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Advocacy for the Production of Geopolymer Concrete Using Plantain Fiber and Coal Ash

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ABSTRACT: The engineering industries most especially in the construction aspects are currently working towards construction materials that are environmental friendly, as the Ordinary Portland cement (OPC) is the main contributor of the emission of carbon dioxide amongst other constituents of concrete. Therefore, the utilization of other alternative materials with cementitious properties such as coal ash is highly recommended and encouraged to reduce the environmental hazards of concrete production. The aim of this study is to advocate for the production of concrete using Coal ash as the binder and plantain fiber serving as reinforcements. This research surveys the collegial effects and properties the coal ash and plantain fiber has on concretes, including its compressive strength. Experiments were conducted to test and analyze the compressive strength of the geopolymer concrete of coal ash with plantain fiber as reinforcement. It was observed that the concrete sample cubes were still very weak and wet at day 7 of curing, it was also observed to be wet at day 14 of curing also, this prevented the cubes from undergoing the compressive strength at the stages, until the 28th day of curing at which the concrete has gained some strength, it was now ready to undergo the compressive strength test. It was revealed that the fibre at 7cm and 1% in each sample produced a weight of 9.05kg and 8.05kg respectively on the two samples. It was also found that the compressive strength of Sample 1 which weighs 9.05kg was 1.03Mpa while the compressive strength of sample 2 which weighs 8.05kg was 3.05Mpa. The study concludes that the plantain fibres, possess properties that are suitable for use as reinforcement in composite material for construction application, also as coal ash possess cementitious properties.

KEYWORDS: Geopolymer concrete, coal ash, plantain fiber, sustainable engineering, environmental friendly materials, cementitious properties, fiber extraction.

I. INTRODUCTION

Global cement production has lots of hazardous effect on the ecosystem. The use of conventional building materials such as cement has globally contributed to environmental issues, resulting in increased greenhouse gas emissions due to the release of carbon dioxide (CO₂) into the atmosphere. A good number of these materials can be replaced using natural fibres from agricultural wastes for use in Civil engineering construction activities to enhance worldwide economy growth and concept. [1], diverse researches using natural fibres such as bagasse, hemp, coir, flax, and pineapple as reinforcement and has proven to have a great potential as a material for building. The use of these natural fibres as building materials can also help in the reduction the energy footprint of buildings thereby contributing to sustainable construction application.

Natural fibres are obtained from plants leaf, bast, seed/ fruit hair, trunk/stem, or fruit bunch. Natural fibres are versatile materials that possess properties that vary with chemical composition and physical structure [2]. They are highly available and affordable and has great mechanical properties for sustainable construction application [3]. The fibres are cellulosic consisting of hemicellulose and microfibrils in an amorphous matrix of lignin [4].

Couple of researches has been carried out to determine the properties and characteristics of natural fibres for composite materials, specifically for applications in construction. [5] investigated the properties of coconut, oil palm, and bagasse fibres as potential building materials. The study found that the fibres possess properties such as specific weight, moisture content, tensile strength, modulus of elasticity, and water absorption that are acceptable as for construction applications. [6] studied the physical and mechanical properties of oil palm broom fibres as an eco-friendly building material, and found that the fibres have a specific gravity between 0.45 and 0.84 g/cm³ and diameter varying between 0.20 mm (at the tail) and 4.00 mm (at the cap), and maximum tensile strength of 900 MPa was recorded.

Recent studies have shown that the use of natural fibres as reinforcement in composite materials is possible for construction application [7,8]. [9] investigated the effect of coconut fibres and lime on the properties of soil-cement mortar and found improvement in the mechanical and durability properties of the mortar. [10] investigated the technological performance of açai natural fibre-reinforced cement-based mortars and found that açai fibres in addition of up to 3.0% relative to cement mass and properly treated with NaOH solution can be used as reinforcement mechanism for mortar applications. [3] investigated the properties of cement mortar reinforced with plantain pseudo-stem fibres and lime, and concluded that the addition of plantain pseudo-stem fibre and lime positively influenced the properties of the cement mortar with the 0.25% fibre content being recommended for construction application. Other studies [11,12,9] investigated different composite materials with rice husk; however, the properties of the rice husk identified in the studies were limited. There is the need to undertake an extensive investigation on the properties of rice husk as reinforcement in composite materials. [5] the technology of reinforcement in composite materials has not been fully adopted by the formal building sector due to the lack of information on the properties of the natural fibre use in the composite materials. There is therefore the need to investigate the properties of natural fibres to be used as reinforcement in composite materials for better understanding of their behavior in the composite materials.

From the foregoing, it is evident that several natural fibre properties have been investigated, including oil palm, coconut, bagasse, raffia fibre, cassava, ambarella, Cocos nucifera, and oil palm broom fibres. However, other natural fibres have potential for use as composite materials such as plantain pseudo-stem, plantain bunch, and rice husk which their properties have not fully been investigated. This study, therefore, seeks to assess the properties of plantain (*Musa paradisiaca*) pseudo-stem fibres as source of reinforcing elements for composite materials, especially for construction application. The plantain pseudo-stem fibres was selected for this study because of abundance of plantain plant globally and relatively cheap cost due to the fact that the fibres are obtained as waste. The novelty of this work is the complete assessment of the potential use of plantain pseudostem fibres and Coal ash for construction applications. The experimental study, therefore, conducted various analyses and tests on the fibres and Coal ash mix, including compressive strength test. This research contributes to the advancement of studies on the properties of natural fibres as potential composite material for construction application.

II. MATERIALS AND METHODOLOGY

2.1 MATERIALS

- **COAL ASH:** This project was carried out with a Coal ash serving as the binder (replacement for cement). Utilizing this Coal ash in concrete enhances the strength, workability, and durability of the concrete that has been hardened. Coal ash is also reasonably priced (cost effective) and easily accessible. When adding Coal ash, the amount of Portland cement supplied to concrete may be decreased or neglected. The coal ash was gotten from Aka Aja Aja mining site in Enugu.
- **FINE AGGREGATE (SAND):** A dry sharp sand was used for the purpose of this study. Sand is a fine aggregate. In this study, the fine aggregate was a sharp sand. The type of fine aggregate (sand) utilized in this work is available locally, and was gotten from a local retailer at Awka, Anambra state.
- **COARSE AGGREGATE:** is the coarse aggregate used for this study on a weighing balance, The locally accessible coarse aggregate utilized provided following characteristic: 20mm maximum and 12.5mm minimum size. It was gotten from a local retailer at Awka, Anambra state.
- **PLANTAIN FIBER:**, *Musa sapientum* fiber, sometimes referred to as plantain fiber, is one of the strongest natural fibers in the world. Being biodegradable, natural fiber constructed from a plantain tree stem and is exceptionally strong. Although plantain fiber resembles genuine bamboo fiber, it displays greater tensile strength. The plantain stem for the production of plantain fiber was gotten in Uli, Anambra state.
- **WATER:** It is advisable and also the best to use clean, safe drinking water from the tap for concrete blending and curing.
- **ALKALI ACTIVATOR:** The Coal ash will be activated with an alkali solution of Sodium silicate, and sodium hydroxide (NaOH). The Coal ash will be mixed with an alkaline activator to create a paste that can set easily and taking a reasonable amount of time to harden. The part of Alkali activator solution is used to dissolve the silica and aluminum reactive components found in Coal ash. The activator for alkaline has a significant impact on geopolymer concrete. Alkaline activator is important in the hydration of binders. Mortars and alkaline activated concretes properties can provide results with stronger mechanical resistance than those derived from an OPC-made concrete. I got the alkali solution of sodium hydroxide and sodium silicate from a vendor at Onitsha.

2.2 METHODOLOGY

- **Extracting the plantain fiber**

The Chemical extraction method was utilized to extract the fiber from the plantain stem. The plantain pseudo-stem was obtained from the plantain tree after the fruit was harvested, leaving the trunk. The trunk was obtained after cutting off the branches and the root. A number of trunks were collected from COOU school farm in Uli. After harvesting the trunk, Peel off the plantain stem outer bark until you reach the pulpy center, then fill a bowl with water and completely pour the sodium hydroxide into the water and stir rigorously. Next, immerse the sheaths of the plantain trunk into the solution and then, give yourself a window of 3-4 days (as shown in plate 1). Take away, clean up with water, and dry (as seen in plate 2)



Plate 1: The immersed sheath.



Plate 2: Sun-drying the fiber

- **Batching the materials**

The process of measuring ingredients or materials to prepare concrete mix, table 1 show the batching results.

Table 1. The results from batching

Materials	Measurements
Sodium hydroxide (NaOH)	8.30 kg
Sodium silicate	8.30 kg
Coal ash	27.76 kg
Fine aggregates	52.52 kg
Coarse aggregates	111 kg
Activators	15.20 kg
Water (for concrete mixing)	
Plantain fiber	

- **Analysis on Slump test**

Slump test was carried out in order to determine the workability of plantain fiber used in coal ash at 1%. The results gotten were displayed in Table 2 below. Mix Ratio: 1:2:4. Concrete Grade: M15. Water Cement Ratio: 0.5 The test result showed that as the fibre is added, the workability reduces.

Table 2. Slump test value

Plantain fiber	Cone height	Height of slump concrete	Slump value	Type of slump
1%	300mm	250mm	40mm	True

- **Mixing and casting of the concrete**

The solids constituents of the Coal ash-based geopolymer concrete, i.e. the aggregates (fine and coarse) and the Coal ash were dry mixed on a dry surface for about three minutes. The liquid part of the mixtures (activators), i.e. the sodium silicate solution, the sodium hydroxide solution, added water were already premixed and allowed to stay for 24 hours before been added to the solids to act as an activator. The wet mixing usually continued for another four minutes. The fresh Coal ash-based geopolymer concrete was dark in colour and has a shiny appearance. The plantain fibres were then added to the mix, and mixed thoroughly. The mixtures are usually very cohesive.

Compaction of fresh concrete in the cubic wooden moulds was achieved by applying some manual strokes per layer in four equal layers, After casting, the specimens were allowed a 24 hours rest before curing.



Plate 3: after placing concrete in cubic moulds



Plate 4: after removing of cubic moulds

III. RESULTS

The results for the compressive strength test carried out on day 28 for two different samples (Sample 1 and Sample 2) are displayed in Table 2. below.

Table 3: The weight and Compressive strength test of sample 1

No of days	Weight of sample(Kg)	Compress strength of concrete (Mpa)
7	Nil	Nil
14	Nil	Nil
28	9.05	1.03

Table 4: The weight and Compressive strength test of sample 2

No of days	Weight of sample(Kg)	Compressive strength of concrete (Mpa)
7	Nil	Nil
14	Nil	Nil
28	8.05	3.05

From the above tables, it is clearly observed that the results achieved from sample 1 and sample 2 of geopolymer concrete produced using plantain fiber as reinforcement even after 28 days of normal curing are too poor than the expected. The results on the day 7 and 14 are not given because the concrete at this stages were still wet(moist) and fragile, and not yet hardened, therefore compressive strength test was not carried out until the 28th day when it was already hardened.

From Table 2, it is seen that the weight of Sample 1 is 9.05kg which produced a compressive strength of 1.03Mpa, while from table 3, the weight of sample 2 was 8.05kg and this produced a compressive strength of 3.05Mpa.

Now judging from these results, it is clearly seen that the results were very poor and therefore cannot be worked with or relied on for engineering activities and this can probably be as a result of poor concrete mix, which can also range from the Chemicals (activators) used.

IV. CONCLUSION

Plantain fiber reinforced concrete have the potential to improve the properties of concrete most especially the mechanical properties and also being eco-friendly, The mechanical properties include slump, density, flexural behavior, modulus of rupture, total flexural energy, and flexural toughness index. Coal ash is also a great innovation in the replacement of cements in the construction industries, as it has less negative effects in the surrounding environments and entire ecosystem. The composite materials using Coal ash as the binder, and reinforced by using natural fibers like plantain fibers were reviewed regarding the future expectations in the utilization of eco-friendly and natural fibers as are in forcing agent.

This review explores the chemical composition, physical and mechanical properties involved in producing a geopolymer concrete using coal ash and Plantain fiber. The properties of plantain fibers are more preferable when compared to other natural fibers. Due to low cost, less density, easy accessibility and certain individual properties of plantain fiber reinforced composites, it could have better implementations in different fields of engineering

applications. In future generations, the employment of plantain fibers will be very desiring because the natural fibers are versatile, abundant, lighter, cheaper, low cost of manufacturing, eco-friendly and superior to other artificial fibers (glass and synthetic fibers). Hence it's concluded that the natural fiber reinforced composites would be the most cherished technology in the developing world. In essence I recommend that further and more intense research should be made towards achieving this goal.

REFERENCES

1. Bonnet-Masimbert P-A, Gauvin F, Brouwers HJH, Amziane S (2020) Study of modifications on the chemical and mechanical compat-ibility between cement matrix and oil palm fibres. Results in Eng 7:1–9. [https:// doi. org/ 10. 1016/j. rineng. 2020. 100150](https://doi.org/10.1016/j.rineng.2020.100150)
2. Adeniyi AG, Ighalo JO, Onifade DV (2019) Banana and plantain fiber reinforced polymer composites. J Polym Eng 39(7):597–611
3. Danso H (2020a) Influence of plantain pseudostem fibres and lime on the properties of cement mortar. Adv Mater Sci Eng 2020. [https:// doi. org/ 10. 1155/ 2020/ 46986 03](https://doi.org/10.1155/2020/4698603)
4. Kulkarni HB, Tambe PB, Joshi GM (2020) Influence of surfactant assisted exfoliation of hexagonal boron nitride nanosheets on mechanical, thermal and dielectric properties of epoxy nanocom-posites. Compos Int 27(6):529–550
5. Danso H (2017) Properties of coconut, oil palm and bagasse fibres: as potential building materials. Procedia Eng 200:1-9
6. Momoh EO, Osofero AI, Martinez-felipe A, Hamzah F (2020) Physico- mechanical behaviour of oil palm broom fibres (OPBF) as eco- friendly building material. J Build Eng. [https://doi.org/10.1016/j. jobbe.2020.101208](https://doi.org/10.1016/j.jobbe.2020.101208)
7. Das SC, Paul D, Khan MA, Grammatikos SA, Papatzani S (2021a) A comparative study between jute and glass fiber reinforced com- posites. Key Eng Mater 891:125-130
8. Das SC, La Rosa AD, Goutianos S, Grammatikos SA (2021b) Natural fiber reinforced polymer composites for small/medium wind tur- bine blades: a LCA study, 5th International Conference on Natural Fibers (ICNF2021), paper ID 82, 191-192
9. Danso H, Manu D (2020) Influence of coconut fibres and lime on the properties of soil-cement mortar. Case Stud Constr Mater 12:1-12
10. de Azevedo ARG, Marvila MT, Tayeh BA, Cecchin D, Pereira AC, Monteiro SN (2021) Technological performance of açai natural fibre reinforced cement-based mortars. J Build Eng 33:1-11. [https://doi.org/10.1016/j. jobbe.2020.101675](https://doi.org/10.1016/j.jobbe.2020.101675)
11. Akinwumi II, Awoyera PO, Olofinnade OM, Busari AA, Oko- tie M (2016) Rice husk as a concrete constituent: workability, water absorption and strength of the concrete. Asian J Civ Eng 17(7):887-898
12. Bisht N, Gope PC, Rani N (2020) Rice husk as a fibre in composites: a review. J Mech Behav Mater 29:147-162



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