Investigation of Properties of Concrete Stabilized with Coconut Fibre

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Abstract
This study investigated the effect of properties of concrete stabilized with coconut fibre (CCF). The following properties were investigated: compressive, flexural, split tensile strength, setting time and workability. 24 concrete cubes and cylinders of size 150mmx150mmx150mm, 100mmx100mmx500mm and 150mmx300mm were cast for both the plain concrete and concrete mix stabilized with coconut fibre. The mix proportion used for the experiment was 1:2:4 batched by weight of one part of Ordinary Portland Cement, two parts of river sand and four parts of crushed granite. The water cement ratio was 0.6. 2%, 4%, and 5% coconut fibre was added to the concrete mix. The control mix had 0% coconut fibre. The compressive, flexural, split tensile strength, were obtained after 7 and 28 days respectively. The workability and setting times of the fresh concrete, containing these percentages by weight of coconut fibre were also determined. The compressive, flexural and split tensile strength decreased as the percentage of coconut fibre was increased at 7 and 28 days respectively. The initial and final setting times and workability of the fresh concrete also decreased as the percentage of the coconut fibre increased.

Keywords- *coconut fibre, Compressive Strength, Flexural Strength, Split Tensile Strength, workability, setting time.*

I. INTRODUCTION

Plain concrete is a brittle material. Concrete without any fibres will develop cracks due to plastic shrinkage, drying shrinkage and changes in volume of concrete [1]. Coconut fibre is extracted from the outer shell of a coconut. The common name, scientific and plant family of coconut fibre is coir, cocos nucifera and Arecaeae (Palm), respectively [2].

Large quantities of coconut fibre are produced in Nigeria from domestic consumption and processing for export. [3] estimates that approximately 500,000 tonnes of coconut fibres are produced annually worldwide, mainly in India and Sri Lanka, followed by Thailand, Vietnam, the Philippines and Indonesia. Around half of the coconut fibres produced is exported in the form of raw fibre. The disposal of the remaining half poses an environmental problem.

The addition of fibres help to check development cracks in concrete due to plastic and drying shrinkage and changes in volume of concrete, therefore studies have been carried out to explore the effect of the use of coconut fibre on the properties of concrete. This is with a view to preserve the environment by using the waste generated from processing coconut for export and local consumption.

[1] investigated the effects of coconut fibres on the properties of concrete. 0%, 1%, 2% and 3% by weight of coconut fibre was added to the 1:1.94:2.93 mix with water/cement ratio of 0.5. They concluded that the slump values decreased as the percentage of coconut fibre was increased. The compressive, flexural and split tensile strength increased between 1% and 2% of the coconut fibre. At 2% coconut fibre, both compressive, flexural and split tensile strength started to decrease as the percentage of the Coconut fibre was increased.

[4] cited the work of [5] and [6] who studied the mechanical properties of cement paste composites for different lengths and volume fractions of coconut fibre. They concluded that the tensile strength and modulus of rupture of cement paste increased up to a certain length and volume fraction, and further increase in length or volume fraction decreased the strength composite

[7], investigated the mechanical properties of coir fibre reinforced cement sand mortar. The researcher tested two different design mixes (cement sand ratio by weight), first was 1: 2.75 with water cement ratio of 0.54.and second was 1:4 with water cement ratio of 0.82. Fibre content was 0.08, 0.16 and 0.32% by total weight of cement, sand and water. The mortars for both design mixes without any fibres were also tested as reference. He concluded that all strengths were increased in case of fibre reinforced mortar as compared to that of plain mortar for both mix design with all fibre contents. However, a decrease in strength of mortar was also observed with an increase in fibre content.

[8] studied untreated and alkalized coconut fibres with two lengths of 20mm and 40mm in cementitious composites as reinforced materials. Mortar was mixed in a laboratory mixer at a constant speed of 30 rpm, with cement:sand:water: super plasticizer ratio of 1:3:0.43:0.01 by weight and fibres were slowly put into the running mixer. They observed that the resulting mortar had better flexural strength, higher energy absorbing ability and ductility, and lighter than conventional mortar. Good results were achieved with the addition of a low percentage of coconut fibres and chemical agents in cementitious matrix.

[9] also investigated the mechanical characterization (flexural strength, fracture toughness and fracture energy) of epoxy polymer concrete reinforced with natural fibres, coconut, sugarcane bagasse and banana fibres). It was observed that fracture toughness and fracture energy of coconut fibre reinforced polymer concrete were higher than that of other fibres reinforced polymer concrete. Flexural strength was increased up to 25% with coconut fibre only.

[10] tested wall panels made of gypsum and cement as binder and coconut fibre as the reinforcement. Bending strength, compressive strength, moisture content, density, and absorption were investigated. Coconut fibres did not contribute to bending strength of the tested wall panels. Compressive strength increased with addition of coconut fibres, but the compressive strength decreased with an increase in water content and density was also increased. There was no significant change of moisture content with increase in coconut fibres. However, moisture content increased with time. There was no significant effect to water absorption on increasing coconut fibre content. [4], experimented with addition of 1%, 2% and 3% coconut fibre.

This study investigated the properties of concrete stabilized with CCF. Large quantities of CCF are produced in Nigeria. The use of CCF, in concrete production will lead to sustainable preservation of the environment and reduction in cost of production of concrete. While [1] added 1%, 2% and 3% CCF, this study was carried out using 2%, 4% and 5% addition of CCF, to explore the effect of CCF addition to concrete above the 3% limit used by [4].

II. MATERIALS AND METHODOLOGY

A. Materials

1) Ordinary Portland Cement

OPC (used was obtained from DANGOTE INDUSTRIES PLC, Nigeria). The cement properties conformed to [11].

2) Coarse Aggregate

The coarse aggregate used is granite produced at CRUSHED ROCK INDUSTRIES at ISHIAGU in Ebonyi State of Nigeria. The size varied between 5 and 24mm.

3) Fine Aggregate

River sand used for the production of concrete is clean river sand with maximum size of 4.75mm with specific gravity of 2.80. It was obtained from Imo River in Oyigbo near Port Harcourt. The sand particles conformed to the requirements of [12].

4) Water

Water is an essential ingredient in the production of concrete. It actively participates in the chemical reaction with cement and aggregates. The potable water used for the experiment was obtained from the Civil Engineering Laboratory of the Rivers State University of Science and Technology, Nkpolu, Port Harcourt. It was checked and found to be free from acid, organic matters, suspended solids, alkalis and other impurities which may have adverse effect on the properties of concrete. The potable water conformed to [13].

5) Coconut Fibre.

The CCF used was obtained from a local coconut distributor in Mile 3 area of Port Harcourt, Nigeria. The fibre were obtained by manually extracting them from the outer coconut fruit shell. The fibres were properly washed in order to remove films of impurities attached to them both in the macroscopic and microscopic levels. They were air-dried for about three days under ambient temperature. The fibres were cut using a pair of scissors to specific maintained length and diameter sizes of 2.0cm and 0.03mm respectively. These were then used in the composite concrete mix.

B. Methodology

1) Moulds

Different moulds sizes and shapes were used, such as cube sizes of 150x150x15mm, beam sizes of 100x100x500mm and cylinder of size 150x300mm. The composite concrete mix where placed in the moulds in order to achieve the specific shape needed to carry out the various tests needed. The preparation of moulds and concrete cubes was done in accordance with [14].

2) Setting Time Test

Vicats apparatus was used to determine the setting time of the mortar with various percentages of CCF. Test was carried out in accordance with [15].

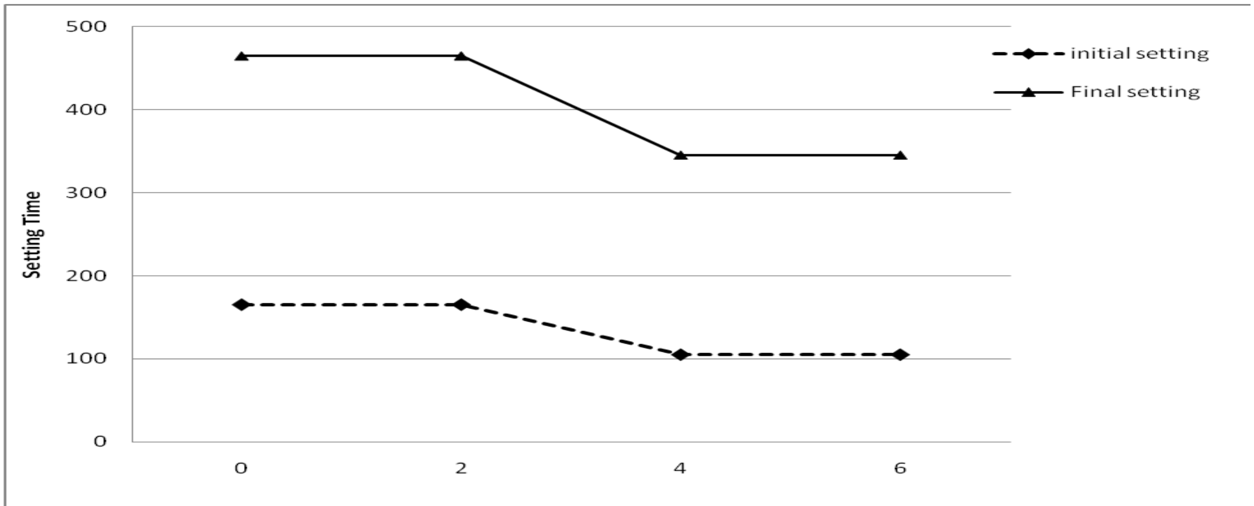

Fig. 1: Variation of Setting Times with CCF

3) *Flexural Strength*

Plain beams of size 100x100x500mm were prepared and loaded to determine the flexural strength after 7 and 28 days. Test was performed in accordance with [[17].

4) *Split Tensile Strength*

Cylindrical specimens of size 150x300mm were prepared and cured. The split tensile strength was determined after 7 and 28 days. Test procedure was in accordance with [18].

5) *Workability*

Slump test were carried out on fresh concrete with various percentages of CCF. The test was carried out in accordance with [19].

6) *Particle Size Distribution*

The particle size distribution for all the aggregates used was determined in accordance with [20].

III. TEST RESULTS AND DISCUSSION

A. Setting Time

Fig. 1 shows the initial and final setting times with the variation of the quantity of the CCF. The trend is that the setting times decreased as the quantity of CCF increased. The addition of the CCF assisted in the reduction of the hydration process and as such both plastic and solid states were attained faster by the concrete.

B. Compressive Strength

Fig. 2 shows that the compressive strength of the concrete at 7 and 28 days decreased as the quantity of CCF was increased. Percentage decrease of 19% and 26% were obtained at 7 and 28 days respectively at 5% CCF. The result is similar to that obtained by [1], which indicated a decrease in compressive strength from 2-3% of CCF content. They concluded that higher CCF content might have caused voids resulting in decreased compressive strength.

C. Flexural Strength

Fig. 3 shows the variation of the flexural strength with the CCF content. The flexural strength decreases as the CCF content in the cement increased. The same reason that contributed to the decrease of compressive strength is applicable for the decrease in the flexural strength. For the 7 days test, there was no change in flexural strength for all the various content of CCF.

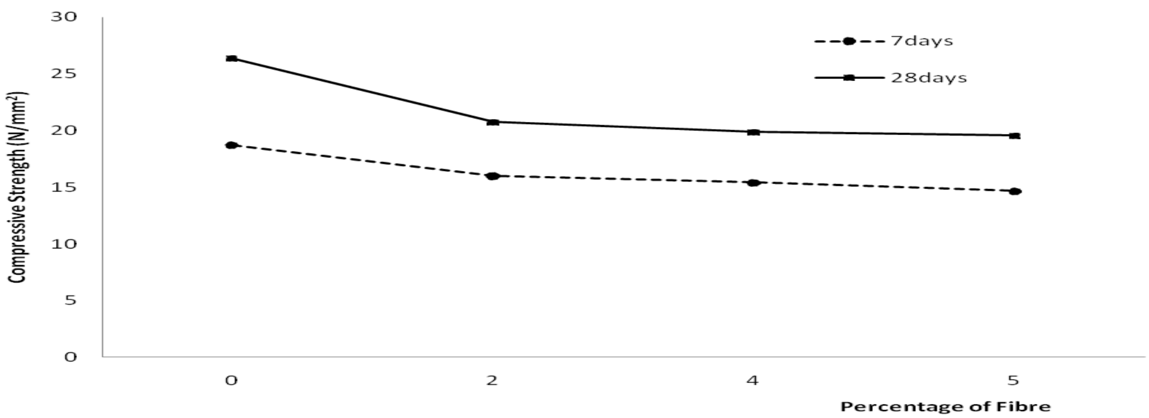

Fig. 2: Variation of Compressive Strength with CCF

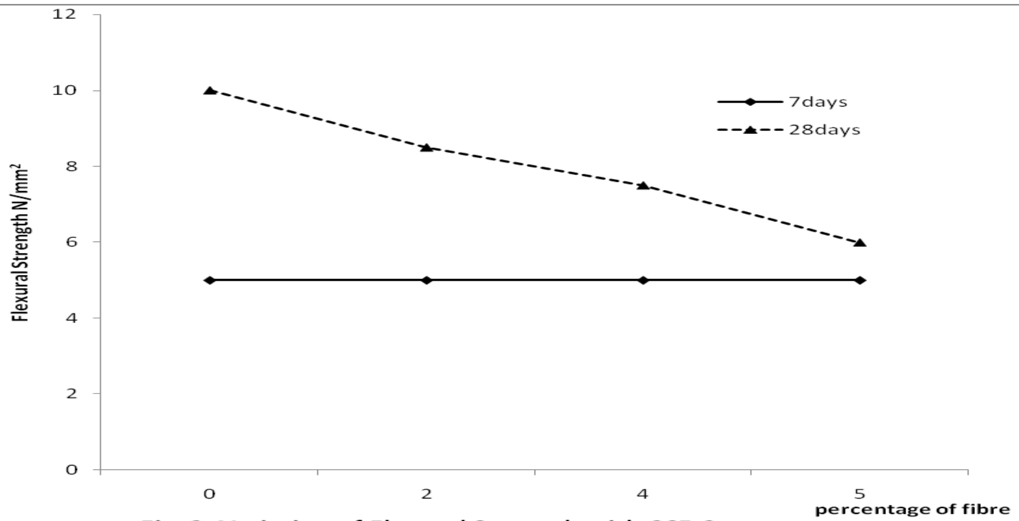

Fig. 3: Variation of Flexural Strength with CCF Content

D. Split Tensile Strength

The variation of the split tensile strength with the CCF content is shown in Fig. 4.

There is a decrease in split tensile strength as the CCF content increased at 7 and 28 days between 2-5% CCF content. [21], concluded that with increment in fibre content, the bond strength between the fibres and the concrete ingredients was not very efficient and as such the tensile stress could not be resisted. In addition to this, the fibres were rather too flexible to resist the bonding stress.

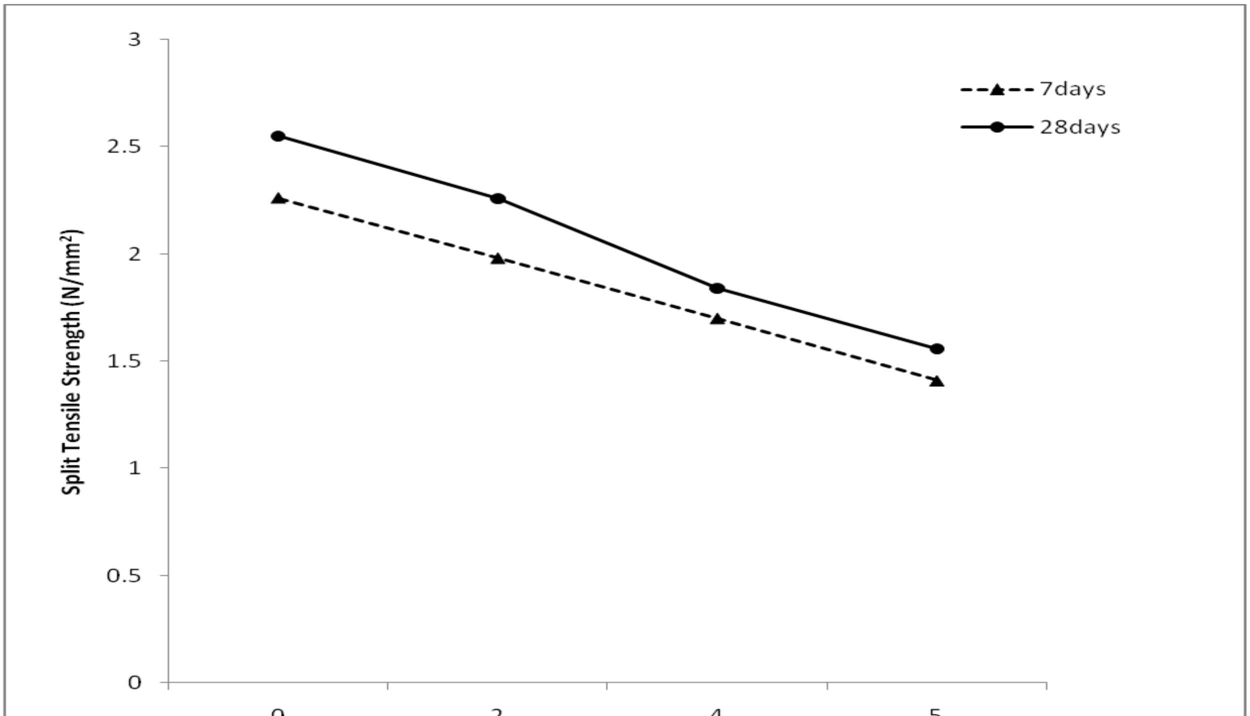

Fig. 4: Variation of Split Tensile Strength with CCF Content

E. Workability

Fig. 5 shows the variation of the workability of concrete mixed with various percentages of CCF. There is a decrease in slump from 30mm at 0% CCF to 5mm at 5% CCF.. This result corresponds to that obtained by [1]. [1] concluded that as more of the CCF were added, the rate of water absorption tended to reduce the amount of water needed to ensure fluidity of the concrete mix.

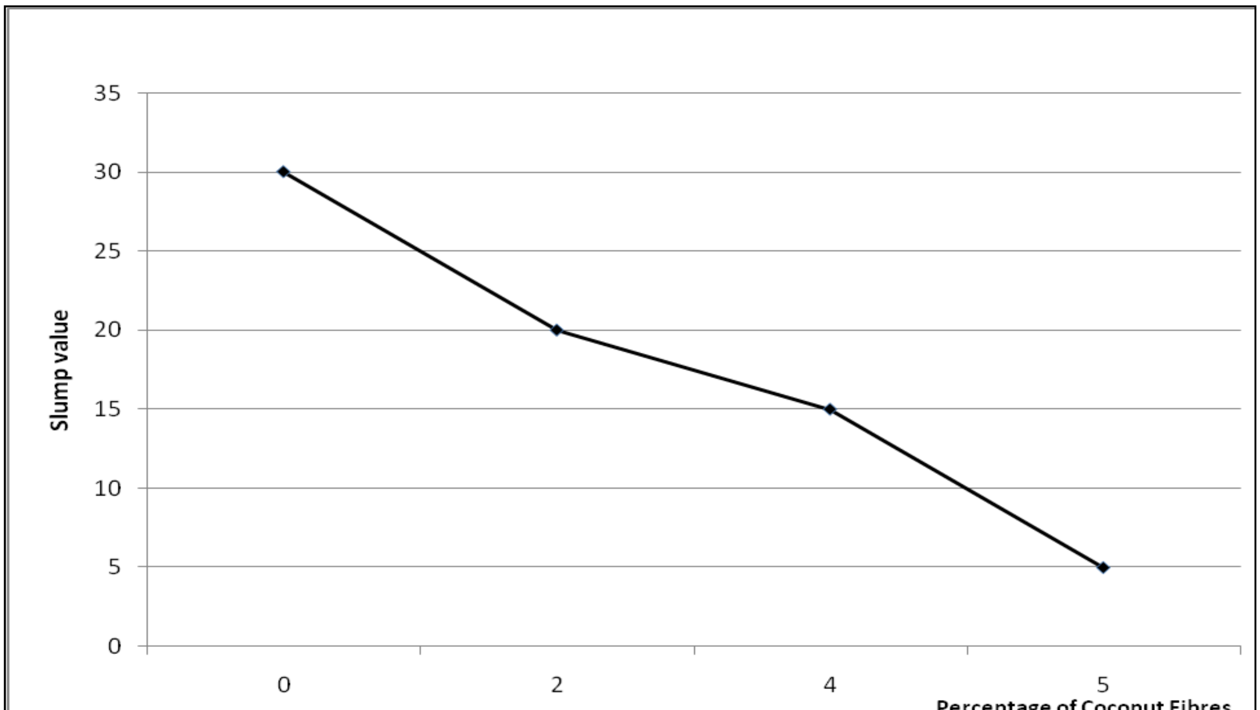

Fig. 5: Variation of Workability with CCF Content

IV. CONCLUSION

The investigation revealed the following:

(a) Addition of CCF reduced the setting time of the cement mortar. The CCF assisted in the reduction of the hydration process leading to attainment of both plastic and solid states much faster.

(b) The compressive strength decreased by 19% and 26% respectively after 7 and 28 days curing period. The CCF might have caused voids in the concrete resulting in decrease in compressive strength.

© The split tensile strength decreased by 38 and 39% at 7 and 28 days respectively.

(d) The flexural strength was not affected by the addition of CCF at 7 days. At 28 days, there was a decrease of flexural strength by 4% at 5% CCF.

(e) The workability decreased as the quantity of CCF was increased. [1] attributed this to the fact that the rate of water absorption tended to reduce the amount of water needed to ensure fluidity of the concrete mix.

In general the study carried out by [1] and this investigation has established that compressive strength, flexural strength and split tensile strength increased between 0-2% CCF content, while they decreased between 2-5% CCF. Up to 4% CCF content, the values obtained for compressive, flexural and split tensile strength conforms to values for lightweight concrete. It therefore follows that at these CCF content, lightweight concrete can be produced by adding CCF to the concrete.

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