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The Use of Palm Kernel Hush Ash in Concrete Production

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Abstract

In this research work, the use of palm kernel husk ash was studied. A mix-proportion of 1:1.84:3.74 with water-cement ratio of 0.47 was used. The percentages of palm kernel husk ash (PHA) in cement are 0%, 5%, 10%, 20%, 30% and 40%. Concrete cubes of 150mmx150mmx150mm of OPC/PHA were cast and cured for 7, 28, 60 and 90 days respectively. At the end of each hydration period, three concrete cubes for each hydration period were crushed and their average compressive strength recorded. A total of seventy two (72) concrete cubes were cast. The results of the compressive strength tests for 5-40% PHA/cement mixtures range from 11.99-34.70N/mm^2 as against 23.93 – 38.15N/mm^2 for the control test. The setting times of 5-40% of PHA in cement range from 59-112mins and 628-837mm for the initial and final setting time respectively. The initial and final setting times of the control tests (0% replacement) are 55mins and 600mins respectively. The result of the slump test of control test is 5mm while the results for 5-40% of PHA in cement range from 12-57mm.

KEYWORDS: Compressive strength, slump, setting time, palm kernel husk ash.

1. Introduction

The incorporation of waste in concrete manufacture may provide a satisfactory solution to the problems posed by waste management (Cook, 1997). The building sector uses large quantities of natural materials, hence, its capacity to recycle and upgrade waste is considerable (Basher et al, 2005). Certain industrial by-products have been used for a number of years in cement or concrete components (Elinwa and Mahmood, 2002). Other waste products may also be recycled and upgraded in concrete (Mehta and Pirtz, 1980). However, the new material thus formed must be usable as a building material and in particular have the performance characteristics to satisfy the specifications determined by its application (Helmuth, 1987). In addition, it should be inoffensive with regards to health and the environment. Finally the incorporation of the waste should not impair concrete durability. Traditional assessment methods must therefore be adapted to evaluate these new materials (Chatterji, 1990).

This study contributes to the development of a methodology for assessing concrete manufactured from waste. The methodology is based on the study of concrete containing experimental waste (Palm Kernel Husk Ash). The ash is considered experimental waste because of its high content of soluble salts in particular (Kessler et al, 1992). The durability and the environmental impact of concrete are closely connected to its transport properties which control the kinetics of the penetration of water and aggressive agents into concrete (Pimienta et al, 1999). The movement of chemical species within the material and the leaching of certain chemicals are also closely linked to concrete diffusivity (Remond et al, 2002).

Finally, the strength characteristics of concrete containing increasing levels of palm kernel hush ash were studied to identify the influence of the ash on concrete produced with it.

2. Methodology

The concrete cube size measuring 150mmx150x150mm in dimension was used. The batching of the concrete cubes was by weight. Concrete mixtures with six levels of palm kernel husk ash (PHA) ranging from 5-40% and concrete mixture with no palm kernel husk ash (PHA) were studied to determine their effect on compressive strength, setting time and workability. The mixtures were labeled M0, M5, M10, M20, M30 and M40 with the different PHA replacement percentage represented by the final digits in the label. The mixtures were proportioned for a target cube strength of 43N/mm^2 and had a cementitious material content of 340kg/m^3, a fine aggregate content of 627kg/m^3, coarse aggregate content of 1273kg/m^3 and a water cement-ratio of 0.47.

The PHA in this research was obtained by burning palm kernel shell in a kiln to obtain the ash. The ash was then sieved with 150µm sieve size. The fine aggregate used was clean river sand, free from deleterious substances with a specific gravity of 2.62. The coarse aggregate was obtained from a local supplier with a maximum size of 20mm with a specific gravity of 2.65. Both aggregates conform to BS 877 (1967) and BS 3797 (1964) respectively for coarse and fine aggregates. The cement used was Ordinary Portland Cement (OPC) (Dangote) which conforms to BS12 (1978).

Tests to determine the setting time, compressive strength and workability were carried out in this study. For the tests, PHA was used to replace 0 to 40% of cement by weight. A total of 72 specimens were cast and cured in water at room temperature in the laboratory for 7, 28, 60 and 90 days. At the end of each hydration period, three specimens for each were tested for compressive strength and the average recorded. The compressive strength (C.S) was calculated by dividing the crushing load (N) with the cross sectional area of the cube.

Mathematically,

$$Compressivestrength = \frac{crushing\,load\,, N}{areaofcube, mm^2}$$

The setting time was determined in the laboratory using Vicat apparatus. For the control test (0% replacement), 200g of cement was used with 94g of water during the experiment to form a cement paste. The paste was then placed inside the Vicat mould and finally placed on the Vicat apparatus. Before the placement of the paste on the apparatus, the initial setting pin was fixed on the apparatus for the initial setting time. The apparatus is calibrated in millimeters. For the initial setting time the initial setting pin was dropped on the paste to 5±1mm calibration mark on the apparatus (Neville A.M, 1995).

The final setting time was recorded using the final setting pin. The final setting time was taken when only the inner pin makes a mark on the paste when allowed to drop freely. The final setting time was then recorded starting from the time water was added to the cement to the time the inner pin of the final setting pin makes a mark on the paste. The experiment was repeated with 5%, 10%, 20%, 30% and 40% of PHA in cement.

The workability of concrete is determined using the standard slump cone of dimension 300mm x 200mm x 100mm. To perform this test, the cone was placed on a smooth platform and filled with concrete to one third of its height and compacted 25 times with a tamping rod. The cone was later filled with concrete to two third of its height and compacted 25 times. Finally, the cone was filled up completely and 25 times of compaction were equally carried out. After compaction, the surface of the concrete in the cone was smoothened with trowel. The cone was then lifted and placed upside down with respect to its original position. A straight edge was then placed on top of the reversed cone and the difference between the cone and the concrete was measured using a metre rule. The difference in height between the cone and the concrete gives the workability of the concrete.

3. Results and Discussion

Table 1 shows the result of the initial and final setting time of Ordinary Portland Cement (Dangote) and the palm kernel husk ash. The initial and final setting times of the control test (0% replacement) are 55mins and 600mins respectively while those for 5-40% of PHA in cement range from 59-112mins and 628-837mins for the initial and final setting times respectively. The setting time increases with the increase in the percentage of PHA in cement. Table 2 shows the result of the slump test of concrete produced with 0-40% of PHA in cement. The result of the slump test of the control test is 5mm while 5-40% of PHA in cement ranges from 12-57mm. The result also shows an increase in the slump of concrete produced as the percentage of PHA in cement increases. Table 3-8 shows the result of the compressive strength of concrete with 0-40% of PHA in cement. The result shows that the strength increases with increase in hydration period. The result of the compressive strength for 5-40% of PHA/cement mixture ranges from 11.99-34.70N/mm^2 as against 23.93-38.15N/mm^2 for the control test. The result shows that there is a decrease in the strength of concrete produced as the PHA/cement mixture increases.

The mechanism at work in setting time as reposted in table 1 is that PHA acts as a retarder since the incorporation of PHA resulted in the increase in the setting time of the concrete produced. The significance of the result is that the higher the setting time of concrete, the lower the strength of the concrete and vice- versa. The validity of the result in table 1 is shown by incorporating certain percentage of PHA in cement during concrete production as shown in table 3.

The higher the workability of concrete, the lower is the strength of concrete. Also, the higher the setting time of concrete, the lower is the strength of concrete. The results of tables 1 and 2 prove the above theory.

Table 1: Initial and final setting time of OPC/PHA paste

% Cement replacement	Initial setting time (mins)	Final setting time (mins)
0	55	600
5	59	628
10	66	661
20	73	689
30	88	743
40	112	837

Table 2: Result of slump test of concrete produced with 0-40% of PHA in cement.

% Cement replacement	Slump (mm)
0	5
5	12
10	19
20	23
30	31
40	57

TABLE 3: Compressive strength data for 150X150X150mm Cement/PHA composite

%PHA	**Age (days)**	**Load (KN)**	**Compressive strength (N/mm^2)**	**%PHA**	**Age (days)**	**Load (KN)**	**Compressive strength (N/mm^2)**
0	7	538.33	23.93	20	7	436.33	19.39
	28	646.67	28.74		28	527.00	23.42
	60	706.00	31.38		60	599.67	26.65
	90	858.33	38.15		90	678.67	30.16
5	7	518.67	23.05	30	7	412.00	18.31
	28	609.67	27.09		28	436.67	19.41
	60	661.00	29.38		60	587.33	26.10
	90	780.67	34.70		90	692.00	30.76
10	7	512.33	22.77	40	7	269.66	11.99
	28	566.33	25.17		28	344.00	15.29
	60	621.33	27.62		60	541.00	24.05
	90	703.00	31.24		90	600.33	26.68

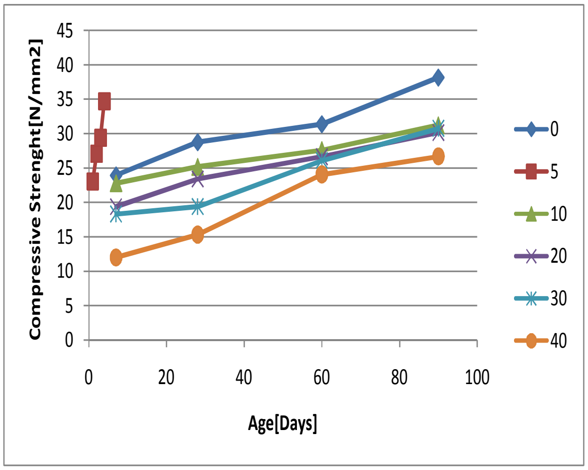

Fig1: Graph of Compressive Strenght Verses Age

4. Conclusion

The results of the study can be summarized as follows:

a. The incorporation of palm kernel husk ash in the production of concrete will reduce the strength of concrete produced.
b. Palm kernel husk ash can be used to replace certain quantity of cement during the production of concrete but cannot exceed 40%
c. The setting time of cement is increased as the percentage replacement level of cement with PHA increases.
d. The workability of concrete increases with the increase in the percentage replacement of cement with PHA.
e. Strength development increases with increase in hydration period.

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