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Parametric Study of Concrete Filled Steel Tube Column

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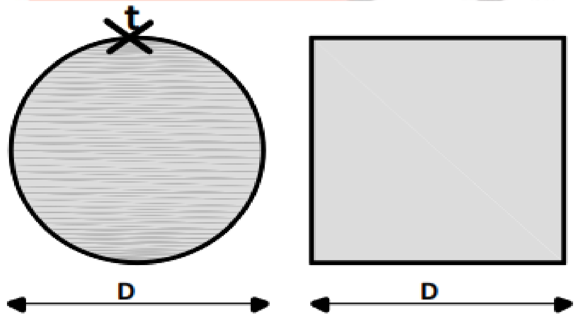
Abstract- **In recent years, the use of concrete filled steel tube columns is increased significantly in medium-rise to high-rise buildings, therefore to understand the load deformation characteristics of composite columns critically, numerical finite element analysis using software package ANSYS is carried out in this paper. This paper focuses on modelling of concrete filled steel tube (CFST) column under axial loading. The main parameters of FEA are circular and square column with varying grades of concrete (30, 50, 70, 90 N/mm^2). It is concluded that the deformation of the column is decreasing 10-15 percentage with increasing grade of concrete.The deformation was influenced by the shape of the CFST section. The circular section leads to better behavior than square section due to better confinement.**

Keywords **- Finite element analysis, Composite column, concrete filled steel tube column, Grade of Concrete.**

I. INTRODUCTION

Because of the local and global stability concerns preventing bare steel tubes from developing their full yielding strength, composite columns are initially suggested. There are a wide variety of composite column types of varying cross-section, but the most commonly used and studied are concrete-filled steel tubes. A concrete-filled steel tubular (CFST) column is formed by filling a steel tube with concrete, see Fig. 1. It is well known that concrete-filled steel tubular (CFST) columns are currently being increasingly used in the construction of buildings, due to their excellent static and earthquake-resistant properties, such as high strength, high ductility, large energy absorption capacity, bending stiffness, fire performance along with favourable construction ability etc. Recently, the behavior of the CFST columns has become of great interest to design engineers, infrastructure owners and researchers.



(a) (b)

Fig.1 (a) Circular concrete filled steel tubular column (b) Square concrete filled steel tube column.

Notation

CFST	Concrete filled steel tube	FE	Finite element
Ac	Concrete cross-sectional area	As	Steel cross-sectional area
L	Length of specimen	D	Outside diameter of steel tube
B	outside width of square steel tube	Ec	Concrete modulus of elasticity
Es	Steel modulus of elasticity	*fc*	Concrete compressive strength
fy	Yield strength of steel	P	Axial load
t	Wall thickness of steel tube	Δ	deformation

This paper shows the comparison of circular and square CFST column, with varying grades of concrete (30, 50, 70, 90 N/mm^2) and for axial load, for their ultimate load carrying capacity and deformation.

II FINITE ELEMENT ANALYSIS (FEA)

FEA modelling

The analysis is conducted in ANSYS workbench module [15], where material nonlinearities are considered.
A schematic view of the FEA model is presented in Fig. 2

1. **Material modelling:** Elastic–plastic model is used to describe the constitutive behavior of steel. Bilinear properties for steel tube and multi-linear property of concrete are used. The modulus of elasticity of concrete is taken as $5000\sqrt{fck}$ according to IS 456:2000, where *f*ck is characteristic strength of concrete. The material properties are listed in Table - 1

Table-1 Material property

Structural steel property
Density - 7850 kg/m^3
Poisson's ratio - 0.3
Elastic modulus - 2x10^5 N/mm^2
Yield strength – 250 N/mm^2
Concrete property
Density - 2300 kg/m^3
Poisson's ratio - 0.18
Elastic modulus - 27386 N/mm^2
Compressive Cube strength – 30 N/mm^2

2. **Element types and meshes:** The end plates and core concrete are simulated by an eight-node 3-D solid element, and a four- node conventional shell element is applied for steel tube. Different grid sizes are attempted to determine an appropriate mesh. The adopted element mesh is shown in Fig. 2.

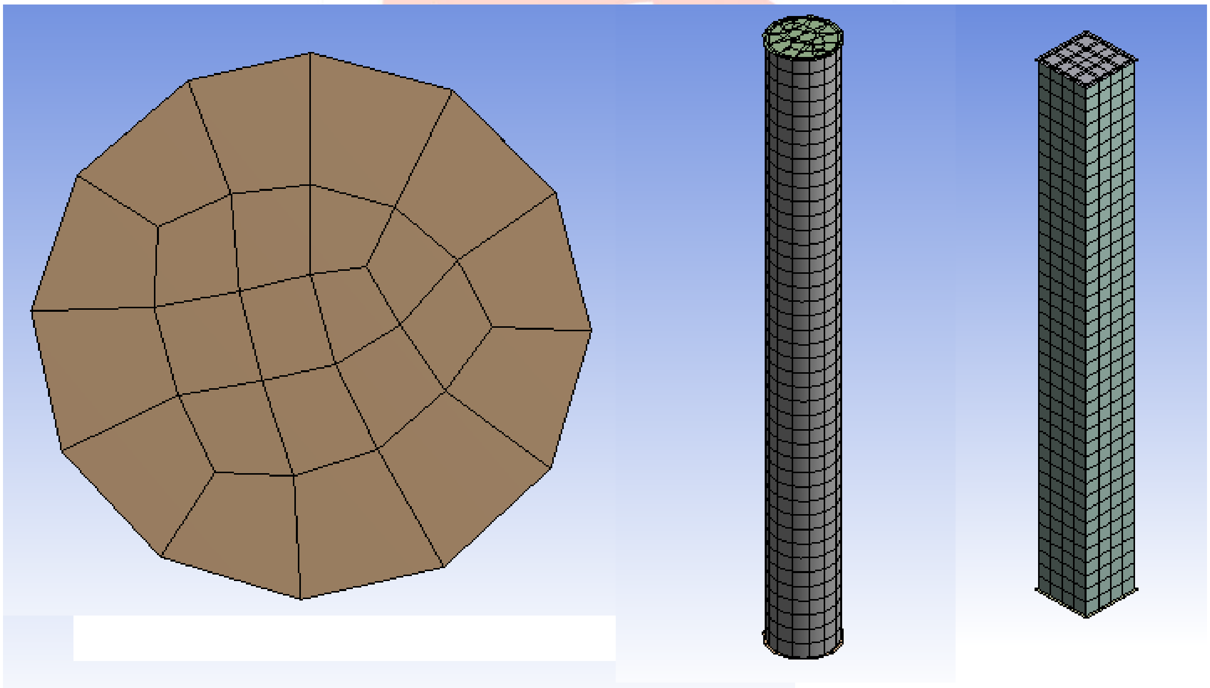


Fig. 2 FEA model-Schematic view with meshing

3. **Concrete to steel interface:** Hard contact is used in the normal direction as well as in the tangential direction of the contact between the steel tube and inner concrete.
4. **Boundary conditions:** The end plate is assumed to be elastic rigid block. Pin-ended and roller conditions are used in FEA model. The compression load is applied to the top end plate along the y axis.
5. **Geometrical parameter:** For the parametric study, it is necessary that area of concrete and steel tube in circular and square CFST column is made same for exact comparison. For that, outer width of square section is reduced to 177mm as well as thickness of the steel tube is reduced to 6.2 mm in square column.

Table 2

	Circular Column	Square Column
Outer Diameter (D) (mm)	200	177
Inner Diameter (d) (mm)	186	164.6
Thickness of steel tube (t) (mm)	7	6.2
Length of column (mm)	2000	2000
Grade of steel (fy) (N/mm^2)	355	355

III ANALYSIS AND DISCUSSION

Fig.3 shows the deformation behavior of circular and square CFST column under axial loading 3600KN. Fig. 4(a) illustrates the load versus deformation relationship of circular as well as square CFST member for grade of concrete 30 N/mm^2 under axial compression. Fig. 4(b) shows the deformation of circular and square column for axial loading 3600KN for different grade of concrete (30, 50, 70, 90 N/mm^2).

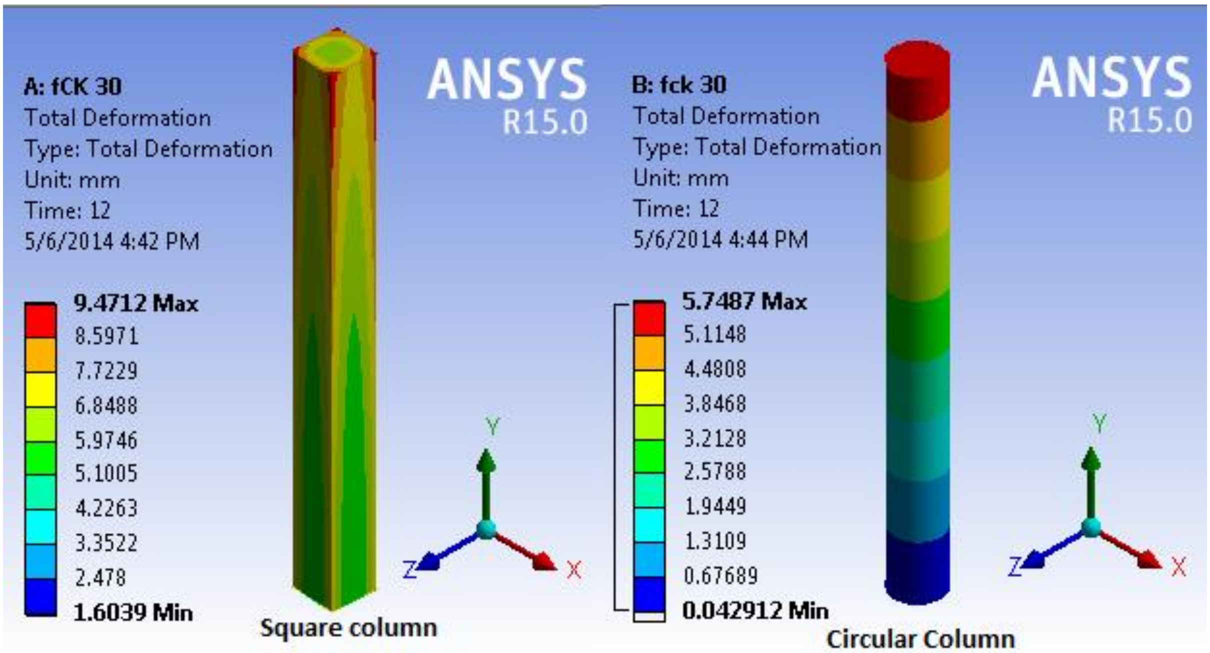


Fig. 3 Deformation for Square and Circular column for Axial load 3000KN

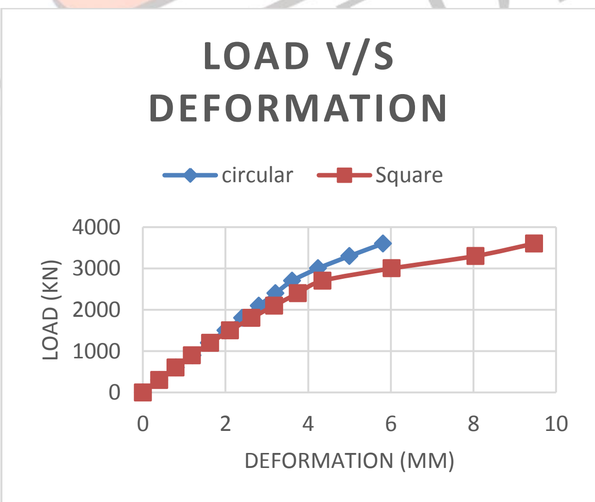


Fig 4 (a) Load v/s Deformation for fck 30N/mm^2

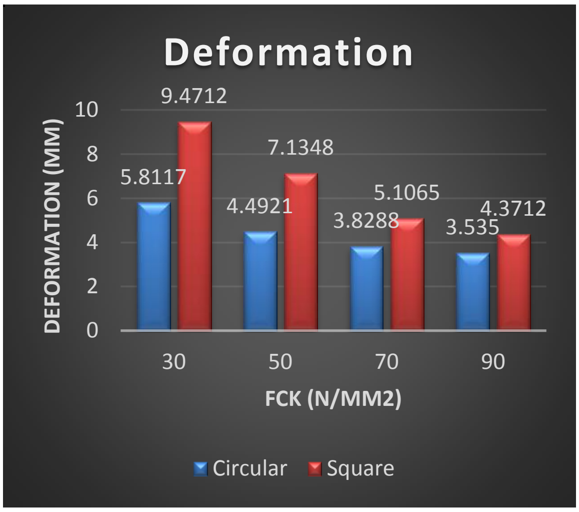


Fig 4 (b) Deformation for different grade of concrete.

Fig. 4 Load (KN) versus Deformation (mm) relations for circular and square column. (Axial Load

It was found that, deformation in a circular CFST column in less than Deformation in Square CFST column. Less Deformation in circular section is due to higher moment of inertia and confining effect. Initially the load versus deformation behavior is linear, but later it attains ductility. Deformation decreases with increasing grade of concrete. For Axial load, deformation in circular section is 29.6, 19.5, 18.0, 16.3 percentage less than Square section for grade of concrete 30, 50, 70, 90 N/mm^2 respectively. Deformation decreases 18.2, 26, 31.5% with increasing grade of concrete from 30 N/mm^2 to 50, 70, 90 N/mm^2 respectively. For higher grade of concrete decreasing in deformation is less compared to normal strength of concrete.

Table 3 percentage variation in deformation in circular and square column w.r.t *f*ck 30N/mm^2

Percentage variation in deformation w.r.t. *fck* 30 Mpa.		
Loading	Axial Load	
Fck	Circular	Square
50	18.22	28.46
70	26.00	36.20
90	31.56	42.10

IV CONCLUSION

The present study is an investigation of the behavior of circular and square concrete filled steel tubes (CFST) subjected to axial loading. Parametric study of 8 CFST columns were performed using finite element analysis. Based on the results of the study, the following conclusions can be drawn.

1. The deformation is in circular section is 20-25 percent smaller compared to square section. This is because circular section takes confining effect better than square section.
2. The equivalent stress value becomes constant after achieving its ultimate strength.
3. Deformation decreases with increasing grade of concrete, but for higher grades of concrete decreasing in deformation is less.
4. Stress concentration is more at the edges of square column while in circular column, due to confining effect, stress concentration is equal throughout the whole section.

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