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INVESTIGATION ON BEHAVIOUR OF FRP-CONCRETE-STEEL TUBULAR COLUMN

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ABSTRACT

FRP has been generally acknowledged as a productive binding material for cement as a result of its high solidarity to-weight proportion and tailor-ability in mechanical properties. The concept of using various materials optimally in order to achieve a more efficient member is presented in this paper. Fibre-reinforced polymer (FRP) - Concrete- Steel double skin tubular (FCSDST) column is an advancement that emerged recently. It consists of outer FRP layer and inner steel pipe with concrete infilled between the tubes obtaining many advantages over existing columns in the vertical direction. This paper presents an analytical study on the behaviour of FRP concrete steel tubular column subjected to axial compression The stiffness and energy absorption capacity are determined. The analytical program includes testing of 12 specimens having height 500mm, varying parameters like thickness of 2mm & 4mm and diameter 160mm of the FRP tube and steel pipe of diameter 88.9mm of 1.6mm thickness. The analytical study has been carried out using Finite element software. Comparing with regular concrete GFRP attaining 25% more strength and prudent to other members.

Keywords: GFRP tube, fibre reinforced polymer, FCSDST, steel pipe, axial compression, analytical model, tension, compression, energy absorption capacity, concrete columns.

INTRODUCTION

Lately fibre strengthened polymer have found progressively important in structural building applications both in fixing and development of new structures. Especially, FRP is being acknowledged as a productive binding material on cement because of its high sturdiness in mechanical properties. It is an ecological amicable material with high quality and furthermore has great holding limit.

Test continued cement filled twofold skin steel rounded stub segments, shaft and pillar columns. Load mishappening conduct of Concrete filled double skin tubular (CFDST) example contrasted and ordinary cement filled steel cylindrical individuals. Improved quality and malleability have been observed for CFDST stub sections, bars and shaft segment. Hypothetical models have been created to foresee the heap versus disfigurement connections for the CFDST individuals. Quality estimation of CFDST individuals has been created [1]. New sort of cement filled twofold skin steel tube part with octagonal segment, with external cylinder has octagon segment and internal cylinder has round cylinder. Concrete filled double skin steel tubular (CFDSST) individuals with octagon area exposed to pivotal pressure are examined, and a few bends of burden strain of steel tube and restricted cement and the bearing limit of individuals are acquired. It is shown that bearing limit of octagonal area is more prominent than square segment and is littler than roundabout segment. The steel quality is completely utilized and there is no loss for presence of hypotenuse of the external steel tubes [2]. Concentrate on conduct of FRP-bound solid steel segments under concentric and flighty pressure. The test work included testing of examples, with factors like area arrangement, thickness of FRP tube and the stacking scheme. Buckling of steel segment was all around obliged and the solid was adequately kept in FRP bound solid steel sections, prompting an exceptionally malleable reaction under both concentric and unpredictable pressure. The pivotal burden limit diminishes with burden unusualness yet the flexibility of segment increments with the heap unconventionality [3]. Half and half DSTCs with a PET-FRP tube process incredibly great malleability. Distance across to-thickness proportion of the inward steel tube is progressively basic parameter in such DSTCs with a glass, carbon or FRP external cylinder [4]. FLAC in the middle of FRP cylinder and steel tube is viably bound bringing about astounding bendable conduct in pressure. Extreme quality and strain of FLAC-filled DSTCs are expanded by a factor of 1.7 and 3, individually. Void proportion has restricted impact on a definitive quality of FLAC-filled DSTC while the effect on a definitive strain is huge [5]. Nearness of internal FRP tube improved hub compressive conduct. Burden bearing limit was expanded between about 10% and half and the pliability was additionally upgraded. Disappointment was commonly slow with no sharp misfortune in burden bearing limit [6]. Sections with superb execution will be persistently utilized with fractional fortification for support. Probability of building DSCT sections in financial and superior design. Nearby clasping of the outside cylinder happens when the inward concrete has plasticized, and it very well may be guaranteed that the plastic pivot could be characterized as the zone where neighborhood clasping happens [7]. Exposure of the prospects and the drawbacks of the betterment of composite elements. There are many advantages when comparing composite materials with conventional material. [8]. Fibers are good in energy absorption, toughness and also in impact resistant properties. A new system was also named as alkali resistance glass fibre reinforced concrete [9].

In the current investigations, the pre-manufactured FRP tubes utilized regularly had a noteworthy longitudinal solidness. In any case, a FRP tube

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containing filaments situated near the loop bearing shows up substantially more alluring for FRP concrete steel columns (FCSC) because of the accompanying reasons: (a) the likelihood and result of clasping of the FRP tube is dodged as it gets restricted hub compressive anxieties; (b) the FRP cylinder can be made more slender to limit its cost; (c) the nearness of a steel channels guarantees a pliable reaction under twisting ruled stacking, which makes the extra longitudinal fortification given by the FRP tube pointless. The current thinks about have additionally been commonly restricted to concentric pivotal pressure trial of FCSC, with small comprehension on their conduct under erratic pressure. Against this foundation, this paper presents an efficient trial ponder on the compressive conduct of FCSC.

Analytical Study

An analytical study has been carried out to examine the influences of various thicknesses on the axial compressive behaviour of GFRP tube with and without reinforced columns. Analytical research was done using Finite element software (FEM). Limited component investigation utilizes numerical strategy for isolating a perplexing framework into little pieces called components. This product executes conditions that oversee the conduct all things considered and fathom them. These outcomes can be classified or can be displayed in graphical structures. The limited component strategy is a computational method and is utilized to get estimated arrangements of limit esteem issues. The limit condition expected and the heap is connected to the best surface of the GFRP segment which is appropriated over the full width of the segment. Precision of the outcomes in the limited component show relies on the limited component work, constitutive material model and limit conditions. Different segments, for example, GFRP tube, concrete; reinforcement bars are fit utilizing part by part premise as opposed to utilizing the global factor.

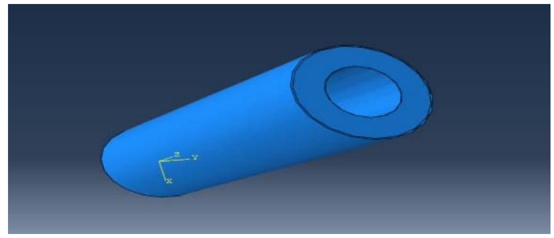

Figure-2.1. Full-scale model of GFRP tube column.

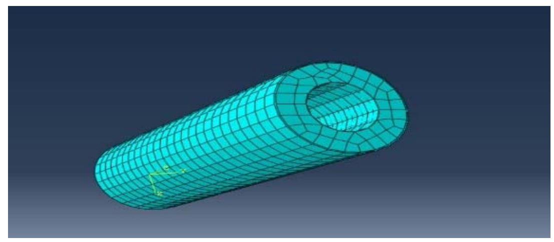

Figure-2.2. Meshing generated.

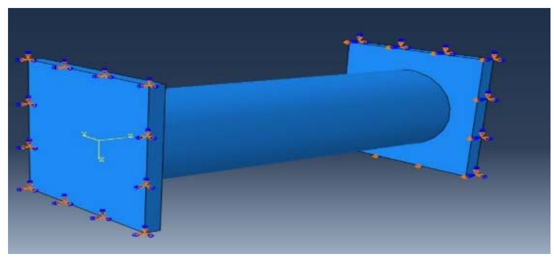

Figure-2.3. Loading Conditions.

Table-1. Details of Geometry of GFRP tube.

Element	Description	Value
GFRP	Orientation angle Height, mm Shape Diameter of concrete cylinder, mm	0° 500 circular 200
	Process adopted Tensile strength, Mpa Ultimate tensile strain, Mpa Resin	Hand layup 30,000 800 Epoxy

VOL. 14, NO. 16, AUGUST2019 ISSN 1819-6608
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Table-2. Details of Geometry of composite elements.

Element	Description	Value
Concrete	Grade Height, mm Shape	M30 500 circular
Steel	Diameter, mm Depth, mm Shape Thickness, mm	88.9 500 circular 1.6

According to the ACI 440.3R the manufacturing of FRP tube is manufactured and the manufactured report is shown in the Table-1 [10]. The initial test for GFRP is performed using ASTM D3039 and ASTM D7205, with the help of these two code books the Coupon test is performed on the GFRP tube [9]. ACI 440.2R-08 used for construction and design of FRP [11]. Various types of GFRP tube thicknesses used is 2 mm and 4 mm and 200 mm diameter are used in the present FEM study. The finite element model with lengths of 500 mm has been analysed to find the deflection parameters.

Analytical Program

The parameters related with the examination comprise of variety in the range length in which distinctive measurement of diameter. Concrete cylinder and the GFRP tube were modelled using four node linear rectangular elements. Steel pipes were modelled using 3D element. Contact between various parts was modelling using interaction and constraint options that replicate the actual contact behaviour in test specimens. Surface to surface interaction were used to model the contacts between steel pipe, concrete and GFRP tube. The analysis study of the column is carried out with the material properties as mentioned earlier and the load- deflection curves was obtained for various parameters. A three-dimensional model has been proposed in which all the structural parameters associated with nonlinearities are included.

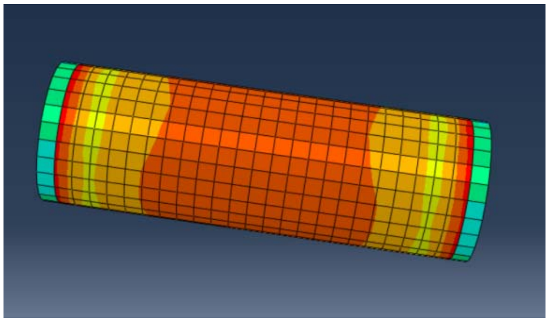

Figure-3.1. Deformation of GFRP tube.

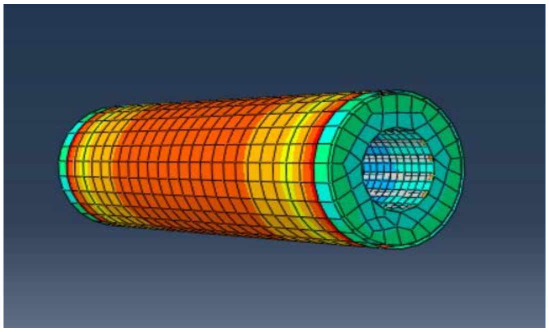

Figure-3.2. Deformation of full model.

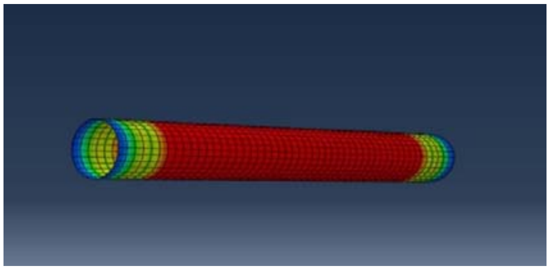

Figure-3.3. Deformation ofsteel pipe model.

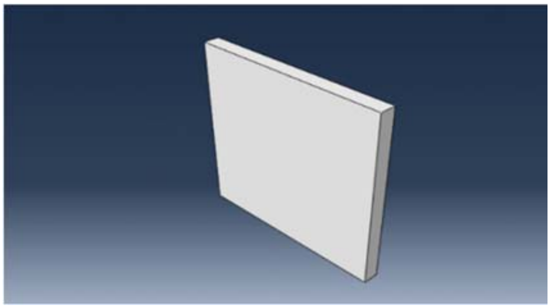

Figure-3.4. Steel plate model.

Procedure

The modelling is done using finite element software, the components created in the software are 1) steel plates 2) GFRP tube with different thickness 3) concrete cylinder 4) steel pipe. The models are created in two different thickness and the properties of GFRP tube is shown in the Table-1 according to the coupon test and manufacture' report and for composite elements the properties are mentioned in the Table-2. The steel plate is created with 20 mm thickness of 300 mm square plate as

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shown in the Figure-3.4. GFRP tube is created with the properties mentioned in the Table-1 and the dimensions of the tube is taken with different diameters and length as same and these tubes are mentioned with the different name according to the thickness and diameter variation shown in the Table-3, the model is shown in Figure-3.1. The circular steel pipe is created with 88.9 mm diameter and thickness 1.6 mm is shown in the Figure-3.3. Meshed model is shown in Figure-2.2. Contact between various parts was modeled using interaction and constraint options that represent the actual contact behaviour in test specimens. Surface to surface interaction were used to model the contacts between steel pipe, concrete and GFRP tube. The loading condition taken in this thesis is axial compression shown in Figure-2.3. The analysis study of the column is carried out with the material properties as mentioned earlier and the load-deflection curves was obtained for various parameters. A three- dimensional model has been proposed in which all the structural parameters associated with nonlinearities are included. The Table-4 and Table-5 states the results of the different types of diameters with presence and absence of core filled in the column with various thickness with different names in order to identify easily.

Table-3. Initial Crack of GFRP and Conventional concrete specimens with core filled.

S. No	Specimen	Length (mm)	Diameter (mm)	Thickness (mm)	L/d	D/t	Crack (kN)
1.	FCSCT 160-2a	500	160	2	2	80	1246
2.	FCSCT 155-2b	500	155	2	2.56	77.5	1216
3.	FCSCT 150-2c	500	150	2	2.63	75	1138
4.	FCSCT 160-4a	500	160	4	2	40	1900
5.	FCSCT 155-4b	500	155	4	2.56	38.75	1890
6.	FCSCT 150-4c	500	150	4	2.63	37.5	1834
7.	CCWS-1a	500	160	-	2	-	880
8.	CCWS-2b	500	155	-	2.56	-	880
9.	CCWS-3c	500	150	-	2.63	-	880

Table-4. Initial Crack of GFRP and Conventional concrete specimens without core filled.

S. No	Specimen	Length (mm)	Diameter (mm)	Thickness (mm)	L/d	D/t	Crack (kN)
1.	FCST 160-2a	500	160	2	2	80	940
2.	FCST 155-2c	500	155	2	2.56	77.5	930
3.	FCST 150-2b	500	150	2	2.63	75	910
4.	FCST 160-4a	500	160	4	2	40	726
5.	FCST 155-4b	500	155	4	2.56	38.75	652
6.	FCST 150-4c	500	150	4	2.63	37.5	541
7.	CCWS-1a	500	160	-	2	-	880
8.	CCWS-2b	500	155	-	2.56		880
9.	CCWS-3c	500	150	-	2.63	-	880

The above two Tables 3 and 4 refers the various specimens with different names and diameters as mentioned. The CCWS refers to Conventional concrete with reinforcement and the diameters are classified with various alphabetical. The CCWOS refers to 1conventional concrete with reinforcement in the concrete columns. In this investigation we are comparing the results of GFRP tubes encased concrete columns of with and without steel pipe with conventional with and without steel pipe specimens and the formation of initial crack in different diameters are listed. The results of different thickness are shown with the respective graphs in the results part.

RESULT AND DISCUSSIONS

Load-Axial Deformation curves obtained for different specimens with various diameter and thickness are shown in figure 4and 5 and the conventional specimen graph obtained with the same size and diameter with and without core filled is illustrated in Figure-5.

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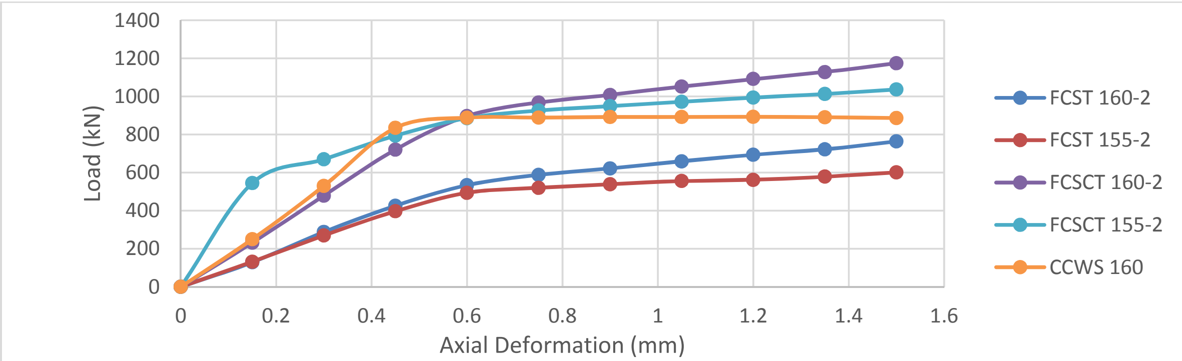

Figure-4. Load vs Axial Deformation curves of GFRP with and without core filled with concrete of 2mm thickness.

The above graph refers comparison of 2mm thickness of GFRP tube column with and without core filled. Here, there are three types of diameters were taken with numerical and alphabetical terms of 160 mm with tube length of 500 mm. The initial cracks formed at different loading conditions are shown in the Table-5. The static loading and axial compression test is done on the above three different diameter tubes. From the above eight specimens the more energy absorption and stiffness is carried out by FCSCT 160-2.

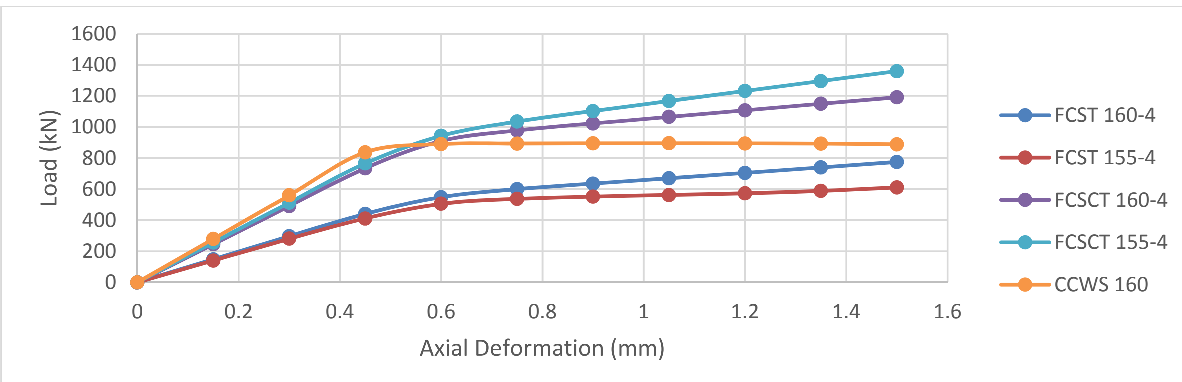

Figure-5. Load vs Axial Deformation curves of GFRP with and without core filled with concrete of 4mm thickness.

The above graph refers comparison of 4mm thickness of GFRP tube column with and without core filled. Here, there are three types of diameters were taken with numerical and alphabetical terms of 160 mm with tube length of 500 mm. The initial cracks formed at different loading conditions are shown in the Table-5. The static loading and axial compression test is done on the above three different diameter tubes. From the above eight specimens the more energy absorption and stiffness is carried out by FCSCT 160-4.

CONCLUSIONS

A numerical investigation is carried out to compare the axial compression behaviour of FRP Tubes Encased Concrete Columns with and without steel pipe is discussed in the present thesis. Total 16 specimens are modelled and made analysis using finite element software. According to the results obtained these conclusions can be drawn:

a) Generally, concrete filled double skin tubular member shown same behaviour lie conventional concrete filled steel tubular member in present analysis.

b) Increased strength has been observed for the members to the composite action between the members.

c) As we add material the difference in the model is clearly shown and observed.

d) The deflection obtained is less for 4 mm GFRP is to 1.6 mm compared to 2 mm.

e) Of the two thickness with reinforcement considering, 4 mm tube is having the optimum strength compared with 2 mm and conventional concrete and having good energy absorption capacity and stiffness.

f) As the diameter of the tube increases, deflection got significantly reduced.

g) All the models are compared and the results obtained are reasonable and satisfied.

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