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Comparative Parametric Study of CFSST and CFST Under Axial and Eccentric Loading using FEA Software

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***Abstract*— Use of stainless steel in construction industry is increasing day by day. High prices of stainless steel are mainly due to presence of nickel about 10-15%. But recently developed grade of stainless steel called as Duplex steel which contains low nickel as compare to stainless steel. Duplex steel have nickel less than 5 – 8 %. Despite of very low percentage of nickel lean duplex steel possess high strength than common stainless steel also have better corrosion resistance, weld ability, fire resistance, etc. Concrete filled steel tube(CFST) with conventional steel is mostly used composite structure in construction field. Nowadays use of duplex steel in CFST is been carried out on large scale due to its high advantages over stainless steel. This paper includes study of comparison of duplex steel and conventional steel in tapered and straight tapered straight (STS) CFST section using ANSYS (WORK BENCH) software. Relations between load vs. strain and deformation vs. load are studied.**

Keywords*— Duplex steel, conventional steel, CFST, ANSYS, tapered column, Straight Tapered Straight (STS).

INTRODUCTION

Steel perform good in tension and weak in compression in case of concrete properties are vice versa concrete perform good compression and weak in tension ,so for good performance in both we generally use composite structure reinforce concrete structure is also one of its example. Composite structure are of two types steel incased in concrete and concrete incased in steel i.e. concrete filled steel structure (CFST). Performance of concrete increases due to surrounding steel. Distribution of material across cross section affects performance lot, so in case steel lies in outer periphery perform effectively in bending. [6] Also it provides good stiffness as it lies at furthest position from the centroid. In case of sea shore structure oil well high rise building or industrial building tapered section are used this concept of tapered CFST was studied by, Lin-Hai Hana,D. Lam [2] [1]. But in case of industrial structure use of CFST with conventional possess disadvantages like its corrosive properties. In industry where chloride sulphar or other corrosive substance in atmosphere is more in that case it has required regular maintaince like panting to avoid corrosion of steel [6]. If steel get corrode its replacement and bonding with concrete is difficult. In such case replacing conventional steel by duplex steel is good option.

Generally mostly used grade of stainless steel are EN 1.4301 /1.4307 and EN 1.4401/1.4404 which contain about 8 % to 12 % of nickel[5]. Nickel stabilizes micro structure but high price of nickel is main reason for high cost of stainless steel from this advance material like duplex steel like is developed which contain 5.7 % nickel [1].
Chemical composition of duplex steel is

Table 1 Chemical composition of duplex steel

Chemical composition % by wt. Typical values						
Element	C	N	Cr	Ni	Mo	Other
Grade 1.4462	0.02	0.17	22.0	5.7	3.1	-

So use of duplex steel in CFST will avoid corrosion but its structural performance has to study. M. F. Hassanein, O. F. Kharoob, Q. Q. Liang study performance of behavior of concrete filled stainless steel tubular section as column, but study of tapered concrete filled lean duplex steel tube has not studied yet. So it is attempt in this paper to study performance of duplex steel CFST and CFST with conventional mild steel. In this paper analytical study of parameter like stress strain curve and load vs. deformation under axial load and eccentric load is studied.

1. *Analytical study*

To study finite element model of the tapered and Straight Tapered Straight (STS) CFST section with duplex steel and conventional mild steel model using ANSYS workbench 14.1 model created. Mechanical properties of duplex steel like Poisson ratio -0.31, Tensile strength – 530 MPa, Density 7.8 gm./cm3 are inserted. Boundary condition one end fixed other free support is used. In 9 steps 45000 axial load at Centre and with eccentricity is applied with 5000 each increment. For each load total deformation, stress (in MPa) strain are found. For that deformation vs. load and load vs. strain graph are found compered. Results obtained are as listed in table no 2 and table no. 3 under axial and eccentric loading.

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Fig 1 Model of tapered CFST tube

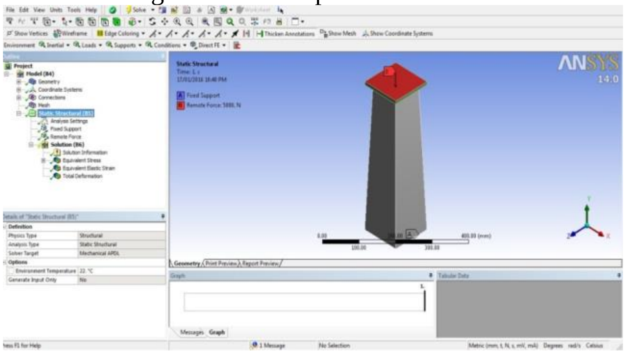


Fig 2 Deformation of tapered section under axial loading

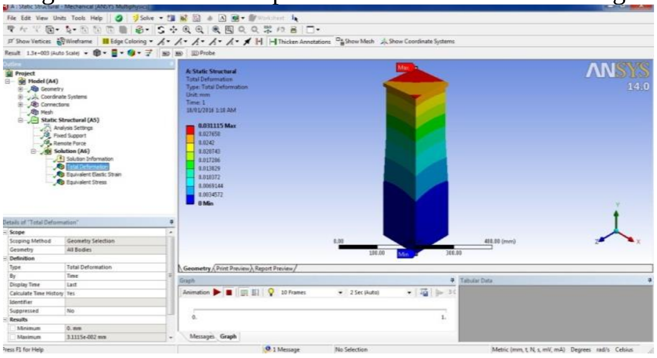


Fig 3 Model of STS CFST tube

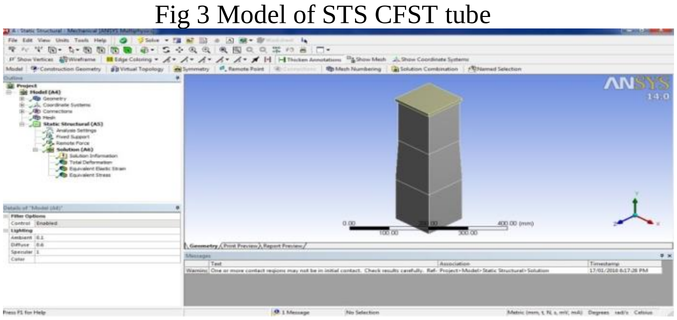


Fig 4 Deformation of STS section under axial loading

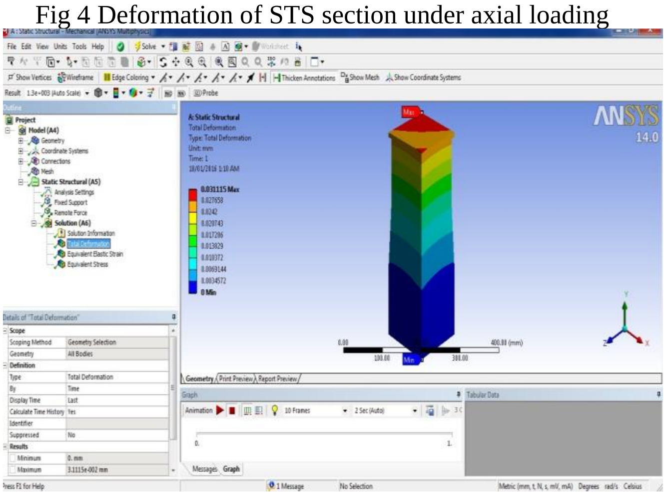


Table no. 2 Deformation for various sections under axial loading

Load (N)	Deformation under axial loading in (MM)			
	Tapered section		Straight tapered section	
	Duplex steel	Conventional mild steel	Duplex steel	Conventional mild steel
5000	0.00663	0.007	0.0032	0.0042
10000	0.013	0.013	0.0062	0.0085
15000	0.02	0.02	0.0082	0.012
20000	0.026	0.031	0.0108	0.017
25000	0.033	0.041	0.0135	0.021
30000	0.041	0.046	0.017	0.025
35000	0.047	0.053	0.021	0.029
40000	0.053	0.061	0.0245	0.034
45000	0.06	0.071	0.029	0.038

TABLE 3 Deformation under axial and eccentric axial loading for various sections

Load (N)	Deformation under eccentric axial loading in (MM)			
	Tapered section		Straight tapered section	
	Duplex steel	Conventional mild steel	Duplex steel	Conventional mild steel
5000	0.046	0.046	0.031	0.031
10000	0.093	0.092	0.052	0.062
15000	0.16	0.13	0.06	0.093
20000	0.19	0.16	0.094	0.12
25000	0.24	0.22	0.12	0.15
30000	0.29	0.27	0.16	0.18
35000	0.38	0.32	0.19	0.031

This result can show graphically as below

Fig 5 Load vs. deformation variation under axial load of tapered CFST section

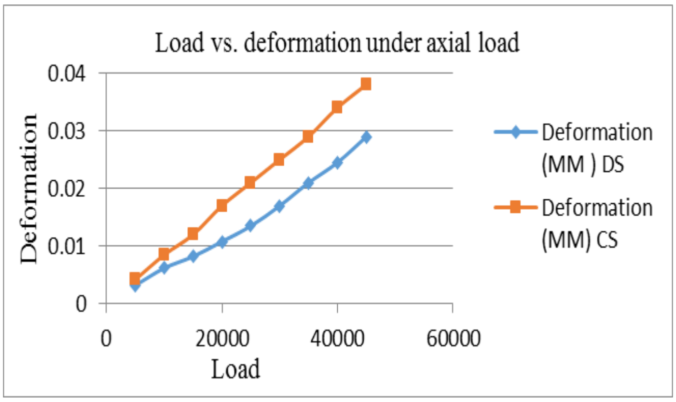
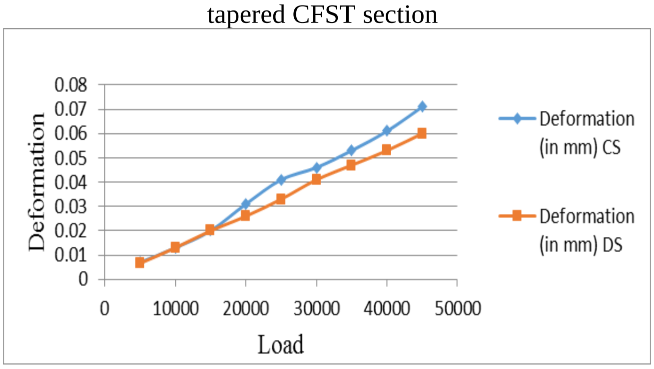


Fig 6 Load vs. deformation variation under axial load of tapered CFST section



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After analysis stress strain for each step result are obtained are listed as in

Table no. 4 Strain for axial and eccentric axial loading

Strain for load (N) under concentrated and eccentric loading				
Load (N)	Tapered section		Straight Tapered Straight section	
	Duplex steel	Conventional steel	Duplex steel	Conventional steel
	Strain	Strain	Strain	Strain
5000	1.1	1.143	1.5	1.48
10000	2.3	2.287	3.022	2.96
15000	3.5	3.431	4.5	4.45
20000	4.623	4.57	6.0045	5.59
25000	5.847	5.71	7.5	7.42
30000	7.015	6.862	9.066	8.9
35000	8.212	9.39	10.5	10.39
40000	9.38	9.75	12	11.88
45000	10.5	10.2	13.51	13.36
5000	4.6	4.52	5.337	5.21
10000	9.2	9.115	10.627	10.42
15000	13.8	13.7	16.016	15.64
20000	18.4	18.3	21.35	20.85
25000	23.1	22.8	26.69	26.066
30000	27.7	27.4	32.03	31.27
35000	32.3	32	37.37	36.495

After calculation stress strain graph plotted which are as below.
Stress strain for tapered mild steel section under axial load and eccentric axial load are as below

Fig 7 load vs. Strain curve for tapered mild steel CFST section under axial loading

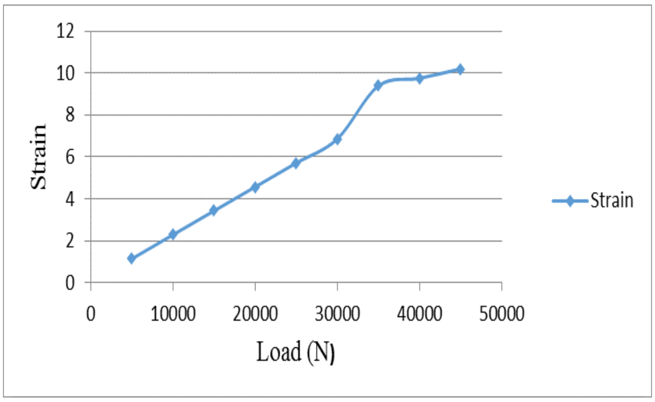
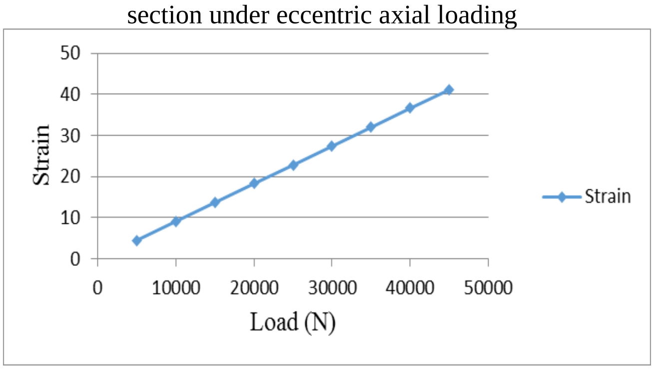


Fig 8 load Vs. Strain curve for tapered mild steel CFST section under eccentric axial loading



Stress strain for duplex steel tapered section under axial loading and eccentric axial loading as below

Fig 9 Stress vs Strain curve for tapered duplex steel CFST section under axial loading

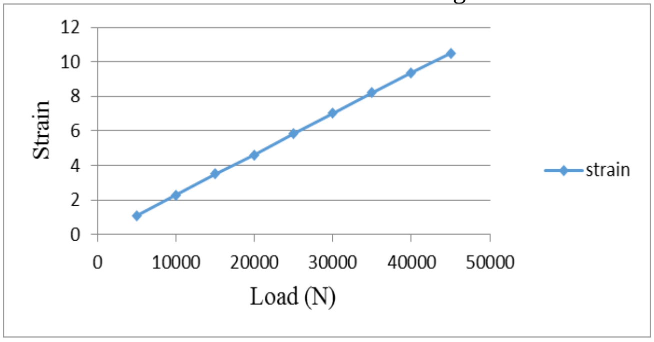
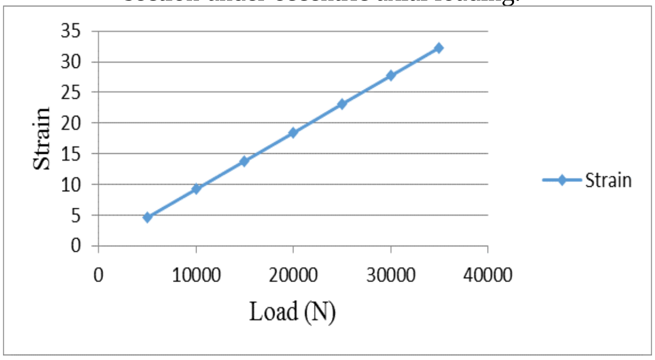


Fig 10 Stress vs Strain curve for tapered duplex steel CFST section under eccentric axial loading.



Stress strain for mild steel STS under axial loading and eccentric axial loading as below

FIG 11 Stress Vs. Strain curve for STS mild steel CFST section under axial loading

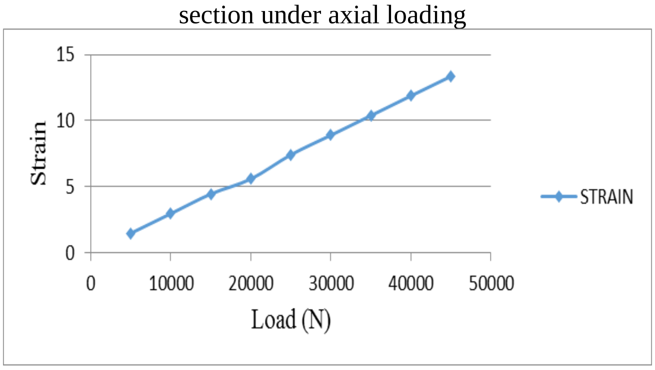
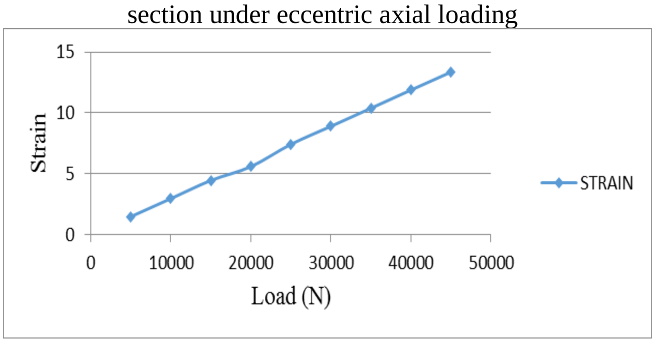


FIG 12 Stress Vs. Strain curve for STS mild steel CFST section under eccentric axial loading



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Stress strain for duplex steel STS section under axial loading and eccentric axial loading as below

FIG 13 Stress vs. Strain curve for STS duplex steel CFST section under axial loading

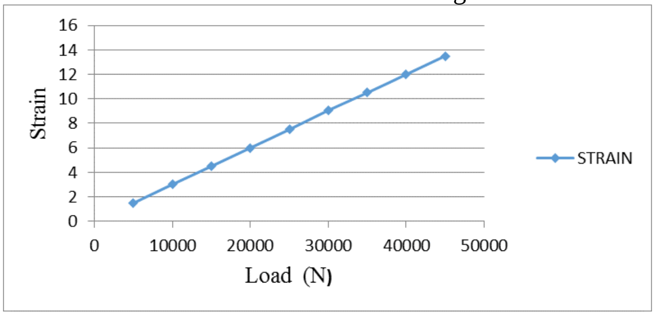
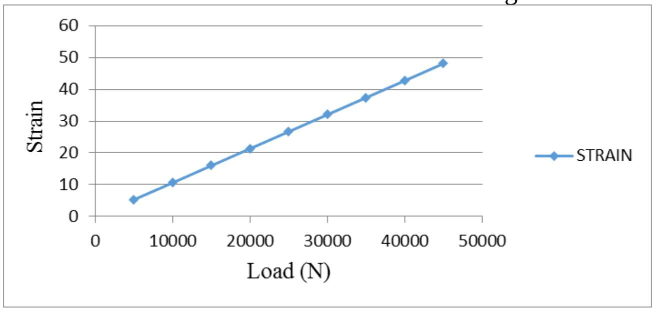


FIG 14 Stress vs. Strain curve for STS duplex steel CFST section under eccentric axial loading



CONCLUSION:

Based on analytical study carried on software following conclusion can be drawn

1. Total deformation for under axial loading and combine is more in conventional steel compare to duplex steel.
2. Strain per load is greater in duplex steel as compare to mild steel with near about 10.23%.

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