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Analysis of Double-Skinned (CFST) Circular and Square columns by Using ANSYS

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Abstract - *In this present study carried out the comparison between normal strength concrete to high strength concrete for solid and double skinned CFST columns of circular and square columns for different hollowness ratio. There are four set of sixteen specimens used in this analysis, single solid circular CFST column and two set of double skinned circular CFST columns. Single solid square CFST column and two sets of double skinned square CFST columns for Normal strength concrete 50MPa and High strength concrete 80MPa. The models were analyzed in axial load carrying capacity for double skinned CFST column for different hollowness ratio of 0.2, 0.4 and 0.6 for circular and square columns by using ANSYS workbench 18.1. The models were analyzed under load carrying capacity. The analyzed model results were compared between the solid and hollow circular and square double skinned CFST columns for normal strength concrete to high strength concrete. Analyzed results concluded from the results, various parameters can be evaluated from this study are, stress, strain and deformation.*

***Key Words*: Double-Skinned (CFST) column, high strength concrete, Hollowness ratio, axial load carrying capacity, deformation, stress and strain.**

1.INTRODUCTION

The Concrete filled double skin steel tubes are a modern composite construction within which 2 hollow steel tubes are concentrically placed and also the annulus between the tubes is full of concrete of desired grade. The hollow steel tubes is chosen with any sort of cross-section relying upon the requirements. Typically, circular and square tubes are adopted. These columns are almost like concrete filled steel hollow columns exclude that within the CFST columns the central core concrete portion that plays terribly less role in the bending and torsion resistance just in case of CFST members is replaced by a hollow steel tube.

1.1 The single-skinned CFST column has several disadvantages:

(a) the strength-to-weight ratio is limited because the concrete near the center is relatively less effective in providing bending and torsion resistance; (b) the initial elastic dilation of concrete is small when compared with steel, and thus the confining pressure. Consequently, the central part of concrete can be effectively replaced by a hollow steel tube of much lighter self-weight, while at the same time maintaining a similar uni-axial, bending and torsion capacity. This type of column construction that utilizes two steel tubes, with the smaller steel tube located concentrically inside the bigger steel tube and with the annulus between these tubes filled up with concrete, is known as double-skinned CFST columns.

1.2 Applications of CFST columns

The first CFST engineering system to be accepted was Beijing No. 1 Subway. The CFST column is smaller than the RC column, which increases the usable area. Good economic benefits have been achieved. Then all the aprons are listed to Beijing No.2 subway adopted as CFST columns.

According to incomplete statistics, there were more than 200 CFST civil engineering structures under construction in China at that time.. Here are some typical technical solutions are as follows.

1. In the application of CFST in high-rise buildings, only part of the pillars of the building are accepted at first, then most of the pillars are accepted, and then all pillars are accepted. This process is very short, a little over 10 years. The tallest building accepted by CFST is Shenzhen SEG Plaza Building, which was completed in 1999. This is the highest at china and abroad. There is no constant zone for construction.

2. Concrete-filled steel pipe (CFST) is a composite material made of thin-walled steel pipe and steel-filled concrete. On the one hand, the concrete inside the pipe improves the compressive strength of the thin-walled steel pipe. On the other hand, the steel pipe restricts the filling of concrete, which is compressed in three directions again.. Therefore, CFST has higher compressibility and ductility. Suitable for arch bridges. CFST Arch Bridge in China - Wang chang East River Bridge. (length of the Span 115 m)

3. Recent application in China, using an CFDST electricity conductor pole of inner diameter 1.2m tapered tube and outer diameter 2.1m tapered tube, to make a 220 kilo volt electricity conductor pole. Here, the CFDST element also does not need to use thick plates to make a single tubular steel pillar. During the entire construction period, the pipeline was first erected, and then the outer pipe was erected.. when erection, concrete was poured within the inter layer. the 2 hollow sections got to be rigorously kept in their correct positions during construction of a CFDST and this can usually involve the use of steel spacers. The internal vacuum port should even be properly sealed to avoid filling with concrete the complete assembly.

1.3 Modelling in Finite Element Tool

ANSYS Software which is used for the modelling of Double-Skinned CFST columns in Finite Element Software, Results were compared with available codes of ASCI, ACI, BS, EC-4

2. OBJECTIVES

I. Study the behaviour of double skinned CFST columns with different hollowness ratio

II. Study the normal strength concrete and high strength concrete

III. To models of double skinned CFST column using ANSYS 18.1 WORKBENCH

IV. To determine deformation characteristic of Double-Skinned CFST columns under axial load

V. To perform the static structural analysis of double skinned CFST columns with circular and square columns and obtain comparative results

3. SCOPE OF THE PROJECT

I. Models of Double-Skinned CFST columns are created using ANSYS Workbench 18.1.

II. Behavior of Double-Skinned CFST columns such as Deformation, Stress and Strain characteristics are studied by conducing static structural analysis for varying hollowness ratio and different grade of concrete

4. MATERIAL PROPERTIES

There are four set of sixteen specimens used in this analysis, single solid circular CFST column and two set of double skinned circular CFST columns. Single solid square CFST column and two sets of double skinned square CFST columns for Normal strength concrete 50MPa and High strength concrete 80MPa.

4.1. Circular CFST column: Inner and outer steel tube grade of Yst-310 were used as per IS 1161. The thickness of both inner and outer steel tubes 8mm thickness used for all specimens. Solid and the outer diameter of the hollow specimen 323.9 mm. Hollowness ratio of double skinned circular CFST columns are 0.2, 0.4 and 0.6 Outer diameters of inner tube 61.58mm, 123.16mm and 184.74mm respectively. Length of the specimen is 3000mm.

Table -1: properties of circular specimen

SL No	Specimen	Hollowness ratio	Grade of Concrete	L mm	Di mm	Do mm	t mm	fc MPa
1	C-SOLID	-	M50	3000	323.9	-	8	50
2	C-1	0.2	M50	3000	323.9	61.58	8	50
3	C-2	0.4	M50	3000	323.9	123.16	8	50
4	C-3	0.6	M50	3000	323.9	184.74	8	50
5	C-SOLID	-	M80	3000	323.9	-	8	80
6	C-1	0.2	M80	3000	323.9	61.58	8	80
7	C-2	0.4	M80	3000	323.9	123.16	8	80
8	C-3	0.6	M80	3000	323.9	184.74	8	80

4.2. Square CFST column: Inner and outer steel tube grade of Yst-310 were used as per IS 4923. The thickness of both inner and outer square steel tubes 8mm thickness used for all specimens. Solid and the size of outer hollow square column is 250X250mm. Hollowness ratio of double skinned CFST columns are 0.2, 0.4 and 0.6. Length of the specimen is 3000mm.

Table -2: properties of square specimen

SL No	Specimen	Hollowness ratio	Grade of Concrete	L mm	BXD mm	bXd mm	t mm	fc MPa
1	S-SOLID	-	M50	3000	250X250	-	8	50
2	S-1	0.2	M50	3000	250X250	111.80X111.80	8	50
3	S-2	0.4	M50	3000	250X250	158.11X158.11	8	50
4	S-3	0.6	M50	3000	250X250	193.64X193.64	8	50
5	S-SOLID	-	M80	3000	250X250	-	8	80
6	S-1	0.2	M80	3000	250X250	111.80X111.80	8	80
7	S-2	0.4	M80	3000	250X250	158.11X158.11	8	80
8	S-3	0.6	M80	3000	250X250	193.64X193.64	8	80

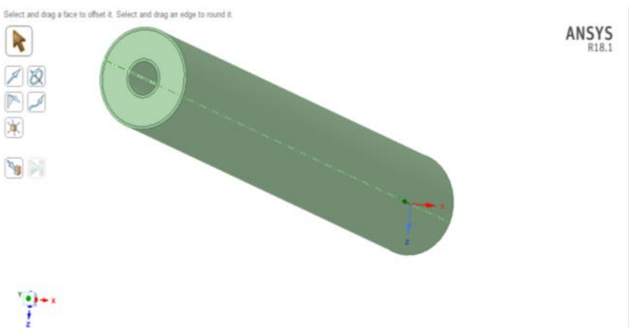

Fig:1 geometry of DSCFST column

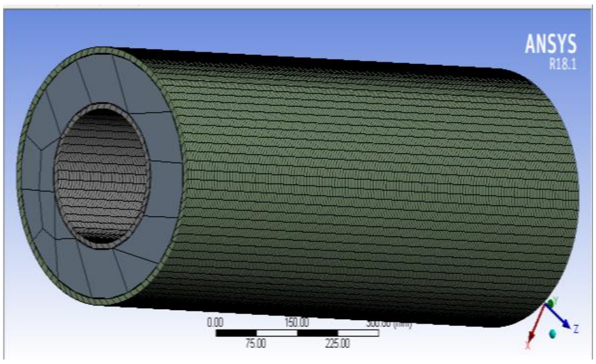

Fig:2 Meshing of DSCFST column

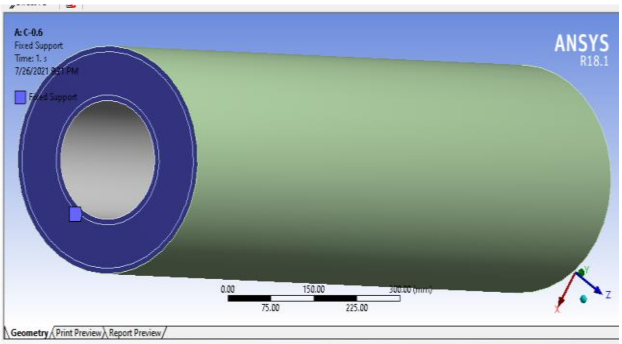

Fig:3 Support condition of DSCFST column

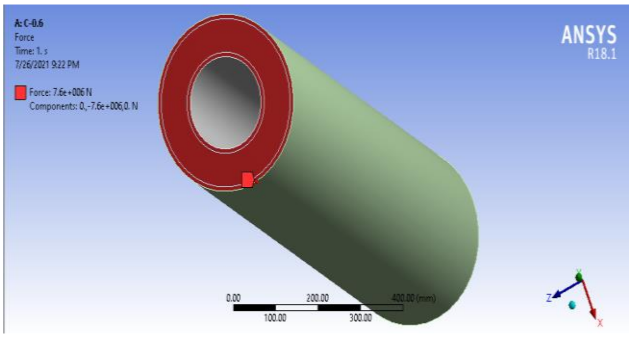

Fig:4 Loading condition of DSCFST column

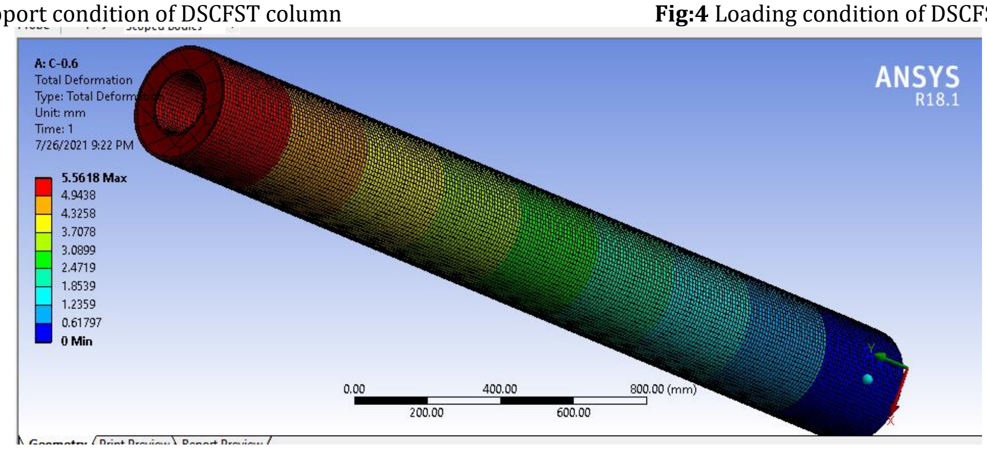

Fig:5 Deformation diagram of DSCFST column

5. VALIDATION OF FINITE ELEMENT METHOD

A. **Euro code 4:** According to EC4: Design of composite steel and concrete structures, the ultimate load carrying capacity of concrete filled steel tubular columns is given by

Pu = Ac*Fc + As*Fs

B. **ACI 318:** According to American concrete institute, the ultimate load carrying capacity of concrete filled steel tubular column is given by

Pu = 0.85 Ac*Fc + As*Fs

C. **BS 400:** According to British standard code, the ultimate load carrying capacity of concrete filled steel tubular column is given by

Pu = 0.675 Ac*Fc + As*Fs

D. Load & Resistance Factor Design Method(AISC 360 10 & ACI 318 14): According to American institute of steel construction, the theoretical load carrying capacity of CFST column is given by

Pu= Po (0.685)^(po/pe)

6. RESULTS SUMMERY

Table:3 comparison of ANSYS software results from code of practices

HOLLOWNESS RATIO	Pu as per ANSYS (KN)	Pu as per ASIC 360-10 (KN)	Pu as per ACI (KN)	Pu as per BS-5400 (KN)	Pu as per EC-4 (KN)
SOLID	8200	7755	7892	7022	8746
C-0.2-50	7400	6827	7108	6225	7950
C-0.4-50	8200	7684	7723	7154	8849
C-0.6-50	7600	7141	7110	6435	8190
SOLID	11800	10850	10447	10095	12850
C-0.2-80	10800	9785	9936	9844	11623
C-0.4-80	12200	10850	10927	11086	13165
C-0.6-80	11200	9792	9580	9960	12250
SOLID	6000	5260	5568	5080	6810
S-0.2-50	7400	6186	6424	6554	8365
S-0.4-50	6800	5855	5995	5922	7640
S-0.6-50	5400	4782	4720	4620	6125
SOLID	8600	7655	7585	7534	9520
S-0.2-80	10600	9262	9042	9650	12050
S-0.4-80	8200	7590	7665	7388	9065
S-0.6-80	7800	6843	7825	6942	8574

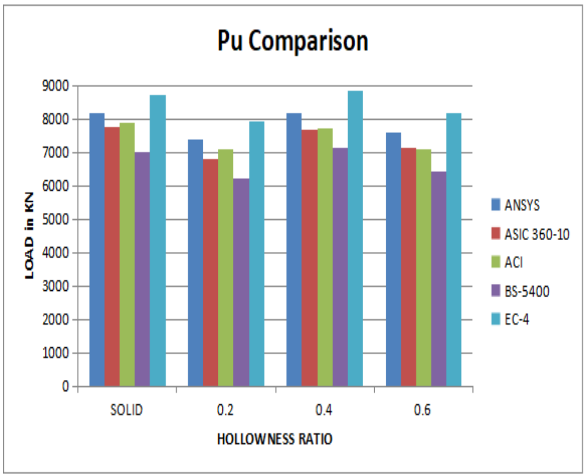

Chart -1: Circular DSCFST-50

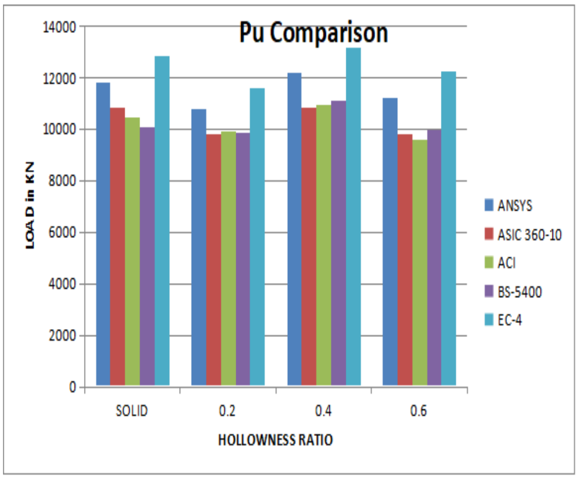

Chart -2: Circular DSCFST-80

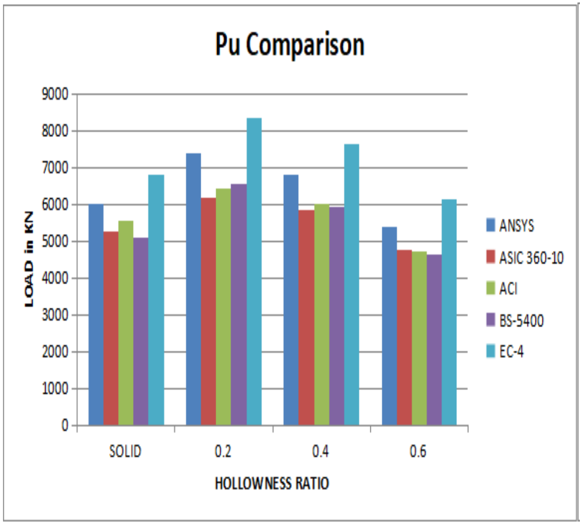

Chart -3: Square DSCFST-50

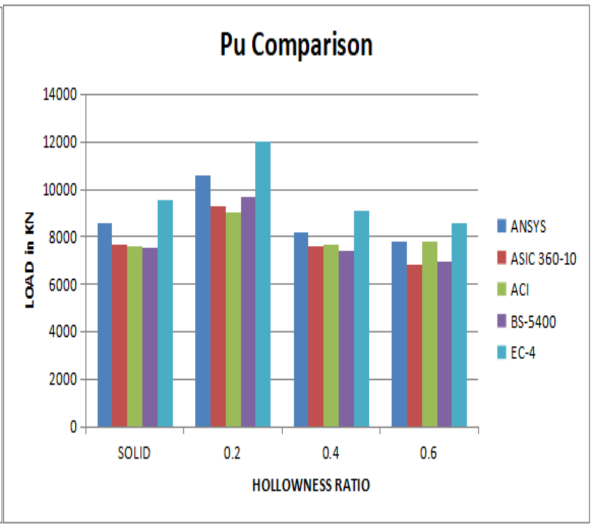

Chart -4: Square DSCFST-80

Table:4 Results of (circular-square) solid and hollow double skinned CFST columns of M50 grade of concrete

Hollowness ratio	Pu (Kn)	deformation (mm)	Strain	Concrete(MPa)	Inner steel tube(MPa)	Outer steel tube(MPa)
C-SOLID	8200	6.0536	0.00025492	49.892	-	53.134
C-0.2-50	7400	5.1667	0.0007937	49.868	204.54	39.916
C-0.4-50	8200	5.9924	0.00018955	49.265	72.552	48.932
C-0.6-50	7600	5.5618	0.00035169	49.584	61.725	69.562
S-SOLID	6000	6.2278	0.0003981	49.049	-	79.964
S-0.2-50	7400	7.1619	0.0005413	49.307	177.55	106.31

S-0.4-50	6800	6.1706	0.00087626	49.801	266.38	168.97
S-0.6-50	5400	4.9573	0.00098136	49.413	182.15	200.26

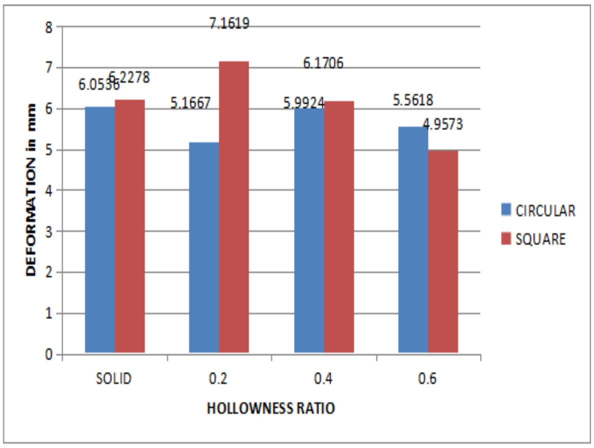

Chart -5: Deformation

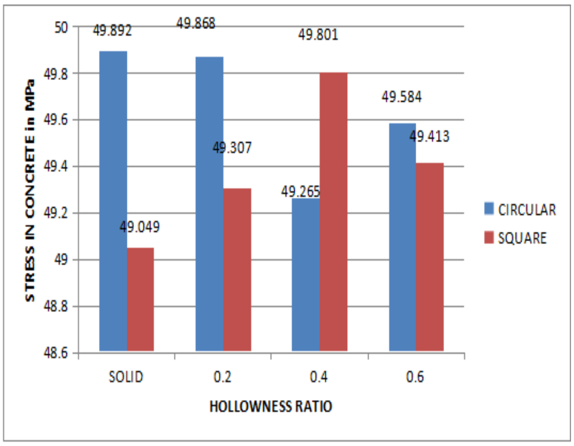

Chart -6: Stress in concrete

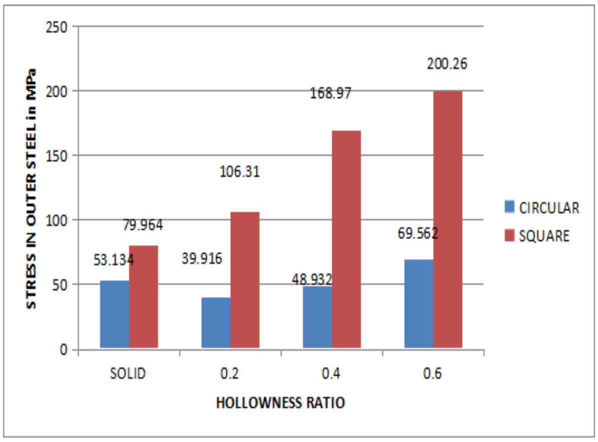

Chart -7: Stress in Steel Tube

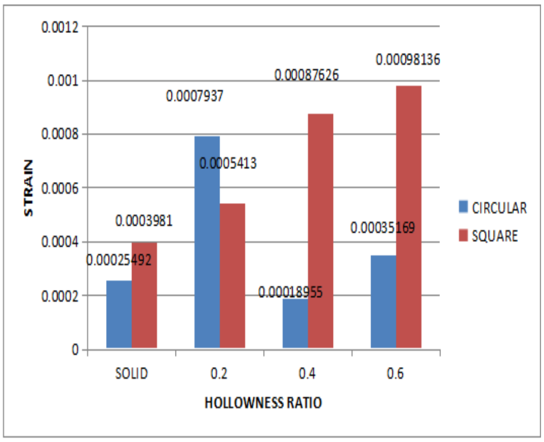

Chart -8: Strain

Table:5 Results of (circular-square) solid and hollow double skinned CFST columns of M80 grade of concrete

Hollowness ratio	Pu (Kn)	deformation (mm)	Strain	Concrete(MPa)	Inner steel tube(MPa)	Outer steel tube(MPa)
C-SOLID	11800	7.6191	0.00037856	78.059	-	84.334
C-0.2-80	10800	6.7422	0.00067962	79.780	186.28	66.305
C-0.4-80	12200	7.7186	0.00027567	79.788	90.979	82.778
C-0.6-80	11200	7.9620	0.00057980	79.7044	101.08	109.986
S-SOLID	8600	7.2399	0.00061611	78.159	-	123.08
S-0.2-80	10600	8.3402	0.00086601	79.178	243.27	170.83

S-0.4-80	8200	7.2331	0.00098736	78.655	312.64	193.61
S-0.6-80	7800	7.0525	0.0013355	79.890	258.20	251.63

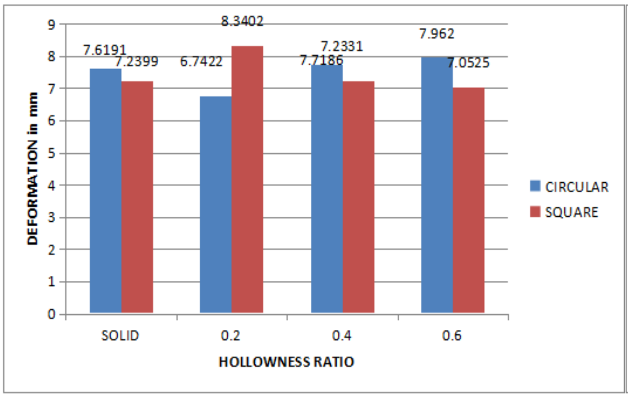

Chart -9: Deformation

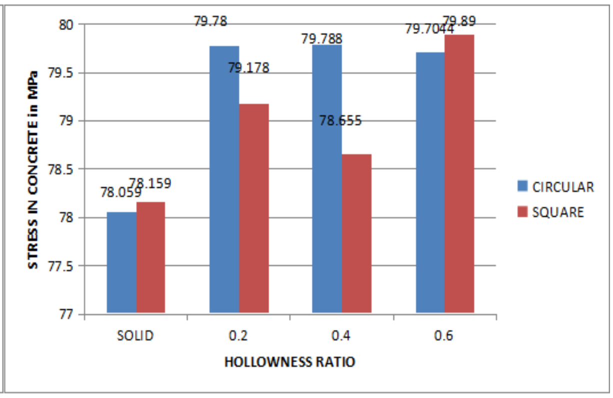

Chart -10: Stress in concrete

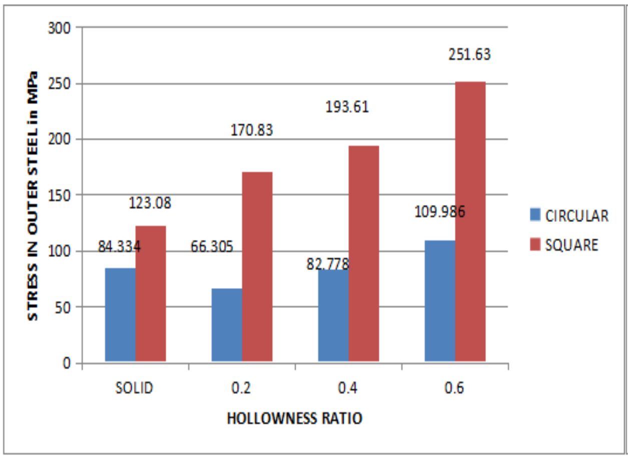

Chart -11: Stress in Steel Tube

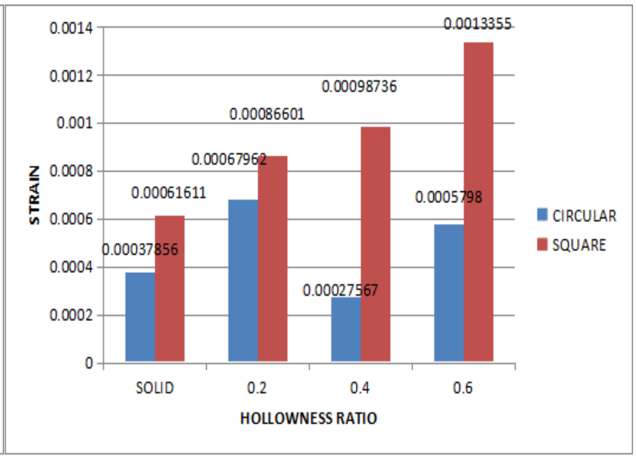

Chart -12: Strain

Table:6 for Deformation (M50)

S no	Model details	Hollowness ratio	Circular DSCFST Deformation mm	Square DSCFST Deformation mm	% of increase in deformation w.r.t circular-square column
1	Solid	Nil	6.0536	6.2278	2.577%
2	DSCFST	0.2	5.1667	7.1619	30.61%
3	DSCFST	0.4	5.9924	6.1706	2.97%
4	DSCFST	0.6	5.5618	4.9573	12.19%

Table:7 for Deformation (M80)

S no	Model details	Hollowness ratio	Circular DSCFST Deformation mm	Square DSCFST Deformation mm	% of increase in deformation w.r.t circular-square column
1	Solid	Nil	7.6191	7.2399	5.237%
2	DSCFST	0.2	6.7422	8.3402	23.70%
3	DSCFST	0.4	7.7186	7.2331	6.712%
4	DSCFST	0.6	7.9620	7.0525	12.896%

Table:8 for Axial load (M50)

S no	Model details	Hollowness ratio	Circular DSCFST Load in Kn	Square DSCFST Load in Kn	% of increase in stress w.r.t circular-square column
1	Solid	Nil	8200	6000	36.66%
2	DSCFST	0.2	7400	7400	-
3	DSCFST	0.4	8200	6800	20.58%
4	DSCFST	0.6	7600	5400	40.74%

Table:9 for Axial load (M80)

S no	Model details	Hollowness ratio	Circular DSCFST Load in Kn	Square DSCFST Load in Kn	% of increase in stress w.r.t circular-square column
1	Solid	Nil	11800	8600	37.20%
2	DSCFST	0.2	10800	10600	1.86%
3	DSCFST	0.4	12200	8200	48.78%
4	DSCFST	0.6	11200	7800	43.59%

7. CONCLUSIONS

Following conclusions are obtained from the study using normal strength concrete and high strength concrete for circular and square double-skinned CFST columns of different hollowness ratio.

1. Considering deformation of normal strength concrete M50 and high strength concrete M80, hollowness ratio 0.2 of circular and hollowness ratio 0.6 of square double-skinned CFST columns gives less deformation respectively

2. Load carrying capacity of the circular Double-Skinned CFST columns carry more load 36.66%, 20.58% and 40.74% of stresses hollowness ratio of solid, 0.4 and 0.6 respectively than the square column for normal strength concrete (M50)

3. Load carrying capacity of the circular Double-Skinned CFST columns carry more load 37.20%, 1.86% and 48.78% and 43.59% of stresses hollowness ratio of solid,0.2, 0.4 and 0.6 respectively than the square column for high strength concrete (M80)

4. Considering axial load for normal strength concrete M50, hollowness ratio 0.4 of circular and hollowness ratio 0.4 of square double-skinned CFST columns are carrying higher axial load compared to other hollowness ratio of the columns

5. Considering axial load for high strength concrete M80, hollowness ratio 0.4 of circular and hollowness ratio 0.2 of square double-skinned CFST columns carrying higher axial load compared to other hollowness ratio of the columns

6. Stress values of steel tube section increases with increase hollowness ratio

7. Considering strain of normal strength concrete M50 and high strength concrete M80, hollowness ratio 0.4 of circular double-skinned CFST and square solid CFST columns gives less strain values respectively compared to other hollowness ratio columns

8. Results obtained from ASIC-360-10 code of practices varied from 4% to 15% when compared with ANSYS software results

9. Results obtained from ACI code of practices varied from 6% to 16% when compared with ANSYS software results

10. Results obtained from BS-5400 code of practices varied from 9% to 20% when compared with ANSYS software results

11. Results obtained from EC-4 code of practices varied from 6% to 15% when compared with ANSYS software results

8. SCOPE FOR FUTURE WORK

I. Different shapes of columns can be tried for various loading condition

II. Different grade of concrete and steel can be studied

III. Different hollowness ratio can be tried

IV. Different Thickness and length of the columns can be tried

V. Double skin hollow and composite columns can be modeled with ABAQUS, MIDAS and other software's

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BIOGRAPHIES

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