Comparison of Hybrid Fibre Reinforced Concrete With Normal Concrete In CFST Short Column

Divya M.A. and Anima P.

Abstract— These Concrete-Filled Steel Tube (CFST) column comprises steel hollow section of circular or rectangular cross section filled with plain or reinforced concrete. Steel confinement helps to reduce columns size and confined columns possess excellent earthquake-resistance and fire resistance properties. CFST columns are most suitable for modern high rise buildings by providing efficient solutions both in terms of strength and stiffness. M20 design mix concrete amalgamated with 0.75 % glass fibre and 0.5 % coir fibre was chosen as hybrid fibre reinforced concrete (HFRC) which is used as an in-fill material for CFST columns. A total of 4 column specimens comprising of two HFRCFST column and two normal concrete filled steel tube columns were tested. Steel tube specimens are of diameter 5cm, height 60 cm and thicknesses 3 mm. Short column were used for experiments. Results show that HFRCFST column specimen have higher ultimate load carrying capacity than NC filled steel tube columns

Keywords— *CFST columns, HFRCFST Columns, Deformations, Coir fibre, Glass fibre, Ultimate load, Concrete*

1 Introduction

CONCRETE filled steel tubes (CFST) are composite members of a structural system. It consisting of a steel hollow section of circular or rectangular cross section filled with plain or reinforced concrete. CFST members utilizes the advantages of both steel and concrete. Steel has high tensile strength and ductility. Concrete has high compressive strength, excellent fire resistance and low cost. The advantages of CFST are high strength, fire-resistance, good ductility, large energy absorption. It possesses excellent earthquake-resistance and fire resistance properties. Concrete filled steel tubes are used in many structural applications: columns supporting platforms of offshore structures, roofs of storage tanks, piers of bridges, piles of buildings, and columns of structures in seismic zones. In recent years, many steel and CFST structures have been found to be suffering from a range of deteriorations, including cracking, yielding and large deformation. These deteriorations are caused by a variety of factors, including fire, ageing, environmental degradation and corrosion. Above all, during an earthquake, many structures, even if they do not collapse, are damaged to some extent. Hence, these structures require greater load carrying capacity to support the designed load, or even repair to resist possible higher load corrosion and premature spalling of concrete cover .

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2 HYBRID FIBRE REINFORCED CONCRETE

Concrete is mixture of cement, sand, coarse aggregate and water. It is brittle in nature and has some disadvantages such as weak crack resistance, low tensile and flexural 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. Fibers are used generally to improve the strength, ductility ,post–cracking resistance, toughness etc. Fiber reinforced concrete helps to reduce the crack propagation and increase the mechanical properties compared to the normal concrete. Only one fiber cannot improve all the desired properties of concrete and hence two or more fibers are rationally combined and the composite is known as hybrid fibre reinforced concrete (HFRC).In this combination of artificial and natural fibre is used as a hybrid fibre. That is glass and coir fibre combination is used. Glass fibres and coir fibres, when added to concrete improves its properties such as fracture toughness, ductility, impact resistance and reduces the plastic cracking in concrete structures. Hence glass and coir fibres were used in the present study. HFRC has greater flexural strength and tensile strength than plain concrete.

3 METERIAL PROPERTIES

The circular hollow mild mild steel tube having an inner diameter of 50 mm was used in this study. The thickness of the hollow steel tube was about 3.0mm and the height of the stub column was 600mm. The yield strength of the mild steel was 250N/mm2. The concrete mix proportion was designed using the IS method to achieve strength of 20 N/mm2, and the mix ratio was 1: 2.1: 2.170. Ordinary Portland cement of 53 grade was used in this study as a binding material.

3.1 Cement

Ordinary Portland cement (53 grades) conforming to IS: 12269-2013 was used for the experimental program. Tests were conducted as per IS: 4031-1988. The properties of the cement are tabulated in Table 1. Tests conducted on cement were fineness of cement, standard consistency test, specific gravity and initial setting time

TABLE 1

PROPERTIES OF CEMENT

Specific gravity	3.1
Standard consistency	32 %
Initial setting time	150 minutes
Fineness of cement	1.3 %

3.2 Fine and Coarse Aggregate

Fine aggregate used was M-Sand which confirms to Table 4 of IS 383-1970. Coarse aggregate confirming to Table 2 of IS 383-1970 was used for the project. It consists of cubically shaped granite type aggregate having maximum size of 12.5mm. The properties of fine and coarse aggregates aggregates are shown in the Table 2.

TABLE 2

PROPERTIES OF FINE AND COARSE AGGREGATE

Specific gravity of fine aggregate	2.67
Specific gravity of coarse aggregate	2.76
Fineness modulus fine aggregate	3.41
Fineness modulus coarse aggregate	4.42

Concrete cubes specimens were caseted and tested at the age of 28 days to determine the compressive strength of the concrete. The average compressive strength of the concrete was about 29.4N/mm2. The compressive strength test, carried out on M20 mix of concrete are shown in Figure 1.

Fig. 1 compressive Strength Test Setup

Glass(artificial fibre) and coir (natural fibre) fibres were used for making hybrid fibre to strengthen the infilling concrete. These fibres when added to concrete it improves properties such as fracture toughness, ductility, impact resistance and reduces the plastic cracking in concrete structures.

Coconut fibre is extracted from the outer shell of a coconut. The common name, scientific name and plant family of coconut fibre are coir, cocos nucifera and arecaceae (palm), respectively. The advantages of coconut fibres include resistant to fungi, provide excellent insulation against temperature and sound, flame-retardant, unaffected by moisture and dampness, tough and durable, resilient, spring back to shape even after constant use. Coconut fibre is the toughest fibre (21.5 Mpa) amongst natural fibres. They are also capable of taking strain 4-6 times more than that of other fibres. While glass fibres improves the strength of the material by increasing the force required for deformation. Due to the presence of these uniformly dispersed fibres, the cracking strength of concrete is increased and the fibres act as crack arresters.

Fig. 2 Coir Fibres

Fig. 3 Glass Fibres

3 EXPERIMENTAL INVESTIGATION

An extensive experimental research has been done to study the axial compressive behavior of circular CFST short column in filled with different types of concrete such as normal M20 mix and HFRC. To obtain suitable fibrereinforced concrete mix forCFST columns several trials were done by axial compression tests on CFST columns and from those test results the optimum dosages of glass and coir fibres was determined. Results show that higher ultimate load can reach at 0.75 % GFRCFST column specimen while 1% for CFRCFST column. Using this optimum values, finally done hybrid fibre reinforced CFST columns.

Fig. 4 Mixing of Hybrid Fibres

4 TEST SETUP AND TEST PROCEDURE

The test set up consists of a Universal Testing Machine of (compression testing machine) 600 KN Capacity. The test specimens were placed appropriately on the center of the end bearing plates of compression testing machine. Axial load was applied to the column. The axial deformation of the column was measured using a dial gauge which was kept on top of the jack. The column was then tested to failure by applying the compressive load in small increments, and observations of occurrences such as axial deformation and ultimate load were carefully recorded. The test setup was shown in fig.5

Fig. 5 Test Setup

4 TEST RESULTS AND DISCUSSIONS

Table 3 gives the result of ultimate loads of HFRCFST and NC filled CFST column. From the compression test results, ultimate load obtained of HFRCFST specimen was 230 KN and for CFST column in-filled with plain concrete have 200kN. From this we can understood that the HFRCFST specimen have higher ultimate load carrying capacity than CFST Column in-filled with plain concrete.

TABLE 3
ULTIMATE LOAD OF HFRCFST COLUMN

Type of CFST Column	Ultimate Load (KN)
Normal concrete filled CFST column	200
HFRCFST column	230

Fig. 6 HFRCFST Column Before Loading

Fig. 7 HFRCFST Column After Loading

Fig. 8 Normal Concrete Filled Steel Tube Column Before loading

Fig. 9 Normal Concrete Filled Steel Tube Column After Loading

In HFRCFST column, the concrete infill prevents the steel tube from buckling inwards and it forces the steel tube to buckle in an outward direction and hybrid fibre delayed the development of macro cracks. Figure 10 shows the load deformation curve of HFRCFST column and NC filled steel tube

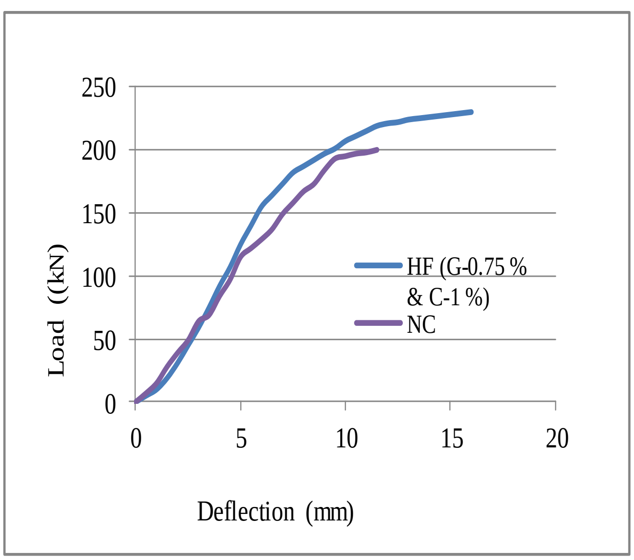

Fig. 10 Load Deformation Curve

7 CONCLUSIONS

Steel tube filled with normal concrete hybrid fibre reinforced concrete were tested under axial compression. The behavior of HFRCFST columns was analyzed with respect to ultimate load carrying capacity. From the experimental study the following conclusions were drawn

1. CFST column in-filled with hybrid fibre reinforced concrete has more load carrying capacity
2. In case of HFRCFST column have 15% increase in ultimate load carrying capacity than CFST column filled with normal concrete.
3. Load deformation curve of HFRCFST columns clearly indicated improved ductility when compared to normal filled concrete columns at ultimate load
4. HFRC filled steel tube column have minimum buckling of steel tube compared to NC filled steel tube. This may be due to the effect of fibres that they provide structural integrity to concrete and prevents the formation of micro cracks

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