PALM KERNEL HUSK ASH (PKHA) AS AN ADMIXTURE (ACCELERATOR) IN CONCRETE

A.W. Otunyo

Department of Civil & Environmental Engineering, University of Port Harcourt, P.M.B. 5323, Port Harcourt, Nigeria.
Email: *umutuigili@yahoo.com*

Abstract

Almost all admixtures used in concrete production in Nigeria are imported. This study was carried out to determine the suitability of PKHA as an admixture, while still retaining the compressive strength characteristics. Results revealed that the setting time of the mixture of the PKHA and cement cube decreases as the percentage of the PKHA increases as compared to the setting time of pure cement cube which was the control test. Also, the cubes obtained by mixing various percentages of the PKHA and cement showed reduced compressive strength for the 7 and 28 days compressive strength tests respectively relative to those made with 100% Ordinary Portland Cement (OPC) which also served as the control test. The main contribution of this technical paper is that PKHA can reduce the setting time of concrete to the detriment of the strength. There was no appreciable change in color in the cubes produced from the mixtures of palm kernel husk ash and cement compared to the pure cement cube.

Keywords: palm kernel husk ash, admixture, accelerator, cement, compressive strength, setting time

1. Introduction

The ingredients of normal concretes are cement, water, fine and coarse aggregates. Concretes produced with just these materials may not be able to provide certain properties or characteristics that may be demanded in concrete construction. It is in this condition, that admixtures become useful, [1].

The most widely used are chemical admixtures to control setting time and/or to reduce water.

Admixtures primarily fall into the following categories, accelerators, retarders, plasticizers, cementitious and pozzolanic materials, water-proofers and materials used to inhibit alkali-silica reaction, [2].

Palm kernel husk is a nuisance material in palm oil mills in Nigeria. Disposal after extraction of the palm kernel seeds poses serious challenges. This study was carried out to find out the setting times of cement moulds made of the PKHA and Ordinary Portland cement (OPC) (different PKHA/cement ratios). This will reduce the cost of cement in concrete construction works and be of great advantage in the disposal of the palm kernel husk from the palm oil production mills.

Also the effect of the PKHA on strength development was carried out by determining the compressive Strength tests of the same mixtures after 7 and 28 days respectively. 200kg of palm kernel husk was collected from a local

Table 1: Compressive Strength Results for Ordinary Portland (OPC), Blast Furnace Portland (PBFC) and Low Heat Blast Furnace Portland Cement (LHPBFC).

	3 DAYS	7 DAYS	28 DAYS
OPC	13.0N/mm^2		29.0N/mm^2
PBFC	8.0N/mm^2	14.0N/mm^2	22.0N/mm^2
LHPBFC	3.0N/mm^2	7.0N/mm^2	14.0N/mm^2

palm oil mill in Ahoada (a town in South-Eastern Nigeria).

[3], carried out a study using Rice Husk Ash, (RHA) as cement admixture for immobilization of liquid radioactive waste at different temperatures. It was discovered that the addition of 30% (RHA) causes a significant increase in the hydraulic stability of cemented waste. [4], carried out a study on the Utilization of RHA as an Admixture in High-Strength Concrete. The 7-day, 28-day and 91 day compressive strengths of the RHA were higher than those of the control concrete without RHA and also the dosage of super plasticizer in concrete increased as the ash content of the cementing material increased. Also, [5], concluded from their study "Mortar Incorporating Rice Husk Ash: Strength and Porosity" that strength and porosity of mortar incorporating (RHA) were better, up to 20% of cement replacement level. [6], studied the effect of Palm Kernel Husk Ash (PKHA) and Free Lime (CaO) as an admixture in concrete production.

Table 1 shows a comparison of the 7 and 28 days compressive strength for OPC, Blast Furnace Portland Cement and Low Heat Blast Furnace Portland Cement. The result for the 28 days strength for Low Heat Blast Furnace Portland Cement - 14.0N/mm^2 compares favorably with the 28 days strength of the 25% palm kernel husk ash and 75% OPC cube.

2. Objective of Study

The objective of this study is to determine the suitability of only PKHA as an admixture while still retaining the required compressive strength.

3. Methodology

3.1. Materials

The following materials were used for the experiment:

Palm Kernel husk: Approximately 200kg of palm kernel husk was collected in 5 jute bags from a local palm oil mill in Ahoada (a town in South-Eastern Nigeria).

Cement: Ordinary Portland cement locally available in Nigeria (the DANGOTE CEMENT Brand Name) in 50kg bags was used for the experiment.

Water: Potable water from the Civil Engineering Laboratory of the Rivers State University of Science & Technology was used to prepare the cubes.

3.2. Methods

The palm kernel husks were washed to clean them and then sun dried for 48 hours in the open air to eliminate moisture to ensure faster burning of the husk. Thereafter, the husks were crushed using a steel mallet to break them into smaller particles prior to burning. The smaller pieces of palm kernel husks obtained after the crushing were burnt inside a steel container until the husks was completely in form of ash. Approximately 100kg of PKHA was obtained from the 200kg of palm kernel husk after burning. The PKHA was sieved with a 425 m sieve to obtain very fine ash particles that will compare in size with particles of Ordinary Portland cement locally available in Nigeria (the DANGOTE CEMENT Brand Name.)

TG, Porosimetry, Microscopy and XRD tests were also carried out to fully determine other properties of the PKHA. Setting time test using a Vicat's apparatus was carried out on various percentages of the ash and Ordinary Portland cement cubes, according to [7] and [8]. Chemical analysis of the PKHA was carried out to determine its chemical composition [9]-[18].

Also the effect of the PKHA on strength development was carried out by determining the compressive Strength tests of the same mixtures after 7 and 28 days respectively.

5 test cubes each were prepared for the following OPC/PKHA ratio: (a) 25%(OPC) + 75%(PKHA), (b) 50%(OPC) + 50%(PKHA), (c) 75%(OPC) + 25%(PKHA) and (d)100%(OPC) 0% (PKHA)- control.

Total weight of each of the test cube (the mixture of PHKA and cement was approximately 350gm. The tests were performed in a room with 90% humidity and room temperature of between 25°C and 29°C.

For the Compressive Strength test, 4 cubes were prepared for the various combinations of the PKHA and cement in the ratio shown in Table 4. The water/cement ratio of the combined mixture was 0.45. A total of 16 cubes were prepared. Eight of the cubes were subjected to 7 days Compressive Strength tests while the other eight cubes were subjected to Compressive Strength test after 28 days. The weight of each cube of concrete for the compressive strength test was 2.5kg.

4. Result of Tests

Table 2 shows the percentage combination of cubes of OPC and PKHA. Table 3 is the average setting times for various mixtures of OPC and PKHA cubes. Table 4 is the result of the 7 and 28 days compressive strength test results. Table 5 is the result of the chemical composition of the PKHA, while Table 6 contains the results of the TG, Porosimetry, Microscopy and XRD tests. Figure 1 is the plot of the final setting time versus the various proportions of PKHA and OPC. Figure 2 is the plot of the compressive strength versus age for various proportions of PKHA and OPC.

Table 2: Percentage combination of cubes of OPC and PKHA.

	Control Cube (%)	Cube 1 (%)	Cube 2 (%)	Cube 3 (%)
OPC	100	25	50	75
PKHA	-	75	50	25

Table 3: Average setting times (hours) for various mixtures of OPC and PKHA cubes.

	Control Cube (%)	Cube 1 (%)	Cube 2 (%)	Cube 3 (%)
OPC (%)	100	25	50	75
PKHA (%)	-	75	50	25
Setting times (hours)	4	3	4	5

Table 4: Compressive strength results for various percentages of PKHA and OPC mixture N/mm^2.

Material combination	7days	28days
25% (OPC) + 75% (PKHA)	4.6	2.5
50% (OPC) + 50% (PKHA)	4.9	5.5
75% (OPC) + 25% (PKHA)	5.9	13.0
100% OPC (control Mix)	25.7	35.0

Table 5: Chemical composition of palm kernel ash (PKHA).

S/No	**Parameter**	**Result**	**Standard**
1	Ph	6.37	> 5
2	Specific Gravity	2.4	2.2 - 2.6
3	Carbonate (%)	0.88	1
4	Silica (%)	97.03	94 - 99
5	Ferric Oxide (%)	0.296	0.5
6	salinity (%)	0.027	0.06
7	Aluminum Oxide (%)	0.032	0.05
8	Sulphur Trioxide (%)	0.52	5
9	Silt Content (%)	0.078	0.3
10	Organic Matters (%)	1.31	5
11	Magnesium (%)	0.37	0.5

Table 6: TG , porosimetry, microscopy, XRD test results.

S/No	Parameter	Result	Standard
1	TG (%)	42.4% Mass loss occurs between 600°C - 900°C	
2	Porosimetry (%)	18.3	15- 30
3	Microscopy		
	Elongation (mm)	1.83	1.09 - 6.06
	Roundness (mm)	0.39	0.10 - 0.98
	Diameter (mm)	30.4	7.9 - 153.8
	Compactness (mm)	0.55	0.36 - 0.99
		Element found	
4	**XRD**	O_2, Mg, Si, Ca, Al	

5. Discussion of Results

5.1. Setting times

The final setting time for 0% PKHA cubes (which is 100% cement cube) is 4 hours. At 25% PKHA and 75% cement cube mixtures, the final setting time is 5 hours. Fig. 1 shows a continuous decrease in setting time to 3 hours for the (75% PKHA and 25% cement cube).

5.2. Compressive Strength

The plot for the 7 and 28 days compressive strength is as shown in Fig. 2. It can be observed that the compressive strength of the cubes made with mixtures of PKHA and OPC decreases as the quantity of the PKHA in the cube mixture increases. In the previous study [6], with the use of PKHA, Free Lime and OPC combination the values of the compressive strength for the 7, 14 and 28 days strength were higher than those of 100% OPC for the 7 and 14 days test but decreased dramatically by the 28th day. The sharp retrogression in compressive strength was attributed to the presence of hard burnt free lime which hydrates only very slowly and since slaked lime occupies larger volume than the original free lime, expansion normally takes place leading to the reduction in strength of the cubes, [2].

5.3. Chemical Analysis of the PKHA

From Table 5, the chemical analysis of the PKHA shows that it has silicon oxide (96.64%) and Ferric Oxide (0.84%). These are also the main compounds of Ordinary Portland Cement (OPC) and Granulated Blast Furnace Slag Cement, From Table 6 it can be observed that 42.4% of mass loss occurs between 600°C and 900°C, the porosimetry is 18.3% which is within the standard range of between 15 - 30%. The values of the elongation, roundness, diameter and compactness of the grains are within the acceptable ranges. The elements found from the XRD tests are O_2, Mg, Si, Ca and Al, these elements correspond with the chemical composition of the PKHA. A typical Granulated Blast Furnace Slag Cement produced in the UK has the following elements:

$CaO = 38.0\%$ $SiO_2 = 34.6\%$ $Al_2O_3 = 14.6\%$ $MgO = 9.3\%$ $MnO = 0.5\%$ $Fe_2O_3 = 0.3\%$ $SO_3 = 1.7\%$ Alkalis = 1.0%

The composition of the Granulated Blast furnace Slag Cement as shown above and the chemical composition of the PKHA in Table 5 show that the major missing compound is free lime (CaO) and Aluminium oxide (Al_2O_3). Between these two compounds, the Calcium Oxide (CaO) is responsible for hydration of cement. The function of the free lime (CaO) in the PKHA would have been to provide the correct level of alkalinity (1%) as against (0.64%) for the PKHA to begin to hydrate in the presence of cement. Calcium Chloride is a very common accelerator. It has a pH of 7.0 which is acidic. The PKHA has a pH value of 6.37 which is acidic. It could therefore be inferred that the acidic nature of

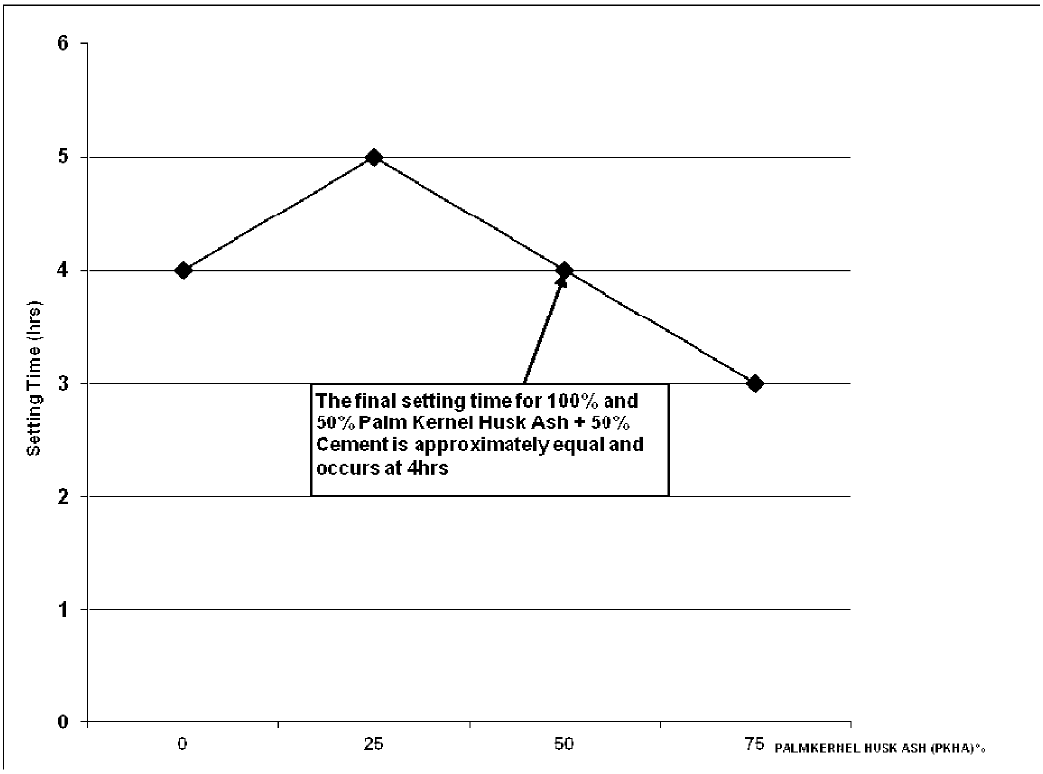

Figure 1:

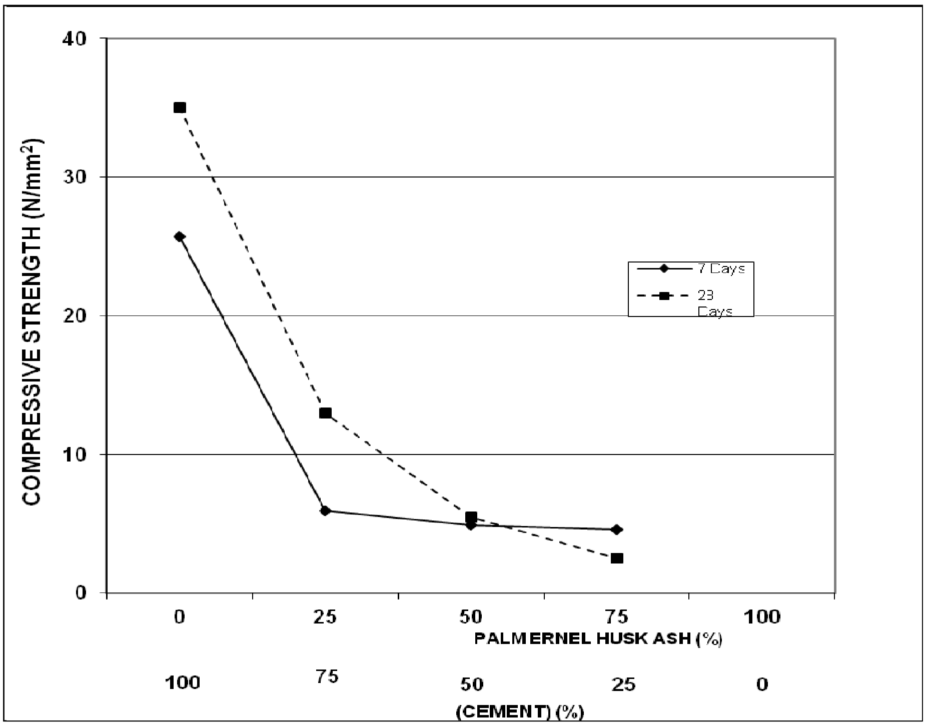

Figure 2: Plot of Compressive strength (N/mm^2), (7 and 28 days) versus percentage of palm kernel husk ash + cement mixture

PKHA is responsible for the shorter setting time of the OPC cubes with higher percentages of the PKHA. Once hydration occurs, the PKHA would have behaved as OPC in its own right. It would have therefore been possible to use the PKHA as an admixture (accelerator) without compromising strength. The presence of the PKHA did not appreciably alter the colour of the PKHA/OPC mixture cube since the colour of the PKHA is similar to that of OPC.

5.4. Comparison of study with previous works

An earlier study on the use of PKHA and Free Lime (CaO) as an admixture has been carried out by [6]. The results indicated that PKHA reduces the setting time of OPC cubes prepared with a mixture of PKHA and OPC. The compressive strength of the 25 and 50% mixture of PKHA and CaO was higher than that of OPC for the 7 and 14 days but dramatically reduced to a value below the standard 28 days compressive strength. In this study, the PKHA alone reduces the setting time but decreases the compressive strength of the cubes at all ages.

6. Conclusion

Results revealed that the setting time of the mixture of the PKHA and cement cube decreases as the percentage of the PKHA increases as compared to the setting time of pure cement cube which was the control test. Also, the cubes obtained by mixing various percentages of the PKHA and cement showed reduced compressive strength for the 7 and 28 days compressive strength tests respectively relative to those made with 100% OPC. The study suggests that PKHA can reduce the setting time of concrete to the detriment of the strength.

In conclusion, it can be stated that although, (PKHA) can be used as an admixture (accelerator) for concrete production, however, it is not desirable in construction works requiring standard concrete compressive strengths. It can find use in areas like blinding, mortar, internal and external rendering in concrete construction jobs that require early setting time and where high strength is not a major requirement.

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