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ANALYTICAL BEHAVIOUR OF STIFFENED AND UNSTIFFENED CFDST SHORT COLUMN

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Abstract – *The Concrete filled double skinned steel tubular column is a new composite column widely used in the construction industries. Due to their high strength, durability and large energy absorption capacity they are used to replace the conventional steel columns and RCC columns. The main area of investigation of this thesis is on the modeling and analysis of CFDST stub columns with and without stiffeners. The CFDST is made by combining steel tubes and concrete. The stiffeners are introduced to increase the strength and reduce the local buckling. The analytical behavior of the FDST stub columns are fine out by considering the parameters like varying cross section, type of loading etc. The Finite element model is developed to evaluate the load carrying capacity and deformation.*

***Key Words*: CFDST, columns, Structural, Stiffeners**

1. INTRODUCTION

Concrete filled double skinned steel tubular (CFDST) column utilizes the advantages of both steel and concrete. Due to their high strength, high ductility, large energy absorption capacity, bending stiffness and fire performance they are widely used in the construction of buildings. A CFDST column comprises of an outer steel tube and an inner steel tube and the filling between these two tubes may be plain or reinforced concrete. The steel tubes act as formwork in construction, which reduced the material and labour costs. In order to improve the performance of CFDST composite columns, stiffening have been proposed. The stiffening of the CFDST is done by welding longitudinal stiffeners on the inner or outer surfaces of a steel tube. Fig 1 shows the cross section CFDST columns with stiffeners.

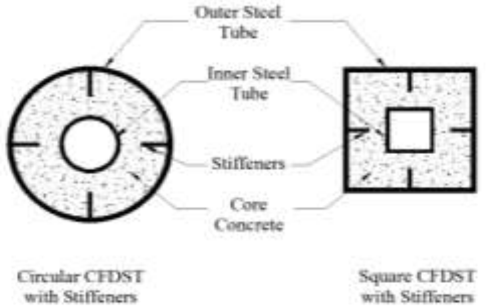


Fig .1 Cross section of CFDST with stiffeners

1.1 Methodology

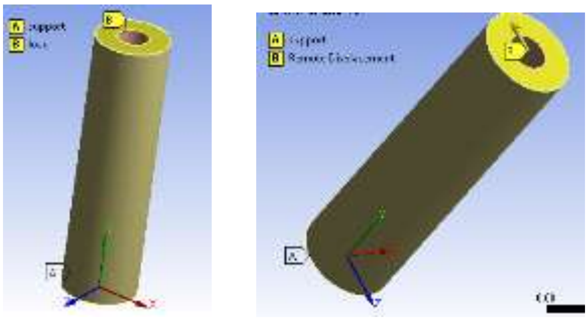
The CFDST columns proposed in this paper includes 4 types of cross sections of circular and square steel tubes with different dimensions and addition of stiffeners. The FEA models are created for all the CFDST columns with and without stiffeners.

1.2 Description of specimen parameters

The CFDST columns were made from steel tubes and concrete filling. The CFDST columns considered in this paper are made from circular steel tubes of diameter 273mm and 114.3 mm and square tubes of size 252.5x252.5mm and 82.5x82.5mm. Four types of cross sections are created using the above mentioned tubes. The height of the columns is considered as 1000mm. The stiffeners are also added to the CFDST columns to increase the strength. The stiffeners used in this study are (i) plain stiffener – 10x5mm, (ii) Angle stiffener – ISA4545 (45x45x6), (iii) T stiffener – ISNT40 (40x40x6), (iv) box stiffener – 40x40x3.6. The stiffeners are connected to the steel tubes by means of welding. The support conditions are considered as fixed. Two types of loading conditions are considered in this study, axially loaded and laterally loaded. The CFDST column axially and laterally loaded are shown in Fig. 2. The material properties of steel and concrete used in this study are given in Table 1.

Table -1: Material properties

Property	STEEL	CONCRETE
Density	7850 kg/m^3	2400 kg/ m^3
Young's modulus	2x 10^5 MPa	31623 MPa
Poisson's ratio	0.3	0.15
Yeild strength	235 MPa	-
Flexural strength	-	4.43 MPa



(a) Axially loaded (b) Laterally loaded

Fig .2: Circular-Circular CFDST column

2 PARAMETRIC STUDY

The main aim of this Master's thesis was to find out how to calculate the maximum load carrying capacity and the deformation corresponding to it with the help of ANSYS 16.1 and to choose an optimized model. To achieve this various parametric studies are carried out in the model. The parameters considered for the study are given as:

- CASE 1: CFDST columns without stiffeners – Axial loading and Lateral loading
- CASE 2: CFDST columns with stiffeners – Axial loading and Lateral loading
- CASE 4: CFDST columns with stiffeners – Lateral loading

2.1 CASE 1: CFDST columns without stiffeners – Axial loading and lateral loading

Four basic models are considered with cross section of Circular-Circular (C-C), Circular-Square(C-S), Square-Square (S-S) and Square-Circular (S-C). The circular cross sections are chosen from *IS 1161 : 1998*. The Square tubes are made by welding steel plates by keeping the area of cross sections constant. The effects of the cross section on axial load carrying capacity of the CFDST columns are evaluated. An optimum model is chosen for further studies. The dimensions of the models used for the study are given in Table 2.

Table -2 Dimensions of the sections

Model Name	D_o or B_o (mm)	t_o (mm)	D_i or B_i (mm)	t_i (mm)
C-C	273	5.9	114.3	4.3
S-S	252.5	5	82.5	5
C-S	273	5.9	82.5	5
S-C	252.5	5	114.3	4.3

2.2 CASE 2: CFDST columns with stiffeners attached to outer tube – Axial loading and lateral loading

The effect of stiffeners with different cross sections on the load carrying capacity of the CFDST columns is evaluated. In order to evaluate this, consider the optimized models from CASE 1. The stiffeners are added to the outer steel tube of the models and the axial and lateral load carrying capacity is evaluated. The models considered are given below:

- C-S with Plain stiffener
- C-S with Angle stiffener
- C-S with T stiffener
- C-S with Box stiffener
- S-S with plain stiffener
- S-S with Angle stiffener
- S-S with T stiffener
- S-S with Box stiffener

2.3 CASE 3: CFDST columns with stiffeners attached to inner tube – Axial loading and lateral loading

The effect of stiffeners with different cross sections on the load carrying capacity of the CFDST columns is evaluated. In order to evaluate this, consider the optimized models from CASE 2. The position of stiffeners is changed from outer steel tube to inner steel tube of the models and the axial and lateral load carrying capacity is evaluated. The models considered are given below:

- C-S with inner plain stiffener
- C-S with inner angle stiffener
- S-S with inner plain stiffener
- S-S with inner angle stiffener

3. RESULTS AND DISCUSSION

3.1 CASE 1: CFDST columns without stiffeners – Axial loading and lateral loading

- **Axial loading**

The CFDST with Circular-Square (C-S) cross section has the highest load carrying capacity about 4596.80 kN with a deformation of 23.63mm corresponding to it. The axial load carrying capacity is inversely proportional to the hollow ratio. Hence the C-S CFDST is chosen for the further study. Chart 1 represents the axial load deformation curve for the CFDST columns with different cross sections.

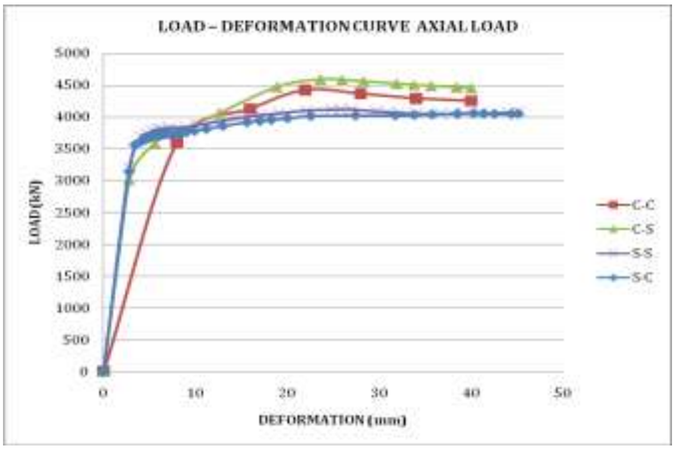


Chart -1: Load deformation curve for CFDST columns without stiffeners – Axial loading

- **Lateral loading**

The CFDST with square-square cross section has a maximum lateral load carrying capacity of 730.43 kN, which the highest maximum load when compared to the other CFDST columns. So the CFDST with square-square cross section is chosen for the further studies. Chart 2 represents the lateral load deformation curve for the CFDST columns with different cross sections.

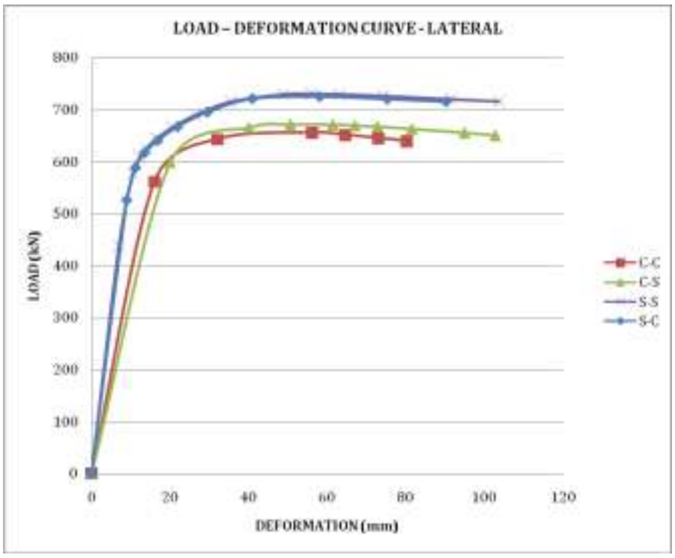


Chart -2: Load deformation curve for CFDST columns without stiffeners – Lateral loading

3.2 CASE 2: CFDST columns with stiffeners attached to outer tube – Axial loading and lateral loading

- **Axial loading**

The axial load carrying capacity of the CFDST columns chosen from the CASE 1 with stiffeners on outer tube is shown in Chart 3 and 4. In the case of Circular-Square CFDST, the addition of plain stiffener has the maximum load carrying capacity (about 5433.9 kN). Also, in the case of Square -Square CFDST, the addition of plain stiffener has the maximum load carrying capacity (about 5588.8 kN). It is clear that the addition of stiffeners to the CFDST increases the load carrying capacity of the CFDST column.

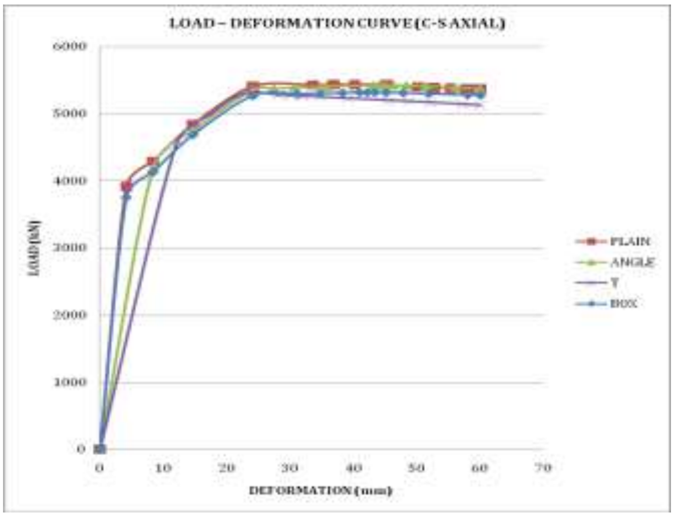


Chart -3: Load deformation curve for C-S CFDST columns with stiffeners on outer tube – Axial loading

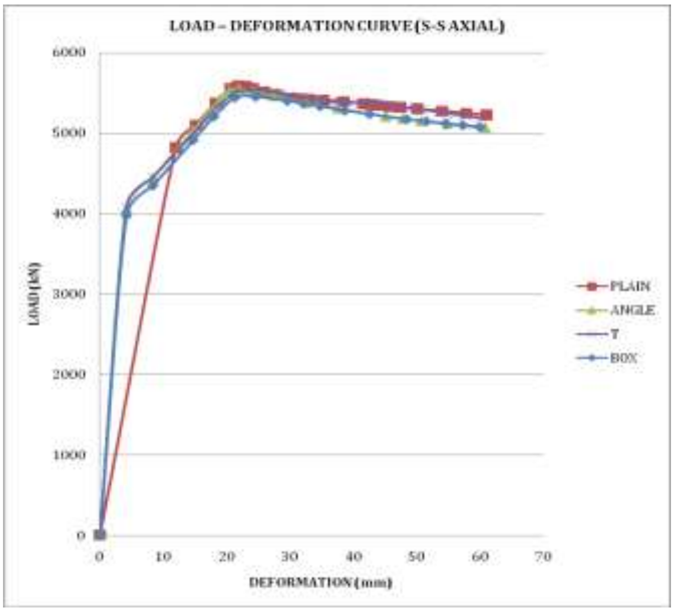


Chart -4: Load deformation curve for S-S CFDST columns with stiffeners on outer tube – Axial loading

- **Lateral loading**

The Lateral load carrying capacity of the CFDST columns chosen from the CASE 1 with stiffeners on outer tube is shown in Chart 5 and 6. In the case of Circular-Square CFDST, the addition of angle stiffener has the maximum lateral load carrying capacity (about 783.72 kN).. Also, in the case of Square -Square CFDST, the addition of angle stiffener has the maximum lateral load carrying capacity (about 880.77 kN). It is clear that the addition of stiffeners to the CFDST increases the lateral load carrying capacity of the CFDST column.

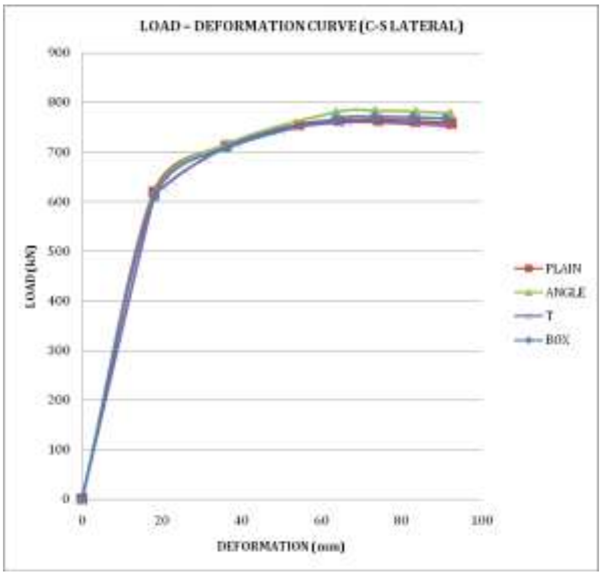


Chart -5: Load deformation curve for C-S CFDST columns with stiffeners on outer tube – Lateral loading

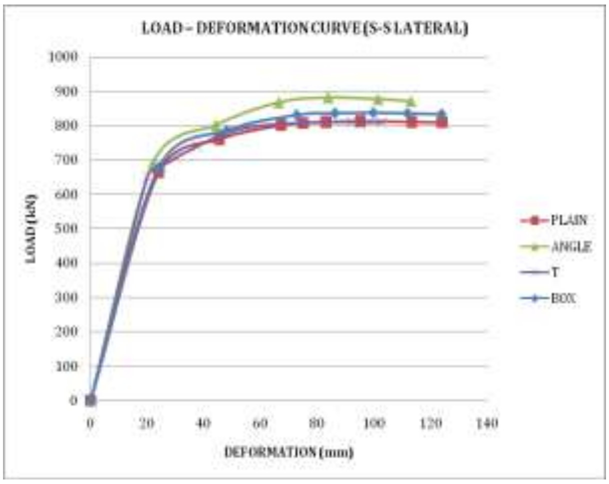


Chart -6: Load deformation curve for S-S CFDST columns with stiffeners on the outer tube – Lateral loading

3.3 CASE 3: CFDST columns with stiffeners attached to inner tube – Axial loading and lateral loading

- **Axial loading**

The axial load carrying capacity of the CFDST columns chosen from the CASE 2 with stiffeners on inner tube is shown in Chart 7. In the case of Circular-Square CFDST with stiffeners on inner tube, the plain stiffener has the maximum load carrying capacity (about 5376.30 kN). It is clear that the addition of stiffeners to the inner tube of the CFDST decreases the axial load carrying capacity of the CFDST column.

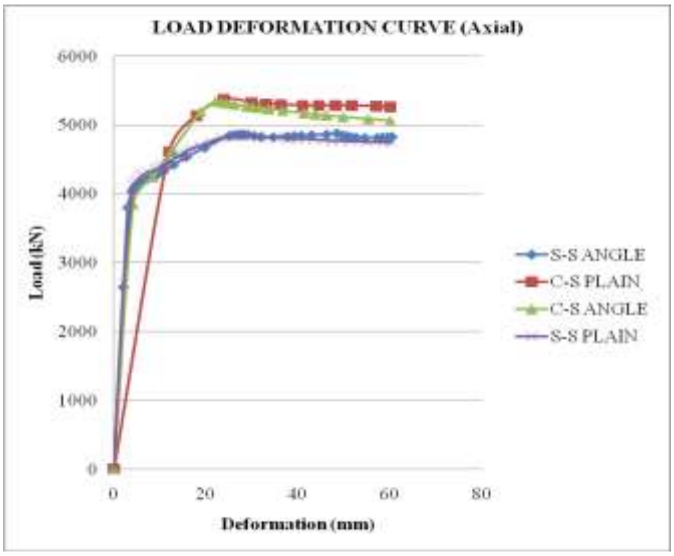


Chart -7: Load deformation curve for C-S CFDST columns with stiffeners on inner tube – Axial loading

- **Lateral loading**

The lateral load carrying capacity of the CFDST columns chosen from the CASE 2 with stiffeners on inner is shown in Chart 8. In the case of Square-Square CFDST with stiffeners on inner tube, the angle stiffener has the maximum load carrying capacity (about 783.62 kN). It is clear that the addition of stiffeners to the inner tube of the CFDST decreases the lateral load carrying capacity of the CFDST column.

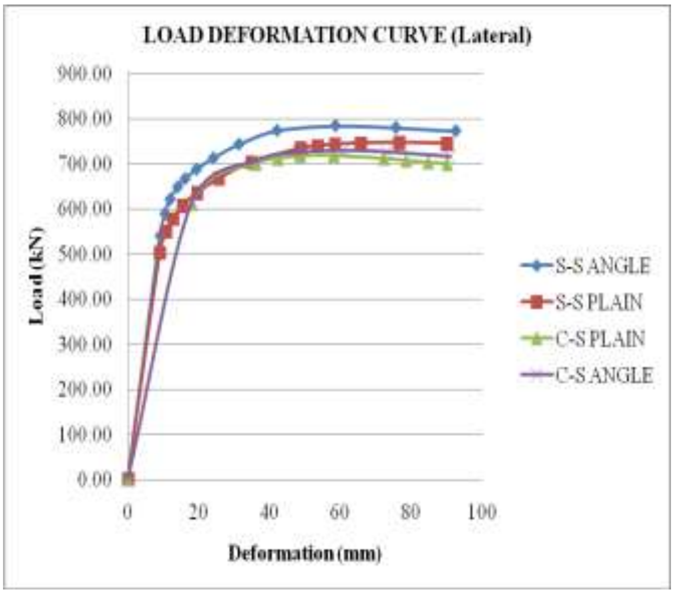


Chart -8: Load deformation curve for C-S CFDST columns with stiffeners on inner tube – Lateral loading

4. CONCLUSIONS

The aim of this paper is to evaluate the effect of cross section types and effect of stiffeners on the load carrying capacity of the CFDST columns using FEA modeling and analysis. The following conclusions are obtained from the analysis:

- For a CFDST without stiffeners loaded axially, the ultimate load carrying capacity is higher for CFDST with C-S cross section.
- For a CFDST without stiffeners, the lateral load carrying capacity is higher for S-S CFDST column
- The load carrying capacities of both axially and laterally loaded CFDST columns are increased when we add the stiffeners.
- Also the CFDST with plain stiffener has the best axial performance and CFDST with angle stiffener has the best lateral performance.
- Changing the position of the stiffeners from outer tube to the inner tube decreases the axial and lateral load carrying capacity of the CFDST.
- From the results it can be concluded that the S-S CFDST with stiffener can be chosen as the optimum model since, it has the best axial and lateral performance.

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