Non-Linear Analysis of Concrete Filled Double Skin Circular Steel Column

Anjaly P Mohan
Post Graduate Student
Department of Civil Engineering
Sree Budha College of Engineering,
Pathanamthitta, Kerala
India

Arathi. S
Assistant Professor
Department of Civil Engineering
Sree Budha College of Engineering,
Pathanamthitta, Kerala
India

***Abstract*—This paper investigates the behaviour of CONCRETE FILLED DOUBLE SKIN TUBULAR (CFDST) Circular stub columns with steel tubes compressed under concentric axial loads. The CFDST member is a new type of composite construction, which consists of two concentric steel tubes with concrete sandwiched between them. Thus, CFDST columns have a series of advantages, such as high strength, high bending stiffness, good seismic and fire performance, and also having favorable construction ability. The finite element analysis of the CFDST circular column is conducted to validate the finite element model with existing experimental data. The results obtained from the finite element investigation are compared with the strength values predicted using existing formulations in the analytical investigation. A good correlation was found between the values obtained from existing formulations in the analytical investigation.**

Keywords—Concrete Filled Double Skin Tubes; ANSYS;

I. INTRODUCTION

Composite steel–concrete construction is widely used in the construction of modern buildings and bridges, even in regions of high seismic risk. The composite construction ideally combines the advantages of both steel and concrete, namely the speed of construction, high strength, and lightweight of steel, and the inherent mass, stiffness, damping, and economy of concrete.A creative innovation of composite construction is known as concrete-filled double skin steel tubes . CFDST members have almost all the same advantages as traditional CFST members. They have better structural performance than those of bare steel or bare reinforced concrete. The steel hollow section acts as formwork as well as reinforcement for the concrete. Concrete eliminates or delays the local buckling of steel hollow section, and increases significantly the ductility of the section. CFST construction has proven to be economic in materials well as providing for rapid construction and thus additional cost savings. Moreover, they have lighter weight, higher bending stiffness, and better cyclic performance.

A concrete-filled double skin tube (CFDST) column with circular cross section (Fig. 1) consists of two concentric steel tubes with concrete filled between the two tubes. The CFDST columns also have excellent resistance to seismic [2-5] and are lighter and have more fire resistant than CFT columns [7]. The ultimate strength of a CFDST column is affected by the compressive strength of the concrete, the concrete confined pressure, the yield strength of the tubes, and the diameter-to-thickness ratios of the inner and outer tubes. It is known that the circular cross sections have the best confinement effect and offshore loading resistance [5,6].Therefore, CFDST columns with circular cross section and subjected to axial compressive forces are studied. In this paper, nonlinear analyses arecarried out using the finite element program ANSYS Workbench15 and verified againstexperiment data reported by Taoet al. [1] and Zhaoet al. [3].

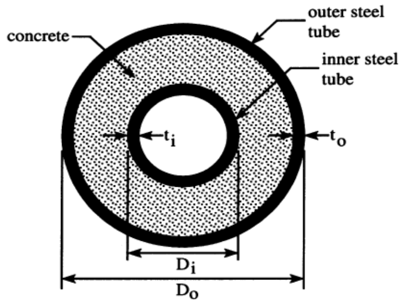

Fig.4.1. Cross-section of a Circular Steel CFDST Column

II. FINITE ELEMENT MODELLING

A. General Information

For the simulation of circular concrete-filled double-skin steel tubes and the analysis of their behaviour, the finite element programme ANSYS Workbench 15 was used. The aim is to create models thatwould accurately predict the behaviour of this form of compositecolumns, therefore the materials with their characteristic stress–strain curves needed to be defined separately along with theirinteractions, the loading and boundary conditions of each sectionas a unit, and the most suitable mesh selected.

B. Material Properties

1. Steel

The Steel is assumed to have isotropic hardening behaviour, i.e., the yield surface changes uniformly in all directions so that yieldstresses increase or decrease in all stress directions when plasticstraining occurs.For the specimen of Taoet al. [1], the elastic Elastic modulus (E_s) and Poisson's ratio for steel are taken as 200,000 $N/mm^2$and 0.3, respectively.The yield strength of the inner tube(f_{yi}) and outer tube (f_{yo})is taken as 370.2 $N/mm^2$and 275.9 N/mm^2.The Density of steel is considered as 79 kN/m^3. A bilinear property of steel tube is used in the analysis.

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2. Concrete

The Poisson's ratio of concrete under flexural stress ranges from 0.15to 0.22, with a representative value of 0.19 or 0.20. In this study, Poisson'sratio of concrete is assumed to be 0.20.For the specimen of Taoet al. [1], the Elastic modulus (E_s) is taken as 333,00 $N/mm^2$and 0.3, respectively.The average cubestrength for the stub column specimens of Taoet al. [1] were taken as 47.4 N/mm^2.The Density of concrete is considered as 24 $k\,N/m^3$.

3. Geometry

The Geometric property of CFDST circular stub column namely CC3a Tao et al. [1] having the length (L) and thickness of column (t) is taken as 540mm and 3mm.The outer diameter$D_o$and inner diameter $D_i$is considered as 180mm and 88mm respectively.

4. Element Mesh

All the parts composing the double-skin composite columns were modelled with a similar mesh size. Generally, the average mesh size used was 15mm for the concrete, 10mm for the outer tube, 10 mm for the inner tube.

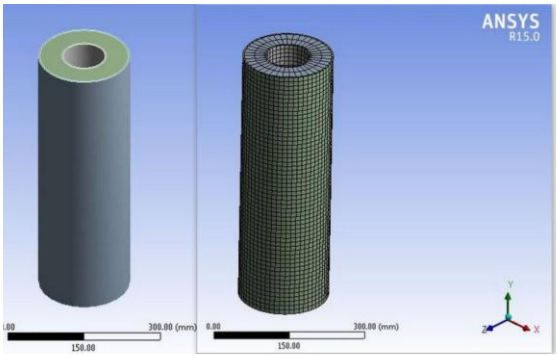

Fig.4.2. Modelling and Meshing Arrangement

5. Boundary Conditions

The loading conditions were applied using the boundary conditions of each cross-section. The bottom was fixed against all degrees of freedom. On the other hand, the node in the centre of the top was fixed against all types of rotation and against lateral displacements (x and y directions).

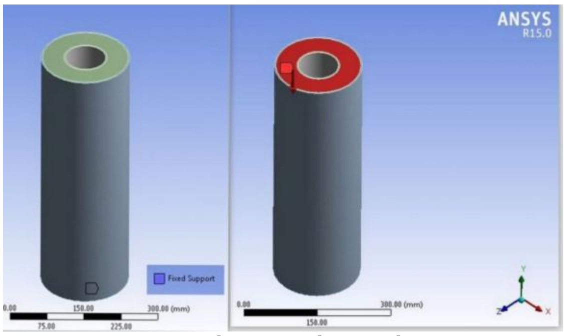

Fig.4.3.Applying Boundary Conditions

III. ANALYIS AND DISCUSSION

Nonlinear analysis is done. Using ANSYS Workbench15, Static analysis of Circular CFDST column is analysed. Comparing the results with experimental data and to be validated through plotting graphs.

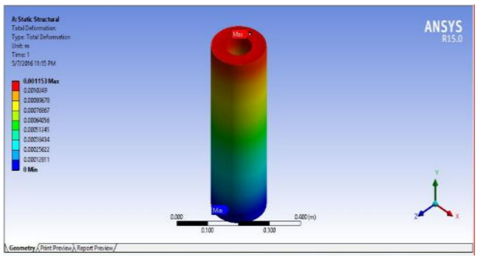

Fig.4.4. Deformation Diagram

Fig.4.4 shows that axial deformation is maximum at top of the column section and decreases with the increase in the distance of the column section from top and becomes zero at the bottom of the column section where column is fixed.Fig.4.5 shows the Deformation curve.

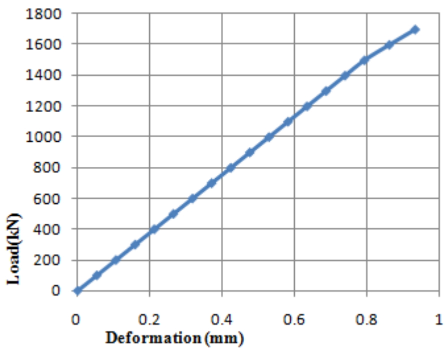

Fig.4.5. Load Vs Deformation

The load–strain behaviour of the circular double-skin specimen, cc3a, was also observed.Fig.4.5 shows the load–strain behaviour.

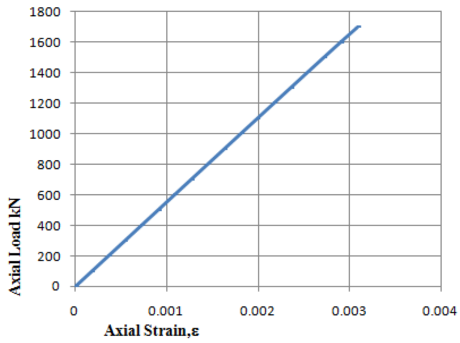

Fig.4.6. Load Vs Strain

The comparison of the experimental observations with themodelled results was drawn using three parameters: the ultimatecapacities, the axial load–strain curves and the final deformationsof the specimen.Table 1 shows the recorded maximum strengthsof the test specimens together with the attained ultimate resistancesof the specimens modelled in ANSYS. Good agreementwas noted generally, with the tested-to-finite element modelstrength ratios being close to unity.

TABLE.1. AXIAL LOAD CAPACITY

Axial Load Capacity			
Model	*Experimental*	*Analytical*	*Error*
CC3a	1648kN	1700kN	3%

IV. CONCLUSION

A finite element analysis was conducted in order to examine thecross-sectional capacity and behaviour of the recently introducedcomposite double-skin columns subjected to concentric loading. Past experimental results were used to verify thatthe accuracy of the utilised method was sufficient. This was implemented by comparing the compressive resistance and axial load–strain curves.

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