COMPARATIVE STUDY ON CFRP CONCRETE FILLED DOUBLE SKIN TUBE (CFDST) COLUMNS

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Abstract— **In structures, columns are considered as the main component in a building. Concrete filled double skin tubes have been widely used in constructing high rise buildings arch bridges factories etc over the past few years in foreign countries. Commonly used material for skin of CFDST are steel and FRP. In this paper I would like to compare circular square and rectangular FRP CFDST under Axial compressive loading. The parameters that is comparing in this paper are Stress strain behavior, Ultimate deflection, crushing pattern with FRP CFDST, normal CFDST and RCC column.**

Index Terms— **CFDST, FRP, square, circular, rectangular, stress-strain, ultimate deflection, crushing pattern**

I. INTRODUCTION

When two or more different fibers are mixed in a common matrix we call it hybrid fiber reinforced Column is a main Axial load transferring Member in building structures. Column should have an unique axial load carrying capacity. It has been a major study is conduted to increase the column strength in past few years. Concrete-Filled Double Skin Tubes (CFDST) is one of the best and latest innovations in Structural engineering to improve the strength of columns. The CFDST members were primarly designed fluid carrying vessels to resist internal pressure but due to its various advantages, it has got strong demand in construction industry.

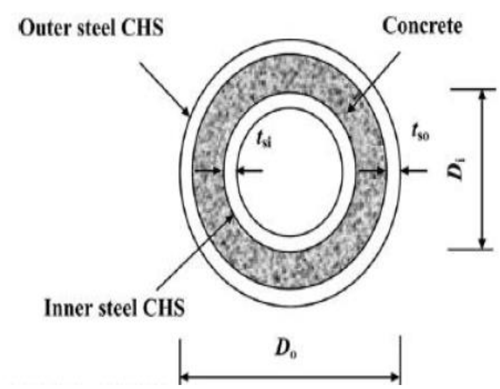

Figure 1.1 CFDST c/s

CFDST is a composite column consists of two concentric steel tubes surrounding concrete, and is sandwitched between steel tubes. The cross section of CFDST are of different shapes, circular, square, rectangular, and hexagonal are commonly used shapes.In this composite column, it is a mixture of the best quality of steel and concrete. the column is behaving similar to that of normal column, with lesser self weight and high stiffness.

CFDST columns is a best option as load bearing members. At the initial stage, the applied load is resisted individually by the steel and concrete elements. The steel withstands in high loading condition, until yielding. At the early stages of increment of loads, will not causes any confinement on the concrete, since the poison's ratio of concrete lies far below than that of the steel.

Types of CFDST

According to cross section

- Circular
- Square
- Rectangular
- Circular- square
- Square-circlar
- Hexagonal-circular

According to material

- Steel
- FRP
- PVC

COLUMNS WITH FRP

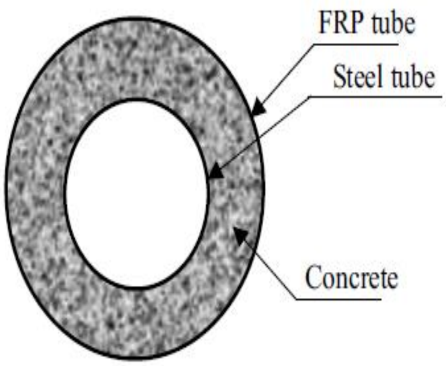

Figure 1.2 cross section of CFDST

FRP CFDST column consists of an outer tube made of FRP and an inner tube made of steel, with the space between filled with concrete fig 1 . The new idea FRP CFDST is to merge the property three best construction material to improve strength and ductility. Concrete-filled steel tubes are used widely in Japan, China, and Europe for the accelerated work and seismic resstance, since they are earthquake predominant countries. The use of CFDST is limited due to the lack of design codes. CFDST members have large advantages over either steel or RC members. The steel tubes act as a formwork, a shear reinforcement, as well as confinement to the inside concrete core, increasing the member's ductility and strength. concrete cracking and spalling is prevented by the steel tube and FRP itself, there by delays lockal buckling. The CFDST Members have higher energy dissipation and low cost compared to RCC members of same dimensions. FRP is accepted as an alternation for steel tube, since it have same benefits as that of steel tube. In addition to that FRP tubes have low weight to strength ratio and higher corrosion resistance.

It is well known that concrete have higher compressive strength and steel have higher tensile strength. In CFDST is a merging of the property steel and concrete. Fig. 1.3 shows schematic failure modes for the stub concrete-filled steel tubular column, steel tube and concrete. It can be seen that both inward and outward buckling failure is found in the steel tube, and shear failure is happened for the plain concrete stub column. For the concrete-filled steel tube, only local buckling is found in the tube, and the inner concrete fails acts like a ductile material.

	Specimen	CFRP thickness	Steel tube Thickness	Inner diameter/size	Outer diameter/size	Height
CFRP-CFDST	Circular	3.2	3.2	76.1	150	300

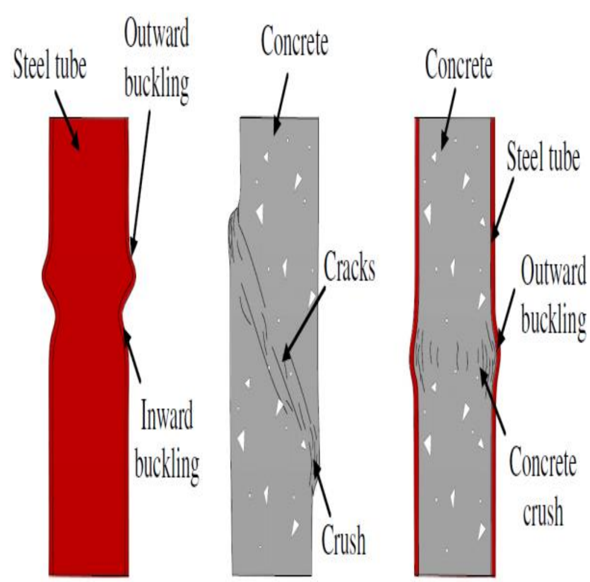

Fig. 1.3. Schematic failure modes of hollow steel tube, concrete and CFST stub columns.

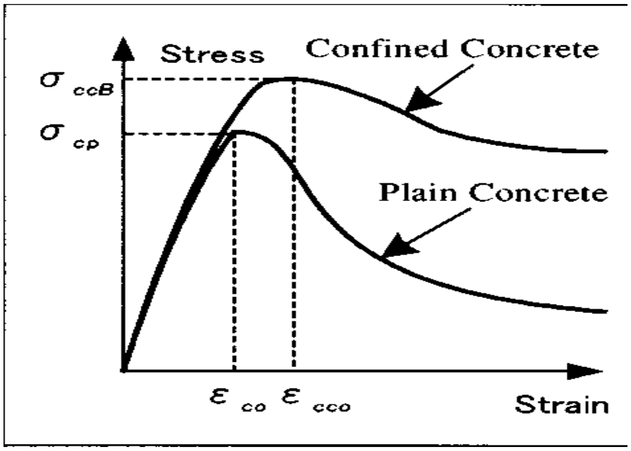

Fig 1.4Stress strain relation

Fig. 1.4 shows a schematic view of the stress strain relationship of plain and confined concrete It can be seen that the strength of the confined concrete is significantly enhanced, when compared to those unconfined concrete.

II. VALIDATION

Validation was done with reference of journal "Axial Compressive Behavior of FRP-Concrete-Steel Double-Skin Tubular Columns Made of Normal- and High-Strength", written by 4]Togay Ozbakkaloglu, and Butje Louk Fanggi, 2013. This paper deals with an experimental study of CFRP CFDST column under axial loading condition. The load is applied as 5000kN on the top of column as compressive load. Load is applied 3kN per second. One end is fixed support and other is free. The height column is 30cm.

Table 2.1. specimen for validation

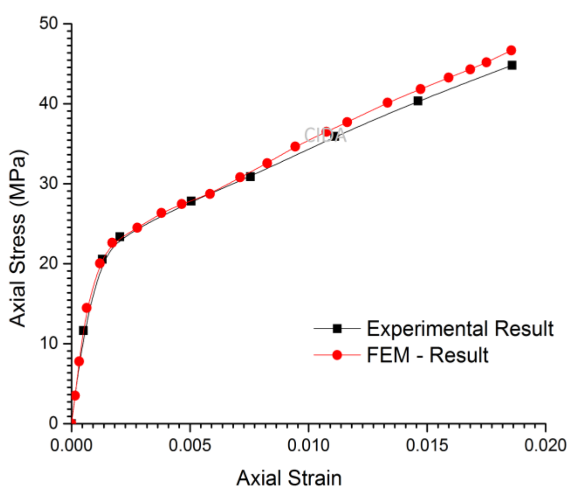

Figure 2.1. comparing experimental and analytical

As per the graph shown in fig there will be a 5% variation in experimental and analytical result. And is within the limit and the software is vaid.

III. MATERIAL MODELLING

The material which is mainly used in this thesis work are CFRP, steel plate, concrete to analyse its behaviour when it is subjected Axial compressive load. Finite Element Method is used for the analysis to investigate behaviour of CFDST.

MATERIAL SPECIFICATION

Table 3.1. material specification

material	**Property**	**Value**
concrete	Compressive strength fc'	36.9MPa
Steel	Thickness	3.2mm
	Grade	350(NSS)
	Peak axial load	312kN
	Yield strength	358MPa
	Peak strength	426MPa
	Elastic failure mode	
	Elastic modulus of steel,	2×10^5 MPa
	Tangent modulus of steel, $E'_s = 0.01\ E_s$ =	2×10^3MPa
CFRP(carbon fibre reinforced polymer)	Tensile strength	3.800 MPa
	Elastic modulus	240GPa
	Tensile strength	3.626MPa
	Elastic modulus	251GPa
	Elastic modulus Ex	21000MPa
	Elastic modulus Ey	7000MPa
	Elastic modulus Ez	7000MPa
	Poissons ratioμ inx	.26
	Poissons ratioμ iny	.3
	Poissons ratioμ inz	.26
	Shear modulus in x=1520MPa	1520MPa
	Shear modulus in y=2650MPa	2650MPa
	Shear modulus in z=1520MPa	1520MPa

MATERIAL MODELLING

a) Concrete Modelling

The uniaxial behaviour of the steel box is simulated by anelastic-perfectly plastic model. The equivalent uniaxialstress–strain curves for both unconfined and confinedconcrete are shown in Fig. 1, where f_c' is the *unconfinedconcrete cylinder compressive strength, which is equal to0.8 (f_{cu}), and f_{cu} is the unconfined concrete cube compressivestrength. The corresponding unconfined strain (ε'_c)is taken as 0.003. The confined concrete compressivestrength (f'_{cc}) and the corresponding confined strain (ε'_{cc})can be determined from Eqs. (2) and (3) respectively [22],*

$$f'_{cc} = f_c' + k_1 f_1 \quad (2)$$

$$\varepsilon'_{cc} = \varepsilon'_c\left(1 + k_2\frac{f_1}{f'_c}\right) \quad (3)$$

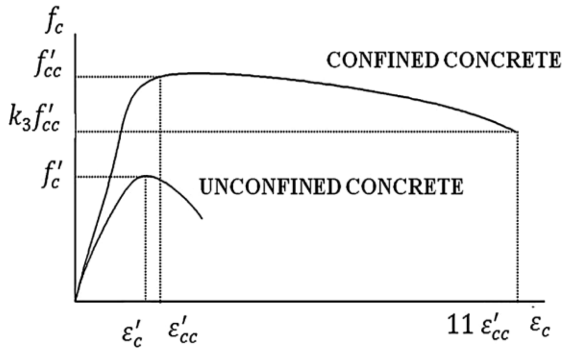

Fig. 3.1. Uniaxial stress–straincurves for confined andunconfined concrete

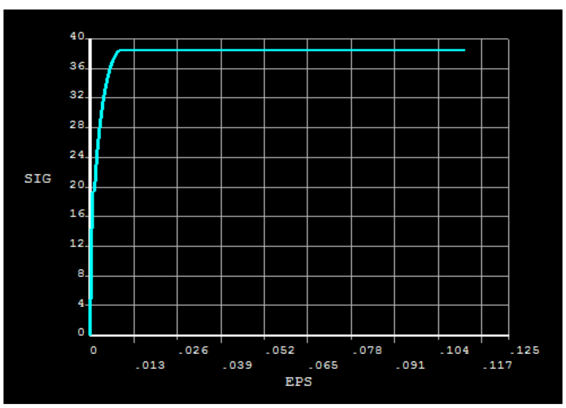

Fig. 3.2.Modelled stress-strain curve for concrete

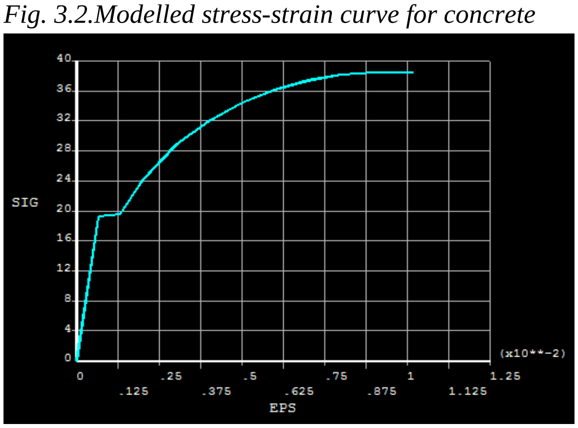

Fig. 3.3.Modelled stress-strain curve for concrete

b) Steel Modelling

The bilinear kinematic hardening model as shown in Fig. 2 was used to simulate the stress–strain curve of steel and assumed to be an elastic-perfectly plastic material. The bilinear model requires the yield stress (f_y) and the hardening modulus of the steel (E_s), the Constitutive law for steel behavior is:

$$\sigma_s = E_s\varepsilon'_s \qquad \varepsilon_s \le \varepsilon_y \qquad (19)$$

$$\sigma_s = f_y + E'_s\varepsilon'_s \qquad \varepsilon_s > \varepsilon_y \qquad (20)$$

Where,σs is the steel stress, ε_s is the steel strain, E_s is the elastic modulus of steel, E'_s is the tangent modulus of steel after yielding, $E'_s = 0.01E_s$, f_y and ε_y are the yielding stress and strain of steel, respectively.

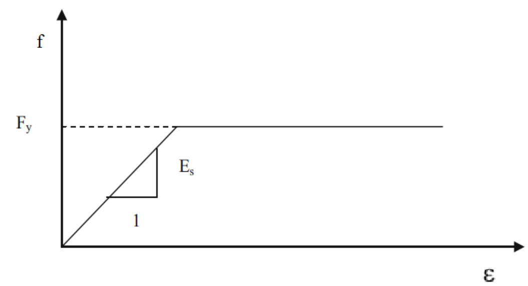

Fig. 3.4. Elastic perfectly plastic model for steel tube

Bilinear Stress-Strain property of steel
Elastic modulus of steel, $E_s = 2 \times 10^5$ MPa
Tangent modulus of steel, $E'_s = 0.01\ E_s = 2 \times 10^3$MPa

Elements used

Solid65

Which is a 8 noded element. Used for concrete.

Link 180

Which is used for reinforcement. It is a two noded tuss element.

Shell 181

Which is a 4 noded curved plate element used to represent steel and CFRP

Loads and supports

Fixed support is provided at one end and other end is free. The load is applied at the free end as compressive load. The load is about 5000kN applied at 3kN per second. The results are taken for the quarter portion since it is symmetric.

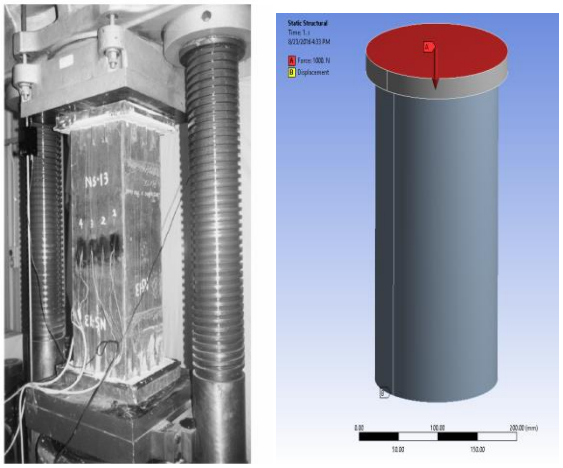

Fig 3.5. experimental and analytical loading

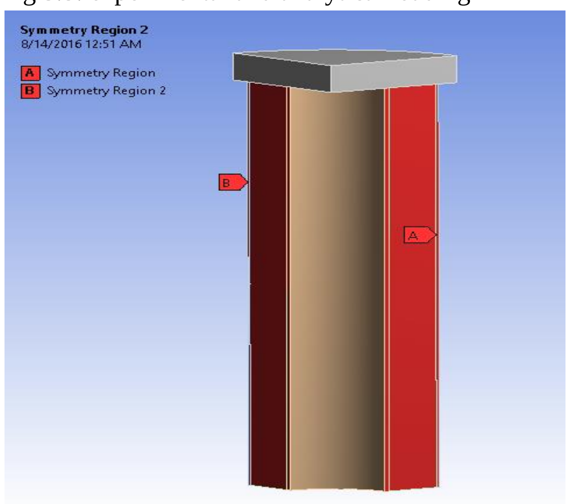

Figure 3 .6. Model of circular CFDST

Figure 4 symmetric quarter portion of CFDST. Results of this portion is taken for study.

1.1. Meshing

Meshing is done by body sizing keeping the mesh size as 25 mm.

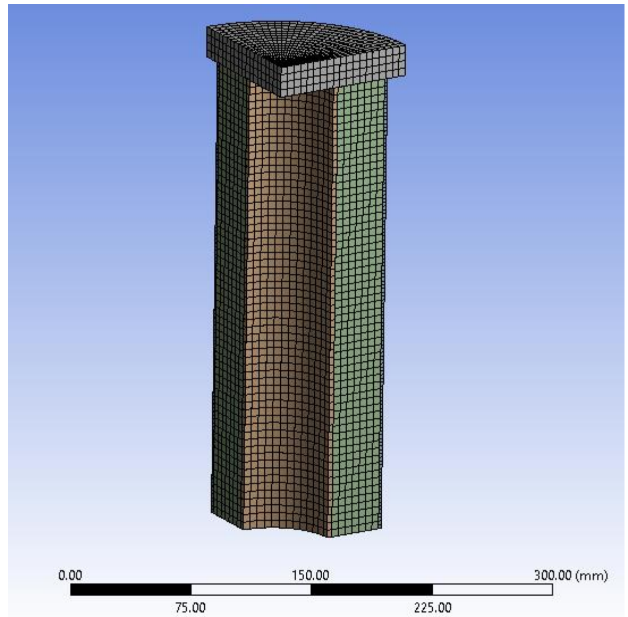

Figure 3.7Meshing

IV. RESULTS AND DISCUSSION

This paper presents the analytical results of the performance of CFRP-CFDST under cyclic loadingand compare the results with steel-CFDST and RCC control specimens. Comparison Stress pattern, Deformation pattern,Stress-strain graph and ultimate deformation are represented in results using figures and graphs.

a) Stress pattern

Figure shaws stress pattern of the Circular,Square,rectangular CFRP-CFDST. In which circular have maximum stress value. The Cross section highly stressed with out failure is circular column.

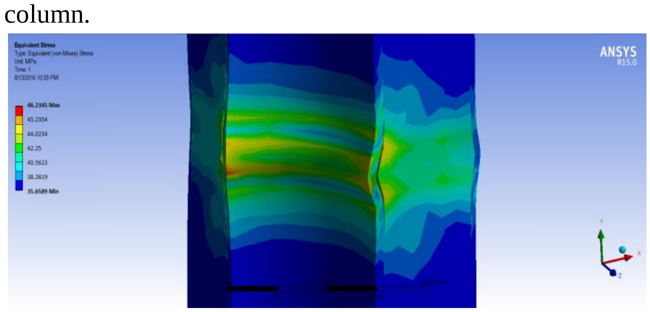

Figure 4.1. stress pattern circular

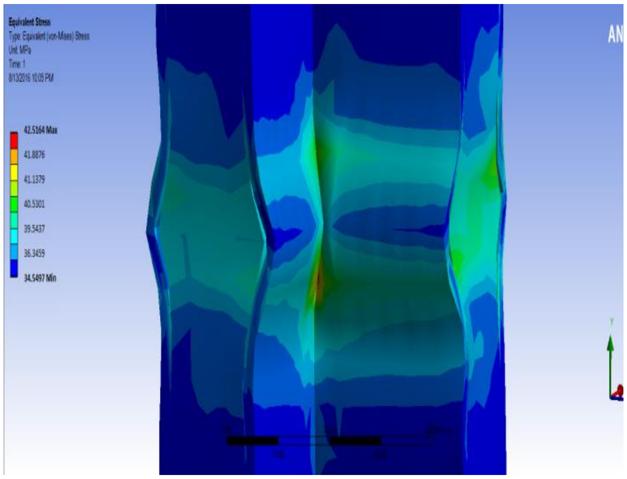

Figure 4.2 stress pattern square

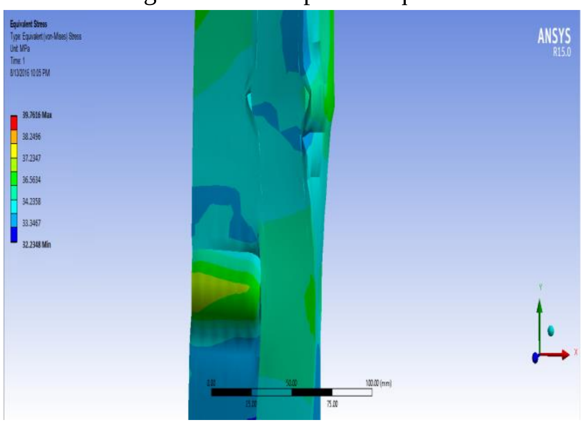

Figure 4.3. stress pattern rectangular

b) Deformation/crushing pattern

Fiigure shows the deformation pattern of the Circular,Square,rectangular CFRP-CFDST. In which circular have smaller deformation value. The Column is least crushed in circular column.

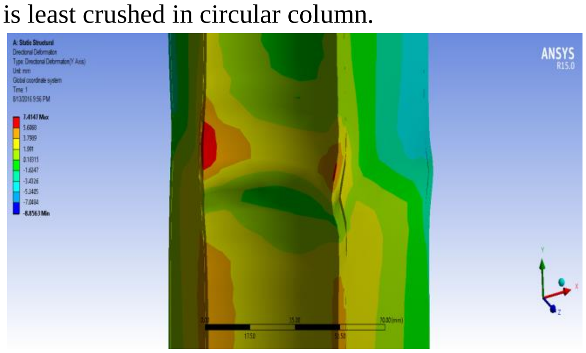

Figure4.4. Deformation pattern circular

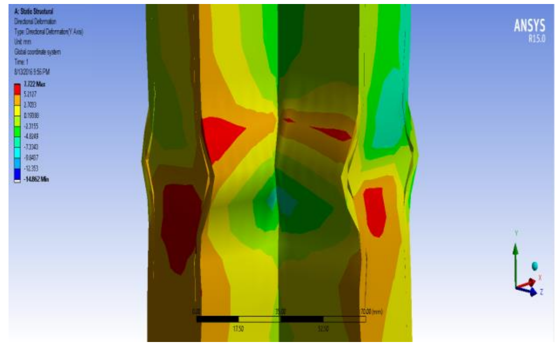

Figure 4.5. Deformation pattern square

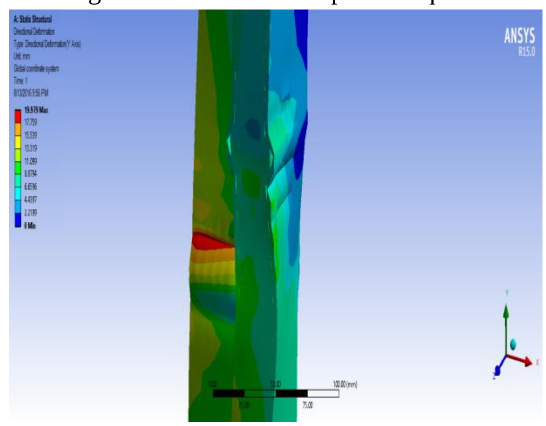

Figure 4.6. Deformation pattern rectangular

1.1. Stress strain graph

The Stress diagram shawn in the graphs. In which circular have maximum stress carrying capacity compared to other cross sections in FRP , steel and RCC. Comparing CFRP, Steel and RCC ,CFRP have maximum load carrying capacity.

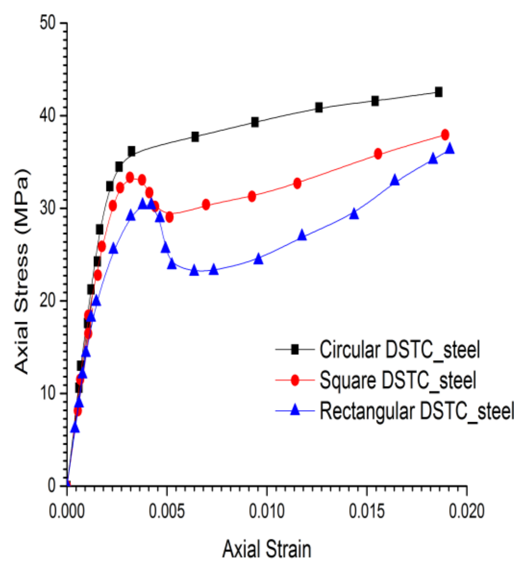

Figure 4.7 stress strain for Steel CFDST

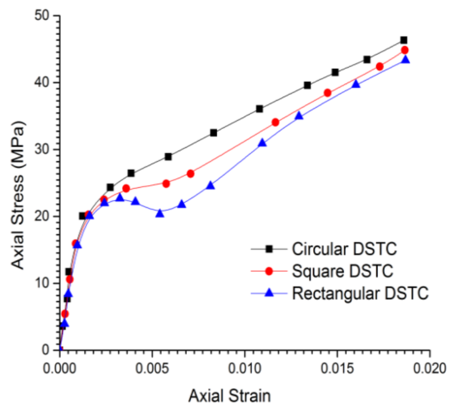

Figure 4.8. Stress strain for CFRP CFDST

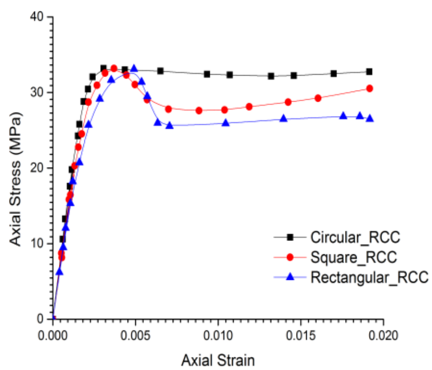

Figure 4.9. stress strain for RCC column

1.2. Ultimate deformation graph

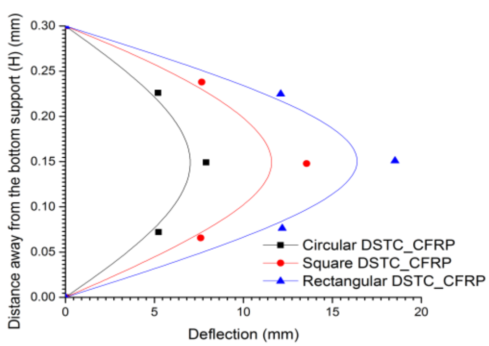

Figure 4.10 deformation in length of column of CFRP CFDST

V. CONCLUSION

This study deals with the analysis and Comparison of CFRP-CFDST with control specimens of steel CFDST and RCC column under axial compressive loading condition with same cross section different shapes. From this study concluded the following.

Stress Pattern

Maximum Stress carrying capacity is for circular CFRP CFDST with least deformation ie, buckling Rectangular have minimum. Square is in between that..

Deformation pattern

Minimum buckling is for circular CFRP CFDST and rectangular have maximum.

Stress-strain relation ship

stress strain relations are similar and the maximum stress value is for CFRP other than steel and RCC in which Circular CFRP-CFDST have maximum value.

Ultimate deformation

The maximum buckling happened in rectangular CFRP CFDST and circular have minimum

3. the CFDST columns fail due to crushing and local buckling. Where as shear failure happens concrete.
4. circular column is the best option as CFRP CFDST columns

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