in this study. The addition of randomly distributed steel fibres increases the fracture toughness, ductility and impact resistance and Siliconized Plastic polypropylene fibres reduces the plastic cracking in concrete structures.

## II. OBJECTIVES

- Study the load carrying capacity of steel tube columns in-filled with different concretes under compression
- Compare the ultimate load and strain capacities of various combinations on CFST columns with that of normal reinforced columns.
- The effect of steel confinement to columns and compare the failure patterns.

## III. REVIEW OF LITERATURE

This chapter presents literature review on CFST columns and fibre reinforced concrete. Literature survey includes the study of findings of previous researches about how CFST columns behave on axial loading and what are the effects of fibre reinforcement in concrete mixes.

### *A. CFST Columns*

**Ahmed Elremaily et.al (2000)** investigated the behavior of concrete-filled tube columns under seismic loads. The test parameters included the level of axial load, the diameter-to-thickness ratio of the steel tube, and the concrete compressive strength. Six concrete-filled tube beam–column specimens were tested. The specimen was subjected to a cyclic lateral loading to simulate seismic loading conditions. In addition, a constant axial load was applied to the specimen. Results showed that CFST columns exhibit very high levels of energy dissipation and ductility. The test results also indicate that the column capacity was significantly improved due to the concrete strength gained from the confinement provided by the steel tube. An analytical model was developed to predict the capacity of circular CFST beam–columns accounting for the interaction between the steel and concrete.

**Mohanad Mursi et.al (2004)** presented an experimental and theoretical treatment of coupled local and global buckling of concrete filled high strength steel columns sometimes termed interaction buckling. A numerical model was developed in order to study the behavior of slender concrete filled high strength steel columns incorporating material and geometric non-linearity. The behavior of concrete filled steel slender columns affected by elastic or inelastic local buckling was also investigated and compared with relevant experimental results. The paper then concludes with a design recommendation for the strength evaluation of slender composite columns using high strength steel plates with thin-walled steel sections.

**P.K. Gupta et.al (2007)** presented an experimental and computational study on the behaviour of circular concentrically loaded concrete filled steel tube columns till failure. The effect of the grade of concrete and volume of fly ash in concrete was also investigated. A nonlinear finite element model was developed to study the load carrying mechanism of CFST columns using ANSYS. Results show the load carrying capacity decreases with the increase in percentage volume of fly ash up to 20% but it again increases at 25% fly ash volume in concrete.

**Ao-yu Jiang et.al (2013)** performed bending tests on square and rectangular thin- walled concrete-filled steel tubes series. An analytical model was developed for the thin- walled CFSTs subjected to bending in axial direction. Material properties of confined concrete, corner strength enhancement of cold-formed steel sections, residual stresses and plate local buckling were considered in the developed model. In addition, the suitability of current AISC standard, Euro code 4 and Han’s model for thin-walled CFSTs subjected to bending was also evaluated.

### *B. Hybrid Fibre Reinforced Concrete*

**C.X. Qiana et.al (2000)** investigated the optimization of fibre size, fibre content, and fly ash content in hybrid polypropylene-steel fibre concrete with low fibre content based on general mechanical properties. The research results show that a certain content of fine particles such as fly ash is necessary to evenly disperse fibres. Additions of a small fibre type had a significant influence on the compressive strength, but the splitting tensile strength was only slightly affected. A large fibre type gave rise to opposite mechanical effects, which were further fortified by optimization of the aspect ratio.

**T. Yu et.al (2006)** presented an experimental and theoretical study on the flexural behavior of a new type of hybrid FRP-concrete-steel member. Hybrid member is in the form of a double-skin tube, composed of a steel inner tube and an FRP outer tube with a concrete infill between the two tubes, and may be employed as columns or beams. The parameters examined in this study include the section configuration, the concrete strength, and the thicknesses of the steel tube and the FRP tube, respectively. Results show that these hybrid beams have a very ductile response because the compressive concrete is confined by the FRP tube and the steel tube provides ductile longitudinal reinforcement. The flexural response, including the flexural stiffness, ultimate load, and cracking, can be substantially improved by shifting the inner steel tube toward the tension zone or by providing FRP bars as additional longitudinal reinforcement.

### *C. Summary of Literature Review*

In case of CFST columns, column capacity was significantly improved due to the concrete strength gained from the confinement provided by the steel tube. Under both cyclic and monotonic tests specimens with carbon FRP cracked, whereas specimens with glass or hybrid FRP did not show any visible cracks throughout cyclic tests. Among all CFST columns, the hybrid lay-up demonstrated the highest flexural strength and initial stiffness. In case of unwrapped CFST columns, the outward buckling of steel tube was observed, as the inward buckling was prevented by in filled concrete. Additions of a small fibre type had a significant influence on the compressive strength, but the splitting tensile strength was only slightly affected.

## IV. METHODOLOGY

*a) Literature survey*
*b) Collection of materials from different sources*
*c) Mix design for M30 grade concrete*
*d) Fabrication of steel tubes*
*e) Experimental investigation*
*f) Preparation of trial mixes*
*g) Test on fresh and hardened concrete*
*h) Casting and curing of CFST specimens*
*i) Analysis and Discussion*
*j) Conclusion*

## V. SCOPE OF WORK

Scope of this work is limited to preparation of mix designs and its corresponding test on fresh and hardened concrete and testing and casting of Steel Wrapped Concrete Filled specimens.

Test on concrete is divided in two sections as Test on Fresh Concrete and Test on Hardened Concrete.

The followings tests is to be done on Fresh Concrete

a. Slump Test (IS 1199 – 1959)

b. Compaction factor test (IS 1199)

c. Vee – Bee Consistometer Test

The followings test is to be done on Hardened Concrete

| Sl. No | Specimen Type | Test |
|---|---|---|
| 1 | Cube | Compression Testing |
| 2 | Cylinder | Split Tensile Strength<br>Compression Testing |
| 3 | Cylinder | Modulus of Elasticity |
| 4 | Beam | Flexural Strength |

Preparation of specimen sample include preparation of Hybrid Concrete Mix by using various proportions of Metallic Fibres (Steel Fibres) and Non Metallic Fibres (Silconized plastic Polypropylene Fibres and Polypropylene fibres)

## VI. CONCLUSION

Steel Wrapped Concrete Filled columns having an L/D ratio less than 12 with various infill materials and different percentages of steel confinement, with or without internal bar reinforcements were tested under axial compression. Steel tubes were in-filled with different materials included normal concrete, steel fibre reinforced concrete; polypropylene fibre reinforced concrete and hybrid fibre reinforced concrete. The behavior of Steel Wrapped columns was analyzed with respect to ultimate load carrying capacity, failure modes and strain characteristics.

- Steel wrapping acts as lateral as well as longitudinal reinforcement for column and also provides a confinement effect to concrete, which increases the ultimate load carrying capacity of Steel Wrapped columns.

- HFRC filled Steel Wrapped Columns has an increase in ultimate load capacity and have minimum buckling of steel tube due to the structural integrity and reinforcement effect provided by the steel and polypropylene fibers.

- Strain carrying capacity of Steel Wrapped columns infilled with SFRC and HFRC is much greater and have minimum buckling of steel tube, which may be due to the structural integrity, increased ductility and post-cracking resistance offered by the fibres.

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