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EFFECT OF PLANTAIN PEEL ASH AS AN ADMIXTURE ON CONCRETE PROPERTIES

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ABSTRACT

This study investigates the effect of plantain peel ash as an admixture on concrete properties, which is a sustainable alternative to conventional concrete production. The aim is to optimize the mix design of concrete required for improved performance, investigate the effect of the plantain peel ash on the compressive strength of the concrete, and examine the effects of plantain peel ash as a supplementary material on the durability and service life of concrete. The use of plantain peel ash as an admixture for cement in concrete has gained increasing popularity due to its ability to reduce the environmental impact of concrete production. This study contributes to the understanding of the durability and performance of plantain peel ash in concrete which is crucial for sustainable construction practices. The methodology involves mix design according to IS 10262:2009 for M15 grade of concrete with 5%, 10%, 15% and 20% plantain peel ash replacement, testing of compressive strength and durability of the concrete samples and also the optimal dosage required, in comparison with conventional concrete. The result of this study shows that the addition of 5% plantain peel ash increases the compressive strength of the concrete with obtained value of 27.30 N/mm^2 and also has the standard workability for a normal concrete at 45 mm for the control and 60 mm for 5% PPA. The 10%, 15% and 20% shows a decrease in their compressive strength compared to the control mix (0%) with a value of 18.42 N/mm^2 for 28 days curing. Overall, it can be said that 5% plantain peel ash has provided a strong basis for the use of plantain peel ash in concrete mixtures. The 5% is equivalent to 0.72 kg PPA.

Keywords: Plantain peel, Concrete, Admixture, Compressive strength.

INTRODUCTION

The growing demand for sustainable building materials leads to the incorporation of waste from agricultural and industrial processes. This waste is used to produce environmentally friendly end products, which reduces total carbon emissions into the atmosphere (Aderinola et al., 2020). In the construction industry, these wastes are incorporated as additives in the production of durable concrete. Concrete is a composite material containing aggregates, cement, water and sometimes admixtures. These additives have been studied and used by engineers, materials 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 an important part of modern concrete mixing and the role of each admixture is focused on a specific need and developed independently of each other. Some additives have chemical properties that affect more than one specific property. Hassan, et al., 2020 evaluated the performance and suitability of plantain ash mixture as a partial substitute for cement in concrete production. . Usman et al.,2018 studied the effect of banana peel ash on the mechanical properties of concrete and obtained optimal results at 10% replacement. Setting time increased while compressive strength decreased when replacing cement with plantain peel ash (PPA). Adetayo and Jubril, 2019 studied the effects of ripe and unripe plantain peel ash on the workability and compressive strength of concrete. The workability of concrete was observed to increase with the addition of ripe plantain peel ash (RPPA) and unripe plantain peel ash (UPPA). It should also be noted that RPPA and UPPA contribute to the late development of concrete strength and the better performance observed with RPPA. Ahmad and Ado, 2016in a study observed that ripe plantain peels reduced the strength of concrete.

Concrete is the most versatile heterogeneous building material and one of the most viable materials for infrastructure development in any country. Concrete is a composite material consisting of a filler and a binder, the cement paste acts as a binder that binds the fillers together to form aggregates. The workability of concrete is an attribute that directly affects strength, quality, appearance and even labour costs for pouring and finishing operations. The strength of hardened concrete is measured by a compression test, the compressive strength of concrete is a measure of the load capacity of the concrete that tends to compress it.

Plantain belongs to the family Musa Ceae, genus Musa is native to South-East Asia between India and Papua (Inusa, 2007). Plantain is an herbaceous plant, perennial unisexual, from 2m to 6m high, all parts are milky white. Plantain peels are waste generated by households and in bulk due to the industrial processing of plantains. This waste often ends up in unregulated landfills, soils or rivers. The availability of national and international programs for the treatment of peel waste resulting from plantain production and consumption as well as plantain development is very limited; thus leading to a huge amount of waste every day, especially in Nigeria. This may be due to limited information on the resources present in skin waste (Babayemi and Dauda, 2009). With a figure of 2,722,000 tons in 2011, Nigeria ranks 5th in the world in terms of plantain production capacity (FAO, 2012). Despite this huge production, plantains are widely consumed locally due to the growth of industries that use plantains as snacks by the townspeople as well as the demand for convenient recipes from plantains (Akinyemi et al., 2010). The importance of studying the use of agricultural waste as an additive in concrete production for sustainable construction cannot be overstated. Therefore, this study aims to present the effect of plantain peel on the properties of concrete.

Admixtures are substances added to concrete in addition to its components to improve its performance. The use of admixtures in concrete is found in many ancient civilizations. Admixtures, derived from the addition of chemicals, are substances added to concrete mixes to change or improve the properties of fresh concrete or hardened concrete, or both (Jackson & Dhir, 1996).

According to ASTM C 494 (1992), admixture is defined as any material, other than cement, water, and aggregate, used as an ingredient in concrete and added to the batch immediately before or while mixing. They are divided into mineral and chemical excipients.

Chemical admixtures are generally classified according to their function in concrete into 7 classes as specified in ASTM C 494 (1992), namely:

Class A - Water reducer, Class B - Retardant, Class C - Accelerator, Class D - Water reducer

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and retarder, Class E - Water reducer and accelerator, Class F - High water reducer grade or Super plasticizer and Grade G-High - water reducer and retarder or super plasticizer and retarder range. These substances are added to concrete in very small amounts mainly to entrain air, reduce water or cement content, plasticize fresh concrete mixes or control setting time.

On the other hand, mineral admixtures are often added to concrete in larger quantities to improve the workability of fresh concrete; to improve concrete's resistance to thermal cracking, expansion of alkaline aggregates and attack of sulphates; and allows to reduce the cement content. Sources of mineral supplements can be natural or artificial obtained as by-products in the form of ash, coal burning and some crop by-product (Neville, 2011).

Concrete workability refers to its ease of placement, compaction, and finishing without segregation. Factors affecting workability include water-cement ratio, aggregate properties, and chemical additives, mixing method, temperature and slump. A balance between water and additive content is required to achieve optimum workability and durability. Proper mixing ensures even distribution and avoiding defects. Extreme temperatures affect preparation time and workability. The deflection test measures consistency. Maneuverability is key to efficient construction and long-term durability. Controlling these factors ensures a manageable, sustainable and efficient concreting process.

Durability is defined as the capability of concrete to resist weathering action, chemical attack and abrasion while maintaining its desired engineering properties. It normally refers to the duration or life span of trouble-free performance. Different concretes require different degrees of durability depending on the exposure environment and properties desired. Factors like proper mix design, adequate reinforcement cover, and curing techniques play key roles.

MATERIALS AND METHODS

The materials and methodology adopted in this study are as described below.

Materials

Plantain peel as the main material was obtained from the environs of Ifo and Ikorodu, both in Lagos, Nigeria.

Methodology

Drying of the plantain peel

The plantain peel was air-dried on a clean surface by spreading them in a moisture and dust free environment (Plate 1) to remove the moisture content. After sun-drying, the plantain peel weighed 44kg.

Plate 1: Dried Plantain Peel

Burning of the plantain peel

The dried plantain peel was burnt in an incinerator (Plate 2)at 600-700^{o}C in a dust free environment.

Plate 2: Burning of plantain peel in the furnace

Sieving and storage

The plantain peel ash was sieved through a 75micron BS sieve, and weighed 7.5kg after sieving. The material that passed through the sieve (Plate 3) was kept in a container. The sieve was selected so that the material gotten is as smooth as cement.

Plate 3: Plantain peel ash obtained

Mix Design and Curing

The concrete is of grade M15 with mix ratio 1:2:4 and water-cement ratio of 0.7. The RPPA and UPPA ash was added at 0%, 5%, 10%, 15%, and 20% by weight as admixture and mixed with cement, fine and coarse aggregates. The concrete mix batching was done by weight and at four curing times: 7, 14, 21, and 28 days.

Table 1 shows the obtained values for the mix design for each cube mix.

Table 1: Mix Design for each cube mix

Percentage	Cement(kg)	Fine aggregate(kg)	Coarse aggregate(kg)	Plantain peel(kg)	W/C
0	1.21	2.71	5.40	0.00	0.70
5	1.21	2.71	5.40	0.72	0.70
10	1.21	2.71	5.40	1.50	0.80
15	1.21	2.71	5.40	2.20	0.72
20	1.21	2.71	5.40	3.00	0.79

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RESULTS AND DISCUSSION

Workability test

The results of the workability test in Table 2shows that the slump values of the plantain peel ash at various percentages are higher than the control mix. It could be observed that at 10% the slump value was the highest, but according to standard for normal workability of concrete, it could be said that at 5% of plantain peel ash at admixture represents a standard workability for the concrete.

Table 2 shows the Slump test results for different mix ratio.

Table 2: SlumpTest

Mix ratio	True Slump
0%	45 mm
5%	60 mm
10%	250 mm
15%	90 mm
20%	180 mm

Compressive strength test

Table 3 shows the compressive strength result recorded by each concrete proportion, the range and standard deviation. The strength of the specimens ranged from 8.03 to 28.05 (N/mm^2). This lies within the range of 9.75 to 15 (N/mm^2) specified as the strength of normal grade 15 concrete. The 5% mix produced concrete specimen with the highest strength of 28.05 N/mm^2 at 21 days. The strength of the 5% specimens continually increased during the days of curing in water, which allows continuous cement hydration ensuring 100% relative humidity.

Table 3: Compressive Strength Test Results

Concrete mix	Curing Age (DAYS)	Average Weight of cube (kg)	Average load (KN)	Strength (N/mm^2)
0%	7	8.191	318.44	14.15
	14	8.325	324.38	14.42
	21	7.988	404.79	17.99
	28	8.114	414.37	18.42
5%	7	8.229	496.81	22.08
	14	8.495	414.85	18.43
	21	8.327	631.04	28.05
	28	8.472	614.34	27.30
10%	7	7.901	241.71	10.74
	14	7.752	303.76	13.50
	21	7.687	303.99	13.51
	28	7.598	309.28	13.75
15%	7	7.854	206.65	9.18
	14	8.080	222.27	9.88
	21	8.011	233.17	10.36
	28	7.810	238.66	10.60
20%	7	8.016	188.70	8.03

14	8.113	198.25	8.81
21	8.082	201.35	8.94
28	8.138	209.07	9.29

Water absorption test

Concrete's water absorption test determines how much water a sample of concrete can hold. This test is crucial for evaluating the concrete's resilience to water and durability, as well as ensuring that it will function as planned in the specified setting.

The results of the water absorption test in Figures 1, 2, 3 and 4 show the values of the plantain peel ash at various percentages. It could be observed from the results obtained that at each percentage, the water absorption values were increasing by each curing days but at a lower rate, which shows that it has a chance of maintaining its durability and withstanding water damage. Figure 1 at 5% PPA showed the highest water absorption rate at 28 days curing reaching a value of 2.5 unlike Figure 2 at 10% PPA which was slightly less than 1.5. Figures 3 and 4 at 15 and 20% respectively gave maximum values at 21 and 14 days respectively.

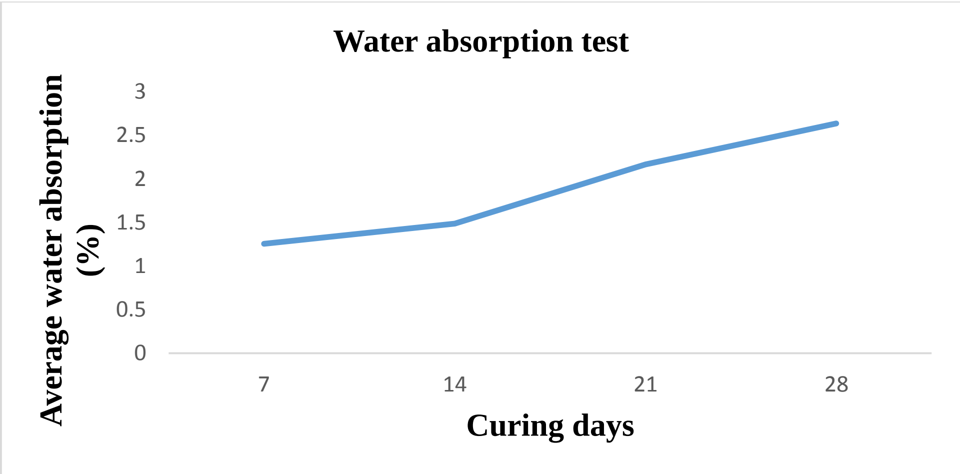

Figure 1: Water absorption result for 5% plantain peel ash.

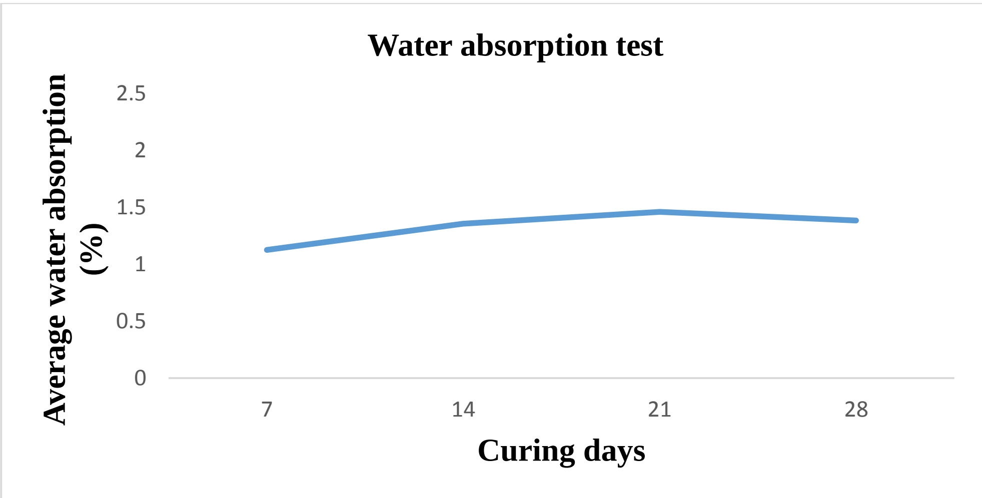

Figure 2: Water absorption result for 10% plantain peel ash.

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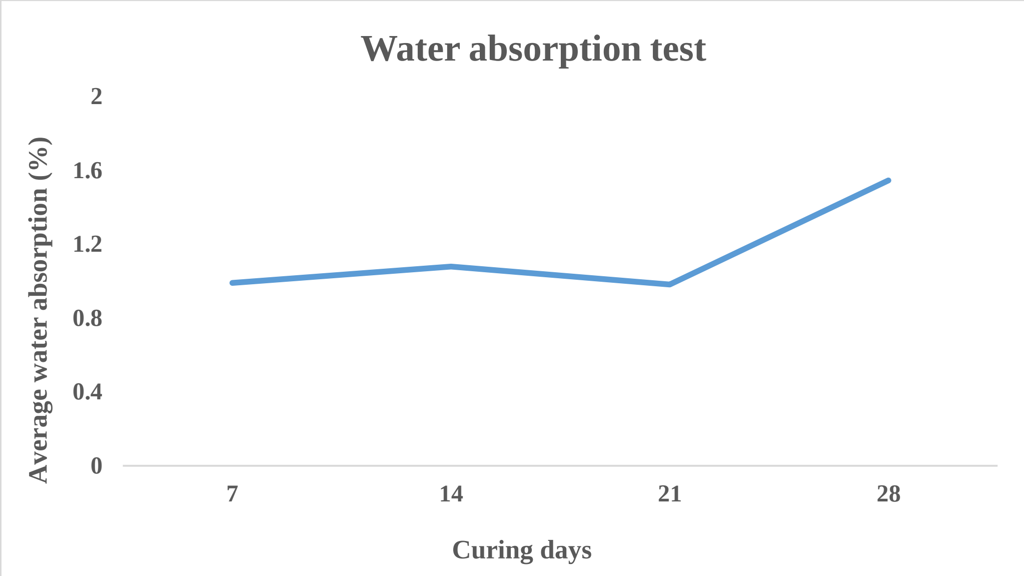

Figure 3: Water absorption result for 15% plantain peel ash.

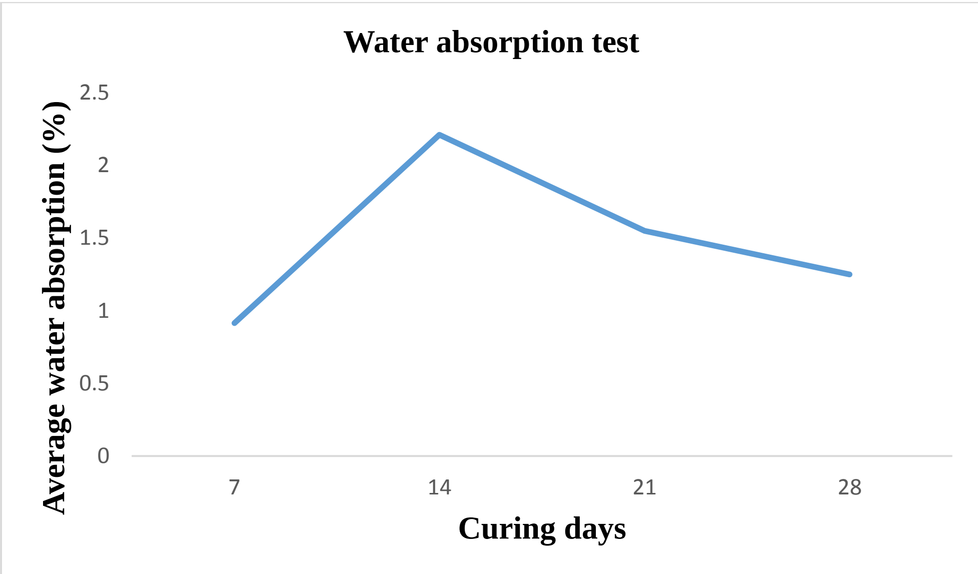

Figure 4: Water absorption results for 20% plantain peel ash.

Overall, the results obtained from the workability test, water absorption test and compressive strength tests, presented plantain peel ash at 5% as a promising material and this provides a strong basis for further research and development of plantain peel ash as an admixture in concrete as a potential alternative building material.

CONCLUSION

The use of plantain peel ash as an admixture for concrete has been shown to have a significant effect on the compressive strength, workability and durability of concrete structures. The use of plantain peel ash in concrete mix design could improve performance and service life of concrete structures.

The workability of concrete increases (from 45 mm for the control to 60 mm for 5% PPA) due to the addition of plantain peel ash. The study ensures that the appropriate mix design is used to address the specific amount of plantain peel ash that can influence the durability of concrete structures.

There were significant differences in the compressive strengths of the concrete with plantain peel ash compared with the control mix at the first 28-day age with control giving 18.42 N/mm^2 while PPA at 5% gave 27.30 N/mm^2, which showed that plantain peel ash admixtures appear to contribute to late strength development of concrete.

The use of by-products such as plantain peel ash as admixture for concrete is proposed as a sustainable and effective solution. The implementation of such solutions will contribute to reducing the carbon footprint of the cement industry and protecting the environment.

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