Analysis of CFDST Columns with Different Geometrical Shapes

Reeba Mary Cherian
PG Scholar, Sree Buddha College of Engineering,
Alapuzha Pathanamthitta cluster of APJ Abdul Kalam Technological University,
Ayathil, Elavumthitta P.O, Pathanamthitta-689625

Linda Ann Mathew
Assistant Professor, Sree Buddha College of Engineering,
Alapuzha Pathanamthitta cluster of APJ Abdul Kalam Technological University,
Ayathil, Elavumthitta P.O, Pathanamthitta-689625

***Abstract*-Concrete plays a major role in the construction field. In recent years, it was proposed by several researchers that Concrete Filled Double Skin Steel Tubes (CFDST) can be studied for their strength as a column or a beam. Advantages of CFDST over fully Concrete Filled Steel Tubes includes: increase in section modulus; enhancement instability; lighter weight; better damping characteristics and better cyclic performance. It is thus expected that concrete filled double skin steel tubes have the potential of being used in building structures. In this work, nonlinear structural behavior of CFDST columns are investigated by varying the cross-sectional shapes of steel tubes. Various parameters that can be evaluated from this study are stress, strain and deformation values.Comparitive results of values of these parameters are obtained.**

Keywords-CFDST, CFST, Section modulus, Nonlinear structural behavior, Crack propagation

I. INTRODUCTION

Composite steel-concrete construction is widely used in construction of modern buildings and structures, even in highly seismic regions. The advantages of both steel and concrete are combined in composite construction. The main advantages includes speed of construction, high strength, lightweightness of steel, inherent mass, stiffnes, damping and economy of concrete. Concrete Filled Steel Tube (CFST) is such a type of construction material which combines advantages of both steel and concrete. They have better structural performance than those of bare steel or bare reinforced concrete. CFST construction has proven to be economic in material as well as providing for rapid construction and thus additional cost savings.Recently, a modified form of CFST known as Concrete Filled Double Skin Steel Tube (CFDST) columns was developed by several researchers. This study investigates the seismic behavior of CFDST columns having varying cross-sectional shapes and concrete properties. Advantages of CFDST over CFST includes: increase in section modulus and stability, light weight ,better cyclic performance, higher bending stiffness, good damping characteristics, higher fire resistance property. It is expected that the CFDST columns can obtain a higher fire resistance period than the CFST columns, due to the inner tubes of the composite columns being protected by the sandwiched concrete during fire. Therefore, CFDST have a potential of being used in building structures.

In this paper, the analysis of CFDST columns having varying cross-sectional shapes are studied and the results are presented. ANSYS software is used for the analysis. This software is based on Finite Element Method. This method makes it possible to take into account non-linear response. It is an analytical tool used to model concrete filled steel tubular columns and is able to calculate the non-linear behaviour of structural members. In structural analysis, Finite Element Method is the dominant discretization technique. This technique is based on the concept of subdividing the mathematical model into disjoint components of simple geometry called finite elements. The response of each element is expressed in terms of a finite number of degrees of freedom characterized as the value of an unknown function, or functions, at a set of nodal points. The method can be used to study the behavior of concrete filled steel tubular column structures including both force and stress distribution. FEM helps in obtaining the load deflection behavior and its stress strain curves.

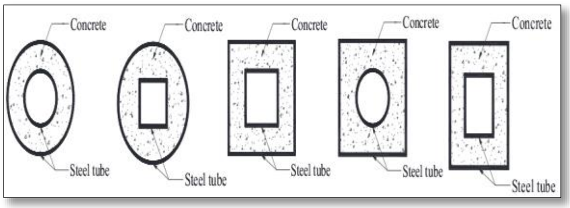

Fig.1.1 Various CFDST Section profiles

II. OBJECTIVES

1. To model columns using ANSYS software.
2. To take the following combinations of shapes for the inner and outer hollow sections of CFDST :
   - Hexagon-hexagon
   - Circle-hexagon
   - Hexagon-circle
   - Square-hexagon
   - Hexagon-square
3. To perform non linear static structural analysis of CFDST column with varying cross-sectional shapes and to obtain comparative results.

III. METHODOLOGY

This chapter describes the methodology of the thesis work..The methodology includes study of sandwich beam and ANSYS software. The whole thesis work is divided into the following sequential steps. The following flowchart represents the methodology of the thesis work to be completed.

A. Modelling

The models are created using ANSYS software. The columns are modeled with different cross-sectional shapes .Then the obtained models were analysed. After analysis the results obtained are evaluated to find out which crossectional shape is more better in resisting lateral and axial loads. Here the study is to be carried out for the behaviour of CFDST column with five different combinations of cross-sectional shapes for steel tubes. It includes outer hexagon-inner circle, outer circle-inner hexagon, outer hexagon-inner square, outer square-inner hexagon and outer hexagon-inner hexagon. The material properties are selected based on several sources such as literature reviews. Grade of concrete used is M20.

B.Dimensional Details

The CFDST column is modeled using ANSYS software with reference to journal [6]. Finite element analysis results were used to develop nonlinear static structural analysis of columns with 1000mm length and 3mm thickness under fixed support condition is studied**.** The cross-sectional details of the CFDST columns are as follows:

TABLE.3.1 DIMENSIONAL DETAILS

Dimensions Of The Columns	**Values(mm)**
Side of hexagon	108.56
Diameter of circle	114
Side of square	101.03
Length of the column	1000
Thickness of steel tubes	3

C. Material Properties

M20 grade concrete is used to fill the columns. The material properties of sandwich beam are given bellow.

TABLE.4.2 MATERIAL PROPERTIES

Materials	**Young's Modulus E (MPa)**	**Density ρ in Kg/m3**	**Poisson's Ratio υ**
M20 grade concrete	22360	2398	0.2
415 grade steel	200000	7850	0.3

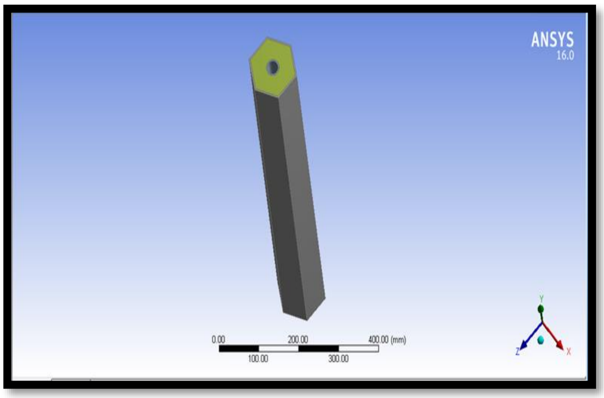

Fig 3.1 3D view of hexagon-circle combination

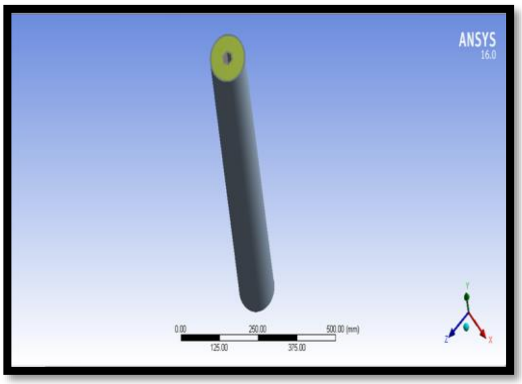

Fig 3.2 3D view of circle-hexagon combination

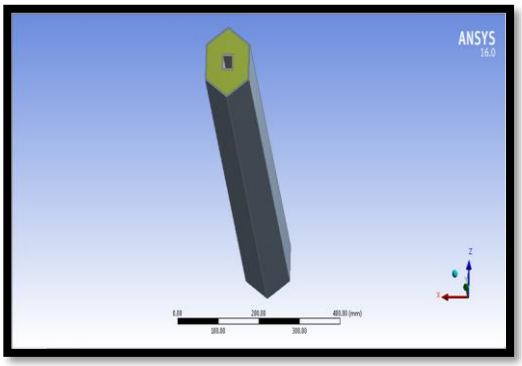

Fig 3.3 3D view of hexagon-square combination

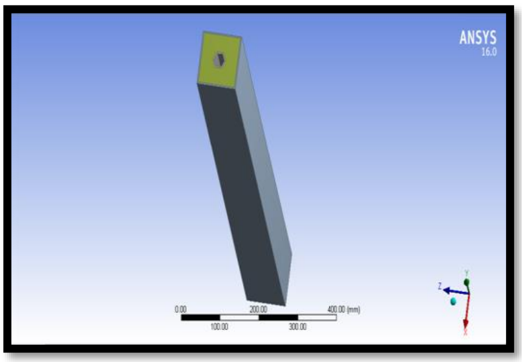

Fig 3.4 3D view of square-hexagon combination

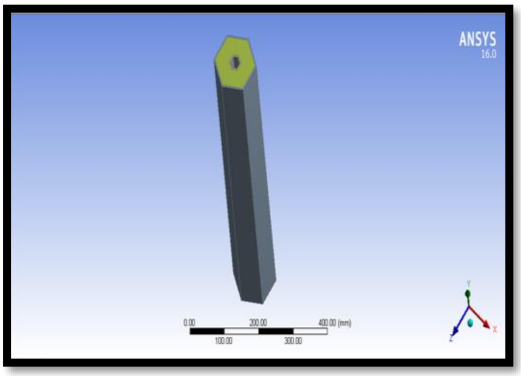

Fig 3.5 3D view of hexagon-hexagon combination

D.Meshing And Loading

The beam is modeled using tetrahedral mesh. The mesh size was provided as 15mm. Loading is provided axially and laterally. Axial load is taken as 10KN. Cyclic loading is provided.

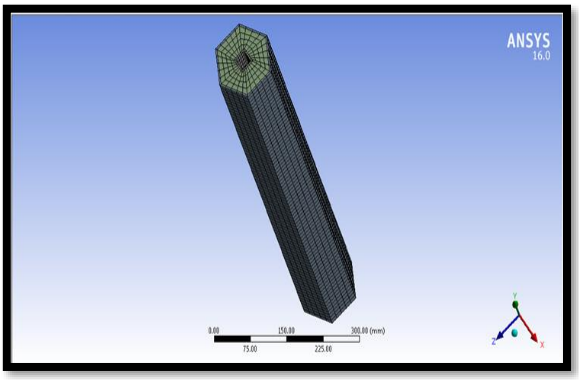

Fig.3.6 Meshing of CFDST columns

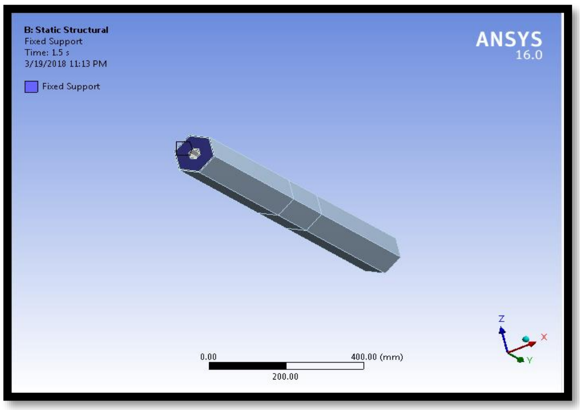

Fig.3.7 support condition of CFDST columns

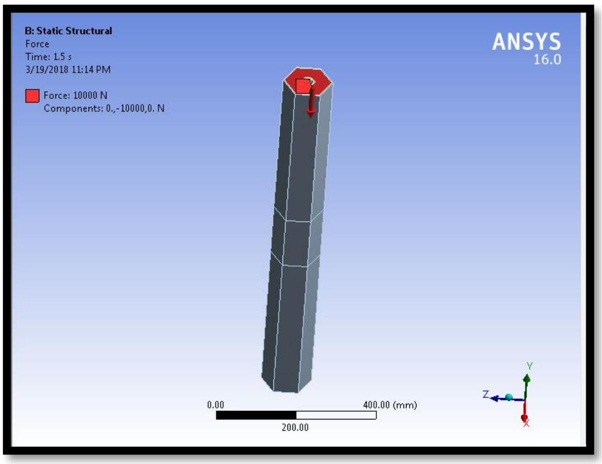

Fig.3.8 Loading condition of CFDST columns

E. Analysis Of CFDST Columns

Non linear static structural analysis was done using ANSYS software. The effect of stress, strain and deformation on the various cross-sectional shaped columns using M20 grade concrete are analysed .

IV. RESULTS AND DISSCUSSIONS

A. Deformation

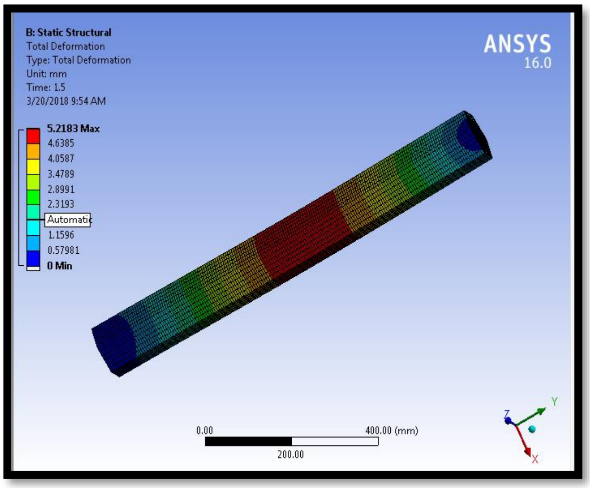

Fig 4.1 Deformation diagram of CFDST column

TABLE.4.1 DEFORMATIONS

Models	**Deformations (mm)**
Outer hexagon-inner circle	5.218
Outer circle-inner hexagon	5.9965
Outer hexagon-inner square	5.105
Outer square-inner hexagon	3.780
Outer hexagon-inner hexagon	5.135

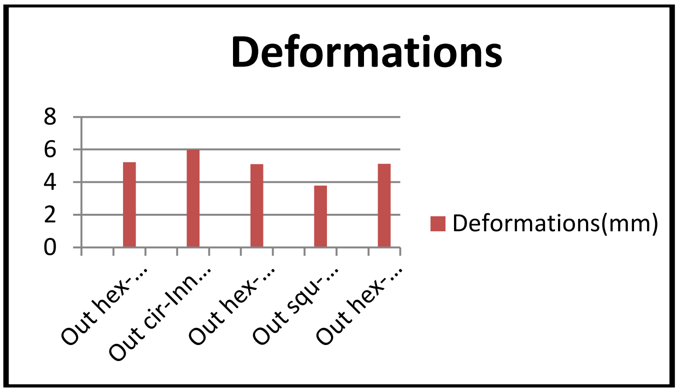

Fig.4.2 Deformation of columns

B. *Stress Distribution*

TABLE.4.2 STRESS DISTRIBUTIONS

Models	Equivalent Strain
Outer hexagon-inner circle	0.0022206
Outer circle-inner hexagon	0.0024532
Outer hexagon-inner square	0.0022559
Outer square-inner hexagon	0.0022745
Outer hexagon-inner hexagon	0.0022589

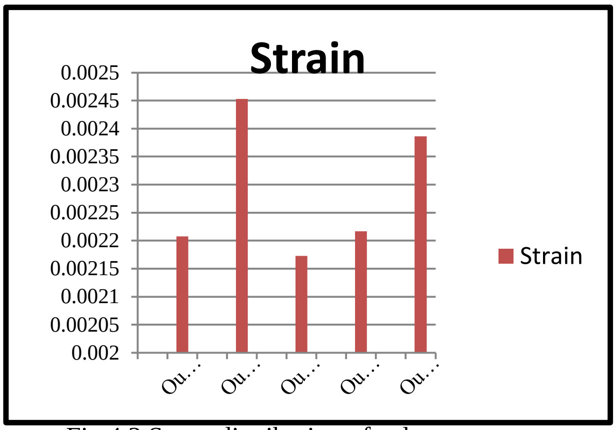

Fig.4.3 Stress distribution of columns

C. *Equivalent Elastic Strain*

TABLE.4.1 EQUIVALENT STRAIN

Models	Equivalent Stress (MPa)
Outer hexagon-inner circle	440.8
Outer circle-inner hexagon	489.24
Outer hexagon-inner square	433.5
Outer square-inner hexagon	441.08
Outer hexagon-inner hexagon	477.09

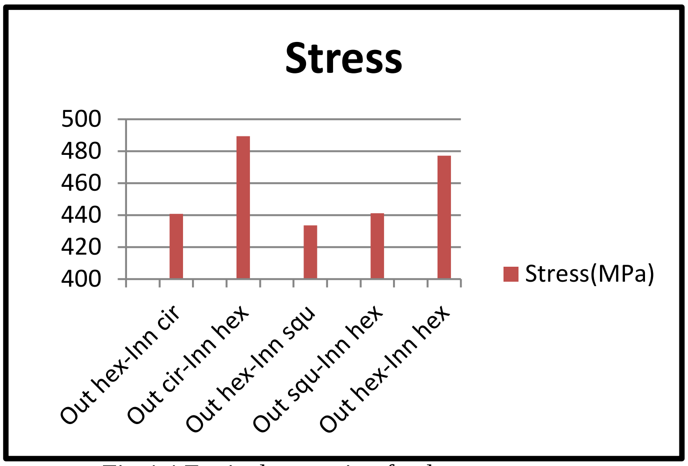

Fig.4.4 Equivalent strain of columns

V. CONCLUSIONS

CFDST columns are analysed in ANSYS software and the results were compared. The following conclusions are obtained from the study using M20 grade concrete and different cross-sectional shapes for inner and outer steel tubes. Considering deformation, the column with outer square and inner hexagon steel tubes gives less deformation compared to other columns. The column with outer hexagon and inner square steel tubes gives less stress and strain values compared to other columns.

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