Study of Structural Strength and Behavior of Concrete Filled Double Skin Columns

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Abstract

Column is a major Axial load transferring Member in most of the structures. According to the revised seismic codes columns should be have better flexural strength in addition to the Axial load carrying capacity. It is been a major concern in construction industry in previous few years to increase the column strength. Concrete-Filled Double Skin Tubes (CFDST) is one of the latest innovations in Structural engineering

The CFDST members were first designed for vessels to resist extreme external pressure but due to its various advantages, it has got strong demand and strong potential for using it in bridges, flyovers and high rise buildings. In this study CFDST is analysed using ABAQUS/CAE 6.11-1 and experimentally tested for stress strain and axial shortening.

***Keywords*— CFDST, ABAQUS.**

1. INTRODUCTION

The concept of CFDST has evolved from the use of hollow Steel tubular members. These members have long been used in offshore and inland construction however, local and global stability often prevent the steel tubular sections from attainment of their full plastic capacity. The possible means of improving the instability of these sections is using the infill in these members such as concrete filled tubes (CFT). This technique has been used in over last four decades and is still used in construction industry.

Advantages of sandwich construction over concrete filled tubular (CFT) sections includes, higher bending stiffness, avoids instability under external pressure, interaction of the three (steel tubes and concrete) components results in good local stability, increase in section modulus, enhances global stability, good for seismic retrofit, lighter weight, good damping characteristics and good cyclic performance

2. CFDST

Concrete-filled double skin steel tubular (CFDST) members are composite members which consist of an inner and outer steel skin with the annulus between the skins filled with concrete. The concrete is properly compacted and packed in-between the two steel surfaces. The interaction between the steel and concrete is due to the frictional resistance between steel and concrete.

3. STEEL TUBES

The inner and outer tube are made of a fabricated box section with yield strength of 415kNm. The inner tube is provided as 30 × 30mm crossection with thickness 2mm, while as the outer tube is provided as 100 × 100mm crossection with thickness of 3mm. The stell tube test specimen are shown in figure 1 below.

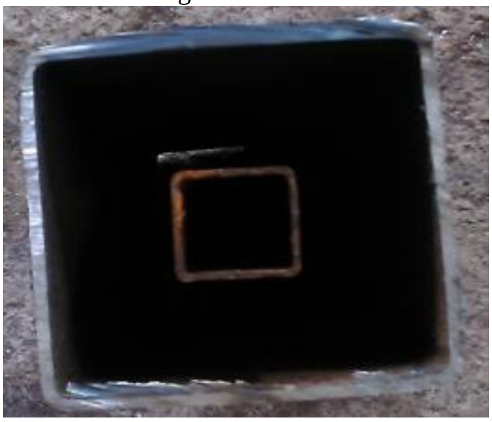

Fig 1: steel tubes

4. CONCRETE

Concrete is designed to have the maximum compressive sterength of 35kN. The concrete is not provided with any admixtures to attain ultimate compressive strength. The cement used for this study is Portland Pozzolanic Cement is conforming to Indian Standard IS 12269 – 1987 of grade 53. The sand is used as fine aggregate and it is collected from nearby area. The sand has been sieved in 2.36 mm sieve. The Fine sieve size is used to increase the strength of the concrete. The coarse aggregate is choosen by shape as per IS 2386 (Part I) 1963, surface texture characteritics of aggregate is classified as in IS 383 - 1970. The aggregates used in the specimen are 10mm seived. They are used for increased workabiltity and to attain high strength.

5. MODELING

The analysis of the CFDST is done using Abaqus/CAE 6.11-1 finite element software as shown in figure 2. The elements are modeled as C-0-C elements. C3D8 elements are used for modeling of concrete (i.e. 8 noded solid 3D elements). Outer tube Inner tube and plate are modeled using S4R (i.e. 4 noded shell elements).. Tie constraint is provided between concrete and steel .The Boundary conditions applied are as

i. For steel translational and rotational were restrained
ii. In concrete translational is restrained.

Finite element analysis of the CFDST is done with least possible no of elements. the stress, strain, and axial deformation is calculated simultaneously for each set of elements. The graphs are drawn for the conclusion of stress strain and axial deformation and the results are compared with the experimental results of CFDST columns. The load applied on the specimen is calculated by strength of material concept.

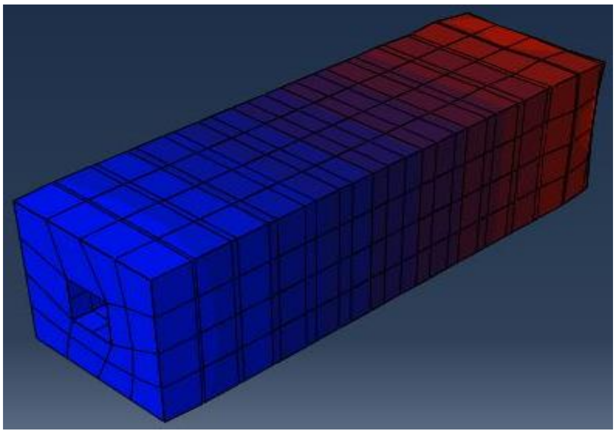

Fig 2: Abaqus model

6. Objective

- The main aim of research is to study the structural integrity and strength of the CFDST.
- To study the failure mechanism in CFDST.
- To study the governing factors for the strength of the CFDST

7. METHODOLOGY

The procedure of the work involves detailed analytical and experimental investigation and the comparison between analytical and experimental results. The analytic study can be done by making use of a structural analysis software while as experimental investigation requires material and CFDST testing with following components:

i. Creating a computer model by making use of Abaqus/CAE 6.11-1
ii. Application of the loads.
iii. Carrying out analysis and evaluating the output of structural parameters.
iv. casting and testing of the CFDST
v. comparison of the analytic and experimental investigation results.

8. Analytical results

The analysis of the CFDST is based upon the Finite element Method (F.E.M) approach. The number of the elements in outer tube, inner tube and concrete is simultaneously increased. The Axial shortening, stress and strain is calculated with increase in the number of the elements. The stress, strain and axial shortening of the 350 mm, 450 mm and 550 mm length CFDST column with respect to the number of the elements shown in table 1, table 2 table 3 respectively.

Table 1: Analytic results of CFDST Column With 350 mm Length

S.No.	Number of elements	Stress N/mm2	Strain (e-3)	Displacement (mm)
1	19	2.42	2.185	4.427
2	30	2.43	3.745	4.408
3	47	2.44	3.707	4.424
4	61	2.45	3.74	4.425
5	78	2.65	4.36	5.06
6	131	2.89	4.523	5.163
7	220	2.96	4.528	5.377
8	287	3.15	4.718	5.375
9	516	3.51	5.22	5.613
10	634	3.33	5.232	5.624
11	1020	3.18	8.766	5.44
12	1074	3.18	9.52	5..44
13	1344	3.14	7.246	5.36
14	1920	3.16	8.65	5.02
15	2112	3.02	9.979	5.177

Table 2: Analytic results of CFDST Column With 450 mm Length

S.No	Number of elements	Stress N/mm^2	Strain e-3	Displacement (mm)
1	19	2.436	4.316	5.66
2	63	2.471	3.955	5.65
3	94	2.616	4.517	6.07
4	157	2.849	4.46	6.327
5	220	2.896	4.242	6.62
6	267	3.091	4.321	6.64
7	430	3.242	5.024	6.69
8	624	3.583	5.799	7.332
9	711	3.511	5.11	6.887
10	807	3.332	5.2	6.887
11	861	3.318	5.227	6.887
12	1176	3.32	5.547	6.889

Table 3: Analytic results of CFDST Column With 550 mm Length

S.No.	Number of elements	Stress N/mm2	Strain (e-3)	Displacement (mm)
1	4	4	2.446	4.535
2	8	8	2.462	4.22
3	12	12	2.475	4.22

4	24	24	2.607	4.443
5	44	44	2.775	4.415
6	72	72	2.786	4.009
7	96	96	3.069	4.673
8	104	104	3.157	4.796
9	224	224	3.066	4.669
10	296	296	3.526	5.49
11	352	352	3.328	5.261
12	552	552	3.167	8.603
13	732	732	3.221	8.171
14	1040	1040	3.078	9.115

9. CFDST TESTING

CFDST were testing in column testing machine and load was applied with the increment of 10kN/s. the specimen was provided with steel plate of thickness 6mm for the uniform distribution of the load. Figure 4 shows the column testing of the CFDST.

Fig 3: CFDST Test

The ultimate load and the maximum deflection in the specimen was recorded. The experimental test results are shown in table 4 & table 5.

Table 4 ultimate load carrying capacity of CFDST after 28 days

Specimen	Predicted / Theoretical load carrying capacity	Experimental value			
		Trail 1	Trail 2	Trail 3	Average value
CFDST 350mm Ht	857.10	910	890	870	890.00
CFDST 450mm Ht	857.10	820	870	820	836.67
CFDST 550mm Ht	857.10	610	670	660	646.67

Table 4 ultimate load carrying capacity of CFDST after 28 days

Specimen	Predicted / Analytic shortening	Experimental value			
		Trail 1	Trail 2	Trail 3	Average value
CFDST 350mm Ht	5.44	4.4	4.9	4.2	4.50
CFDST 450mm Ht	6.88	4.9	4.6	4.9	4.80
CFDST 550mm Ht	7.80	4.6	5.8	4.6	5.00

10. RESULT COMPARISON

The comparison between the analytic and experimental results for ultimate load carrying capacity and axial shortening of the CFDST is shown in figure 4 and figure 5 respectively.

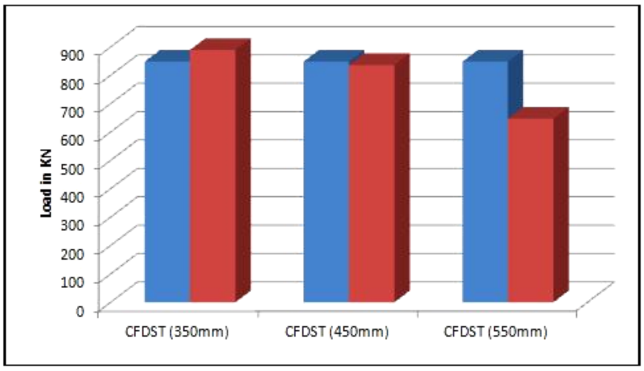

Fig. 4 Comparison Of Ultimate Load Carrying Capacity

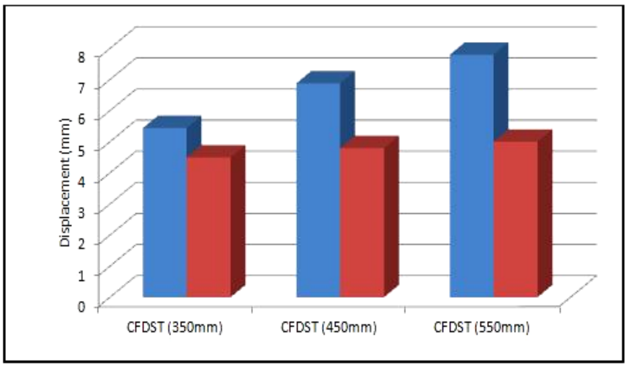

Fig. 4 Comparison Of Axial shortening

Conclusion

The CFDST columns show substantial increase in axial load carrying capacity with less axial shortening. the effective composite action of the steel tubes and concrete increases the strength of the CFDST columns. The failure mechanism which is local buckling is favorable for construction industry. The results of Axial shortening, Stress And Strain are in acceptance with the experimental results, thus proper formulae can be adopted for future use of the CFDST columns in construction. The ductile failure mechanism of the column also makes it good for seismic construction and seismic retrofit.

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