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CHARACTERISTICS STRENGTH OF COCONUT FIBER REINFORCED CONCRETE

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ABSTRACT

Sustainability is widely embraced in modern construction, despite rising costs and environmental harm from industry advancements. This has spurred a balanced, eco-centric approach, incorporating natural fibers like coconut for concrete reinforcement. Abundant at test sites, coconut fiber is a viable, eco-friendly option that boosts strength, cuts carbon emissions, and offers income for producers by repurposing coir waste, easing landfill pressure. High water absorption is mitigated by oil-coating the fibers. This study assessed coconut fiber-reinforced concrete's strength, sourced from Ivbiaro, Owan West, Edo State. Using M20 grade concrete (1:2:4) with a 0.5 water-cement ratio, fibers were added at 1%, 2%, 3%, 4%, and 5%. Seventy-two cubes (150 x 150 x 150 mm) were cast, with 18 per mix ratio. Fresh concrete was tested for slump and compaction, while hardened concrete underwent rebound hammer (RH), ultrasonic velocity (UVT), and compressive strength tests at 7, 14, 21, and 28 days under lab conditions. Results showed workability decreases as fiber content rises, while density increases. Compressive strength peaks at 1% fiber (22.44 N/mm²) from 0% (19.87 N/mm²), but declines beyond 1%. Thus, coconut fiber enhances concrete sustainability and strength optimally at 1%, supporting eco-friendly construction with economic and waste management benefits.

Keywords: Aggregate, Cement, Concrete, Pycnometer, Reinforcement

INTRODUCTION

Concrete is a composite material composed of aggregate bonded together with fluid cement that cures over time. It is the second-most-used substance in the world after water and is the most widely used building material (Mehta & Monteiro, 2014). Concrete primarily consists of aggregates, such as natural sand and gravel or crushed rock, combined with cement. However, plain concrete exhibits limited tensile strength compared to its compressive strength, necessitating the use of reinforcements to enhance its structural performance. Fiber-reinforced concrete (FRC) has emerged as a viable alternative to conventional reinforcement methods. FRC is known for its high strength-to-weight ratio, ability to be molded into various shapes, and enhanced resistance to environmental conditions, resulting in reduced maintenance costs (ACI Committee 544, 2016). These attributes make FRC a suitable choice for innovative construction projects, including the upgrading of existing structures and the construction of new ones, such as offshore platforms, buildings, and bridges.

Coconut fiber, extracted from the outer shell of a coconut, has been identified as a potential reinforcement material for concrete. Scientifically known as Cocos nucifera and belonging to the Arecaceae (Palm) family, coconut fiber is widely available and has been used in various industries (Ali et al., 2012). The high costs and corrosion issues associated with steel fiber reinforcement have led researchers to explore natural fiber alternatives. Coconut fiber, recognized as the most ductile among natural fibers, offers a cost-effective, environmentally friendly, and biodegradable alternative for concrete reinforcement (Munawar et al., 2007), Ugwu and Egwuagu (2022). Additionally, utilizing coconut fibers as reinforcement helps manage agricultural waste effectively, reducing environmental pollution. FRC differs from conventional reinforcement methods in several key ways: fibers are generally distributed throughout the concrete matrix, whereas reinforcement bars are placed in specific locations; fibers are relatively short and closely spaced, unlike reinforcement bars, which are continuous and widely spaced; while fiber reinforcement does not provide the same level of reinforcement as steel bars, it significantly enhances toughness by transmitting forces across cracks, thereby improving the structural performance of concrete (Bentur & Mindess, 2007).

Coconut fibers, derived from the husk of coconuts, are agricultural waste products widely available in tropical regions, particularly in Africa, Asia, and South America. In Nigeria, they are abundant in the southern regions (Ogunbiyi et al., 2019). Previous studies have demonstrated that coconut fiber enhances the toughness of concrete and mortar (Ramakrishna & Sundararajan, 2005). However, challenges related to long-term durability and the influence of coconut species and cultivation sub-region on reinforcement effectiveness remain areas for further research. Coconut fiber is extensively used in the textile industry and by rural dwellers for manufacturing furniture, ropes, brushes, sacks, doormats, rugs, mattresses, carpet insulation panels, and vehicle seats. However, significant quantities of residual coconut fibers remain unused and are often disposed of by burning, which contributes to severe air pollution. Furthermore, exposure to environmental factors such as rain accelerates the decomposition of these residues, resulting in foul odors and environmental degradation. To mitigate these environmental issues, researchers have sought alternative ways to repurpose coconut fiber waste. One promising approach is optimizing the use of coconut fiber residues as reinforcement in concrete, thereby converting waste into a valuable construction material while addressing both environmental and structural challenges (Hasan et al., 2021).

The aim of this study is to assess the characteristic strength of coconut fiber-reinforced concrete (CFRC). The objectives include determining the physical and mechanical properties of the constituent materials and evaluating the compressive strength of coconut fiber-reinforced concrete. This study seeks to contribute to the advancement of sustainable construction materials by exploring the feasibility of using coconut fiber as an effective reinforcement in concrete structures.

MATERIALS AND METHODS

Materials

The materials used in this research included Dangote 3X brand Ordinary Portland Cement, river sand (fine aggregate), crushed granite (coarse aggregate), coconut palm fiber, and potable water. Details of each material are provided below.

Portland cement

The cement used was Dangote 3X brand Ordinary Portland Cement, procured from Samara Market in Zaria, Kaduna State, Nigeria. This cement conformed to standard specifications for ordinary Portland cement.

Fine Aggregate

Locally available river sand was used as the fine aggregate. Prior to use, sieve analysis was conducted in accordance with BS 812-103.1 (1995) to determine its particle size distribution and grading.

Coarse Aggregate

Crushed granite, sourced from Samara, Zaria, was used as the coarse aggregate. Sieve analysis was performed following BS 812-103.1 (1995) to assess its grading.

Coconut Palm Fiber

Coconut palm fiber was obtained from Ivbiaro, Owan East Local Government Area, Edo State, Nigeria. The fiber was incorporated into the concrete mix as a reinforcement material.

Water

Potable water supplied by Ahmadu Bello University, Zaria, with a pH range of 6.8 to 8.0, was used for preparing all concrete mixes. The water was deemed suitable for drinking and concrete production.

Methods

The experimental procedures employed in this study included specific gravity tests for fine and coarse aggregates, aggregate impact value (AIV), aggregate crushing value (ACV), sieve analysis, standard consistency test, initial and final setting time tests, soundness test, slump test, rebound hammer test, ultrasonic velocity test, and compressive strength test. These tests were conducted to evaluate the properties of the materials and the resulting concrete mixes.

Specific Gravity of Fine Aggregate

The specific gravity of the fine aggregate was determined following BS 812: Part 2 (1995). A pycnometer was filled with distilled water, sealed with a screw cap, dried externally, and weighed (Ps, g). A 500 g sample of surface-dry sand (B) was added to the pycnometer, which was then refilled with water to full capacity. Trapped air was removed by rotating the pycnometer while covering the opening with a finger. The pycnometer was dried externally and weighed again (P, g). The apparent specific gravity was calculated using the formula: a: $= B/(P + B - Ps$ (1)

Specific Gravity of Coarse Aggregate

The specific gravity of the coarse aggregate was determined as per BS 812: Part 2 (1995). A 1 kg sample was tested using a gas jar with a round disc covering the top, following a procedure similar to that for fine aggregate.

Aggregate Impact Value (AIV)

The AIV was determined according to BS 812-112 (1990). Two tests were conducted, and the average value was reported. A 500 g sample of coarse aggregate (A) was placed in a 76 mm diameter cylinder in three layers, each tamped 25 times with a rod. Excess material was leveled off, and the remaining aggregate was weighed (B). The sample was transferred to an impact machine cup, subjected to 15 hammer blows, and sieved using a 2.4 mm sieve. The weight of fines passing the sieve (C) was recorded. AIV was calculated as:

$$\text{AIV} = \frac{c}{A-B} \times 100 \quad (2)$$

Aggregate Crushing Value (ACV)

The ACV was determined following BS 812-110 (1990), with two tests averaged for accuracy. A 500 g sample (A) was placed in a cylinder in three layers, each tamped 25 times. The surface was leveled, and remaining aggregate weighed (B). The sample was compressed at 40 kN for 10 minutes in a compression machine, then sieved using a 2.36 mm sieve. The weight of fines passing the sieve (C) was recorded. ACV was calculated as:

$$\text{ACV} = \frac{c}{A-B} \times 10 \quad (3)$$

Sieve Analysis of Fine and Coarse Aggregates

Sieve analysis was conducted per BS 812-103.1 (1985). Approximately 1 kg of fine aggregate and 3 kg of coarse aggregate were air-dried and sieved. No hand pressure was applied to force material through the sieves; lumps were broken by hand, and light brushing was used on the underside of sieves.

Standard Consistency Test

The standard consistency of cement was tested per BS 4550-3.5 (1978). A 400 g sample of dry cement was mixed with water (30% of cement mass) to form a paste. The paste was placed in a Vicat mould, smoothed, and tested with a plunger until a penetration of 6-8 mm was achieved.

Initial and Final Setting Times

Setting times were determined per BS 4550-3.6 (1978). For the initial setting time, a cement paste of standard consistency was prepared, and the time of water addition was recorded. A 1 mm² needle was used to test penetration. For the final setting time, the needle was replaced with a 1 mm² needle with an annular attachment, applied every 15 minutes until the needle made an impression but the annular edge did not. Results showed an initial setting time of 144 minutes and a final setting time of 171 minutes.

Soundness Test

The soundness test followed BS 4550-3.7 (1978). A Le Chatelier mould was filled with cement paste, covered with a glass plate, and immersed in water for 24 hours. The initial distance between indicator points (L1) was measured as 6.0 mm. After further submersion and cooling, the final distance (L2) was 6.8 mm. Soundness was calculated as: $L2 - LI = 6.8 - 6.0 = 0.8$

Slump Test
The slump test was conducted per BS 1881: Part 102 (1983) using a mix ratio of 1:2:4 (cement:sand:stone) and a water-cement ratio of 0.5. Coconut fiber was added at 0%, 1%, 2%, 3%, 4%, and 5% by mass. The concrete was placed in a slump cone in three layers, each tamped 25 times. The cone was lifted, and the slump height was measured.

Mix Design (M20)
The mix ratio was 1:2:4:0.5 (cement:sand:stone:water), with a concrete density of 2400 kg/m³. Cube mould dimensions were 150 mm × 150 mm × 150 mm (volume = 0.003375 m³). Mass per cube was calculated as 8.1 kg, with a 5% allowance for shrinkage/waste (0.41 kg), yielding a total mass of 8.51 kg per cube. For 12 control cubes: cement = 13.62 kg, sand = 27.23 kg, stone = 54.46 kg, water = 6.81 kg. Fiber contents were 1% (85.1 g), 2% (170.2 g), 3% (255.3 g), 4% (340.4 g), and 5% (425.5 g).

Mixing and Casting
Concrete grade M20 was prepared with a 1:2:4 mix ratio and 0.5 water-cement ratio. Coconut fiber was added at 1%, 2%, 3%, 4%, and 5% by mass. A total of 72 cubes were cast (18 per mix, 3 per fiber percentage), with each layer tamped 25 times. Cubes were demoulded after 24 hours and cured in water for 7, 14, 21, and 28 days.

Rebound Hammer Test
The rebound hammer test, a non-destructive method, was used to assess concrete compressive strength per BS 1881: Part 202 (1986), using a Schmidt hammer.

Ultrasonic Velocity Test
The ultrasonic velocity test measured concrete elastic properties by sending ultrasonic pulses through the specimens and calculating wave velocity based on transit time.

Compressive Strength Test
Compressive strength was tested per BS 1881: Part 116 (1983). Air-dried cubes were weighed, placed axially in a compression machine, and crushed at 7, 14, and 28 days. Strength was calculated as:

$$\text{Compressive strength} = \frac{crushing\ load\ (N)}{Area\ (mm^2)} \qquad (4)$$

RESULTS AND DISCUSSION

Consistency test

Test on Cement

Experiment no 1: Standard consistency

Table 1: standard consistency test results

Sample no	Weight of cement	Weight of water	Water/cement ratio	Average water/cement ratio
1	400	130	150/400 = 0.33	0.32
2	400	120	155/400 = 0.30	

The standard consistency test results for the cement, as presented in Table 1, were determined using two samples. For sample 1, with a cement weight of 400g and a water weight of 130g, the water/cement ratio was calculated as 130/400 = 0.325 (rounded to 0.33). For sample 2, with a cement weight of 400g and a water weight of 120g, the water/cement ratio was 120/400 =0.30. The average water/cement ratio across the two samples was 0.32(32%, which conforms to the BS 4550: part 3, 1978 specification requiring a standard consistency value between 25% and 35%

Setting Time Test
Result of setting time test on cement paste

Table 2: Result of setting time test on cement paste

Volume water ml	Initial setting Final Setting (mins)	Final setting time (mins)
128	56	150

The experiment conducted on the cement paste, as detailed in Table 2, indicates that with a water volume of 128 ml, the initial setting time is 56 minutes, and the final setting time is 150 times. These values fall within the acceptance limits specified by BS 12, 1991, which mandates that the initial setting time should not be less than 45 minutes and the final setting time should not exceed 10 hours. Therefore, the setting time of the cement is demand acceptable according to the standard.

Soundness Test
BS 4550, part 3, section 3:7 1978 stated that if the expansion exceeds 10mm, the cement is unsound.
The practical work carried out showed that the cement has an expansion of 0.3mm, averagely taken between 5.6 and 5.9mm which does not exceed 10mm as stated in the code. Therefore, the cement is sound.

Table 3: Soundness test result

Distance of the pointers before boiling (mm) UI	Distance of the pointers after boiling (mm) U2	U2 – U1
5.60	5.90	0.30

The cement was determined to be sound based on the results of the soundness test, as shown in Table3. The test measured the distance between the pointers before and after boiling. Initially, the distance (U1) was 5.60 mm, and after boiling, it increased to 5.90 mm (U2). The difference (U2 – U1) was calculated as 0.30 mm. this expansion value indicates that the cement is sound, as it falls well below the maximum allowable expansion of up to 10mm for soundness.

Specific Gravity Test
Specific gravity is a measure of a material's density (mass per unit volume) as compared to the density of water at 73.40F (230C). Therefore, specific gravity of both fine and coarse aggregate found to be 2.63 and 2.90 respectively, and corresponds to ASTM D854-14 which recommends a standard minimum value of 2.6 and maximum value of 2.9 for fine and coarse aggregates respectively. Thus, the aggregates are fit for use in this research.

Table 4: Showing results of specific gravity test

Test No.	Mass of dry Pycnometer Kg	Mass of Aggregate (B)	Mass of pycnometer + water (p)Kg	Mass of pycnometer + water + aggregate (P_s) Kg	Specific gravity B/ (P+B-P_s)
1	0.50		1.60	1.90	2.50
2	0.50		1.60	1.92	2.78
Average	0.50		1.60	1.93	2.63

The specific gravity test results from Table 4 show an average value of 2.63 for the aggregates, with individual tests yielding 2.50 and 2.78, indicating consistency with the ASTM D854-14 standard range of 2.6 to 2.9

Aggregate impact value (AIV) test

RS812 part 112 (1990), specifics a maximum mass loss of 50% for gravel, crushed gravel, or rushed stone. And between 0 to 30% are good for engineering works, which also corresponds other result obtained from the research was 19.64%

Table 5: Aggregate impact value (AIV) test

Test No.	Mass of total aggregate A	Mass of remaining aggregate B	Mass of fine passing 2.36mm sieve C	AIV = C/(A-B) 100	Average AIV in %
1	500	130	70	18.92	19.64
2	500	135	73	20	
Average	500	135	73	20	

The AIV test results from Table 5 indicate an average value of 19.64%, with individual tests showing 18.92% and 20%, well within the 0% to 30% range recommended by RS812 part 112 (1990) for engineering purpose.

Aggregate crushing value (ACV) test

The aggregate crushing value test is a standard test used to measure the strength of aggregates. It involves taking a sample of the aggregate and crushing it to a specific size. It can be seen that the ACV found is between the range of 0 to 30% which is 20.81%. This shows that the aggregate is good for engineering works.

Table 6: Aggregate crushing value (ACV) test

Test No.	Mass of total aggregate A (g)	Mass of remaining aggregate B (b)	Mass of fine passing 2.4mm sieve C (g)	ACV = C/(A-B) 100	Average ACV in %
1	500	150	800	20.78	20.81
2	500	1160	800	20.83	

The ACV test results from Table 6 show an average value of 20.81%, with individual tests yielding 20.78% and 20.83, confirming that the aggregates possess sufficient strength within the 0% to 30% range suitable for engineering purposes

Test on Aggregate

Experiment 1: Sieve analysis of fine aggregate
Weight of sample taken, W = 1000g
% retained = (mass retained / total mass of sample) x 100

Table 7: Sieve analysis of fine aggregate

S/N	Sieve Size	Mass Retained (g)	% Retained	Cummulative Retained	% Passing
C1	C2	C3	C4	C5	C6
1	4.76mm	78	7.61	7.61	92.39
2	2.36mm	101	10.11	17.72	82.28
3	1.18mm	160	16.02	33.74	66.26
4	600µm	370	37.04	70.78	29.22
5	300µm	190	19.02	89.80	10.20
6	150µm	22	2.20	92.00	8.00
7	Pan	80	8.01	100	0.00
Fineness Modulus ∑C6/100 =					2.88
The Grading of the Fine Aggregate is					Zone 1

From table 7 the particle size distribution of fine aggregate, the fineness modulus of the aggregate is 2.88, which indicates that the fine aggregate falls under the category of medium sand. The fineness modulus of medium sand falls between 2.62 and 2.9. The grading of the aggregate as per BS EN 1097-2 (2010), BS 882:1973 grading is in Zone I. The higher the value of the fineness modulus, the coarser the sand, and vice versa. Generally, fine aggregate with lower fineness modulus results in more paste making the concrete easier to finish.

Experiment 2: Sieve analysis of coarse aggregate
Weight of sample taken, W = 3000g
% retained = (mass retained / total mass of sample) x 100

Table 8: Sieve analysis of coarse aggregate

S/N	Sieve Size (mm)	Mass Retained (g)	% Retained	Cummulative Retained	% Passing
C1	C2	C3	C4	C5	C6
2	38.1	0	0	0	100
3	25.4	350	11.67	11.67	88.33
4	19.05	1037	34.59	46.26	53.74
5	12.7	1480	49.37	95.63	4.37
6	9.52	116	3.87	99.5	0.5
7	6.35	12	0.4	99.9	0.1
8	Pan	3	0.1	100	0
Fineness Modulus Coarse Aggregate (∑C6 + 500)/100 =					7.47
The Size of Coarse Aggregate					40mm

Table 8 shows the particle size distribution of coarse aggregate, the fineness modulus of the aggregate is 7.47, this indicates that for a fineness modulus of the range 6.9 – 7.5 the maximum size of coarse aggregate is 40mm.

Result of slump test on concrete Coconut fiber content

Table 9: slump test on concrete Coconut fiber content

S/No	Concrete coconut fiber content to the (%)	w/c ratio	Height of cone (mm)	Height of concrete (mm)	Slump value (mm)
1	0	0.5	300	296	4
2	1	0.5	300	297	4
3	2	0.5	300	297	3
4	3	0.5	300	298	2
5	4	0.5	300	298	2
6	5	0.5	300	299	1

From table 9 at each replacement level, the type of slump obtained is a true slump which also corresponds to the specifications given in BS 1881: Part 102: 1983, which stated that the test is only valid if it yields a true slump, this being a slump in which the concrete remains substantially intact and symmetrical. And also stated that the difference between the height of the concrete and the height of the cone should not exceed 5mm, which also corresponds to the slump values obtained in table 4.10 above, the workability of a concrete mix changes with time due increase in coconut fiber content, hydration of the cement and, possibly loss of moisture. Hence further increase in the percentage of fiber reduce the slump value, which make it less workable.

Rebound Hammer Test (RHT)

Table 10: Showing rebound values of concrete for 28 days' strength at various % additive of coconut fiber corresponding compressive strength (N/mm2) x impact energy value (0.75)

Coconut fiber content %	Rebound nos.	Av. Rebound No.	Corresponding compressive strength (N/mm2)	Quality of concrete
0	30,29,28,26,25,24,20,27,31,34	27	20.25	fair
1	24,26,24,25,23,26,28,30,29,32	30	22.5	fair
2	24,20,29,24,25,20,16,27,22,16	22	16.50	Poor
3	21,27,17,20,22,19,25,18,26,19	23	17.25	Poor
4	19,21,22,20,30,22,15,30,24,17	24	18.00	Poor
5	10,16,17,13,17,15,12,20,19,12	15	11.25	Poor

According to BS 1881-203, the quality of concrete can be determined by comparing the rebound value to a table of recommended limits. From table 10, 20.25 and 22.5 are fair concrete which is between 20-30 (N/mm^2) on the code.

Ultrasonic Pulse Velocity Test (UPV)

Table 11: Ultrasonic pulse velocity test

S/N	Coconut fiber content (%)	Transit period (µs)	Transit velocity (m/s)	Transit velocity (km/s)	Quality of concrete
1	0	36.03	4157	4.18	good
2	1	35.63	4170	4.17	good
2	2	34.77	4261	4.26	good
4	3	36.96	4039	4.04	good
5	4	34.50	4313	4.31	good
6.	5	35.80	4195	4.2	good

According to BS 1881-203, the quality of concrete can be determined by comparing transit velocity value to the recommended limits. From table 11, result gotten falls within the range of 3.5-4.5, which indicate good quality as stipulated on the code.

Result of Compressive Strength Test of Concrete Cubes

The results of the compressive strength of concrete produced during this study at various percentages of coconut fiber at 7, 14, 21 and 28 days are shown in tables 12.

Table 12: Summary of compressive strength test of concrete cubes at various percentage of coconut fiber from 7 to 28 days curing

S/No	Days	Cube strength @ 0% (N/MM^2	Cube strength @ 1% (N/MM^2	Cube strength @ 2% (N/MM^2	Cube strength @ 3% (N/MM^2	Cube strength @ 4% (N/MM^2	Cube strength @ 5% (N/MM^2
1	7	15.78	10.67	12.00	12.62	12.44	10.67
2	14	15.87	17.33	15.11	10.84	14.00	12.87
3	21	18.80	16.13	15.56	16.67	12.00	14.22
4	28	19.87	20.44	17.33	16.67	15.56	14.00

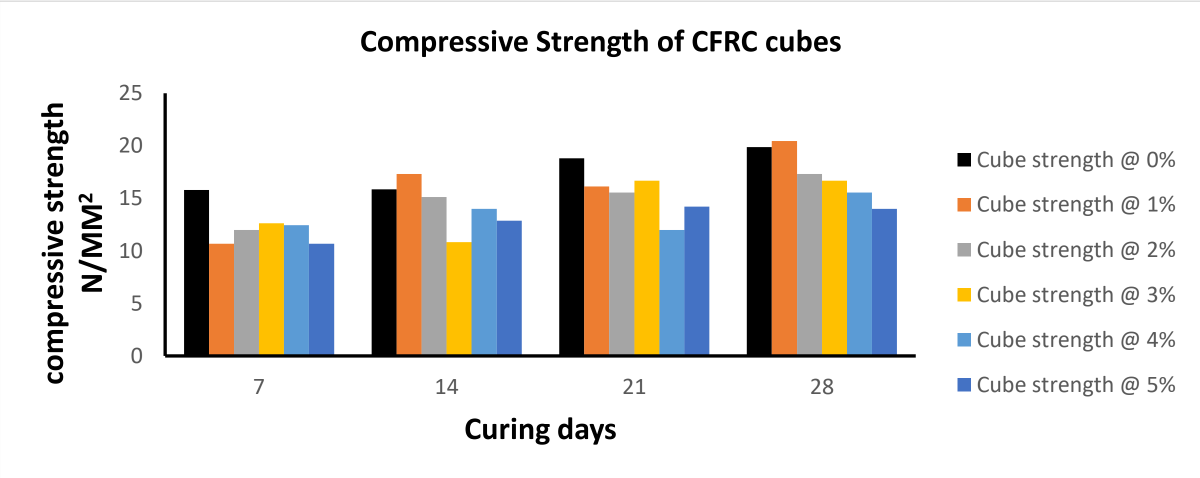

Figure 1: Graph showing variation of compressive strength at varying percentages of coconut fibre at 28days curing

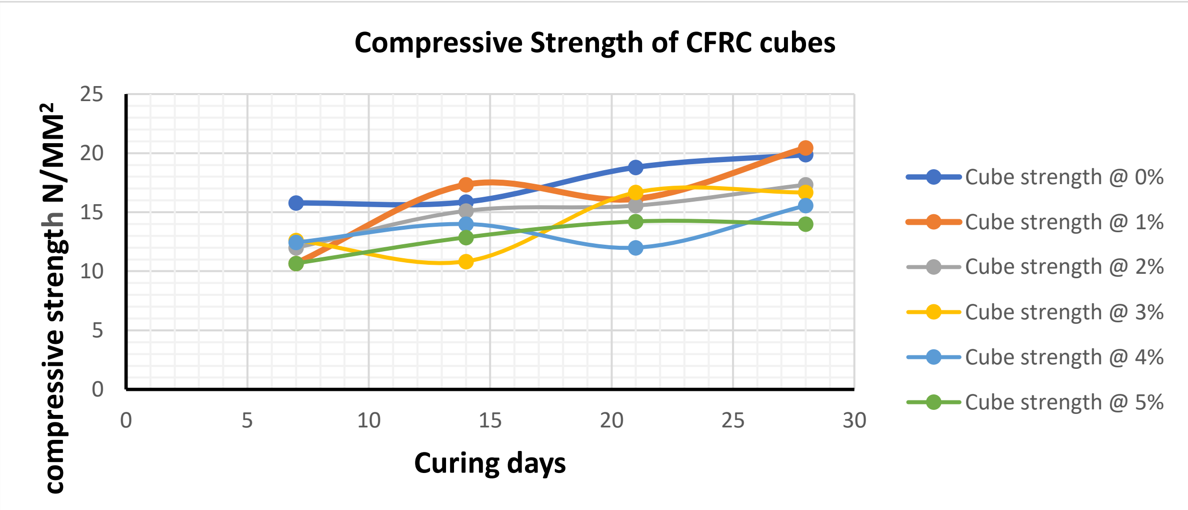

Figure 2: Graph showing variation of compressive strength at varying percentages of coconut fibre at 28days curing.

From table 12 the results obtained for 0%,1%,2%,3%,4% and 5% proportion of coconut fiber and water cement ratio 0.5, yielded optimum results for compressive strength at 1% CFRC. However, the compressive strength decreased on the increase in fibre content. This may be due to the fact that, when fibres are added initially the finer sized fine aggregates enter into the surface pores in the fibre creating a better bonding between the fibre and mix, however further addition of fibres causes formation of bulk fibre in the mix decreasing the bonding. Hence there is an optimum value of fibre to cement ratio, beyond which the compressive strength decreases. Hence 0.5 was taken as the optimum water cement ratio and optimum fibre content was taken as 1%.

CONCLUSION

The study confirms coconut fiber's viability as a sustainable reinforcement in CFRC, meeting the aim of assessing its characteristic strength and material properties, with cement and aggregates satisfying standards-consistency at 32% (BS 4550:1978, 25%-35%), setting times of 56 min initial and 150 min final (BS 12:1991), specific gravity of 2.63 (fine) and 2.90 (coarse) aggregates (ASTM D854-14), and AIV(19.64%) and ACV (20.81%) within 0-30% (BS 812:1990)-achieving an optional compressive strength of 20.44 N/mm² at 1% fiber (vs. 19.87 N/mm² at 0%), supported by UPV (4.04-4.31 km/s, 'good' per BS 1881-203), though strength drops to 14.00N/mm² at 5% with slump decreasing from 4mm to 1mm, implying low fiber enhances strength via pore-filling and crack-bridging, while excess compromises cohesion, necessitating admixtures fro broader use. Compared to Gunasekun et al. (2012), who report 1%-2% optima (5%-10% and 22N/mm² gains), our 1% peak aligns, but Hasen et al. (2016) found 2%-3% (25N/mm²), possibly due to treated fibers improving bonding unlike our untreated ones, and Ozerkan et al. (2013) note similar workability issues offset by superplasticizers absent in our 0.5w/c ratio, suggesting 1% CFRC aids sustainability but requires refinement to match synthetic options.

REFERENCES

ACI Committee 544. (2016). Report on Fiber Reinforced Concrete. American Concrete Institute.

Ali, M., Liu, A., Sou, H., & Chouw, N. (2012). Mechanical and dynamic properties of coconut fibre reinforced concrete. Construction and Building Materials, 30, 814-825. https://doi.org/10.1016/j.conbuildmat.2011.12.068

Bentur, A., & Mindess, S. (2007). Fibre Reinforced Cementitious Composites (2nd ed.). Taylor & Francis.

Gunasekaran, K., Kumar, P. S., & Lakshmipathy, M. (2011). Mechanical and bond properties of coconut shell concrete. Construction and Building Materials, 25(1), 92–98.

Hasan, N. M., Sobuz, M. H., & Tamanna, N. (2021). Utilization of coconut fiber in concrete: A review. Journal of Sustainable Construction Materials, 3(1), 45-58.

Mehta, P. K., & Monteiro, P. J. M. (2014). Concrete: Microstructure, Properties, and Materials (4th ed.). McGraw-Hill Education.

Munawar, S. S., Umemura, K., & Kawai, S. (2007). Characterization of the morphological, physical, and mechanical properties of seven nonwood plant fiber bundles. Journal of Wood Science, 53(2), 108-113. https://doi.org/10.1007/s10086-006-0836-x

Ogunbiyi, M. A., Olawale, S. O., & Tudjegbe, O. E. (2019). Assessment of coconut fibre as an enhancement material in concrete production. Nigerian Journal of Technology, 38(3), 678-684.

Ozerkan, N. G., Ahsan, B., Mansour, S., & Iyengar, S. R. (2013). Mechanical performance and durability of treated palm fiber reinforced concrete. International Journal of Sustainable Built Environment, 2(2), 131–142.

Ramakrishna, G., & Sundararajan, T. (2005). Impact strength of a few natural fibre reinforced cement mortar slabs: A comparative study. Cement and Concrete Composites, 27(5), 547-553. https://doi.org/10.1016/j.cemconcomp.2004.09.006

Ugwu, j. N., & Egwuagu, O. (2022). Compressive strength of concrete made with mashed periwinkle shell as fine aggregate for disaster mitigation. *Fudma journal of sciences, 6*(5), 1 - 7. Https://doi.org/10.33003/fjs-2022-0605-1082