"Analysis of Buckling Behavior of Concrete Filled Steel Tube Column using ANSYS"

Mr. Dhananjaykumar. J[1], Dr. B.S. Jayashankar babu[2]

[1]*PG Student of PES college of Engineering, Mandya, Karnataka, India*
[2]*Professor, Dept, of civil Engineering, PES College of Engineering, Mandya, Karnataka, India*

Abstract – *Now a days concrete filled steel tube have been widely used in construction industry in all around the world. Because of their excellent earthquake resistance properties like high strength and ductility, larger energy absorption capacity and as well as better fire resistance properties. In this paper the study was focused on buckling behavior of concrete filled steel tube column under axial load using ANSYS work bench (2019) finite element software by varying slenderness ratio (31.58-125). Analysis was run for hallow tubes, CFST and concrete column. Comparison of result obtained from ANSYS with Euler's buckling formula.*

Key Words: BUCKLING LOAD, CFST, HALLOW STEEL TUBE, CONCRETE COLUMN, ANSYS (2019).

1. INTRODUCTION

CFST is a column in which concrete is surrounded by a steel tube. CFST column gives better performance in ductility, stiffness, strength, toughness and buckling of the column compared to RC column. CFST is gaining importance now a days because of amazing look in favor of building, bridges, as well as column supporting platforms like offshore structures, storage tanks, piles, columns in seismic zones and other civil engineering structures. It possesses economic advantage in construction because steel tube conserve as the form work for a cast of concrete cores.

1.1 BUCKLING OF COLUMNS

Buckling of the column is a mode of failure under axial compressive force this is due to instability of column. Short column fails by compression yielding where long column or slender column fails by buckling. These modes of failure depend upon the EI (flexural rigidity) and stiffness factor.

Buckling load obtained from the ANSYS is compared with Euler's formula for composite columns.

$$N_{cr} = \frac{\pi^2 (EI)_{eff}}{L_{eff}^2}$$

Where, $(EI)_{eff} = E_s I_s + 0.8 E_c I_c$
N_{cr} = Critical load on column
$(EI)_{eff}$ = Effective flexural rigidity
E_s = Modulus of elasticity of steel
I_s = Moment of inertia of steel tube
E_c = Modulus of elasticity of concrete
I_c = Moment of inertia of concrete
L_{eff} = Effective length of column

2. OBJECTIVE

The objectives of the present study are as follows below.

- Creating the 3-dimensional model of hallow steel tube column, concrete filled steel tube column and concrete column by varying its slenderness ratio (SR or λ).
- To perform buckling capacity of hallow steel tube column, concrete column and concrete filled steel tube column using ANSYS and compare with Euler's formula.

2.1 SCOPE OF STUDY

In the present study an attempt is made to understand the concept of buckling behavior of concrete filled steel tubes using finite element software ANSYS.

3. METHOD OF ANALYSIS

3.1 Eigen value buckling

Eigen value buckling analysis predicts the theoretical buckling strength of a structure. For instance, an Eigen value buckling analysis will match the classical Euler's solution. Thus, linear buckling analysis yield quick results this method recommended for accurate, real world problems. It computes the structural Eigen values for the given loading and constraints conditions. It is used for design of actual structure.

4. MODELLING OF COLUMN

Preliminary data consider for the analysis are as given below

Table 1: Materials and geometric properties of column

Properties	Steel	Concrete(M_{25})
Young's Modulus	200 Gpa	25000 Mpa
Poisson's Ratio	0.3	0.16
Density	7800Kg/m3	2400Kg/m3

4.1 Boundary condition used.

Bottom end of the column is fixed. i.e., displacement degree of freedom in 1, 2, 3, directions (U1, U2, U3) as well as rotational degree of freedom in 1, 2, 3 directions were restrained to be zero. At top end is roller support movable end rotational degrees of freedoms are free and translation U2 is free remaining U1 and U3 are restrained.

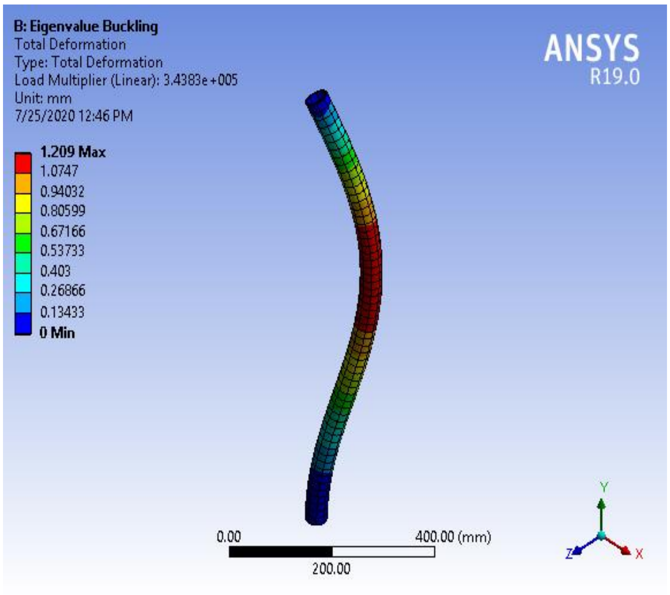

Fig 1: 3D hallow steel tube model for SR 45

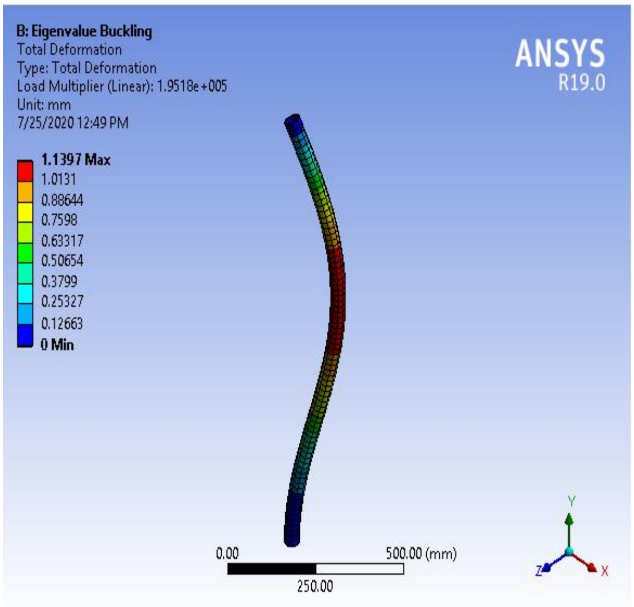

Fig 2: 3D hallow steel tube model for SR 60

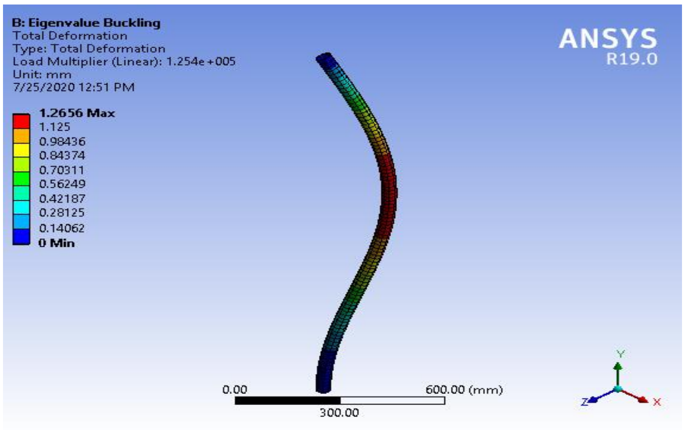

Fig 3: 3D hallow steel tube model for SR 75

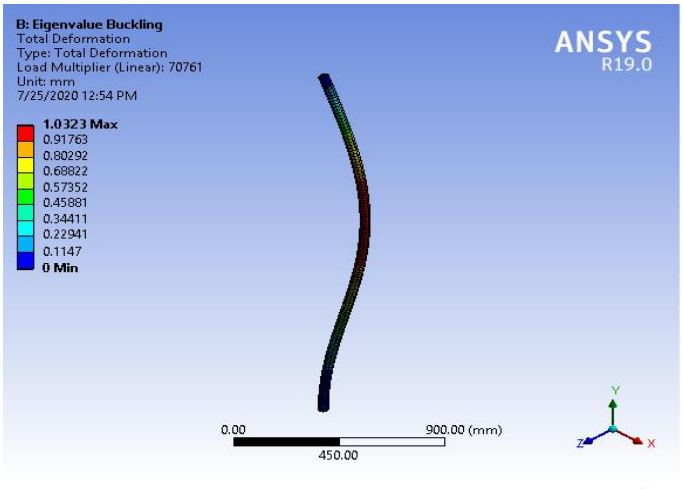

Fig 4: 3D hallow steel tube model for SR 100

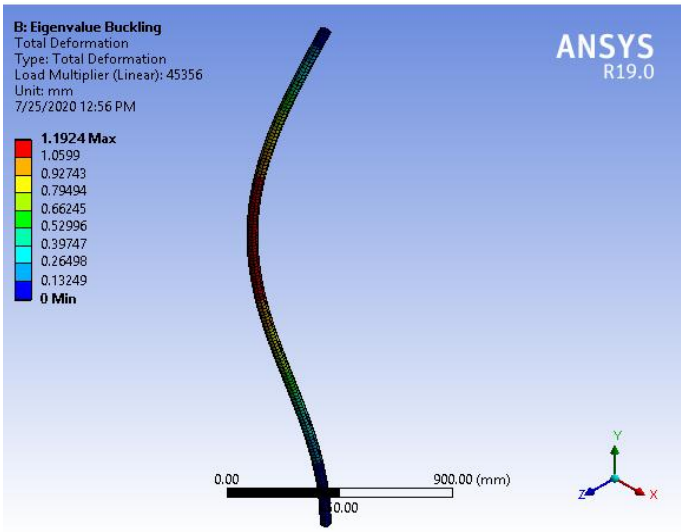

Fig 5: 3D hallow steel tube model for SR 125.

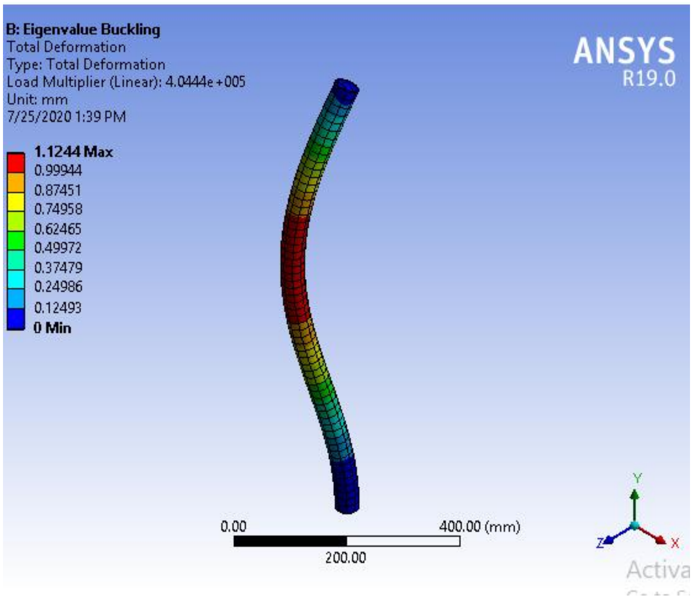

Fig 6: 3D CFST model for SR 59.43

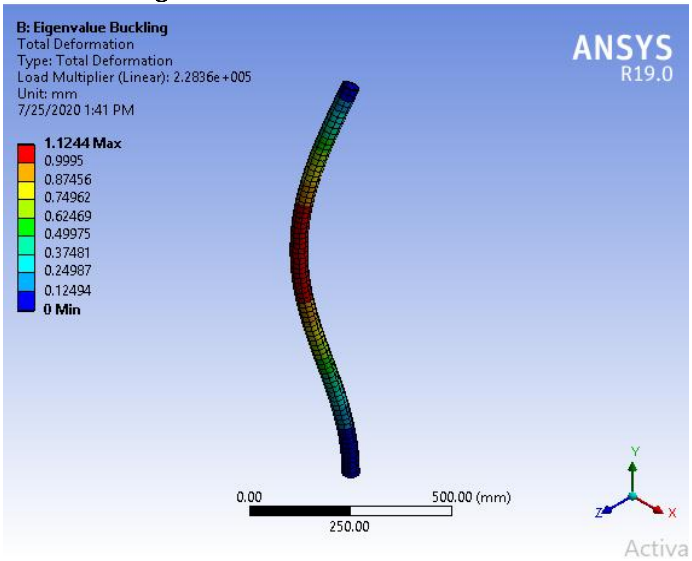

Fig 7: 3D CFST model for SR 79.24

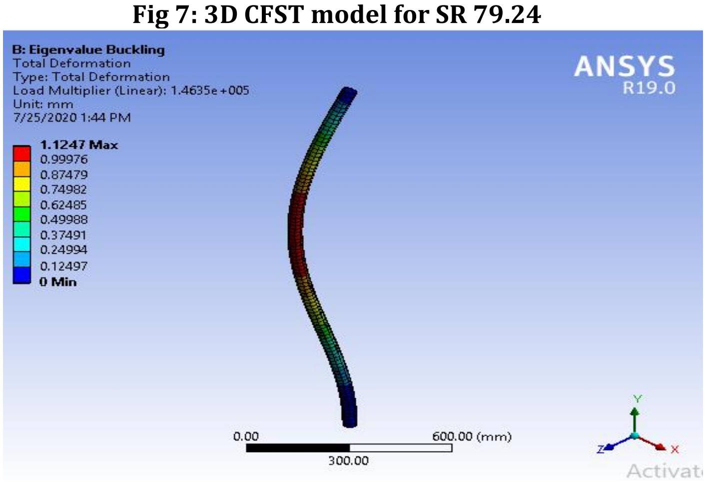

Fig 8: 3D CFST model for SR 99.05

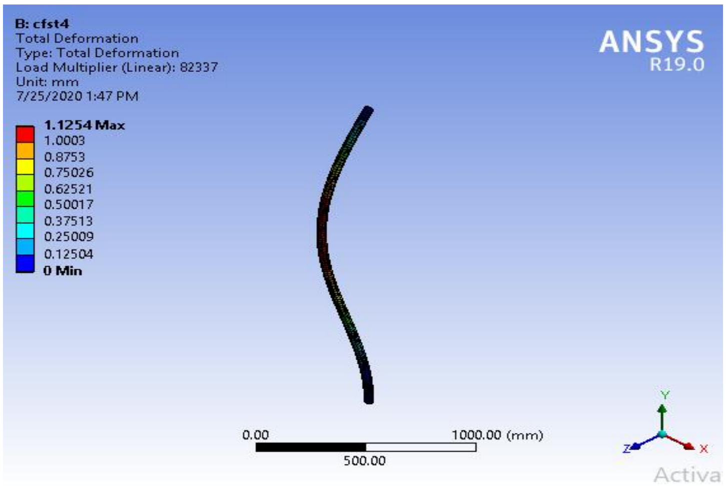

Fig 9: 3D CFST model for SR 132.07

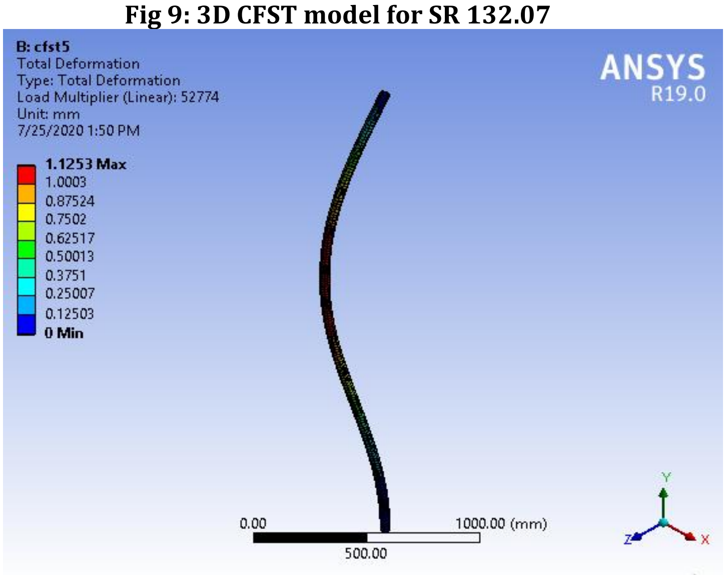

Fig 10: 3D CFST model for SR 165.07

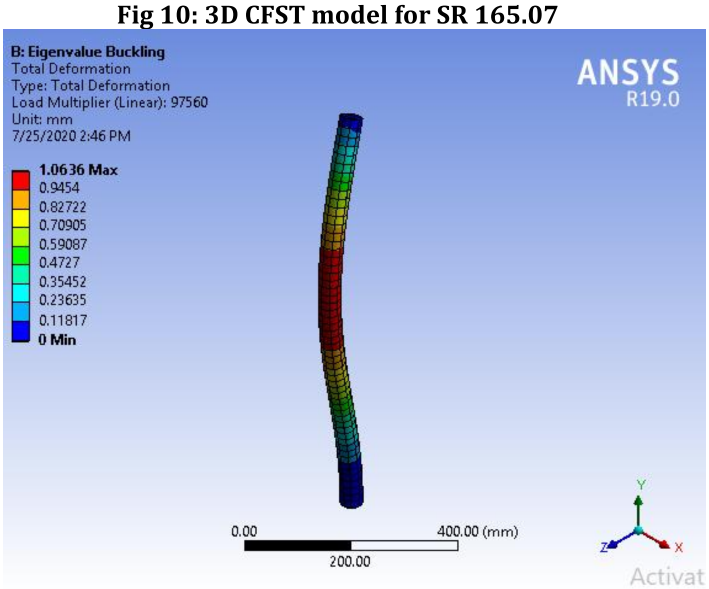

Fig 11: 3D concrete column model for SR 59.43

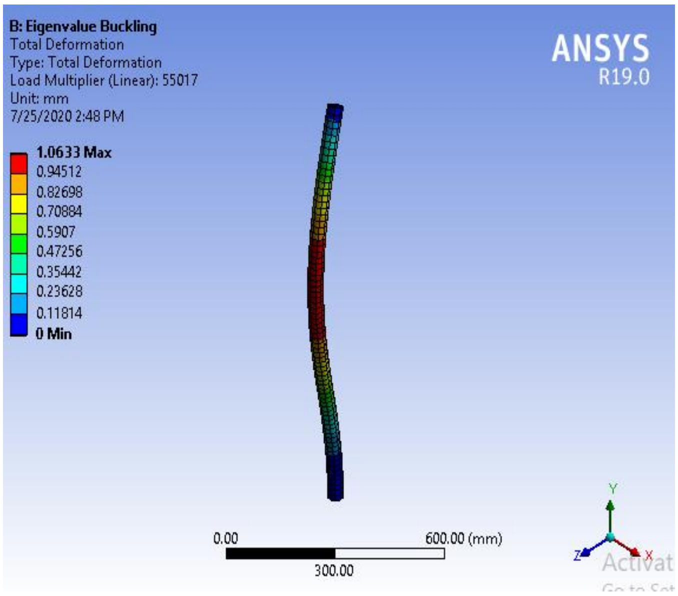

Fig 12: 3D concrete column model for SR 79.24

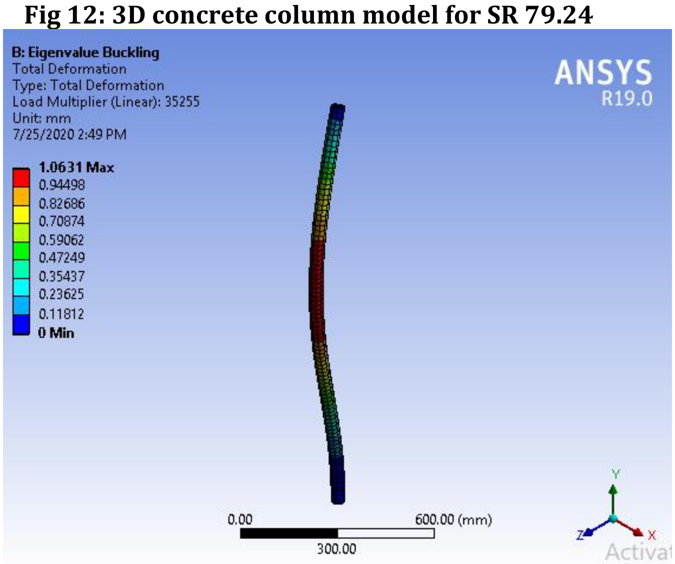

Fig 13: 3D concrete column model for SR 99.05

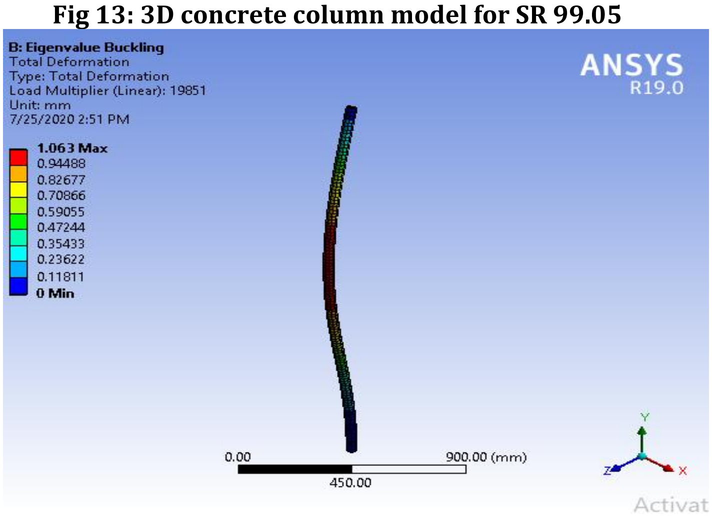

Fig 14: 3D concrete column model for SR 132.07

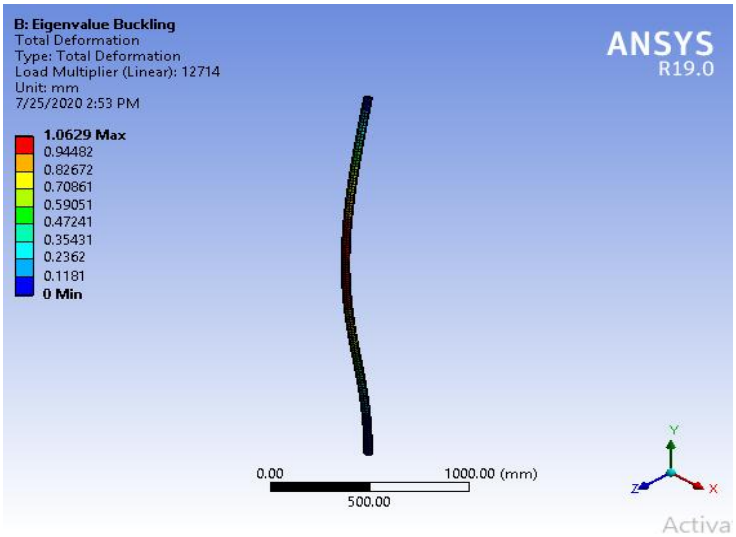

Fig 15: 3D concrete column model for SR 165.07

5. RESULTS AND DISCUSSIONS

5.1 ANALYSIS OF HALLOW STEEL TUBE, CFST COLUMN AND CONCRETE COLUMN

To keep the length of column constant slenderness ratio (λ) varies as in below tables.

Table: 2 Buckling load of Hallow Steel Tube Results

Sl. No	Series	Dia in mm	Thickness (mm)	λ	Buckling load ANSYS (kN)	Euler's Buckling load (kN)
1	1	42.4	2.9	45	343.83	350.79
2				60	195.18	197.35
3				75	125.4	126.3
4				100	70.76	71.04
5				125	45.36	45.47
6	2	48.3	3.7	39.82	629.24	645.43
7				53.82	348.47	353.32
8				66.37	230.15	232.29
9				88.49	129.14	130.7
10				110.61	83.38	83.63
11	3	60.3	4	31.58	1345.8	1401.04
12				42.1	770.51	778.34
13				52.71	495.6	502.9
14				70.28	280.57	282.88
15				87.71	180.68	181.62

Table: 3 Buckling load of concrete filled steel tubes results

Sl. No	Series	Dia in mm	Thickness (mm)	λ	Buckling load ANSYS (kN)	Euler's Buckling load (kN)
1				59.43	404.44	406.16
2				79.24	228.36	228.23
3	1	42.4	2.9	99.05	146.35	146.07
4				132.07	82.237	82.24
5				165.07	52.77	52.6
6				52.19	728.15	730.43
7				69.59	410.3	410.83
8	2	48.3	3.7	86.99	263.15	262.91
9				115.99	148.23	147.88
10				144.98	98.45	94.65
11				41.8	1606.7	1628.7
12				55.73	912.3	916.28
13	3	60.3	4	69.67	585.82	586.25
14				92.89	330.36	329.81
15				116.12	211.6	211.05

Table: 4 Buckling load of concrete column results

Sl. No	Series	Dia in mm	Thickness (mm)	λ	Buckling load ANSYS (kN)	Euler's Buckling load (kN)
1				59.43	97.56	98.73
2				79.24	55.02	55.48
3	1	42.4	2.9	99.05	35.26	35.51
4				132.07	19.85	19.97
5				165.07	12.72	12.78
6				52.19	163.87	165.98
7				69.59	92.47	93.35
8	2	48.3	3.7	86.99	59.28	59.74
9				115.99	33.38	33.60
10				144.98	21.38	21.51
11				41.8	397.02	403.28
12				55.73	224.46	226.88
13	3	60.3	4	69.67	143.97	145.17
14				92.89	81.15	81.66
15				116.12	51.98	52.26

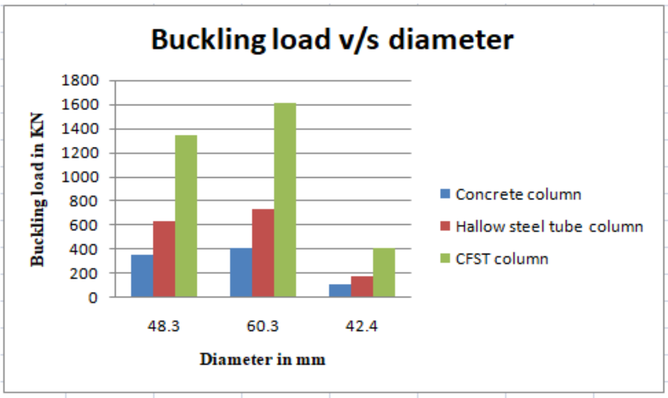

Fig 16: Buckling load v/s diameter

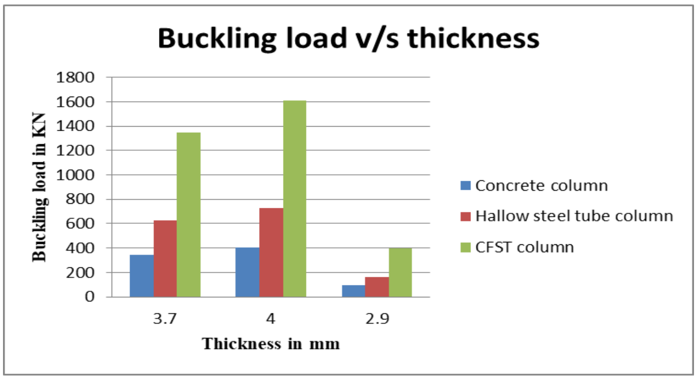

Fig 17: Buckling load v/s thickness

Series specimen-1

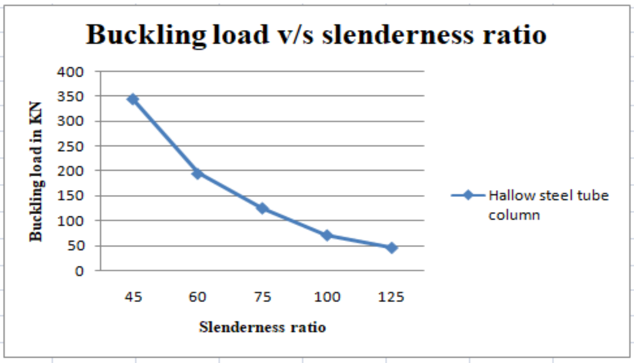

Fig:18 Buckling load v/s slenderness ratio for hallow steel tube column

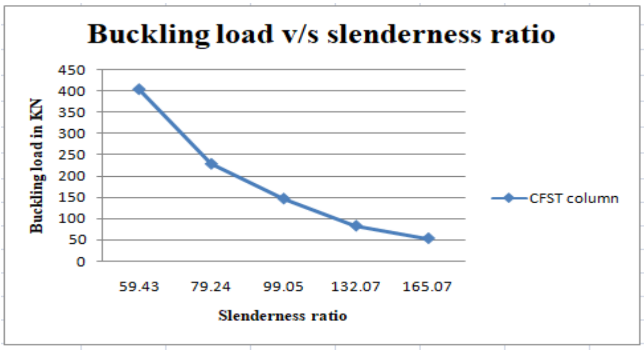

Fig 19: Buckling load v/s slenderness ratio for CFST column

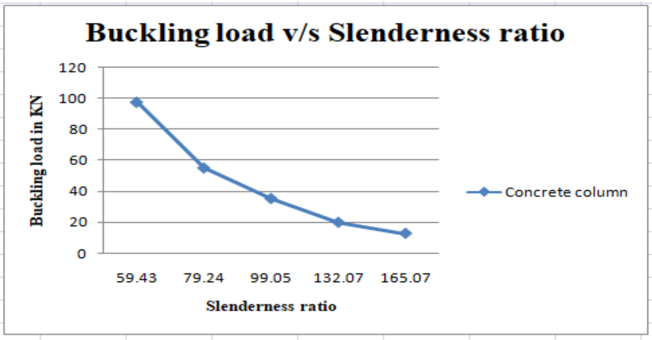

Fig 20: Buckling load v/s slenderness ratio for concrete column

Series specimen-2

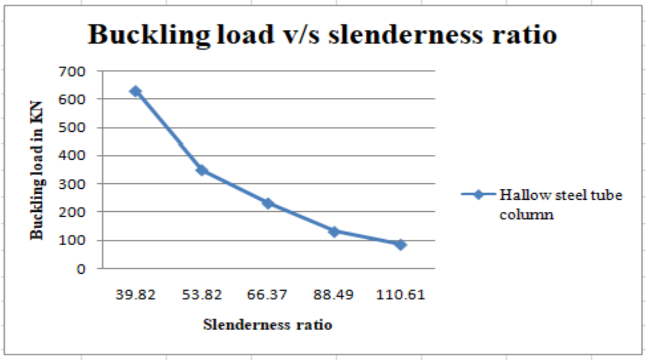

Fig 21: Buckling load v/s slenderness ratio for hallow steel tube column

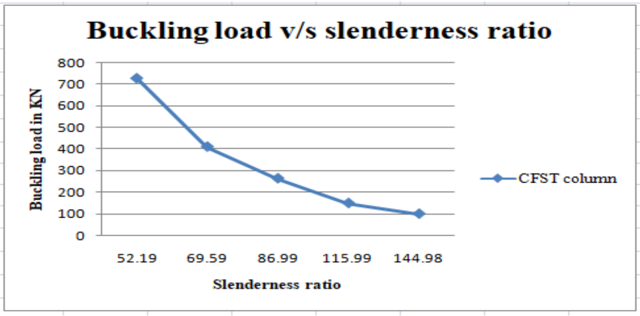

Fig 22: Buckling load v/s slenderness ratio for CFST column

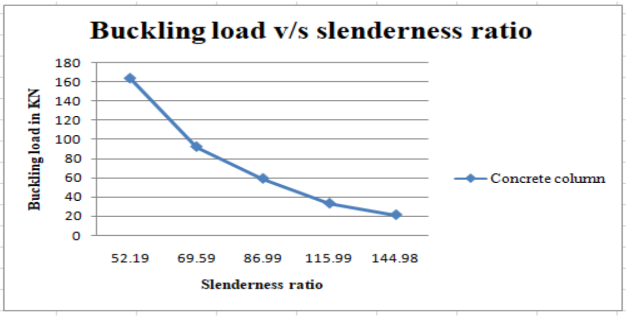

Fig 23: Buckling load v/s slenderness ratio for concrete column

Series specimen-3

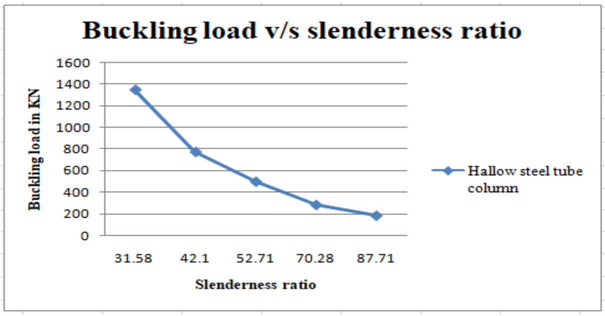

Fig 24: Buckling load v/s slenderness ratio for hallow steel tube column

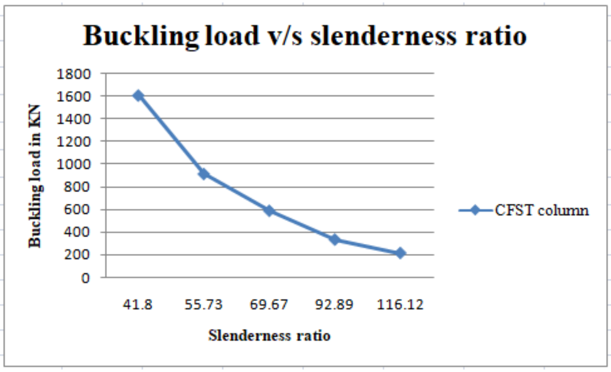

Fig 25: Buckling load v/s slenderness ratio for CFST column

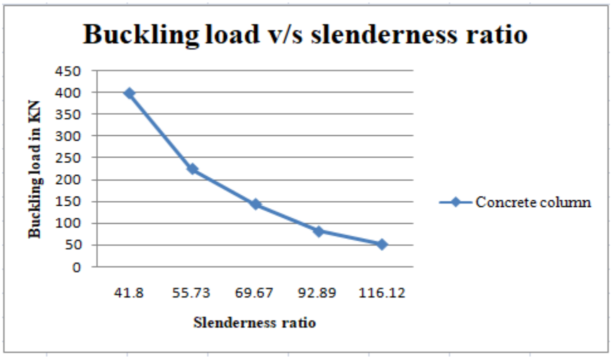

Fig 26: Buckling load v/s slenderness ratio for concrete column

6. CONCLUSIONS

Based on the above analysis the following conclusion are drawn

- As CFST carries buckling load 14.3% more than hollow steel tube column and hallow steel tube carries 72% more buckling load than that of concrete column.
- As thickness and diameter increases buckling load capacity also increases in CFST compared to hallow steel tubes and concrete column.
- Buckling load obtained from the analysis is good agreement with Euler's buckling load.

REFERENCES

[1] Anil Kumar Patidar (2013), "Behavior of concrete filled rectangular steel tube column". IOSR journal of Mechanical and Civil Engineering,. Volume: 04, Issue: 02, pp. 46-52.

[2] Bhushan H. Patil, P.M Mohite (2014), "Parametric study of square concrete filled steel tube columns subjected to concentric loading". International journal of Engineering Research and Applications,. Volume:04, Issue:08. Pp. 109-112.

[3] Darshika k.shah, M.D vakil, M.N patel (2014), "parametric study of concrete filled steel tube column". International journal of engineering development and research,. Volume:02, Issue:02, ISSN: 2321-9939

[4] M. Pragna, PartheepanGanesan (2016), "Analysis of concrete filled steel tube using ansys". International journal of latest engineering research and applications, Volume:01, Issue: 09, pp. 71-78

[5] Raghu K.S, E. Ramesh Babu, Dr. M. Manju Prasad, Dr. N.S Kumar (2013). "Buckling behavior of concrete filled steel tube under finite element method". International journal of emerging trends in engineering and development, Volume: 04, Issue:03, ISSN:2249-6149.

[6] Shilpa Sara Kurian, DinuPaulose, Sreepriya Mohan (2016). "Study on concrete filled steel tube". IOSR Journal of mechanical and civil engineering, 2016. Pp. 25-33, ISSN: 2278-1684.

[7] S. Mathankumar, M. Anbarasan (2016). "Finite Element Analysis of Steel Tubular Section Filled with Concrete". International Journal of Innovative Research in Science, Engineering and Technology, Volume:05, Issue:06, ISSN: 2347-6710.