Compressive Behavior of Low Strength Concrete Confined with Water Hyacinth and Jute NFRP

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1. Introduction

Recently, there are many researches on confined concrete, which is one of the main applications of FRP sheets. FRP sheets are used as external jackets for the confinement for reinforced concrete columns for enhancement in strength and/or ductility.[1] Natural fiber reinforced polymer, NFRP is a low-cost material and has less environmental impact than conventional FRPs such as carbon-FRP or aramid-FRP.[2), 3)] In this study, we used Jute fiber and Water hyacinth fiber sheets as inexpensive environment-friendly material for confinement which can be used for low-cost RC structures.

There are several existing structures having insufficient structural capacity due to low material strength.[4] However, we can continue using such existing RC structures with low strength of concrete by strengthening low strength concrete with economically and technically feasible way. This is preferable in economic and environmental view point compared to demolishing old structures and constructing new ones.

2. Test programs

2.1 Coupon tensile test

We conducted coupon tensile test to obtain mechanical properties of Jute-NFRP and Water hyacinth-NFRP. Fiber sheets were cut into coupons with 30 mm in width and 300 mm in length and impregnated with epoxy resin. Surface of the grip were treated by a sandpaper. Table 1 summarizes the properties obtained in this tensile test.

Table 1 Summary of coupon tensile test

	Design thickness (mm)	Tensile strength (MPa)	Young's modulus (GPa)	Rupture strain (%)
Jute	0.43	378	30.6	1.84
Water hyacinth	0.59	63.2	8.52	1.70

2.2 Cylinder compression test

Cylinder concrete was 200 mm in height and 100 mm in diameter. NFRP sheet was attached by impregnating adhesive epoxy resin. After curing for one week, cylinders were tested under monotonic concentric compression using Universal Testing Machine. The number of layers is varied from 1 to 4 layers. 4 strain gauges were mounted in the middle of height at every quarter of circumference to obtain strain in lateral direction. As Figure 1 shows, 2 Linear Variable Differential Transducers (LVDTs) were set in compressometer and measured axial strain

Figure 1 instrumentation of compression test

3. Experimental results and discussion

3.1 Failure mode

Jute-confined concrete failed in NFRP rupture with a sudden loud noise. Crack in Jute-NFRP developed suddenly and axial stress decreased rapidly. On the other hand, rupture of Water hyacinth-NFRP developed gradually. Loud noise and sudden drop of axial stress were not seen in water hyacinth-confined concrete.

3.2 Relationship between stress and strain

Compression test results are summarized in Table 2. Confinement of Jute-NFRP enhanced compressive strength of normal concrete by 171.61 % at most compared to un-confined specimen. On the contrary, confinement of Water hyacinth-NFRP did not increase compression strength of normal concrete. In case of low strength concrete confined with Jute-NFRP, the compressive strength showed 5.06 times larger than that of un-confined concrete. This indicates that confinement for low strength concrete has large reinforcing effect. Confinement for low strength concrete with Water hyacinth-NFRP improved compressive strength by 224.6 %.

Figure 2 shows the relationship between axial compression stress and strain in lateral and axial direction. Lateral strain is represented in negative values, whereas axial strain is represented in positive values. The more layers of Jute-NFRP were applied, the larger axial strains were developed, leading to larger compressive strength. This

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means that confinement with Jute-NFRP could improve concrete specimens' ductility.

Table 2 Summary of compression test result

Concrete core (f_{c0})	Fiber	1-layer	2-layer	3-layer	4-layer
Normal concrete (33.1 MPa)	Jute	40.84	48.28	56.80	56.56
	Water hyacinth	35.67	35.15	36.11	35.49
Low strength concrete (7.69 MPa)	Jute	21.38	31.36	37.75	38.91
	Water hyacinth	12.69	13.89	17.25	17.25

f_{c0}: Compressive strength of unconfined concrete

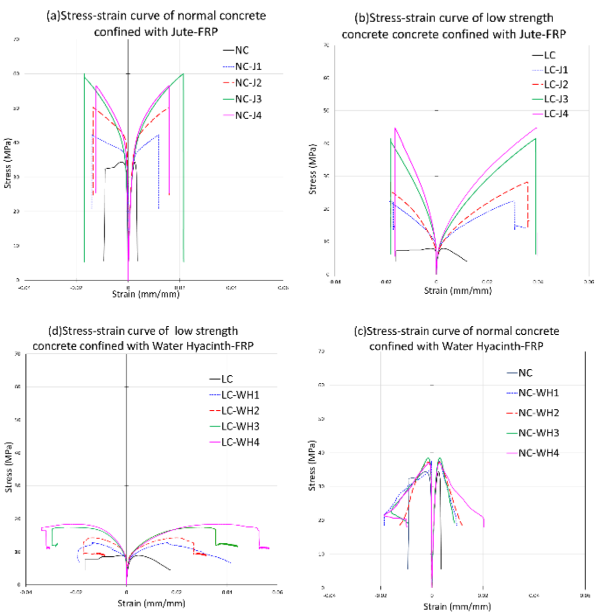

Figure 2 Stress-strain curves of NFRP confined concrete

4. Prediction model

From data obtained from these experimental tests, equation for prediction of compressive strength of confined concrete is modified based on proposal by S. Saleem (2018)[5] using regression analysis.

$$\frac{f_{cu}}{f_{c0}} = 1 + 6.58\left(\frac{f_{la}}{f_{c0}}\right)^{0.76}$$

Where f_{cu} = compressive strength of confined concrete and f_{la} = confining stress.

Figure 3 shows comparison of compressive strength between prediction and test. Data named CL in Figure 3 is data of PET-FRP confined concrete shown by S. Saleem (2018)[5].

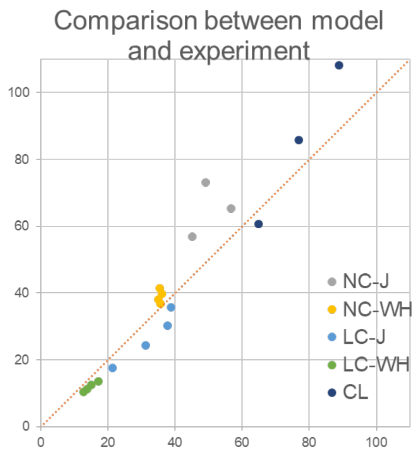

Figure 3 Comparison of compression strength between prediction and experimental data

5. Conclusion

1) Jute-NFRP confinement enhances compressive strength and ultimate strength and improves its ductility. Water Hyacinth-NFRP confinement has small reinforcing effect.
2) Concrete having low compressive strength can be more effectively reinforced by both Jute and Water Hyacinth-NFRP jacketing than concrete with normal strength.
3) Prediction model to predict compressive strength of confined concrete is obtained.

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