POTENTIALS OF SAWDUST AND PALM KERNEL SHELL AS PERFECT SUBSTITUTES FOR SAND AND GRANITE IN CONCRETE

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ABSTRACT

This research investigated the effect of replacing sand with sawdust in palmkernel shell concrete. Sawdust is a waste produced during the processing of timber. The unsustainable disposal method of sawdust aids global warming and its adjoining effects are inimical to healthy living and detrimental to our environment. The objectives of the research include: to examine the workability level of palm kernel shell sawdust concrete, to measure and compare the Compressive, Splitting tensile and Flexural strength of sawdust palm kernel shell concrete with normal weight concrete, to determine the water absorption of sawdust palm kernel shell concrete at different level of sand replacement. Sand was replaced with Sawdust in percentages of 10%, 25%, 50%, 75%, and 100% and Palm kernel shell was used instead of granite at ratio 1:2:4. The materials were batched in volume due to the relative density of sawdust, the specimen were produced and cured using membrane curing method. The specimens were tested at 7, 14and 28 days and the results were presented in tables and figures. The results show that the workability of Sawdust palmkernel shell concrete decreases as the volume of sawdust increases, the compressive and tensile strength also decreases as the volume sawdust increases and water absorption of Sawdust palmkernel shell concrete increases as the volume of sawdust increases. The study recommends the usage of sawdust and palm-kernel shell as good and cost-effective replacement for sand and granite in concreting works for building with nonstructural requirements, especially at 10% to 25 % sawdust to sand replacement.

KEYWORDS: ***Sustainable Building Material, Compressive Strength, Tensile Strength, Replacement***

1.0 INTRODUCTION

Concrete is a structural material consisting of aggregates (usually sand and gravel), that is bonded together by cement in a reaction aided by water. Its composition has greatly been used across the world for over hundreds of years ago, because of its strength and durability (Bederina et al., 2012, but in the recent times, structures requires a less dense material which would still maintain the same characteristics as concrete and will also be easily accessible. (Adebakin et al, 2012). One way of producing a less dense concrete is by making light weight Concrete with compatible waste materials. This will add value to the waste materials and also reduce the cost of the Concrete. (Rominiyi et al., 2017). Lightweight concrete has been in use recently because of its density and capability to reduce the dead load of structures. Many researches has been done and still ongoing on the use of waste materials to replace the constituents of concrete. Such waste materials include Sawdust, Palm Kernel Shell, Plastics, Mine waste, Garbage frit etc. (Ekhuemelo and Atondo 2015).

Hence is a need in construction for massive use of lightweight materials in wherever applicable to reduce the dead loads of building which imposes great stress on the foundation of the building causing a situation that can lead to collapse of building. The use of lightweight Concrete can also reduce fatality during building collapse (Jian 2014). The cost of construction nowadays is quite expensive and unaffordable by average working class citizens of many countries and the high cost of building materials is a dominant factor hence the emergence of suitable and affordable materials to replace concrete in building will be a great deal in the provision of affordable housing. Therefore, this research assessed the properties of Concrete containing Sawdust and Palmkernel shell as replacement for sand and stone respectively with a view to evaluate the use of Sawdust Palmkernel Shell Concrete as a sustainable building material

2.0 LITERATURE REVIEW

The density of palm kernel shell lightweight concrete is approximately 80% of normal weight concrete. The density of structural LWC typically ranges between 1440 and 1850 kg/m3. Whereas these values vary between 2240 and 2400 kg/m3 for normal weight concrete (Ekhuemelo and Atondo 2015). The volume of wood waste increases day by day due to the wide range of purposeful use of woods to meet growing demand for wood products. Nigeria has not fully exploited the potentials for recycling waste materials, especially Sawdust. Sawdust heaps are considered waste and therefore are uncontrollably incinerated, making a significant contribution to the greenhouse gas emissions (Rominiyi et al, 2017). Palm Kernel Shell is a bye product from the production of Palm oil and it is also readily available in most oil producing states in Nigeria. Although few Companies use it as fuel but its usage has not been fully explored. This research focuses on the use of Sawdust and Palm Kernel Shell to produce Lightweight Concrete.

Also, wood wastes in the form of wood shavings can be incorporated into Sandcrete without any preliminary treatment. The results have demonstrated that the inclusion of shavings in sandcrete, not only reduces the density of the material but also improves its thermal conductivity, while the structure of the material remains homogeneous and with strong adherence of the wood to the concrete matrix (Sales et al., 2011). Sawdust has been used in concrete, but not widely. Although seriously limited by its low compressive strength. It has serious limitations that must be understood before it is subjected to use. Within these limitations, Sawdust concrete offers considerable reduction in weight of the structure, thereby reducing the dead loads transmitted to the foundation, high economy when compared to normal weight concrete, reduce damage and prolonged life of formwork due to lower pressure being exerted, easier handling as compared with other types of concrete, improved sound absorbent properties due to its high void ratio (Bdeir, 2012), improved thermal insulation up to 35%. (Taoukil et al., 2011).

The use of sawdust for making lightweight concrete has received some attention over the past years. Although studies on structural properties of sawdust concrete have shown encouraging results (Antwi-

Boasikol., et al. 2018). Globally, there is a resurgence of interest in this era of information revolution and environmental awareness. However, modern applications are being discovered and several are based on wood's unique physical and mechanical properties like strength (Ganiron, 2014). The volume of sawdust from sawmills continues to increase due to a rise in lumber production to meet growing demand for wood products. And this waste material does not have a means of recycling yet but rather burnt which imposes a great hazard on our society by making a greenhouse gas emission. So if sawdust can be used in concrete it will reduce the pollution and depletion of the ozone layer caused by the burning of these materials and creates economic advantages. (Ganiron., 2014 and Turgut and Algin, 2007).

3.0 MATERIALS AND METHODS

Run off sand sourced from ilaro in Ogun State Nigeria was used for this project. The Sand is sieved so as to remove debris and some other impurities so as to conform to ASTM C 33. Sawdust used is sourced from sawmill at ilaro, and it was Sun dried to ensure that it did not have water retained in it apart from the water used in casting and sieved to remove unwanted particles so as to conform to ASTM C 33. Palmkernel shell used is sourced from ilaro in Ogun State, Nigeria. The palmkernel shell was treated and Sun dried to remove oil content from the shell which might cause improper bonding with other components and to conform to ASTM C 33. Dangote portland cement was used as binder for the casting, conforming to ASTM C150M-21. Clean, drinkable, Portable water; free from impurities was used for casting so as to conform with ASTM 1602M-06.

Cubical shaped Mold of 100×100mm in size was used to produce specimen for compressive strength test and water absorption test, Prismatic shaped Mold of 100×100×500mm in size was used to produce specimen for flexural strength test, Cylindrical shaped Mold of 100×200mm in size was used for splitting tensile test. The constituents of the concrete was mixed using nominal mix ratio of 1:2:4 to achieve concrete grade of M15, with palmkernel shell totally replacing coarse aggregate, and sand being replaced with sawdust in percentages of 10%,25%,50%,75%,100%. Water used for the mix was increasing as the volume of sawdust increases so as to aid workability of the concrete and to prevent the concrete from flash setting. Batching of materials was done in volume using measuring cylinder to conform to ASTM C 685. Mixing was done using a mobile mixer, concrete was manually placed into the molds and it was compacted manually using tamper rod to cause vibration in the concrete so as to remove air void. Membrane curing was used to prevent water loss.

Table 3.1: Numbers of Specimen used

S/N	TEST	SPECIMEN
1	Compressive Strength	54
2	Flexural strength test	36
3	Water absorption test	18
4	Splitting tensile test	54
	Total	**162**

Source: Researcher's Laboratory Results, 2022.

Total number of seventy two (72) Cubes, Thirty six (36) Prisms and fifty four (54) cylinders was used for the study.

3 .1 Laboratory Testing

The tests conducted for this research include

i. Slump Test
ii. Compressive Strength Test
iii. Flexural Strength Test
iv. Splitting Tensile Test
v. Water Absorption Test

4.0 RESULTS, ANALYSIS AND DISCUSSIONS

Table 4.1: Specimens Name

Specimen	Name
0%	SPKC 1
10%	SPKC 2
25%	SPKC 3
50%	SPKC 4
75%	SPKC 5
100%	SPKC 6

Source: Researcher's Laboratory Results, 2022.

4.1 SLUMP TEST

The result of slump test for this research is stated in table 3.

Table 4.2: Slump Test Result

Mix	Value(mm)
SPKC 1	11
SPKC 2	4
SPKC 3	2.5
SPKC 4	1
SPKC 5	0
SPKC 6	0

Source: Researcher's Laboratory Results, 2022.

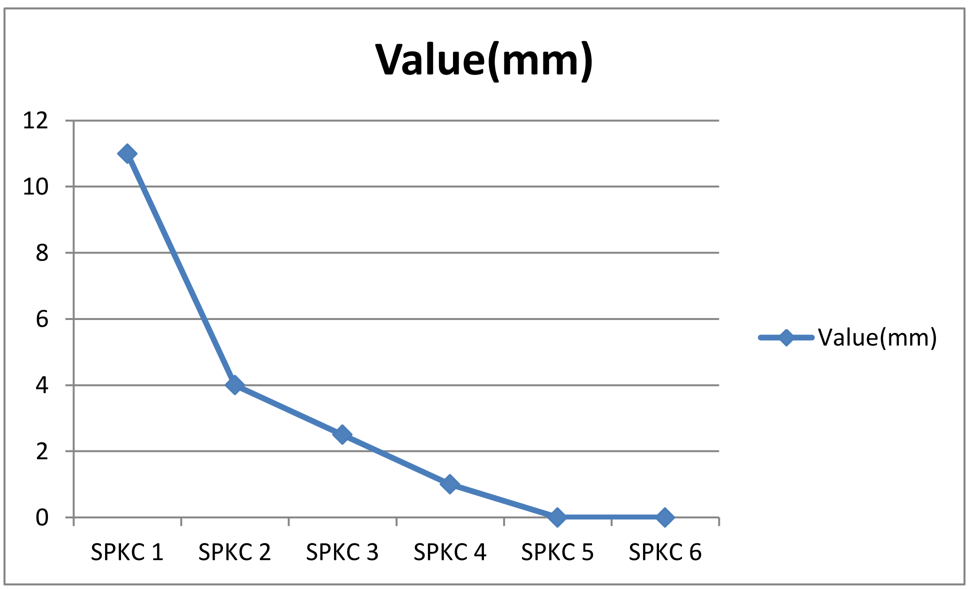

Fig. 4.1: Slump Test Result [Researcher's Laboratory Results, 2022]

In Fig. 4.1, SPKC 1 which is the control with no sawdust content has the highest slump value (11mm) compared with others. The result above shows that as the volume of sawdust increases the Workability of the sawdust palmkernel shell concrete decreases and there will be need for additional water input to make it workable as the volume of sawdust increases.

4.2 COMPRESSIVE STRENGTH TEST

Table 4.3: Compressive Strength Test Result

Mix	7days (Mpa)	14days(Mpa)	28days(Mpa)
SPKC 1	4.28	6.5195	9.314
SPKC 2	1.54	2.34	3.34
SPKC 3	1.08	1.647	2.353
SPKC 4	0.69	1.050	1.500
SPKC 5	0.60	0.915	1.307
SPKC 6	0.55	0.839	1.199

Source: Researcher's Laboratory Results, 2022.

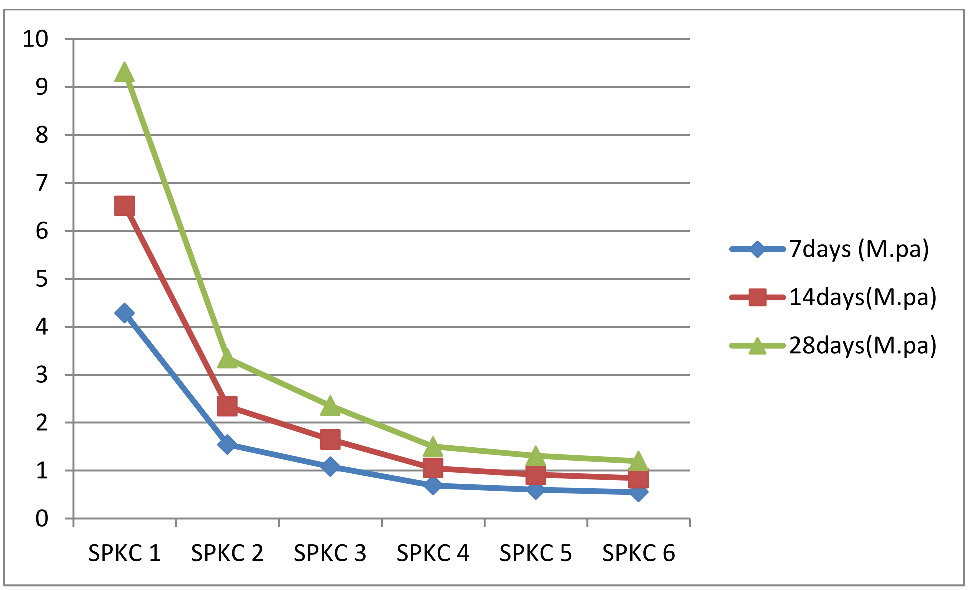

Fig. 4.2 Compressive Strength Test Result [Researcher's Laboratory Results, 2022]

Fig. 4.2 shows the result for test day 7; only the control was able to surpass 2.5 Mpa which is the benchmark for lightweight concrete, for test day 14 despite that the control still has the highest performance, SPKC 2 and SPKC 3 increased in strength significantly with 2.34 Mpa and 1.65 Mpa respectively. For test day 28, the control still maintains the highest performance of 9.3Mpa while SPKC 2 and SPKC 3 has 3.34Mpa and 2.35Mpa respectively. The compressive strength decreases as the percentage of sawdust increases but it increases as the day increases. Mix 2 performs above 2.5Mpa and Mix 3 is also closer to the benchmark (2.5 Mpa) at 28 days. This indicates that mix 2 and mix 3 are suitable for lightweight concrete.

4.3 FLEXURAL STRENGTH TEST

Table 4.4: Flexural Strength Test Result

Mix	7days(Mpa)	14days(Mpa)	28days(Mpa)
SPKC 1	1.63	2.01	2.41
SPKC 2	0.98	1.21	1.44
SPKC 3	0.82	1.01	1.21
SPKC 4	0.66	0.81	0.97
SPKC 5	0.61	0.75	0.9
SPKC 6	0.59	0.72	0.86

Source: Researcher's Laboratory Results, 2022.

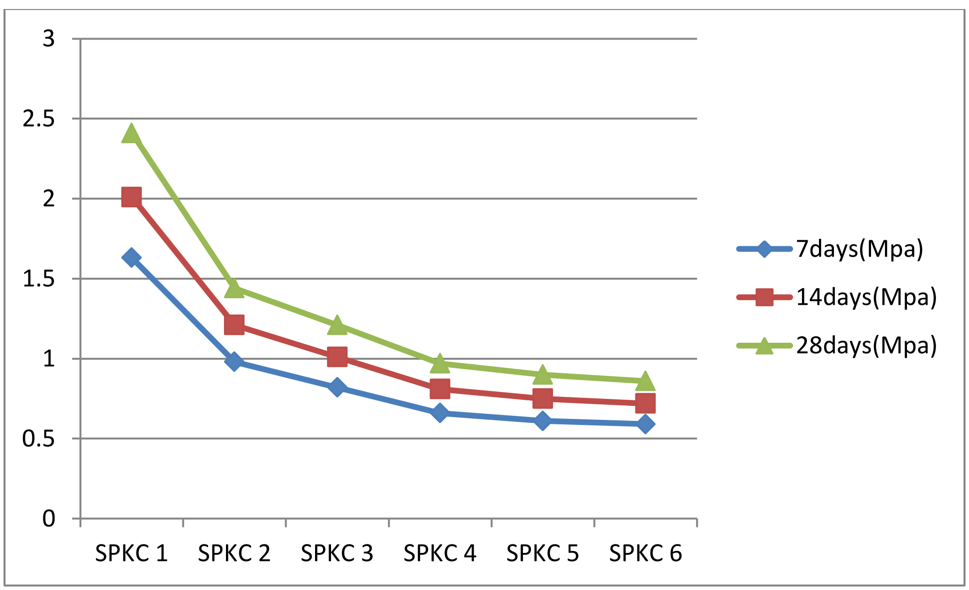

Fig. 4.3 Flexural strength Test Result [Researcher's Laboratory Results, 2022]

Fig. 4.3 shows the result for flexural strength. For test day 7, the control has 1.63 Mpa while others have 0.59 – 0.98 Mpa respective , for test day 14 despite that the control still has the highest performance, other mixes also increased in strength with the range 0.75 – 1.21 Mpa respectively. For test day 28, the control still maintains the highest performance of 2.41 Mpa while SPKC 2 and SPKC 3 has 1.44Mpa and 1.21Mpa respectively. It can be deduced that sawdust palmkernel shell concrete is not suitable for beam or slab because the result shows that it can not resist bending failures. As observed from Fig. 3, the more the volume of sawdust the lesser the flexural strength of the concrete becomes but it gains flexural strength as the days increase.

4.4 SPLITTING TENSILE TEST

Table 4.5: Splitting Tensile Test Result

Mix	7days(Mpa)	14days(Mpa)	28days(Mpa)
SPKC 1	1.15	1.31	1.70
SPKC 2	0.69	0.81	1.02
SPKC 3	0.58	0.68	0.85
SPKC 4	0.46	0.56	0.68
SPKC 5	0.43	0.52	0.64
SPKC 6	0.42	0.50	0.61

Source: Researcher's Laboratory Results, 2022.

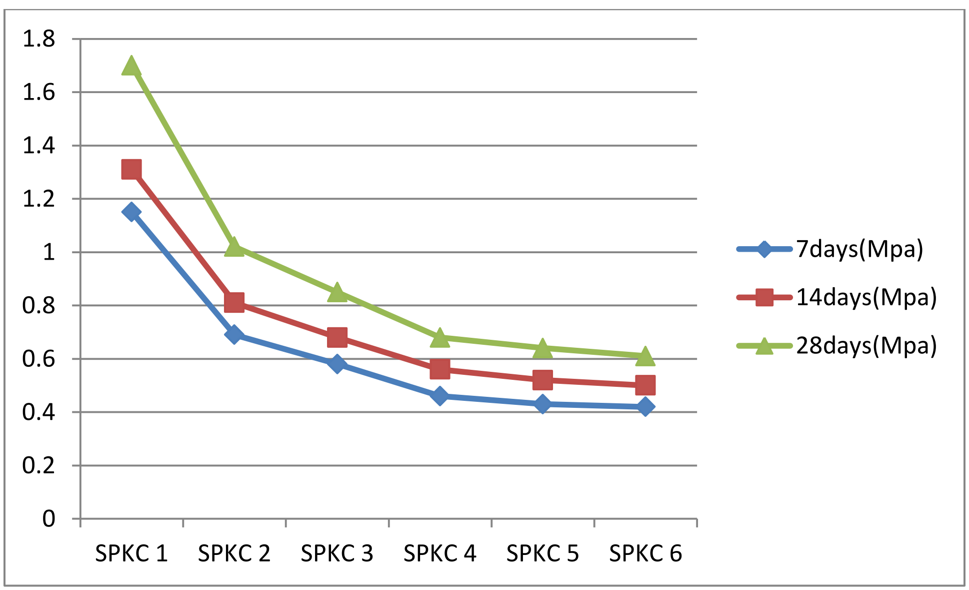

Fig. 4.4 Splitting Tensile Test Result [Researcher's Laboratory Results, 2022]

Fig. 4.4 presents the result for the Splitting Tensile test of the specimen. For 7 days test the control has the higest performance 1.15 Mpa, while the others has 0.42 – 0.69 Mpa, for test day 14, the control has 1.31 Mpa while others has 0.50 – 0.81 Mpa. For Test day 28, the control has 1.70 Mpa, while others has 0.61 – 1.02 Mpa. The result shows that the strength decreases as the volume of sawdust increases just as in the previous strength tests and it gains strength as day passes. This shows that Sawdust palmkernel shell concrete is only suitable for non-structural works.

4.5 WATER ABSORPTION TEST

Table 4.6: Water Absorption Test Result

Mix	Before immersion (B)	After immersion (A)	Water absorption= (A-B)/B × 100%
SPKC 1	1.75	1.85	5.7%
SPKC 2	1.4	1.60	14.3%
SPKC 3	1.4	1.60	14.3%
SPKC 4	1.2	1.40	16.7%
SPKC 5	1.10	1.3	18.2%
SPKC 6	1.0	1.2	20%

Source: Researcher's Laboratory Results, 2022.

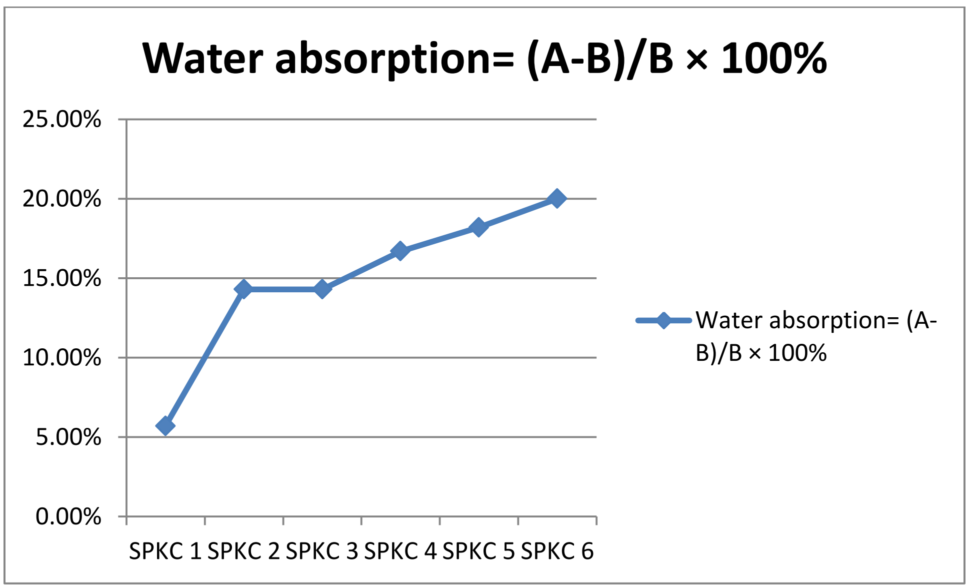

Fig. 4.5 Water Absorption Test Result [Researcher's Laboratory Results, 2022]

Fig. 4.5 shows the result of water absorption test for all specimens on the 28 days test. The result shows that the control has 5.7% while SPKC 2 , SPKC 3, SPKC 4, SPKC 5 and SPKC 6 has 14.3%, 14.3%, 16.7%, 18.2% and 20% respectively. It shows that, as the volume of sawdust increases the rate of water absorption of the specimen increases which denotes that the concrete will be less durable in water compared to normal concrete.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The following conclusions were drawn from the study on the performance of sawdust palm-kernel shell concrete:

i. As the volume of sawdust increases the Workability of the sawdust palmkernel shell concrete decreases hence more water is needed to make the concrete matrix workable and this might pose a negative effect on its strength.
ii. The compressive strength decreases as the percentage of sawdust increases but it increases as the day increases.
iii. The compressive strength of sawdust palmkernel shell concrete containing 10% and 25% sand replacement is closer to 2.5 Mpa which is the benchmark requirement according ASTM.
iv. As the volume of sawdust increases the flexural strength of the concrete decreases but it gains flexural strength as the days increases. Sawdust palmkernel shell concrete is not suitable for beam or slab because the result shows that it cannot resist bending failures.
v. Sawdust palmkernel shell concrete is only suitable for non-structural works.
vi. As the volume of sawdust increases the water absorption rate of the concrete increases which denotes that the concrete will be less durable compared to normal concrete in the presence of water.

5.2 RECOMMENDATION

Based on the above conclusions the following recommendations are made:

i. Usage of Sawdust palmkernel shell concrete at 10 to 25% sand replacement should be encouraged for the production of walling materials like Blocks
ii. Sawdust palmkernel shell can also be used to produce nonstructural members of building especially redundant members
iii. The use of Sawdust palmkernel shell concrete in building will create economic importance for sawdust and palm kernel shell which are usually used as fuel or burnt, a scenario that poses threat to healthy living.
iv. Sawdust palmkernel shell concrete should be used in building only above the Damp prove course.

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