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ANALYSIS OF CONCRETE FILLED DOUBLE SKIN TUBULAR COLUMNS INFILLED WITH CONCRETE BY USING NASTRON

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ABSTRACT

This experimental study is to proposing novel model for evaluating the axial compressive load carrying capacity (ultimate axial compressive strength) of concrete-filled double skin steel tubular (CFDST) columns. The several experimental data were collected from the existing literature for design and modeling of CFDST column. For this study, six parameters were considered for analysis such as, diameter, thickness of both inner and outer steel tubes are varying, changing various grade of concrete and steel were employed as the parameters to determine the ultimate axial compressive strength of the CFDST columns. FEM based software has been used to design a model and for analysis NASTRON and PATRON software was used. The analysis has been done and results were plotted. It concludes that, there is a significant enhanced in an axial compressive load carrying capacity in the model type 1. Assessment of the obtained results indicated that the novel generated model by varying cross sectional areas to provide a significant performance compared to the existing models by the previous researchers and the equations specified in the design codes.

KEYWORDS: *concrete-filled double skin steel tubular (CFDST) columns, NASTRON /PATRON, Axial compressive load, Diameter and length*

1. INTRODUCTION

In the last few decades, Hybrid double skinned composite columns have been widely used in USA, Japan, China, and Europe. Hybrid double skinned composite columns tubes have gained acceptance as an alternative to steel tubes in concrete filled steel tubes (CFST) [1]. CFFTs have many numerous merits such as light weight-to-strength ratio, high confinement and corrosion resistance compared to steel tubes. Hybrid double skinned composite steel columns have their own distinct advantage related to structural system which enhances aesthesis of column, also enhances strength and stiffness since because surface area of steel sheet and moment of inertia of tube increases [2]. Most of researcher's considered the geometric properties like length/ diameter (L/D) ratio, thickness/diameter (t/d) ratio with some of boundary condition's and type of loadings. Generally, it has been found that Hybrid double skinned composite steel columns fails due to local bucking or yielding failure [3]. Double skinned steel tubular (DSST) columns possess excellent earthquake-resistant properties such as high strength, high ductility, and large energy absorption capacity. In the last decades, they have gained increasing popularity in buildings, bridges and other structural applications such as scaffoldings etc.., the advantages of DSST columns can be attributed to the composite action between the steel tube and the infill material [4-5]. CFDSTs are structural members that have a double steel skin with concrete sandwiched between the two steel tubes. These structural elements can be concrete-filled double-skin rectangular tubes (CFDSRTs), concrete-filled double-skin circular tubes (CFDSCTs) or concrete-filled double-skin rectangular-circular tubes (CFDSRCTs) [6-7]. If the outer diameter, material properties and design capacities of a DSCT wind power tower are given, the developed software performs axial force-bending moment interaction analyses for hundreds of sections of the tower and suggests ten optimized cross-sectional designs [8]. The effects of eccentric axial loads on stub CFDST columns were investigated by Tao et al. [9]. A series of tests on circular –circular specimens where performed and a theoretical model was developed. The authors concluded that the failure mode of eccentrically loaded CFDST columns was global buckling. In this campaign, all the tubes were 3mm thick and NSC was employed. In the same line, the work from Han et al. [10] included some beam-column tests on square-circular columns and the research from Tao and Han [11] on specimens with rectangular-rectangular section.

2. MATERIALS AND METHODS

2.1 Steel

Modelling of the MS steel circular – circular tube is elastic - perfectly plastic in nature with von mises yield criterion. The circular steel tube subjected to multiple stresses and hence stress-strain curve across the elastic limit and then exhibits to plastic region. CFDS tube is having nonlinear behavior is obtained from uniaxial tensile test. These are the properties of materials are as follows Material = Fe360 Structural steel; Modulus of Elasticity for steel, Es = 210 MPa; Yield stress for structural steel, fy = 360 MPa; Poisons ration=0.3; Density = 7800kg/m^3 [12].

2.2 Concrete

The material considered for analysis RC is M-30, M40, M50, M60 grade concrete and Fe360 Structural Steel.

Characteristic strength for concrete, Fck = 30 MPa, 40 MPa, 50 MPa, 60MPa.

Modulus of Elasticity for concrete, EC =27386 MPa (M30)

Modulus of Elasticity for concrete, EC =31622 MPa (M40)

Modulus of Elasticity for concrete, EC =35355 MPa (M50)

Modulus of Elasticity for concrete, EC =38729 MPa (M60)

2.3 Geometrical Modelling

The modelling part is done by using FEM software; it consists of several steps. The hollow specimen is modelled by using as SOLID SHELL ELEMENT and concrete specimen is modelled with considering CONCRETE65/SOLID65 element with identical geometry. The analysis of the CFDST is done by finite element software and analysis done by Nastron/Patron as shown in figure 2.1 to 2.4 respectively.

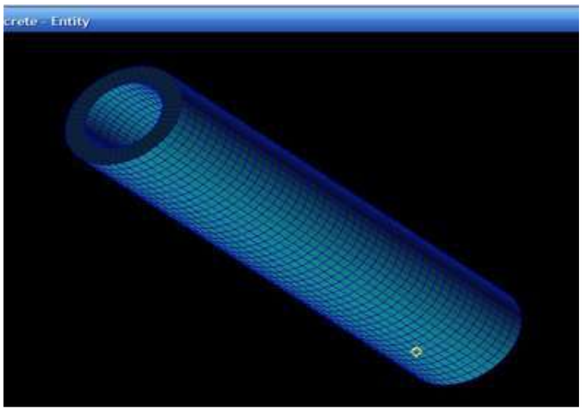

Fig 2.1 Solid concrete section

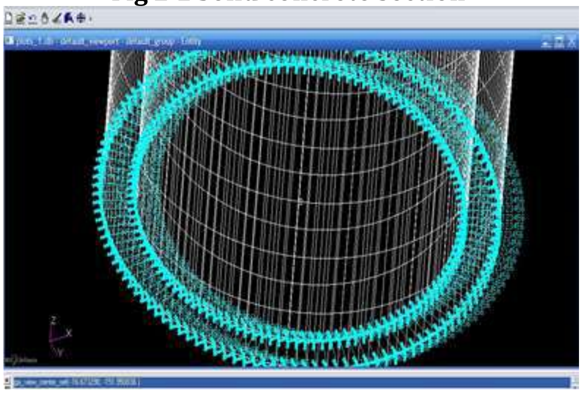

Fig 2.2 Assigning Boundary Condition

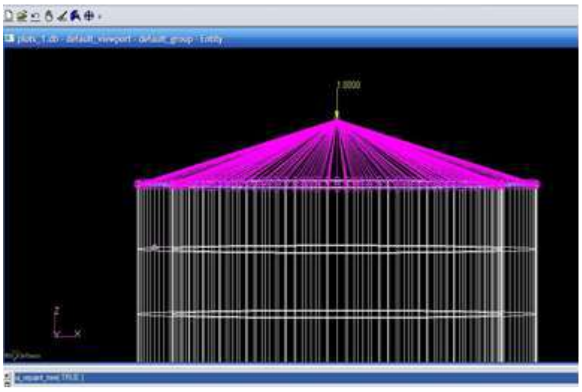

Fig 2.3 MPC Point and Meshing

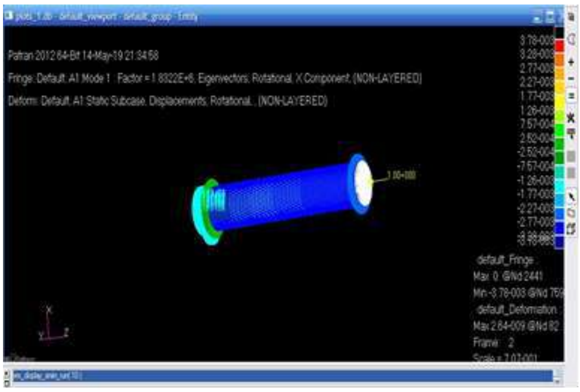

Fig 2.3 Typical Bucking output

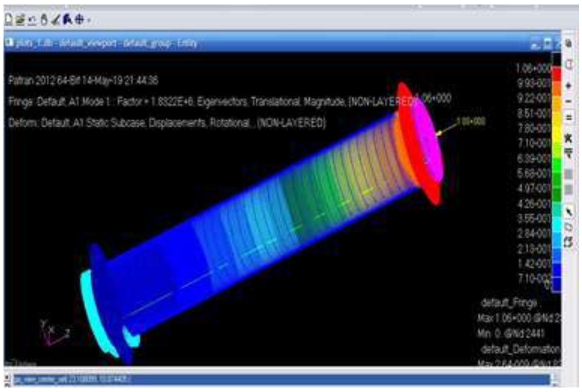

Fig 2.4 Typical load and Stress diagram

3.0 RESULTS AND DISCUSSION

3.1 Model Type -1:

From the fig 3.1 shows the variation of outer diameter in mm v/s axial load carrying capacity in kN. In the model type 1 shows that, enhancing load carrying capacity by increasing the outer diameter of concrete-filled double-skin tubular steel tube by 87.5mm, 112.5mm and 145mm respectively and all corresponding results were tabulated in the table 3.1. The enhancement of load carrying capacity is 57% in case of model type 1.

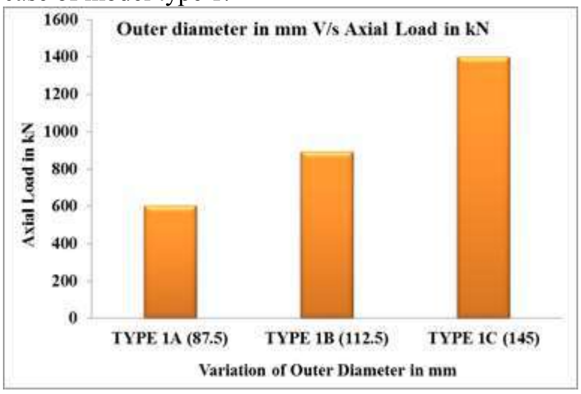

Fig 3.1 Variation of Outer Diameter in mm v/s Axial load in kN

Model Type	Outer Diameter in mm	Axial Load in kN
1A	87.5	603.75
1B	112.5	892.5
1C	145	1401.75

Table 3.1 Dimension of Model Type 1

3.2 Model Type -2:

From the fig 3.2 shows the variation of outer thickness in mm v/s axial load carrying capacity in kN. In the model type 2 shows that, improving load carrying capacity by increasing the outer thickness of concrete-filled double-skin tubular steel tube by 3.5mm, 4.5mm and 5.5mm respectively and all corresponding results were tabulated in the table 3.2. The enhancement of load carrying capacity is 16.5% in case of model type 2.

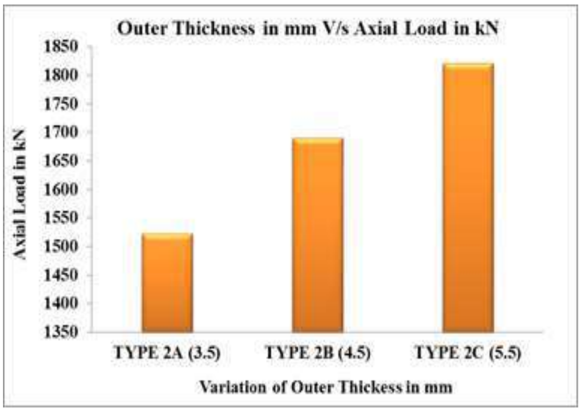

Fig 3.2 Variation of Outer thickness in mm v/s Axial Load in kN

Model Type	Outer Thickness in mm	Axial Load in kN
2A	3.5	1522.5
2B	4.5	1690.5
2C	5.5	1821.75

Table 3.2 dimension of Model Type 2

3.3 Model Type -3:

From the fig 3.3 shows the variation of inner diameter in mm v/s axial load carrying capacity in kN. In the model type 3 shows that, decreases the load carrying capacity by increasing the inner diameter of concrete-filled double-skin tubular steel tube by 77mm, 105mm and 125mm respectively and all corresponding results were tabulated in the table 3.3. Its shows slightly dropped the value of load carrying capacity by 25% in case of model type 3.

Model Type	Inner Diameter in mm	Axial Load in kN
3A	77	1260
3B	105	1102.5
3C	125	945

Table 3.3 Dimension of Model Type 3

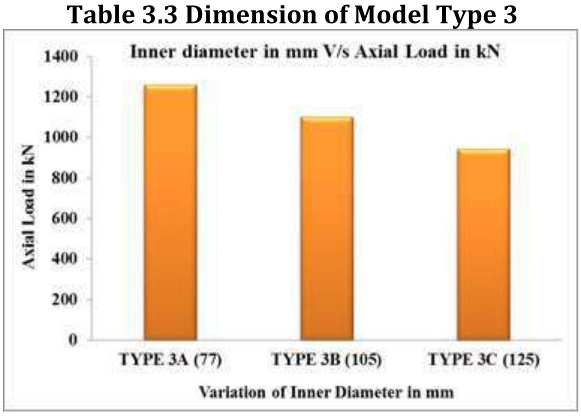

Fig 3.3 Variation of Inner diameter in mm v/s Axial Load in kN

3.4 Model Type -4:

From the fig 3.4 shows the variation of inner thickness in mm v/s axial load carrying capacity in kN. In the model type 4 shows that, improving load carrying capacity by increasing the inner thickness of concrete-filled double-skin tubular steel tube by 3.5mm, 4.5mm and 5.5mm respectively and all corresponding results were tabulated in the table 3.4. The enhancement of load carrying capacity is 22% in case of model type 4.

Model Type	Inner Thickness in mm	Axial Load in kN
4A	3.5	1186.5
4B	4.5	1354.5
4C	5.5	1522.5

Table 3.4 dimension of Model Type 4

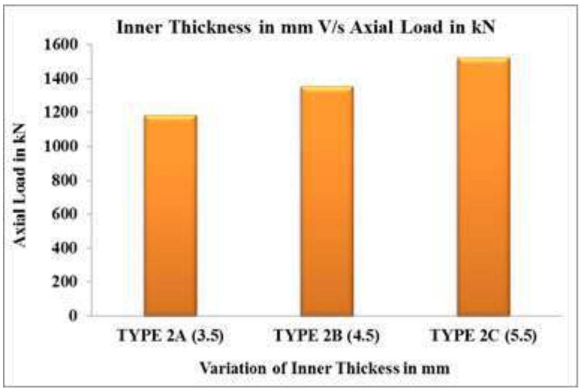

Fig 3.4 Variation of Inner Thickness in mm v/s Axial Load in kN

3.5 Model Type -5:

From the fig 3.5 shows the variation of grade of concrete v/s axial load carrying capacity in kN. In the model type 5 shows that, improving load carrying capacity by increasing the grade of concrete of concrete-filled double-skin tubular steel tube by 40mm, 50mm and 60mm respectively and all corresponding results were tabulated in the table 3.5. The enhancement of load carrying capacity is 14% in case of model type 5.

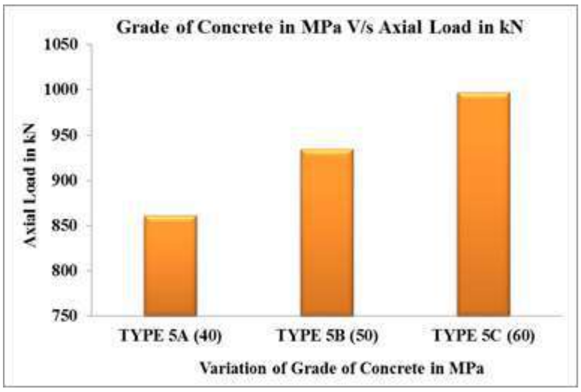

Fig 3.5 Variation of Grade of Concrete in MPa v/s Axial Load in kN

Model Type	Grade of Concrete in MPa	Axial Load in kN
5A	40	861
5B	50	934.5
5C	60	997.5

Table 3.5 dimension of model type 5

3.6 Model Type -6:

From the fig 3.6 shows the variation of grade of steel v/s axial load carrying capacity in kN. In the model type 6 shows that, improving load carrying capacity by increasing the grade of steel of concrete-filled double-skin tubular steel tube by 40mm, 50mm and 60mm respectively and all corresponding results were tabulated in the table 3.6. The enhancement of load carrying capacity is 7% in case of model type 6.

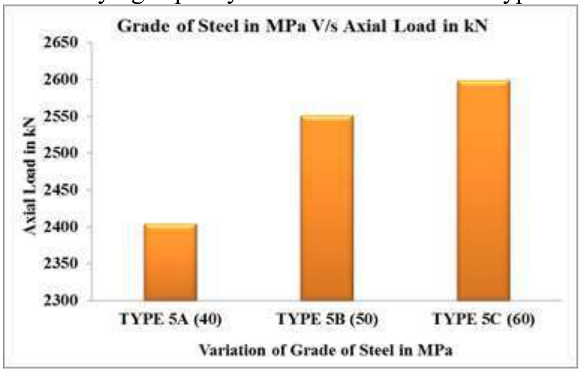

Fig 3.6 Variation of Grade of Steel in MPa v/s Axial Load in kN

Model Type	Grade of Steel in MPa	Axial Load in kN
6A	275	2404.5
6B	420	2551.5
6C	460	2598.75

Table 3.6 dimension of Model Type 6

3.7 Validation

The comparison between the Experimental and Nastron results for ultimate load carrying capacity and an axial shortening of the CFDST is shown in figure 3.7 and corresponding reading are shown in the table 3.7. The analytical results were conducted to find the ultimate load carrying capability of CFDST tubes and by changing the thickness of 1.6 mm, 2.0 mm and 2.6mm respectively, and M30 grade concrete is used for the validation.

Table 3.7 Comparative analysis of Experimental & Nastron results by Variation of thickness of the column

T_0 (mm)	Axial Load in kN	
	Experimental (kN)	NASTRAN (kN)
1.6	181	184
2	229	233
2.6	279	280

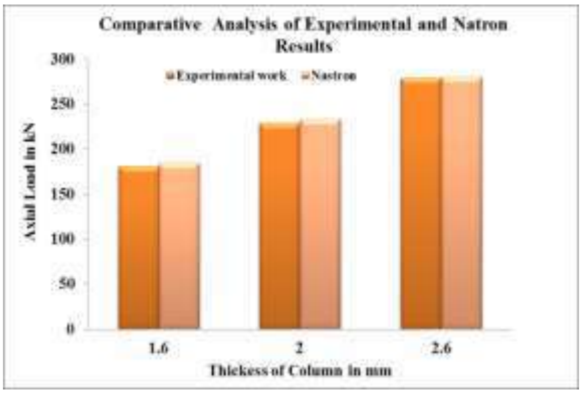

Fig 3.7 Comparative analysis of Experimental and Nastron results by varying thickness of the column in mm

It can be concluded that, the obtained experimental results were almost equal compared with Nastron values.

CONCLUSION

In this work, the results from an experimental campaign on concrete-filled double-skin steel tubular columns subjected to axial compressive loads are presented.

- Enhancement of load carrying capacity esteemed by 57% in case of model type 1 by increasing the outer diameter of concrete-filled double-skin tubular steel tube by 87.5mm, 112.5mm and 145mm respectively.
- Enhancement of load carrying capacity esteemed by 16.5% in case of model type 2 by increasing the outer thickness of concrete-filled double-skin tubular steel tube by 3.5mm, 4.5mm and 5.5mm respectively.
- Slightly drooping the load carrying capacity esteemed by 25% in case of model type 3 by increasing the inner diameter of concrete-filled double-skin tubular steel tube by 77mm, 105mm and 125mm respectively.
- The enhancement of load carrying capacity esteemed by 22% in case of model type 4 by increasing the inner thickness of concrete-filled double-skin tubular steel tube by 3.5mm, 4.5mm and 5.5mm respectively.
- The enhancement of load carrying capacity esteemed by 14% in case of model type 5 by increasing the grade of concrete of concrete-filled double-skin tubular steel tube by 40mm, 50mm and 60mm respectively.
- The enhancement of load carrying capacity esteemed by 7% in case of model type 6 by increasing the grade of steel of concrete-filled double-skin tubular steel tube by 40mm, 50mm and 60mm respectively.
- Finally concluded all obtained value from the experiments was compared with Nastron values. So finally validated that, both the values of analytical and practical results are same and gives more accurate results.
- This analytical experiment proves, the practical modelling is not required. Since the same results can be expected from the FEM based NASTRAN & PATRAN output.

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