Comparism of Effect of using Saw Dust Ash and Banana Leaves Ash as Pozzolan on Engineering Properties of Concretes

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Abstract - *The high cost of building materials such as cement has been a source of concern to stakeholders in the building industry. One way of bringing down the cost of concrete is to source for alternative materials for its production. Saw dust and Banana leaves are agricultural waste produced after being processed for human consumption. These agricultural wastes are largely discarded, thus causing pollution to the environment. Incorporating these wastes in concrete could be an effective way of recycling them. Thus, this paper investigate the effect of partial replacement of Limestone Portland cement with Saw dust ash (SDA) and Banana leaves ash (BLA) at 0%, 2.5%, 5%, 7.5% and 10% by weight in concrete production. The SDA and BLA were obtained by calcinations of saw dust and banana leaves into ash using open burning method. Chemical composition and specific gravity test were carried out on the SDA and BLA. A total of 72 concrete cubes were casted and cured up to 28days. The SDA and BLA concrete were subjected to slump, density and compressive strength test. From the test results, the BLA paste has a slow reaction rate, high specific gravity compared to SDA. The best 28days compressive strength of the cement –SDA Concrete was examined at 2.5% with a value of 23.41 N/mm² an approximate 98.9% of the strength of control sample. The best 28days compressive strength of the cement – BLA Concrete was also examined at 2.5% with a value 22.81 N/mm² an approximate 94.6% of the strength of the control sample. Thus, both SDA and BLA concrete have lower compressive strength compared to the control sample at all corresponding curing ages. It can be concluded that the SDA and BLA can be classified as a good pozzolan but requires ample time to chemically react and bond with other constituent materials of the concrete to achieve a significant structural strength.*

***Keywords:* Saw Dust Ash (SDA), Banana Leaves Ash, Concrete, Pozzolan, Compressive Strength, Ordinary Portland Cement (OPC)**

1 INTRODUCTION

Concrete is enormously becoming a main building material used in construction industry in developing countries like Nigeria due to its strength, durability, resistance to severe environmental condition and versatility [1, 2]. Cement, a major binder in concrete, whose price tag is skyrocketing due to its high demand, high economic inflation in the country, high energy consumption, environmental pollution restriction law in the country and depletion of limestone has make it difficult to meet housing dmand [3 - 6]. To meet the demand for infrastructures, there is a need to find an alternative, which can be total or partial replacement of cement in concrete [7, 8].

The use of industrial by-products and agricultural wastes as cementious materials to serves as alternative binder or cement replacement is greatly of interest to researchers [9 -11]. If these waste ashes have high pozzolanicity, they could incredibly influence properties of soft and hardened concrete and provide technological advancement in replacing cement in concrete production [12]. According to [13], significant amount of energy and cost could be saved as a result of the use of industrials by-products and agricultural wastes in total or partial replacement of cement in concrete. Similarly, [14] stated that adopting a proper method of recycling industrial by-products and agricultural waste would significantly reduce waste and help maintain a sustainable environment. The use of industrial and agricultural by-product in cement production is an environmental friendly method of disposal of large quantities of materials that would have otherwise pollutes land, water and air.

Some of the agricultural waste products which possess pozzolanic properties and have been studied for use in blended cements include fly ash [15], wood waste ash[16], Saw dust ash [17], Yam peel ash [6], bamboo leaf ash [18], sugar cane bagasse ash[19], corn cob ash [20] e.t.c. This research work compares the use of Saw dust ash (SDA) and Banana leaves ash (BLA) in partial replacement of Ordinary Portland Cement in concrete.

2 MATERIALS AND METHODOLOGY

2.1 Material Used

Ordinary Portland Cement used in this research work is Dangote cement of grade 42.5N, conforming to [21]. The researcher ensured that the cement used was fresh, uniform in color, free from lumps and foreign matter.

The saw dust used for this study was collected from saw mill points at Ajegunle in Offa, Kwara State, Nigeria. While the banana leaves were obtained from a local farm around Ansar-ru-Deen College, Ijagbo, Kwara State, Nigeria. The Sample was then sun dried before it was burned in a metal container using uncontrolled open air burning method. The cooled ashes were further grinded and sieved through a 700μm sieve in order to remove any impurity and larger size particles. The SDA and Banana leaves ash were taken to SMO Laboratory Services, Ibadan, Nigeria for chemical composition analysis.

The fine sand obtained from a dealer in Offa and the coarse aggregate obtained from a quarry site in Ijagbo, Kwara State, were used as fine and coarse aggregate respectively.

2.2 Preparation of Testing Specimens

The concrete investigated was of mix ratio of 1:2:4 (cement and SDA: sand: granite) with a constant water/cement ratio of 0.50. The cement was replaced with SDA/BLA at 0%, 2.5%, 5%, 7.5% and 10% by weight and mixed with sand and granite as fine and coarse aggregates respectively. A total number of 72 concrete cubes of sizes 150mm x 150mm x 150mm were casted as shown in Figure 1(a).

(a)

(b)

Figure 1: Casting and Curing of Concrete. (a) Casted Concrete in moulds (b) Concrete cubes being placed in curing tank.

After setting for 24 hours, the concrete cubes were removed from their moulds and immersed in water tank for curing for 7, 14, 21 and 28 days as shown in Figure 1(b).

2.3 Chemical Composition

Atomic Absorption Spectrophotometer and Gravimetric methods at the SMO Laboratory Services, Ibadan, Nigeria were used to determine the chemical composition of the Saw dust ash (SDA) and Banana leaves ash (BLA).

2.4 Specific Gravity

Specific gravity test on cement, SDA, BLA, blended cement - SDA and blended cement -BLA was done using density bottle in accordance to [22]

2.5. Slump and Density Test

Slump test was done in accordance with [23] to ensure the workability of the blended concrete, while the density was determined by following the procedures specified in [24]

2.6 Compressive Strength

After the required age of curing, the concrete cubes were removed from the curing tank and allowed to surface dry after which they were weighed on a balance to obtain the weight of each cube. The weighed cubes were carefully placed in a Compressive Testing Machine with a capacity of 100kN at the Civil Engineering Department, Federal Polytechnic Offa, Kwara State as show in Figure 2. The concrete cubes were crushed at the end of curing age of 7, 14, 21 and 28 days.

Figure 2. Crushing of Concrete Cubes

3 RESULTS AND DISCUSION

3.1 Chemical Composition

The chemical composition of the SDA and BLA are as shown in Table 1.

Table 1: Chemical composition of Saw Dust ash and Banana Leaves Ash

Test Parameter	Saw Dust Ash (%)	Banana Leaves Ash (%)
Alumina (Al_2O_3)	9.85	2.8
Silica (SiO_2)	62.87	48.7
Calcium (C_aO)	10.35	9.89
Iron (Fe_2O_3)	4.45	1.8
Magnesium Oxide (M_gO)	4.18	3.82
Sodium (Na_2O)	0.035	0.21
Potassium (K_2O)	1.71	1.45
Loss on ignition	5.85	5.08

The silica content (SiO_2) of the SDA and BLA are 62.87% and 48.7 respectively. The silica content of SDA is greater than that of the BLA. This indicates that the SDA has potential of high pozzolanic activity compared to BLA.

The following observations were deduced from Table 1:

- The silica content (SiO_2) of the SDA and BLA are 62.87% and 48.7 respectively. The silica content of SDA is greater than that of the BLA. This indicates that the SDA has potential of high pozzolanic activity compared to BLA.
- The combination of SiO_2+ Al_2O_3 +Fe_2O_3 of the saw dust ash (SDA) and Banana peels ash have a value of 77.17% and 53.3%. According to [25], fly ash with SiO_2+ Al_2O_3 +Fe_2O_3 greater than 50% and above 70% can be classified as fly ash class C and fly ash class F respectively. Thus, the SDA is classified as Fly ash class F, while BLA is classified as Fly ash class C. F. This indicates that saw dust ash (SDA) is a highly reactive pozzolan material compared to banana leaves ash.
- The SDA and BLA loss of ignition (a measure of unburned carbon) are 5.85 and 5.08 respectively. The loss of ignition of both ashes is below the prescribed maximum of 6% set by [25]. Thus the presence of soot in both ashes is very negligible.
- Traces of alkalis such as K_2O and Na_2O were found with a percentage of 1.745% and 1.66% in SDA and BLA respectively. These values are slightly greater than the 1.5% set by the [25], thus the possibility of alkali-silica reactions is minimal.

3.2 Physical Properties

The results of the slump, specific gravity and density test conducted on SDA and BLA cement and concrete are shown in Table 2.

3.2.1 Slump Test

The slump values for SDA concrete ranges between 45 – 65 and slump values of BLA concrete ranges from 65 – 81 as shown in Table 2. From Table 2, it is observed that as the SDA increases, the slump values decreases. These results indicate that concrete becomes less workable as the SDA content increases, thus more water is required to make the concrete mixes more workable. Further, it can be observed that as the BLA content increases, the slump value increases, thus indicating less water is required to make the concrete mixes workable. The high demand of water by SDA could be attributed to high presence of silica as indicated in Table 1 above.

3.2.2 Specific Gravity

The specific gravity values ranges from 2.19 to 3.15 as shown in table 2. The specific gravity for pure cement, SDA and BLA are 3.15, 2.19 and 2.54 respectively. It is observed that as the SDA and BLA content in cement paste increases, there is a consequential reduction in its specific gravity.

3.2.3 Density

The density values for SDA and BLA concrete ranges between 2419.75 kg/m^3 and 2646.9 kg/m^3 as shown in Table 2. From Table 2, it is observed that as the SDA increases, the density of concrete initially increases up to 2.5% cement replacement but further increase in SDA and BLA leads to reduction in density. Further, it can be observed that the density values of BLA concrete are higher than the density values of SDA concrete.

Table 2: Physical Properties

% of cement replacement	Slump (mm)		Specific Gravity		Density at 28days (kg/m^3)	
	SDA	BLA	SDA	BLA	SDA	BLA
0%	65	65	3.15	3.15	2548.1	2548.1
2.5%	55	68	2.98	3.05	2637	2646.9
5.0%	53	73	2.87	2.95	2488.9	2607.41
7.5%	50	78	2.82	2.89	2518.5	2567.9
10%	45	81	2.73	2.78	2488.9	2419.75
100%	-	-	2.19	2.54	-	-

Table 3. Compressive strength of Concretes

Age (days)	Mean Compressive Strength of Concrete Cubes (N/mm²)								
	0%	2.5%		5.0%		7.5%		10%	
		SDA	BLA	SDA	BLA	SDA	BLA	SDA	BLA
7	19.7	19.08	18.21	17.94	13.03	14.44	10.36	11.30	11.07
14	21.92	21.30	18.73	18.36	15.4	16.66	13.18	13.52	13.03
21	22.36	21.69	18.81	19.69	18.66	17.89	15.4	14.86	14.06
28	23.68	23.41	22.81	21.56	20.87	20.87	20.73	18.06	16.73

3.2.4 Compressive Strength

The variation of compressive strength of Control sample, SDA and BLA concrete with curing time are as shown in Table 3.

The best 28days compressive strength of the cement – SDA Concrete was examined at 2.5% with a value of 23.41 N/mm² an approximate 98.9% of the strength of control sample. The best 28days compressive strength of the cement – BLA Concrete was also examined at 2.5% with a value 22.81 N/mm² an approximate 94.6% of the strength of the control sample.

From table 3, it is observed that the compressive strength of control sample, SDA and BLA concrete increases with curing ages. Also, it is observed that the compressive strength of the SDA and BLA concrete are lower than the compressive strength of the control sample at all corresponding curing ages. Thus, as the SDA and BLA content increases, there is a corresponding decrease in the compressive strength. Similarly, the compressive strength of all BLA concrete is lower than the compressive strength of SDA concrete. This is an indication that the SDA has fast cementious reaction than the BLA due to the high presence of silica content in SDA.

4. CONCLUSIONS

This research work evaluates the properties of SDA and BLA as a partial replacement of ordinary Portland cement in concrete production.

From the test results and discussions, the following conclusion were made

1. The results from the chemical position indicate that both SDA and BLA are good pozzolan due to

their high silica and alumina contents. But, SDA is considered to be a better pozzolan.

2. From the slump test, the mixes of SDA concrete requires more water than BLA concrete to make it workable.

3. From the specific gravity test, inclusion of SDA and BLA in cement paste leads to corresponding reduction in specific gravity.

6. Increases, there is a corresponding decrease in the compressive strength of the concrete. But, the SDA has more structural strength compared to BLA.

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4. Similarly, as the SDA and BLA content in concrete increase there is a corresponding reduction in density. But, the BLA is more denser than SDA concrete

5. Also, as the SDA and BLA content in concrete

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