EFFECTS OF FLY ASH ON THE PROPERTIES OF COCONUT FIBRE REINFORCED CONCRETE

[1]S. I. Anowai, [2]T. S. Ketkukah, [3]M. Pam, [4]M.E. Gukas, [5]J.B. Rwang and [6]C.D. Gyang

[1] Senior Lecturer, Department of Building, University of Jos, Nigeria
[2] Reader, Department of Civil Engineering, University of Jos, Nigeria
[3]Lecturer, Department of Quantity Surveying, University of Jos, Nigeria
[4] Lecturers, Department of Building, University of Jos, Nigeria
[5] Lecturer, Department of Quantity Surveying, University of Jos, Nigeria
[6] Student, Department of Building, University of Jos, Nigeria

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Abstract - *This study investigates the effects of partially replacing Ordinary Portland Cement (OPC) with fly ash on properties of coconut fibre reinforced concrete. OPC was partially replaced with fly ash at 0%, 10%, 20% and 30% in coconut fibre reinforced concrete. The coconut fibres were extracted from coconut seeds and shredded into 60mm lengths. All the concrete specimens were reinforced with coconut fibre weighing 0.5% of the weight of fine the aggregates. Mix ratio of 1:2:4 and water/cement ratio 0.58 were adopted in this study. The slump, compaction factor, compressive strength, splitting tensile strength, flexural strength, alkalinity and water absorption of the concrete specimens were tested and analysed after curing periods of 7, 28 and 56 days respectively. Fly ash improved the workability, water absorption and reduced the alkalinity level of the matrix as percentage replacement of OPC with fly ash increases. The results also showed that specimens containing 10% partial replacement of cement with fly ash achieved highest compressive strength, flexural strength and splitting tensile strengths at all ages of curing. It can be concluded that 10% replacement of cement with fly ash replacement gave the best results for compressive strength, flexural strength and split tensile strength and reduced alkalinity and water absorption of coconut fibre reinforced concrete. It is thus recommended that OPC should be partially replaced with fly ash to improve the mechanical and durability properties of coconut fibre reinforced concrete.*

Key Words: **Coconut fibre, fly ash, workability, alkalinity, water absorption, mechanical properties.**

1. INTRODUCTION

Plain concrete possesses a high compressive strength but low tensile strength. Cracks develop in plain concretes even before loading due to drying shrinkage and when load is eventually applied the internal cracks propagate and open up due to stress and additional cracks are formed [1]. The propagation of these cracks can be arrested by the introduction of randomly distributed small pieces of reinforcing materials known as fibres. The introduction of fibres in concrete help to transfer loads at the internal micro cracks [2]. The fibres could be synthetic or cellulose (plant) fibres. The development of steel reinforcement has overcome the problem of poor tensile strength but it does not completely solve the problem of micro cracks due to drying and plastic shrinkage owing to weathering conditions and it is also expensive. The presence of micro cracks in the mortar-aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by inclusion of fibres in the mixture. Fibres cannot be used as conventional reinforcement but it can lower down the requirements of steel reinforcements [3].

Fibres are broadly classified into man-made and natural fibres. Man-made fibres are made from synthetic materials (such as petrochemicals) and metals while natural fibres originate from vegetable, animal and mineral sources. Natural fibre such as coconut fibre has certain physical and mechanical characteristics that can be utilized effectively in the development of reinforced concrete material [4].. Use of coconut fibre can lead to improvement in properties of cement concrete in addition to providing a proper solution for disposal of this natural waste. In most cases, these coconut fibres are dumped as agricultural waste, so can be easily available in large quantity hence making them cheap [5]. Coconut fibre has been described as the most ductile fibre amongst all natural fibres being that they are capable of taking strain 4-6 times more than other fibres [6].

Coconut fibre is extracted from the outer shell of a coconut. Its scientific name and the plant family of the coconut fibre is "Cocos Nucifera" and "Arecaceae (Palm)" respectively, while it is commonly referred to as "Coir" [7]. Large quantities of coconut fruit are produced in the rainforest zones of South-West and South-South regions of Nigeria with minor productions in other geo-political zones [8]. Coconut fibre is obtained from the husk of the coconut palm. The fruits are dehusked with a spike and after retting, the fibres are subtracted from the husk with beating and washing.

The short comings of natural (plant) fibre reinforced concrete includes poor workability, high water absorption and degradation in cementitious matrix. Plant fibres degrade in concrete due to high alkalinity of concrete. The durability of plant fibres in concrete can be improved by reducing the alkalinity of concrete with pozzolanas. The degradation of fibres immersed in Portland cement is due to the high alkaline environment that dissolves the lignin and hemicellulose phases, thus weakening the fibre structure [9].

Ede and Agbede [10] investigated the effect of coconut fibre on the properties of concrete and found that compressive and flexural strengths of coconut fibre reinforced concrete increased with curing age and with increasing percentage of coconut fibre up to 0.5% of the weight of fine the aggregates and then gradually began to decrease with increase in percentage of the fibre. The study also found that addition of coconut fibre in concrete resulted to poor workability. Babafemi, Kolawole & Olalusi [11] investigated the effect of incorporating coir fibre content on the workability, density, compressive strength, splitting tensile strength, and durability of concrete and found that coir fibre in concrete reduced its workability and improved the compressive and tensile strength of the concrete. Kshitija [12] found that addition of coconut fibres improved the flexural strength of concrete by about 12%, and they also formed good bonding in the concrete.

Addition of pozzolanas like fly ash in concrete also reduces the water absorption of the concrete through pozzolanic activity which produces additional cementitious gel which fills the voids in the concrete [13]. It is thus expected that partial replacement of cement with fly ash in coconut fibre reinforced concrete will improve the workability and the durability of the concrete.

Fly ash consisting mostly of silica, alumina, and iron, forms a compound similar to Portland cement when mixed with lime and water. Fly ash is a non combusted by-product of coal-fired power plants and generally ends up in a landfill. Fly ash tends to reduce the alkalinity of concrete due to calcium hydroxide consumption, which is the main controlling factor of pH in cement paste. Fly ash is most effective in reducing the alkalinity of the pore solution [14]. Fly ash is available in Nigeria as waste product of electricity generation plant in Oji River, Enugu State.

This study is aimed at investigating the effects of partially replacing cement with fly ash on the workability, mechanical and durability properties of coconut fibre reinforced concrete.

2. MATERIALS AND METHODS

The materials used for this work are coconut husk fibre, cement, fine aggregate, coarse aggregates, water and fly ash. The coconut fibres used in this Study were obtained from coconut sellers in Terminus market in Jos, Plateau state. The Coconut fibre was extracted from the outer shell of a coconut by hand picking. The length of the coconut husk fibres were cut to average lengths of 60 mm. The average diameter of the coconut fibres is 0.75 mm meaning the length/diameter ratio (i.e. aspect ratio) of the fibre used in this study is 80. The density of the fibre was 0.81g/cm^3.

BUA brand of ordinary Portland cement (OPC) manufactured by BUA Cement Company PLC in Benin Okene Expressway, Okpella in Edo State of Nigeria was used for all the tests. The cement conforms to [15]. The fine aggregate used was clean river sand conforming to the specification of [16]. The sand was gotten from Dogona Hauwa in Jos North Local Government area of Plateau state. The sand was sieved through 5mm diameter sieve and only the portion passing through the sieve was used in this study. The fine aggregate (sand) has a specific gravity of 2.62 and compacted bulk density of 1621kg/m^3. The coarse aggregate used was 12mm diameter crushed gravel. The coarse aggregate was gotten from a private quarry in Jos, Plateau State. The coarse aggregate (gravel) used has a specific gravity of 2.60 and compacted bulk density of 1484kg/m^3 respectively. The water used in this study was obtained from taps in concrete laboratory of Department of Building, University of Jos. The water is fit for drinking.

The fly ash used was sourced from the waste dump of Oji River thermal power station in Enugu State Nigeria. The Physical properties and chemical composition of the fly ash were determined in accordance with [17]. The chemical analysis of the sample was carried out at National Metrological Development Centre (NMDC) Jos, Plateau State, Nigeria using Energy Dispersive X-ray Fluorescence Spectrometer (EDXRF). The apparent specific gravity of the fly ash was 2.24, which was less than that obtained for cement. The loose bulk density and compacted bulk density of the fly ash were 1300 kg/m3 and 1418 kg/m3 respectively. The result shows that the sum of SiO_2, Al_2O_3 and Fe_2O_3 is 90.24% which is greater than the minimum of 70.00% specified in [15]. The fly ash was sieved through 212μm and only the portion passing the sieve size was used for this study.

A concrete mix of ratio 1:2:4 (Cement: Fine Aggregate: Coarse Aggregate) was adopted for the production of the concrete at a water-cement ratio of 0.58. An addition of 0.5% coconut fibre by weight of fine aggregate was made on all the mixes being the optimum percentage established by Ede et al. [10] for coconut fibre reinforced concrete. Cement was partially replaced with fly ash at 0%, 10%, 20% and 30% replacement levels. Batching by absolute volume was adopted. A total of 48 number 100mm x 100mm x 100mm cube, 36 number 100mm x 100mm x 500mm beams and 36 number 100mm diameter x 200mm high cylinders were cast and subsequently cured in water for 7days, 28days and 56days. The mix proportions used for all the mixes are presented in Table 1.

Batching, mixing and casting were done adopting a standard procedure in accordance with [18]. The fine aggregates and coarse aggregates were first measured. The required quantity of the coconut fibres were computed and measured ready for mixing. The concrete mixing was done by hand mixing on a watertight platform. The coarse and fine aggregates were firstly thoroughly mixed before the required quantity of cement and fibres were added. All the materials were then mixed to a uniform colour. For mixture in which Portland cement was partially replaced with fly ash, the fly ash and cement were mixed dry to uniform colour separately. The required amount of water were weighed and added carefully so that no water was lost during mixing.

The slump test for each of the concrete mix was determined in accordance with the provisions of [19] on the wet concrete. The compaction factor tests were also conducted on each concrete mix in accordance with the provisions of [20]. The wet concrete was then cast into cubes, cylinders and beams for compressive, splitting tensile and flexural strength tests respectively and vibrated using table vibrator. After setting for 24 hours, the specimens were demoulded and cured in water for 7, 28 and 56 days. The compressive strength, splitting tensile strength and flexural strength of the concrete specimens were determined in accordance with with the provisions of [21], [22] and [23] respectively.

A digital pH meter was used to determine the pH of the concrete specimens. The pH meter was first calibrated by immersing the tester in pH 7 buffer. After allowing the reading to stabilise the calibration trimmer was turned to read 7.0. Concrete powders were scrapped from the concrete cubes after specified days of curing and ground to fine powders. One part of the powder was mixed with two parts of distilled water. After mixing, the water was sieved through filter paper into a beaker. The digital pH meter was then immersed into the water and the pH reading taken. Water absorption tests were conducted on each mix in accordance with [24].

Table 1. Concrete Mix Proportions of Coconut Fibre Reinforced Fly Ash Concrete

% Replacement	Mix Ratio	W/C Ratio	Cement (kg)	Sand (kg)	Gravel (kg)	Coconut fibre (kg)	Fly ash (kg)	Water (kg)
0	1:2:4	0.58	25.84	56.27	110.67	0.28	0.00	14.98
10	1:2:4	0.58	23.25	56.27	110.67	0.28	2.58	14.98
20	1:2:4	0.58	20.67	56.27	110.67	0.28	5.16	14.98
30	1:2:4	0.58	18.08	56.27	110.67	0.28	7.75	14.98

3. RESULTS AND DISCUSSION

3.1 Workability Tests Results

The slump and compacting factor values for the wet coconut fibre reinforced fly ash concrete are presented in Table 2. The slump ranges from 15mm to 20mm At 0% replacement of cement with fly ash the slump is 15mm. 10% replacement of cement with fly ash resulted to the slump of 17mm. 20% replacement of cement with fly ash gave slump of 19mm while 30% replacement of cement with fly ash gave the slump of 20mm. This implies that as the percentage of fly ash increases for all the various mixes the workability slightly increases. The compacting factor was also found decrease progressively as the percentage replacement of cement with fly ash increases with the sample with 0% fly ash having the highest compacting factor of 0.90. It can therefore be deduced that fly ash increases the workability of coconut fibre reinforced fly ash concrete because as the percentage replacement of the cement with fly ash increases, the slump also increases at a constant free water/cement ratio of 0.58.

Table 2. Workability of Coconut Fibre Reinforced Fly Ash Concrete

Sample	W/C Ratio	Slump (mm)	Compacting factor
0% fly ash	0.58	15	0.90
10% fly ash	0.58	17	0.89
20% fly ash	0.58	19	0.87
30% fly ash	0.58	20	0.85

3.2 Density Tests Results

The densities of the concrete cubes of various mixes tested are presented in Table 3. The results indicate a strong relationship existing between the density and the addition of fly ash in the mix. The higher the amount of fly ash in the mix, the lesser the density of the concrete produced. This could be as a result of the low specific gravity of the fly ash at 2.49 which occupied a proportion of the volume with significant weight decrease. It was also observed that the density was also affected by the hydration period for all the mixes. The density increases progressively with increase in hydration period.

Table 3. Densities of Coconut Fibre Reinforced Fly Ash Concrete Cubes

Age (days)	W/C Ratio	0%	10%	20%	30%
7	0.58	2270	2260	2130	2090
28	0.58	2550	2270	2160	2130
56	0.58	2800	2370	2190	2140

3.3 Compressive Strength Test Results

Figure 1 shows the compressive strength of coconut fibre reinforced concrete produced with different percentage replacement of cement with fly ash. The results indicate that the compressive strength of coconut fibre reinforced concrete increases with increase in curing age. The maximum strength attained at 56 days is 29.5N/mm^2 .The compressive strength of coconut fibre reinforced concrete with 10% replacement of cement with fly ash at 56days is 32.00N/mm^2. This is slightly higher than the compressive strength of the control mix (with 0% fly ash). The result of compressive strength at 20% replacement of (OPC) with fly ash are 11.83N/mm^2, 14.50N/mm^2 and 19.50N/mm^2 at 7, 28 and 56 days respectively showing decrease in values when compared to the control specimen.

The compressive strength of coconut fibre reinforced fly ash concrete with 30% replacement showed further reduction in compressive strength. This indicated that partial replacement of cement with fly ash beyond 10% adversely affects the compressive strength of coconut fibre reinforced concrete. Similar trend was observed by Anowai and Job [13] for banana fibre reinforced fly ash concrete.

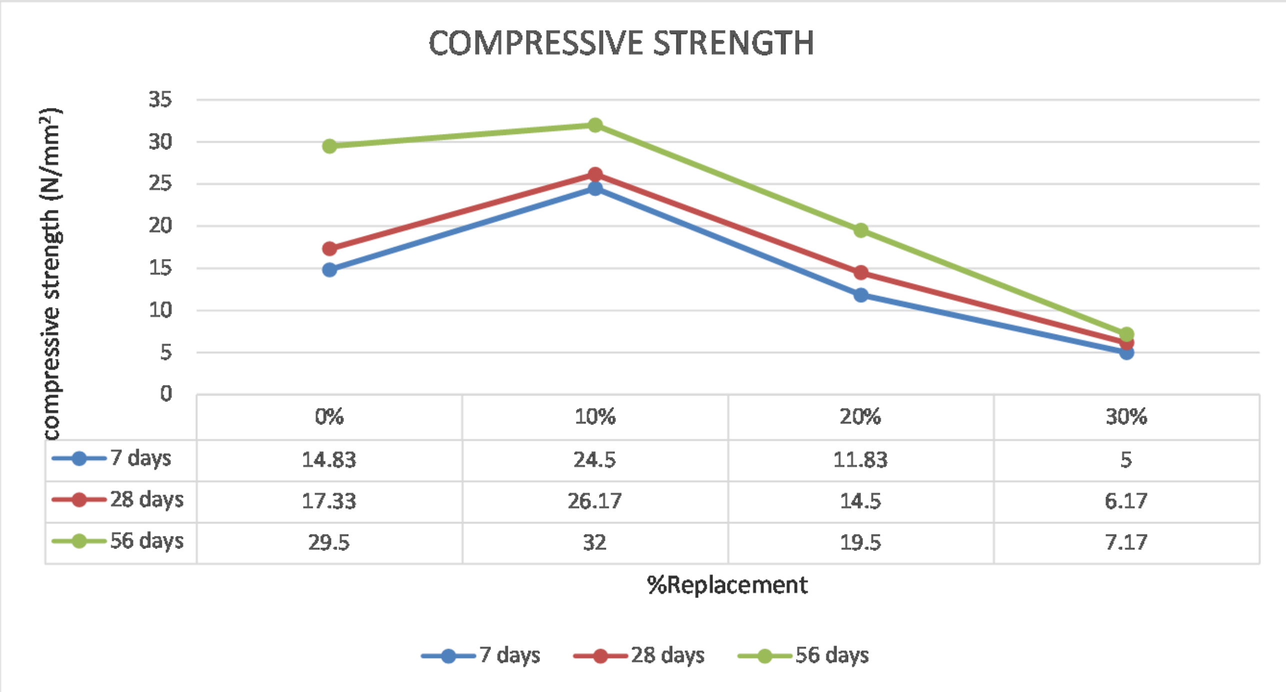

Figure 1: Compressive Strengths of Coconut Fibre Reinforced Fly Ash Concrete at Various Hydration Periods

3.4 Flexural Strength Test Results

Figure 2 shows the results of flexural strength tests on coconut fibre reinforced fly ash concrete produced with 0%, 10%, 20% and 30% replacements of cement with fly ash cured in water for hydration period of 7, 28 and 56 days. At 7 days the flexural strengths of specimens with 0%, 10%, 20% and 30% replacements of cement with fly ash were 6.38 N/mm^2, 6.62 N/mm^2, 1.23 N/mm^2 and 1.13N/mm^2 respectively.

At 28 days curing age the flexural strengths were 7.58 N/mm^2, 8.00 N/mm^2, 3.00 N/mm^2 and 1.63N/mm^2 for specimens with 0%, 10%, 20% and 30% replacements of cement with fly ash respectively. At 56 days curing age, the flexural strengths were 8.5 N/mm^2, 8.63 N/mm^2, 3.75 N/mm^2 and 1.75N/mm^2 for specimens with 0%, 10%, 20% and 30% replacements of cement with fly ash respectively.

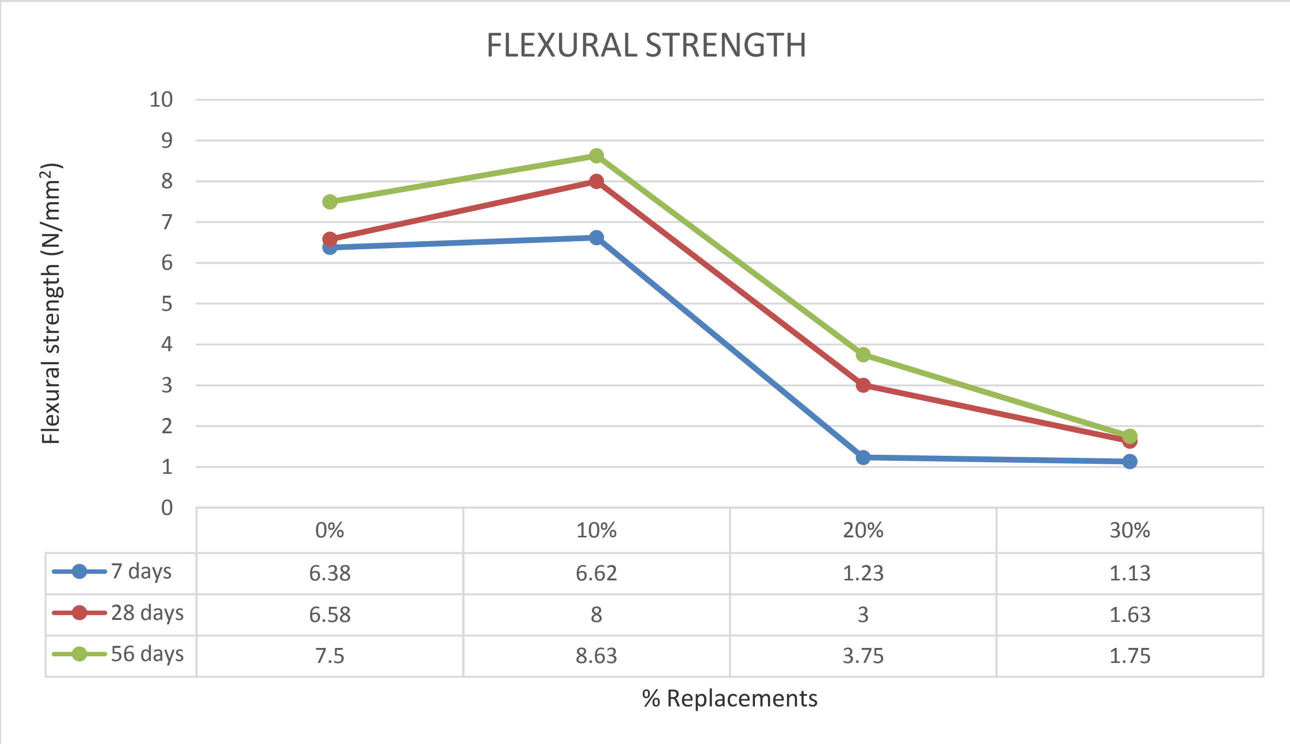

Figure 2: Flexural Strengths of Coconut Fibre Reinforced Fly Ash Concrete at Various Hydration Periods

3.5 Flexural Strength Test Results

The results of the splitting tensile strength test obtained for the various cylindrical samples of coconut fibre reinforced fly ash concrete at different percentages of fly ash and hydration periods of 7, 28, and 56 days are presented in Figure 3. The results show that the splitting tensile strength of coconut fibre reinforced fly ash concrete decreases with percentage increase in fly ash. The specimen with 10% replacement of cement with fly ash achieved the highest splitting tensile strengths of 2.49 and 2.97N/mm^2 at 28 and 56 days curing periods respectively.

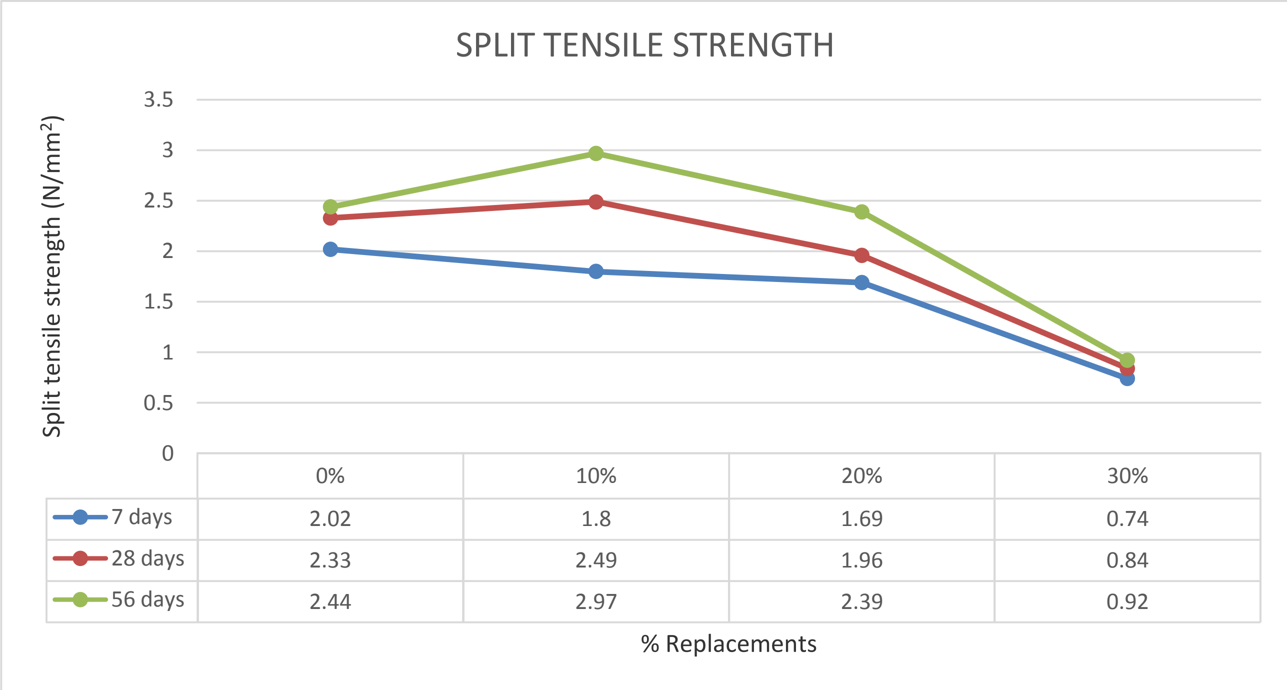

Figure 3: Splitting Strengths of Coconut Fibre Reinforced Fly Ash Concrete at Various Hydration Periods

3.6 Water Absorption Test Results at 28 Days

The results of water absorption obtained are shown in Table 4. The results showed that coconut fibre reinforced normal concrete absorbed more water than the coconut fibre reinforced fly ash concrete. At 0% replacement of cement with fly ash, the water absorption was 6.30% for coconut fibre reinforced concrete while 10%, 20% and 30% replacement of cement with fly ash the water absorptions were 5.40%, 3.30% and 3.3% respectively.

Table 4. Water Absorption of Coconut Fibre Reinforced Fly Ash Concrete at 56 Days

Mix Proportion	Water Absorption (%)
0.5% Fibre + 0% Fly ash	10.3
0.5% Fibre + 10% Fly ash	8.7
0.5% Fibre + 20% Fly ash	8.5
0.5% Fibre + 30% Fly ash	8.2.

3.7 Effects of Fly Ash on the pH of Coconut Fibre Reinforced Concrete

The results of pH of Coconut fibre reinforced fly ash concrete specimens are presented in Table 5. The results showed that the partial replacement of cement with fly ash resulted to a reduction in the concentration of OH^- ions and led to significant reduction of the pH of the concrete specimens tested. At 0%, 10%, 20% and 30% partial replacements of cement with fly ash the pH of the concrete produced are 10.2, 9.8, 9.8 and 8.8 respectively after curing for 56 days. These results follow the same trend as that obtained by Rewi and Khafagy [25] which showed that partial replacement of cement with bauxite (pozzolana) at various percentages of replacement of 10%, 20% and 30% resulted to significant reduction of pH of concrete. Gram (1988) also found that the alkalinity of cement matrices were reduced by partially replacing ordinary Portland cement (OPC) with silica fume, fly ash or completely replacing ordinary Portland cement with high alumina cement.

Table 5. The pH-Level of Coconut Fibre Reinforced Fly Ash Concrete at 56 Days

Mix Proportion	pH
0.5% Fibre + 0% Fly ash	12.2
0.5% Fibre + 10% Fly ash	10.2
0.5% Fibre + 20% Fly ash	9.6
0.5% Fibre + 30% Fly ash	9.3

4. SUMMARY OF FINDINGS

The findings of this research can be summarizes as follows;

1. The workability of coconut fibre reinforced concrete increases with increase in percentage replacement of cement with fly ash.
2. The pH of coconut fibre reinforced fly ash concrete decreases with increases in fly ash dosage.
3. The Compressive Strength results revealed that the concrete with 10% replacement of cement with fly ash achieved highest compressive strength at all hydration periods.
4. The results revealed that flexural strength of coconut fibre reinforced fly ash concrete with 10% replacement of cement with fly ash achieved the highest flexural strength at all ages of hydration. The flexural strengths reduced drastically at 20% and 30% replacements of cement with fly ash.
5. The splitting tensile strength results showed progressive increase in splitting tensile strengths with increase in hydration period. The control sample gave splitting tensile strengths of 2.02 N/m^2, 2.33 N/m^2, 2.44N/m^2 at 7, 28 and 56 days respectively. Specimens with 10% replacement of cement with fly ash which gave the highest splitting tensile strengths of 1.8 N/m^2, 2.49 N/m^2 and 2.97N/m^2 at 7, 28 and 56 days respectively.
6. The water absorption test results at 56 days revealed that there was a progressive decrease in the water absorption coconut fibre reinforced concrete with increase in percentage replacement of cement with fly ash.
7. The results showed that the partial replacement of cement with fly ash resulted to a reduction in the concentration of OH^- ions and led to significant reduction of the pH of the concrete specimens tested. This shows that the alkalinity of coconut fibre reinforced concrete reduces with increase in percentage replacement of cement with fly ash.

5. CONCLUSION

Based on the findings of this study, it can be concluded that partial replacement of cement with fly ash improves the workability and durability of coconut fibre reinforced concrete. The optimum percentage replacement of cement with fly ash in coconut fibre reinforced concrete was found to be 10%.

6. RECOMMENDATION

Partial replacement of cement with ten percent fly ash is recommended to improve the workability, mechanical properties and durability of coconut fibre reinforced concrete.

REFERENCES

[1] Vejje, S., & Krishna-murthy N.R. (2013). Study on Addition of the Natural Fibres into Concrete. *International Journal of Scientific and Technology Research.* 2(11), 213-218.

[2] Kene, K.S., Vairagade, V.S., & Sathawane, S. (2012). Experimental study on the behaviour of steel and glass fibre reinforced concrete composites. *Bonfring International Journal of Industrial Engineering and Management Science,* 2(4), 125-130.

[3] Patel, P., & Patel, I. (2013). A literature Review on Use of Cellulose Fibre and Supplementary Material, Silica Fume in Concrete. *Global Research Analysis International,* 2(5), 63-64.

[4] Uday, V.S. & Ajitha, B. (2017). Concrete Reinforced with Coconut Fibres. *International Journal of Engineering Science and Computing*, 7(4), 10436-10439.

[5] Kshitija, N. (2015). Coconut Fibre Reinforced Concrete. *International Journal of Mechanical and Production Engineering.* 1(3), 2320-2092.

[6] Munawar, S. S., Umemura .K., & Kawai, S. (2007). Characterization of The Morphorlogical, Physical, and Mechanical Properties of Seven Non-Wood Plant Fibre Bundles.J. Wood Science. 53(2), 108-113.

[7] Patil, D., Vanmali, M, Sonar, J., Tandel, T. & Dhurve5, S. (2021). Effects of coconut fibers on mechanical properties of concrete. *International Journal of Innovations in Engineering and Science,* 6(3), 1-5.

[8] Olanade, K.A., Aleke, A.D., & Morakinyo (2013). Strength development and crack pattern of coconut fibre reinforced concrete. *Civil and Engineering research.* 4, 46-53.

[9] Gram, H.E. (1988). Durability of Natural Fibre in Concrete, Concrete Technology and Design. London: Blackie and Sons Ltd.

[10] Ede, A.N. and Agbede, J.O. (2015). Use of coconut husk fiber for improved compressive and flexural strength of concrete. *International Journal of Scientific & Engineering Research*, 6(2), 968-974.

[11] Babafemi, A J., Kolawole, J. T., & Olalusi, O. B. (2019). Mechanical and Durability Properties of Coir Fibre Reinforced Concrete. *Journal of Engineering Science and Technology.* 14(3), 1482 – 1496.

[12] Kshitija, N. (2015). Coconut Fibre Reinforced Concrete. *International Journal of Mechanical and Production Engineering.* 1(3), 2320-2092

[13] Anowai, S.I. & Job, O.F. (2017). Properties of Banana Fibre Reinforced Fly Ash Concrete. *International Journal of Modern Trends in Engineering and Research* 4(7), 227-236.

[14] Marcelo, H. M., Janderson, W. R., Juarez, H. F. & Ronaldo, A. M. (2017). Partial replacement and addition of fly ash in Portland cement: influences on carbonation and alkaline reserve Springer. *International Publishing Switzerland.*

[15] American Society for Testing and Materials, ASTM C595/C595M. "Specification for Blended Hydraulic Cements", USA: ASTM International, 2016.

[16] British Standard Institution. BS EN 12620. "Aggregates for concrete", 2002.

[17] American Society of Testing and Materials. ASTM C618-19. “Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete”, 2019: 1-5.

[18] American Society for Testing and Materials, ASTM C172. “Standard Practice for Sampling Freshly Mixed Concrete”. USA: ASTM International, 2017.

[19] British Standards Institution, BS EN 12350-2. “Testing Fresh Concrete. Slump Test”. 2019; 1-26.

[20] British Standards Institution, BS 1881 Part 103:1993. “Method for Determination of Compacting Factor,” 1993.

[21] British Standards Institution, BS EN 12390-3. “Testing Hardened Concrete. Compressive strength of test specimens”. 2019; 1-24.

[22] British Standards Institution, BS EN 12390-5. Testing Hardened Concrete. Flexural Strength of Test Specimens”. 2019; 1-14.

[23] British Standards Institution, BS EN 12350-6. “Testing Hardened Concrete. Tensile Splitting Strength of Test Specimens”. 2019; 1-12.

[24] American Society for Testing and Materials, C1585. “Standard Test Method for Measurement of Rate of Water Absorption in Hydraulic Cement Concrete”. ASTM International, 2016.

[25] Rewi, K.H.A, & Khafagy, M.A.S.A. (2011). Effects of adding Sisal Fibre and Iraqi Bauxite on Some Properties of Concrete. *AL-TAQANI,* 24(2), 58-73.