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Comparative Evaluation of Open Air Burnt and Controlled Burnt Isoberlinia Doka Sawdust Ash As A Supplementary Cementitious Material in Mass Concrete

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ABSTRACT *: Concrete is a major construction material, which is usually made by mixing cement, water, fine and coarse aggregates and sometimes admixtures in prescribed proportions. Communities around the world rely on concrete as a safe, durable and simple building material. With the ever increasing population in most developing countries and the corresponding increase in demands and need for infrastructural development, there is an urgent need to focus attention on functional but low-cost alternative construction materials. This study assessed and compared the properties of sawdust ash (SDA) produced by two different methods as a supplementary cementitious material in mass concrete to the conventional concrete. The sawdust ash used was prepared using open air and controlled burning (electric Muffle Furnace). It also investigated the physical properties and chemical composition of sawdust ash as well as the workability and compressive strength properties of the concrete produced by replacing 5%, 10% and 15%, by weight of Portland limestone cement with SDA. Slump test was carried out on the fresh concrete and compressive strength test on hardened concrete. The concrete cubes were tested at the ages of 7, 14, 21 and 28 days. The results showed that SDA is a good pozzolan with combined* SiO_2*,* Al_2O_3 *and* Fe_2O_3 *of 74.22%. The slump decreased as the SDA content increased indicating that concrete became less workable as the SDA content increased. The compressive strength decreased with increasing SDA replacement. The compressive strength of concrete with SDA was lower at early stages but improves significantly up to 28 days. At 28 days of curing, concrete gained significant strength of* $34.50N/mm^2$ *for Open air burnt sawdust concrete and* $34.00N/mm^2$ *for controlled burnt sawdust concrete with 5% SDA replacement. It was concluded that open burnt sawdust has higher compressive strength than controlled burnt sawdust and both 5% SDA substitution for the methods is adequate to enjoy maximum benefit of strength gain.*

KEYWORDS*: Concrete, Sawdust Ash, Isoberlinia Doka, Portland limestone cement, Compressive Strength.*

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I. INTRODUCTION

There is need for affordable building materials in providing adequate housing for the teaming populace of the world. The cost of conventional building materials continues to increase as the majority of the population continues to fall below the poverty line. Thus, there is the need to search for local materials as alternatives for the construction of functional but low-cost buildings in both the rural and urban areas (Mokal et al, 2023).Continuous generation of wastes arising from industrial by-products and agricultural residue create acute environmental problems both in terms of treatment and disposal, the use of these wastes as concrete materials promotes sustainability in the production of structural concrete (Fapohunda et al., 2021). Saw dust (SD) is a waste material from the timber industry. It is produced as timber is sawn into planks at saw mills located in virtually all major towns in Nigeria, for instance Ilorin. This result into total volume of 119.522m^3 translating into 100.4 tonsof wood waste produced daily within Ilorin metropolis (Lasode et al., 2010). Research has shown that this waste product could be useful in the construction industry. Previous studies have converted the waste into ash using electric means, while some have used open burning. However, comparison has been done on both to establish if the properties are obtainable when converted into ash. El-Nadoury (2021) investigated the properties of concrete produced by partially replacing sand and cement in concrete with sawdust and sawdust ash respectively. Ikponmwosa et al., (2020) investigated the use of sawdust ash as a partial replacement of Portland cement up to 20% on the performance of concrete mixtures. Based on his results of the experimental investigations, empirical models were developed to predict the impact of the proportion of sawdust ash on the performance of concrete mixtures. The empirical models for predicting the properties of sawdust ash blended concrete were developed using the multivariate interpolation method, multiple regression analysis and coefficients equations approaches. Experimental results revealed that sawdust ash is a class C type pozzolan. The incorporation of up to 20% sawdust ash as replacement of Portland cement resulted in approximately 10%, 33% and 35% reduction in the slump, compressive strength and split tensile strength, respectively. The mechanical properties observed for mixtures incorporating saw dust ash showed that these mixtures can still be used for structural applications where sustainable building material is desired.

Sawdust waste generated from the saw mills was converted into ash by using controlled burning (Electric Muffle Furnace) and by open burning in which the ash is a form of a pozzolana. According to American Society for Testing Materials (ASTM, C-618-1978), A pozzolana is a siliceous or a siliceous aluminous material which contains little or no cementitious value, but in finely divided form and in the presence of moisture or water, chemically reacts with calcium of moisture at ordinary temperature to form compound possessing cementitious properties.

Concrete is a good construction material made by mixing cement, coarse aggregate (gravel or crushed stone), fine aggregate (sand) and water either in designing or prescribed proportions. It is strong in compression and has some resistance to some chemical and biological attack like termites etc. while steel, which is strong in tension, is incorporated in it thus becoming "reinforced concrete"; a strong and durable material, which can be formed into various sizes and shape. This account for its wide spread use in civil engineering structures such as buildings, dams and so on (Smith, 1989).Building construction has been in existence since the creation of mankind, from the Stone Age to the present use of concrete. In the past, people built houses with leaves, tree branches and even grasses. The use of alternative walling material to cement in its various forms continues alongside with the development of cement technology. The building and allied industries have shifted from the use of conventional construction materials to newer materials like fibre, reinforced plastics, aluminums, new varieties of bricks, cement, glass and steel due to economy enhanced in the use of these materials (Shestoperov, 1983. The choice of a particular material depends largely on its availability, nature of project, durability, individual preference and economic consideration.

Ayuba et al 2022 investigated the durability properties of self-compacting concrete (SCC) modified with Saw dust ash (SDA) exposed to an aggressive media. A number of trials mixes were conducted to obtain grade 40 SCC, with a suitable mix proportion varied at 5, 10, 15, 20, 25 and 30 % by weight of the binder as OPC replacement in SCC. Constant water to binder ratio of 0.37 with water reducing admixtures was used in all the mixtures. The research revealed that SDA enhanced the resistance of SCC against Na_2SO_4 attack at 5% replacement but performed poorly in H_2SO_4. The water absorption of SCC decreased with an increase in SDA content. The resistance of SDA-SCC to elevated temperature was reduced with an increase in SDA content. The compressive strength of the SDA-SCC decreased with the age of exposure in an aggressive media. The SEM result revealed the presence of crystal like spikes of SDA particles, which contributed significantly to the high surface area of the ash particles

Attempts have also been made by various researches to reduce the cost of its constituents and hence total construction cost by investigating and ascertaining the usefulness of materials which could be classified as local materials. Some of these local materials are agricultural or industrial waste which include sawdust ash, palm kernel shell, pulverized fuel ash, slag, fly ash, coconut shell among others which are produced from milling stations, thermal power station, waste treatment plant and so on (Ettu et al, 2013). As a result of the increase in the cost of construction materials, there is a need to investigate the use of alternative building materials which are locally available. Most building construction works have some form of concrete. Consequently, reduction in the concrete cost, if other factors remain the same, should reduce the building construction cost.

High cost of building materials has resulted in some builders/contractors cutting corners leading to failure in buildings (Usman et al, 2012). It is therefore necessary to use alternative local material for concrete production. Intensified local economic ventures in many Nigerian communities have led to increased agricultural and industrial related waste such as saw dust. Large quantities of saw dust are generated daily in saw mills and timber markets scattered all over Nigeria. There is therefore a need to further specifically investigate the suitability of using sawdust ash (SDA) as possible cement replacement in making cement composites. Its utilization as pozzolanic material would both reduce the problem of solid waste management (Mokal, 2023) and add commercial value to the otherwise waste product.

The aim of this research was to assess and compare the properties of sawdust ash (SDA) produced by two different methods (Open air burning and controlled burning using electric muffle furnace) as a supplementary cementitious material in mass concrete with that of the conventional concrete since it is available in large quantities in Nigeria and constituting environmental nuisance.

II. MATERIALS AND METHODOLOGY

2.1 Material Collection

The sawdust ash (SDA) used for this research was collected from waste products of timber sawn in sawmills, around Tanke, Ilorin. The sawdust was from homogeneous specie of timber "Isoberlinia*doka*" commonly called "Baho" in the south west area of Nigeria, common in the Nigerian market. The SDA was produced by burning saw dust to a temperature of 650^0C for 1 hour using a muffle furnace (Electric SXL-1030 Series Muffle Furnace) at the Chemical Engineering Laboratory, University of Ilorin and open burning that was done without a controlled temperature. The cooled ash was sieved using 425μm (micron).The coarse aggregate from uncrushed granite of igneous origin, the aggregate was normal weight, irregular shaped with a maximum size of 20mm, and conforming to BS 882 was sourced from a construction site within the University of Ilorin premises. Fine aggregate was collected from a construction site at the University premises. Silt content was carried out to know the amount of silt present in accordance with BS 882. Proper inspection was carried out to ensure that it was free from deleterious materials. The fine aggregate was clean, sharp, and free from clay and organic matter, and well graded in accordance with BS 882. Portland limestone cement type, Dangote brand whose properties conform to the requirement of ASTM Type I and British Standard Code (BS 12 of 1978), in which the composition and properties is in compliance with the Nigerian Standard Organization defined standard of cement for concrete production. It was sourced from a cement depot at Tanke, Ilorin. The water used was Pipe borne water; it was clean, free from dirt and contaminants collected from the Civil Engineering concrete laboratory tap and satisfactory for making concrete.

Analysis of SDA for the determination of its pozzolanicity was carried out using X-Ray fluorescence Analyzer at Chemistry Department, University of Ilorin, Kwara State, Nigeria. Slump and compacting factor tests were carried out to check the effect of SDA on the workability of fresh concrete in accordance with the requirements of BS1881 (1983) for slump test and compacting factor tests.

Table 1: Proportion of Concrete mix

SDA REPLACED (%)	SDA (g)	CEMENT (g)	SAND (g)	GRANITE (g)	WATER (g)
0	0	414	828	1656	230
5	21	393	828	1656	230
10	42	373	828	1656	230
15	62	352	828	1656	230

2.2 Methods

In the determination of compressive strength of concrete partially replaced with sawdust ash as an admixture, certain laboratory tests were carried out on the materials used for the production of concrete cube specimens in accordance with BS 812 part 103 and BS 5328.

2.2.1 Laboratory Tests

Silt Content test: To determine the content percentage of silt in the sand not more than the specified limit.

Sieve Analysis test: To determine the particle size distribution of aggregates according to BS 812 part 103.

Fineness modulus (FM)

$$\frac{(\text{\% Cumulative Weight retained from 8.0mm to 0.075mm})}{100} \quad \text{--------------- - - - - -} \quad (1)$$

The coefficient of uniformity, $C_u = \frac{D_{60}}{D_{10}}$ and - (2)

Coefficient of curvature, $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ - (3)

Specific Gravity Test: To determine the specific gravity of sharp sand, granite and sawdust ash.

Normal Consistency of Cement test: To make normal consistence cement paste and to measure the initial setting time and the final setting time of the standard consistence of the cement paste.

Water absorption test: To determine the water absorption capacity of sharp sand and granite BS 1881: Part 122 (2011)/

Slump Test: To determine the workability of the fresh concrete paste prior casting in accordance to BS 1881: Part 102 (1983).

Density Test: To determine the density of the hardened concrete cubes (in accordance with BS 1881-114).

Compressive Strength test: To determine the compressive strength of concrete cubes produced at age 7, 14, 21 and 28 days respectively (BS 1881: Part 116: 1978).

2.2.2 Production of Concrete Cubes

The mixing involved the replacement of 5%, 10%, 15% and a control of no ash 0% by the weight of Portland Limestone Cement with sawdust ash. Concrete without sawdust ash served as control. The mix ratio used was 1:2:4 (cement, sand and granite) with water cement ratio of 0.6. Cubic specimens with size 100mm by 100mm by 100 mm were cast for determination workability, density and compressive strength. For each batch of SDA replacement, a total of twelve cubes were cast, totaling 48 cubes in all. They were subsequently placed in the curing tank covered with water for certain number of days prior to the tests.

III. RESULTS AND DISCUSSION

Data and results of tests on sawdust ash (SDA) concrete constituents.

3.1 Chemical Analysis of Sawdust Ash: This analysis was carried out in the department of chemistry laboratory, University of Ilorin.

Table 2: Chemical Analysis of Open Air burnt Sawdust Ash

Chemical constituents	Percentage composition (%)
Silicon Oxide (SiO_2)	67.30
Iron Oxide (Fe_2O_3)	4.29
Aluminum Oxide (Al_2O_3)	2.63
Calcium Oxide (CaO)	10.80
Magnesium Oxide (MgO)	5.80
Sodium Oxide (Na_2O)	0.10

Potassium Oxide (K_2O)	2.40
Sulfur Trioxide (SO_3)	1.50
Phosphorous Pentoxide (P_2O_5)	0.50
Manganese Oxide (MnO)	0.01
Loss of Ignition (LOI)	4.30

The result from chemical analysis showed that they are elemental oxides present in the SDA sample. The SDA has combined percentages of (SiO_2+Al_2O_3+Fe_2O_3) of 74.22% which is more than 70%, indicating that it is a good pozzolanic material in accordance with the requirements in ASTM C 618 (1991).

3.2 Silt content

The silt content was 7.7% which showed it was good for use in concrete mix since it has percentage silt content less than 10%.

3.3 Sieve Analysis (Particle Size Distribution)

(a) Sharp sand

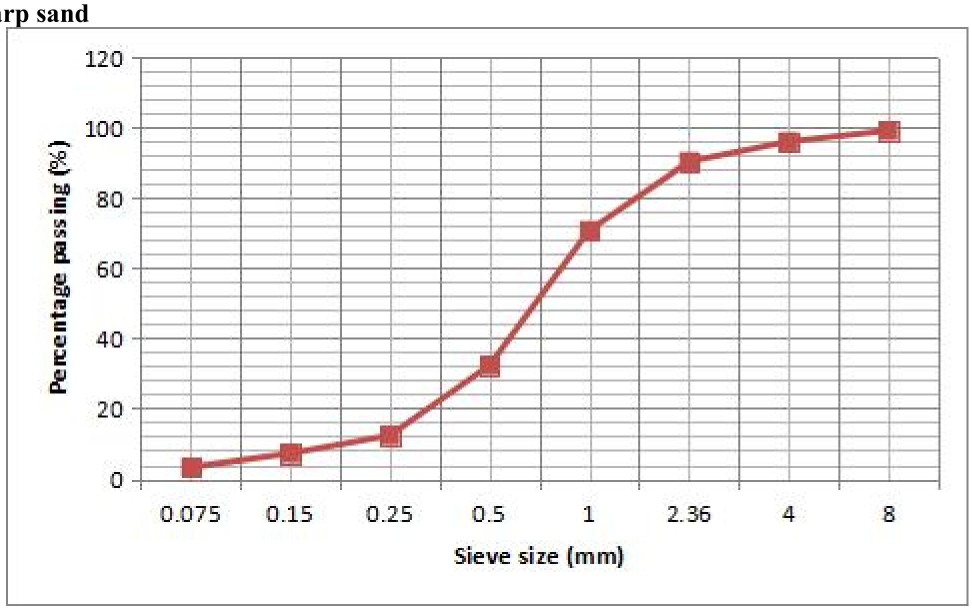

Fig. 1: Particle size distribution curve of sharp sand

From the grading curve above;

Fineness modulus (FM) = 3.9

Coefficient of uniformity, $C_u = \frac{D_{60}}{D_{10}} = \frac{0.9}{0.2} = 4.5$

Coefficient of curvature, $C_c = \frac{{D_{30}}^2}{D_{60} \times D_{10}} = \frac{0.45^2}{0.9 \times 0.2} = 1.13$

Based on the results shown above the F. M of the sand is 3.9 i.e. coarse sand, Coefficient of uniformity is 4.5 and Coefficient of curvature is 1.13 respectively and according to (Smith and Smith, 1998), the sand is well graded.

(b) Granite

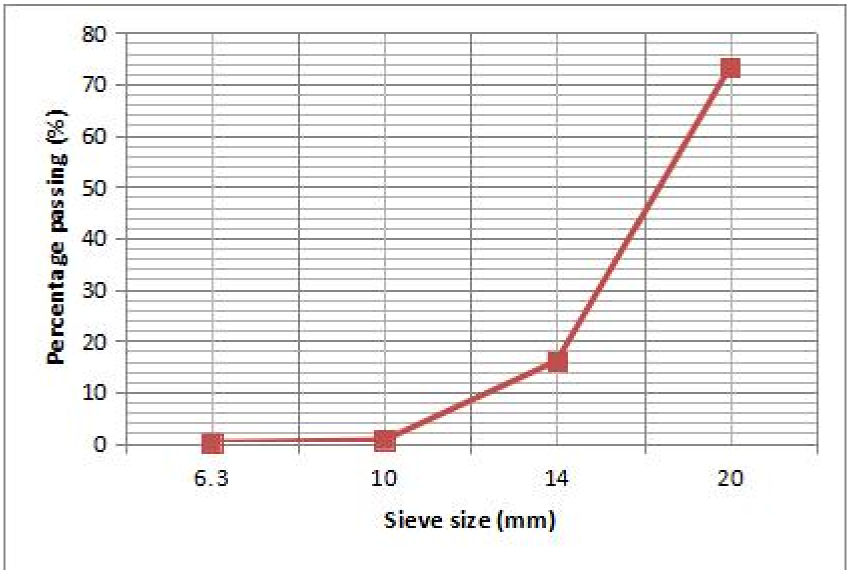

Fig. 2: Particle size distribution curve of granite

Therefore, D_{10} = 12.0mm; D_{30} =16.0mm, and D_{60} = 19.0mm

Coefficient of uniformity, $C_u = \frac{D_{60}}{D_{10}} = \frac{19}{12} = 1.6$

Coefficient of curvature, $C_c = \frac{{D_{30}}^2}{D_{60} \times D_{10}} = \frac{16^2}{19 \times 12} = 1.12$

Based on the results above, the coefficient of uniformity is 1.6 and coefficient of curvature is 1.12 respectively and according to (Smith and Smith, 1998), granite is uniformly graded.

3.4 Normal Consistency Test

Trials were made to achieve the result of the normal consistency using fresh cement in each trial in which 34mm was achieved.

Table 3: Normal Consistency

Trials	Amount of Cement (g)	Amount of Water (mm^3)	Depth of penetration (mm)	Gauging time (minutes)
1	400	100	0	4
2	400	120	12	4
3	400	128	23	4
4	400	132	36	4
5	400	130	34	4

The Normal consistency was achieved at a volume of water of 130mm^3 which was used for the initial and final setting time.

3.5 Water Absorption Capacity (WAC)

The water absorption capacity of sharp sand was 4.80% and that of water absorption capacity of granite was 1.90 % which was in accordance with BS 1881-122.

3.6 DATA AND RESULT OF TESTS ON FRESH AND HARDENED CONCRETE

Table 4: Comparison between Open and Controlled burnt sawdust.

Tests Done	Percentage replacement with SDA	Days of Curing	Controlled burnt method	Open burnt method
Slump	0		47mm	47mm
	5		42mm	40mm
	10		40mm	38mm

	15		38mm	37mm
Density	0	7	$2.569\frac{g}{cm^3}$	$2.569\frac{g}{cm^3}$
		28	$2.620\frac{g}{cm^3}$	$2.620\frac{g}{cm^3}$
	5	7	$2.578\frac{g}{cm^3}$	$2.614\frac{g}{cm^3}$
		28	$2.631\frac{g}{cm^3}$	$2.663\frac{g}{cm^3}$
	10	7	$2.515\frac{g}{cm^3}$	$2.480\frac{g}{cm^3}$
		28	$2.550\frac{g}{cm^3}$	$2.602\frac{g}{cm^3}$
	15	7	$2.343\frac{g}{cm^3}$	$2.434\frac{g}{cm^3}$
		28	$2.373\frac{g}{cm^3}$	$2.467\frac{g}{cm^3}$
Compressive Strength	0	7	$25.60\frac{N}{mm^3}$	$25.60\frac{N}{mm^3}$
		28	$35.60\frac{N}{mm^3}$	$35.60\frac{N}{mm^3}$
	5	7	$23.60\frac{N}{mm^3}$	$24.20\frac{N}{mm^3}$
		28	$34.00\frac{N}{mm^3}$	$34.50\frac{N}{mm^3}$
	10	7	$14.80\frac{N}{mm^3}$	$15.90\frac{N}{mm^3}$
		28	$20.40\frac{N}{mm^3}$	$22.80\frac{N}{mm^3}$
	15	7	$12.40\frac{N}{mm^3}$	$12.30\frac{N}{mm^3}$
		28	$17.70\frac{N}{mm^3}$	$19.00\frac{N}{mm^3}$

3.7 CONTROLLED BURNT METHOD (ELECTRIC MUFFLE FURNACE)

3.7.1 Workability (Slump) Test

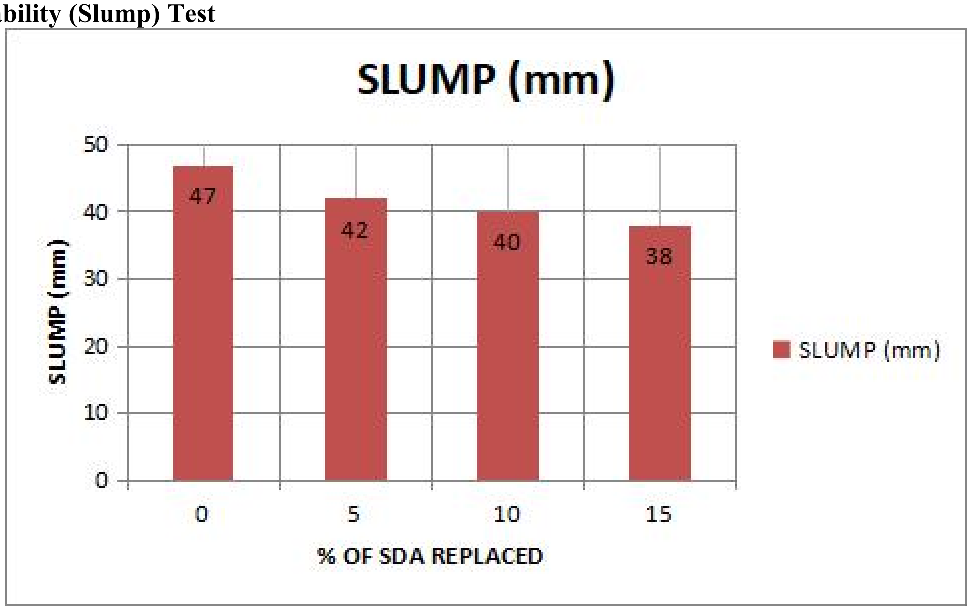

Fig. 3: The Effect of Sawdust ash on the workability of the fresh concrete for controlled burning

The results of the slump test indicating the workability of the SDA concrete are shown in Table 4. It showed that the slump value decreased as the SDA content increased. It was noticed that concrete became less workable as the SDA percentage increased meaning that more water would be required to make the mixes more workable. Consequently, the water binder ratio was increased from 0.5 to 0.6 for 15% substitution since the mix was becoming stiff. The high demand for water as SDA increases is due to increased amount of silica in the mixture. This is typical of pozzolan cement concrete as the silica-lime reaction requires more water in addition to the water needed during hydration of cement (Adesanya and Raheem, 2009a).

3.7.2 Density Test

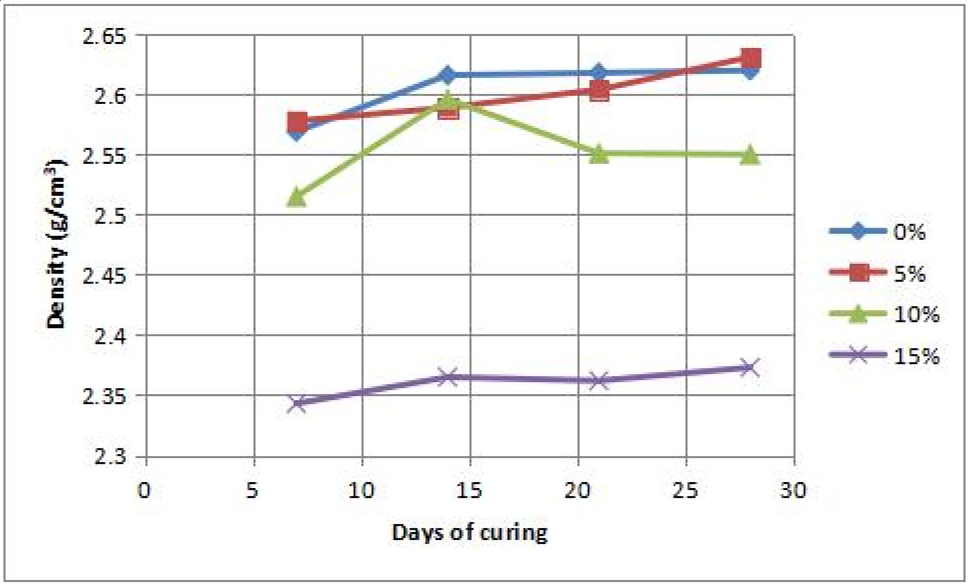

Fig. 4: The Effect of curing on the concrete density for controlled burning

This implies that SDA has little or no significant effect on the density of the concrete comparatively as the densities are almost within the same range in each variation.

3.7.3 Compressive strength on hardened concrete cubes

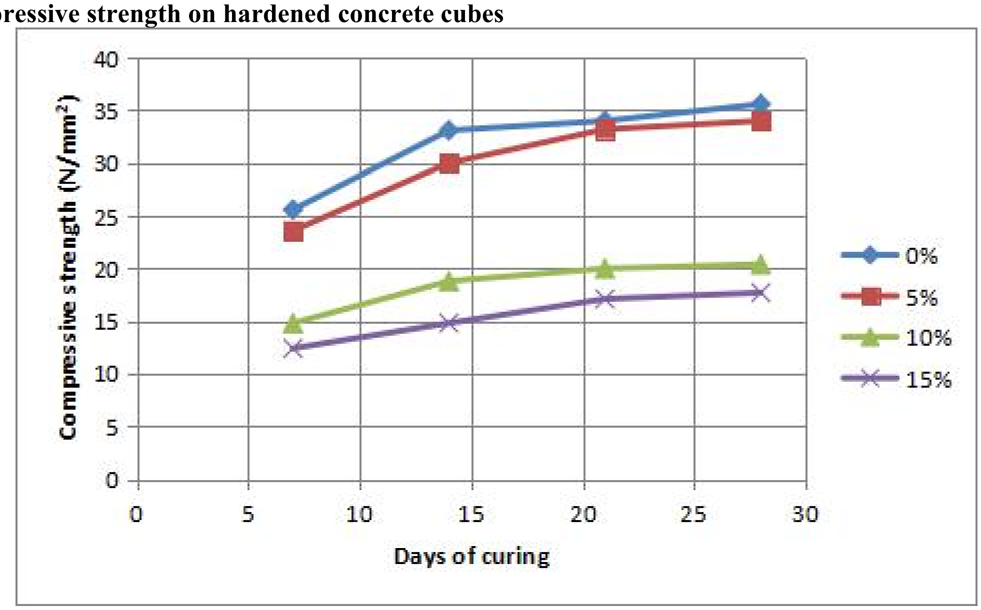

Fig. 5: Effect of curing on Sawdust ash concrete for controlled burning

3.7.4 Discussion of Results of compressive strength on controlled burnt sawdust (Electric furnace method)

The effect of curing ages on the compressive strength of sawdust ash concrete is presented in Figure 5. The figure indicates that compressive strength generally increased with curing period and decreased with increased amount of SDA. The result at 7 days shows a decrease in strength from 25.60N/mm^{2}for control to 12.40N/mm^{2}for 15% SDA replacement. Similar trend was observed at 14 days from 33.10N/mm^2 of control to 14.80N/mm^2 for 15% SDA replacement as shown in Figure 5. These results indicate that concrete containing SDA gained strength slowly at early curing age. This is in line with previous findings that concrete containing pozzolanic materials gained strength slowly at early curing ages (Adesanya and Raheem, 2009a). At 28 days, there was continuous increase in compressive strength for all the classes of concrete with values ranging from 35.60N/mm^{2}for the control, to 17.7N/mm^{2}for 15% SDA replacement. The control still has the highest compressive strength at this age. This increase in compressive strength can be attributed to the reaction of SDA with calcium hydroxide liberated during the hydration of cement. However, the significant increase in strength of SDA concrete is due to the pozzolanic reaction of SDA. The strength gain can be attributed to the cementitious products formed as a result of hydration of cement and those formed when lime reacts with the pozzolan incorporated (Adesanya and Raheem, 2009a). A value of 34.00N/mm^{2}at 28 days was obtained for concrete with 5% SDA replacement. It was concluded that 5% SDA substitution is adequate to enjoy maximum benefit of strength gain. Since all the specimens meet the minimum strength of 6N/mm^{2}after 28 days of curing recommended by BS 5224 (1976) for masonry cement, SDA concrete could be used for general concrete works where strength is of less importance such as in mass concrete, floor screed and mortar.

3.8 OPEN AIR BURNT METHOD

3.8.1 Workability (Slump) Test

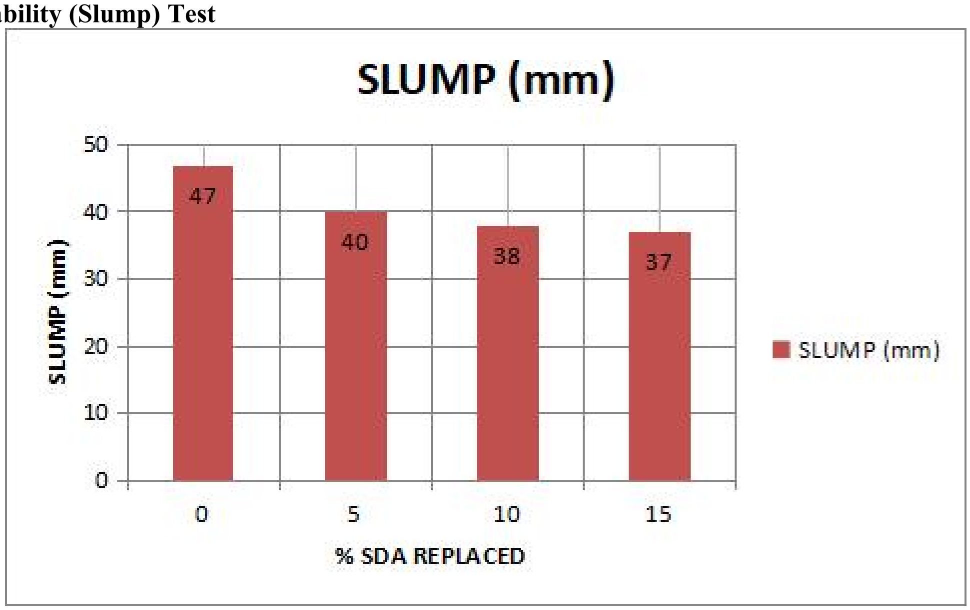

Fig. 6: The Effect of Sawdust ash on the workability of the fresh concrete for open burning

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The results of the slump test indicating the workability of the SDA concrete are shown in Table 4. It showed that the slump value decreased as the SDA content increased. It was noticed that concrete became less workable as the SDA percentage increased meaning that more water would be required to make the mixes more workable. Consequently, the water binder ratio was increased from 0.5 to 0.6 for 15% substitution since the mix was becoming stiff. The high demand for water as SDA increases is due to increased amount of silica in the mixture. This is typical of pozzolan cement concrete as the silica-lime reaction requires more water in addition to the water needed during hydration of cement (Adesanya and Raheem, 2009a).

3.8.2 Density Test

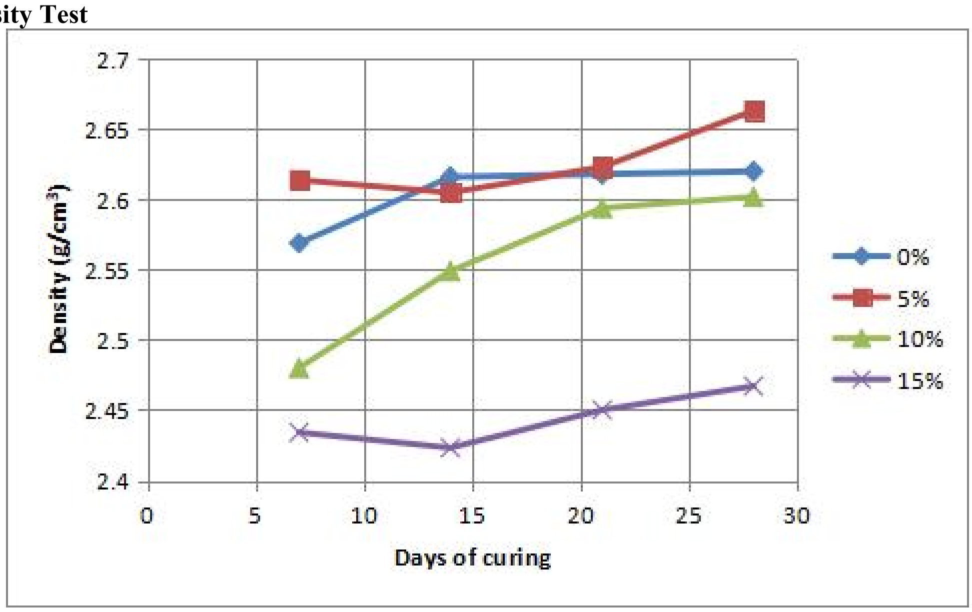

Fig. 7: Effect of curing on Sawdust ash concrete for open burning

This implies that SDA has little or no significant effect on the density of the concrete comparatively as the densities are almost within the same range in each variation.

3.8.3 Compressive strength on hardened concrete cubes

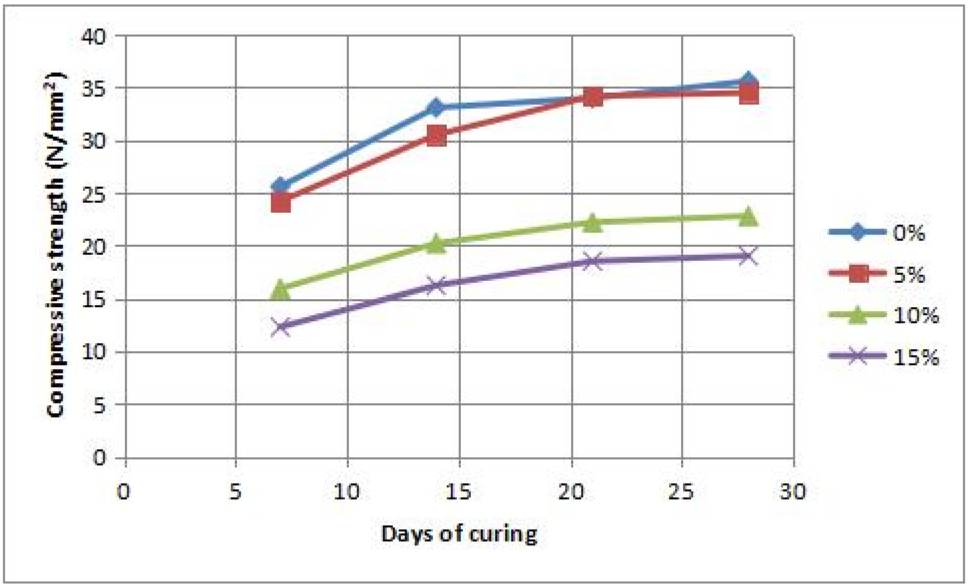

Fig.8: Effect of curing on Sawdust ash concrete for open burning

3.8.4 Discussion of Results of compressive strength on Open Burnt sawdust

The effect of curing ages on the compressive strength of sawdust ash concrete is presented in Figure 8. The figure indicates that compressive strength generally increased with curing period and decreased with increased amount of SDA. The result at 7 days shows a decrease in strength from 25.60N/$mm^2$for control to 12.30N/$mm^2$for 15% SDA replacement. Similar trend was observed at 14 days from 33.10N/mm^2 of control to 16.20N/mm^2 for 15% SDA replacement as shown in Figure 8. These results indicate that concrete containing SDA gained strength slowly at early curing age. This is in line with previous findings that concrete containing pozzolanic materials gained strength slowly at early curing ages (Adesanya and Raheem, 2009a). At 28 days, there was continuous increase in compressive strength for all the classes of concrete with values ranging from 35.60N/$mm^2$for the control, to 19.00N/$mm^2$for 15% SDA replacement. The control still has the highest compressive strength at this age. This increase in compressive strength can be attributed to the reaction of SDA with calcium hydroxide liberated during the hydration of cement. A value of 34.50N/mm^2at 28 days was obtained for concrete with 5% SDA replacement. It was concluded that 5% SDA substitution is adequate to enjoy maximum benefit of strength gain. Since all the specimens meet the minimum strength of 6N/mm^2after 28 days of curing recommended by BS 5224 (1976) for masonry cement, SDA concrete could be used for general concrete works where strength is of less importance such as in mass concrete, floor screed and mortar.

IV. CONCLUSION

4.1 Conclusions

From the results of the various tests performed, the following conclusions can be drawn:

1. SDA is a suitable material for use as a pozzolan, since it satisfied the requirement for such a material by having a combined (SiO_2+Al_2O_3+Fe_2O_3) of more than 70%.
2. SDA has little or no significant effect on the density of the concrete comparatively.
3. Concrete becomes less workable as the SDA percentage increases meaning that more water is required to make the mixes more workable. This means that SDA concrete has a higher water demand.
4. After assessing and comparing the two methods, the open burning SDA concrete has more compressive strength than that of controlled burning. Although their compressive strength at 28 days for 5% is greater than 25N/mm^2which is recommended for concrete strength at transfer for pre-tensioning and post-tensioning according to BS 5328-1: (1997).
5. Burning can be done using open burning which does not need expertise because it also produced good results.
6. The compressive strength generally increasedwith curing period and decreased with increased amount of SDA. Only 5% SDA substitution is adequate to enjoy maximum benefit of strength gain. Therefore, Functional low-cost buildings materials can be produced using SDA of 5%.
7. SDA concrete can be used for general concrete works where strength is of less importance such as in mass concrete, floor screed and mortar. Since all the specimens meet the minimum strength of 6N/mm^2after

28 days of curing recommended by BS 5224 (1976) for masonry cement.

4.2 Recommendations

Based on the investigation carried out and conclusion drawn, it can be recommended that:

1. For an optimum compressive strength of concrete to be attained, 5% replacement of cement with SDA is recommended.
2. When preparing the sawdust ash, controlled burning involved more labour and it's not cost effective, but open burning which is more economical and less labour intensive should be adopted.
3. For large works, furnace with a large capacity and temperature monitoring system will be required which is difficult to get access to, but large drums which are readily available should be used for burning the saw dust since there have almost the same strength.
4. The smoke generated by open burning will cause environmental pollution but it can be controlled by the use of chimney.
5. This can create employment opportunities for small to medium scale enterprises.
6. Research can be carried out on other species of wood and compared to check their compressive strength.
7. Recycling of waste materials in a more useful way like this should be encouraged by government and any organization, with viable programs and adequate funds to encourage interested researchers to venture into it.

References

Adesanya, DA. and Raheem, AA. (2009a). A study of the workability and compressive strength characteristics of corn cob ash blended cement concrete, Construction and Building Materials, 23, 311–317

ASTM C 618. 1978. Specification for pozzolanas, ASTM standards, Philadelphia, USA.

ASTM C 618. 1991. Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for use as a Mineral Admixture in Portland Cement Concrete, Annual Book of ASTM Standards, Philadelphia, USA.

Ayuba. S., Uche OUA, Haruna S. and Mohammed A. (2022). Durability Properties of Cement – Saw Dust Ash (SDA) Blended Self Compacting Concrete (SCC). Nigerian Journal of Technology (NIJOTECH) Vol. 41, No. 2, pp.212 –221 www.nijotech.com

British Standards Institution, BS 882. 1992, Specification for aggregates from natural sources for concrete.

British Standard Institution, BS 12. (1978), Specification for Portland cement.

British Standard Institution, BS 1881: Part 102. (1983), Methods for determination of Slump, London.

British Standard Institution, BS 1881: Part 122. (2011), Methods for determination the water absorption of hardened concrete samplea, London.

British Standard Institution, BS 812-103-1. (1985). Testing Aggregates. Methods for determination of particle size distribution, Sieve tests.

British Standard Institution, BS 5328-1. (1997). Concrete. Guide to specifying concrete.

British Standards Institution, BS 1881 – 116. (1978). Methods for determination of compressive strength of concrete cubes.

British Standard Institution, BS 5224. (1976). Standard Specification for Masonry Cement, London.

El-Nadoury, WW. (2021). Production of Sustainable Concrete Using Sawdust. Magazine of Civil Engineering. 105(5)

Ettu, LO., Osadebe, NN., Mbajiorgu. and MSW. (2013). Suitability of Nigerian Agricultural By-Products as Cement Replacement for Concrete Making. International Journal of Modern Engineering Research (IJMER). 3(2), 1180-1185.

Fapohunda, C., Kilani, A., Adigo, B.(2021). A Review of Some Agricultural Wastes in Nigeria for Sustainability in the Production of Structural Concrete. Nigerian Journal of Technological Development 18(2), 76-87.

Ikponmwosa, E., Falade, F., Fashanu, TA., Ehikhuenmen, SO., and Adesina, A. (2020). Experimental and numerical investigation of the effect of sawdust ash on the performance of concrete. 5(1), 1–11.

Jackson, N. and Plur, RK. (1988). Civil Engineering Materials (Third Edition). London: ELBS|Macmillan.

Lasode, OA. and Balogun, AO. (2010). Wood Waste Generation in Ilorin Metropolis: Problems, Management and Prospects. Journal of Solid Waste Technology and Management. Pg. 586-593.

Shestoperov, SV. 1983. Road and building materials, Mir Publishers, Moscow. Vol. 1.

Mokal M.P, Mandal. R, Nayak. S, and Panda S.K, (2023). Efficacy of high-volume fly ash and slag on the physicomechanical, durability, and analytical characteristics of high-strength mass concrete, Journal of Building Engineering.

Smith, MJ. (1989). Soil Mechanic (Second Edition), The English Language Book Society MacDonald and Evans Ltd, London.

Smith, GN. and Smith, IGN. (1998). Elements of Soil Mechanics, Seventh Edition, Blackwell Science, London

Usman ND, Idusuyi FI, Ojo EB. and Simon B. (2012). The use of Sawdust and Palm Kernel Shell as Substitute for fine and Coarse Aggregate in Concrete Construction in Developing Countries. *Journal of Chemical, Mechanical and Engineering Practice*, 2(3), 51-62.

