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Design and Production of Concrete Kerbs for Pavement Construction Made with Saw Dust Ash as Partial Replacement of Cement

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ABSTRACT

This study evaluates the design and production of concrete Kerbs for pavement construction made with sawdust ash as partial replacement of cement. Fine aggregates used were obtained from a natural source from the Umudike River, Abia State. Sand passing the 4.75 mm sieve was used. The fine aggregate conforms to BS EN 13139, 2002 as the sand is free from contaminants. Coarse aggregates (uncrushed) used were obtained from Abakaliki, Ebonyi State. The Cement used to be the Ordinary Portland Cement (Dangote brand (42.5N)) that complies with the specifications NIS 444-1, 2003 and BS EN 197-1, 2000, bought from the market. Potable water from the tap in Civil Engineering Laboratory, Michael Okpara University of Agriculture, Umudike, was used for the curing of the cubes. This water conforms to the requirement of BS EN 1008-2002. Saw dust were obtained from timber shed at Umudike town, and was air-dried and then ashed by burning in an incinerator at temperatures generally bellow 650^{0}C. The ash was then sieved and the bigger particles remained in the 600$\mathcal{M}$m sieve were thrown away, however those passing the sieve were used for the research. No crushing or any exceptional action to advance the ash quality and increase its pozzolanic properties were applied as the researchers sought to use simple processes that can be easily simulated by local community residents. The concrete kerbs were produced with the use of concrete cubes mix design proportion of 1:2:4 was achieved. Fine aggregate was partially replaced with saw dust ash. Five (5) samples of 1,2,3,4 and 5 of 60 pieces of 150mm x 150mm cubes, the mix 1 were cast in cement only [100% OPC] which serves as the control mix, then sample 2,3,4 and 5 was cast with some percentage replacement of 0%, 5%, 10%, 15% and 20% of cement with saw dust ash respectively. The result showed that the compressive strength of the kerbs stones increased slightly with curing period and the amount of saw-dust ash (SDA) with early curing aging, but the strength improved significantly at the later curing aging, indicating a pozzolanic reaction. Only 5% saw dust ash replacement is adequate to achieve maximum strength gain and thus recommended for production of Concrete kerbs for pavement construction.

1. Introduction

Kerbs can be produced from one form of concrete or a wear layer and structural layer made from various concretes. If the kerbs are made with a wear layer, the layer should have a minimum thickness of 4 mm on the total surface declared by the manufacturer as the visible surface. The standard specifies the requirements concerning the flexural strength, wear resistance, slip resistance, shape and dimensions as well as visual aspects. Kerbs are usually laid on a concrete bed of at least 100 mm thickness in such a way that they are joined with the pavement [1]. The back of the kerb should be hunched with concrete to a thickness of at least 150 mm to afford lateral support. They can then be tapped down to the correct level. The joints between kerbs are often not mortared but instead they are laid as tight to each other as possible without risking the units spalling. The basic kerb profiles that are used for road construction are: Half-battered, Bull-nosed, Splayed and Square. Bull-nosed or chamfered kerbs are used to lower the profile of the kerb for pedestrian crossings and drive way access. Connecting kerbs between two different profiles are termed as transition kerbs or ‘droppers’.

The roadway structure ought to be able to provide a surface of adequate riding quality, sufficient skid resistance, favorable luminaire features, and little noise contamination. Inadequate design of roadways results in quick failure of pavements which leads to the riding quality. Today, permeable paving methods are beginning to be used for low-impact roadways and walkways. Pavements are vital to countries like the United States and Canada that seriously depend on road transportation. Hence, research projects such as Long – term pavement Performance have been launched to heighten the life cycle of diverse road surfaces [2]. Concrete surface scaling is a complex phenomenon due to the substantial number of autonomous factors and is the subject of many broad studies [3, 4]. The paper presents the results of testing double-layered concrete kerbs with surface impairment ensued after 3 years of construction.

A concrete kerb is an important addition to a road cycle way or footpath. It has relatively so much of the application with its key purpose being to neatly create separation and visual demarcation of walkways and other trafficked regions. Concrete kerbs offer a chain of functions as well as constructing a boundary amid the roadway and the pavement or the footpath and the area besides it, they can support in directing surface water into drainage systems, direct where a person’s driveway is, which is expedient when planning a housing project, and promote traffic calming, therefore creating a safer space for pedestrians, drivers and cyclists [5]. Therefore, whether physical setting out the edge of the road or creating clear markers that direct the flow of traffic, a concrete kerb is a vastly useful part of a road or pathway. Authors in [6] and [7] considered the behavior and mechanical properties of curves made from natural recycled aggregates. So far, and up to the author’s knowledge, several researchers as [8] and [9] have justified the use of salvaged aggregates as a measure towards the environmental preservation. Nevertheless, the energetic implications of the whole recycling process have not been questioned, at least for all applications. The whole recycling process implies important energy consumption as pointed out by author [10] that the use of this kind of recycled process does not save any energy in comparison with the use of natural aggregates.

Due to the problem of managing waste, research in the area of minimizing waste accumulation through reclamation and recycling has been recently ignited considering aesthetic and ecological problems caused by the improper disposal of waste. Areas of research aimed at reducing waste include the use of rice-husk ash, coconut shell ash and groundnut-husk ash to produce cement. Also, high cost of many construction materials has resulted engineers to keep searching for alternative materials to enable construction cheaper and also to reduce the environmental pollution. As a result of the high cost of ordinary Portland cement (OPC) and the necessity to reduce the cost of building generally, Researchers have made much effort in sourcing local materials that could be used as a fractional replacement for cement (OPC) in civil engineering and building works. Authors in [11] reported that an auxiliary cementitious resources are said to be effective in meeting most of the requirements of durable concrete and blended cements are now used in many parts of the world. The soaring price of construction resources and the associated problems of shelter in developing countries have challenged many engineers to seek and develop new materials, relying on locally available ingredients for building construction. These include the use of by-products of industries and waste materials as cementitious

materials for the production of concrete. All these sum up to why saw dust, ash is being added to get the compressive strength required in concrete kerbs production.
A host of researches on utilization of waste materials have been increasingly conducted during the last two decades. In the construction industry, the development and use of industrial and agricultural wastes, such as fly ash, blast furnace slag, metakaolin, rice husk ash (RHA), and bagasse ash (BA) were widely studied by past scholars [12]. The viable application of RHA is in the silica extraction practice [13], as pozzolanic material [14] and other uses. They discovered that application of ashes (fly ash or RHA) by the grinding process in cement concrete reduces porosity and improved opposition to sulphate attack and chloride penetration thereby improves the properties of concrete. Another vital agricultural waste that is cheap, easy to find than the above mention which can be used as when used or partially replaced in concrete replacement can improve its strength is Sawdust Ash [15].

Sawdust can be defined as a by-product of tools pulverized wood. It is made up of the particles of wood. It is also the by-product of certain animals, birds and insects which live in wood, such as the woodpecker and carpenter ant. It is based on the present exorbitant cost of construction/building material (cement) which has caused those in the construction industry to manipulate or reduce the required quantity of cement needed to achieve maximum strength in concrete kerbs structure, thereby leading to failure and instability [16]. It is mainly used for particle board production: coarse sawdust can be employed in the production of wood pulp and a range of other applied uses such as a substitute to the advent of refrigeration. It was frequently used in Kehoudes to keep ice frozen during the summer [17]. It is also sometimes used to soak up liquid spills, allowing the spill to easily collect or swept aside. Concrete kerbs production when added more than saw dust as required can also cause untimely destruction of its life span [18]. As such, it was formerly common on barroom floors. Saw-dust is the key constituent of particle board, it is used to make cutler's resin mixed with water and frozen, it forms picked a low melting much stronger form of ice. Sawdust is used in the manufacture of charcoal briquettes. The claim for the invention of the first commercial charcoal briquettes was created by British from the wood scraps and saw-dust was produced b-y his automobile factory. Saw-dust as a fine aggregate in concrete making is of particular interest because its use can considerably reduce the problem of dumping and waste storage simultaneously and also help in the preservation of natural fine aggregate resources. These wood processing enterprises are commonly concerned with the finished product and carefree about the vast quantity of wood dust (wastes) generated at sawmills. As a common by-product of sawmills, these wood shavings are recycled particleboard, burned in a sawdust burner that creates ultrafine air pollutants, or exploited to make heat for other milling operations. This show high availability of saw dust waste in our environment today. Some industrial by-products have been studied for use as supplementary cementations materials (SCM) viz. Saw dust, ash, silica fume, pulverized fuel ash, volcanic ash, rice husk ash and corn cob ash (CCA). However, literature limits on the application of sawdust ash.

Authors in [18] worked on the performance of cement based products like paste, mortar and concrete by using ash to partly replace additive produced by incinerating solid waste substance collected from the municipal garbage's. Authors in [16] also reviewed the properties of mortar and concrete used in the construction of structural members produced by using WWA as a mineral admixture in partial replacement levels. Authors in [19] investigated on the performance of self-compacting concrete prepared by incorporating ash made from burning sawdust during fresh stage as a mineral additive and from the studies carried out by authors in [20] on the utilization of ash obtained from incineration of timber waste products as cement replacement material. Sawdust ash is suggested to be used in construction works like masonry, pavement works both in surface and sub-surface works and it can serve as a cement blended with rich siliceous product i.e., ash to increase durability. Concrete is a compound material which is made up of aggregates and paste [21, 22]. The aggregate, the paste is a mixture of water and Portland cement. The strength of the concrete increases as it gets older [23].

This research is aimed at design and production of concrete kerbs for pavement construction made with sawdust ash as partial replacement of cement. This was achieved by obtaining physical and chemical properties of the constituent materials in order to find out its suitability for the production of concrete kerbs. Furthermore, the mechanical property of the concrete proposed for the kerb is determined to know its ultimate strength after replacing with saw-dust ash at various percentages.

2.0. Materials and Methods

Fine aggregates used were obtained from a natural source from the Umudike River, Abia State. Sand passing the 4.75 mm sieve was used while the coarse aggregates (uncrushed) used was gotten from Abakaliki, Ebonyi State. The fine aggregate conforms to BS EN 13139: 2002 [23, 24, 25] as the sand is free from contaminants. The Cement used to be the Ordinary Portland Cement (Dangote brand (42.5N)) that conforms to the provisions made in NIS 444-1:2003 and BS EN 197-1:2000 [26, 27], obtained from the market. Potable drinking water, was used for this research and it conforms to the requirement of BS EN 1008-2002. Saw dust were obtained from timber shed at Umudike town, and was air-dried and then burnt into ashes in an incinerator at temperatures generally bellow 650^0C. The ash was made to go through a set of sieve and large particles retained on the 600μm sieve were thrown away whereas those passing the sieve were used for the test. No crushing or other forms of exceptional treatment were done to improve the ash quality nor enhance its pozzolanic properties so as to utilize simple processes that can be easily replicated by local community dwellers.

The concrete kerbs were produced with the use of concrete cubes. The standard prescribed mix proportion of 1:2:4 (cement: sand and water) mix ratio was used. Sand was partially replaced with saw dust ash. Five (5) samples each of 150mm cubes were produced in 0, 5, 10, 15 and 20% replacement of cement with saw dust ash respectively. Laboratory test conducted include; preliminary tests (Sieve analysis, Specific gravity, Moisture content and strength tests in accordance with BS 812 Part 109, 1990 [28]. The analysis requires a set of test sieves of the following sizes: 2.36mm, 1.18mm, 600um, 425um, 300um, 212um, 150um, 75um; a receiver, lid cover, weighting balance, wire brush, towel, evaporating plates, head pan, shovel, stop watch and washing bowel. The soil samples obtained were made to pass through a set of sieves after necessary preparations and thereafter, a destructive form of compression test were conducted and analyzed to determine the strength of a concrete mix after curing 7, 14, 21 and 28 days respectively, which the maximum load at failure and the cross-sectional area of the hardened concretes gives the idea of the grade of the concrete according to C39/C39M in accordance to Roads and Bridges, 1998.

3.0. Result and Discussion

The result of sieve analysis, particle size distribution, slump, specific gravity and bulk density obtained for both fine aggregate, and coarse aggregate on dry mass process, and after batching casting and re-molding after 24 hours the results were gotten as presented in figures and Tables 10a to 16 for the various concrete from control to the various replaced concrete partial replaced by Sawdust ash..

Table 1: Results of the sieve analysis of sand

Sieve size (mm)	Retained mass (gm)	%Retained (%)	Cumulative percentage retained (%)	Passed percentage (%)
4.75	7.6	1.5	1.5	98.5
2.36	12.5	2.5	4	96
1.18	42.6	21.3	25.3	74.7

0.6	94	18.8	44.1	55.9
0.425	98	19.6	63.7	36.3
0.15	155	31	94.7	5.3
0.075	16	3.2	97.9	2.1
PAN	10.5	2.1	100	-

Table 2: Results of the sieve analysis of saw dust

Sieve size (mm)	Retained mass (gm)	%Retained (%)	Cumulative percentage retained (%)	Passed percentage (%)
4.75	6	3	3	97
2.36	12	6	9	91
1.18	80	40	49	51
0.6	70	35	84	16
0.425	15	7.5	91.5	8.5
0.15	10	5	96.5	3.5
0.075	2	1	97.5	2.5
PAN	5	2.5	100	0

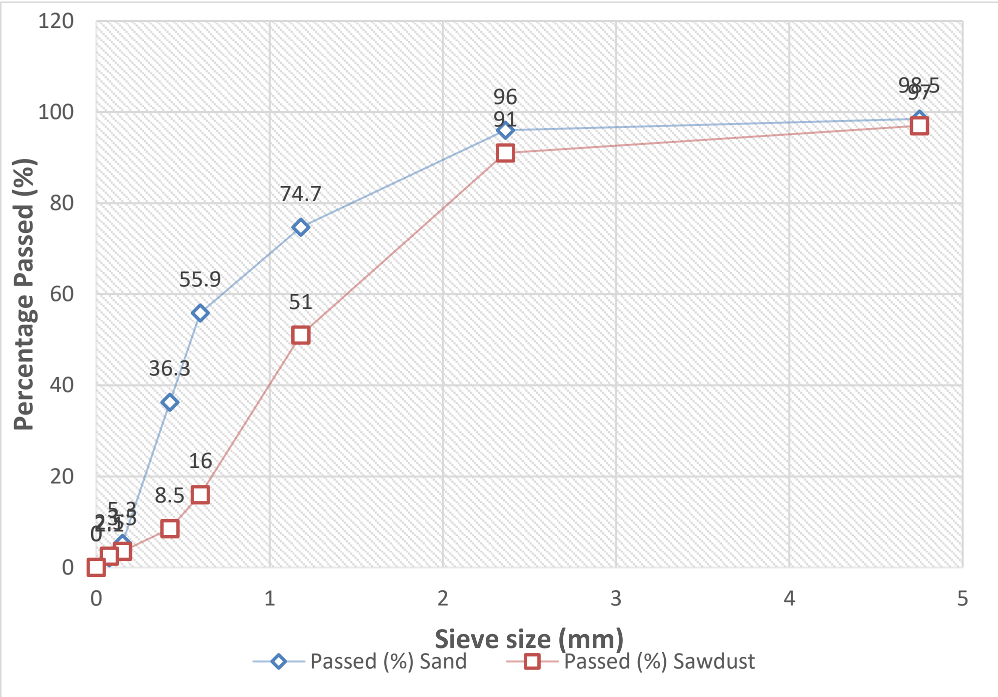

Figure 1: Particle size graph on sand and saw dust

Table 3: Results of the sieve analysis of stone dust aggregate

Sieve size (mm)	Retained mass (gm)	%Retained (%)	Cumulative percentage retained (%)	Passed percentage (%)
4.75	14	7	7	93
2.36	17	8.5	15.5	84.5
1.18	54	27	42.5	57.5
0.6	34	17	59.5	40.5
0.425	24	12	71.5	28.5
0.15	14	7	78.5	21.5
0.075	8	4	82.5	17.5
PAN	35	17.5	100	-

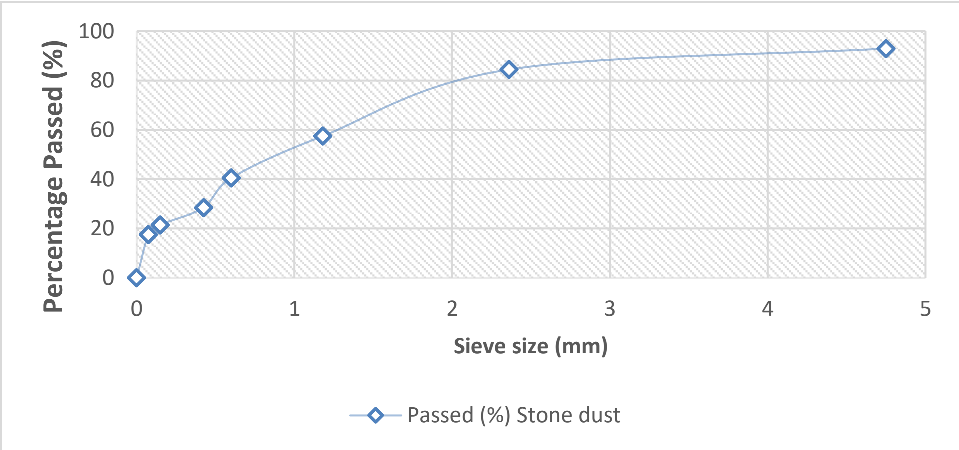

Figure 2: Particle size graph stone dust

Table 4: Specific gravity of sand

DESCRIPTION	**SAMPLE A**	**SAMPLE B**
Mass of vessel (g)	595	518
Mass of vessel + sample (g)	996	789
Mass of sample (A) (g)	405	375
Mass of vessel + sample + water (B) (g)	1745	1379
Mass of vessel + water (C) (g)	1540	1157
$P = \frac{A}{A - (B - C)}$	$\frac{405}{405 - (1745 - 1540)} = 2.02$	$\frac{375}{375 - (1379 - 1157)} = 2.45$
Average specific gravity	2.24	

Table 4b: Bulk density of sand

DESCRIPTION	Un-compacted	Compacted
Weight of Mould + sample (g)	**5795**	**6400**
Weight of mould (g)	**1986**	**1986**
Volume of mould (cm^3)	**2832**	**2832**
Bulk density (g/cm^3)	**1.35**	**1.56**

Table 5: Specific gravity of saw dust

DESCRIPTION	SAMPLE A	SAMPLE B
Mass of vessel (g)	585	425
Mass of vessel + sample (g)	640	460
Mass of sample (A) (g)	55	50
Mass of vessel + sample + water (B) (g)	1494	1147
Mass of vessel + water (C) (g)	1538	1157
$\boldsymbol{P} = \frac{\boldsymbol{A}}{\mathbf{A} - (\mathbf{B} - \mathbf{C})}$	$= \frac{55}{55 - (1494 - 1540)}$ $= 0.54$	$\frac{47}{47 - (1147 - 1157)}$ $= 0.75$
Average specific gravity	0.65	

Table 5b: Bulk density of saw dust

DESCRIPTION	Un-compacted	Compacted
Weight of Mould + sample(g)	**2360**	**2490**
Weight of mould (g)	**1986**	**1986**
Volume of mould (cm^3)	**2832**	**2832**
Bulk density (g/cm^3)	**0.13**	**0.18**

Table 6: Specific gravity of stone dust and water absorption

DESCRIPTION	SAMPLE A	SAMPLE B
Mass of Air-Dried Sample (A)	2836.9	2227.7
Mass of Basket + Sample in Water (B)(g)	2045.09	1655.7
Mass of Basket in Water (C) (g)	232.9	232.9
Mass of Oven Dried Sample (D) (g)	2807.2	2198
$\boldsymbol{P} = \frac{\boldsymbol{A}}{\mathbf{A} - (\mathbf{B} - \mathbf{C})}$	$\frac{2836.9}{2836.9 - (2045.09 - 232.29)}$ $= 2.768$	$\frac{2227.7}{2227.7 - (1655.7 - 232.29)}$ $= 2.768$
Average Specific Gravity	2.76	
Water Absorption = $\frac{100(A-D)}{D}$	$\frac{100(2836.9 - 2807.2)}{2807.2}$ $= 1\%$	$= \frac{100(2227 - 2198)}{2198}$ $= 1.3\%$
Average Water Absorption	1.15%	

Table 7: Specific gravity of Dangote cement

DESCRIPTION	SAMPLE A	SAMPLE B
Mass of empty bottle(W1) (g)	28.0	27.6
Mass of bottle +cement (W2) (g)	50.1	49.5
Mass of bottle+cement+ kerosene (W3)	85.0	85.4
Mass of bottle +kerosene (W4) (g)	68.4	68.0
Mass of bottle + water (W5) (g)	77.8	78.4
SPof kerosene= $\frac{W4-W1}{(W5-W1)}$	0.81	0.80
SP of Cement $\frac{W_2-W_1}{(W3-W1)-(W5-W1)}$	3.06	3.13
Average specific gravity	3.09	

Table 7b: Setting time and fineness of Dangote cement

DESCRIPTION	Result	Limit of specification	Remark
Weight of cement(g)	400g	Minimun200g	Good
Weight of water(g)	103g	Minimum50g	Good
Initial setting time	140mins	Minimum 45 mins	Good
Final setting time	285mins	Maximum 600mins	Good
Fineness of cement using BS sieve NO. 170			
Weight of sample	100g	Minimum of 50g	Good
Fineness of cement	2%	Maximum 10%	Good

Table .8: Cone Slump Test Result

% Saw dust ash replaced	**Height of concrete (mm)**	**Slump of concrete (mm)**
0% SDA	225	60
5% SDA	235	65
10% SDA	240	70
15% SDA	240	60
20% SDA	245	55
25% SDA	250	50

Table 9a: Weight of cubes after 24hours

Period/% SDA	WEIGHT AFTER 24 HOURS MOULDING (KG)											
0% SDA	7.45	7.40	7.40	7.45	7.65	7.60	7.45	7.50	7.55	7.45	7.55	7.50
		7.42			7.57			7.5			7.5	
5% SDA	7.40	7.45	7.35	7.40	7.50	7.55	7.40	7.45	7.50	7.50	7.40	7.40
		7.40			7.48			7.45			7.43	
10% SDA	7.55	7.45	7.50	7.50	7.55	7.45	7.40	7.45	7.50	7.55	7.45	7.50
		7.50			7.50			7.45			7.50	
15% SDA	7.45	7.45	7.50	7.50	7.45	7.50	7.50	7.55	7.60	7.55	7.45	7.40
		7.47			7.48			7.55			7.47	
20% SDA	7.50	7.50	7.55	7.60	7.65	7.60	7.60	7.65	7.50	7.55	7.55	7.60
		7.52			7.62			7.58			7.57	
25% SDA	7.60	7.55	7.60	7.65	7.60	7.55	7.60	7.55	7.65	7.60	7.60	7.65
		7.58			7.60			7.60			7.62	

The cubes and cylinder of 150x150x150 where tested for strength at 7, 14, 21 and 28 days using a compressive machine of 2000kN capacity. The different crushing and splitting load where obtained as tabulated below.

Table 10a: Crushing load for cube (150x150 surface area) (kN)

Days /%SDA	0% Saw Dust Ash			5% Saw Dust Ash			10% Saw Dust Ash			15% Saw Dust Ash			20% Saw Dust Ash			25% Saw Dust Ash		
7 days	130	120	125	150	155	165	100	120	115	90	95	90	85	80	85	70	80	85
Mean	125			156.7			111.7			91.7			83.3			78.3		
14 days	135	130	135	160	165	170	125	120	125	95	105	110	90	95	100	80	95	95
Mean	133.3			165			123.3			103.3			95			90		
21 days	140	145	145	180	175	185	120	125	130	120	115	120	110	115	110	100	105	105
Mean	143.3			180			125			118.3			111.7			103.3		
28 days	155	160	170	190	190	195	135	140	145	125	125	130	120	125	120	115	110	115
Mean	161.2			191.7			140			126.7			121.7			113.3		

From the results obtained in the Table 1, the particle size distribution revealed the uniformity coefficient and fines modulus calculated. The Table 4, 5 and 6 the specific or unit weight of sand having an average of 2.24 and coarse aggregate 2.76 whereas that of sawdust is 0.65 this which is approximately 3.5 and 4 times lesser in weight compared to sand and stone used making it a great light aggregate to reduce the overall weight of the concrete while the test on the fresh concrete before setting the following was deduced for the concrete having its fine aggregate partially replaced.

From Table 8, the value gotten from the slump test matches the designed slump range of 25mm-100mm. The slump, which increases from the control sample with value of 60mm to 10% sawdust, ash replacement and then decreases to 60mm for 15% replacement and decreased more 50mm for 25% replacement, which was as a result of more fiber bond between the cement material and sawdust ash which was still workable but has high plasticity than that of the control showing that it serves as plasticizer and makes concrete for substructure work and repair possible. For the hardened concrete, the weight presented in Table 9 at the different densities is thus computed below after 24 hours of molding with cubes having surface volume of 150mmx150mmx150mm in accordance to BS1881:114 [29, 30, 31]. The percentage of the specific density is 2441.5kg/m^3.

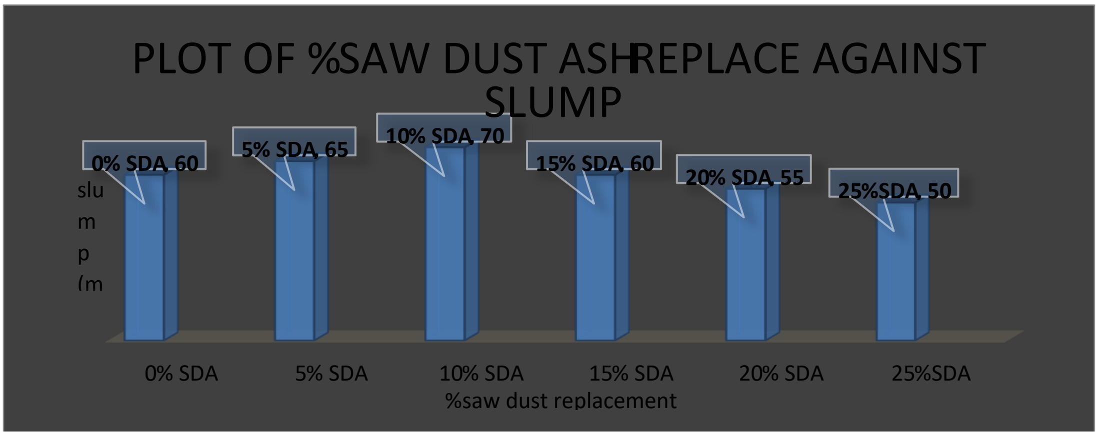

Figure 4: Results for slump test

Table 11: Density of concrete at different level of replacement

% SAW DUST ASH	DENSITY OF CONCRETE (Kg/M³)				AVERAGE
0%SDA	2207.4	2192.6	2222.2	2222.2	2211.1
5%SDA	2192.6	2216.2	2207.4	2201.5	2204.4
10%SDA	2222.2	2222.2	2207.4	2222.2	2218.5
15%SDA	2213.3	2216.3	2237	2213.3	2219.9
20%SDA	2228.1	2257.8	2245.9	2242.9	2243.7
25%SDA	2245.9	2251.9	2251.9	2257.8	2251.9

From the table and figure the effects of SDA replacements on the density of the herb stone at different curing periods are presented in Fig. 4. Findings indicate that the density of the SDA in carbs stones, largely dwindled with curing aging and the fall became insignificant after 28 days curing periods. At 7-days and 14-days curing, density increased with SDA substitution from 0 to 15%, but a further edition of SDA led to a decrease in density, with the lowest density observed in 25% SDA substitution. Results in 21 and 28-days curing are similar and showed a decreased in density from 0 to 5% SDA replacement. It increased from 20% to 25%, but further amount of SDA gave rise to a decrease in density.

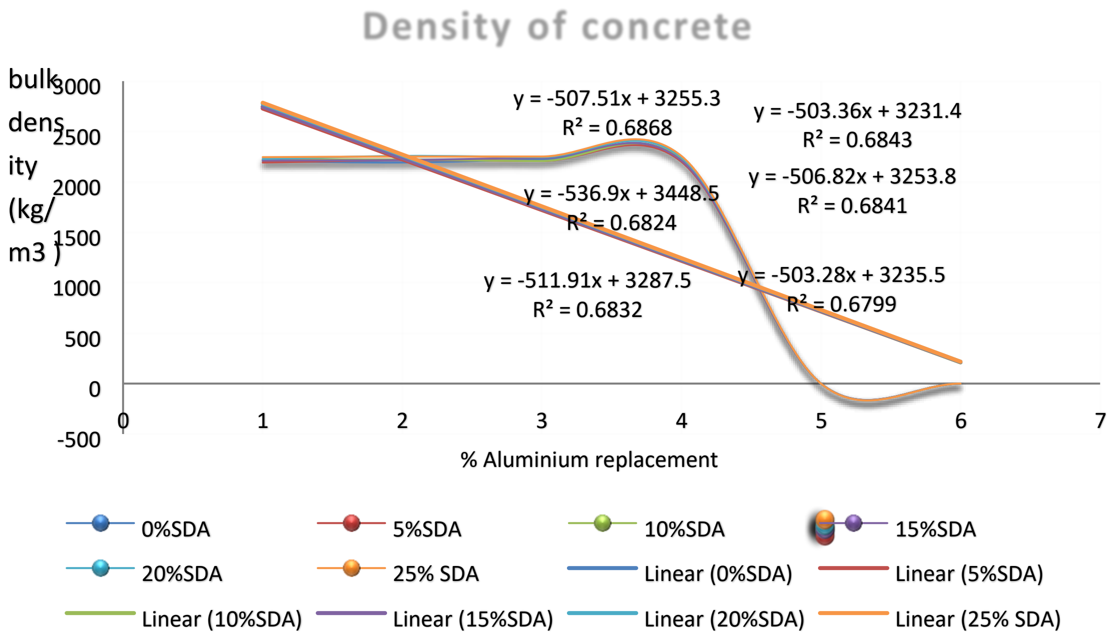

Figure 4: Density of Concrete in kg/m^3

Table 13: Water absorption of concrete after curing (%)

Date	0% Saw Dust Ash			5% Saw Dust Ash			10% Saw Dust Ash			15% Saw Dust Ash			20% Saw Dust Ash			25% Saw Dust Ash		
7day	0.05	0.05	0.05	0.1	0.05	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.25	0.25	0.25
mean	0.05			0.08			0.10			0.20			0.20			0.25		
14day	0.15	0.15	0.10	0.15	0.2	0.2	0.2	0.2	0.2	0.2	0.25	0.25	0.25	0.25	0.25	0.3	0.3	0.3
mean	0.13			0.18			0.20			0.23			0.25			0.30		
21day	0.2	0.2	0.2	0.2	0.25	0.25	0.25	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.35	0.35
mean	0.20			0.25			0.28			0.30			0.30			0.33		
28day	0.25	0.25	0.25	0.25	0.3	0.25	0.3	0.3	0.35	0.3	0.35	0.35	0.3	0.40	0.3	0.35	0.35	0.35
mean	0.25			0.27			0.32			0.33			0.33			0.35		

Figure 5 shows the effects of SDA replacements on the water absorption rate of the kerbs stone. It could be observed from the figure that the rate of absorption of water increased with increasing amount of saw dust ash, with the values ranging from 0.05% for the control specimen to 0.35% from 25% SDA substitution. This indicates that the affinity of the kerbs stone for water rise with an increasing quantity of the saw dust ash, which may be as a result of the increasing content of silica. This is also in agreement with previous findings that higher content of ash in concrete increased its affinity for water. The results further revealed that only the control experiment (specimen containing 100% OPC) and specimen with 5% SDA replacement satisfied the standard absorption rate used by the author in [32] which states that the water absorption rate for individual kerbs stone must not be greater than 5%.

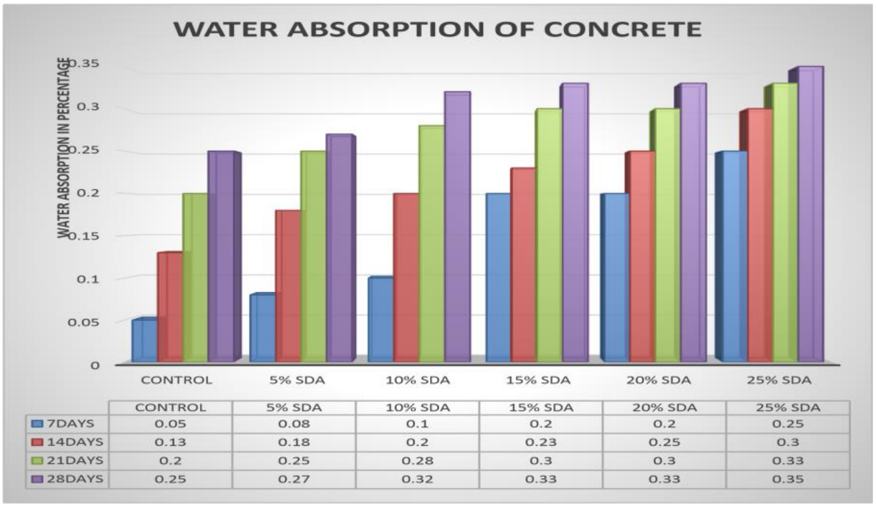

Figure 5: Results for water absorption of concrete for 7 -28 curing days

The Figure 5 shows maximum of 3.5 which is within the permissible rage of 1-4 for Fcu 25N/mm^2 concrete 4.2.3.3 Compressive Strength of Concrete after 7-, 14, 21, and 28 days curing. After the curing and the concrete crushed with the compression machine, the load tabulated in Table 10a thus the compressive strength calculated using the expression
$Fcu = \frac{\text{crushing load(N)}}{\text{surface area(mm}^2\text{)}}$ for the mean crushing load.

Table 14: Compressive strength of concrete cubes (150x150mm) in (N/mm^2)

Date	0% Saw Dust Ash	5% Saw Dust Ash	10% Saw Dust Ash	15% Saw Dust Ash	20% Saw Dust Ash	25% Saw Dust Ash
7DAYS	5.6	7.0	5.0	4.1	3.7	3.5
14DAYS	5.9	7.3	5.5	4.6	4.2	4
21DAYS	6.4	8	5.6	5.3	4.9	4.6
28DAYS	7.1	8.5	6.2	5.6	5.4	5

$$\text{Sample using 0\% at 7days Fcu} = \frac{125 \times 1000(\text{N})}{150 \times 150\text{mm}^2} = 5.6$$

The influence of SDA on the compressive strength of kerbs stone is presented in Figure 11a. The results from the figure indicated a general increase in compressive strength with both curing period and increasing amount of SDA and decrease from 10% of SDA to 25% SDA.
At 7 days curing, findings indicated a similar compressive strength between SDA kerbs stones and that of the control. The strength of the SDA kerb stones increased from 5.6 N/mm2 for the control to nearly 7.00 N/mm2 for 5% replacements, but the strength decreased with further replacements of SDA. The high compressive strength was observed for 5% replacement of cement with saw dust ash.
The results at 7 days of curing for all the SDA kerbs stones showed improved compressive strengths compared to that of the control. Highest strength was observed for 5% replacement while lowest strength was observed for 25% replacement. The results at 14 days of curing were similar to that of 7 days, but maximum strength was observed for 5% replacement. Findings indicate that concrete containing SDA gained strength slowly at the early curing period, which is in agreement with earlier findings.

At 28 days curing, the strengths of the SDA kerbs stone were significantly higher than that of the control. However, strength decreased with increasing amount of SDA, with highest and lowest values observed in 5% and 25% replacements respectively. The results at 28 days indicated a higher increase in strength when compared to those of 28 days curing. This increase in strength of SDA kerbs stone can be ascribed to the pozzolanic activity of SDA. These results clearly that indicate that the SDA had significant impacts on the strength of the corps stone, with its effective optimum performance observed at 5% replacement.

Table 16: Summary of the Engineering properties of saw dust ash Concrete

% Replacement	Compressive Strength (N/mm^2)	Density (kg/M^3)	Slump (mm)	Water Absorption
Control	7.1	2211.1	60	0.25
5% Saw Dust Ash	8.5	2204.4	65	0.27
10% Saw Dust Ash	6.2	2218.5	70	0.32
15% Saw Dust Ash	5.6	2219.9	60	0.33
20% Saw Dust Ash	5.4	2243.7	55	0.33
25% Saw Dust Ash	5	2251.9	50	0.35

Table 16, illustrates the samples meet the minimum and maximum requirement for normal and light weight concrete. The results up to 5% sawdust ash replacement has little or no different at the 0 % level of significance. Therefore, from the table the 5% saw dust ash replacement is being recommended as it meet both strength, moderate density and had the highest workability in terms of slump.

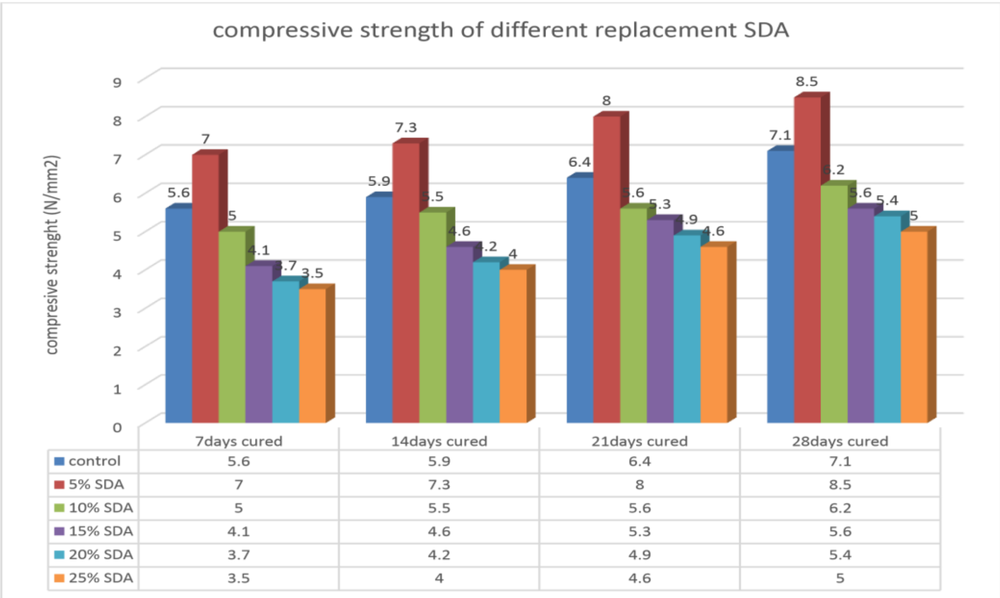

Figure 6: Compressive strength of concrete at 7-28 days curing (N/mm^2)

4.0. Conclusion and Recommendations

From the findings of various experimental tests conducted on the SDA kerbs stones, the following conclusions were drawn:

(i) The strength of the concrete improved significantly as curing ages, the mechanical property of the of the material used in the concrete kerbs production decreased as the SDA replacement percentage increases, indicating a pozzolanic reaction found in the SDA. Only 5% saw dust ash replacement is adequate to achieve maximum strength (8.5) gain thereby recommended for concrete kerbs production.

(ii) The density of the concrete kerbs increased as the SDA replacement and curing periods increased. Only the 5% replacement is lighter than the control mix and thereby recommended for use as it's regarded light-weight concrete which is economical in production of the kerbs.

(iii) The rate of water absorption of the SDA kerbs which increases with an increase in the amount of saw dust ash. Kerbs stones made with 5% SDA replacement is therefore recommended for use in the building, especially in residential driveway and walkways.

Reference

[1] Mohan, D., Tiwari, G. (2021) "Transport and Safety Systems, Approaches, and Implementation" Springer.com/book/10.1007/978-981-16-1115-5

[2] Cho, N., El Asmar, M., Underwood, S. (2020) "Long-Term Performance Benefits of the Design-Build Delivery Method Applied to Road Pavement Projects in the U.S" KSCE J Civ Eng, Volume 24, pp. 1049–1059. DOI: https://doi.org/10.1007/s12205-020-1814-3

[3] Jóźwiak-Niedźwiedzka, D. (2001): Influence of Concrete Composition on Damages of Concrete's Surfaces Due to Cyclic Freezing and Thawing (Wpływ Składu Betonu Na Uszkodzenia Powierzchni Betonowych Spowodowane Cyklicznym Zamrażaniem I Odmrażaniem), Second Scientific Conference of Civil Engineering Faculties Doctoral Students, Wisla, Poland volume 1.

[4] Wawrzeńczyk, J., Molendowska, A., Kłak, A. (2016) "Effect of Ground Granulated Blast Furnace Slag and Polymer Microspheres on Impermeability and Freeze-thaw Resistance of Concrete" Procedia Engineering, Volume 161, pp. 79-84. DOI: 10.1016/J.PROENG.2016.08.501

[5] Momotaz, H., Rahman, M. M., Karim, M., Iqbal, A., Zhuge, Y., Ma, X., Levett, P. (2022) "A Review of Current Design and Construction Practice for Road Kerbs and a Sustainability Analysis" Sustainability, Volume 14, Issue 1230. DOI: 10.3390/su14031230.

[6] Yang, K. H., Chung, H. S., Ashour, A. F. (2008) "Influence of Type and Replacement Level of Recycled Aggregates on Concrete Properties" ACI Materials Journal, Volume 105, Issue 3, pp. 289–296.

[7] Uygunoğlu, T., Topcub, I. B., Genecel, O., Brostow, W. (2012) "The Effect of Fly Ash Content and Types of Aggregates on the Properties of Pre-Fabricated Concrete Interlocking Blocks (PCIBs)", Constr. Build. Mater, Volume 30, pp. 180-187.

[8] Su, H., Yang, J., Ling, T., Ghataora, G. S., Dirar, S. (2015) "Properties of Concrete Prepared With Waste Tyre Rubber Particles of Uniform and Varying Sizes" Journal of Cleaner Production, Volume 91, pp. 288-296. DOI: doi.org/10.1016/j.jclepro.2014.12.022

[9] Sampson, A., Stephen, A., Kwadwo, A., Humphrey, D, (2022) "Utilization of Sawdust Ash as Cement Replacement for Landcrete Interlocking Blocks Production and Mortarless Construction, Case Studies in Construction Materials, Volume 16. DOI: https://doi.org/10.1016/j.cscm.2022.e00945.

[10] Marinković, S., Radonjanin, V., Malešev, M., Ignjatović, I. (2010) "Comparative Environmental Assessment of Natural and Recycled Aggregate Concrete" Waste Management, Volume 30, Issue 11, pp. 2255-2264. DOI: https://doi.org/10.1016/j.wasman.2010.04.012

[11] Bakar, B. H. A., Putrajaya, R. C., Abdulaziz, H. (2010) "Malaysian Saw Dust Ash-Improving the Durability and Corrosion Resistance of Concrete" Pre-review. Concrete Research Letters, Volume 1, Issue 1, pp. 6-13.

[12] James, J., Padian, P. K. (2016) "Industrial Wastes as Auxiliary Additives to Cement/Lime Stabilization of Soils" Advances in Civil Engineering, Volume 2016, DOI: https://doi.org/10.1155/2016/1267391

[13] Joglekar, S. N., Kharkar, R. A., Mandavgane, S. A. (2019) "Process Development of Silica Extraction from RHA: A Cradle to Gate Environmental Impact Approach" Environ Sci Pollut Res, Volume 26, pp. 492–500. DOI: https://doi.org/10.1007/s11356-018-3648-9

[14] Chindaprasirt, P. and Cao, T. (2015) "The Properties and Durability of High-Pozzolanic Industrial By-Products Content Concrete Masonry Blocks, Eco-Efficient Masonry Bricks and Blocks" Woodhead Publishing, pp. 191-214. DOI: https://doi.org/10.1016/B978-1-78242-305-8.00008-5.

[15] Adebakin I. H., Adeyemi A. A., Adu J. T., Ajayi F. A., Lawal A. A., Ogunrinola O. B., (2012) "Uses Of Sawdust as Admixture in Production of Lowcost and Light-Weight Hollow Sandcrete Blocks" Am. J. Sci. Ind. Res., Volume 3, Issue 6, pp. 458-463. DOI: 10.5251/ajsir.2012.3.6.458.463.

[16] Cheah, C. and Ramli, M. (2011) "The Implementation of Wood Waste Ash as a Partial Cement Replacement Material in the Production of Structural Grade Concrete and Mortar: An overview" Resources Conservation and Recycling-Resour Conserv Recycl, Volume 55, pp. 669-685. DOI: 10.1016/j.resconrec.2011.02.002.

[17] Etru, L. C., Osadebe, N. N., Mbajiorgu, M. S. W. (2013) "Suitability of Nigeria Agricultural By-Products as Cement Replacement for Concrete Making" International Journal of Modern Engineering Research (IJMER), Volume 3, Issue 2, pp. 1180-1185.

[18] Elinwa, A. U. and Ejeh, S. P. (2004) "Effects of the Incorporation of Saw Dust Waste Incineration Fly-Ash in Cement Pastes and Mortars" Journal of Asian Architecture and Building Engineering, Volume 3, Issue 1, pp. 1-7.
[19] Elinwa A. U., Ejeh, S. P., Mamuda, A. M. (2008) "Assessing of the Fresh Concrete Properties of Self-Compacting Concrete Containing Sawdust Ash" Construction and Building Materials, Volume 22, Issue 6, pp. 1178-1182. DOI: https://doi.org/10.1016/j.conbuildmat.2007.02.004
[20] Elinwa, A. U., Mahmood, Y. A. (2002) "Ash from timber waste as cement replacement material" Cement and Composites, Volume 24, Issue 2, pp. 219-222. DOI: 10.1016/S0958-9465(01)00039-7
[21] Neville, A. M., 2008 "Properties of Concrete", ELBS Edition of Fourth Edition, Addison Lesley Longman Limited, Edinburgh Harlow Essex CM20 2JE, England.
[22] Okoloekwe, R. C., 2010 "Concrete Technology, Principle and Practice", Scann Publisher, Nigeria.
[23] Yusel, E. (2010) "The Effect of Cure Condition and Temperature Changes on the Compressive Strength of normal Concrete and Fly-ash added Concrete" International Journal of Physical Science, Volume 5, Issue 17, pp. 2598-2604.
[24] Chandra. S, and Berntsson. L. (2004) "Lightweight Aggregate Concrete Standards" Publishers Distributiors, Delhi.
[25] British Standard Institute (1983) "BS 812: Part 103, Testing Aggregate, Method of Determination of Particle Size Distribution", BSI London.
[26] British Standard Institute (2000) "BS EN 206-1, Concrete- Specification, Performance, Production and Conformity" BSI London.
[27] British Standard Institute (2000) "BS EN 197-1, Composition specification and Conformity criteria for common cement" BSI London.
[28] British Standard Institute (1990): BS 812 Part 109, "Methods for Determination of Moisture Content" BIS London.
[29] British Standard Institute (1983) "BS 1881 Part 114, Method for Determination of Density of Hardened Concrete" BIS London.
[30] British Standard Institute (2000) "BS EN 12390-1, Testing of Hardened Concrete, Shape, Dimension and other requirements for Specimens and Moulds" BSI London.
[31] British Standard Institute (2000) "BS EN 12390-3, Testing of Hardened Concrete, Compressive Strength of Test Specimen" BSI London.
[32] Onyeka, F. C. (2019) "Effect of Partial Replacement of Coarse Aggregate by Crushed Broken Glass on Properties of Concrete" International Journal of Civil Engineering and Technology, Volume 10, Issue 10, pp. 356-367.