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Analytical Studies Of Fiber Reinforced Concrete Steel Tube Under Axial Compression

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***Abstract*—In the present investigation an attempt is made to study strength of 42 Specimens, Of Which half of the specimens are of diameter 33.7mm and remaining half are of diameter 42.4mm. Tests are conducted for concrete filled steel tubes (CFST) of L/D ratio 10,12 and 14 with infilled concrete of grade M30 and M40 having fiber content of 0%,0.2% and 0.3% .This paper deals with comparative study between experimental results and analytical results obtained by linear finite element analysis software ABAQUS , for CFST under axial compression. The experimental investigation is carried out on circular CFST specimens. The tests on said CFST specimens are carried out with the help of monotonic loading machine. Experimental and analytical results are compared. From which it is observed that analytical results are in good agreement with experimental results. Analysis was run for both hollow tubes and CFST. The important factors which affect axial shortening and ultimate axial load bearing capacity of CFST column are cross-sectional area (A), thickness of steel tube (t) and strength of infilled concrete (f_{ck}). Glass fibre reinforced concrete (GFRC) is a new material which enhanced strength and improved ductility.**

***Index Terms*— CFST, Hollow Tube, Finite element analysis, ABAQUS, Axial load.**

I. INTRODUCTION

Concrete Filled Steel Tubular (CFST) columns are used in Infrastructure and Buildings Projects in every part of the world. Instead of other forms of construction, CFST Columns helps in structural performance and speed of construction. Among Various infill materials, fibre is used extensively in CFST column. CFST columns are structural members used in both low-rise and high-rise building construction. CFST columns are constructed by erecting hollow steel columns as a structure's frame which is then filled with concrete as construction advances.

CFST has the advantages of both hollow structural steel and concrete is utilized. CFST having excellent static and earthquake resistant properties .CFST possess properties such as high strength, high ductility and large energy absorption capacity. 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 steel tube itself acts as longitudinal and transverse reinforcement. The concrete core can act to increase the stiffness 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.

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The main objective of this research program is to investigate the compressive behavior of CFST columns with concrete infill of M20 and M30 grade. Comparisons are made with analytical results using ABACUS software.

A. Types Of CFST Columns

CFST tubes are classified as circular, rectangular and square, hexagonal shapes and circular tubes are most commonly used ones. CFST tubes are classified as follows.

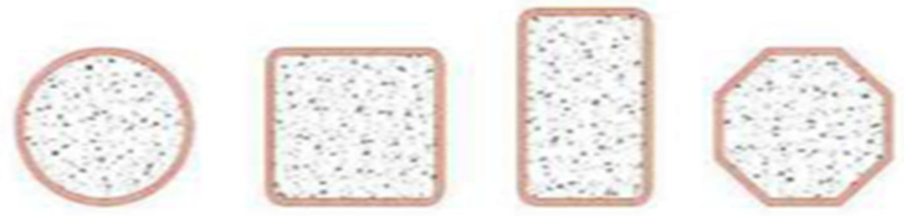


Fig I. cross sections of concrete filled tubes

B. Fiber Reinforced Concrete (Frc)

- *Glass fiber*
  In this section the glass fibre-reinforced concrete is examined. It is a cement-based Material reinforced with short glass fibres. When glass fibre is added to a concrete mix, They are randomly distributed and act as crack stemmers. It increase in resistance and toughness under monotonic loading. The mechanical properties of FRC to the fundamental properties of fibres, such as, diameter, length, and percentage in the matrix material, shape, bond characteristics and tensile strength.

Figure2: Glass Fiber

TABLE I. PROPERTIES OF GLASS FIBER

SL NO	PROPERTIES	VALUES
1	Tensile strength	1020 to 4080N/mm2
2	Length	20mm
3	Diameter	13.2 µm
4	Impact strength	1500%
5	Young's modulus	70GPa
6	Poisons ratio	0.23
7	density	2.54

C. Compressive Strength after 28 days

TABLE II : COMPRESSIVE STRENGTH AFTER 28 DAYS

Sl no	Mix designation	% of polypropylene Fiber	C/S Area of cube in mm^2	Load in Tons	28 days Compressive strength in N/mm^2
1	M20	0Percentage	225	51.5	22.5
2		0.2Percentage	225	62	27.05
3		0.3Percentage	225	65.5	28.6
5	M30	0Percentage	225	73.2	31.95
6		0.2Percentage	225	78	34.06
7		0.3Percentage	225	81.5	35.5

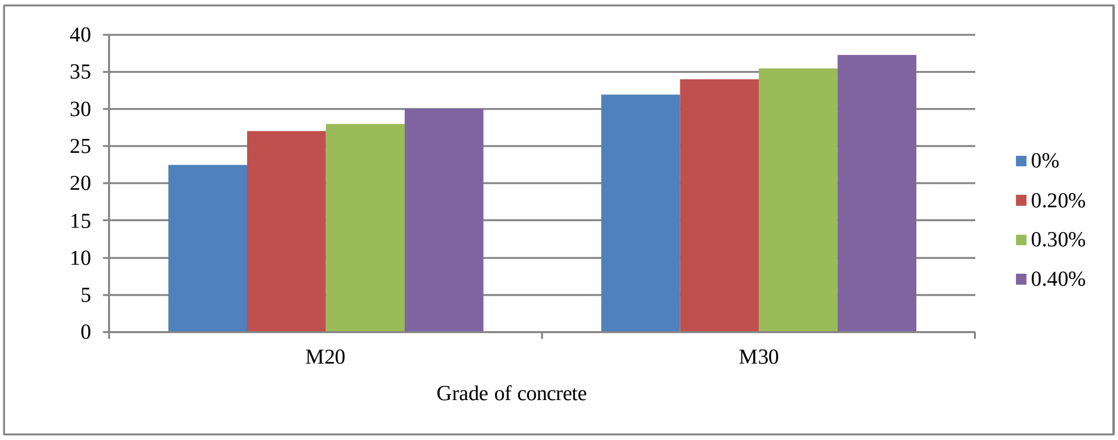


Figure 3: Variation Of Compressive Strength For M20 And M30 Grade Of Concrete

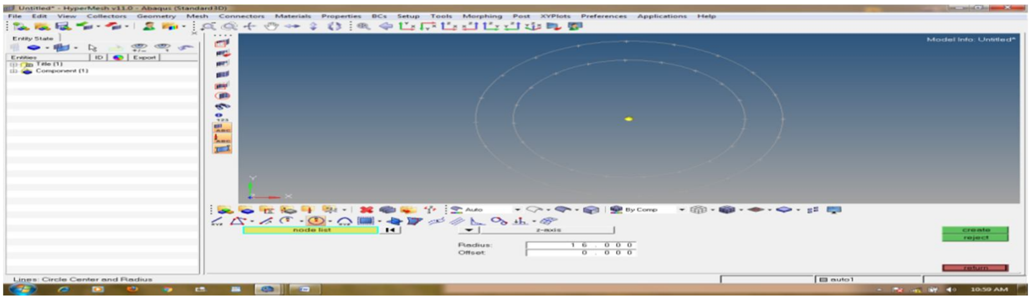
II. FINITE ELEMENT ANALYSIS

A. Load carrying capacity and comparison with experimental results

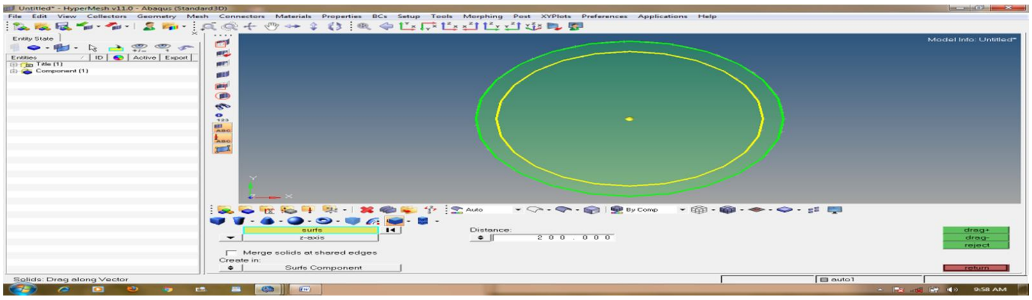
ABAQUS software is used for analytical study. Concrete core and steel pipe both are consider as solid homogeneous elements. No inter-particle friction is considered. Only linear analysis is done. Load is applied according to final axial deformation observed at experimental failure of specimen. The final load carrying capacity is calculated for the same final axial deformation in ABAQUS software which is shown in deflection output diagram. Concrete properties in the specimens were molded as isotropic Theoretical results obtained by ABAQUS are quite comparable with experimental results.

Material specification

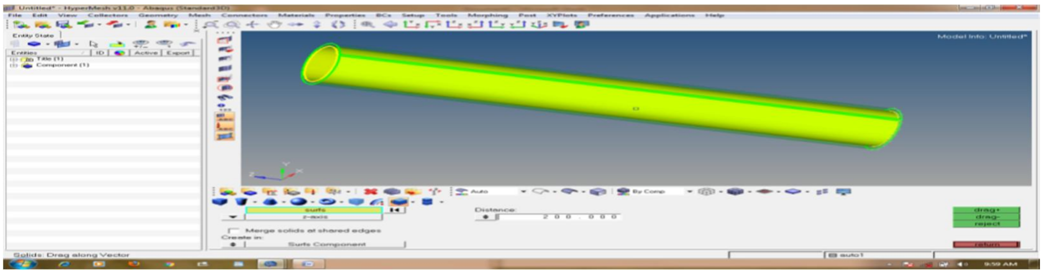
- Steel
  Material: Structural Steel Fe 310Mpa
  Young’s Modulus E=200Gpa
  Poison’s ratio v=0.3
  Density p=7800kg/m3.
- Concrete
  Grade of Concrete: M20/M30
  Young’s Modulus E=22360.7Mpa/25000Mpa
  Poison’s ratio v=0.16-0.3
  Density p=2400kg/m^3
  Modeling and Analysis Using HYPER MESH AND ABACUS



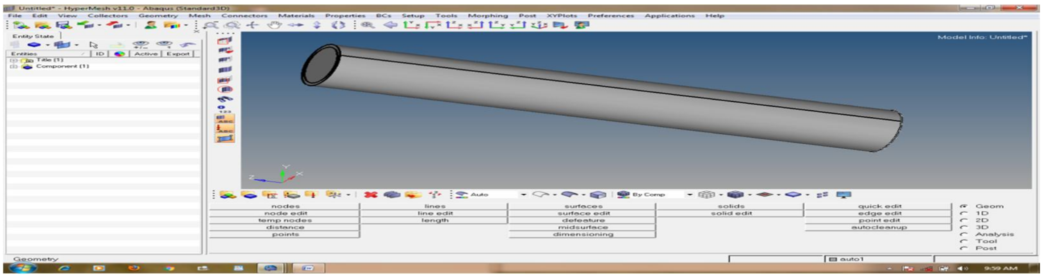
Step 1: Selecting The Diameter Of The Tube In The Hyper Mesh



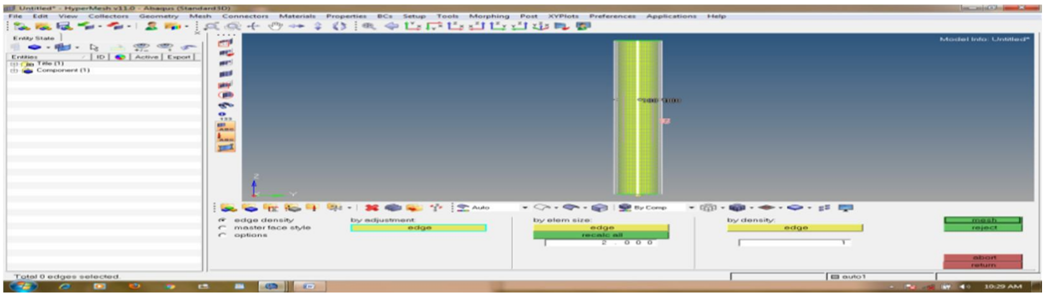
Step 2: Defining Material Properties And Components



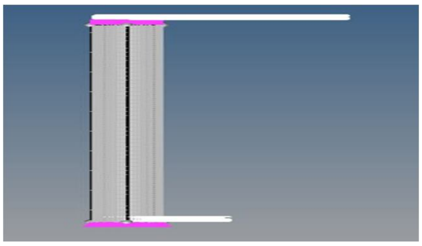
Step 3:Segregation Of Elements



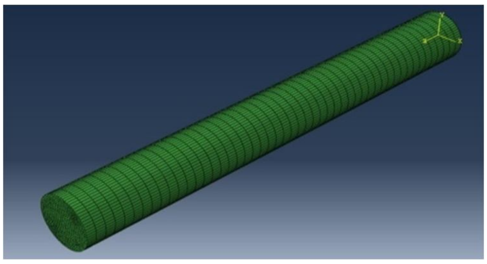
Step 4: Creating Solid Model

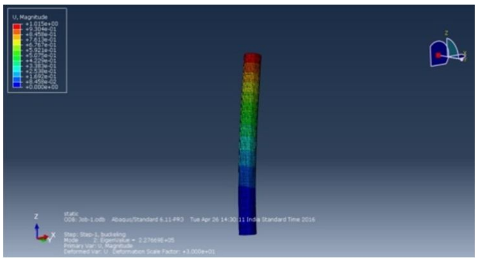


Step 5: Meshing of CFST column



Step 6: Applying Load At End Support





Step7 Analysis using ABAQUS

Figure 4: Export the model into ABAQUS

Figure 5: Buckling of column

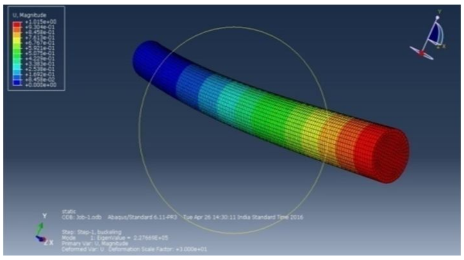


Figure 6: Mode 1 deformation

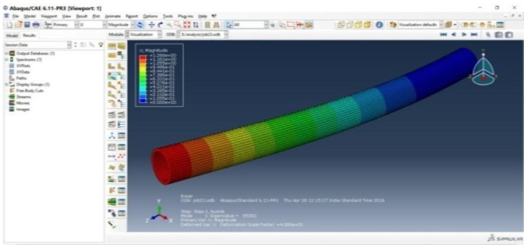


Figure 7: Mode 2 deformation

III. Analysis Results

TABLE III: ANALYSIS RESULTS

Exp no	Diameter, mm	Thickness, mm	Percentage of Fiber	Grade	Length, mm	Area, mm2	(Analysis) Pu (Kn)	(Exp)Ultimate Load, Pu(Kn)	Percentage Error	Type
1	33.7	3.2	-	-	337	306.62	146	112	12.5	HOLLOW
2	33.7	3.2	-	-	405	306.62	142	109	11.9	
3	33.7	3.2	-	-	472	306.62	135	103	16.5	
4	42.4	3.2	-	-	424	394.08	163	135	3.7	
5	42.4	3.2	-	-	509	394.08	157	128	7.0	
6	42.4	3.2	-	-	594	394.08	142	121	12.4	
7	33.7	3.2	0	M20	337	891.96	183	130	13.8	M20 GARDE
8	33.7	3.2	0.2	M20	337	891.96	198	136	13.2	
9	33.7	3.2	0.3	M20	337	891.96	212	139	13.7	

10	33.7	3.2	0	M20	405	1411.95	176	127	15.0	
11	33.7	3.2	0.2	M20	405	1411.95	189	133	13.5	
12	33.7	3.2	0.3	M20	405	891.96	209	137	13.1	
13	42.4	3.2	0	M20	424	891.96	232	165	6.1	
14	42.4	3.2	0.2	M20	424	891.96	258	171	10.5	
15	42.4	3.2	0.3	M20	424	891.96	273	176	9.7	
16	42.4	3.2	0	M20	594	891.96	230	158	5.7	
17	42.4	3.2	0.2	M20	594	1411.95	251	162	8.6	
18	42.4	3.2	0.3	M20	594	1411.95	258	166	7.8	
19	33.7	3.2	0	M30	337	891.96	218	140	11.4	M30 GARDE
20	33.7	3.2	0.2	M30	337	891.96	222	146	11.6	
21	33.7	3.2	0.3	M30	337	891.96	239	149	12.1	
22	33.7	3.2	0	M30	405	1411.95	198	137	8.0	
23	33.7	3.2	0.2	M30	405	1411.95	211	141	12.8	
24	33.7	3.2	0.3	M30	405	891.96	226	146	11.0	
25	33.7	3.2	0	M30	472	891.96	192	133	7.5	
26	33.7	3.2	0.2	M30	472	1411.95	216	138	10.1	
27	33.7	3.2	0.3	M30	472	1411.95	229	142	9.9	
28	42.4	3.2	0	M30	509	1411.95	256	171	4.7	
29	42.4	3.2	0.2	M30	509	1411.95	269	175	6.2	
30	42.4	3.2	0.3	M30	509	891.96	272	178	12.6	
31	42.4	3.2	0	M30	594	891.96	234	163	4.9	
32	42.4	3.2	0.2	M30	594	1411.95	246	169	7.7	
33	42.4	3.2	0.3	M30	594	1411.95	258	172	9.9	

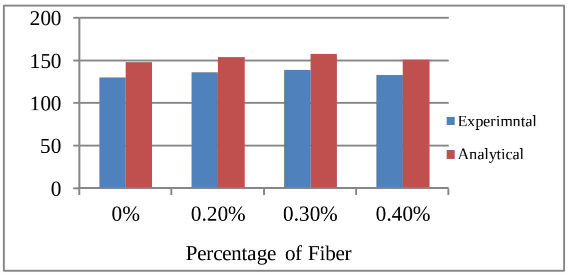


Figure 8: Variation of Pu for different Percentage of fiber d_2=42.4 mm L/D ratio =10 for M30 grade of concrete

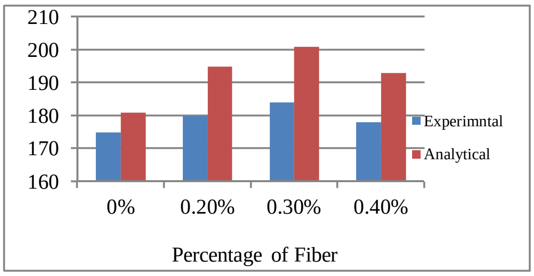


Figure 9Variation of Pu for different Percentage of fiber d_1=33.7 mm L/D ratio =10 for M20 grade of concrete

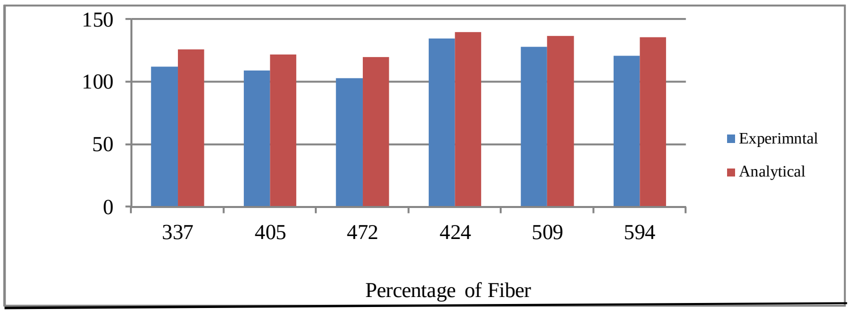


Figure 10. Variation of Pu for different length of hollow tube

IV. Results

- Analytical results obtained by ABAQUS are in good agreement with experimental results and quite comparable with experimental results.
- The CFST specimens are failed due to local buckling. Circular specimens failed in length in upper half part load carrying capacity (Pu) increases, as the length of the steel tube decreases for a given diameter and thickness.
- As percentage of glass fiber is increased, load carrying capacity (Pu) also increases up to 0.3% fiber
- Load carrying capacity (Pu) decreases with increase in L/D ratio for a given thickness and a given grade of concrete.
- Load carrying capacity (Pu) increases with increase in diameter of steel tube for a given L/D ratio, grade of concrete and a given thickness.
- The deformation decreases with increase in diameter for a given L/D ratio, grade of concrete and thickness of tube.
- Hollow steel tubes take lesser load when compared to tubes with M30 and M40 grade concrete infills.

References

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