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Effect Of Gfrp Jacketing & Cfrp Jacketing On Rc Columns Of Different Cross-Sectional Shapes

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Abstract: *FRP is an Advanced Composite Material (ACM) that is relatively new material to civil engineering. It holds a better choice than reinforcing steel in certain applications. In order to attain large deformation before failure occurs and to enhance an adequate load resistance capacity, RC columns has to be laterally jacketed. Jacketing RC column with FRP improves column performance not only by carrying some fraction of axial load applied to it but also by providing lateral confining pressure to the column externally. In this work effect of circular, rectangular and square columns on GFRP jacketing and CFRP jacketing having same cross-sectional area were analysed. RC columns were analysed in ANSYS 15. The percentage area reduction of concrete in RC columns when FRP jacketing is provided is found out.*

Keywords - *Column Jacketing, buckling analysis, different cross-sectional shapes, concrete area reduction*

I. Introduction

Column jacketing with FRP (Fiber Reinforced Polymer (FRP) composites have their advantage over traditional materials. Problems associated with the deterioration of RC structures are usually due to corrosion of the reinforcing steel and spalling of the concrete. Thus, retrofitting methods have to be considered in order to maintain the integrity of structures.

Now, for the up gradation of existing structures FRP composites have their merits over traditional materials. Corrosion resistance, light weight, high-strength to weight ratio, and high efficiency in construction are the advantages of FRP for civil engineers to prefer this sheet material. Compressive strength of column can be improved by providing effective lateral confinement with FRP. R.Kumutha reported that GFRP jacketing in RC column resulted in enhancing the compressive strength and ductility [1].

The Glass Fiber Reinforced Polymer (GFRP) jacketed RC column performed much better than steel reinforced column. GFRP has significantly increased the strength and ductility of concrete by creating a perfect adhesive bond in between concrete and the jacketing material [8].

Carbon Fiber Reinforced Polymer (CFRP) is a strong, very light composite material used for civil engineering purposes. External jacketing of concrete columns by high-strength fiber composites around the surface of column improves the strength and ductility.

Area of concrete required for construction of new RC column can be reduced by jacketing it with FRP sheets. With the reduction in concrete area the dead load of the structure can be decreased which in turn increases the available free space. Also FRP jacketing is an economical construction method.

Fig. 1. Jacketing of FRP sheet around RC column

II. Scope

The scope includes comparison of performance of externally jacketed CFRP jacketing and GFRP jacketing on behaviour of square, rectangular and circular RC columns. As the load carrying capacity of RC columns increases with FRP jacketing, the area of concrete for construction can be reduced. Hence the dead load of the structure can be reduced and the available free space can be increased. So FRP jacketing is economical too

III. Objectives

1. To determine the ultimate failure load of RC columns using Finite Element software.
2. To find out the percentage area reduction in concrete for designing new RC columns when FRP jacketing is provided.
3. To compare the results obtained from CFRP jacketed RC Columns and GFRP jacketed RC Columns

IV. Validation

An FE model of RC control column and FRP jacketed RC column of square, rectangular and circular cross-sectional shapes was validated using experimental results from journal [1] and [2]. The Results of validation are shown in Table 1.

Table 1. Results of Validation

Column Designation	Ultimate Failure load (kN)	Deformation (mm)		Error (%)
		Experiment	ANSYS	
0 Square	766	1.18 mm	1.25	5.9
1 Square	786	1.2 mm	1.27	5.8
0 Rectangular	750	1.21 mm	1.22	0.8
1 Rectangular	772	1.34 mm	1.24	7.4
0 Circular	509	4.5 mm	4.26	5.3
1 Circular	876	7.9 mm	7.3	7.5

V. Present Study

A. RC Columns

Square, rectangular and circular RC columns having same cross-sectional were modelled. Design details of RC column are presented in Table 2.

Table 2. Design details of RC columns

Column c/s Shape	B (mm)	D (mm)	H (mm)	Main Bars	Lateral Ties
Square	150	150	3000	4# 8 mmØ	6 mmØ @ 100 mm c/c
Rectangular	110	210	3000	4# 8 mmØ	6 mmØ @ 100 mm c/c
Circular	Diameter 170mm		3000	4# 8 mmØ	6 mmØ @ 100 mm c/c

B. Finite Element Material Models

1. Concrete

M25 mix concrete having modulus of elasticity (E) = 25000 N/mm^2 and Poisson's ratio (ν) = 0.15 was taken.

2. Reinforcement

Fe415 steel bars having modulus of elasticity (E) = 200000 N/mm^2 and poisson's ratio (ν) = 0.2 was taken.

3. FRP Sheet

Properties of GFRP and CFRP sheets are shown in Table 3

Table 3. Properties of GFRP sheet[1] and CFRP sheet[14]

FRP Sheets	Modulus of Elasticity (MPa)	Poison's ratio (ν)	Sheet Thickness (mm)	Shear Modulus (MPa)
GFRP	10500	0.26	1.1	1520
CFRP	230000	0.22	1.1	3270

C. FE Model

Finite Element modelling has been done in ANSYS 15. All control RC columns and FRP jacketed RC columns were modelled.

D. Boundary Condition

All columns were fixed at one end and free at other end. Axial loading is applied to find out the buckling load.

VI. Results And Discussion

A. RC Columns subjected to axial loading

Buckling analysis has been carried out on columns in ANSYS 15 to find out the ultimate load carrying capacity.

Table 4. Load carrying capacity of columns

Column c/s Shape	Jacketing Provided	Layers of FRP Jacketing	Ultimate Load Carrying Capacity (kN)
Rectangular	Control	-	140.94
	GFRP	1	164.23
		2	199.27
	CFRP	1	249.49
		2	293.73
Circular	Control	-	257.48
	GFRP	1	287.87
		2	318.57
	CFRP	1	399.98
		2	445.38
Square	Control	-	262.52
	GFRP	1	297.36
		2	333.17
	CFRP	1	369.08
		2	479.52

VII. Area Reduction Of Concrete When Frp Jacketing Is Introduced

Both GFRP and CFRP jacketing on RC columns increases the load carrying capacity in all cross-sectional shapes. Hence in designing new columns with FRP jacketing the amount of concrete area can be reduced with respect to control column without jacketing.

In this study trial sections are selected and buckling analysis is carried out to find out the concrete area reduction when FRP jacketing is introduced to RC columns of rectangular, circular and square cross-sectional shapes.

1. Concrete Area Reduction for GFRP Jacketed RC Columns

For 1 layer GFRP jacketed rectangular RC column, 200 mm × 105 mm is having the same load carrying capacity compared to control RC column.

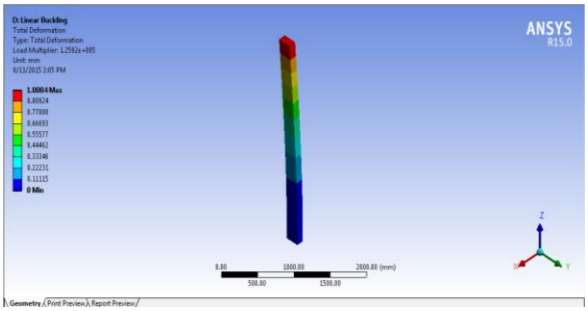

Fig.1. Ultimate load carrying capacity of 200 mm × 105 mm 1 layer GFRP jacketed rectangular RC column.

For 1 layer GFRP jacketed circular RC column, 168 mm diameter circular column is having the same load carrying capacity compared to control RC column.

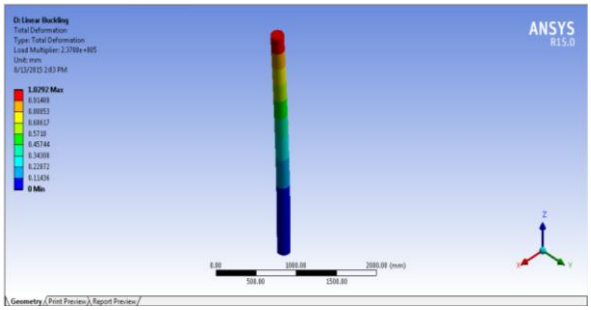

Fig.2. Ultimate load carrying capacity of 168 mm diameter 1 layer GFRP jacketed circular RC column

For 1 layer GFRP jacketed square RC column, 147 mm × 147 mm square column is having the same load carrying capacity compared to control RC column.

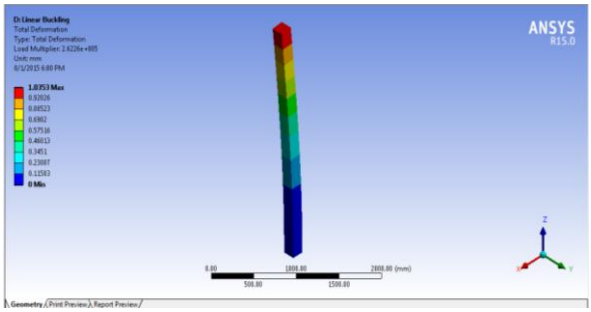

Fig.3. Ultimate load carrying capacity of 147 mm × 147 mm 1 layer GFRP jacketed square RC column.

For 2 layer GFRP jacketed rectangular RC column, 196 mm × 103 mm is having the same load carrying capacity compared to control RC column.

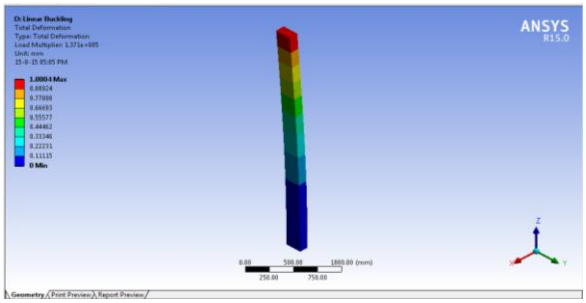

Fig.4. Ultimate load carrying capacity of 196 mm × 103 mm 2 layer GFRP jacketed rectangular RC column.

For 2 layers GFRP jacketed circular RC column, 165 mm diameter circular column is having the same load carrying capacity compared to control RC column.

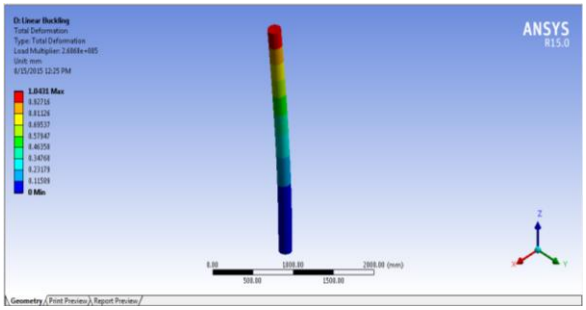

Fig.5. Ultimate load carrying capacity of 165 mm diameter 2 layer GFRP jacketed circular RC column.

For 2 layer GFRP jacketed square RC column, 145 mm × 145 mm square column is having the same load carrying capacity compared to control RC column.

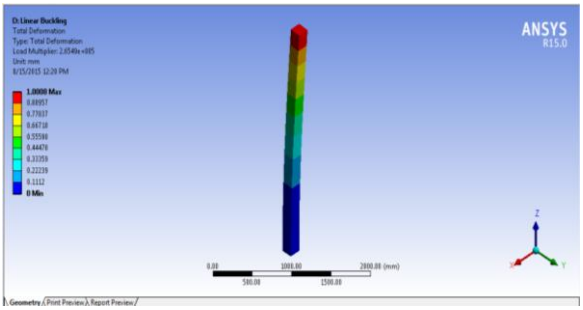

Fig.6. Ultimate load carrying capacity of 145 mm × 145 mm 2 layer GFRP jacketed square column.

2. Concrete Area Reduction for CFRP Jacketed RC Columns

For 1 layer CFRP jacketed rectangular RC column, 190 mm × 100 mm is having the same load carrying capacity compared to control RC column.

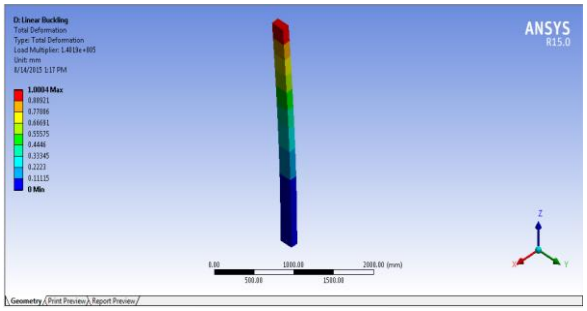

Fig.7. Ultimate load carrying capacity of 190 mm × 100 mm 1 layer GFRP jacketed rectangular RC column.

For 1 layer CFRP jacketed circular RC column, 162 mm diameter circular column is having the same load carrying capacity compared to control RC column.

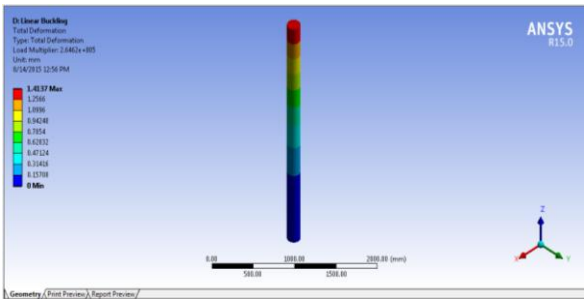

Fig.8. Ultimate load carrying capacity of 162 mm diameter 1 layer CFRP jacketed circular RC column.

For 1 layer CFRP jacketed square RC column, 140 mm × 140 mm is having the same load carrying capacity compared to control RC column.

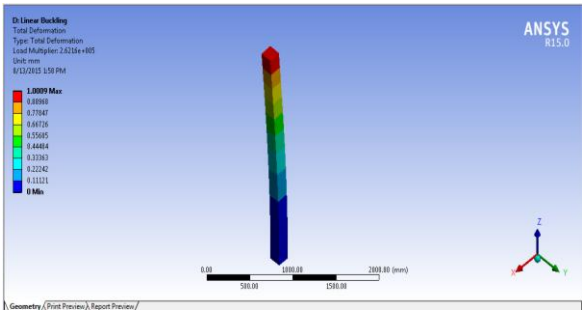

Fig.9. Ultimate load carrying capacity of 140 mm × 140 mm 1 layer CFRP jacketed square RC column.

For 2 layer CFRP jacketed rectangular RC column, 175 mm × 92 mm is having the same load carrying capacity compared to control RC column.

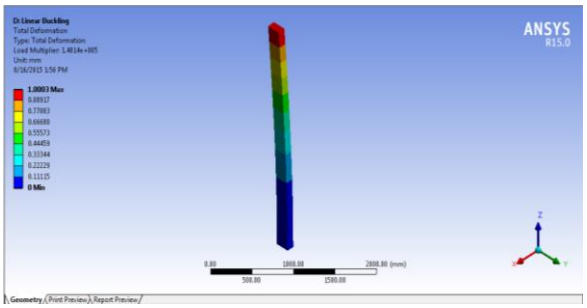

Fig.10. Ultimate load carrying capacity of 175 mm × 92 mm 2 layer CFRP jacketed rectangular RC column.

For 2 layer CFRP jacketed circular RC column, 150 mm diameter circular column is having the same load carrying capacity compared to control RC column.

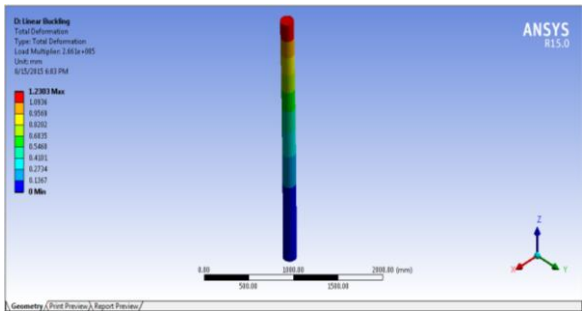

Fig.11. Ultimate load carrying capacity of 150 mm diameter 2 layer CFRP jacketed circular RC column.

For 2 layer CFRP jacketed square RC column, 128 mm × 128 mm square column is having the same load carrying capacity compared to control RC column.

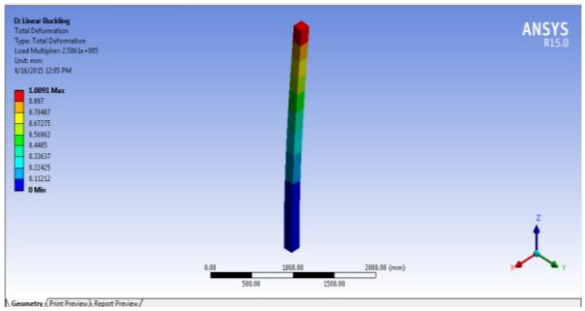

Fig.12. Ultimate load carrying capacity of 128 mm × 128 mm 2 layer CFRP jacketed square column.

The percentage area reduction in concrete when FRP jacketing is provided to RC columns summarized in Table 5.

Table 5. Concrete Area Reduction under FRP Jacketing

Column c/s	Jacketing Provided	Layers of FRP	Area of Column (mm^2)	% Reduction in concrete area
Rectangular	GFRP	1	21000	9.09
		2	20188	12.60
	CFRP	1	19000	17.74
		2	16100	30.30
Circular	GFRP	1	22167	3.50
		2	21382	5.79
	CFRP	1	20612	9.19
		2	17671	22.14
Square	GFRP	1	21609	3.96
		2	21025	6.55
	CFRP	1	19600	12.88
		2	16384	27.18

VIII. Conclusion

- GFRP and CFRP jacketing enhances the axial load carrying capacity of rectangular, circular and square RC columns by providing additional confinement without increasing the column size.
- As FRP jacketing increases the load carrying capacity of RC columns the percentage area reduction in concrete in rectangular cross-section is found to be more effective than square and circular in designing new RC columns.
- Thus, it can be recommended from the study that FRP jacketing is a very good alternative for strengthening of existing square, circular and rectangular RC column and it helps in economical construction by concrete reduction in designing new RC columns

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