ANALYTICAL STUDY ON CONCRETE FILLED ELLIPTICAL STEEL TUBULAR COLUMN

APARNA V C[1], SARAVANA KUMAR N[2], BALAJI C D R[3]

[1]PG student, Dept of Civil Engineering, Mepco Schlenk Engineering College, Sivakasi, Tamil Nadu, India
[2]Assistant professor, Dept of Civil Engineering, Mepco Schlenk Engineering College, Sivakasi, Tamil Nadu, India
[3] Managing Head, Inner Engineering Management and Consultancy, Sivakasi, Tamil Nadu, India

---***---

Abstract - *Concrete filled steel tubular columns have gained immense importance in recent decades due to numerous benefits especially in developed countries like china, Japan, U.S.A, Britain. Experimental programs are expensive, time consuming and limited to small ranges of parameters, therefore it is important to develop an analytical model for Concrete filled elliptical steel tubular members. This research provides an analysis of the interaction between concrete core and steel tube in CFEST columns. For this analysis, ABAQUS software was selected. Using this software Analysis was done by varying the thickness of steel tube, length of the column, grade of concrete and diameter ratios (a/b) and then observe the performance of the CFEST column. Currently there is no design guidance available in any Code of Practice for this elliptical cross section. The main aim of the research presented in this paper is to develop a numerical method to be able to predict the axial compressive behaviour of short concrete-filled elliptical steel tubular columns. The ultimate load carrying capacity and failure modes were obtained from the numerical models and then compared against the experimental results; good agreements were obtained .Finally local buckling of steel tube associated with the concrete infill could be observed.*

***Key Words*: abaqus, elliptical cfst column, finite element method, diameter –to –thickness ratio, buckling**

1. INTRODUCTION

Concrete filled steel tubes [CFST] are composite members consists of steel tubes filled with concrete. The inner concrete core adds stiffness and compressive strength and it reduces local buckling. The outer steel tube acts as both longitudinal and lateral reinforcement and also it resists tension and bending moment. This type of composite column does not need any formwork. Therefore it reduces cost of construction, labour cost and construction time. Concrete filled steel tubular column research began in 1990s. Most of the researchers work with square, rectangular, circular cross section. Now, one of the new cross section elliptical [fig4] attracted most of the architects and structural engineers due to their aesthetic appearance and excellent structural behaviour. Only few papers are available on the research of concrete filled elliptical steel tubular column can be found.

Researches on Experimental study of elliptical concrete filled steel columns under axial compression by Jamaluddin [1] showed that the strength and stiffness of CFEST increase as the concrete strength increases. Tests on CFEST beams and columns [3] by Quing Xin Ren showed that the compressive strength of CFEST Columns under axial compression is 2.47 times that of the hollow steel tubular columns. Using Abaqus/Standard software develop a model and then analyze the parameters like a)thickness of steel tube b)grade of concrete c)diameter ratios (a/b) d)length of the column.

2. FINITE ELEMENT ANALYSIS

Finite element analysis is a numerical method. In this paper, finite element software Abaqus/ standard was used to capture the structural behaviour of elliptical CFST column. ABAQUS is a highly sophisticated, Finite Element program designed primarily to model the behaviour of solids and structures under externally applied load. ABAQUS is used by a wide range of industries, including aircraft manufacturers, automobile companies, oil companies and micro electronics industries as well as national laboratories and research universities.

2.1 MODELING AND MATERIAL PROPERTIES

Abaqus provides a wide range of elements for different geometries and analysis types. In this paper, Concrete was modeled as a C3D8R [Continuum 3D 8noded reduced integration element] and Steel tube was modeled as a S4R [shell 4 node reduced integration element].

The Poisson's ratio for concrete and steel was 0.2 and 0.3. In this analysis, parts were meshed individually and then assembled for further process. More finer mesh generally leads to more accurate analysis, but also requires larger computational resources and time. Fig 1 shows meshed model.

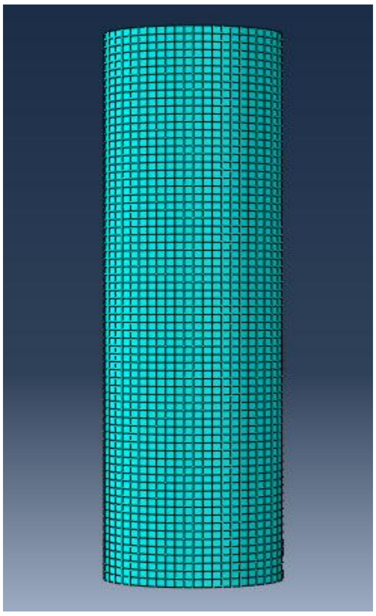

Fig – 1: Meshed model

2.2 ANALYSIS TYPE:

ABAQUS 6.13-4 has various types of analysis procedure to analyze the behaviour of models according to their needs. In this analysis for Concrete filled elliptical steel tubular columns, linear perturbation type of procedure was chosen. In our analysis linear perturbation buckle analysis was used to obtain the buckling load of the CFEST column. Linear perturbation buckle analysis provides Eigen values corresponding to buckle loads. The interface of FEM Software for assigning liner perturbation buckle analysis is shown in figure 2.

2.3 BOUNDARY CONDITIONS AND LOADING

To stimulate the interaction between steel tube and Concrete, surface to surface interaction was used. The inner surface of the steel tube serves as a rigid surface and the outer surface of the concrete core acts as a slave surface. The coefficient of friction between the steel tube and concrete as 0.25. In this analysis, the bottom of the column was fixed where all the degrees of freedom were restrained and the other end was pinned condition was shown in fig 3. The uniform compressive loading is applied to the top surface of the column in the z direction directly.

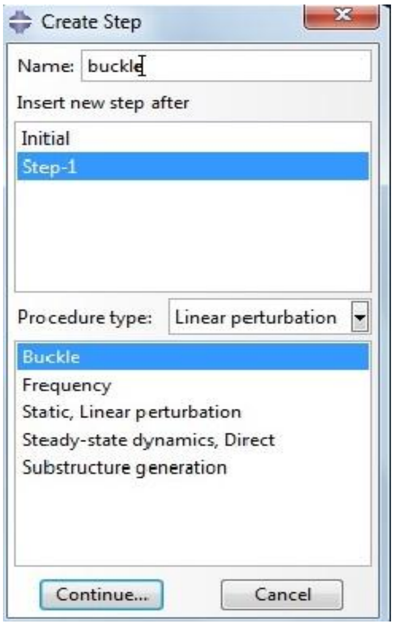

Fig -2: Step module

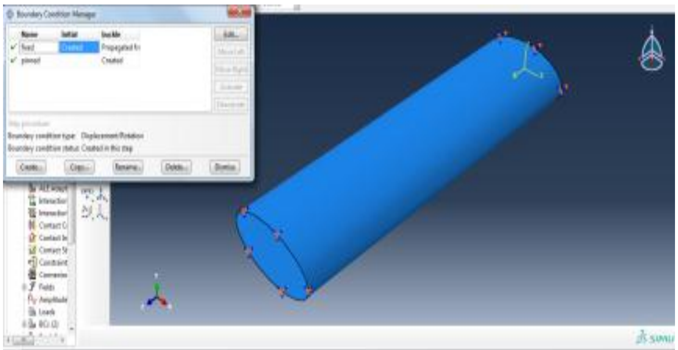

Fig – 3: Load module

3. SPECIMEN DETAILS

In this paper, FE model was developed according to experimental specimen [1]. In this analysis, totally four specimens with two grades of concrete (30, 60) were used and the steel tube sizes 200*100*5 and 150*75*4 which were commercially available sizes. The strength of the concrete-filled elliptical steel tubular columns investigated in this parametric study and the failure modes were predicted using the developed finite element model.

Table -1: Specimen details

No	specimen label	major axis 2a (mm)	Minor axis 2b (mm)	Thickness (mm)	Height (mm)	d/t
1	c-1-30	200	100	5.3	1400	37.03
2	c-2-60	200	100	5.6	1500	35.71
3	c-3-30	150	75	4.0	1600	37.5
4	c-4-60	150	75	4.1	1500	36.58

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 03 | Mar -2017 www.irjet.net p-ISSN: 2395-0072

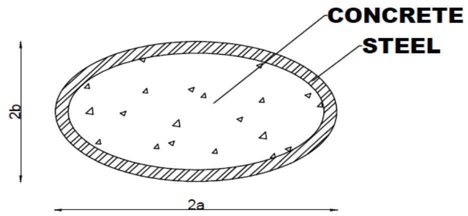

Fig - 4: Cross section of the specimen

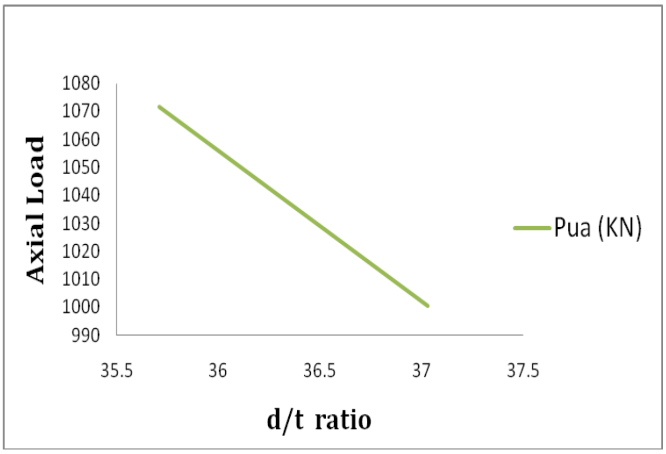

Chart -1: Load vs d/t ratio

4. VALIDATION WITH THE EXPERIMENTAL STUDY

The proposed model was used to numerically simulate different elliptical CFT columns. The accuracy of the numerical model is evaluated based on the difference between the experimental and ABAQUS peak load capacities. The model must also be able to successfully capture the deformed shape of the composite member. The final deformed shape of the concrete filled elliptical steel tubular column in fig 5 simulated in Abaqus 6.13-4.

Table -2 Comparison between Experimental and Analytical Results

No	Specimen label	Pu (KN)	Pu_a (KN)
1	c-1-30	938.4	1000.4
2	c-2-60	1064	1071.8
3	c-3-30	650.8	654.6
4	c-4-60	742.8	762

Table – 2 shows a comparison between the maximum axial compressive loads P_u obtained from the experiments and the maximum axial compressive loads $P_{u(a)}$ predicted by the finite element method: very good agreements have been obtained. The maximum difference observed between the experimental and analytical result is 5%.

From the above results, it can be found that from the first two specimens (200 ×100 ×5) second one carries more axial load compared to the first specimen. It shows that if diameter to thickness ratio decreases load carrying capacity increases was shown in chart -1 .Therefore d/t ratio is one of the important parameter which influences the load carrying capacity. C-4-60 carries higher axial load compared to C-3-30 which indicates that high strength concrete carries more axial load. Analytical results are more accurate compared to theoretical results. This may be due to the consideration of specimen as a perfect model with zero imperfection was assumed.

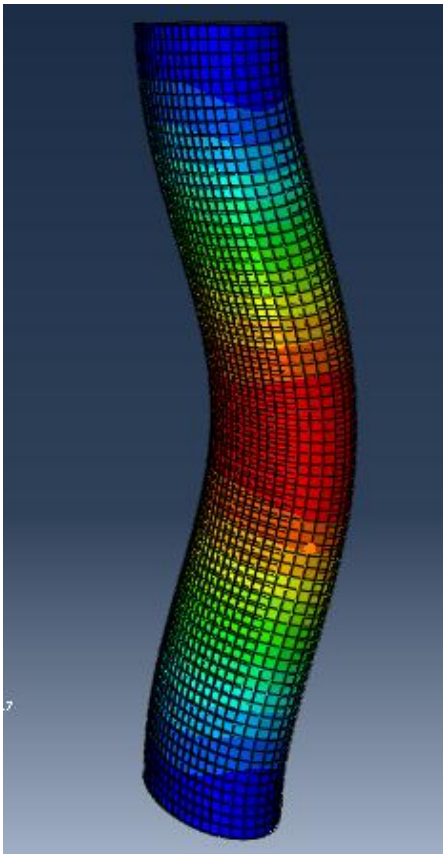

Fig – 5: Deformed shape

5. CONCLUSIONS

Various significant characteristics such as strength, stiffness and failure mode were discussed. Based on the above results, the following conclusions can be made

1) Increase in concrete strength increases the stiffness of the concrete core which reduces the lateral expansion.
2) With the increase in the length of CFEST column, load carrying capacity decreases.
3) Axial rigidity of elliptical CFEST increases with the decrease of the diameter to thickness ratio. The strength and stiffness depends upon the thickness of steel tube.
4) The effect of cross section has a significant role . In elliptical cross section because of the presence of major and minor axis direction it carries higher axial load compared to square and rectangular cross section.
5) The role of the concrete core is not only to resist compressive forces but also to reduce the potential failure of local buckling by the steel sections. Concrete core will prevent inward buckling and therefore buckling of steel tubes will generally occur towards outward.

REFERENCES

[1] N.Jamaluddin, D.Lam, X.H.Dai, J.Ye, “An Experimental study on elliptical concrete filled columns under axial compression,” Journal of Constructional Steel Research 87 (2013) 6–16.

[2] Kojiro Uenaka, “Experimental study on concrete filled elliptical/oval steel tubular stub columns under compression,” Thin walled structures 78 (2014) 131-137.

[3] Quing-Xin Ren , Lin-Hai ,Wei Li ,“Tests on elliptical concrete filled steel tubular beams and columns,” Journal of Constructional Steel Research 99 (2014) 149–160.

[4] Yang H, Lam D, Gardner L., “Testing and analysis of concrete-filled elliptical hollow sections,” Engineering Structures 2008;30:3771_81.

[5] Lam D, Testo N, “Structural design of concrete filled steel elliptical hollow sections,”Composite Construction VI. Colorado USA; 2008.

[6] Lam D, Williams CA, “Experimental study on concrete filled square hollow sections,” Steel Compos Struct 2004;4(2):95–112.

[7] Zhao XL, Packer JA ,“Tests and design of concrete-filled elliptical hollow section stub columns,” Thin-Walled Struct 2009; 47(6–7):617–28.

[8] Testo N, “Axial capacity of elliptical concrete-filled steel tube columns,” Research Report School of Civil Engineering, University of Leeds; 2007.

[9] L-H. Han, “Tests on stub columns of concrete-filled RHS sections,” Journal of Constructional Steel Resarch vol. 58, no. 3, pp. 353-72, March 2002.

[10] S.P. Schneider, “Axially loaded concrete-filled steel tubes,” Journal of Structural Engineering, ASCE, vol.124, no. 10, pp 1125-38, Oct. 1998.

[11] Boyd, P. F., Cofer, W. F., and McLean, D. I., (1995), "Seismic Performance of Steel Encased Concrete Columns under Flexural Loading," Structural Journal, ACI, 92, (3), pp. 3 5 5-364 .

[12] Gardner, J., and Jacobson, R., (1967),"Structural Behavior of Concrete Filled Steel Tubes," ACI Journal, 64, pp. 404-413.

[13] Hu, H.T., Huang, C.S., Wu, M.H., & Wu, Y.M. (2003), “Nonlinear analisys of axially loaded concrete-filled tube columns with confinement effect,” Journal of Structural Engineering, 1322-1329.

[14] Artiomas and Audronis (2006), “Behaviour of hollow concrete-filled steel tubular composite elements,” Journal of Civil Engineering and Management http:/www.jcem.vgtu.lt 2007, vol. xiii, no 2, 131–141.

[15] Zhi Wua (2007), “Experimental behaviour of circular concrete filled steel tube stub columns,” Journal of Constructional Steel Research 63, pp. 165-174.

[16] C. Douglas Goode, Artiomas Kuranovas, Audronis Kazimieras Kvedaras, (2009), “Buckling of slender composite concrete-filled steel columns”.

[17] Dr. B.R. Niranjan and Dr.Erremma,“Experimental Investigation on Reinforced Concrete Filled Steel Rectangular Fluted Columns,” International Journal of Scientific & Engineering Research, Volume 3, Issue 11, November-2012.

[18] Giakoumelis G, Lam D, “Axial capacity of circular concrete-filled tube column,”Journal of Constructional Steel Research 2004;60:1049–68.

[19] Espinos A, Gardner L, Romero ML, Hospitaler A, “Fire behaviour of concrete filled elliptical steel column,”Thin-Walled Struct 2011;49(2):239–55.

[20] Sheehan A, Dai XH, Chan TM, Lam D, “Structural response of concrete-filled elliptical steel hollow sections under eccentric compression,” Eng Struct 2012;45:314–23.