IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN : 2278-1684, p-ISSN : 2320–334X
PP 40-45
www.iosrjournals.org

Analysis of Column Retrofitted With Fiber Reinforced Polymer in Civil Infrastructure

Poonam A. Patil[1], Prof. G.R. Patil[2]
[1](M.E. (Structure) Student, Department of Civil Engineering Rajarshi Shahu College of Engineering, Tathawade, Pune, Maharashtra-India)
[2](Associate Professor Department of Civil Engineering Rajarshi Shahu College of Engineering, Tathawade, Pune, Maharashtra-India)

Abstract: *The present paper deals with the verification of experimental results in terms of load-carrying capacity and strains, by using software. Also to check the load carrying capacity with different shapes of columns with same cross sectional area. Parameters considered are the number of composite layers and the corner radius for a square shape. The number of layers of FRP materials and the corner radius are the major parameters, having a significant influence on the behavior of specimens. The test results from preliminary testing proved that the benefit of confinement could be enhanced by increasing the stiffness of external confinement applying multiple layers and by a good corner radius for square shape.*
Depending on the selected radius of edge, the section varied from square to circular. The primary variables are corner radius and lap length of FRP. The test result shows that smoothing the edge of square cross section plays a significant role in delaying the rupture of FRP composite at these edges, and efficiency of FRP confinement is directly related to the radius of cross section edges.
Keywords: *Introduction, Literature review, Methodology of work, Preparation of model, model description, discussion of results, conclusion, appendix, acknowledgment*

I. Introduction

In recent years, the repair of un-strengthened and damaged reinforced concrete member by externally bonding of fiber reinforced polymer laminates has received considerable attention. Jacketing confines concrete, and hence increase the strength and ductility of jacketed column. A significant amount of research has been devoted to circular column that have been retrofitted with FRP. But much less is known about FRP confined rectangular/square column in which concrete is non-uniformly confined and effectiveness of confinement is much reduced. Some studies suggest that sharp corner offer no confinement. However, most published research indicates that a certain degree of effective confinement is provided by jacket with sharp corner. To study this problem, this study undertook compressive testing to investigate the effect of corner radius on strength and ductility of FRP confined concrete column

Fiber-reinforced polymer (FRP) composite materials were first introduced in the early 1940s. Although composite materials have been used in limited architectural applications since 1950s, their use in construction, and particularly concrete application, remained a novelty into the 1980s. Some use of FRP reinforcing products was introduced in Europe and Asia in 1970s & 1980s. The FRP plate bonding technology was first investigated at Swiss Federal Laboratory for Materials Testing and Research, where tests on RC beams strengthened with CFRP plates started in 1984

II. Literature Review

Mohamed H. Harajli (2006) Author explains, axial stress–strain relationship for FRP confined circular and rectangular concrete Columns, Cement & concrete composites. A general mathematical model is developed to describe the stress–strain relationship of FRP confined concrete. The relationship is applicable to both circular and rectangular columns, and accounts for the main parameters that influence the stress–strain response. These include the area and material properties of the external FRP wraps, the aspect ratio of rectangular column sections, the corner radius used for FRP application, and the volumetric ratio and configuration of internal transverse steel. The proposed model reproduced accurately experimental results of stress–strain or load–deformation response of circular and rectangular columns. In addition to its importance in evaluating the effect of FRP confinement on the ultimate axial strength of concrete columns, the developed stress–strain relationship can be employed very efficiently and effectively for analyzing the response of FRP confined concrete under different types of load application.

Riad Benzaid1, Nasr-Eddine Chikh, Habib Mesbah.(2008) explained behavior of square concrete column confined with GFRP composite wrap.The present paper deals with the analysis of experimental results in terms of load-carrying capacity and strains, obtained from tests on square prismatic concrete column, strengthened with external glass fiber composite. The parameters considered are the number of composite layers and the corner radius for a square shape. A total of twenty-one prisms of size 100 × 100 × 300 mm were tested under strain control rate of loading. The external confinement with reinforced polymers composite can significantly increase the strength of the specimen under axial loading. The experimental results clearly demonstrate that composite wrapping can enhance the structural performance of concrete columns under axial loading. The number of layers of FRP materials and the corner radius are the major parameters, having a significant influence on the behavior of specimens. The test results from preliminary testing proved that the benefit of confinement could be enhanced by increasing the stiffness of external confinement applying multiple layers and by a good corner radius for square shape.

Amir Mirmiran and Mohsen Shahawy (1997) explained behavior of concrete confined by fiber composite. The present study indicates that these models generally result in overestimating the strength and unsafe design. The study also shows a unique characteristic of confinement with fiber composites in that, unlike steel, FRP curtails the dilation tendency of concrete, as it reverse the direction of volumetric strains. This paper provides a framework for better understanding of the behavior of fiber-wrapped of FRP-encased concrete columns.

M.N.S. Hadi((2006) explained behavior of FRP wrapped normal strength concrete columns under eccentric loading. This paper presents results of testing six normal strength concrete columns under eccentric loading. The columns are wrapped with different number of layers of FRP. Results show that wrapping a column with an adequate number of FRP layers will result in higher strength, ductility and energy absorption than a column reinforced with steel bars.

Sangeeta Gadve, A. Mukherjee, S.N. Malhotra(2009) studied corrosion of steel reinforcements embedded in FRP wrapped concrete Construction & building materials. This paper investigates the progression of corrosion of steel in concrete after it has been treated with surface bonded FRP. Concrete cylinders with embedded steel bars are immersed in salt water and anodic current is passed through the reinforcement to initiate cracking in concrete due to accelerated corrosion of steel. Glass and carbon FRP sheets have been adhesively bonded on the cylinders. Anodic current was continued for specified times. Pull out strength, mass loss, half cell potential of the steel and cell voltage have been reported as metrics of performance of the samples. FRP wrapped samples have shown substantially higher resistance to corrosion. Cyclic behavior of FRP wrapped column under axial and flexural loadings, by Barbara FERRACUTI and Marco SAVOIA. The behavior of RC columns wrapped by composite material sheets (FRP) under axial force and cyclic bending is studied. Cyclic constitutive laws for confined and unconfined concrete in compression, for concrete under tension and for steel reinforcing bars are introduced. Numerical results are in good agreement with experimental tests. Hysteretic dissipated energy for cyclic bending is also estimated. Wrapping with FRP is shown to be very effective, increasing significantly ductility of columns under bending

III. Methodology Of Work.

3.1Preparation of model

The program conducted into two stages. The first stage consists of testing control specimen 150mm×150mm×300mm. The second stage consists of testing FRP wrapped specimens. All of the specimens were 300 mm in height but had different corner radii. The primary variables in this investigation are corner radius and lap length. Fig. 1 shows corner radius variation. Corner radius is of 0, 25, 50, 75mm, where 0 and 75 mm corresponds to square and circular column respectively. Lap length of FRP sheet is of 150, 300, 450 mm. The total number of specimen is 4(corner radius) ×3(lap length) = 12 plus 4 control specimen.. In this study, the specimen with different corner radius and same FRP lap length were analyzed by using the Ansys..

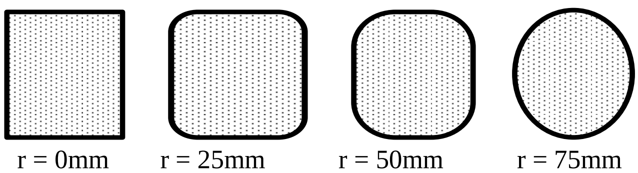

Fig. 1 Cross-section of column specimen

3.2 Model description

For the analysis of specimen total 16 models has prepared. For concrete model used material properties Youngs modulus E=25000 N/mm^2 , Poisson's ratio $\mu = 0.2$ and for the lamination of FRP sheet used GFRP material properties are Youngs modulus E=73000 N/mm^2 , Poisson's ratio $\mu = 0.22$

First prepared the the model of concrete cube and then applied the pressure on it until its failure. Note down the stress,strain and deformation values of the element. In the same manner prepared model for FRP gave 1mm thickness of glass fiber to the concrete cube model and analyzed it. Fig.2 shows the loading on column in ansys.

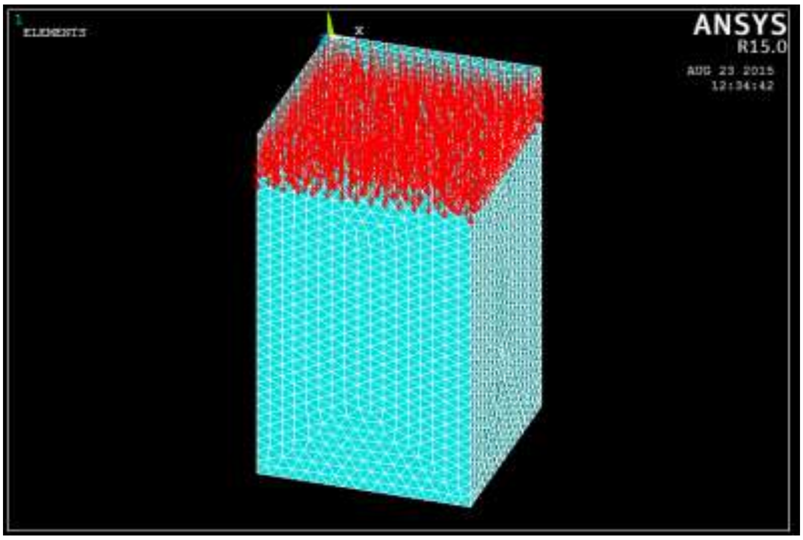

Fig. 2 Distributed loading on column

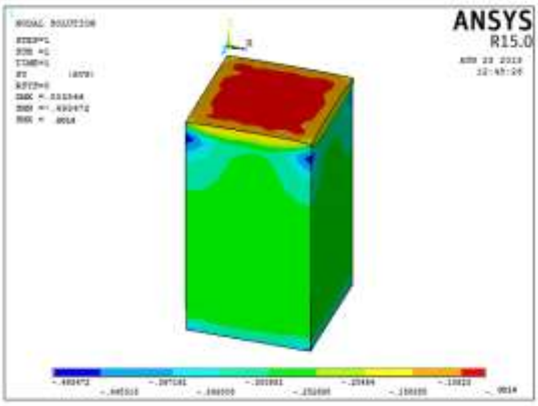

Fig. 3 Stress and defection on S-cr0 without wrapped frp sheet

For to check the load carrying capacity of different shapes with same cross sectional area prepared five different shapes of columns with same cross sectional area and wrapped it with CFRP material used CFRP material, properties are Youngs modulus E=23000 N/mm^2 , Poisson's ratio $\mu = 0.21$, density = 18x10^-6 N/mm^3. Fig.4 shows the results of stress and deflection of different shapes of column.

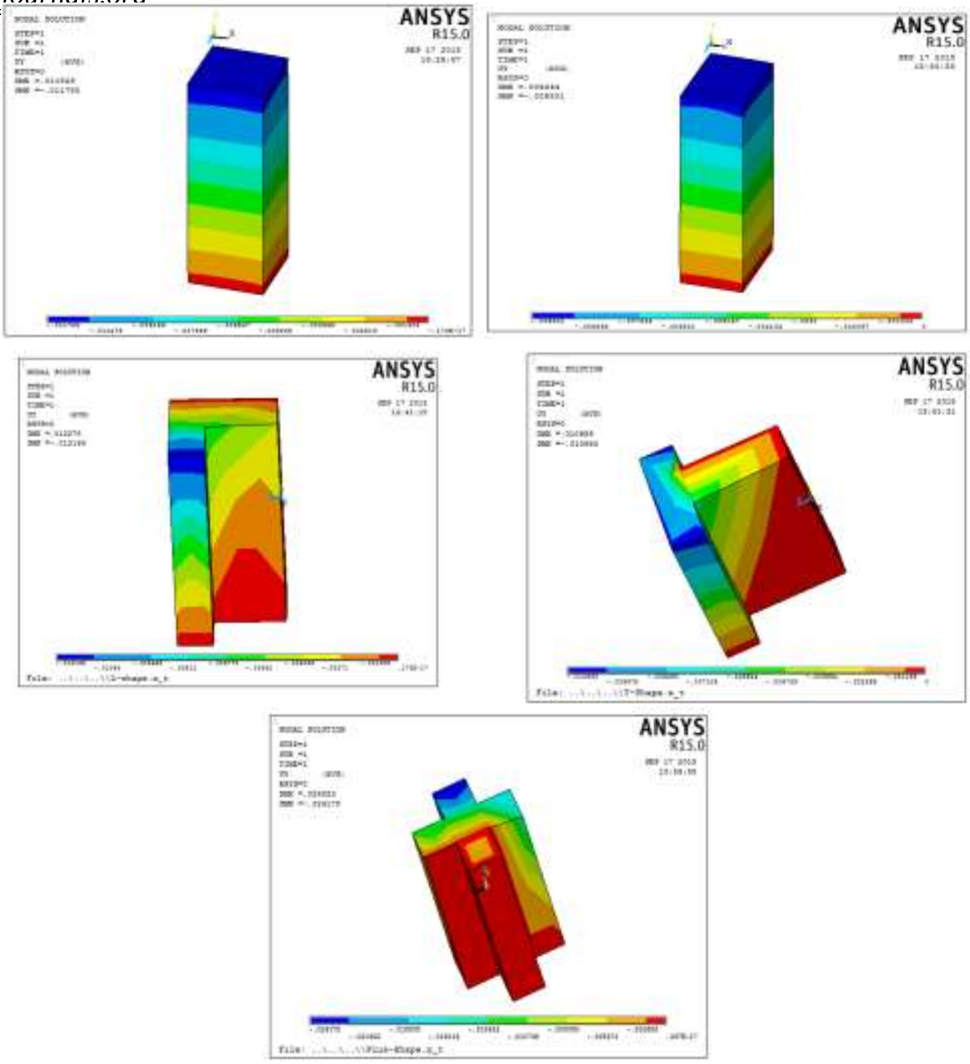

Fig.4 Stress and defection on different shapes of columns wrapping with CFRP.

1.3 Discussion of results

In this analytical program, we have created concrete specimens of grade M25 with corner radius varies from 0 mm to 75 mm with lap length varies from 150mm to 450mm. Designation used for specimen has been given below to avoid confusion during testing and after testing;

Specimen with 0 mm corner radius = S-Cr0
Specimen with 25 mm corner radius = S-Cr25
Specimen with 50 mm corner radius = S-Cr50
Specimen with 75 mm corner radius =S-Cr75
Where, S= Specimen, Cr= Corner radius
For discussion purpose we have divided this into two groups:

1. Cylindrical specimen(S-Cr75)
2. Non-cylindrical specimen(S-Cr0, S-Cr25, S-Cr50)

Cylindrical specimens(S-Cr75)

As load was increasing gradually, concrete at bottom expanded gradually before GFRP rupture. Lap length was also played very vital role before failure.

Non-cylindrical specimens(S-Cr0, S-Cr25, S-Cr50)

As expected, the degree of enhancement was directly related to the corner radius. Thus, column with 50 mm corner radius had among all square specimens the highest improvement but less than that of the cylindrical specimen. The failure was gradual and less explosive than that of cylindrical This proves the fact that confining force created by square jacket tends to be concentrated at the corner and only for this reason rounding of square column corners was used to provide a uniform confined stress.

Table I shows summary of results obtained for all unconfined and Table II for confine square and cylindrical specimen. This table clearly shows gain in strength, further this table also illustrates that as corner radius increases gain also increases and it becomes maximum for cylindrical column.

From the Table I it can be seen that, from square specimen (S-Cr0) to circular specimen (S-Cr75), the cross sectional area of section decreases but the strength of unconfined specimen goes on increasing. After comparing Table I and Table II it very clear that strength of confined specimens increases. In case of S-Cr75, we got maximum strength as compared to other specimens, because FRP offers more confinement to circular section.

From Table II, in case of S-Cr0, as lap length increases, strength also increases but the rate of increase in strength reduces. This is not true in case of S-Cr75; here rate of increase in strength also increases. So we can conclude that 150mm lap length gives good results for non cylindrical specimens.

For S-Cr0 specimen, the load carrying capacity for different lap length goes on increasing with very small amount. As we go from 150 mm wrap to 450 mm wrap for same corner radius of the specimen, the load carrying capacity of specimen goes on increasing and it increases significantly as we go from square to circular section. As we go from 0 mm to 75 mm corner radius for same lap length, there is significant increase in load carrying capacity. This concludes that we have to provide some minimum corner radius to improve load carrying capacity.

Table No.I: Results of unconfined specimens

	Specimen Designation	C/S Area (mm^2)	Strength of Un-confined specimen after 28 day's (N/mm^2)			
			1	2	3	Average
1	S-Cr0	22500	321.12	129.10	227.40	225.87
2	S-Cr25	21963.49	268.95	227.70	320	272.21
3	S-Cr50	20353.96	227.25	447.15	300	324.8
4	S-Cr75	17671.45	393.20	377.95	375	382.05

Table No. II: Results of confined specimens

Sr. No.	Strength of Confined specimen (N/mm^2)											
	150mm				300mm				450mm			
	1	2	3	Avg.	1	2	3	Avg.	1	2	3	Avg.
S-Cr0	493	578	587.8	552.93	533.75	575.73	558.5	556.0	591.4	629.1	532.8	584.45
S-Cr25	842.65	900.5	880	874.38	910	970	970	950	1150	1100	1180	1143.3
S-Cr50	1050	990	1030	1023.3	1150	1100	1060	1136.6	1250	1150	1090	1196.6
S-Cr75	830	990	780	866.66	1020	1040	870	976.66	820	1060	1180	1020

Table no.III Results of specimen with same cross sectional area but different shapes wrapping with CFRP

Sr. No.	Shape of column	Area of column (mm2)	Length of column (mm)	Radius of gyration (mm)	Slenderness ratio	Load (KN)	Deflection (mm)
1	Rectangular	90000	1000	72.16	4	1000	0.0092
2	Square	90000	1000	86.6	3.3	1000	0.0118
3	L- shape	90000	1000	78.06	6.66	1000	0.012
4	T- shape	90000	1000	160.31	8	1000	0.0106
5	+ shape	90000	1000	156.12	13.33	1000	0.02

From the TableIII it can be seen that, from rectangular column to + shape column with the same cross sectional area and the same loading radius of gyration, slenderness ratio and deflection is for rectangular column.

IV. Conclusion

- From above result and discussion, it can be concluded that FRP wrapping not only increases the load carrying capacity of a member but also increases life of the structure, provided that the care is taken to reduce stress concentration because of shape of cross section and providing sufficient lap length.
- It also can be concluded that lap length of 150 mm is the best for all specimen. If we go from 150 mm to 450 mm there is no significant increase in load carrying capacity and also lap length of 600 mm increases the cost of rehabilitation.
- The software results for validation of experimental results showed in general good agreement there is no as much difference in experimental results and software results.
- The CFRP wrapping column is more stronger than GFRP wrapping column. CFRP wrapped column can beared 15 to 20 % more load than GFRP wrapped column.
- For the same cross sectional area but different shapes of columns wrapping with CFRP
  It shows that the rectangular shape of column is best for load carrying capacity due to it shows less deflection, less slenderness ration and less radius of gyration
- CFRP wrapping is costlier when compared to GFRP wrapping

References

[1] Avinash Kadam. Use of fiber reinforced polymer composites in civil construction : A general review on column. (2009).
[2] Karbhari VM. Materials consideration in FRP rehabilitation of concrete structures. ASCE J Mat Civil Eng 2001; 13(2):90–7.
[3] Sandeep S. Pendhari, Tarun Kant, Yogesh M. Desai. "Application of polymer composites in civil construction: A general review". Composite Structures 84 (2008) 114–124.
[4] Bakis CE, Bank LC, Brown VL, Cosenza E, Davalos JF, Lesko JJ,et al. Fiber-reinforced polymer composites for construction – state of-the-art review. ASCE J Compos Const 2002; 6(2):73–87.
[5] Debaiky AS, Green MF, Hope BB. Carbon fiber-reinforced polymer wraps for corrosion control and rehabilitation of reinforced concrete columns. ACI Mater J 2002(March-April):129-37.
[6] Harajli MH. Behavior of gravity load-designed rectangular concrete columns confined with fiber-reinforced polymer sheets. ASCE J Compos Const 2005; 9(1):4–14.
[7] Pessiki S Harries KA, Kestner JT, Sause R, Ricles JM. Axial behavior of reinforced concrete columns confined with FRP jackets.ASCE J Compos Const 2001; 5(4):237–45.
[8] Mirmiran A, Shahawy M, Samaan M, Echary HE, Mastrapa JC,Pico O. Effect of column parameters on FRP confined concrete. ASCE J Compos Const 1998;2(4):175–85.
[9] Guoqiang Li, Dinesh Maricherla, Kumar Singh, Su-Seng Pang, Manu John." Effect of fiber orientation on the structural behavior of FRP wrapped concrete cylinders". Composite Structures 74 (2006) 475–483
[10] Azadeh Parvin, Aditya S. Jamwal. "Performance of externally FRP reinforced columns for changes in angle and thickness of the wrap and concrete strength". Composite Structures 73 (2006) 451–457.
[11] Theriault M, Neale KW, Claude S. Fiber-reinforced polymer-confined circular concrete columns investigation of size and slenderness effects. J Compos Constr, ASCE 2004; 8(4): 323–31.
[12] Mirmiran, A., Shahawy, M., and Beitleman, T. (2001). ''Slenderness limit for hybrid FRP- concrete columns.'' J. Compos. Constr., 5(1), 26–34.
[13] Yousef A. Al-Salloum. "Influence of edge sharpness on the strength of square concrete columns confined with FRP composite laminates". Composites: Part B 38 (2007) 640-650.
[14] Lei-Ming Wang, Yu-Fei Wu. "Effect of corner radius on the performance of CFRP-confined square concrete columns: Test" Engineering Structures 30 (2008) 493–505