Experimental Studies on Axially Loaded Fiber Reinforced Circular Column

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Abstract: **This paper investigates the behavior of steel fiber reinforced circular column. Totally four columns of 700 mm height and 100 mm diameter were casted and tested up to failure under axial loading conditions. The test specimens were divided into two groups, which were named as Group "A" and Group "B" of Ordinary ties and helical ties reinforcement respectively, each group has two columns. In every group one column is chosen as control column and another one column is 1% of steel fiber added. In this paper to evaluate and compared to the test results in various parameters such as ultimate load carrying capacity, stiffness, deflection ductility, energy ductility, stress and strain behavior, etc.,**

Keywords: Circular Column, Steel Fibre Reinforced Concrete, Axial Load.

I. INTRODUCTION

Column is the major structural element in all the structures to transmit the loads bound to it. Nowadays, to increase the strength of the column in the various methods have been adopted.

In the last two decades, attempts have been made to increase the tensile property of concrete since it is weak to withstand tension and these attempts have succeeded by the application of steel fiber in the concrete which has high strength and high modulus of elasticity. The important properties of steel fiber reinforced concrete are its superior resistance to cracking and crack propagation. They show excellent behavior in the seismic energy absorption. Andrea Porte et.al.,(1) The analysis of test results highlights that glass FRP (GFRP) confinement could determine significant strength and ductility increases; The rectangular columns with cross-section 115 mmx420mm, and height equal to 1.5m. At top and bottom of each specimen two bulbs with cross- section 700mmx350mm high, were realized in order to ensure a proper distribution of the axial load. Significant strength increase can be achieved by wrapping RC wall-like columns with GFRP laminates. Atri Dave et.al.,(2) RC cylinders of 600 mm height and 200 mm diameter were designed and cast with M25 grade concrete as per the guidelines of IS 456-2000 and tested in unconfined and confined conditions. Compare test results of compressive strength of the ordinary representative sample and wrapped sample also. The main objective is to predict ultimate axial load carrying capacity of FRP confined RC columns. The FRP confinement increases the axial load carrying capacity of concrete structures. The increase of 72.25% axial load carrying capacity of specimen was observed after confinement. Baris Binici et.al.,

(3) The main objective of this paper is to propose a Simplified analytical model to estimate the ductility of an FRP retrofit for circular columns at section and member levels In order to achieve this objective, a simple bilinear stress-strain model for FRP confined concrete is employed along with a closed form approximate solution. The accuracy of the model is verified by comparing model estimations with numerical sectional analysis and test results. Parameters such as reinforcement index, axial load ratio, and jacket rupture strain are found to influence the expected ductility of FRP retrofitted columns. Cengiz Duran Atis et.al.,(4) Comprehensive study on the properties of concrete containing fly ash and steel fibres. Properties studied include unit weight and workability of fresh concrete, and compressive strength, flexural tensile strength, splitting tensile strength, elasticity modulus, sorptivity coefficient, drying shrinkage and freeze-thaw resistance of hardened concrete. M.N.S. Hadi (5) wrapped RC columns with FRP straps both in vertical and horizontal directions and tested them under axial and eccentric loading. Seven RC columns of diameter 205 mm height of 905 mm were used. One column was reinforced with steel reinforcement while another six columns were made up of plain concrete and then vertical straps were provided,

followed by wrapping the column horizontally with FRP. Performance of CFRP straps was more effective compared to GFRP and conventional steel reinforcement. GFRP strengthened RC column performed better than steel reinforced concrete column. R. Kumutha et al. (8) studied the behaviour of RC rectangular columns strengthened using GFRP. Three aspect ratios (a/b) where a and b are respectively, the longer and shorter sides of column cross-section, a/b=1.0, a/b=1.25 and a/b=1.66 were considered. Specimens wrapped with 0,1,and 2 layers of GFRP were investigated. Total nine specimens were subjected to axial compression. Effective confinement with GFRP resulted in improving the compressive strength. Better confinement was achieved when the number of layers of GFRP was increased, resulting in enhanced load carrying capacity of the column, in addition to the improvement of the ductility.

II. SIGNIFICANCE OF THE RESEARCH

The steel fibre is used in the concrete in various applications of civil engineering. The important properties of steel fibre reinforced concrete are its superior resistance to cracking and crack propagation. Increases tensile strength and toughness, very durable, resistance to freezing and thawing, reduces surface permeability, dusting and wear, reduction in maintenance and repair cost and easy material handling. The scope of this research is to investigate the performance of ordinary ties reinforced concrete with helical ties reinforced concrete with steel fibre under axial load condition with respect to ultimate load carrying capacity, stiffness, deflection ductility, energy ductility and load-deformation. The test results were compared to the all type of columns.

III. EXPERIMENTAL PROGRAM:

3.1 Material Properties:

The Portland cement of 53 grade with specific gravity 3.12 was used for casting of the specimens which were collected from the local market (Dindigul). Locally available river sand was used as fine aggregate which passed through 2.62 mm size sieve having specific gravity 2.69 and fineness modulus 2.75 and conforming to grading zone III of IS 383:1970 specifications. The maximum size of the coarse aggregate is taken as 20mm and their specific gravity is found to be 2.72. Poly carboxylic ether super plasticizer is used in concrete for workability. 1% of steel fibres were used in volume of concrete having 50 mm length, 1 mm diameter and aspect ratio 50 was used. The properties of steel fibres were provided in Table 1. Compressive strength of conventional concrete is 30.53N/mm^2. Compressive strength of 1% of steel fibre added to conventional concrete is 45.51 N/mm^2.

Table.1: Properties of steel fibre

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PARAMETERS	VALUES
Length (mm)	50
Diameter (mm)	1
Density (Kg/mm^3)	7680
Modulus of elasticity (GPa)	200
Tensile strength (MPa)	1100

3.2 Details of Test Specimen:

The circular columns had 100 mm diameter and 700 mm height. 8mm diameter steel bars were used for longitudinal reinforcement and 7 mm diameter stirrups were spaced at every 150 mm as lateral reinforcement. Reinforcement details as shown in Fig. 1. A totally four columns were casted by using mould of PVC pipes of particular size as mentioned above. The test column specimens were divided into two groups, namely group 'A' and Group 'B'. Each group have two columns. The specimen names as shown in the Table 3. Group 'A' casted by ordinary ties reinforced concrete and group 'B' casted by helical ties reinforced concrete. One column from each group of specimen was control column. Another one is 1% of steel fibre added to the reinforced concrete. Compared to the test results in various parameters such as ultimate load carrying capacity, stiffness, deflection ductility, energy ductility, stress and strain behaviour, etc.,

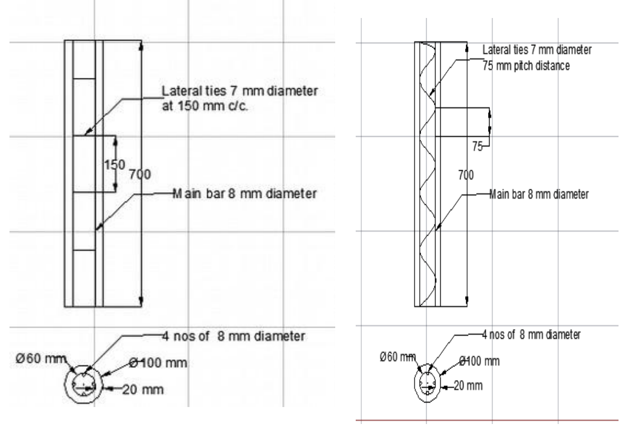


Fig.1a) Ordinary ties reinforcement b) Helical ties Reinforcement

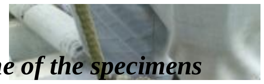



Table.3: Name of the specimens

A	CC(O)	Circular Column Ordinary ties
	CCSF(O)	Circular Column with Steel Fibre Ordinary ties
B	CC(H)	Circular Column Helical ties
	CCSF(H)	Circular Column with Steel Fibre Helical ties

3.3 Preparation of Test Specimen:

The concrete mix ratio for test specimens consisted of 325 kg/m3 of ordinary Portland cement, 656.67 kg/m3 of fine aggregate, 930.78 kg/m3 of coarse aggregate with water cement ratio of 0.45 are calculated as the design guidelines of 10262:2009. Super plasticizer were added to improve the workability of the concrete. Fresh reinforced concrete is placed into the two columns moulds and another two columns casted by 1% steel fibre added to the fresh reinforced concrete. Concrete properly compacted by the damping rod. After 24 hours, the moulds were removed and cured for 28 days until the time of testing. Preparation of test specimen in as shown in Fig. 2

Fig:2 a) Reinforcement details

b)PVC Mould

c) Placing of the concrete

d) Casting of columns

3.4 Experimental Set-Up:

All the circular column specimens were tested under constant axial load on Universal Testing Machine (UTM) of 1000kN capacity having a least count of 0.01kN. The test set-up for circular column as shown in Fig. 3. The column was supported with steel circular plate at top and bottom enabling partial fixity condition and to prevent the local crushing. The load was applied until failure of the columns. Axial deformation of column noted down at equal interval with help of the LVDT. Then ultimate load and corresponding deformation noted down.

Fig: 3 Test set- up for axial loading of columns

IV. RESULTS AND DISCUSSIONS:

4.1 Compressive strength

The cube size is 150 mm x 150 mm were casted and cured for 28 days. The cubes were tested in Universal Testing Machine (UTM) of 2000kN capacity having a least count of 0.01kN. Compared to the compressive strength of conventional concrete and 1% steel fibre added to the conventional concrete. The average compressive strength at 28 days was 30.52N/mm2 for concrete without fibres and 35.75N/mm2 for concrete with fibres. The result is Steel fibre reinforced concrete compressive strength is higher than the conventional concrete as shown in Fig. 4. Table 4. shows results of the compressive strength tests.

Table.4: Compressive strength

S.No	Specimen Indentify	Compressive strength @ 28 days (N/mm^2)	Average (N/mm^2)
1	A (CC)	32.26	30.52
2		28.78	
3		30.52	
4	B (SFCC)	35.75	35.75
5		36.62	
6		34.88	

A – Conventional concrete
B – 1% steel fibre added to conventional concrete

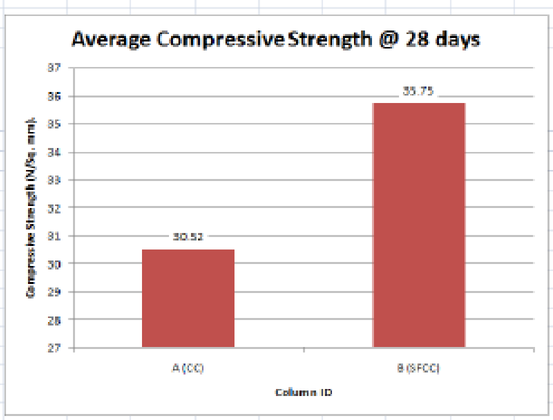


Fig:4 Compressive strength

4.1 Load carrying capacity:

The ultimate load of the tested columns presented in Table 5. Helical ties Steel fibre reinforced concrete columns higher axial load carrying capacity as compared to the other columns as shown in Fig. 5. Therefore Helical ties steel fibre reinforced concrete columns resulted the highest compressive strength

Table.5: Ultimate Load

S. No.	Column ID	Ultimate Load (kN)
1	CC(O)	210
2	CCSF(O)	216
3	CC(H)	220
4	CCSF(H)	235

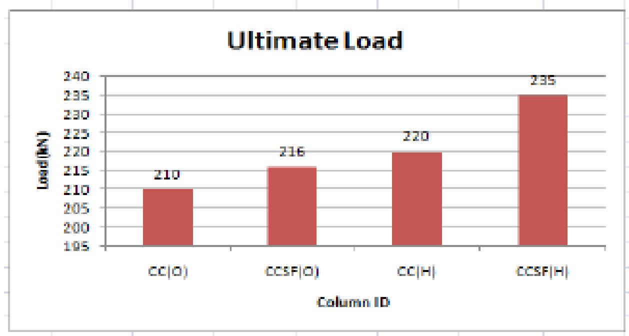


Fig:5 Ultimate Load

4.2 Stiffness:

The stiffness is defined as the ratio of ultimate load to the ultimate load deflection. The stiffness of the CC(O), CCSF(O),CC(H) and CCSF(H) columns were respectively as shown in Table 6. The ultimate load and ultimate load

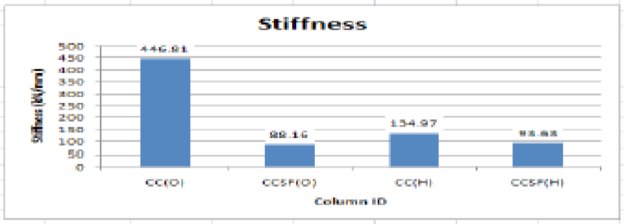
S. No.	Column ID	Ultimate Load (kN)	Deflection at Ultimate Load (mm)	Stiffness (kN/mm)
1	CC(O)	210	0.47	446.81
2	CCSF(O)	216	2.45	88.16
3	CC(H)	220	1.63	134.97
4	CCSF(H)	235	2.51	93.63

deflection curve of columns were plotted in Fig. 6.

Fig:6 Stiffness

4.3Deflection Ductility:

The deflection ductility is defined as the ratio of ultimate deformation to the yield deformation. The yield deformation can be determined from the load-deformation curve by assuming bilinear behaviour of the circular column



specimen. The deflection ductility of the CC(O), CCSF(O),CC(H) and CCSF(H) columns were respectively as shown in Table 7. The deflection at yield load versus deflection at ultimate load curve of columns were plotted in Fig. 7.

Table 7: Deflection Ductility

S.No.	Column ID	Deflection at Yield Load (mm)	Deflection at Ultimate Load (mm)	Deflection Ductility
1	CC(O)	0.45	0.47	1.04
2	CCSF(O)	1.71	2.45	1.43
3	CC(H)	1.1	1.63	1.48
4	CCSF(H)	1.49	2.51	1.68

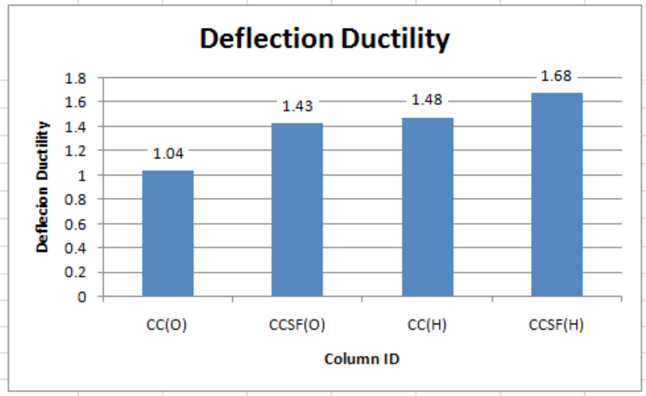


Fig:7 Deflection Ductility

***4.4 Energy Ductility*:**

The energy ductility is defined as the ratio of ultimate load area to the yield load area. The energy ductility of the CC(O), CCSF(O),CC(H) and CCSF(H) columns were respectively as shown in Table 8. The deflections at yield load area versus deflection at ultimate load area curve of columns were plotted in Fig. 8.

Table 8: Energy Ductility

S.No.	Column ID	Deflection at Yield Load Area (mm^2)	Deflection at Ultimate Load Area (mm^2)	Energy Ductility
1	CC(O)	22.5	49.35	2.19
2	CCSF(O)	145.34	264.6	1.82
3	CC(H)	88	179.29	2.03
4	CCSF(H)	119.19	294.89	2.47

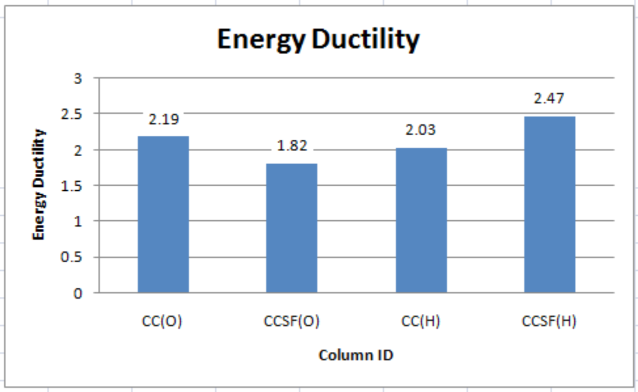


Fig:8 Energy Ductility

4.5 Load – Deformation Behaviour:

The loading was applied gradually and the deformation readings were taken at regular intervals of 30kN. The column was gradually loaded up to the ultimate load level. The results ofload and corresponding deformation were recorded in Table. 9. The load and deformation curve were plotted as shown in Fig. 9.

Table 9.a): Load Vs Deformation

S.No.	Load (kN)	CC(O)	CCSF(O)
1	0	0	0
2	20	0.24	0.1
3	40	0.33	0.61
4	60	0.41	0.83
5	80	0.45	1.1
6	100	0.46	1.35
7	120	0.47	1.5
8	140	0.47	1.62
9	160	0.47	1.81
10	180	0.47	2.01
11	200	0.47	2.24
12	210	0.47	2.45
13	216		2.45

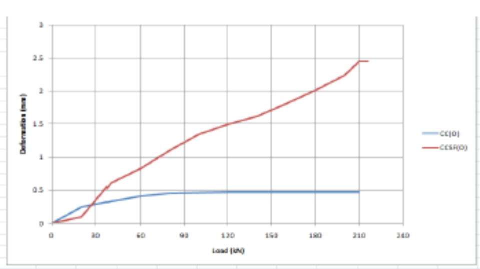


Fig. 9 a) Load Vs Deformation
Table.9.b): Load Vs Deformation

S.No.	Load (kN)	CC(H)	CCSF(H)
1	0	0	0
2	20	0	0
3	40	0.4	0.11
4	60	0.59	0.26
5	80	0.71	0.42
6	100	0.8	0.72
7	120	0.91	0.97
8	140	1.03	1.27
9	160	1.1	1.79
10	180	1.31	2.25
11	200	1.59	2.44
12	220	1.63	2.51
13	235		2.51

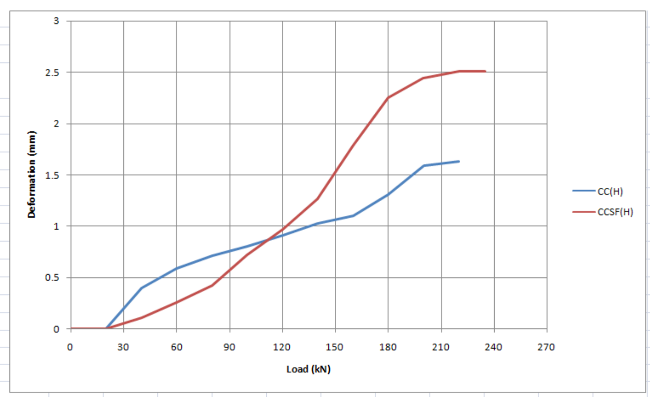


Fig. 9 b) Load Vs Deformation

V. CONCLUSIONS:

1. Compressive strength of Steel fiber reinforced concrete is higher when compared to the conventional concrete.
2. Ultimate load carrying capacity increased in steel fibre reinforced concrete in helical ties columns compared to the ordinary ties columns.
3. The deflection ductility of CCSF (H) column is times greater than the other columns.
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5. The deflection ductility of CCSF (H) column is times greater than the other columns.

In general it is found that CCSF (H) column has higher values of ultimate load carrying capacity, load – deformation, deflection ductility energy ductility and stiffness when compared to the other columns.

VI. IN FUTURE:

Each group of six columns preloaded for 60% of total load. After preloading the columns retrofitted in fully wrapped and partially wrapped in helical and transverse directions. Find the results in all aspect parameters including ultimate load carrying capacity, stiffness, deflection ductility, energy ductility etc., finally compare to the results.

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