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Structural Imperfection Assessment of Voided Defects and Strengthening in Double Skin Composite Columns

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Abstract: In this paper a double skin concrete filled steel tubes are to be analysed in ANSYS Workbench. A normal CFDST column comprise of many voided defects like Spherical Cap-Gap and Circumferential Cap-Gap. CFDST with and without these defects are to be analysed and to study the performance of these defects on double skin CFST columns along major – minor axis, throughout the full height of the column. Models which have low loading capacity with standard ones, its strength has to be increased using strengthening material like CFRP.

Key Words: CFST- Concrete Filled Steel Tubes, CFDST- Double skin concrete filled steel tubes, Voided defects, Spherical cap gap, Circumferential cap gap, CFRP- Carbon Fiber Reinforced Polymer

I. INTRODUCTION

CFST are a creative and adaptable structural solution that combines the best qualities of steel and concrete. By encasing a steel tube in high-strength concrete, this composite construction technique produces an efficient and effective structural element that is used in a variety of engineering and building projects. The desire to take advantage of the complementing qualities of concrete and steel led to the development of concrete-filled steel tubes. Steel provides strong tensile strength and ductility, while concrete delivers exceptional compressive strength and fire resistance. When these materials are combined, CFST produces a synergistic performance that improves the load-bearing capacity, durability, and adaptability of the structures. The effective resistance of CFST to axial and lateral loads is one of its main features. The concrete is contained by the steel tube, which delays premature failure and improves overall performance. Because of this, CFST is especially well-suited for use in projects involving bridges, tall buildings, industrial structures, and other constructions where structural resilience and integrity are crucial. Many wide varieties of CFST tubes are available out of this Double skin concrete filled steel tubes are used for analysis. A concrete filled double skin tubes consist of an inner tube filled with concrete and an exterior tube around it. It offers advantage advantages including better resistance to buckling, fire and enhanced loading capacity.

II. OBJECTIVE

- To study the concept of Cap – Gap defects
- To familiarize with ANSYS Workbench software
- To study the performance of spherical cap-gap defect on the double skin elliptical CFST column along major and minor axis.
- To study the performance of circumferential cap gap defects that effect the column and how this defect effect along exterior tube-concrete and inner tube-concrete
- To study the methods of strengthening the columns subjected to this defect.

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III. SUMMARY

From the literature review following conclusions are made: Taking into account the properties of the elliptical cross-section and spherical-cap gap, a finite element model of the eccentrically pressured CFET short column is created. It is discovered that the eccentrically-loaded CFET-SG short column's bearing capacity and ductility dramatically decrease as the gap size increases by comparing the experimental findings of CFET-SG short columns with gap values of 0, 10, 20, and 30 mm, respectively. Local collapse and brittle splitting of the compressive concrete core, as well as local buckling of the elliptical HSS surrounding the gap zone, are the main failure characteristics of the CFET-SG under eccentric pressure. When the specimens are compressed along their primary axis, outward buckling happens. When specimens are compressed along their minor axis, there is noticeable inward local buckling that happens. The confining stress between the elliptical HSS and the concrete core is significantly reduced when the spherical-cap gap is present.

IV. MODELLING

A CFDST column with elliptical section of dimension 278x140x6x500mm (2a x 2b x t x l) keeping the concrete thickness as 40mm between outer and inner tube was designed. Loading is provided in a displacement control method till its failure and maximum load and deflection is obtained.

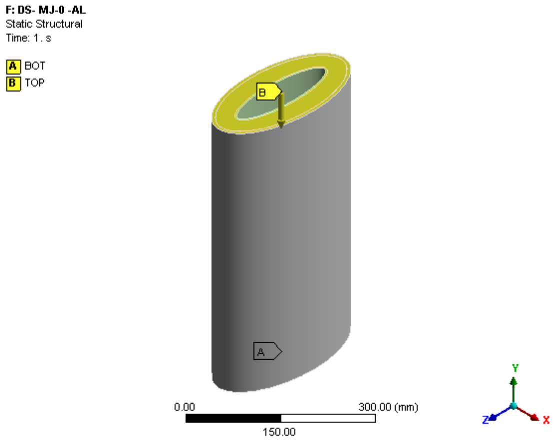

Fig 4.1: Displacement control method

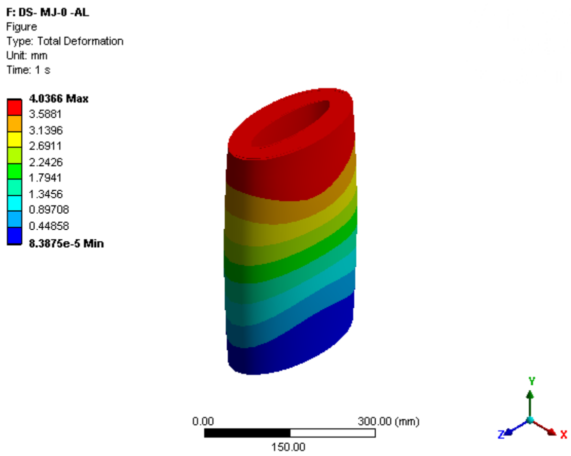

Fig 4.2: Total Deformation of CFDST

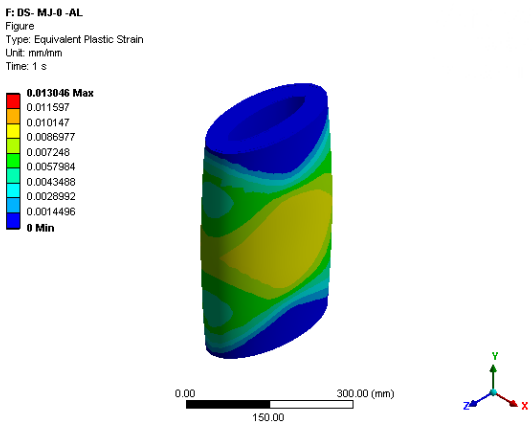

Fig 4.3: Strain Distribution of CFDST

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Provide spherical cap gap of 5mm, 10mm, 15mm, 20mm and 25mm along major axis then finite element modelling is performed, loading is applied at top of the column and subjected to analysis, maximum load and deflection is determined. Similarly repeat the procedure by changing the axis to minor axis and determine maximum force reaction and deflection.

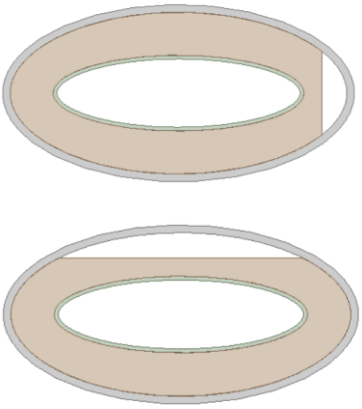


Fig 4.4: Cap gap value of 20mm along major axis and minor axis

In order to determine the performance of circumferential cap gap on CFDST provide a gap value of 2.5mm between exterior tube – concrete and interior tube – concrete along major and minor axis. Repeat the same loading condition and determine maximum deflection and force reaction.

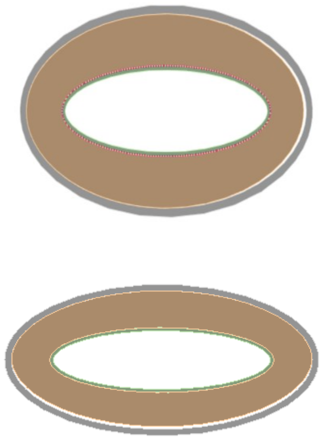
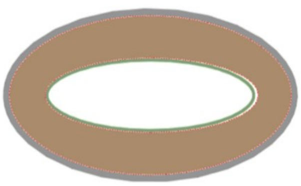


Fig 4.5: Effect of CCG on exterior tube along major and minor axis



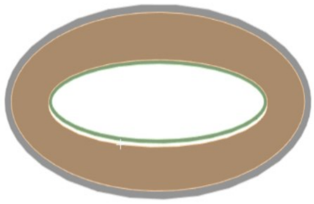


Fig 4.6: Effect of CCG on interior tube along major and minor axis

V. RESULTS OF CAP GAP

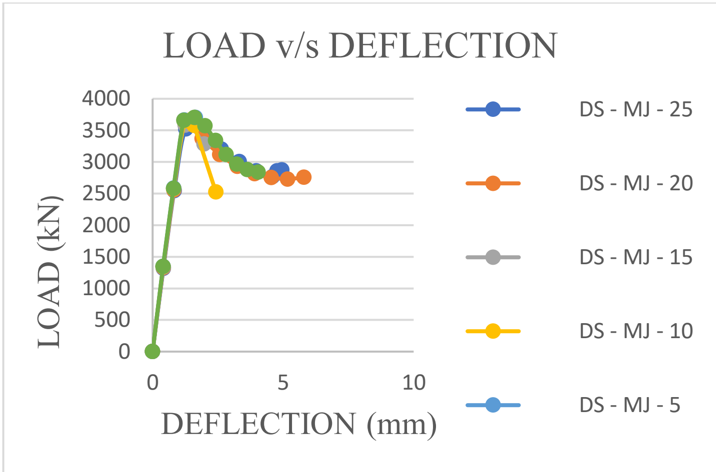


Fig 5.1: Load v/s Deflection along Major axis of SCG

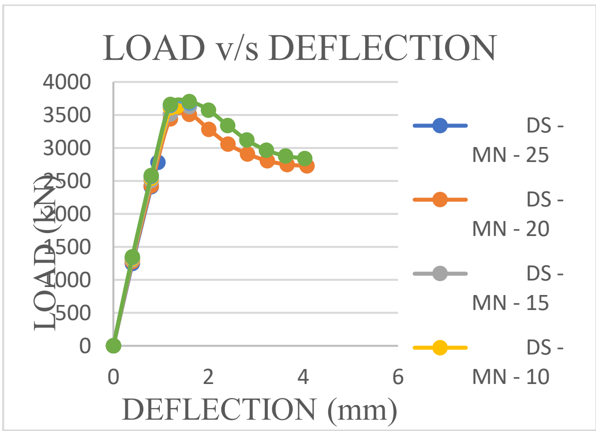


Fig 5.2: Load v/s Deflection along Minor axis of SCG

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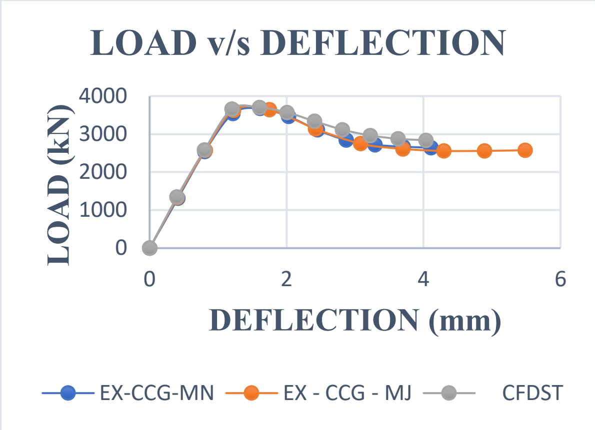

Fig 5.3: Load v/s Deflection of CCG along Exterior tube

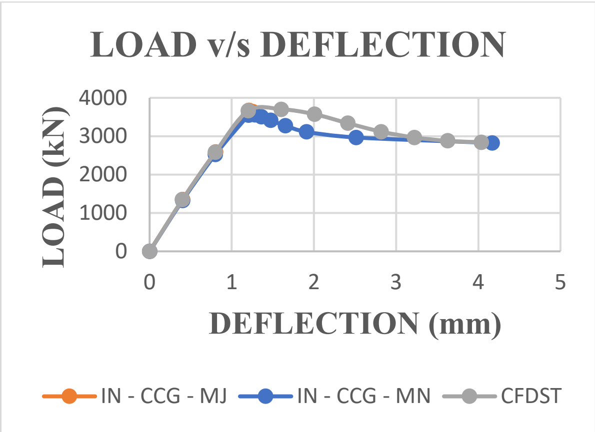

Fig 5.4: Load v/s Deflection of CCG along Inner tube

Table 1: Maximum Deflection and Load of models

MODEL	**DEFLECTION (mm)**	**LOAD (kN)**
CFDST	1.6032	3702.1
DS-MJ-5	1.6355	3702
DS-MJ-10	1.443	3664.3
DS-MJ-15	1.246	3581.6
DS-MJ-20	1.2412	3563.9
DS-MJ-25	1.2718	3524
DS-MN-5	1.6	3677.9
DS-MN-10	1.3435	3628
DS-MN-15	1.6033	3623
DS-MN-20	1.6023	3510.2
DS-MN-25	0.94075	2781.1
EX-CCG-MN	1.6131	3675.9
EX-CCG-MJ	1.7474	3645.6
IN-CCG-MN	1.2445	3570.8
IN-CCG-MJ	1.2092	3673.9

VI. STRENGTHENING OF MODELS

Divide the models into four categories, from each category one model have very low load carrying capacity with standard one, these models have to be strengthened using Carbon Fiber Reinforced Polymer. Models to be strengthened are: DS-MJ-25, DS-MN-25, EX-CCG-MJ, IN-CCG-MN

Table 3: Properties of CFRP

PROPERTIES	AVERAGE VALUE
Tensile Strength (MPa)	1240
Modulus of Elasticity (GPa)	91.7
Thickness (mm)	1.27

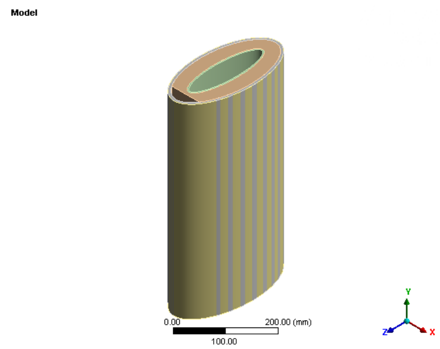

Fig 6.1: DS-MJ-25 with CFRP

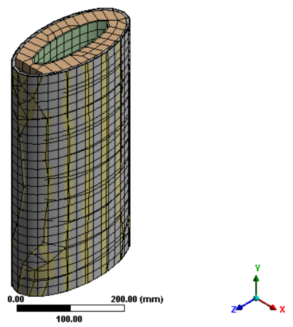

Fig 6.2: Finite Element Modelling

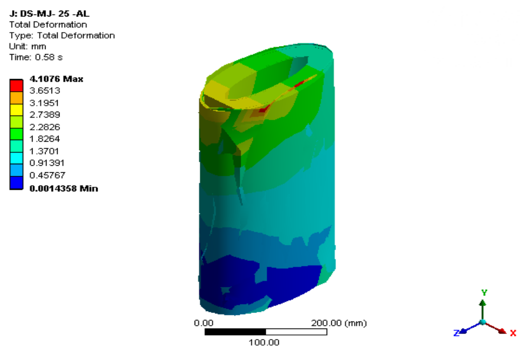

Fig 6.3: Total deformation of DS-MJ-25
Increase the thickness from 1.27mm to 3.81mm

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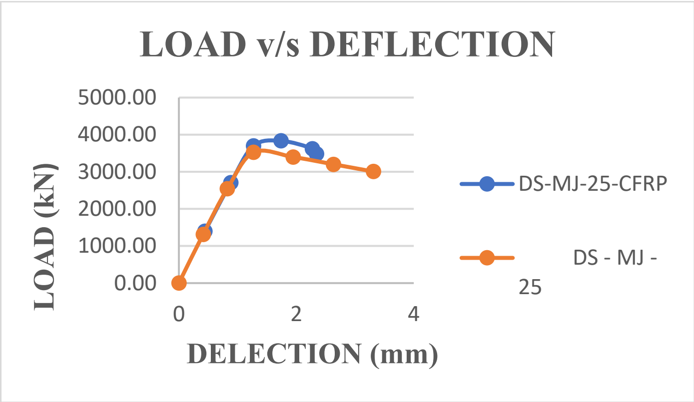

Fig 6.4: Load v/s Deflection of 25mm SCG value along Major axis with and without CFRP

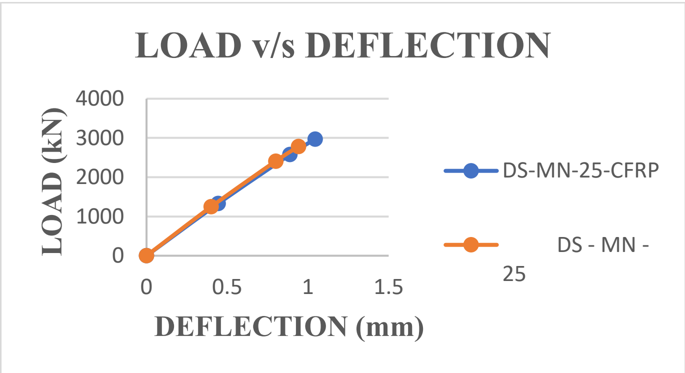

Fig 6.5: Load v/s Deflection of 25mm SCG value along Minor axis with and without CFRP

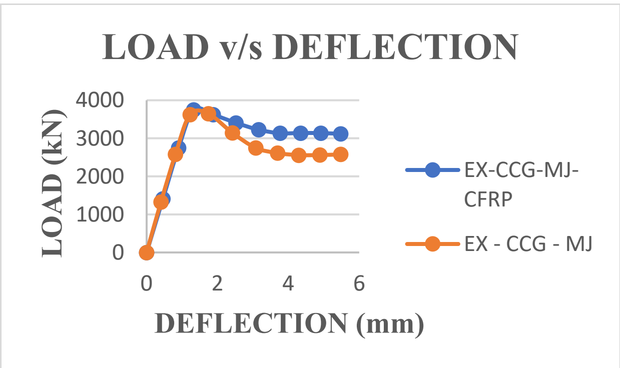

Fig 6.6: Load v/s Deflection on Exterior tube due to CCG along Major axis with and without CFRP

Table 3: Models with CFRP thickness 3.81mm

MODEL	DEFLECTION (mm)	LOAD (kN)	% INCREASE IN LOAD
DS-MJ-25	1.7404	3833.30	8.07
DS-MN-25	1.0446	2972.80	6.5
EX-CCG-MJ	1.3529	3748.60	2.74
IN-CCG-MN	1.3476	3782.60	5.6

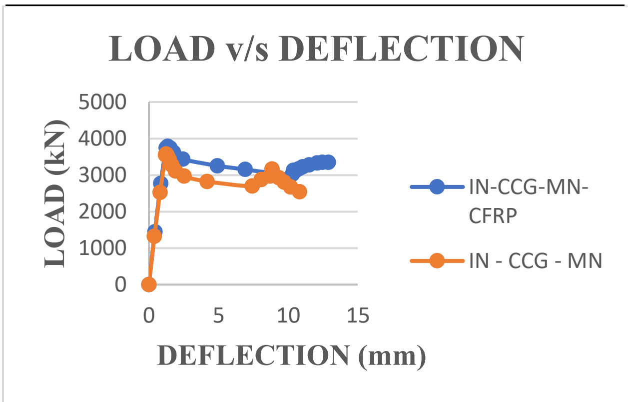

Fig 6.7: Load v/s Deflection on Inner tube due to CCG along Minor axis with and without CFRP

VII. CONCLUSIONS

In this work a double skin composite concrete filled steel tubes are analyzed using the software ANSYS Workbench. Voided defects such as Spherical cap gap and Circumferential cap gap are common in Concrete Filled Columns it may not be even visible to our eyes but after certain period of time these defects can cause failure of structures hence it is necessary to analyses such concrete filled tubes and necessary strengthening methods have to be adopted.

The following conclusions are obtained:

- For a CFDST without cap gap is designed and analysed, a maximum load of 3702.1 kN and deflection of 1.6032mm is obtained.
- CFDST with Spherical Cap gap value of 5,10,15,20 and 25mm is provided along Major and Minor axis it is then analysed and maximum load and deflection is obtained.
- CFDST with Circumferential cap gap of 2.5mm is provided along major and minor axis and determined the effect of defect along exterior and interior tube.

- Out of the categories four models have to be strengthened using CFRP since it has the low loading capacity with standard one.
- Warping of CFRP of thickness from 1.27-3.81mm increased the overall loading capacity of CFDST from 2% to 8%

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