

Effect of Retrofitting on High Performance Geo Polymer Concrete Filled Aluminium Tubular Section Using Glass Fibre Wrapping

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Abstract

Concrete filled tubular columns play an important role in the construction industry due to its structural behavior and earthquake resistant properties. In this paper the behavior of circular concrete filled aluminium tubular column with glass fibre wrapping is studied experimentally. High performance geo polymer concrete is used for the study. A total of twenty one specimens with 300mm height and 100mm diameter are casted and subjected to axial load. A portion of the columns were wrapped with glass fibre of different layers(single and double) with varying spacings (25mm,46.7mm and 90mm). The retrofitted effect between various layers with respect to wrapping spacings are compared. The stiffness of the columns are also found analytically using the ANSYS software.

Keywords: High performance geo polymer concrete, Aluminium tubular section, glass fibre, retrofitting.

1. Introduction

Composite columns made of concrete filled steel tubes are most preferably used in the construction industry because of their significant advantages over the traditional construction methods. Its combination makes the uses of best properties of both concrete and steel materials. This usage of these composite structures leads to economical saving because of the reduction in the column size. These columns are used where the floor space is premium such as for car parking etc.

The concrete filled steel columns normally have many advantages such as the ductility, high bearing capacity, ease of construction and economical. In the same case concrete filled aluminium columns can provide high strength and high stiffness. It has more advantages such as corrosion resistance, lightness, appearance and ease of production. Also concrete filled aluminium columns eliminate formwork so that the construction time can be reduced. However there is only minimum number of works has been carried out in concrete columns. Hence the structural behavior of concrete filled aluminium tubular section is investigated.

The main function of composite column is to transfer the vertical forces to the bottom. The concrete in composite column resists the compressive force and also reduces the buckling of aluminium member. The aluminium tubes reinforces with concrete to resist the shear force, bending moment and tensile forces.

2. Material Properties

2.1 Geopolymer Concrete:

The concrete mix ratio used for the geo polymer concrete is given in Table 1.

Table 1. Mix proportions of geo polymer concrete

MATERIALS	PROPORTIONS	UNIT
GGBS	413	Kg/m ³
Fly ash	100	Kg/m ³
Fine aggregate	683	Kg/m ³
Coarse aggregate	1050	Kg/m ³
Alkaline activator solution	250	l/m ³

2.2 Glass Fibre:

The fibres are cheaper and more flexible than the carbon fibre. Its applications include aircrafts, boats and external door skins. The properties of glass fibre is shown in Table 2.

Table 2.- Properties of Glass fibre:

PARAMETER	VALUE	UNIT
Density	2500	Kg/m ³
Young's modulus	70	Gpa
Tensile strength	3400	Mpa
Elongation at break	2.5	%

3. Specimen Detail

The 300mm long circular hollow aluminium tubular sections with diameter 100mm is used. The slenderness ratio of the column is $D/t=33.3$ and $L/D=3$. The hollow circular aluminium tubular section is infilled with the high performance geopolymer concrete. Then the glass fibre reinforced polymers is wrapped along the surface of the aluminium tube. During the wrapping process, the hardener and the epoxy resin are correctly proportioned and mixed together thoroughly. Careful attention should be made to the effectiveness of bonding between the aluminium and the fibre. The aluminium tubular section is divided into two groups G1 and G2. In G1 the glass fibre wrapping is of one layer wrapping with the spacings namely 25mm,46.7mm and 90mm these various spacings are named differently as CGF11,CGF12 and CGF13 respectively. In G2 the wrapping is done with two layers with the same spacings and named as CGF21,CGF22 and CGF23 respectively. The test specimens were cast into the shape and dimensions as illustrated in the Fig.1.

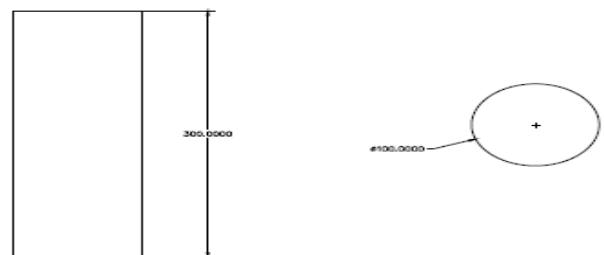


Figure1: Dimensions of specimen in mm

4. Experimental Results

4.1 Compression Test

The ultimate compressive strength of the concrete cube is determined using this test. The concrete specimens were casted to 100×100×100mm sized cubes. The curing and testing days were adopted at the age of 7day,14day and 28 day. The specimens are casted with both conventional concrete and geo polymer concrete. The results were shown in Table 3. And results are compared in Fig 2.

Table 3.Compression test on CC and HPGPC

MIX	CURING DAYS	COMPRESSIVE STRENGTH (N/mm ²)
CC	7	51.5
	14	72.8
	28	81.2
HPGPC	7	64.8
	28	87.63

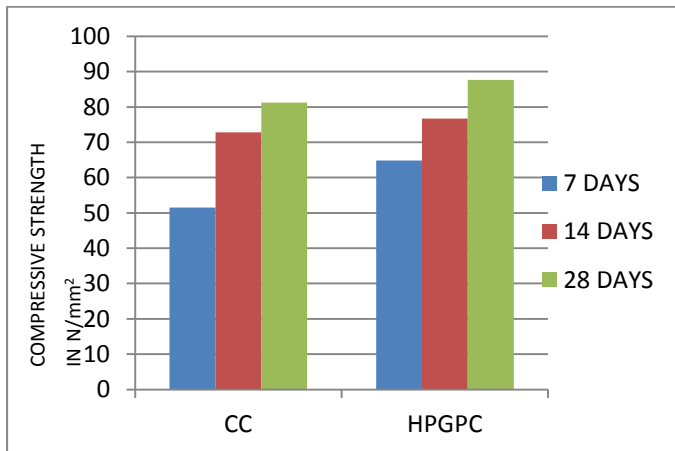


Figure 2.Comparison of compressive strength of CC and HPGPC

4.2 Split Tensile Test

Cylindrical specimens of size 100×200mm were used. This test is done in the compression testing machine by placing the cylinder specimen horizontally. This test is also done for both conventional concrete (CC) and high performance geo polymer concrete (HPGPC). The results were shown in Table 4. and compared in Fig.3.

Table 4.Split Tensile test on CC and HPGPC

MIX	CURING DAYS	TENSILE STRENGTH (N/mm ²)
CC	7	5.3
	14	6.9
	28	8.1
HPGPC	7	6.4
	28	8.8

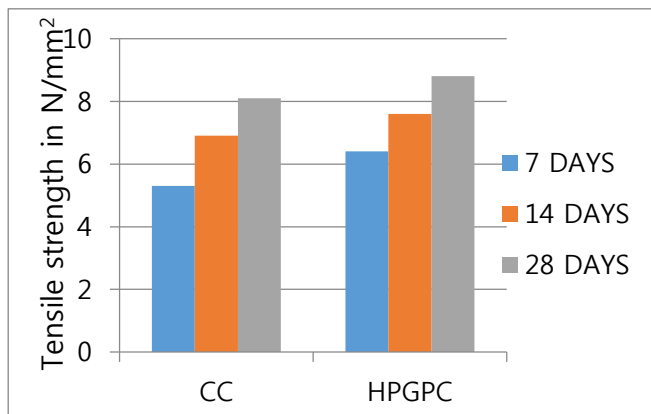


Figure 3.Comparison of tensile strength of CC and HPGPC

4.3 Flexure Test

The two point loading method was used to test the beam of size (100mm×100mm×500mm). The flexure test was conducted only for the high performance geo polymer concrete as it gives the highest strength in the previous tests. The test results were shown in Table 5.

Table 5.Flexural strength test of HPGPC.

MIX	CURING DAYS	FLEXURE STRENGTH (N/mm ²)
HPGPC	28	8.03

4.4 Ultimate Load Comparison

The ultimate load of the aluminium short column is tested with the compression testing machine. The results were shown in Table 6. And compared in Fig.4

Table 6.Ultimate load of the column

GROUP	COLUMN DESIGNATION	ULTIMATE LOAD(KN)
Sample Column	SC	728.6
	CGF11	838.3

G1	CGF12	821
	CGF13	761
G2	CGF21	861
	CGF22	837.6
	CGF23	801.6

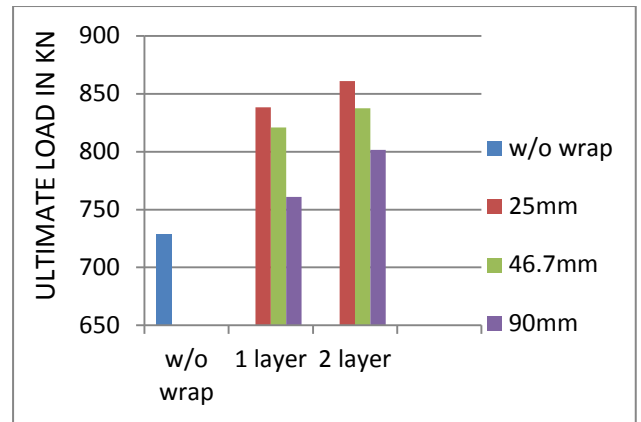


Figure 4.Comparison of ultimate load of columns

5. Analytical Results

The column of 300mm length and 100mm diameter is modeled and meshing is done. One face of the column is kept fixed and the ultimate load of 800kN is applied on the other face. The modelling and meshing details are shown in Fig 5

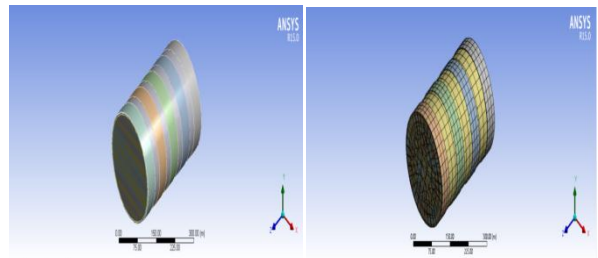


Figure 5.Modelling and meshing of columns

5.1 Total Deformation of Column:

The total deformation of the aluminium short column is analysed using the finite element method. The deformation is shown in Fig 6.

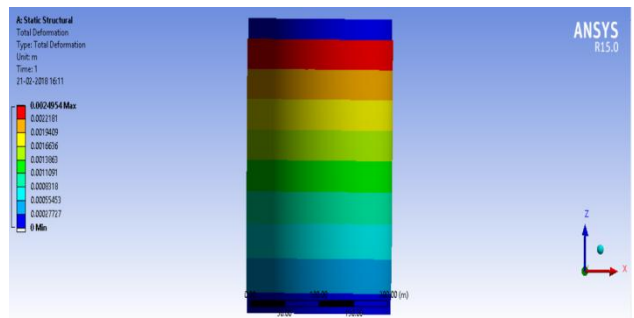


Figure 6.Deformation of the column

The deformation is taken for the ultimate load of the column. The results are shown in Table 7. And compared in Fig 7.

Table 7.Deformation of the column:

GRO UP	COLUMN DESIGNATION	LOAD(KN)	DEFLEC TION (mm)	STIFFN ESS (KN/m m)	YOUN GS MODU LUS (Gpa)
SC	SC	800	4.16	192.30	7.276
	CGF11	800	2.49	321.28	12.273
G1	CGF12	800	2.62	305.34	11.446
	CGF13	800	3.32	240.96	9.260
G2	CGF21	800	2.41	331.95	12.73
	CGF22	800	2.70	296.29	11.318
	CGF23	800	3.30	242.42	9.26

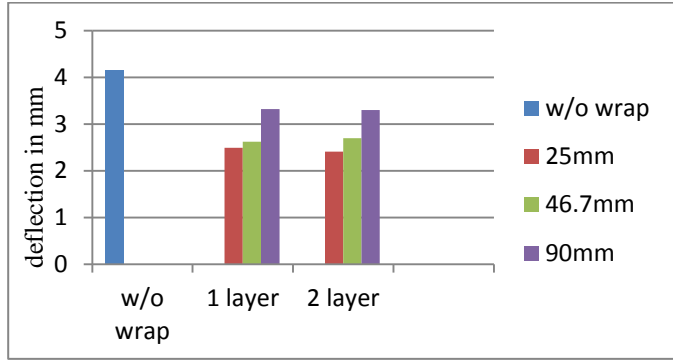


Figure 6: Deformation of the column-comparison

5.2 Stiffness

The stiffness of columns with varying spacings of wrapping are shown in Fig 7.

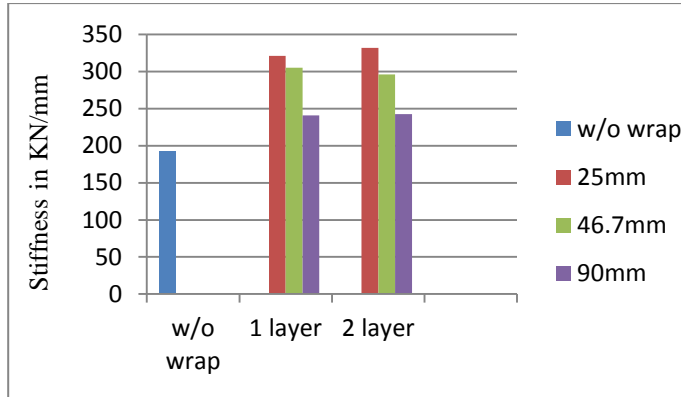


Figure 7: Stiffness of the column-comparison

5.3 Stress Strain Curve

The stress strain characteristics for various loads are shown in Fig 8

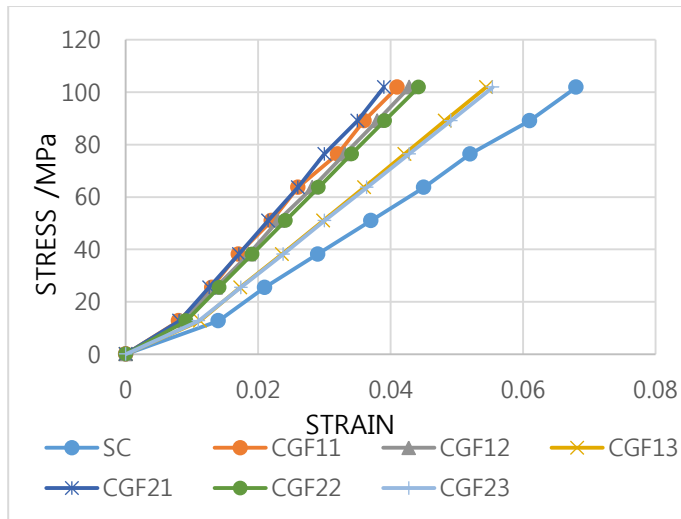


Figure 8: Stress-strain curve

6. Conclusion

From the experimental study it is observed that the the load carrying capacity of the circular aluminium column is greatly enchaced by the use of GFRP. The column with the wrapping of lesser spacings shows greater strength when compared it with the larger spacings. There sholud be 14% increase in load carrying capacity for the single layered wrapping and 18% increase for the two layer wrapping of GFRP. The analytical study shows that the total deformation of the column. the deformation is controlled for the GFRP wrapped specimens than the unwrapped columns. The stiffness is also increased for the GFRP wrapped column based on the analytical results.

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