Experimental Study on Comparison of Strength Properties of Natural Waste Fiber (Coir and Jute) Reinforced Concrete

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Abstract

For this study, natural waste fiber (coir and jute) were used as they are freely available in large quantities. The property of natural waste fiber (coir and jute) reinforced concrete was compared with conventional concrete based on experiments performed in the laboratory. The use of coir and jute fiber will also lead to better management of these natural waste fibers. Coconut and jute fibers were cut into desire length of 71.67 mm and 96.48 mm per aspect ratio of 75. 1:2:4 ratios concrete mix was produced which contains coir and jute fiber of 0.5, 1 and 1.5% by volume of concrete. Engineering properties such as workability, flexural strength and compressive strength of coir and jute fibers reinforce concrete specimens were determined following standard procedures at curing ages of 7, 14 and 28 days. The results showed that the workability decrease from increase of fibers, while the compressive strength increased up to 4.5% and flexural strength increased up to 5.9% but dropped afterwards when compared with conventional concrete.

Keywords: Natural Fiber; Coir Fiber; Jute Fibers; Concrete; Compressive Strength; Flexural Strength; Workability

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INTRODUCTION

Concrete is inexpensive, durable, and readily moldable into complicated shapes and has good compressive strength and stiffness due to which it is most frequently used man made material in the world. However, it has low ductility, low energy absorption and low tensile strength. In structures, it is reinforced with reinforcement bars or mesh (rebar's) due its lack of tensile strength. But this type of reinforcement is crude and ineffective for controlling cracks. Also, this reinforcement gets decayed and corroded in abusive environments. Concrete technology now contains reinforcement in the form of fibers, Fiber-reinforcement is not used for structural strengthening, and rather it reduces the requirement of amount of rebar's or mesh and adds to the improvement of durability by delaying the crack propagation.

The concept of reinforcement in the form of fibers is not new. In ancient times horsehair was used in mortar and straw in mud bricks as fiber reinforcement. Considerable efforts have been made world-wide to add various types of fibers to concrete so to make it more strong, durable and economical. Natural fiber such as coir and jute has certain mechanical and physical characteristics due to which it can be utilized effectively in the development of reinforced concrete material. In most cases, these fibers are dumped as agricultural waste, so can be easily available in large quantity hence making them cheap.

(Hasan et al., 2012) from Malaysia, have investigated concrete physical and mechanical characteristics after adding coconut fiber on a volume basis. They conducted a micro structural analysis test using a scanning electron microscope for understanding the bonding behavior of the coconut fibers. (Domke, 2012) from Nagpur, Maharashtra has investigated the use of natural and agricultural waste products such as coconut fibers and rice husk ash to enhance the properties of concrete. The study also emphasizes on the fact that coconut fibers and rice husk ash not only improve the properties of concrete, but it also leads to proper disposal of these waste materials and reduces their impact on the environment.(Baruah and Talukdar, 2007) Investigated coir fiber reinforced concrete with the volume fraction 0%, 0.5%, 1.0%, 1.5%, 2.0% by the volume fraction of concrete shows compressive strength, modulus of rupture, split tensile strength, toughness and shear strength continuously increases up to 2% volume fraction of concrete.

(Majid et al., 2012) from New Zealand has investigated coconut fiber reinforced concrete (CFRC) members mechanical and dynamic properties. An assessment between the static and dynamic moduli was conducted. The influence of 1%, 2%, 3% and 5% fiber contents by mass of cement and fiber lengths of 2.5, 5 and 7.5 cm is investigated. CFRC with higher fiber content has a higher damping but lower dynamic and static modulus of elasticity. It is found that CFRC with a fiber length of 5 cm and a fiber content of 5% has the best properties. (Ramli et al., 2013) from Malaysia studied the strength and durability of coconut fiber reinforced concrete in aggressive environments. Their aim was to mitigate the development of cracks in marine structures by introducing coconut fibers which would provide a localized reinforcing effect. The result shows that the fibers play a role in restraining the development of cracks. However, the dosage of coconut fiber should be low, not exceeding 1.2% of the binder volume, due to the drawback of its natural degradation.
(Yalley and Khen, 2009) from United Kingdom performed various tests to study the enhancement of concrete properties after addition of coconut fiber. Their study focused on the coconut fiber obtained from Ghana Africa. They investigated the compressive strength, tensile strength, torsional strength, toughness and its ability to resist cracking and spalling. That addition of coconut fiber to concrete leads to improvement of concrete the toughness torsion and the tensile stress, further work is however, required to assess the long-term durability of concrete enhanced with coconut fibers.

MATERIALS AND METHODS

The materials used for this research include: ordinary port land cement (OPC), coarse aggregates with size 19 mm to 12.5 mm, fine aggregates, coir and jute that was purchased from local market respectively. The aspect ratio of the fiber in this study was kept 75 and the required length of the coir jute fiber was calculated as Shown in Table 1.

Table 1: Fiber aspect ratio

Fiber Type	Aspect Ratio L/D	Diameter mm	Length mm (L=ARxD)
Coir	75	0.9556	71.67
Jute	75	1.2864	96.48

In this research 1:2:4 ratio concrete mix was used. The experimental investigation was carried out for both Plain Concrete and Fiber Reinforced Concrete on casting cubes of 6" × 6", and beams of 6" × 6" × 18" by varying the percentage of addition of 75 Aspect ratio Natural fibers by 0%, 0.5%, 1% & 1.5% to the total volume of the concrete. Three samples for dissimilar percentages and proportions of fibers added to concrete was casted and cured. The cured sample was tested for fresh and hard properties of concrete for 7, 14 and 28-day strength.
Weigh batching was adapted to batch materials like cement, fine aggregate, coarse aggregate, coir and jute for a higher degree of accuracy in experimental work. Concrete mixing has been done with help of concrete mixing machine and manual distribution of fiber was adopted to overcome the problem of uniform distribution in concrete. Once the concrete was mixed thoroughly it was placed in a large rigid pan where the quality of concrete was observed and test for fresh concrete was conducted according to (ASTM International, 2003) and then it was poured in the moulds of cubes and beams. The inner surface of the moulds was coated with oil before pouring so that they can be easily demoulded after 24 hours.
Once the concrete was set thoroughly, the cubes and beams were demoulded and were cured in ordinary water by complete immersion for the required time of 7, 14 and 28 days. After curing period of 7, 14 and 28 days, the specimens were allowed to dry for about one hours then they were tested in universal testing machine, for studying the properties compressive strength (British Standard, 1983) and flexural strength (ASTM International, 2016) of hardened concrete. Finally, the results got from several percentages of fibers in concrete were compared.

RESULTS AND DISCUSSION

Workability

The workability was tested by slump test in accordance with ASTM. The results are shown in Table 2, from the obtained results, it was observed that there was decrease in the concrete workability with increase in the percentage of fiber in the concrete as shown in Figure 1. The reason was due to the absorption capacity of fibers which absorb the water from the concrete mix which lowers the workability furthermore the fiber in concrete prevented the concrete ingredients from flowing which also decreased the workability.

Table 2: Workability results (slump)

%age of Fiber (Coir & Jute)	Slump Value (inch)	Slump Value (mm)
0	3.30	84
0.5	2.32	59
1	1.25	32
1.5	0.62	16

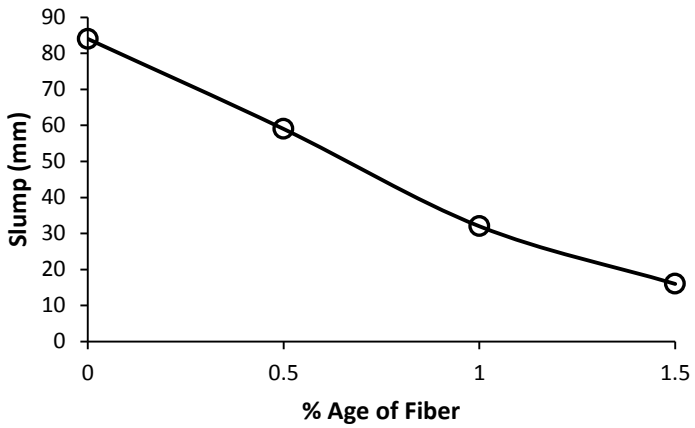

Figure 1: Workability of concrete mix with different % of fiber

Compressive Strength

Compressive strength test was conducted on compressive testing machine in accordance with British Standard to evaluate the strength development of concrete containing various percentages result is shown in Table 3. From the obtained results, it was observed that the compressive strength of all concrete samples was increasing up to addition of 1% fiber and after that, strength reduced with the increase in fiber Percentage. After 28 days compressive strength of 1% fiber reinforced concrete increases 4.5% as compared to plain concrete as shown in Figure 2.

Table 3: Compressive strength results of cube

Days	Sample No.	0 %fiber	0.5 % fiber	1.0 % fiber	1.5 % fiber
		Strength (Psi)	Strength (Psi)	Strength (Psi)	Strength (Psi)
7	1	1488.318	1510.869	1555.969	1398.117
	2	1518.085	1541.086	1587.089	1426.08
	3	1465.994	1488.206	1532.63	1377.146
	Average	**1490.799**	**1513.387**	**1558.563**	**1400.448**
14	1	2060.749	2060.593	2154.419	1935.855
	2	2101.964	2060.593	2197.507	1974.572
	3	2029.837	2060.593	2122.103	1906.817
	Average	**2064.183**	**2095.459**	**2158.01**	**1939.081**
28	1	2266.824	2301.169	2369.861	2129.44
	2	2312.16	2347.193	2417.258	2172.029
	3	2232.821	2266.652	2334.313	2097.499
	Average	**2270.602**	**2305.005**	**2373.811**	**2132.989**

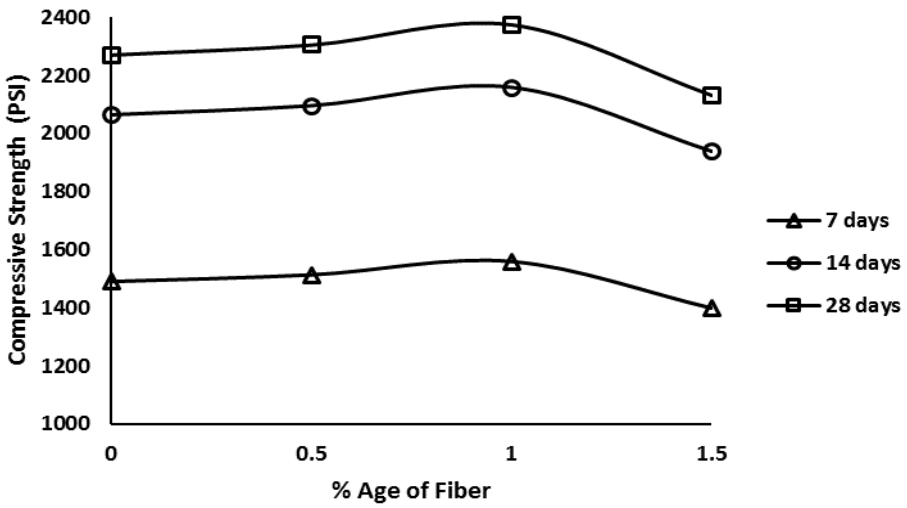

Figure 2: Average compressive strength

Flexural Test

Flexural strength test was conducted on universal testing machine as per ASTM to evaluate the strength development of concrete containing various fiber contents. Test results obtained for different sample are shown in Table 4. From the obtained results, it was observed that the flexural strength of the beam specimens obtained from fiber reinforced concrete at different ages are effectively increases with the increase in fiber percentage and the flexural strength of 28 days sample for 1% fiber increased 5.9 % as compared to plain concrete as shown in Figure 3.

Table 4: Flexural test results of beam

Days	Sample No.	0 % fiber	0.5 % fiber	1.0 % fiber	1.5 % fiber
		Strength (Psi)	Strength (Psi)	Strength (Psi)	Strength (Psi)
7	1	502.456	520.555	550.981	566.066
	2	511.215	510.142	541.145	552.893
	3	512.145	524.357	544.112	559.312
	Average	**508.6053**	**518.3513**	**545.4127**	**559.4237**
14	1	710.154	720.768	753.426	783.619
	2	712.541	722.488	742.457	780.921
	3	706.871	728.741	749.185	788.814
	Average	**709.8553**	**723.999**	**748.356**	**784.4513**
28	1	789.348	800.854	837.141	862.125
	2	778.244	803.917	825.154	879.657
	3	785.125	799.158	830.541	870.119
	Average	**784.239**	**801.3097**	**830.9453**	**870.6337**

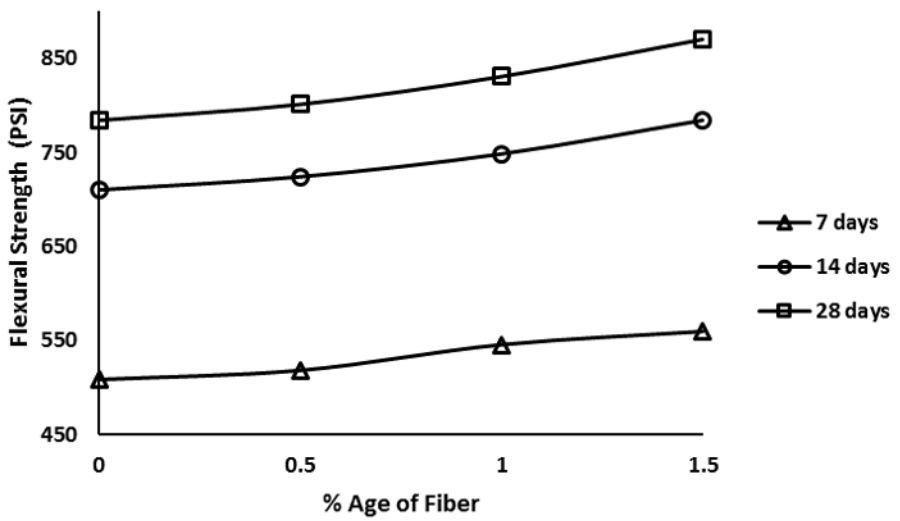

Figure 3: Average flexural strength

CONCLUSION

The following conclusions are drawn based on current study and the laboratory experimental work carried out in the research. Workability reduced as the fiber content increases. Because as the fiber percentage was enlarged, the mix became more cohesive. The compressive strength has an increasing trend up to 1%. After that, strength reduced with the increase in fiber Percentage. The compressive strength of 1% of coir and Jute fibers by volume of concrete gave optimum results with increase of 4.5% compressive strength as compared to normal concrete. The flexural strength also has an increasing trend. The flexural strength of 1% of coir and Jute fibers by volume of concrete increases up to 5.9% as compared to normal concrete.

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