iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** VII **Month of publication:** July 2022

DOI: https://doi.org/10.22214/ijraset.2022.45379

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VII July 2022- Available at www.ijraset.com

Non Linear Analysis on CFDST columns with and without GFRP Wrapping

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Abstract: Concrete Filled Double Skin Steel Tube (CFDST) columns are modified form of Concrete Filled Steel Tubular (CFST) columns, developed by several researchers. CFDST column composed of two concentric steel tubes in which concrete is packed in between them. It is available in various geometrical shapes. CFDST have many advantages such as high strength, high bending stiffness, good seismic and fire performance. But it is found that CFDST columns have some disadvantages including ageing of structures, corrosion of steel tubes etc. which reduces the strength of the column. So, to prevent these drawbacks and to strengthen the structure, Glass Fiber Reinforced Polymer (GFRP) can be used as an external cover. The present study aims to do nonlinear static analysis of CFDST columns having different hollow ratio wrapped with and without GFRP under axial compression using ANSYS finite element analysis software.
Keywords: CFDST columns, Class Fibre Reinforced Polymer (GFRP), axial compression, finite element analysis, load deformation

I. INTRODUCTION

Concrete Filled Double Skin Tubular (CFDST) column is made up of two concentric steel tubes in which concrete is filled in between them. It has various geometrical shapes. The main advantages of the CFDST column include high strength, high bending stiffness, good seismic and fire performance. CFDST is gaining importance nowadays because of its amazing look in favour of building, bridges, as well as column supporting platforms like offshore structures, storage tanks, piles, columns in seismic zones and other civil engineering structures. But it has some drawbacks such as ageing of structures, corrosion of steel tubes etc. So it is necessary to strengthen these columns. Glass fibre reinforced polymer (GFRP) is a fibre reinforced polymer composite which can strengthen CFDST columns by wrapping it as an external cover. This study aims to evaluate the nonlinear static structural analysis of CFDST columns with and without wrapping of GFRP.

II. OBJECTIVE

The main objective of the current study is to do nonlinear static analysis and to evaluate the load deformation of the Concrete Filled Double Skin Tubular Columns (CFDST) with and without wrapping of Glass Fibre Reinforced Polymer (GFRP) and also to compare the results obtained from finite element analysis.

III. FINITE ELEMENT ANALYSIS

Finite element analysis (FEA) is an extremely useful tool in the field of civil engineering for numerically approximating physical structures that are too complex for regular analytical solutions. Within the fields of structural and civil engineering, there are several such problems where FEA can be used to simplify a structure and understand its overall behaviour. The finite element analysis software used in this study is ANSYS workbench.

A. Material Dimensions and Properties

CFDST columns having different hollow ratios such as 0.11, 0.28 and 0.48 are modelled. The length of the column is kept constant as 3000mm. M40 grade concrete is used to fill the columns. Also, CFDST Column wrapped with CFRP and GFRP were modelled. The thickness of the GFRP provided is 0.3mm. The dimensions and material properties considered for the CFDST columns are described in table 1 and table 2 respectively.

TABLE-DIMENSIONS OF CFDST COLUMNS

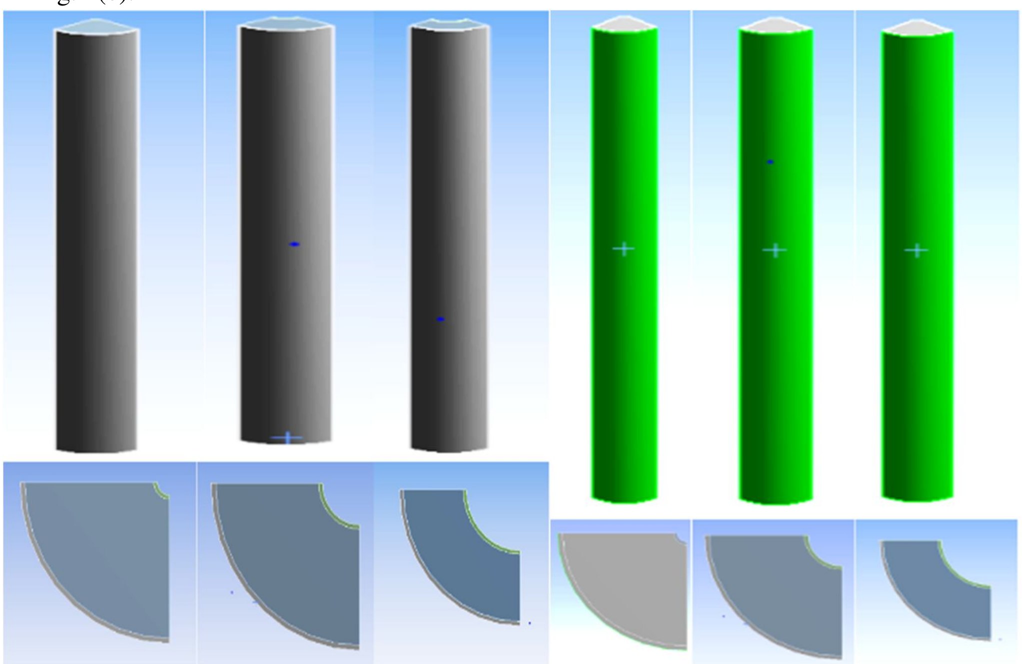
Sl. No.	D_o (mm)	T_o (mm)	D_i (mm)	T_i (mm)
1	323.9	6.3	33.7	4.0
2	323.9	6.3	88.9	4.0
3	323.9	6.3	152.4	4.0

TABLE -MATERIAL PROPERTIES OF CFDST COLUMNS

Properties	Concrete	Steel	GFRP
Young's Modulus	31623MPa	200GPa	73GPa
Poisson's Ratio	0.2	0.3	0.26
Density	2400kg/m^3	7850kg/m^3	1.26g/cm^3

B. Modelling

CFDST columns having hollow ratio 0.11, 0.28 and 0.48 without wrapping and three CFDST Columns having hollow ratio 0.11 with wrapping is modelled. Finite element model of CFDST columns without wrapping is shown fig. 1(a) and CFDST columns with wrapping is shown in fig. 1(b).



(a) (b)

Fig. 1 (a) CFDST columns having hollow ratio 0.11, 0.28 and 0.48 without wrapping; (b) CFDST Columns having hollow ratio 0.11 with GFRP wrapping

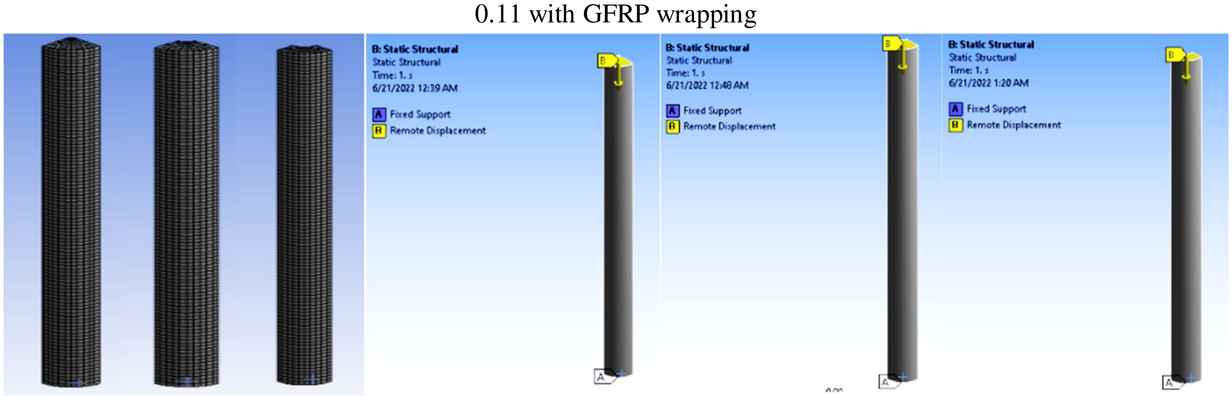


Fig. 2 (a) Meshed model having hollow ratio 0.11, 0.28 and 0.48 without wrapping; (b) Boundary Conditions having hollow ratio 0.11 with GFRP wrapping

C. Analysis

Nonlinear static structural analysis was done on the CFDST column having hollow ratios 0.11, 0.28 and 0.48 and also analysis was done on the CFDST column wrapped with a different number of GFRP layers. Load - Deformation characteristics of the column were evaluated.

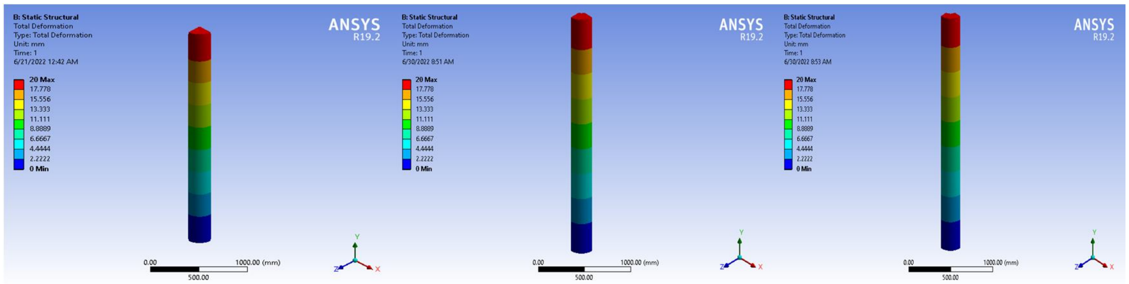


Fig. 3 Analysed model having hollow ratio 0.11, 0.28 and 0.48 without wrapping

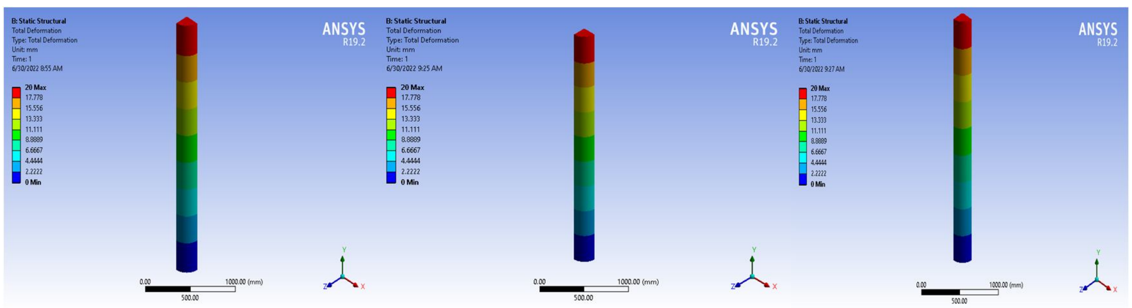


Fig. 4 Analysed model having hollow ratio 0.11, 0.28 and 0.48 without wrapping

IV. RESULTS AND DISCUSSIONS

A. CFDST Columns Without Wrapping

The CFDST columns with hollow ratios 0.11, 0.28 and 0.48 without wrapping of GFRP were analysed. The load - deformation graph is obtained and is shown in figure. From the graph, it is noted that as the hollow ratio increases, the load that can be carried by the column decreases.

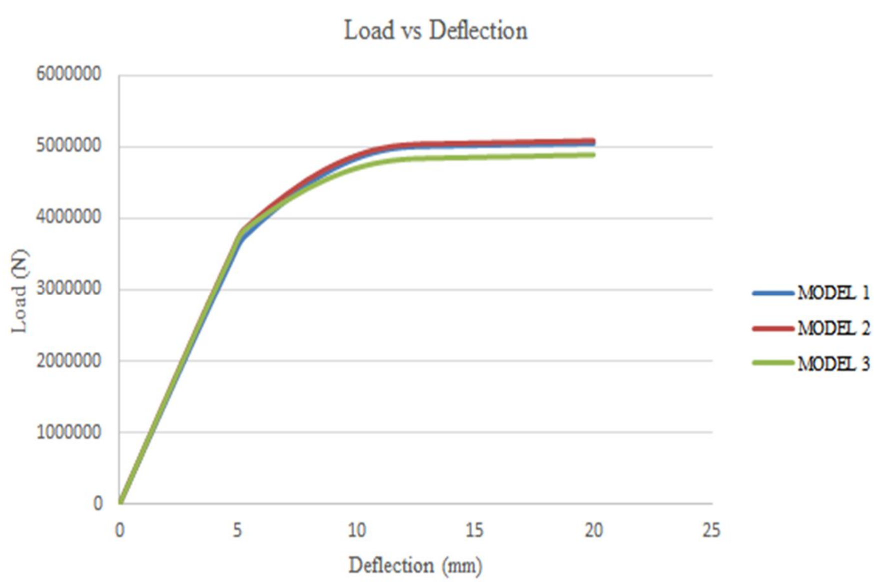


Fig. 2 Load vs. Deformation graph of CFDST columns with hollow ratio 0.11(model 1), 0.28(model 2) and 0.48(model 3)

B. CFDST Columns With Wrapping

The CFDST columns with hollow ratios 0.11, 0.28 and 0.48 with GFRP wrapping were analysed. Also, the effect of the number of layers of GFRP wrapping on CFDST columns was evaluated. The load - deformation graph is obtained and is shown in figure. From the graph, it is noted that the CFDST columns wrapped with GFRP can carry more load than that of CFDST columns without wrapping. As the number of layers of GFRP increases the load carrying capacity also increases.

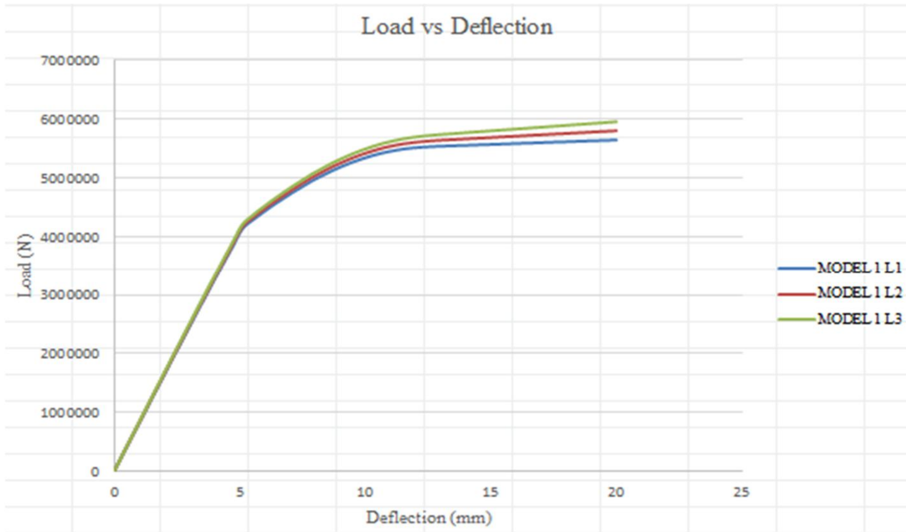


Fig. 2 Load vs. Deformation graph of CFDST columns (model 1) with 1, 2, & 3 GFRP layers

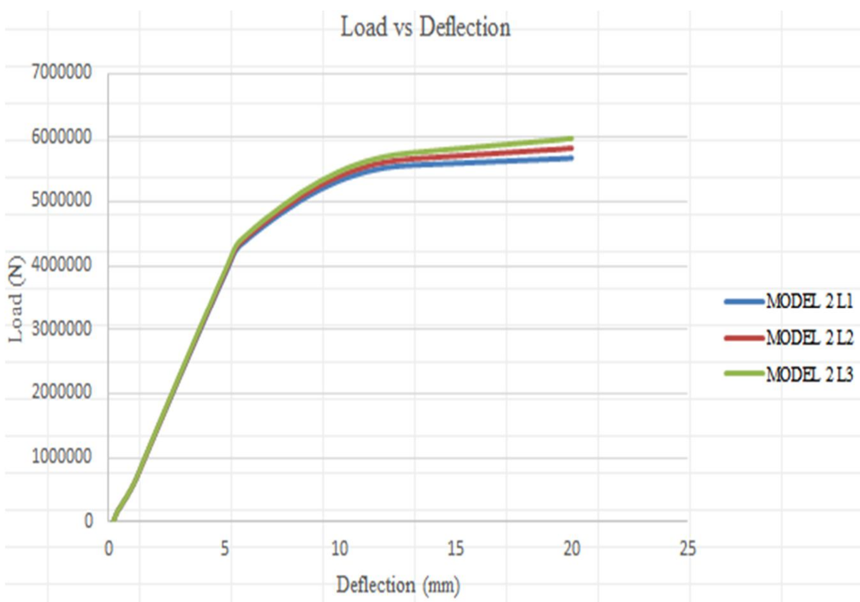


Fig. 2 Load vs. Deformation graph of CFDST columns having hollow ratio 0.28 (model 2) with 1, 2, & 3 GFRP layers
Fig. 2 Load vs. Deformation graph of CFDST columns having hollow ratio 0.48 (model 3) with 1, 2, & 3 GFRP layers

V. CONCLUSIONS

Nonlinear static analysis on CFDST columns having different hollow ratios with and without GFRP wrapping were done on ANSYS software. The following conclusions were obtained from the study: The hollow ratio has a significant effect on the strength of CFDST columns. As the hollow ratio increases the load carrying capacity of CFDST columns decreases.

Due to some drawbacks, the strength will be reduced. This can be rectified by wrapping the CFDST with GFRP. From the results, it is obtained that the load carrying capacity of the CFDST column increased as it is wrapped with GFRP. Also, the effects of the number of GFRP layers were evaluated. As the number of layers increases, the load carrying capacity also increases.

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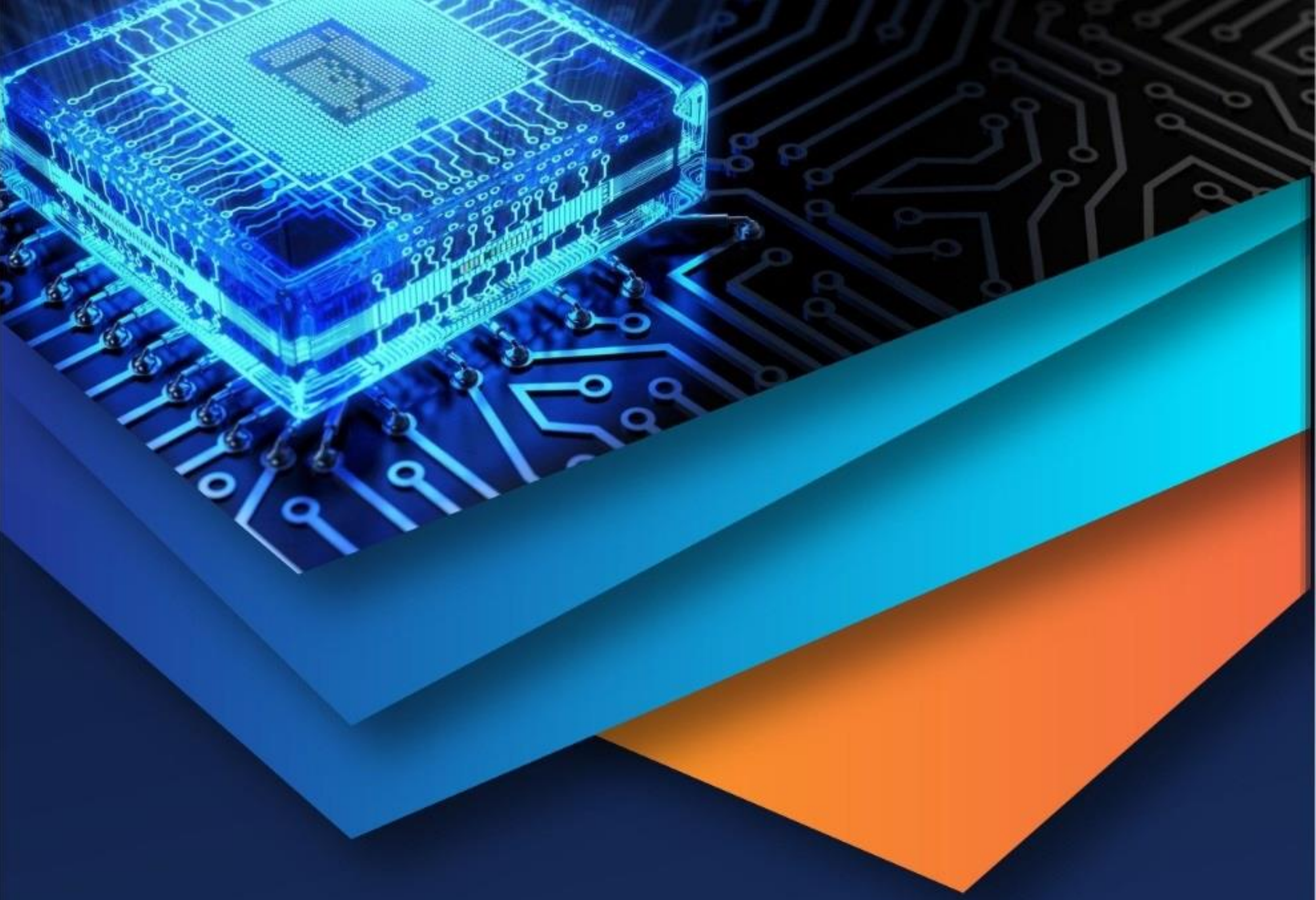

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