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A Study of Quality Management in Construction

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***Abstract*: Numerous criteria affect the efficacy of FRP couplings on circular and square concrete columns, and the objective of this work is to explore how tiny FRP concrete columns behave when subjected to axial pressure loading. Design, technique, and strategy as an example, these factors include the browser's form (circular or rectangular), the core's size, and the number of layers of FRP (1–3). Other elements include concrete strength (low, normal, and high), FRP type (carbon or glass), and the number of square columns. The suggested equations and the present experimental findings show a good correlation. As the average hoop strain in FRP wraps at rupture might be lower than that determined by tensile coupon testing, the assumption that the FRP-contained concrete cylinder ruptures at its maximum tensile strength is not valid. Using the effective hoop rupture strain composite materials, the effective peak strength and strain formula for FRP concrete restricted columns must be based on this observation.**

***Keywords*: Compressive strength, Effective circumferential failure, FRP composite, Ultimate strain, FRP column.**

1. Introduction

Most structures were built worldwide for gravitational loads alone or following the recommendations of earlier code in seismic areas with reinforced concrete. These buildings cannot be entirely replaced. In these cases, the earlier columns constructed in order to decrease causes during serious earthquakes, are upgraded to the current seismic code. Fiber concrete is characterized as "a composite fabric that includes cement or concrete blending and discontinuous fibres, discreet and evenly scattered." Non-stop meshes, tissues, lengthy cables and tubes are not placed in separate fibres (Saadatmanesh, et al., 1994). Glass. Fiber is a tiny reinforcing material that possesses positive, round or flat homes. The fibre is typically characterized using a comfortable metric called the "factor ratio" The fibre ratio is the ratio between its length and its diameter. In current years, using externally bonded fibre strengthened polymer composite plate or sheets for bolstered concrete (rc) reinforcement has grown in reputation (Saeed, et al., 2016). The famous blessings of FRP composite over conventional substances whilst utilized for boosting tasks have contributed to its reputation. For the reason that early Nineties, researchers have been checking out a number shear strengthening techniques with a view to improve the shear potential of bolstered concrete beams. Shear is a highland sheep breed. The technique of joining steel plates with epoxy adhesives is acknowledged as an effective and convenient way for the repair and rehabilitation of reinforced concrete structures. Glass fibre has been employed in several constructions for over 30 years (hahawya et al., 2000). It is mostly utilized in non-construction products such as façade panels, sanitary pipework, decorative non-recoverable form work, and other items. The advantages of FRP for RC structure retrofitting include exceptional corrosion resistance, low density, extraordinarily high strength to weight percentage, and effortlessness of operation and assembly (hence substantially compact working time). Polypropylene, polyester, and nylon are the most common materials used in India (Spoelstra, et al., 1990).

Synthetic fibres give similar benefits when used as secondary concrete reinforcement, despite the fact that the fibres within each type come in a variety of lengths, thicknesses, and geometries. 4 BIJEN.J., et.al Studies on enhanced mechanical properties of polymer-modified glass fibre cement (1990) - Studies on enhanced mechanical characteristics of polymer-reinforced glass fibre cement have been conducted. A bird-eye perspective of the improvements to be made to glass fibre reinforced concrete by modifying polymers is available. Biswarupsaikiaet al. (27) examined the energy and serviceability performance of GFRP strengthened beams constructed using restriction ideas. GFRP strengthened beams had a block kind rotation failure in the course of the analysis, but manipulate beams strengthened with metallic rebars had a flexural failure at the equal time. For the strength evaluation of GFRP reinforced beams, an analytical model become created. The analytical model's predictions are compared to the experimental statistics.

2. Materials and Methods

This investigation utilized three concrete mixtures with a strength of 25 MPa, 40 MPa, and 60 MPa: low resistance concrete (LSC), normal resistor concrete (NSC), and high resistance concrete (HSC). The concrete specimens were mixed with the mechanical mixer at the civil engineering laboratory. Ordinary Portland cement was used with water/cement ratios of 0,59, 0,46, and 0,34 in LSC, NSC and HSC, respectively. In total, 0,6 and 1,4% of super-plasticizers were used in the NSC and HSC mixing schemes.

The fibre utilized in the testing is:

1. unidirectional carbohydrate wrap fabric;
2. Unidirectional wrap glass fibre fabric.

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A 2/1 mixing ratio of the two components by weight by use of an adhesive resin and durisor forms the linkage between the concrete and the FRP. The resin specifications and main characteristics of the FRP tissue used for testing are shown in Table 1 (data are given by the manufacturer). The mechanical properties of FRP composites such as module, tensile strength and failure extension are also included in Table 1.

A. Wrapping and testing FRP process

For each layer of FRP wrap, two epoxies plying is used: one on the surface of the specimen and one on the placed wrap surface. The FRP layer must be wrapped in the specimen with a 1/4-perimeter overlap based on assumptions of Shahawya et al. (2000). This is so as to minimize slippage or detaching fibers in experiments and to ensure composite strength increases. In this research, the last FRP layer was enveloped with a 150-mm overlap. Specimens were assessed for failure under a monotonic axial compression load. To assess axial and side stresses, an essential extensometer was utilized. The instrument featured a radial linear differential transducer placed in the center of the sample as a hoop. In order to quantify axial stress in concrete in the center of the concrete, the examples were also fitted with an implanted strain gauge. Tests recorded axial loads and related stress using an automatic data collection system.

The cement specimens were purified and completely dried after 28 days of cure. Two epoxy folds, one on the surface of the specimen and the other on the surface of the installed wrap, are applied for each FRP layer. Based on the premise of Shahawya et al. (2000), that the layer of the final FRP should be covered with 1/4 perimeter overlay in order to achieve complete composite strength and that sliding or separating fibres are prevented during testing. The last FRP layer was wrapped with an overlap of 150 mm around the sample in this research Under monotonous axial compression load, specimens were evaluated to fail. Using a notable extensometer, axial and lateral stresses were measured. The equipment included a radial linear difference transducer positioned as a hoop in the center of the specimens.

3. Results and Discussion

This section provides and analyses results for final conditions (fortitude and ductility), FRP fault circumferential strain, failure technique, FRP material type, stress streaming and corner radius influence. This part examines results.

A. Overall behavior

Higher carrying capacity than for unwrapped columns was observed for all wrapped specimens. The average growth rate of the specimens for CFRP-confined concrete cylinders was 93 and 523 percent, respectively. The average improvement in capacity and ductility for CFRP confined concrete samples with square cross-sections is 12 and 220 percent. Tables 2 and III correspondingly examine the strength and stress improvements in circular and square specimens. In comparison with circular specimens, the average loss in strength and ductility of square specimens is approx. 90 and 65% respectively.

The confinement effect is limited to the corners for square specimens because of the large stress concentration at the corners, thereby ensuring that the side stress in the concrete is evenly distributed. Therefore, the strength and ductility of the squares covered with CFRP were less visible than those of the circular wrapped with CFRP. Therefore, the strength and ductility of the wrapped specimens of the CFRP square were not that evident as the CFRP-wrapped circular specimens. The

Table 1
Mechanical properties of FRP materials

Material	E_{frp} (GPa)	Tensile strength (MPa)	*t* (mm)	Viscosity (mPaS)	Elongation at failure (%)
CFRP/fiber Sika Wrap 230C	235	3,540	0.14	–	1.7
GFRP/fiber Sika Wrap 430G	75	2,210	0.18	–	2.7
MEDAPOXY STR	–	24	–	11,100	–
CFRP composite (TCT)	33	402	1	–	1.5
GFRP composite (TCT)	25	324	1	–	1.8

Table 2
A comparison of circular/square axial strength with full circular / hollow – circular core

	Specimen designation	strength f_{cc} (Mpa)	$f_{cc}-f_{co}$ (Mpa)	Specimen designation	strength f'_{cc} (Mpa)	$f_{cc}-f_{co}$ (Mpa)	GFRP cylinders respect to CFRP ones
Comparison of axial capacity between	CC1	41.55	16.66	CG1	37.65	10.80	−32.22
CFRP and GFRP	CC2	52.45	31.66	CG2	43.02	16.81	−47.22
confined cylinders	CC3	66.5	52.42	CG3	51.53	30.82	−50.71

Table 3

Specimen designation (full circular core)	Average axial strain (ε_{cc})	$\varepsilon_{cc}-\varepsilon_{co}$	Specimen designation (square)	Average axial strain (ε_{cc})	$\varepsilon_{cc}-\varepsilon_{co}$	Specimen designation (hollow circular core)	Average axial strain (ε_{cc})	$\varepsilon_{cc}-\varepsilon_{co}$	% Decrease in strain enhancement of squares with respect to circulars	% Decrease in strain enhancement of circular hollow/full
CCL1	13.97	11.25	SCL1	7.22	4.67	CCLH1	10.27	7.91	−58.45	−29.74
CCL2	23.77	21.07	SCL2	8.64	6.18	CCLH2	17.38	15.01	−70.95	−28.74
CCL3	31.55	28.85	SCL3	9.91	7.38	CCLH3	22.27	19.87	−74.39	−31.11
CCN1	11.82	8.70	SCN1	6.82	4.27	–	–	–	−50.87	–
CCN2	18.05	14.94	SCN2	7.647	5.116	–	–	–	−65.78	–
CCN3	23.59	20.46	SCN3	8.318	5.785	–	–	–	−71.75	–

Table 4
CFRP-confined concrete specimens GFRP confined concrete specimens

CFRP-confined concrete cylinders				GFRP confined concrete cylinders				Average axial Average axial % decrease in strength of
Specimen designation	**strength f_{cc} (Mpa)**		**$fcc-fco$ (Mpa)**	**Specimen designation**	**strength f'_{cc} (Mpa)**		**$fcc-fco$ (Mpa)**	**GFRP cylinders respect to CFRP ones**
CC1	40.65		16.65	CG1	37.65		10.83	−31.21
CC2	56.46		32.48	CG2	43.01		17.84	−48.21
CC3	76.42		52.44	CG3	51.52		31.81	−51.72

Table 5
The axial strain comparison of the confined cylinders of CFRP and GFRP

Specimen designation	Average strain ε_{cc} (10^{-3})	$\varepsilon cc-\varepsilon cc$ (10^{-3})	Specimen designation	Average strain ε_{cc} (10^{-3})	$\varepsilon cc-\varepsilon cc$ (10^{-3})	% decrease in strain of GFRP cylinders respect to CFRP ones
CC1	13.98	11.25	CG1	9.68	5.03	−55.43
CC2	23.78	21.05	CG2	15.83	8.18	−61.20
CC3	31.56	28.84	CG3	22.91	15.26	−47.10

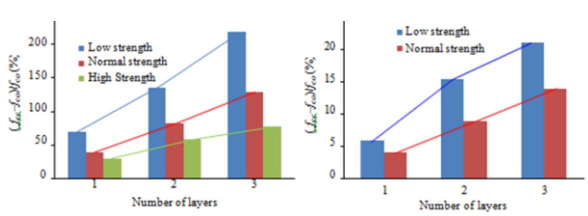
mean decrease in strength and ductility of the hollow core in respect of all the circular core specimens amounts to around 44 and 30%. The hollow portion within the concrete wall for hollow center columns that do not obtain an FRP containment activity may cause a lateral locking pressure to fail, which would result in less force and tension than the whole cement core.

B. Circumferential FRP failure pressure

The ultimate condition is the compressive strength and final axial pressure of FRP constrained concrete columns. According to the test findings obtained, the circumferential failure strains were detected at lower strain of all FRP-confined concrete specimens than the ultimate stress capacity µu reported in the tensile stress coupon testing. The curved shape of the composite wraps, or the abnormal axial strength of FRP can be reduced; approaching failure, the concrete is fractured inside, leading to uniform deformations.

C. Observed failure modes

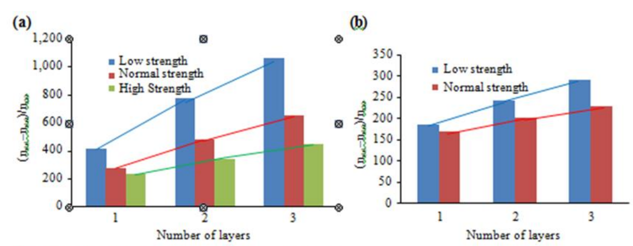
The tensile breakage of the FRP jacket due to hoop stress failed for all FRP-wrapped cylinders. When charged, crack noises in the FRP jacket began to break down the FRP wraps and the cracking of the epoxy resin at around 50 percent of the ultimate compressive stress. The collapse was progressive, and then a sudden and explosive noise ended. The failure mechanism was a continuous breaking of the FRP wrap from top to bottom for all sample GFRP confined concrete cylinder whereas the breakup of the FRP jacket in CFRP-confined concrete cylinders may be broken in two ways, ringed and located FRP breakage in the lower, middle and top portions.



Notes: (a) Circular specimens; (b) square specimens

Fig. 1. Effect of concrete resistance and reinforcing ratio for improving strength of confined FRP specimens

Figure 1 and 2 show that the gain in strengths and strains of high and normal strength, circular and square, confined FRP concrete is considerably lower than in specimens that have been observed in low-force specimens, as in the case of low-force specimens, for instance, CFRP low-force confined concrete cylinders, in which the single-layer reinforcement specimen showed an increasing number of cylinders. The specimen showed an increase of 40% in compressive strength and 280% in axial strain in the case of normal strength. The specimen showed a 31% increase in compression strength and 237% in axial strain in high concrete cylinders. As the strength of uncontained concrete grows, it can be shown that the axial strength and stress increase ratio of FRP-confined concrete specimens decrease.



Notes: (a) Circular specimens; (b) square specimens

Fig. 2. Effect of concrete strength and strengthening ratio on strain enhancement of FRP confined concrete specimens

Figures 1 and 2 illustrate the reinforcement ratio effect of CFRP confined concrete examples, respectively, on strength and strain increases. Results demonstrate that the CFRP material content impacts the strength and strain enhancement ratios for both circle and square specimens substantially. As already noted, the containment is dependent on the effective lateral pressure from CFRP wraps on the concrete core. For conclusion, higher concrete compressive strength and lower strengthening ratio reduce the effect of confinement with FRP material.

D. Effect of corner radius

Last conditions. Last conditions. Compare the average gain strength ratio fcc/fco, and the average gain strain ratio µcc/µco, respectively, Figures 3 and 4.

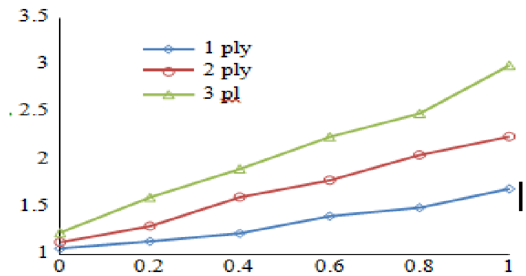


Fig. 4. Effect of corner radius on strength enhancement ratio

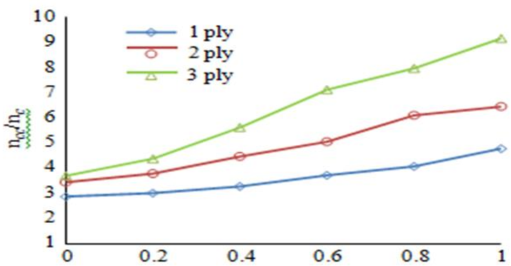


Fig. 5. Corner radius effect on strain improvement ratio

It has been proven that the increased corner radius increases square specimens' axial strength. This is due to changes in the localised stress level at the corners to the centre.

4. Conclusion

The last strain of the wraps is significantly lower than the breaking strain obtained by TCT, which show a clear link between the final breaking strain of fibres and the effective lateral compression. The results have shown that, compared to FRP glass samples, the FRP-confined concrete has considerably improved outcomes. With a rise in unconfined concrete strength, containment efficacy diminishes. With the increased number of composite layers, however, containment efficiency dramatically rises.

Appendix

fco	Ultimate strength of unconfined concrete
fcc	Ultimate strength of FRP-confined concrete
f_l	Effective lateral confining stress
εco	Ultimate strain of unconfined concrete
εcc	Ultimate strain of FRP-confined concrete
ε	Ultimate circumferential strain in the composite jacket
εh,rep	Effective failure strain of FRP-confined concrete
k_e	Area confinement effectiveness coefficient
Efrp	Tensile modulus of FRP
ρfrp	FRP volumetric ratio
kef	Effective FRP strain factor
kmef	Mean effective FRP strain factor
Ø	Angle of internal friction of concrete
t	Thickness of FRP composite
D	Diameter of the concrete core

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