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Experimental Investigation of CFRP wrapped low and normal strength concrete cylinders

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Abstract: This paper presents the variant experimental results of carbon fibre reinforced polymer (CFRP) jacketing effect on a range of cylindrical concrete compressive strengths. Twenty four cylinders were cast (twelve cylinders were wrapped with single layer of CFRP and remaining cylinders were unconfined) and tested under axial compressive loading. The two grades of concrete compressive strength were used in this experimental study i.e low strength and normal strength. The test was carried out in terms of confined compressive strength for low and normal strength concrete cylinders. The results obtained shows that the carbon fibre reinforced polymer jacketing is more effective for low strength concrete rather than the high strength.

Keywords: *Low Strength, Normal Strength, Axial Loading, Compressive Strength*

Introduction:

The use of fibre reinforced polymers (FRP) as reinforcement for structures is rapidly gaining popularity. This is due to many advantages of these materials as compared to its alternatives such as conventional steel reinforcement or concrete encasements that are advantageous in strengthening of civil engineering structures.

Several studies on concrete columns/cylinders confined with carbon fiber composites are reported in the literature. Carbon fibers have been used successfully for strengthening structures such as columns and beams. Experimental testing was first performed on concrete cylinders wrapped with composites and subjected to uni-axial compression by Harmen and Slatery (1992) and Nanni et al. (1993).[1,2] The model is used to assess gain in strength of concrete column confined by FRP materials. This model was also adopted by ACI 440 for the estimation of confined concrete strength.

Both serviceability and ultimate load carrying capacity of most of the existing concrete structures and bridges became inadequate to meet the users demand. An attractive solution is strengthening of the existing structures using FRP materials. High tensile strength, lightweight and corrosion resistance characteristics of FRP make it ideal. It is contemporary method of strengtheningbecause of their excellent mechanical properties, corrosion resistance, durability, light weight, ease of application, reduced construction time,resistance to corrosion, efficiency, and low life cycle cost. Major of the experimental data on the axial behavior of FRP confined concrete is on small size cylinder specimens without internal reinforcement. For better apprehension of the behavior of the FRP jacketed concrete members with circular cross-section, moreexperimental work examining the strength distinction on the behavior is needed.[3-12]

Objectives:

The core objective is the Experimental study to predict the strength variation in CFRP wrapped concrete circular cylinders for low and normal strength concrete.

Experimental programme:

A total of twenty four concrete standard sized cylinders circular in shape were cast and tested within the laboratory of University of Engineering and Technology, Taxila, Pakistan. The adhesive used was Sikadur 330 and cabon fiber Sika-wrap Hex 230 C. After wrapping the fiber, 4 inches overlap was also provided to avoid local failure in the end region. The experimental program was designed to achieve target strengths as under.

Table. 1 *Illustrating concrete grades and mix properties*

Target Concrete strength	Ratio	slump **(mm)**	W/C
1500psi	1:3:6	90	0.81
2500psi	1:2:4	90	0.5
3500psi	1:1.3:2.6	80	0.4
5000psi	1:0.9:1.8	80	0.35

Figure 1.Cracking behavior of CFRP wrapped cylinders

Results and Discussions:

The damage to layers occurred as the cylindrical specimens tend to expand and resulted in explosive noise of cracking just like a brittle failure. Strength was recorded with the help of compression testing machine in Civil Engineering Testing laboratory.Testing of single wrapped cylinders is performed in the compression testing machine under axial compression.

Table 2 *Illustrating comparison of confined versus unconfined specimen*

Sr. No.	Strength of Concrete Cylinders (Target strength)		Unconfined Strength (MPa)	Confined Strength (MPa)
1	1500Psi	S1	10.06877	18.16434
		S2	9.640309	17.88052
		S3	10.21159	16.17762
		S avg.	9.973555	17.40749
2	2500Psi	S4	18.78075	25.54361
		S5	19.10209	23.55688
		S6	18.81646	26.39506
		S avg.	15.95213	25.16518
3	3500Psi	S7	23.70802	27.81415
		S8	24.38641	25.25979
		S9	24.10077	28.94942
		S avg.	24.06507	27.34112
4	5000Psi	S10	37.20445	37.18014
		S11	37.34727	41.43741
		S12	36.91881	40.58595
		S avg.	37.15685	39.7345

Strength of the specimen was provided by the confining action of the CFRP wrap on the concrete core.Experiments to be carried out to test the effectiveness of CFRP wrapping over low and normal strength concrete cylinders the figure shows the comparison of the confined and unconfined cylindrical strength obtained through experimental testing.

The graph showing gain of confined strength, here we have observed that confined strength increment is about 80% than that of unconfined strength.

The carbon fiber reinforced polymer confinement effectiveness reduces with increasing the unconfined compressive strength of concrete; here we observe an increment about 40%.

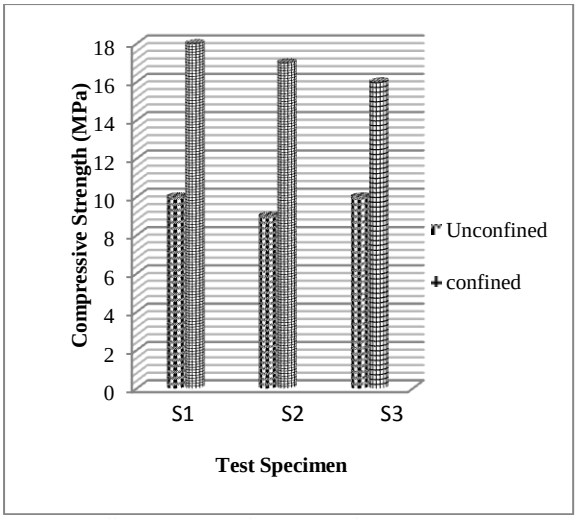

Figure 2: Difference b/w confined/ unconfined strength (10-18Mpa)

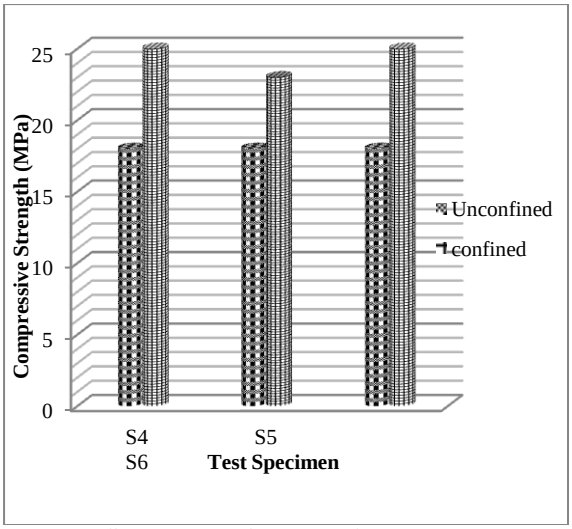

Figure 3: Difference b/w confined/ unconfined strength (10-18Mpa)

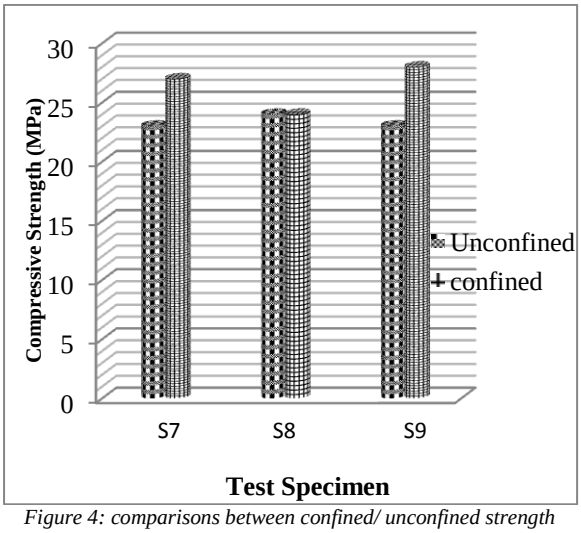

Figure 4: comparisons between confined/ unconfined strength (24-36Mpa)

Graph interprets that the percentage strength increased in confined cylinder for normal strength is 18%.

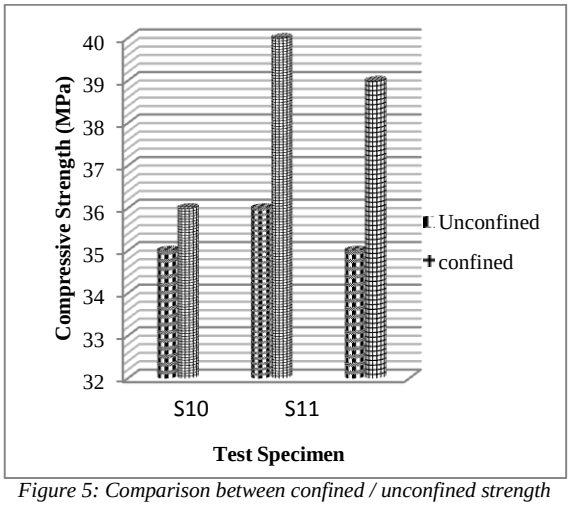

Figure 5: Comparison between confined / unconfined strength (24-36Mpa)

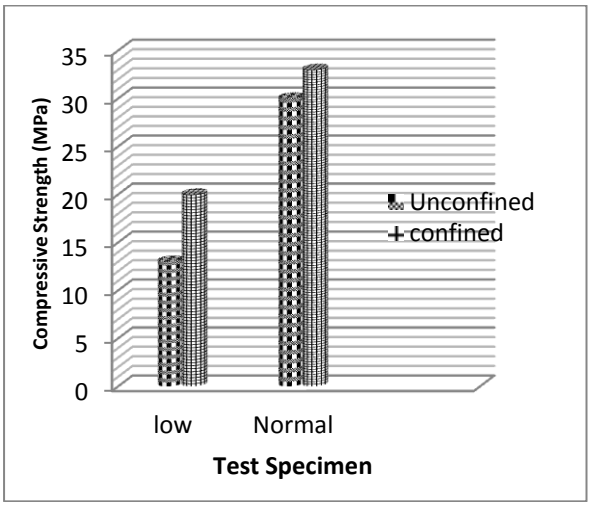

Figure 6: Comparison between low and normal strength concrete

This graph discusses the gain of confined compressive strength, after experimental data it is observed to be increased by 09% of unconfined compressive strength, in confined strength for low and normal is 80, 40, 18 and 09 percent respectively which also shows that the confinement becomes less effective as the unconfined strength increases.

Conclusion:

This investigation was carried out to observe effect of CFRP on low and normal strength based concrete. The efficiency of CFRP is far clear from above experiments as under:

1. Higher increment in strength (40-80%) was observed for CFRP wrapped specimens with 10-18 MPa strength
2. A relatively lesser enhancement (9-18%) in strength was observed for CFRP wrapped specimen with 24-36 MPa strength
3. The confined strength of concrete cylinders increases with reduction in concrete compressive strength and decreases with increase in concrete compressive strength
4. Based on the above mentioned results and conclusions, it is found that the carbon fibre reinforced polymer jacketing is more effective for low strength concrete rather than normal strength concrete.

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