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Analysis of Concrete Filled Steel Tubes using Ansys

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Abstract : This paper presents the load carrying capacities of concrete filled steel tubes (CFT) subjected to compression loading. The study on the behavior of CFT and various parameters influencing their behavior are carried out using commercially available ANSYS, FEM software. Predicting the behavior of CFT using the modeling software has become economical and this is time saving. Nonlinear finite element analysis of Concrete filled steel tube is performed by varying parameter such as grade of concrete infill, diameter to thickness ratio of the steel (D/t).

Keywords: FEM software, Concrete filled steel tubes, ANSYS, Load carrying capacity, axial compression, D/t ratio.

I. INTRODUCTION

In recent years, the composite members are used in many modern structures. Among the composite members, Concrete filled steel tubes are widely using in these days in civil engineering constructions. These are used in bridges as piers and as columns in high rise buildings. Usage of CFT columns is advantageous when compared to reinforced concrete columns. In CFT concrete is confined by the outer steel tube.

To study the behaviour of CFT many researchers conducted experimental studies and also used advanced software tools for understanding the composite behaviour by developing analytical CFT models. Hsuan- Teh Hu et al., (2003) observed that circular CFT had provided a good confinement effect whereas the confinement effect for square CFT can be improved by using reinforcing ties. They also developed an FE model, using ABAQUS for comparing the results. P.K. Gupta et al., (2007) made studies on CFT via the effect of D/t ratio and L/D ratio on confinement of concrete core. Zhong et al., (2009) used to study non circular CFT using ABAQUS and concluded that longitudinal stiffeners improve the overall performance of CF square and rectangular thin walled steel tube columns. Walter Luiz Andrade de Oliveira et al., (2009) studied the confinement effects in steel concrete composite columns based on two parameters: concrete compressive strength and column slenderness. Brian Uy et al., (2011) observed stainless steel composite column show more ductile behaviour when compared to conventional carbon steel CFST. Burak Evirgen et al.,(2014) observed that rounded CFT are ductile than angular CFT. Conducted study on concrete cube strength ranging from 30MPa to 110MPa with steel tube to plate thickness D/t ratio ranging from 15 to 70. Predicted the load axial curves and deformed shapes of the columns using the FE model. Qing-XinRen et al. (2014)conducted series of tests on Elliptical concrete filled steel tubular (CFST) beams and columns to study their behaviour under bending and compression. Main parameters were the shear span to depth ratio for beams, the slenderness ratio and the load eccentricity for columns and the effect of these parameters on the behaviour of the columns were discussed. A.K.H.Kwan et al. (2016) studied the effectiveness of external steel confinement and developed a theoretical model for evaluating the confining stress and axial load in a CFST with external steel confinement up to the post peak stage is developed and compared the measured and predicted lateral stress strain curves and axial load strain curves. Performed a parametric study for evaluating the required equivalent thickness /diameter ratios of the external steel confinement for eliminating the delaminating effect.

In this study, the main objective is modelling and analysis of concrete filled steel tube with varying grades of concrete using a finite element model ANSYS release 12.0. A nonlinear static analysis is performed to study the behaviour of CFT column subjected to axial loading.

II. FINITE ELEMENT MODELLING

Material properties

The materials steel and concrete are used for developing the composite model. Material properties such as compressive strength of the concrete and the yield strength of the steel influences the ultimate strengths of CFT. Also the ultimate strengths of CFT columns are influenced by the geometric properties of the tubes such as the shape of the cross section, the diameter-to-thickness ratio.

The input parameters used in the study for the concrete fill is given in Table 1.

Table 1 Input Properties of concrete

Properties	**Grade of concrete infill**		
	M30	**M40**	**M60**
Modulus of elasticity (MPa)	27386	31622	38729.83
Density (Kg/m^3)	2300	2300	2300
Poisson's ratio	0.15	0.15	0.15
Compressive strength (MPa)	30	40	60
Tensile ultimate strength (MPa)	3.83	4.427	5.42

Fig. 1 shows the true stress-plastic strain curve used for M30 grade concrete for the nonlinear analysis of CFT. Similar curves were inputted for M40 as well as for M60 grade concrete infill.

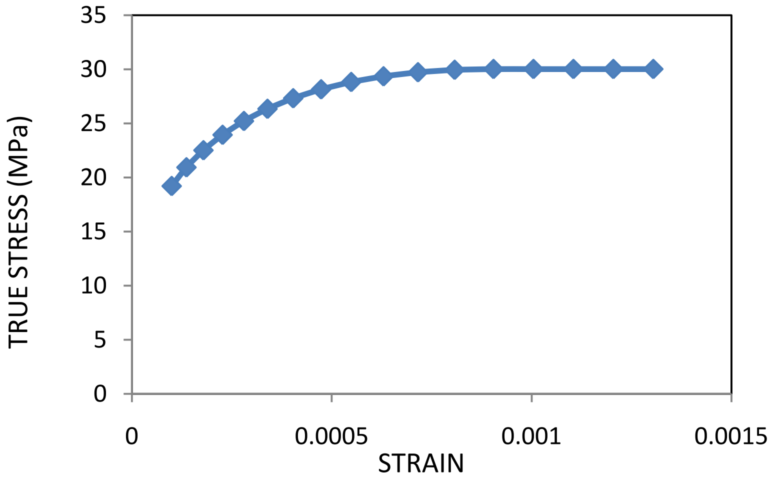

Fig. 1 The true stress-plastic strain curve used for M30 grade concrete infill.

The input parameters used in the study for the steel is given in Table 2.

Table 2 Input Properties of steel

Properties	**Fe275**
Modulus of elasticity (GPa)	200
Density (Kg/m^3)	7850
Poisson's ratio	0.27
Tensile yield strength (MPa)	275
Tensile ultimate strength (MPa)	475

The true stress-plastic strain curve used for the steel pipe in the nonlinear analysis of CFT is shown below:

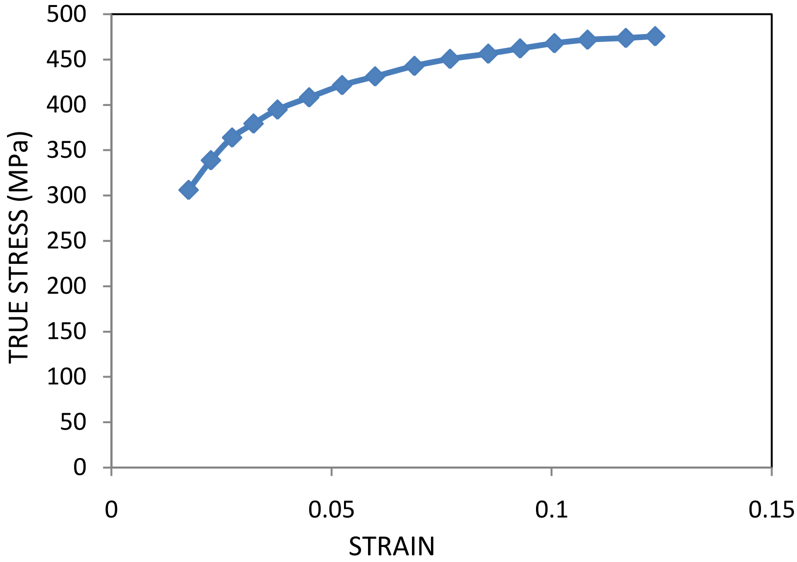

Fig. 2 The true stress-plastic strain curve used for Fe 275 steel.

Finite element modelling and meshing

A Hollow cylinder representing the steel tube with required dimensions of thickness, height and diameter was generated. Also a solid cylinder resembling concrete infill was generated with required dimensions. The model is confined with the end plates at top and bottom. Mesh was generated with the element size of 30 mm. The model was meshed using free mesh which was generated with elements.

Connections in between steel and concrete

The connection between steel tube inner face and outer face of concrete infill was defined as rough and the friction coefficient is taken as 0.2.In between CFST and end plates, connection was defined as no separation. Contact regions are also defined, the connection between Steel tube and concrete infill was defined as rough, where as the connection in between CFT and endplates was defined as no separation.

Applying boundary conditions and loads

Static structural analysis is the analysis used for the present study. Compression testing was simulated in ansys workbench. Here the modelled end plates at top and bottom of the concrete filled steel tube are subjected to loads and displacements and acts as if in the case of a compression testing machine. Degree of freedom of the bottom end plate and the bottom surface of CFT specimen were constrained. The bottom end plate was restricted in all the directions i.e., displacements and rotations in all the directions are set zero, where as the top end plate is subjected to move in the direction of application of load and the load is applied on the top surface of the top end plate. Rate of loading on the specimen is taken as 5kN/sec.

III. RESULTS

Table.3 Load carrying capacities of CFT with increasing the steel tube thickness of Fe 275 grade of steel.

D (mm)	t (mm)	D/t	Load carrying capacity P (KN) of CFT with concrete grades			HOLLOW Steel KN
			M30	M40	M60	
167	3.1	53.87	1100	1300	1700	750
168	3.6	46.66	1200	1400	1750	800
170	4.6	36.95	1380	1580	2000	875
172	5.6	30.71	1550	1750	2100	965

It is observed from above table that as the D/t ratio decreases the load carrying capacity of CFT increased considerably. It is further enhanced when the grade of concrete infill used is of higher one. More than 50% of decrease in load capacity for hollow steel is observed for lesser D/t ratio.

Table.4 Load carrying capacities of CFT with decreasing steel tube thickness of Fe 275 grade of steel.

D (mm)	t (mm)	D/t	Load carrying capacity P (KN) of CFT with concrete grades			Hollow steel (KN)
			M30	M40	M60	
167	3.1	53.87	1100	1300	1700	750
166	2.6	63.84	1000	1250	1650	400
164	1.6	102.5	850	1090	1500	250
162	0.6	270	700	925	1350	90

It is observed from above table that as the D/t ratio increases the load carrying capacity of CFT decreased considerably. But the load carrying capacity is enhanced when the grade of concrete infill used is of higher one for same D/t ratio. Percentage decrease in load capacity for hollow tube is decreasing with increase in D/t ratio and for higher D/t ratio more than 70% of decrease in load is observed.

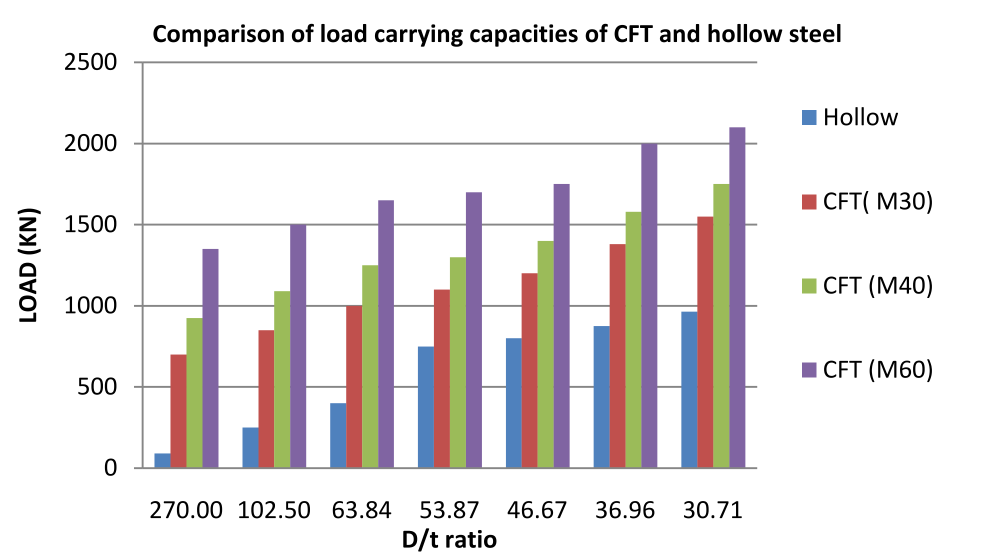

Fig. 3Load carrying capacities of CFT and hollow steel

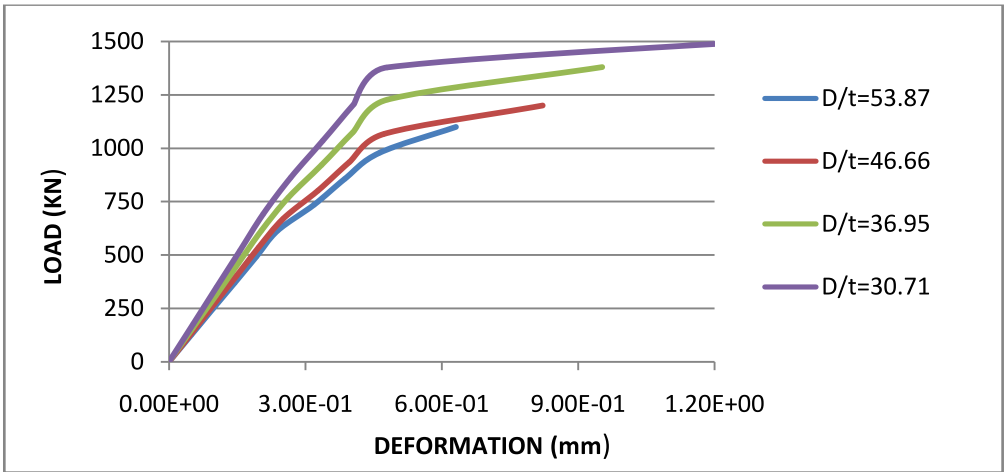

Fig.4 Load vs. Deformation graph for CFT M30, Fe 275

For the D/t=30.71, the load carrying capacity of CFT is high with a value of 1550 KN and for D/t=53.87, load carrying capacity of CFT is low (1100 KN).

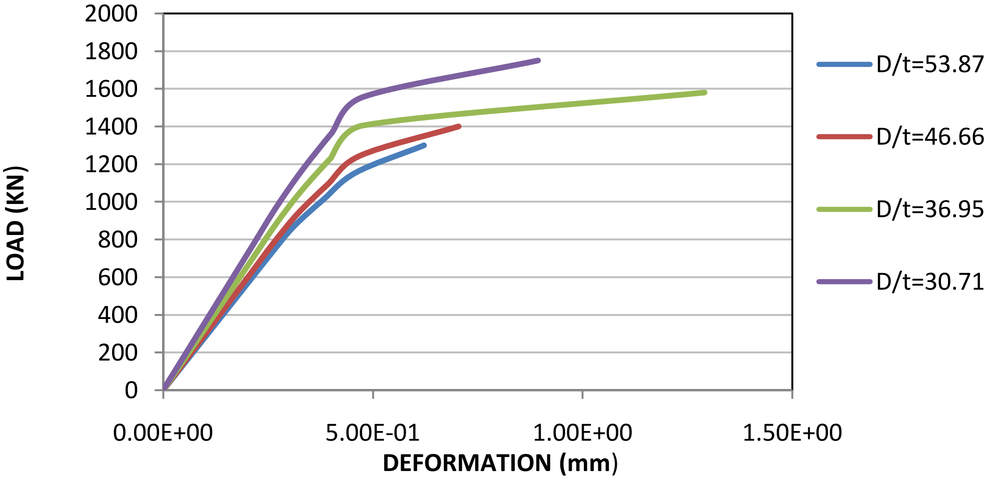

Fig.5 Load vs. deformation graph for CFT M40, Fe 275

For the D/t=30.71, the load carrying capacity of CFT is high (1750 KN) and for D/t=53.87, load carrying capacity of CFT is low (1300 KN).

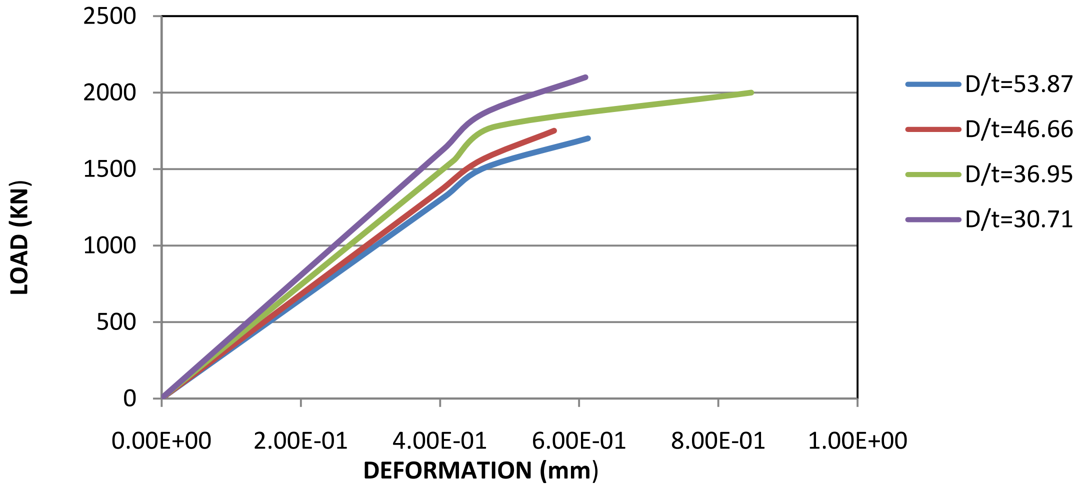

Fig.6 Load vs. deformation graph for CFT M60, Fe 275

For the D/t=30.71, the load carrying capacity of CFT is high (2100 KN) and for D/t=53.87, load carrying capacity of CFT is low (1700 KN).

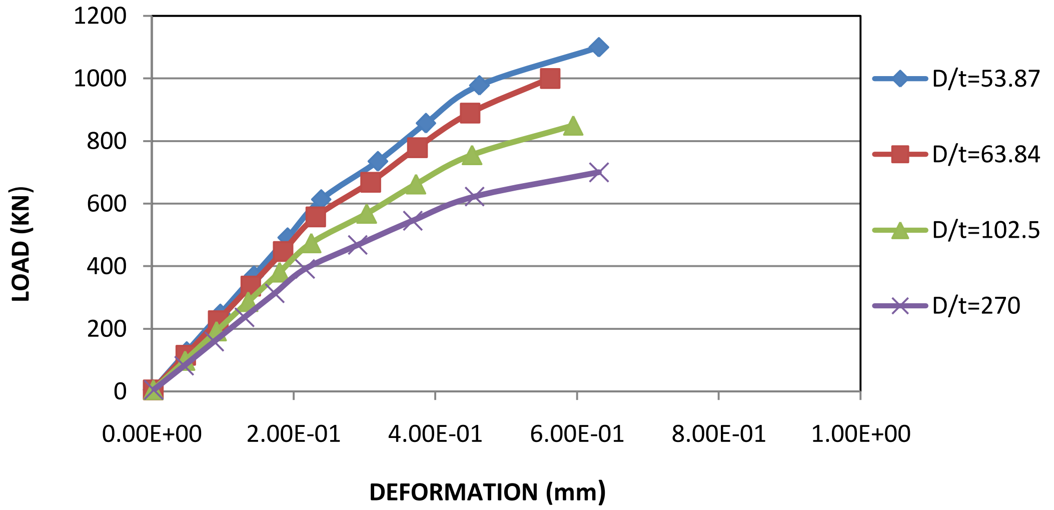

Fig.7 Load vs. deformation graph for CFT M30, Fe 275

For the D/t=53.87, the load carrying capacity of CFT is high (1100 KN) and for D/t=270, load carrying capacity of CFT is low (700 KN).

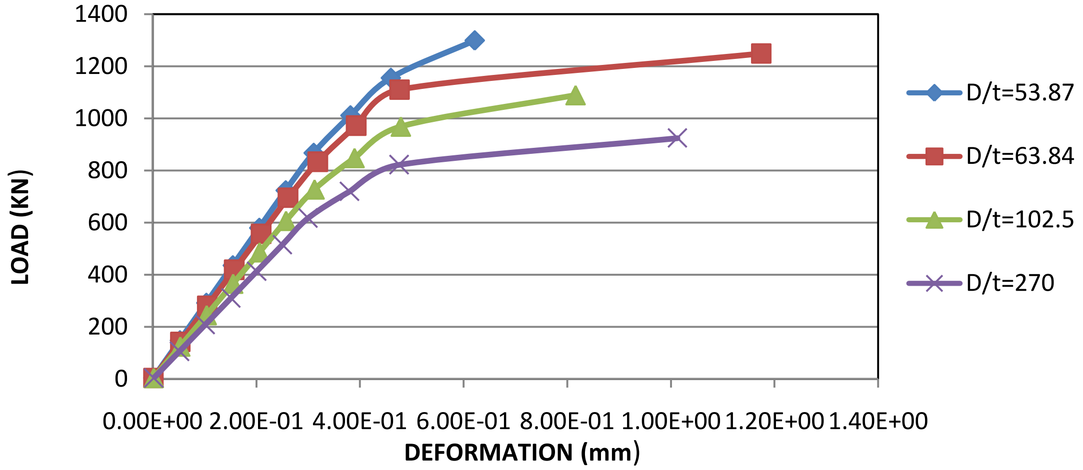

Fig.8 Load vs. deformation graph for M40, Fe 275

For the D/t=53.87, the load carrying capacity of CFT is high (1300 KN) and for D/t=270, load carrying capacity of CFT is low (925 KN).

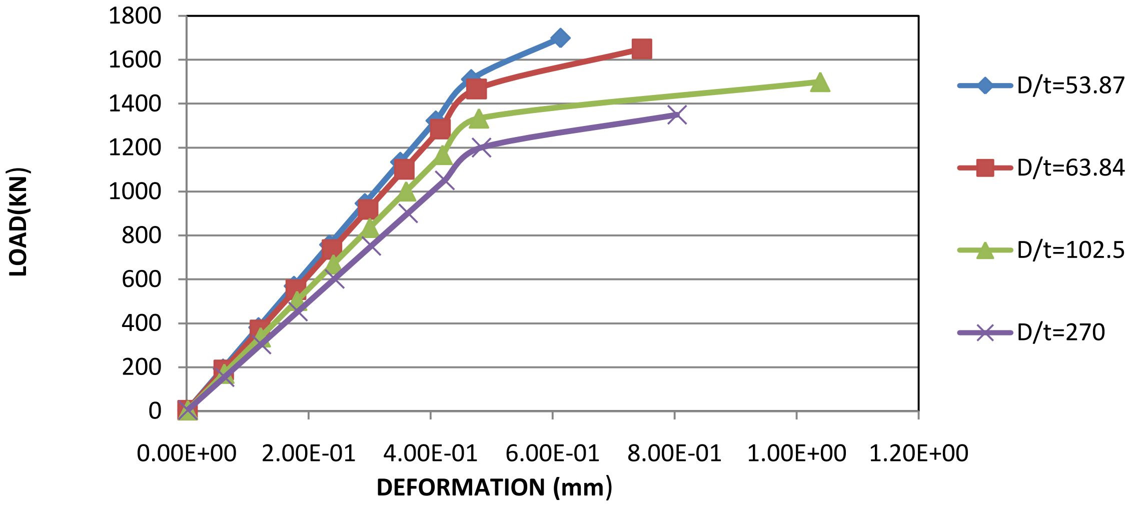

Fig.9 Load vs. deformation graph for CFT M60, Fe 275

For the D/t=53.87, the load carrying capacity of CFT is high (1700kN) and for D/t=270, load carrying capacity of CFT is low (1350 KN).

IV. CONCLUSION

1. As the D/t ratio increases, load carrying capacity of CFT decreases. Also observed the load carrying capacity can be increased by providing high grade of concrete as infill.
2. For higher D/t ratio, D/t beyond 63.8, more than 50% of decrease in load is observed for hollow steel compared to CFT (M30, Fe 275).
3. For D/t ratio 53.87, 42% of decrease in load is observed for hollow tube compared to CFT. Higher the D/t ratio, higher the percentage decreases in load.
4. More than 50% of decrease in load capacity for hollow steel is observed for lesser D/t ratio when compared with CFT (M60, Fe 275).

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