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INVESTIGATION OF CONCRETE FILLED STEEL TUBE SECTION BY ANALYTICAL METHOD

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Abstract—* Concrete filled steel tube (CFST) have been used in the practice of civil engineering under the pile, columns and fill the docks. As Compare to conventional steel and reinforced concrete components, there are several advantages of CFST. This article presents an analytical modelling for concrete filled steel (CFST) tube section under concentric axial compression. Curly, the main objective of this study to evaluate the effect on buckle load for various geometric of the CFST model condition Finite element model is validated by comparing its results with those included in the experimental study of the researcher. Three Dimensions Non-Linear finite element analysis of the axial compression process is performed using commercial software ABAQUS v6.14. The Results of various models are compared.

***Keywords*— concrete filled steel tube (CFST), Finite element method, ABAQUS v6.14, Linear perturbation, Non-linear Analysis, Buckled load.**

I. INTRODUCTION

Concrete filled steel tube columns (CFST) consists of a steel tube place at outer section and at inner section with concrete. Steel section in CFST is subjected to biaxial stress, such as longitudinal compression and hoop tension Simultaneously concrete is subjected to triaxial stress. In addition, the location of the steel and the concrete is such that section optimizes the stiffness and strength of the section. In concrete filled steel tube (CFST) columns, steel lies at the outermost perimeter where it performs most efficiently in tension and in resisting bending moment. Similarly, the stiffness of the concrete filled steel tube column is greatly enhanced because the steel is located farthest from the centroid, where it makes maximum contribution to the moment of inertia [12]. As CFST is composite section consist of steel and concrete section, it exhibits good seismic resistance property as well as some other properties like strength, stiffness and huge capacity of energy absorption The interaction of the steel tube with the concrete also prevents the local buckling of the steel tube, due to the restraining effect of concrete. The strength of concrete is enhanced due to confinement effect by the steel tube, because its location is around outer section of concrete. [5].

It provides not only an increase in the load carrying capacity but also economy and rapid construction, and thus additional cost saving [10]. The CFST columns do not require formwork and additional steel reinforcement, and the steel tube protects its surface from impact and abrasion. The local buckling of the steel wall, due to the relatively very small wall thickness as compared to concrete thickness, is delayed due to resistance to inward buckling of concrete. [14].

II. LITETRACTURE REVIEW

This literature review focuses on recent contributions related to concrete filled steel tubular columns, materials used for concrete filled steel tubular columns and past efforts most closely related to the needs of the present work.

Schneider investigated behaviour of short concrete steel tube columns concentrically loaded to compression in failure. In this paper 14 specimen of CFST were subjected to concentrically load in compression up to failure. Also investigated effect of steel tube shape and wall thickness on ultimate strength. In this paper it was found that circular tubes give substantial post-yield strength which is not available in square or rectangular [1]. Uy. *et al* carried out similar square concrete CFST subjected to axially loading condition. In this paper 6 specimen were studied the influence of slenderness, grade of concrete 36.3 Mpa and 75.4 Mpa. Their results were compared with various code such as Australian code, Euro code 4, Chinses code etc. This paper concluded that for larger ratio, smaller will be peak load [2]. Various research is also available for CFST improve design with and without internal reinforced under combined axial and bending. Also alternate P-M interactive curve for CFST was proposed by Jiho moom *et al* [3]. Also in recent year calibration against experimental data were introduced and compared, El-Heweity had done such work by ANSYS software [13]. For circular CFST under monotonic axial loading. Singh and Gupta had examined rectangular CFST short column loaded under axial compression. Here Non-linear FE analysis is performed with ABAQUS v6.9. In this paper 16 specimen for different steel tube size, wall thickness, and length with normal and high strength are chosen for modelling and confinement were examined [12]. Various literatures on Concrete filled steel tubes were studied and it was found that most feasible method for composite section analysis is Finite Element based Method. In the past study, done by various researchers, finite element modelling of CFST under axial loading condition has been workout with the intension of study of various parameter related to CFST.

Finally results from FEM compared with available experimental results and parametric study shows the behaviour of CFST under axial loading. From this study it was inferred that The FE based ABAQUS software is an analytical tool which can be used to model composite structures and is able to calculate the non-linear behaviour of the structural members.

III. NUMERICAL MODELING

the column detail, material properties and loading conditions as taken in the experimental study. The control concrete filled steel tubular column under axial loading was taken and analysed by finite element method (FEM) using the commercial available software ABAQUS 6.14.

IV.MATERIAL MODELLING

ABAQUS creates each section as an individual part and then different parts are assembled using instances option provided in ABAQUS.

List of symbol use in table, Fc- unconfined strength of concrete, F_y -Yield stress of steel, E_s - Young's Modulus of Steel

Table 1. Geometric and Material details of Square Specimen

Specimen label	Tested By	B (mm)	H (mm)	t (mm)	L/B	B/t	L (mm)	Fc (Mpa)	Fy (Mpa)	Es (Gpa)
SQ1	Neogi & Chapman	114.3	114.3	9.63	3.55	11.9	406	32.6	258	203
SQ2		114.9	114.9	4.39	3.53	26.2	406	32.6	258	203

Table 2. Geometric and Material details of Circular Specimen

Specimen label	Tested By	Dia(mm)	t(mm)	D/t	L/D	L(mm)	F_c(MPa)	F_y(MPa)	E_s(GPa)
1-C1	Cheng	165.0	4.50	36.7	4.00	660	33.2	254.4	200
2-C2		114.0	4.50	25.3	4.00	456	33.2	271.0	200

A. STEEL TUBE

For modelling steel section in ABAQUS v6.14 elastic-perfectly plastic model is used. In modelling of this section all the required data is filled from table 1 and table 2 respectively. Also value of ratio of lateral change to longitudinal change i.e. poison ratio is taken as 0.3 as per suggestion from literature.

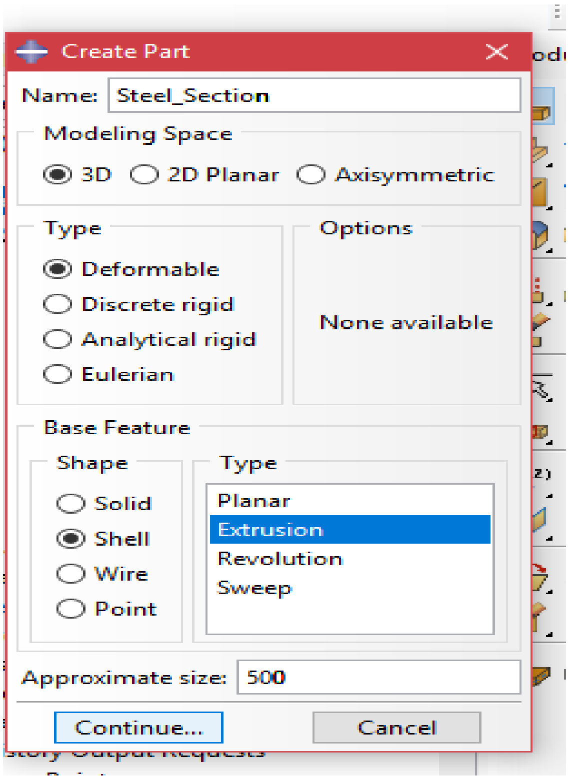

Figure 1. Creating steel section

B. CONCRETE CORE

While defining the concrete section one thing we need to consider that, whatever values of concrete are to be assign is only applicable to unconfined concrete. So incorporate confinement of concrete we need to used Prager plasticity model option available in ABAQUS v6.14. In modelling of this section all the required data is filled from table 1 and table 2 respectively. Also value of ratio of lateral change to longitudinal change i.e. poison ratio is taken as 0.2 as per suggestion from literature.

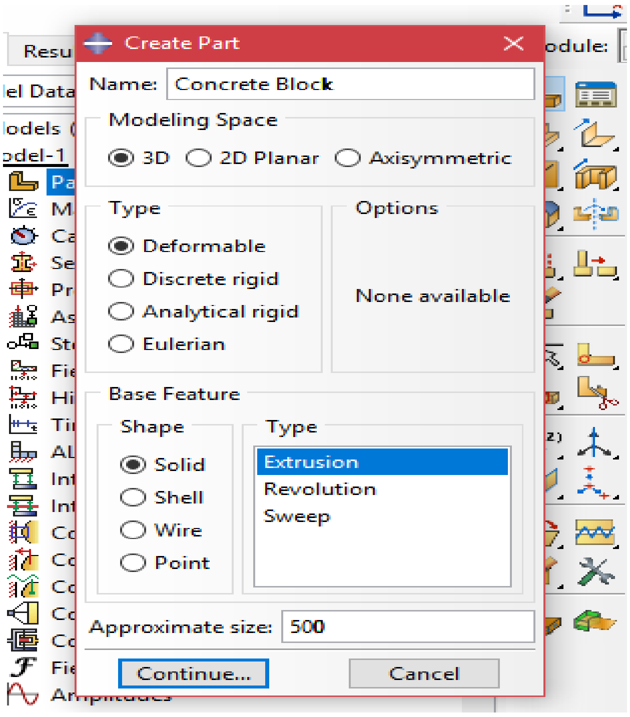

Figure 2. Creating Concrete Section

C. INTERFERENCE

The confinement of concrete is done by outer place steel section is key factor to incorporate various benefits of CFST section. So in modelling, assigning the steel section and concrete section is done such that both the section should behave as single unit. To achieve this goal, contact between steel and concrete section is provided as friction. Master surface is assign to inner section of steel and slave section is assign to outer section of concrete. The values of coefficient of tangential friction is chosen as 0.25, as suggested in literature. Also default hard contact is provided between steel section and concrete section.

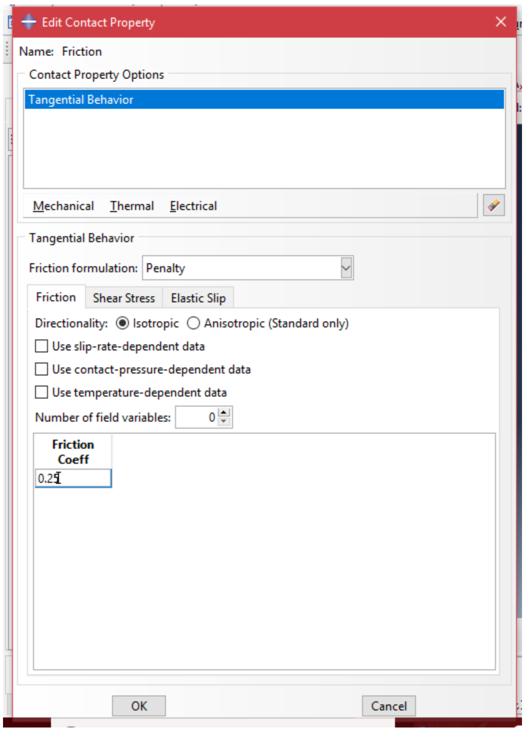

Figure 3. Defining contact property between steel and concrete section

D. MESHING

In ABAQUS v6.14 meshing can be done on individual part or on assembled part. The key of finite element analysis is to assign proper selection of element type. ABAQUS commonly provides 4-node linear tetrahedron (C3D4) elements, 6-node linear triangular prism (C3D8) elements and 8-node linear brick (C3D8) elements. In this analysis C3D8 element is chosen, because it shows good results in previous composite section, involving large contact, plasticity and deformation.
The Solid Section and Hollow steel section geometry generated in ABAQUS are illustrated in figure 4 and 5 respectively.

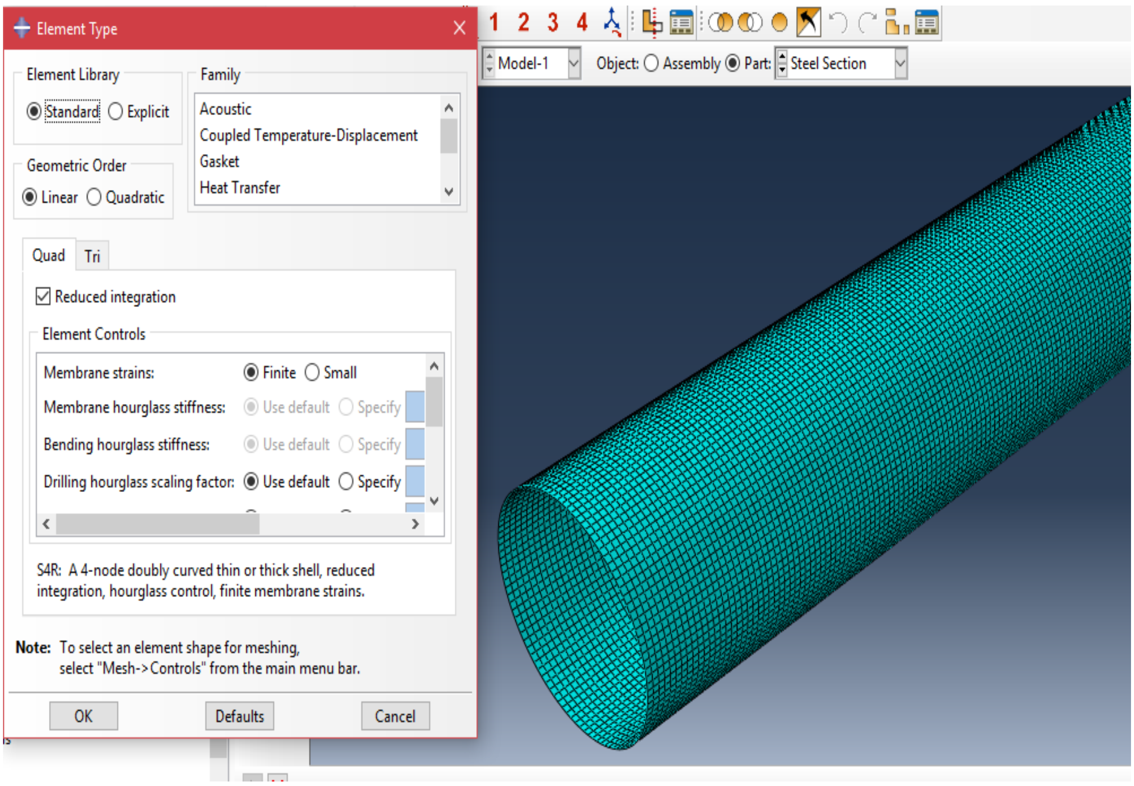

Figure 4. Steel Section Meshing property

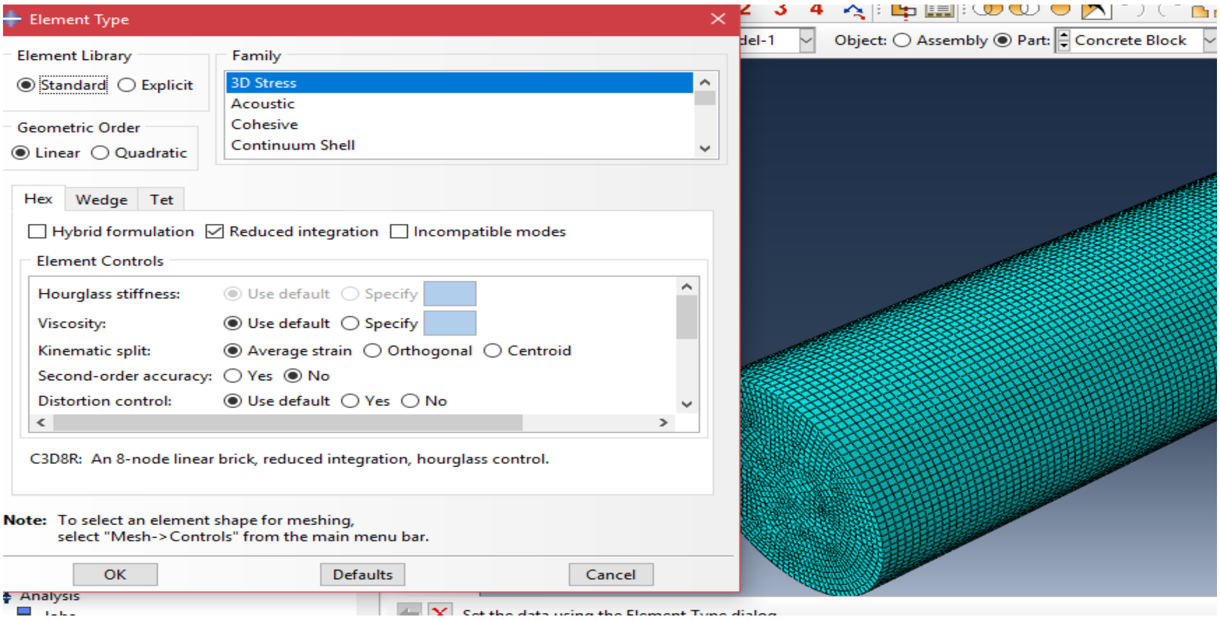

Figure 5. Solid Concrete Section Meshing Property

E. ANALYSIS TYPE

ABAQUS v6.14 provides various analysis procedures to analyse the behaviour of different models catering different condition required. In this analysis, step is created and linear perturbation type analysis is chosen. in linear perturbation buckle type is chosen for this case, also various analysis type can be chosen to cater different models. In this analysis, it gives Eigen value corresponding to obtain buckle load o CFST section. The interface of FEM Software for assigning liner perturbation buckle analysis is shown in figure 6.

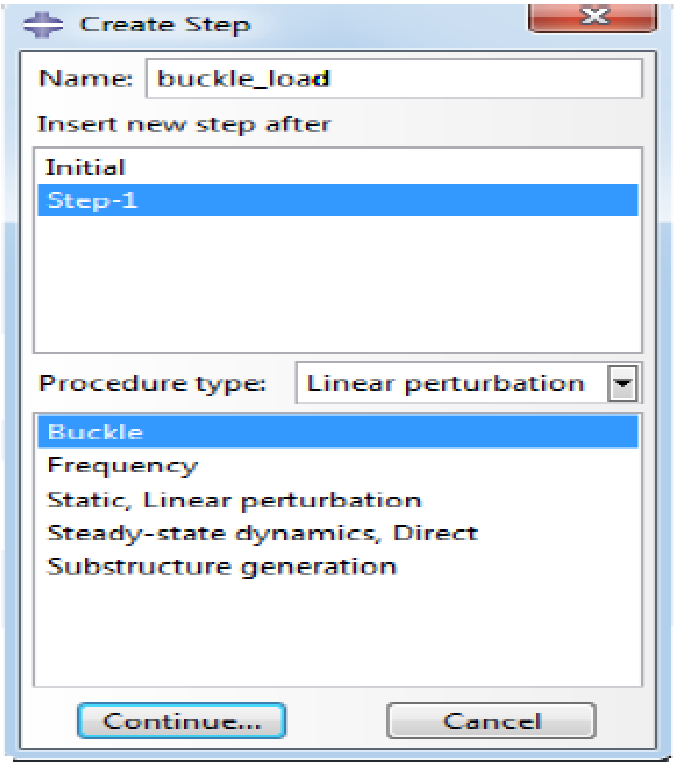

Figure 6. Creating Job for Buckle load

F. LOAD AND BOUNDARY CONDITIONS

In this analysis, two boundary condition are used, one end is symmetry/Antisymmetry/Encastre and other end is Displacement/Rotation condition is used. Loading and boundary condition must be assign properly to get more realistic results. The bottom section is Encastre, i.e. displacement degree of freedom as well as rotational degrees of freedom in all direction were restrained to zero. The top nodes are subjected to displacement condition i.e. in rotational degrees of freedom and translation U3 is free remaining U1, U2 are restrained. Boundary condition of rectangular and circular section are illustrated in figure 7 and figure 8 respectively.

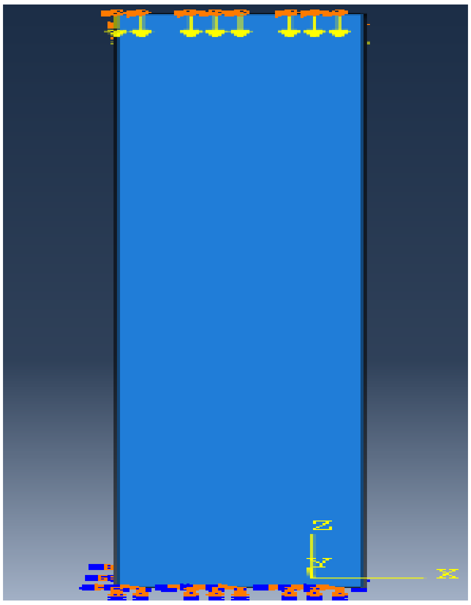

Figure 7. Boundary Condition for Square section

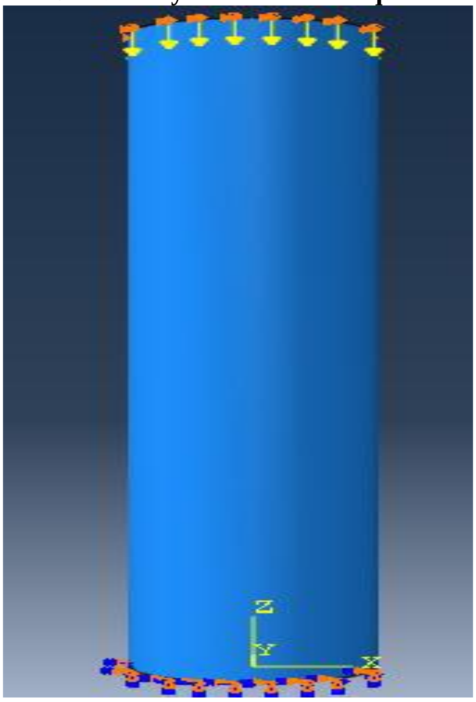

Figure 8. Boundary Condition for circular section

V. RESULTS

The results obtained are tabulated in table 3 and 4 for Square CFST columns and circular CFST columns respectively. Figures 9 to 10 provide the final buckled shape of the concrete filled tabular columns simulated in ABAQUS v6.14.

Table 3. Comparison of Capacities Square Specimen

Specimen Label	Tested By	Test Load (KN)	ABAQUS	
			Load Pu (KN)	% error
DF3	Neogi and Chapman	2442	2492	2.0
DF4		897	903	0.6

Table 4. Comparison of Capacities Circular Specimen

Specimen Label	Tested By	Test Load (KN)	ABAQUS	
			Load Pu (KN)	% error
1-3Y6	Cheng	1647	1607	-2.4
1-3Y4		856	1089	5.0

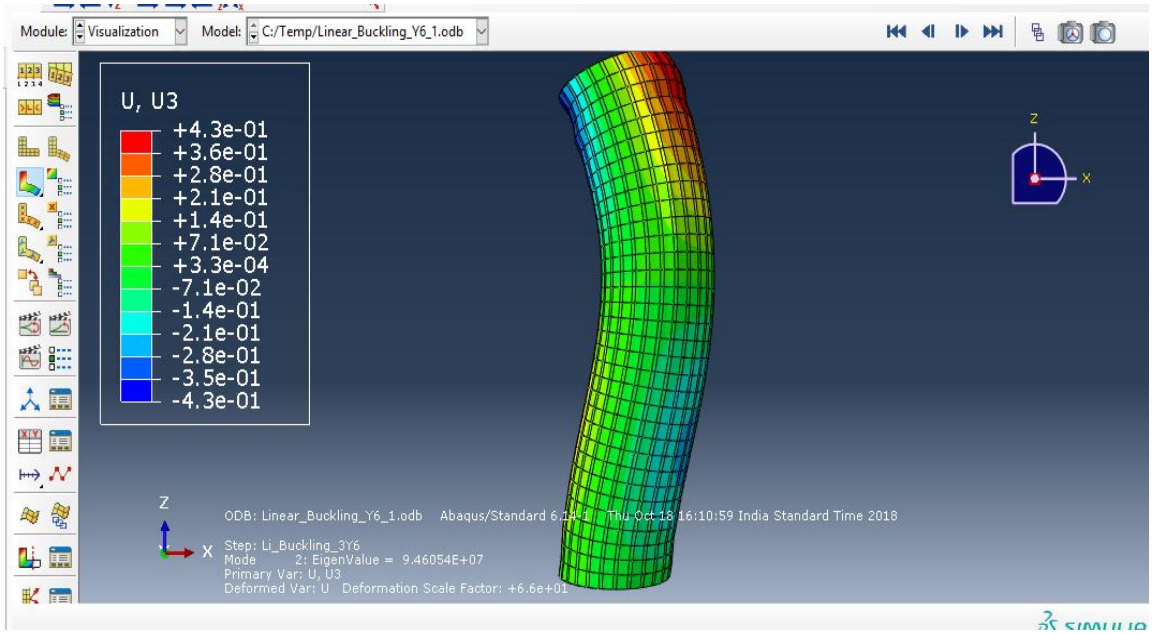

Figure 9. Deflected Shape of Circular Section

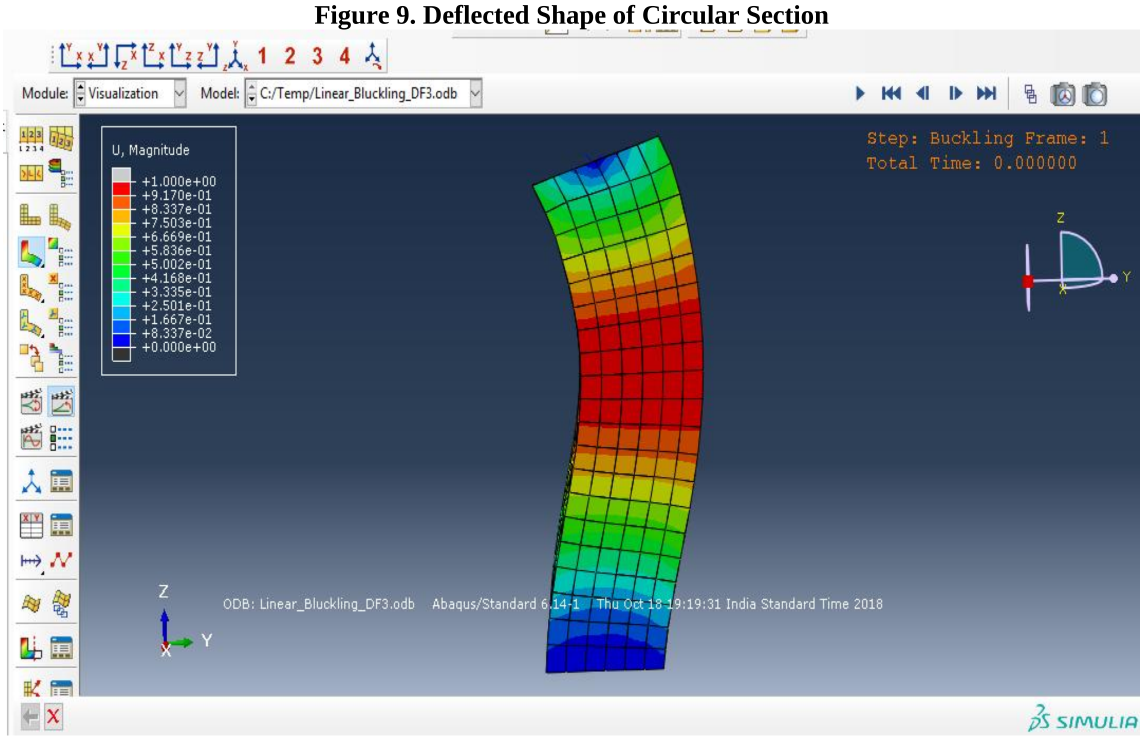

Figure 10. Deflected Shape of Square Section

VI. CONCLUSION

The non-linear linear perturbation of CFST under axial loading is carried out for various geometric condition as mention earlier and following points are concluded.

1. As length of section increases, load carrying capacity decreases.
2. As mention geometric properties of various section, it was found that thickness of steel tubes does not affect model behaviour drastically.
3. The variation between experimental and numerically simulated results was varying within the range of 0.6% to 5%.
4. Slenderness ratio plays vital role in the strength calculation of column and its behaviour.

REFERENCES

[1] Schneider, S. P. (1998). "Axially loaded concrete-filled steel tubes." Journal of Structural Engineering, 124(10), 1125–1138.

[2] Uy, B.; Tao, Z.; Lizo, F, Y.; Han, L, H. (2009), "Behaviour of slender square concrete filled stainless steel columns to axial loads", Nordic steel construction conference, 359-366.

[3] Jiho Moon, Dawn E. Lehman, Charles W. Roeder,and Hak-Eun Lee(2013)" Strength of Circular Concrete-Filled Tubes with and without Internal Reinforcement under Combined Loading", Journal of Structural Engineering.

[4] Ghannam, S.; Al-Ani, H, R.; Al-Rawi, O. (2010), "Comparative study of load carrying of steel tube columns filled with light weight concrete and normal concrete", Jordan journal of civil engineering, volume 4, 164-169.

[5] Patil, V, P. (2012), "Finite element approach to study the elastic instability of concrete filled steel tubular columns under axial loads", International Journal of Emerging Technology and Advanced Engineering, volume 2, 276-284.

[6] Kwasniewski, L.; Szmigiera, E.; Siennicki, M. (2012), "Finite element modelling of composite concrete steel sections", Archives of Civil Engineering, 4, 373-388.

[7] Tao, Z.; Wang, Z, B.; Yu, Q. (2013), "Finite element modelling of concrete filled steel stub columns under axial compression", Journal of Constructional Steel Research, 89, 121-131.

[8] Bukovska, P. (2012), "Influence of concrete strength on the behaviour of steel tubular columns filled with concrete", International Journal of Mechanics, volume 6, 149-157.

[9] Dundu, M. (2012), "compressive strength of circular concrete filled steel tube columns", Journal of Thin Walled Structures, 56, 62-70.

[10] Evirgen, B.; Tuncan, A.; Taskin, K. (2014), "Structural behaviour of concrete filled steel tubular sections under axial compression", Thin Walled Structures, 80, 46-56.

[11] Kvocak, V.; Varga, G.; Vargova, R. (2012), "Composite steel concrete filled steel tubes", Procedia Engineering, 40, 62-70.

[12] Singh, H.; Gupta, P, K. (2013), "Numerical modelling of rectangular concrete filled steel tubular short columns", International Journal of Scientific and Engineering Research, volume3, 52-55.

[13] El-Heweity, M, M. (2012), "On the performance of circular concrete filled high strength steel columns under axial loading", Alexandria Engineering Journal, 51, 109-119.

[14] Lin-Hai Han, Wei Li, Reidar Bjorhovde, (2014), "Developments and advanced applications of concrete-filled steel tubular (CFST) structures: Members", Journal of Constructional Steel Research, 100 (2014) 211–228

