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THE EFFECT OF PLANTAIN AND BANANA PEEL ASH ON THE PROPERTIES OF CONCRETE

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ABSTRACT

Ingredients that import certain qualities to either fresh or hardened concrete mix other than cement, aggregates (fine and coarse aggregates), and water is called an admixtures. In recent times, efforts to reduce the harmful environmental impacts as a result of agricultural and industrial activities has led to the utilization of wastes and by-products which will normally end up in landfills. Over the years, several agro-wastes and industrial by-products has been investigated by researchers and incorporated into concrete as admixtures to access their suitability in influencing specific properties of the concrete. The massive production of banana (145 million tonnes globally) and plantain (over of 2,722,000 metric tons in Nigeria) has resulted in large waste generation in the form of banana peels. Therefore, it is significant to research ways of recycling such waste for further use. This paper reviews the effect of utilizing plantain peel ash and banana peel ash/powder as admixtures in concrete. The findings revealed that banana peel ash and banana peel powder positively influence the strength properties of concrete; while plantain peel ash did not yield adequate strength qualities but can be satisfactorily employed as a retardation admixtures because it increases setting time of concrete. Research gaps were identified and recommendations outlined.

Keywords: Admixture, Plantain Peel Ash, Banana Peel Powder, Banana Peel Ash, Sustainable Construction, Atmospheric Carbon

INTRODUCTION

The growing demand for sustainable construction materials results in the incorporation of wastes produced from agricultural and industrial processes. These wastes are used to produce final products that are environmentally friendly leading to a total reduction in atmospheric carbon emissions **(**Aderinola et al., 2020**).** In the construction industries, these wastes are incorporated as admixtures in the production of sustainable concrete. Concrete is a composite material containing coarse aggregate, fine aggregate, cement, water and sometimes admixtures. These admixtures have been investigated and employed by Engineers, material scientists, and chemists to effectively control workability, water/cement ratio, setting time, durability, fire resistance, density, cracking and compressive strength of concrete (Dyuran et al., 2018). Admixtures are considered a significant component of the modern day concrete mix and the role of each admixtures focuses on a particular need and they are developed independent to the other. Some admixtures possess the chemistry that influences more than one characteristics of concrete. Jackson et al (1996) observed that the changes in concrete resulting from the addition of admixtures are generally due to the influence of admixture on liberation of heat, hydration, development of gel structure and formation of pores.(Hassan, et al., 2020)

Plantain and banana peels are waste generated from homes and massively from the industrial processing of plantain and banana. These wastes normally end up in landfills, unregulated grounds or rivers. The availability of national and international programs to address the waste peels resulting from the ever booming production and consumption of plantain and banana is very limited; consequently resulting in huge

waste deposition daily especially in Nigeria. This can be due to limited information on the resources within the waste peels (Babayemi and Dauda 2009).

With a production figure of 2,722,000 metric tons in 2011, Nigeria ranked fifth in the world in terms of plantain production capacity (FAO, 2012). Despite this huge production, plantain is largely consumed locally due to the rise in industries utilizing plantain for snacks in the urban population as well as the demand for convenient and easy recipes made from plantain locally (Akinyemi et al., 2010). Furthermore, about 145 million tonnes of banana is consumed globally and with the average mass of banana peel being 20-25% of the total mass of banana; the amount of banana peel will be approximately 40 million tonnes. (Gadgihalli et al., 2017)**.** Mineral content of banana peel include manganese, potassium, calcium, sodium, and iron; and despite being considered as a vegetable waste, they have been employed for water purification, production of ethanol, fertilizer, lactase and in composting.

The significance of investigating the utilisation of agricultural wastes as admixture in the production of concrete for sustainable construction cannot be over-emphasised. Therefore, the current study aims to present the influence of banana or plantain peel on the properties of concrete.

ADMIXTURES

The booming generation of industrial wastes and by-product led researchers in the construction industry to incorporate admixtures as partial replacement for cement. The adoption of mineral admixture is very advantageous towards as it reduces environmental damages and improves the durability of concrete (Thomas et al. 2012 and Thomas, 1996). The improvement is achieved due to alteration of pore structure in concrete resulting in permeability reduction and consequently an increased resistance to water related deterioration and penetration. (Ayub et al, 2013; Nura, 2021) Several admixtures have been investigated over the years such as, Fly ash, silica fume, rice husk ash, slag (steel, lead, copper), sand stone, carbon black, polypropylene imitation steel fibers, metakaolin, waste paper sludge ash and stone waste powder. The influence of these admixtures on mechanical properties of concrete has shown the significance of their incorporation as well as displays the gaps where further research is needed. (Nura, 2021).

PLANTAIN PEEL ASH AS ADMIXTURE IN CONCRETE

The effect of plantain peel ash on the mechanical properties of concrete was investigated by Usman et al. (2018). The study was conducted by replacing cement with plantain peel ash at 0%, 5%, 10%, 15%, 20% and 25%; and the finding revealed a decrease in compressive strength with an increase in replacement percentage. At 10% PPA (Plantain Peel Ash) concrete showed the highest value of 28 compressive strength but still considerably lower than that of the control concrete. An increase in soundness, initial and final setting times, and consistency was observed as the replacement percentage increased. Aluminum, silica, and ferric oxides content which does not satisfy the ASTM C618-84 requirements disqualified the material as a pozzolanic material.

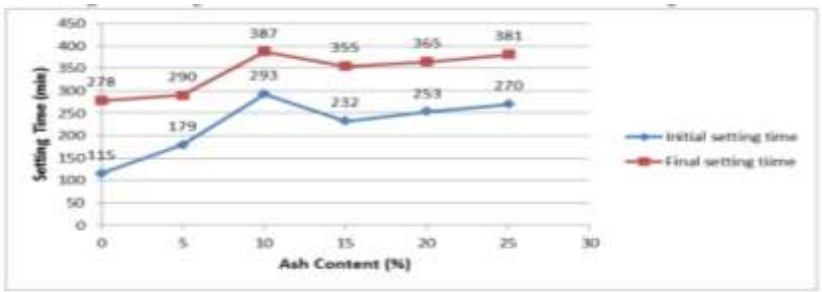

Figure 1: Setting time test results – PPA Content

Source : Usman et al, (2018)

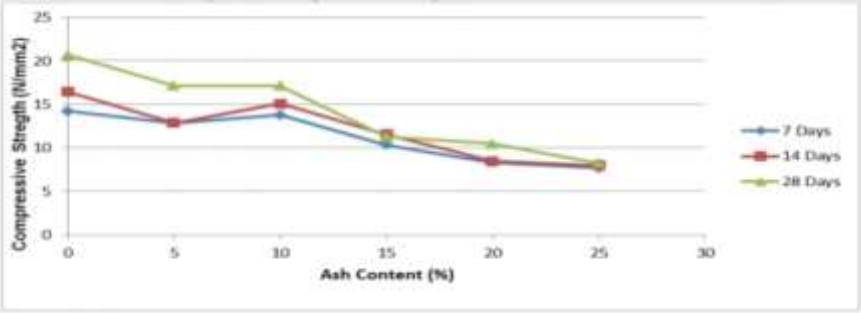

Figure 2: Compressive strength of concrete – PPA Content
Source : Usman et al, (2018)

The effect of PPA (Plantain Peel Ash) on compressive strength was further consolidated by Dyuran et al. (2018). They incorporated PPA at varying percentage of 0%, 0.5%, 1%, 1.5%, 2%, and 2.5%. A decrease in compressive strength compared to that of the control concrete was recorded and a highest value was realized at a replacement percentage of 1.2%. It was observed that the compressive strength of PPA concrete increases with curing age similar to the normal concrete. The setting time increases; slump and workability of the concrete decreases with an increase in PPA content. From the findings obtained in the study, the researchers recommended that PPA adopted as a set retarder since it increases the setting of concrete. This can also be backed by findings from Hassan et al. (2020) which showed that plantain peel ash fulfilled all requirements of BS EN 934 part 2 (2000) for set retarding admixture.

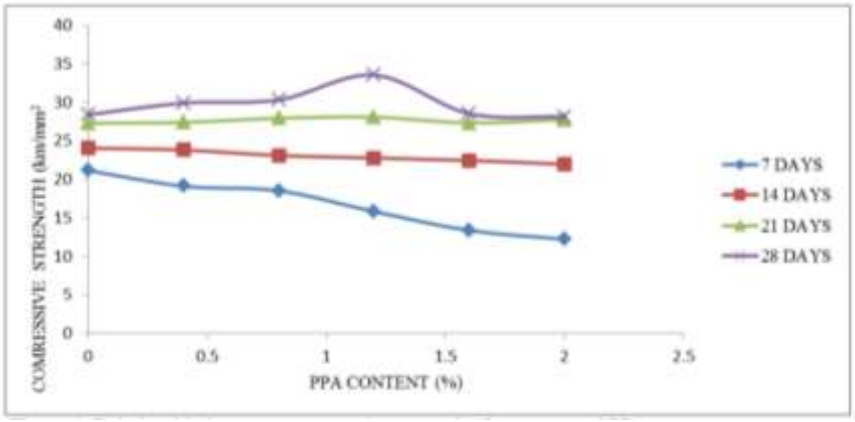

Figure 3: Compressive strength of concrete – PPA Content
Source : Dyuran et al, (2018)

Hassan et al. (2020) incorporated PPA (Plantain Peel Ash) at 11 different percentage of 0%, 0.2%, 0.4% up to 2.0% at 0.2% interval for mortar and cement pastes. The cement paste was tested for soundness and setting time which revealed a retardation of about 222 minutes at 1% PPA replacement beyond which a decline was evident. PPA displayed no effect on the soundness of the cement as a maximum of 1mm expansion was recorded at 0.2% and 1% ash content. Strength tests displayed a significant delay in early strength development of the mortar. At 2 days, the recorded compressive strength value of the control specimen was 5.26N/mm^2 whereas the value at 0.2% PPA replacement was 4.64N/mm^2. The maximum values for compressive (8.75N/mm^2) and flexural (6.95N/mm^2) strength were obtained at a PPA content of 1% and 0.8% respectively in the cement mortar. From the findings, the researchers categorized PPA as a set retarder and recommend an optimum replacement of 1.0%. The suitability of the 1% optimum replacement percentage can be confirmed from the study by Jubril, (2021) where he investigated the effects of ripe and

unripe plantain ash at 1.5% and 2.5% on the properties of concrete. The 28 day compressive strength decreased significantly at 1.5% compared to the conventional concrete, thus following similar trend.

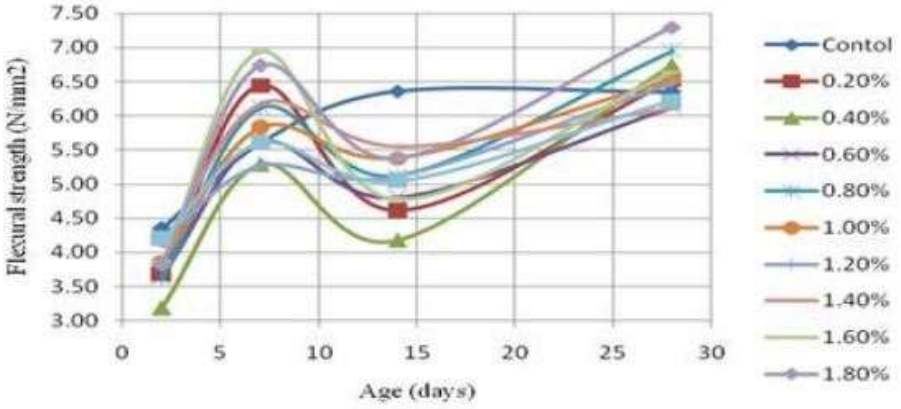

Figure 4: Flexural Strength Variation with age
Source : Hassan et al, (2020)

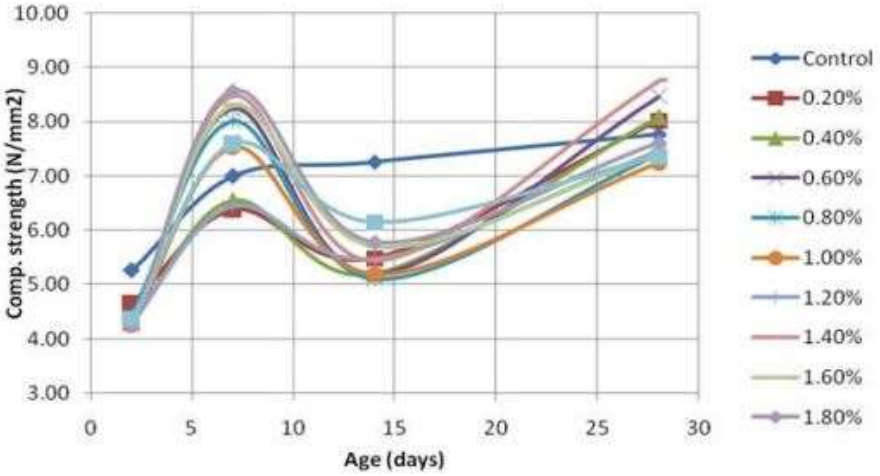

Figure 5: Compressive strength variation with age
Source : Hassan et al, (2020)

BANANA PEEL ASH AS ADMIXTURE IN CONCRETE

The properties of lightweight foamed concrete using banana peel as admixture in concrete was analysed by Mohamad et. al.,(2018). For the study, they casted cylindrical, cubes and prism specimens with banana peel powder replacing cement at 0%, 0.2%, 0.4%, 0.6%, 0.8% and 1% by weight. Furthermore, palm oil fuel ash was incorporated at 0% and 15% as sand replacement for each mix. The findings from the study revealed that the highest value of 28 day compressive strength (31.7 MPa) was realized at BPP (Banana Peel Powder) content of 0.8%. When POFA (Palm Oil Fuel Ash) was incorporated at 15%, 28 day compressive strength increased with highest value 36.4 MPa at BPP (Banana Peel Powder) content of 1%. The tensile strength increased linearly as BPP content increased up to 0.6% beyond which no significant difference was recorded and a maximum value of 2.7 MPa realized. With the addition of POFA at 15%, maximum tensile strength value (3.74 MPa) was recorded at 1% BPP content. The modulus of elasticity increased with an increase in BPP content giving a maximum value of 82000 MPa at 28 days and 1% BPP content. The addition of POFA (15%) resulted in a reduction in Modulus of elasticity by 8.5% at 1% BPP content. Compared to the control specimens, the researchers found that compressive strength was increased by 63.2% at 28 days; as well as slight increment in modulus of elasticity and tensile strength.

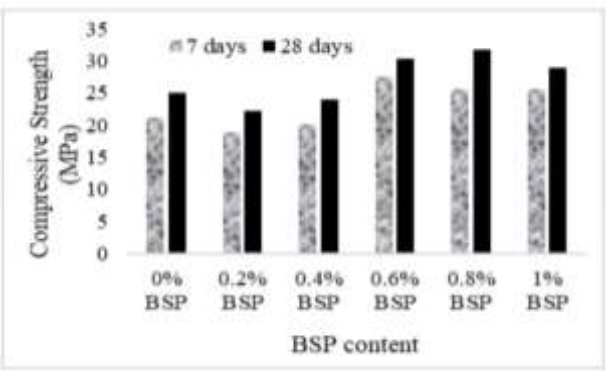

Figure 6: Compressive strength of concrete – BPP Content for 0% POFA
Source : Mohamad et al, (2018)

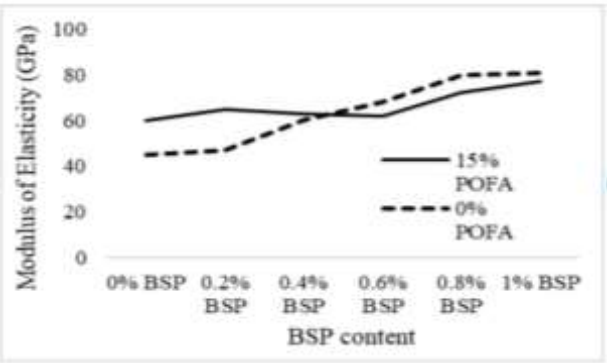

Figure 7: Modulus of Elasticity – BPP Content for 0% and 15% POFA
Source : Mohamad et al, (2018)

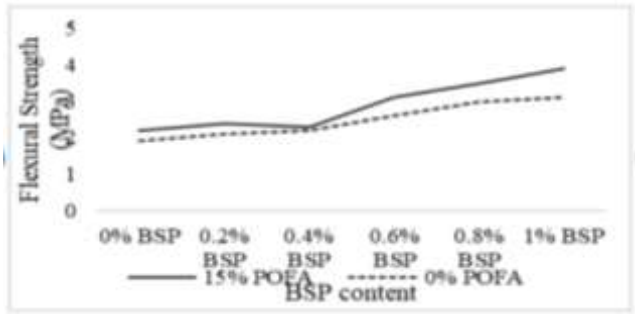

Figure 8: Flexural Strength – BPP Content for 0% and 15% POFA
Source : Mohamad et al, (2018)

Manan et al., (2021) reported an increased compressive strength of concrete when BPA (Banana Peel Ash) was incorporated in concrete at 0%, 1%, and 2%. The compressive strength at 28 day was the maximum recorded value (29.50 ± 1.45 MPa) at 2% BPA content. For the Control content, compressive strength was 31.61 ± 1.60 MPa. However, using a contour plot for BSA content, curing days and compressive strength, it was observed that the compressive strength increases with an increase in curing days following similar trend for strength development in concrete. The finding revealed that for a given curing days, strength was highest at 1 to 1.5% BPA content, making the optimum BPA content for maximum compressive strength to be 1.25%. At a weight of 20 g, BPA showed higher bulk density (36.32 ± 0.00 cm^3) than ordinary Portland cement (198.43 ± 0.00 cm^3); signifying large surface are for water absorption.

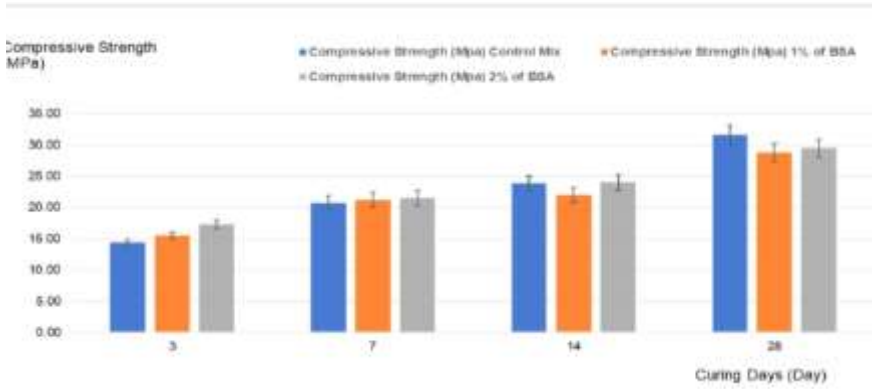

Figure 9: Compressive Strength for 0%, 1% and 2% BPA – Curing days
Source : Manan et al, (2021)

CONCLUSION

The paper reviews the influence of plantain peel and banana peel on the strength properties of concrete when incorporated as admixtures. Conclusions outlined are based on the findings and results of past research.

- Plantain peel ash has been shown to considerably reduce the strength of concrete. However it offers advantage when use as a set retarder with an optimum replacement of 1%.
- Banana peel powder and Banana peel ash positively influence the properties of concrete making it suitable as a supplementary cement material with maximum strength obtained between 0.8% BPP content and 1.25% BPA content. Tensile strength was positively influenced by the addition of Banana peel powder
- More research is required to improve strength properties by combining other agro-waste materials or industrial by products with Plantain peel ash to produce PPA concrete with adequate strength properties
- The effect of plantain peel ash and banana peel ash on other properties of concrete like, shrinkage, CO2 absorption, abrasion, fire resistance, acid resistance, modulus of elasticity, tensile strength and sulphate attack resistance needs to be explored.

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