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Research Article

EXPERIMENTAL INVESTIGATION OF COMPRESSIVE STRENGTH OF COMPOSITE GFRP DOUBLE SKIN TUBULAR COLUMN

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A R T I C L E I N F O

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A B S T R A C T

A glass fibre reinforced polymer (GFRP) concrete-steel double-skin tubular column (DSTC) consists of an outer GFRP tube and an inner steel tube, with the space in between filled with concrete. This paper focuses on the compressive strength of the glass fibre reinforced polymer and steel double skin tubular columns. Double skin tubular columns considered usually are of similar casing material on the inner as well as outer side of the column or both inner and outer tube of same shape, in this paper the never before variations taken are, the circular outer tube is glass fibre reinforced polymer tube with variations in its thickness and inner tube being of steel with variation in its shape As obtained from results, the optimum specimen is the one which has circular cross section on the periphery and as well on the inner side, the specimens with different cross sections demonstrated less compressive strength than the specimens with similar cross sections, but more compressive strength than the control section, thus these columns can be also an optimum replacement of conventional columns. Thickness of the GFRP tube also played an important role in determining the compressive strength of the specimens, the specimens which had more thickness showed enhanced results of compressive strength as compared to specimens which had lesser thickness.

INTRODUCTION

Double Skin Tubular Column (DSTC) is a hollow column which contains concrete section sandwiched between two tubes made of steel, FRP etc DSTC offers numerous structural benefits, including high strength and fire resistances, favorable ductility and large energy absorption capacities. This structures could also be used for utility purposes, there is also no need for the use of shuttering during concrete construction; hence, the construction cost and timeare reduced. These advantages have been widely exploited and have led to the extensive use of concrete-filled tubular structures in civil engineering structures. This column might also be used for utility purposes such as to transfer cables from on floor to another without any serious structural damage to the structure thus the space in column can also be benefitted from.

In research done by Qing Quan Liang (October 2016) presents a new numerical model for predicting the structural performance of circular DCFST short columns under axial compression. The numerical model incorporates new material constitutive relationships of sandwiched concrete in circular DCFST columns. The confinement effects provided by the outer and inner steel tubes on the sandwiched concrete in circular DCFST columns were taken into account in the numerical formulations. Comparisons with existing experimental results on circular DCFST short columns are made to verify the numerical model developed. The numerical model was used to undertake parametric study to examine the effects of important geometric and material parameters on the strength and ductility of axially loaded DCFST short columns. It was demonstrated that the numerical model accurately captured the complete axial load-strain characteristics of circular DCFST short columns under axial compression. A designing formula was proposed and is found to predict the ultimate axial loads of circular DCFST short columns. [1]

In research done by Tao Yu, Shishun Zhang, Le Huang, Chunwa Chan (March 2017) A hybrid fibre-reinforced polymer (FRP) concrete steel double skin tubular column (DSTC) consisted of an outer FRP tubes and an inner steel tube, with the space in between filled with concrete. Paper presented results from the first ever experimenting study on hybrid DSTCs with a large rupture strain (LRS) FRP tube, namely, polyethylene terephthalate (PET) FRP tube. The experimental program involving the testing of 12 hybrid DSTC specimens with or without additional concrete inside the inner steel tube. The test results confirm the ample ductility of hybrid DSTCs with a PET-FRP tube despite the severe local buckling of the inner steel tube at large axial deformations.

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The test results also suggest that the diameter-to-thickness ratio of the inner steel tube is a more critical parameter in such DSTCs than in DSTCs with a glass, carbon or aramid FRP outer tube. [2]

In research done by Yingwu Zhou, Xiaoming Liu, Feng Xing, Dawang Li, Yaocheng Wang, Lili Sui (December 2016) This paper developed a new type of DSTCs that was filled with full lightweight aggregate concrete (FLAC) and reports a systematic study on the compression performance of the FLAC-filled DSTCs at the first time. The results indicate that FLAC in between the FRP and steel tubes was effectively confined, resulting in an excellently ductile behavior in compression and that the ultimate strength and strain of FLAC filled DSTCs were increased by a factor of 1.7 and 3, respectively. The void ratio had limited effect on the ultimate strength of FLAC-filled DSTC while the impact on the ultimate strain was significant. On the basis of the stress-strain model developed for FRP-confined FLAC, a stress-strain model for FLAC-filled DSTC was proposed, which provided a satisfactory agreement with the experimental results. [3]

Experimental Work

Total 15 specimens were cast, out of which 3 were Control specimens, 3 were outer 5 mm thick GFRP tube with inner Circular steel tube, 3 were outer 7 mm thick GFRP tube with inner Circular steel tube, 3 were outer 5 mm thick GFRP tube with inner Square steel tube and 3 where outer 7 mm thick GFRP tube with inner Square steel tube. All specimens cast were tested on Load Testing Machine after 28 days of curing and results were studied for deflection and axial compressive loads

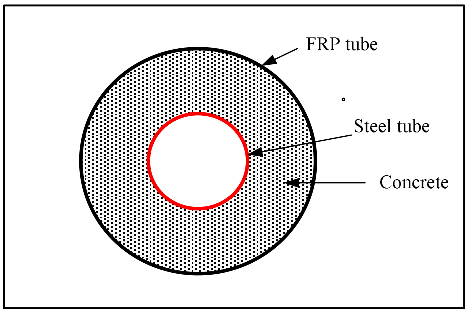

Fig 1 GFRP DSTC

Control Specimen

The diameter of control specimen is 165 mm, the reinforcement of control specimen includes 6 bars of 12 mm (minimum R/F) with lateral ties of 6 mm at 190 mm c/c

Double Skin Tubular Column (DSTC) specimen

These column specimens consist of outer GFRP tube and inner steel tube. The inner diameter of all GFRP tubes is 200 mm and with variation in thickness from 5 mm to 7 mm, the shape of steel tube is varied from circular to square (The cross sectional area is kept approximately equivalent) keeping the thickness constant as 2 mm. Diameter of circular steel tube is 112 mm. The side of square steel tube is 100 mm.

Fig 2 GFRP pipes

RESULTS AND DISCUSSION

Total 15 specimens were tested, which contained 12 specimens of GFRP double Skin tubular columns with variation in thickness of outer GFRP tube from 5 mm to 7 mm and also in the shape of inner steel tube, from circular to square, 3 control specimens with properties of conventional circular columns. All the specimens were tested for axial loads.

Fig 3 Testing Setup

Table 1 Compression strength of DSTC

Sr.No.	Column specification	Ave. Max. Deflection (mm)	Average compressive stress (MPa)
01	CC	13.10	20.78
02	CCF1	22.50	64.07
03	CCF2	24.43	73.78
04	CSF1	22.95	48.38
05	CSF2	24.70	58.51

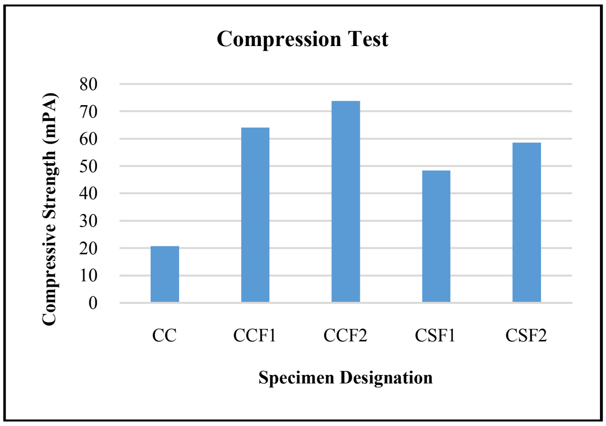

Fig 4 Compression Strength

DISCUSSION

Compressive Strength of control section is on lower side compared to the other specimens and specimen fails very early as compared to other glass fibre reinforced polymer double skin tubular column specimens. The specimens which have inner tube of square shape show much increased compressive strength than the control section but as compared to specimens which have circular inner tube the compressive strength of specimen containing square inner tube is on lowers side. The specimens which have thicker glass fiber reinforced polymer tube in both cases i.e. square inner tube and circular inner tube show higher compressive strength than the specimens having less thicker glass fiber reinforced polymer tube, thus as the thickness increases there is increase in the compressive strength. When we compare the weight of all the specimens the control specimen have much greater weight than the glass fibre reinforced polymer double skin tubular column specimens though the weight of the control section is more the strength exerted by the specimen is on much lower side as compared to glass fiber reinforced polymer sections As the glass fiber reinforced polymer double skin tubular column sections are hollow the cavity present in the column can be used for serviceability in various types of structure without causing any adverse effect on the structural members of the structure.

CONCLUSION

The following conclusion are

After obtaining the test results, the columns having similar cross sections i.e. circular showed average compressive strength of 64.07 MPa for 5 mm thick GFRP tube and 73.78 MPa for 7 mm thick GFRP tube, which is on higher side than specimens having different inner and outer cross sections i.e. circular on outside and square on inside, which showed average compressive strength of 48.38 MPa for 5 mm thick GFRP tube and 58.51 MPa for 7 mm thick GFRP tube

Another aspect which is known after obtaining the results is that the variation in the thickness of outer GFRP tube has an important role in compressive strength of specimens. The specimen which had 7 mm thick GFRP tube showed average compressive strength of 73.78 MPa for circular steel tube and 58.51 MPa for square steel tube which his on higher side than the specimen which had 5 mm thick GFRP tube which show average compressive strength of 64.07 MPa for circular steel tube and 48.38 MPa for square steel tube

When the results of the GFRP double skin tubular column were compared with the control section it was understood that all GFRP double skin tubular column showed average compressive strength of 73.78 MPa, 64.07 MPa, 58.51 MPa and 48.38 MPa were on much greater side than the average compressive strength 20.78 MPa, of control sections. There is 57.04% increase in average compressive strength of lowest compressive strength of GFRP double skin tubular column.

Thus the concluding statement is that the glass fiber reinforced polymer double skin tubular column which has inner as well as outer cross section similar is the optimum replacement of the conventional columns and the thickness of outer tube is an important factor while considering the compressive strength of the section. When these types of columns will be used the overall weight of structure will be reduced drastically because of the cavity present in the section, but the strength will have no negative effect.

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