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Study on Strength Behavior of Axially Loaded Cracked and Non Cracked Short Column Using Wrapped FRP Wire Mesh

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Abstract: In recent years Fibre Reinforced polymer gained wide use of strengthening and repairing works for the beams columns and slabs of buildings and bridges. FRP is commonly used in the aerospace, automotive, marine, construction industries and ballistic amour. The present study is mainly focused on the investigation of the effect of externally bonded FRP upon the strength characteristics of R.C columns. Large number of studies on R.C columns wills shows that the column will fail due to improper or insufficient confinement. In case of FRP, it will provide effective confinement to the column, this property of FRP makes it much suitable as strengthening material. So I had planned to study the effect of FRP on strength and durability aspect of RC column. For this purpose 6 RC circular columns, dimensions 300mm height and 150mm diameter are to be considered. Among the 6 specimens, 2 will be confined with FRP wraps of single layer (3mm thickness), another 2 are confined with FRP wraps of double layer (5mm thickness) and the rest were unconfined and are tested for compressive strength and deflection using dial gauge. The axial bending of casted short column is wrapped with double layered FRP was performed and monitored, and a cracked section of short column was repaired using FRP and checked.

Keywords: *Fibre Reinforced polymer, Wire mesh, RC circular columns, Confined, Unconfined, Strengthening material.*

1. Introduction

Fibre reinforced polymer (FRP) materials have emerged as promising alternating repair materials for reinforced concrete structures, and they are rapidly becoming materials of choice for strengthening and restoration of concrete infrastructure. FRP can be bounded to the outer of concrete structures using high strength gums to provide tensile or confining reinforcement, which increases that provide by internal reinforcing steel.

FRP can be functional to strengthen the Beams, Columns, and Slabs of structures. It is possible to increase the strength of structural members even after they have been severely damaged due to loading conditions. There are different methods for applying FRP on the structural elements like U-wrap, Complete wrap, Strip wrap and Side Wraps.

FRP is used in designs that require a measure of strength or modulus of elasticity that non-reinforced plastics and other material choices are either ill-suited for mechanically or economically. This means that the major design consideration for using FRP is to guarantee that the material is used economically and in a way that takes advantage of its structural improvements specifically.

The FRP made of Glass material have up to a 60% reduction in weight, improved the surface quality, Reduction in components by combining parts and Increasing the durability and safety.

2. Material Properties

The properties of materials used in the concrete are discussed below:

2.1 Cement

Ordinary Portland cement of grade 43 is used was confirming to IS 8112-1989 and having specific gravity 3.15

2.2 Fine Aggregate

The sand sieved through 2.36 mm sieve is used having specific gravity of 2.65. The fine aggregates belonged to grading zone III.

2.3 Coarse Aggregate

Locally available coarse aggregate having the maximum size of 12.5 mm is used. The specific gravity of coarse aggregate that was taken was 2.74.

2.4 Epoxy resins

The epoxy polymers have higher mechanical properties, particularly dynamic and fatigue resistant properties, and water resistance then polyester. They are used as a binding material. The properties are given in Table-4.Applying of resin, 1mm thickness as per specification.

Table 1: *Properties of Epoxy resins*

S.No	Properties	Values
1	Tensile strength at	2.8 Mpa

	break	
2	Elongation at break	16.0%
3	Young's Mould	14.6 Mpa
4	Tensile strength at yield	3.5 Mpa
5	Shear strength	6.0 Mpa
6	Flexural strength	0.32 Mpa
7	Compressive strength	10.5 Mpa

2.5 Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Potable water available in the laboratory was used.

2.6 Acrylic primer

Which helps to remove oil and grease by detergent cleaning followed by scuff sanding? To remove rust, wire brush is being used and the primer has been applied and allows them to stay for 10-15 minutes

2.7 FRP wire mesh

FRP wraps used were to be of woven roving type wire mesh. FRP is a composite material made of polymer matrix reinforced with fibers.

2.8 Wall putty

Which has been used for the finishing for the FRP bonded concrete column .It provides an ideal base for painting and damp resistant smooth finish for further application of all kinds of paints.

3. Experimental Investigation

In this investigation the hardened properties of concrete and FRP wrapped concrete are determined.

3.1 Mix proportions

Recommended guidelines of concrete mix design using Indian Standard Code (IS: 10262-2009) the mix proportions of concrete were prepared for M25 grade.

3.1.1 Hardened properties of FRP on cylinder

In order to find the mechanical properties Compressive strength tests were conducted at 28 days of cylinder (150 X300mm) specimens, six specimens were tested out of which 4 specimen were wrapped with FRP, and deformation of various load is recorded.

The compressive strengths of test specimens are tabulated below and graphs are plotted:

***Table 2**: Compressive Strength of Concrete*

Sl. No	Type of specimen	Load at failure (KN)	Area (mm^2)	Compressive strength (N/mm^2)	
1	Unconfined Strengthened column	395	$3.14*75^2$	22.3	22.5
		400		22.6	
2	Confined single layer FRP column	480	$3.14*75^2$	27.1	27.6
		495		28.0	
3	Confined double layer FRP column	600	$3.14*75^2$	33.9	38.2
		750		42.4	

***Figure 1:** compressive strength test using dial gauge*

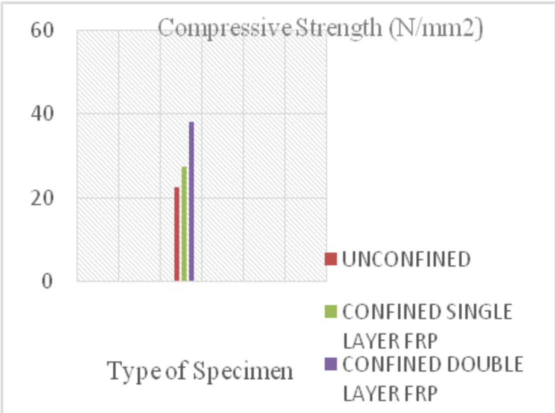

***Figure.2** Bar chart for compressive strength (N/mm^2)*

The following table shows the ultimate strength with deflection values of unconfined and confined specimens:

***Table 3:**Un-Strengthened Column- 1*

S. No.	Load (KN)	Deflection (mm)
1.	0	0
2.	50	0.19
3.	100	0.36
4.	150	1.47

5.	200	2.34
6.	250	2.95
7.	300	3.30
8.	350	4.02
9.	395	Ultimate

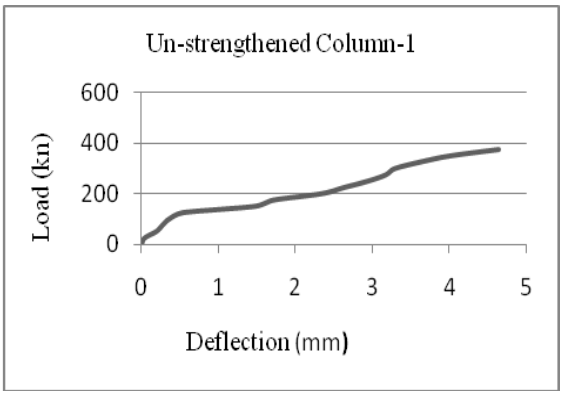

Figure 3: *Load vs Deflection graph*

Table 4*: Un-Strengthened Column- 2*

S.NO	Load (KN)	Deflection(mm)
1	0	0
2	50	018
3	100	0.54
4	150	1.08
5	200	1.55
6	250	2.06
7	300	2.67
8	350	315
9	400	Ultimate

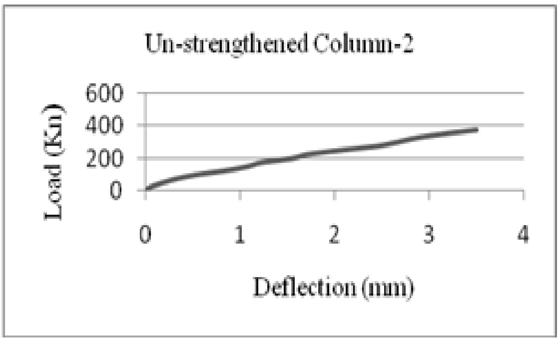

Figure 4: *Load vs Deflection graph*

Table 5*: confined single layer FRP column-1* **(***3mm)*

S.NO	Load (KN)	Deflection(mm)
1	0	0
2	50	0.11
3	100	0.34
4	150	0.54
5	200	0.77
6	250	1.10
7	300	1.34
8	350	1.50
9	400	1.75
10	450	1.89
11	480	Ultimate

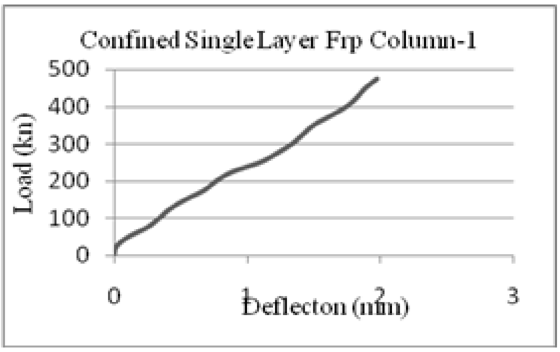

Figure 5: *Load vs Deflection graph*

Table 6: *confined single layer FRP column-2(3mm)*

S.No.	Load (KN)	Deflection (mm)
1	0	0
2	50	0.14
3	100	0.33
4	150	0.52
5	200	0.73
6	250	0.92
7	300	1.13
8	350	126
9	400	1.43
10	450	165
11	495	Ultimate

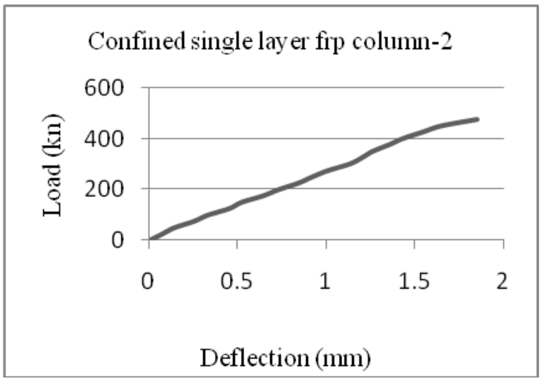

Figure 6: *Load vs Deflection graph*

Table 7*: confined double layer FRP column-1* (*5mm)*

S.No.	Load (KN)	Deflection (mm)
1	0	0
2	50	0
3	100	0
4	150	0.10
5	200	0.21
6	250	0.33
7	300	0.48
8	350	0.67
9	400	0.85
10	450	1.08
11	500	1.21
12	550	1.36
13	600	Ultimate

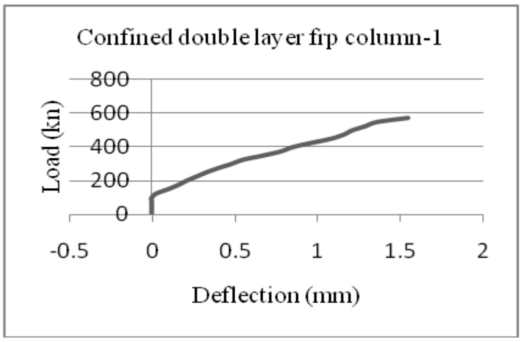

Figure 7: *Load vs Deflection graph*

Table 8: *confined double layer FRP column-2(5mm)*

S.No.	Load (KN)	Deflection (mm)
1	0	0
2	50	0
3	100	0
4	150	0.02
5	200	0.13
6	250	0.20
7	300	0.29
8	350	0.38
9	400	0.48
10	450	0.59
11	500	0.69
12	550	0.81
13	600	0.69
14	650	1.08
15	700	1.22
16	750	Ultimate

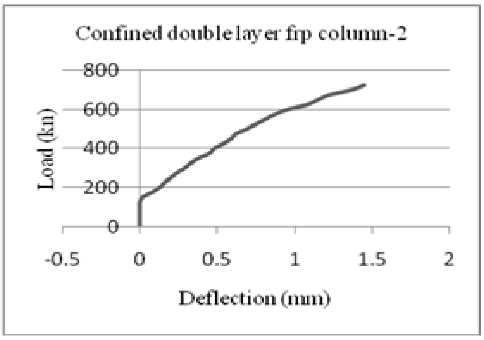

Figure 8: *Load vs Deflection graph*

Figure 9: *Specimens after Compressive Test*

4. Experimental Test Result of 1m Height Column

The first specimen tested was of non-cracked and non-wrapped column of 1m height was tested on load frame testing machine. The axial load was applied gradually in increments of 25 KN when load reaches 550 KN, first crack occurred at the middle of the column. That specimen was repaired using double layer FRP wrapping and tested again and load is checked. The load obtained is 630 KN which shows that the repair work is effective. The second specimen is wrapped double layer using FRP and tested. When the load reaches 660 KN, first crack was occurred and the maximum load obtained for the second specimen was 750 KN, at which the failure occurred. Finally the experiment found successful.

Figure 10: *Testing of column in load frame*

The test results for short columns are listed in the tables and graphs below:

Table 9: *Non cracked and Non wrapped column*

S. No.	Load (KN)	Deflection (mm)
1.	0	0
2.	50	0.24
3.	100	0.69
4.	150	1.23
5.	200	1.68
6.	250	2.21
7.	300	2.75
8.	350	2.99
9.	400	3.25
10.	450	3.58
11.	500	3.71
12.	550	3.82

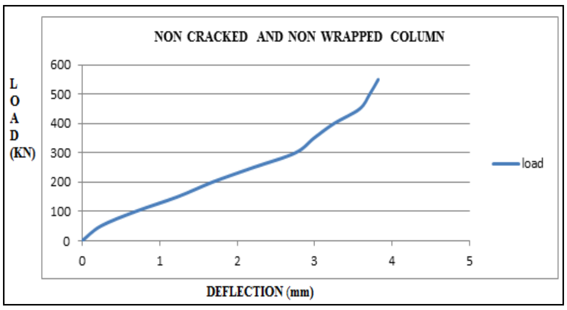

Figure 11: *Load vs Deflection graph*

Table 10: *Non cracked and wrapped column*

S.NO.	Load (KN)	Deflection (mm)
1.	0	0
2.	50	0.2
3.	100	0.39
4.	150	0.55
5.	200	0.71
6.	250	0.89
7.	300	1.02
8.	350	1.11
9.	400	1.28
10.	450	1.39
11.	500	1.55
12.	550	1.82
13.	600	2.01
14.	650	2.28
15	700	2.50
16	750	2.63

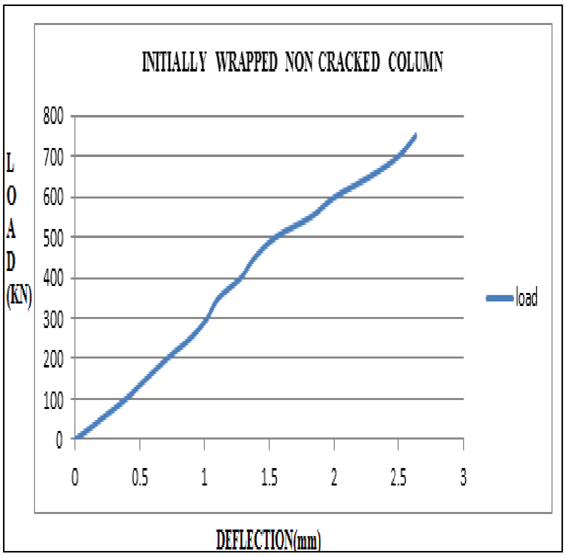

Figure 12: *Load vs Deflection graph*

Table 11: *cracked and wrapped column*

S.NO.	Load (KN)	Deflection (mm)
1.	0	0
2.	50	0.22
3.	100	0.65
4.	150	1.11
5.	200	1.39
6.	250	1.74
7.	300	2.22
8.	350	2.49
9.	400	2.74
10.	450	2.89
11.	500	3.01
12.	550	3.22
13.	600	3.95
14.	630	4.08

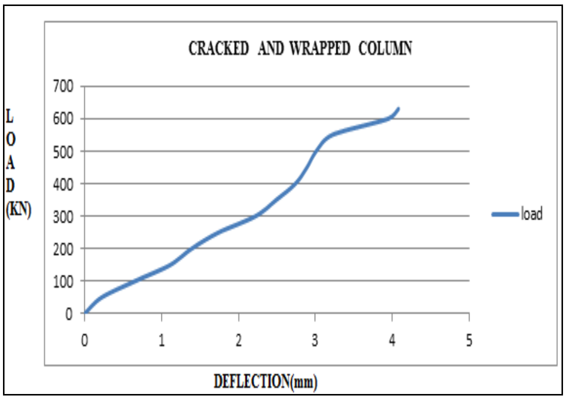

Figure 13: *Load vs Deflection graph*

5. Conclusion

Based on the reported test results the following conclusions are drawn:

- Columns with external confinement exhibit enhanced performance with respect to strength and deformation.
- Lateral strengthening is increased through confinement.
- Confined columns provide adequate resistance to buckling.
- Confinement increases tensile strength.
- By confinement, the column size can be reduced making it economical.
- Since confinement provides greater strength to the columns, thereby column reinforcement can be minimized.
- Confinement minimizes lateral cracking when subjected to loading.
- As the number of external confinement layer increases strength also increases.
- Columns with FRP confinement exhibit an increase of 1.2 to 1.7 times in axial strength and reduction in axial deformation in the range of 20 to 50% when compared with unconfined columns.

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