

Structural Performance and Investigation of Double Skin Rubberized Steel Fiber Mixed Composite Column Using ANSYS

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Abstract— This paper discusses about concrete-filled steel tubular (CFST) structures which offers numerous structural benefits, including high strength and fire resistance, favorable ductility and large energy absorption capacities. This investigation study carries the structural performance of double skin rubberized steel fiber mixed composite column by using ANSYS. The column utilized both compressive strength of concrete and tensile strength of steel. Initially the performance of rubberized steel fiber mixed concrete is determined. Crumb rubbers of 20mesh are used to increase the damping property and arrest the vibration. Different ratio (5%, 10%,15%,20%) of crumb rubbers are replaced with fine aggregate. Steel fibers are added in 0.75% to minimize the diffusion of crack and withstand against dynamic and static load. The compressive strength test, splitting tensile strength test, and flexural strength tests were conducted. The compression strength, split tensile strength and flexural strength increases with crumb rubber replacement up to 15%, after that the strength tends to decreases, hence it is found that crumb rubber replacement up to15% and steel fiber 0.75% can be adopted. Various type of columns is modeled (Hexagonal in square (HS), Hexagonal in circular (HC), and Hexagonal in Hexagonal (HH) and analyzed their structural performance loads. CFST columns are economical, speed in construction and withstand high load when compared to normal Reinforced concrete (RC) columns. Axial load is applied and analyzed the above columns by using ANSYS (finite element method). Finally, the result was compared with various sections of column. The load carrying capacity of HS column is twice when compared with HS and HH columns.

Index Terms: ANSYS, CFST, Double skin, Dynamic Load, Finite Element Analysis, Rubberized concrete, Static Load.

Abbreviations: CFST- Concrete Filled Steel Tube, HS – Hexagonal in Square, HC – Hexagonal in Circle, HH- Hexagonal in Hexagonal.

I.INTRODUCTION

To reduce the long column failure double skin rubberized steel fiber reinforced composite column are suggested. In recent studies composite columns are widely use in industrial structures. Steel fibers are added in the mortar to increases the flexural strength from 25% to 100%, controls the propagation of cracks and high resistance to spalling. Crumb rubber induced to increases the ductile behavior and play a major role of minimizing the vibrations, sometimes it also acts as a damper. Mild steel is mainly used to reduce the cost by replacing the conventional reinforcement. Recent research carried out

II.MATERIAL AND METHODS

A. Cement

Cement is a binding material which is used for making of concrete. There are many types of cements in that we in Steel fiber and crumb rubber were combined to investigate the structural behavior of concrete with different ratios of crumb rubber. Use of steel fiber and crumb rubber showed a potential improvement in impact resistance. Moreover, a positive synergy of various concrete properties are often observed by combining these two materials. In current study, the benefits related to the addition of steel fibers to concrete were joined with the one resulting from rubberized concrete concept. In this research work, the resulting material is designated as

Steel Fiber Reinforced Rubberized Concrete used Ordinary Portland cement of grade 53 for the present experimental research work.

S.No	Type of tests	Observed values
1	Specific gravity	3.15
2	Fineness modulus	3%
3	Initial setting time	37min
4	Final setting time	525min

Table 1: Physical Properties of Cement

B. Aggregate

Aggregate is used for many different projects within the construction sector. In construction, an aggregate is used for its economic factor to reduce the crack and most essentially to provide strength to the structure. An aggregate is important part of making concrete and is used for many different uses.

TABLE 2: Physical Properties of Aggregate

Specific gravity	2.76
Fineness modulus	2.88
Water absorption (%)	0.65
Bulk modulus (kg/m ³)	1789
Moisture content (%)	0.1

C. Mild Steel

Mild steel consists of iron and alloyed with less than 0.3 percent carbon. it has very little carbon and other alloying elements to block dislocation in crystal structures. The building industry frequently uses mild steel plate due to ductile material, machinable and weld able. it can bend without cracking; it makes far more sense to recycle mild steel as a means of saving energy and putting it to further good use.

Table 3: Properties of Mild Steel

Density	7850kg/m ³
Tensile strength	360MPa
Elongation at break	15%
Young's modulus	200MPa
Bulk modulus	140MPa

D. Crumb Rubber

Recycled tire is a practical and ecological solution, it arrests the vibrations and annoying noised caused by trains and trams in area which near to the structure. Crumb rubbers are added to the mass of the concrete to improving its property and low cost in maintenance.

Table 4: Properties of Crumb Rubber

Chemical composition of crumb rubber	Test data%
Acetone extract	10
Rubber hydrocarbon	25
Carbon black content	30
Natural rubber content	31
Ash content	4

E. Steel Fibers

Steel fibers are added to increases the flexural strength, toughness, impact resistance and abrasion resistance.

Steel fibers mixed to the concrete to reduce the usage of conventional steel rebar's. In this paper, steel fibres is used to reduce plastic shrinkage cracking.

Table5: Properties of Steel Fiber

Length (mm)	40 to 60
Diameter (mm)	0.60
Available form	Winded
Color	Silver thin wires
Specific gravity	0.87
Water absorption%	210

III. ANSYS MODEL

The dimension of column designed according to IS 1239-2004.

A. Modeling and Material properties

Three-dimensional models were developed in ANSYS Workbench to show the behaviour models developed. The dimensions and material properties defined in this are fixed with reference to Indian Standards.

The CFST columns are modelled using ANSYS Workbench. The material properties were assigned support and loading conditions were provided. The analysis done in this research is structural analysis. In structural analysis the column models are analysed under axial loading. Column support is fixed at bottom and free at top.

Steel tube is modelled by using ANSYS Workbench 16.1.M30 grade of concrete and Fe 250 MPa steel is used. The model developed by considering Slenderness ratio (L/D=16.09). Poisson's ratio of steel is 0.3, Poisson's ratio of concrete is 0.15, Poisson's ratio of crumb rubber is 0.48 and Poisson's ratio of steel fibre is 0.3.

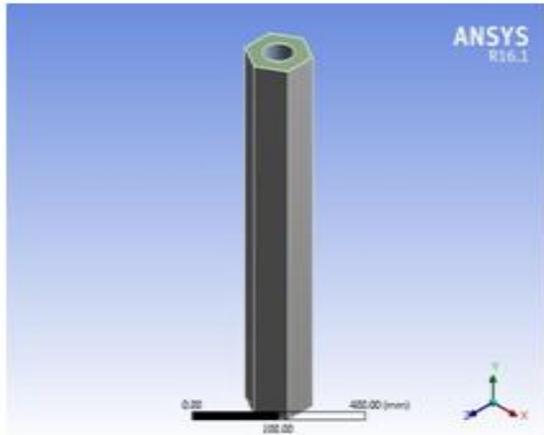


Fig.1 Hexagonal in circular (HC)

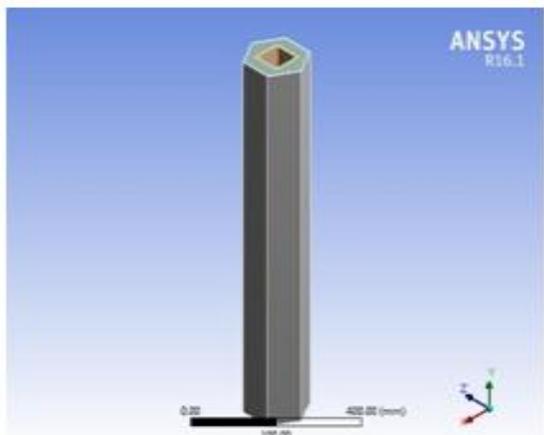


Fig. 2 Hexagonal in square (HS)

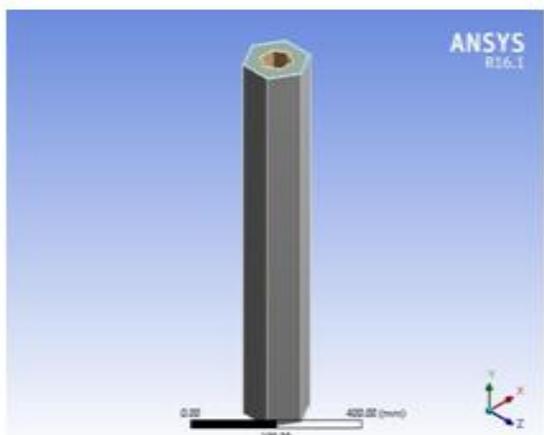


Fig. 3 Hexagonal in Hexagonal (HH)

IV.RESULTS AND DISCUSSION

Double skin HS column shows maximum load in axial compression as 1183.70 kN and maximum lateral deformation as 22.27mm shown in fig 4.

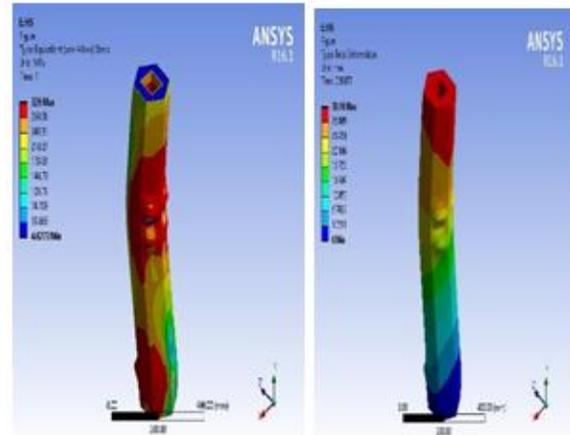


Fig. 4 Stress behavior for HS column
Double skin HC column shows maximum load in axial compression as 951.25 kN and maximum lateral deformation is 12.101 mm as shown in fig 5.

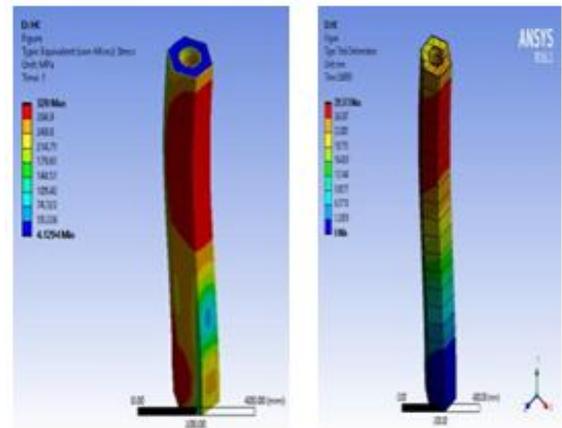


Fig. 5 Stress behavior for HC column
Double skin HC column shows maximum load in axial compression that is 951.25 kN and maximum lateral deformation is 12.101 mm as shown in fig 5.

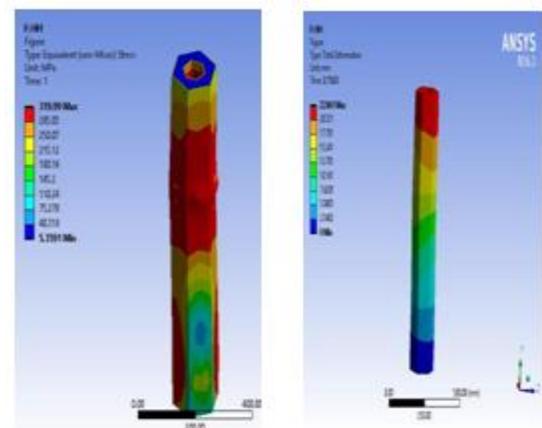


Fig. 6 Stress behavior for HH column

Ultimate crack of 1m height CFST column occurred at 1183.70 kN load at the maximum deflection of 22.279 mm as described in the table 6.

Deflection mm	Load kN
0	0.00
6.0075	1026.20
12.036	1090.20
18.088	1154.40
19.534	1169.10
20.887	1180.30
22.279	1183.70
23.116	1182.30
23.94	1171.90
24.901	1158.20
26.35	1135.90
28.499	1101.40
29.256	1090.60
30.011	1080.30
31.143	1066.00
32.009	1055.80

Ultimate crack of 1m height CFST column occurred at 951.25 kN load at the maximum deflection of 12.101 mm as described in the table 7.

Table 7: Load deflection table for HC column

Deflection mm	Load kN
0	0.00
4.3205	910.35
4.5225	921.81
5.2556	927.99
6.3069	934.13
7.3305	938.70
7.8603	940.83
8.3885	942.69
9.175	945.24
10.345	948.64
12.101	951.25
13.861	949.84
15.633	944.55
17.396	936.92
19.164	927.82
20.932	917.52

Ultimate crack of 1m height CFST column occurred at 1096.30kN load at the maximum deflection of 22.797mm as described in the table 8.

Table 8: Load deflection table for HH column

Deflection mm	Load kN
0	0.00
6.0059	980.37
12.014	1039.70
13.592	1054.70
15.169	1069.60
17.539	1092.10
21.398	1112.30
21.979	1105.60
22.797	1096.30
24.376	1074.30
26.74	1043.10
29.065	1017.40
31.396	993.64
32.402	984.58

The graph represents the axial load and lateral deformation for all three columns. The load carrying capacity of HS column is twice when compared with HS and HH columns.

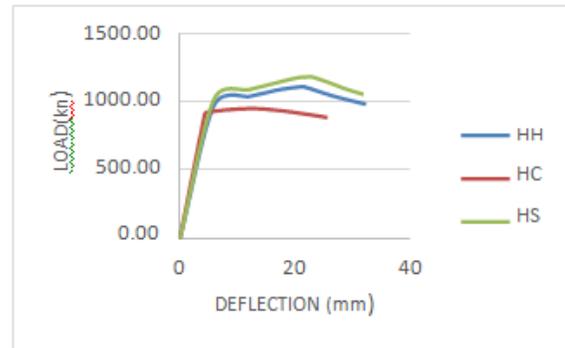


Fig.7 Load vs Deflection graph

The experimental study carries over in the steel fiber mixed rubberized concrete. The compressive strength test, splitting tensile strength test, and flexural strength tests were conducted. The compression strength, split tensile strength and flexural strength increases with crumb rubber replacement up to 15%, after that the strength tends to decrease, hence it is found that crumb rubber replacement up to 15% and steel fiber 0.75% can be adopted. According to the test values the CFST columns are modeled by using ANSYS. Maximum load carrying capacity of hexagonal in square column is 1183 kN of deflection 22.279mm. Maximum load carrying capacity of hexagonal in circular column is

951.25kN of deflection 12.101mm. Maximum load carrying capacity of hexagonal in square column is 1183.70kN of deflection 22.792mm. Hence comparing the other column, the hexagonal in square double skin column have 2 times more load carrying capacity than hexagonal in circular and hexagonal in hexagonal columns.

VI.FUTURE SCOPE

The CFST column specimens has to be casted experimentally and the test results are compared with ANSYS model values.

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