



Palm Kernel Shell Ash as a Partial Replacement for Cement in the Production of Paving Blocks

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ABSTRACT

Palm kernel shell is known for its similar mineral element with cement and little binding ability in ash form. This research presents a report on the study of the material properties of paving block by inclusion of Palm Kernel Shell Ash (PKSA) as partial replacement for cement, to know the optimum replacement without falling below minimum breaking strength to which Paving blocks can still be produced. In achieving this, a mix of 1:1.5:3 with a 0.5 w/c was used throughout the production with PKSA replacing cement for 0%, 5%, 10%, 15%, 20%, and 25% for 7 days, 14 days, 21 days, and 28 days considered in the test for compressive, and tensile strength and 7 days, 21 days, and 28 days for flexural strength for all percentages. The findings revealed that 10% cement replacement yielded an optimum strength increase of 6%, 9%, 6% and 5% for compressive strength; 5%, 8%, 13% and 3% for split tensile strength for the curing days respectively. In addition, 4% increase in flexural strength for 7 days curing with no significant increase for 21 and 28 days curing. On the overall, the research revealed that PKSA inclusion as partial replacement for cement as binder in paving block making resulted in cost reduction of about 3.3% savings

1.0 Introduction

Paving blocks are precast concrete elements. They are of different sizes and shapes. Paving blocks are of different shapes such as: square, hexagon and multiple hexagons. They are good-looking and colourful when placed. Concrete paving blocks have been in use in Europe for a long time but were introduced in Central

and South America and in South Africa in the mid 1960's. It was publicized in Britain, Canada, USA,

Australia, New Zealand and Japan in 1970's. Recently, concrete paving blocks has been introduced in the Asia and Middle- East. Concrete paving blocks are used in foot paths, car parking lots, gardens, passenger waiting sheds and other public places. (Shackel, 2003).

In Nigeria today, developers are using paving blocks and it has been observed that the use is increasing each day. The use of concrete paving block is common in some residential areas in Nigeria. According to Beaty and Raymond (1995), the use of paving blocks has a lot of advantages such as: easy to maintain and repair, easy to access underground utilities, cost of maintenance is cheap, and also has shapes and colours that are useful and good-looking. Because of these qualities, paving blocks have attracted the attention of developers all over the world.

Ordinary Portland cement (OPC) is known to be the most common material used as binder in the production of concrete elements all over the world. This cement has a lot of problems associated with it. The economic and environmental problems associated with the production and use of cement cannot be neglected. The production process of Portland cement creates a lot of environmental issues especially carbon dioxide emissions. The emission is roughly one ton of Carbon dioxide for each ton of cement produced (Malhotra, 2000). Therefore, the amount of Portland

cement used if reduced by the used of Agro waste materials like palm karnel shell ash; the carbon dioxide emissions will be significantly reduced.

However, reduction of Agro waste has become more complex and costly. Currently, Agro waste are attracting a great deal of attention as materials that can replace cement in concrete production without affecting the properties of concrete and also decreasing carbon dioxide emissions generated during the production of cement. This study aims to explore the possibility to produce paving blocks using Palm Kernel Shell Ash as a partial replacement, and this will bring about a reduction in the percentage of cement being used in paving block production.

1.1. Background

PKSA are by-product of palm kernel shells after undergoing the combustion process, while the shells are wastes of the palm fruit. Mechanically the shells are strong. It is dark-brown in colour with some strand-like look. When heated, it is a fuel. PKSA is cheap and availability in Nigeria and other parts of the world. The use of PKSA is an advantage as engineers and scientist are trying to control waste production in the environment by converting waste materials to something useful.

According to Mehta (1987), PKSA has some pozzolanic properties like fly ash having its main chemical constituents as CaO, SiO₂, Al₂O₃, and Fe₂O₃. Pozzolans are a broad class of siliceous or siliceous and aluminous materials which in themselves possess little or no cementitious value but will in finely divided form and in the presence of water react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. Just like other ashes, PKSA cannot be hundred percent hazards free but very less comparing to Portland cement.

2.0. Materials and Methods

2.1. Materials

2.1.1 Palm Kernel shell Ash

The palm kernel shells used was obtained from a commercial palm fruit dealer in Ue-Gwerre, Bo-ue, Khana Local Government Area of Rivers State. The shells were sun dried for 48 hours to remove moisture and burnt using a drum (with the shells inside) and with a shovel for turning; furthermore, the burnt Palm

kernel shells noticeable in size were further crushed to dust particles using Los-Angeles Abrasion Machine and later sieved through a sieve 75micron. The physical properties and chemical analysis are shown in tables 1 and 2 respectively.

Chemical Properties of PKSA		
S/N	Parameter	Percentage
1	Magnesium (Mg)	5.54%
2	Calcium (Ca)	14.99%
3	Silica	50.85%
4	Others	28.62%

Table 1

Physical Properties of PKSA		
S/N	Physical Property	Test Result
1	Standard Consistency	32.00%
2	Fineness	11.00%
3	Specific Gravity	0.93
4	Initial Setting time	30mins

Table 2

2.1.2 Cement

The cement used in this study was Portland cement of grade 32.5 produced by Dangote cement. The physical properties of cement are presented in tables 3 below.

Physical Properties of Cement		
S/N	Physical Property	Test Result
1	Standard Consistency	30.00%
2	Fineness	5.00%
3	Specific Gravity	3.2
4	Initial Setting time	28mins

Table 3

2.1.3 Aggregates

Dry and clean natural river sand as fine aggregates (FA) and gavels as coarse aggregates (CA) obtained from a dealer in mile 3 building material market were used in concrete mixture. Table 4 and 5 respectively shows some of their properties.

Fine Aggregates		
S/N	Physical Property	Test Result
1	Specific Gravity	2.44
2	Fineness Modulus	4.5

Table 4

Coarse Aggregates		
S/N	Physical Property	Test Result
1	Specific Gravity	2.58
2	Fineness Modulus	5.4
3	Water Absorption	0.90%

Table 5

2.1.4 Methods

In this research the objective was to find out the best way to achieve good and consistent tests result for paving blocks made in the laboratory with the replacement of OPC with PKSA. The Palm Kernel Shell Ash (PKSA) with the required fineness was collected for use. The mix design ratio of 1:1.5:3 with water binder ratio of 0.55 was adopted in this research after a trial mix of different water binder ratio ranging from 0.45 to 0.60 was used. Twelve cubes were casted for each percentage replacement making a total of seventy two concrete cubes of size 150x150x150mm using varying OPC:PKSA ratios of 100:0 , 95:5, 90:10 , 85:15 , 80:20 , 75:25 respectively. The cubes were cured and crushed after 7, 14, 21 and 28 days respectively to determine the compressive strength. Tensile strength test was carried out in line with the provisions in BS 1881 Part 4 using concrete cylinders. A total of four cylindrical molds per percentage replacement of cement with diameter of 101.6 mm and height 203.6 mm were prepared, oiled and freshly mixed concrete poured in it for production. And for the flexural strength test, a double point load was applied on a beam while testing. A total of three beam moulds per percentage replacement of cement, each with a size of 500mm × 100mm × 100mm were prepared, oiled and freshly mixed concrete poured in it for production. Simultaneously, one beam is crushed after every 7 days interval of curing down to

28 days excluding the 14th day of curing (a total of 18 beams produced).

3.0 Results and Discussion

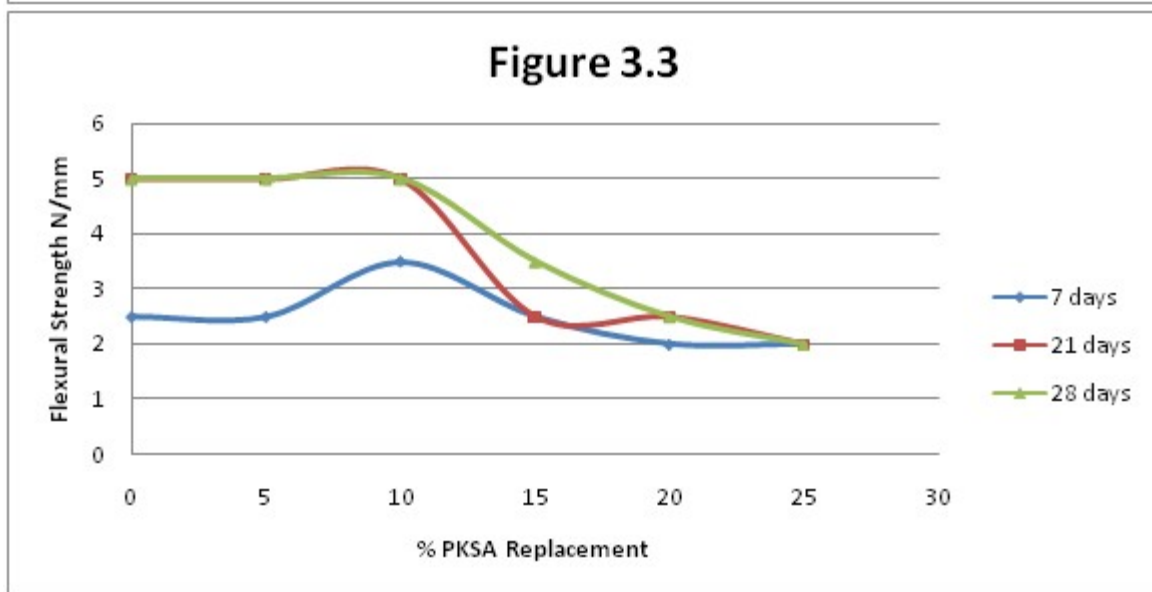
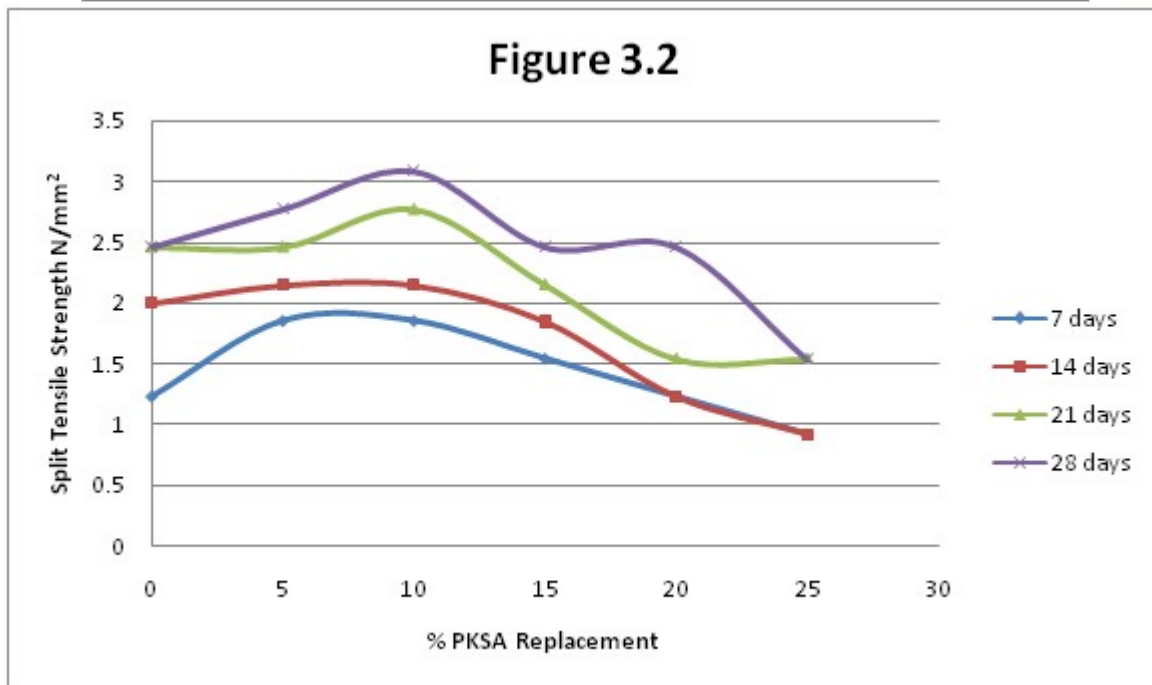
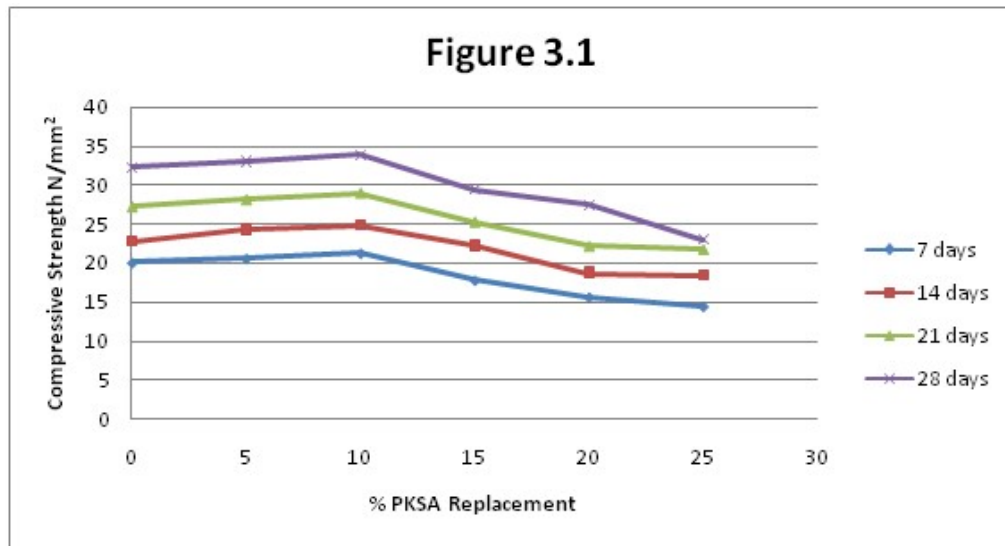
Table 6 show the averaged mechanical test results obtained from the tests, respectively. The test results showed that the compressive strength values for 7, 14, 21 and 28days respectively are increasing gradually up to 10% replacement of PKSA before reducing in all paving block samples. The results further revealed that the value of compressive strength at 10% addition of PKSA was 21.27 N/mm², 24.75 N/mm², 28.90 N/mm² and 33.85 N/mm² for 7, 14, 21 and 28 days respectively. This implies an increase in compressive strength of 6%, 9%, 6% and 5% increase respectively for the different curing days.

Similarly, from the results it was observed that addition of PKSA to the paving block mix resulted in linear increase in the split tensile strength of the paving blocks between 0 – 10% of partial replacement of cement content with PKSA for the various curing days considered (i.e. 7, 14, 21 and 28 days) respectively; after which further additions resulted in decrease of split tensile strength. The value of split tensile strength at 10% addition of PKSA was 1.85 N/mm², 2.15 N/mm², 2.77 N/mm² and 3.08 N/mm² for 7, 14, 21 and 28 days respectively. This shows an increase in split tensile strength of 5%, 8%, 13% and 3% increase respectively for the different curing days at 10% replacement of PKSA.

Also, the results further revealed that the value of flexural strength at 10% addition of PKSA was 3.50 N/mm², 5.0 N/mm², and 5.0 N/mm² for 7, 21 and 28 days respectively. This implies an increase in flexural strength of 4% for 7days curing at 10% replacement. While at 21 and 28days the values remained constant.

MECHANICAL ANALYSIS RESULT SUMMARY											
% PKSA	Compressive strength N/mm ²				Spilt Tensile strength N/mm ²				Flexural strength N/mm ²		
	7 days	14 days	21 days	28 days	7 days	14 days	21 days	28 days	7 days	21 days	28 days
0	20.07	22.7	27.20	32.25	1.23	2.00	2.46	2.46	2.50	5.00	5.00
5	20.61	24.22	28.10	33.05	1.85	2.15	2.46	2.77	2.50	5.00	5.00
10	21.27	24.75	28.90	33.85	1.85	2.15	2.77	3.08	3.50	5.00	5.00
15	17.8	22.21	25.29	29.44	1.54	1.85	2.15	2.46	2.50	2.50	3.50
20	15.65	18.73	22.21	27.43	1.23	1.23	1.54	2.46	2.00	2.50	2.50
25	14.45	18.46	21.81	23.01	0.92	0.92	1.54	1.54	2.00	2.00	2.00

Table 6



4.0. Conclusion and Recommendation

4.1 CONCLUSION

From the results and observations of the present study the following conclusions were made:

1. That the addition of PKSA up to a maximum 10% into paving block mix resulted in paving blocks having a higher compressive strength than that of the conventional paving block for all the curing days considered.
2. That the addition of PKSA up to a maximum 10% into paving block mix resulted in paving blocks having a higher split tensile strength than that of the conventional paving block for all the curing days considered.
3. That the addition of PKSA up to a maximum 10% into paving block mix resulted in paving blocks having a higher flexural strength than that of the conventional paving block for all the curing days considered.
4. Addition of PKSA up to maximum of 10% to paving block mix resulted in cost reduction of about 3.3% savings.
5. An increase in the percentage inclusion of PKSA will led to a corresponding decrease in the workability of concrete.

4.2 RECOMMENDATION

However, based on the above conclusion drawn from the present analysis on previous chapter, the following recommendations are made:

1. PKSA inclusion in concrete as partial replacement for cement should be considered for the construction of Light weight structure
2. Paving blocks made from PKSA inclusion in concrete production can be used for the paving of packing lots, garage, and walkways.
3. Processing of PKSA should be carried out with a high intensive temperature just as in cement production and a smaller sieve size should be used to obtain the PKSA to make it very fine and very compactable with cement when mixed.
4. Further studies on the compressive strength of paving blocks by inclusion of PKSA should be carried out for up to 90days test.
5. Finally, investigation should be carried out on the durability of paving blocks by inclusion of PKSA as partial replacement for cement in an aggressive environment.

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