

EFFECT OF PALM KERNEL SHELL ASH AS PARTIAL REPLACEMENT OF CEMENT CONTENT ON THE COMPRESSIVE STRENGTH OF CONCRETE

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Abstract

The use of palm kernel shell which is the agro waste from palm oil industry as pozzolans in concrete production cannot be overemphasized as it improves environmental sustainability and also reduces cost of concrete production when used as replacement of cement content. Palm kernel shell were obtained from palm oil factory along Towobowo market in Igboora, Ibarapa central local government of Oyo State. The palm kernel shell were sundried and calcinated to palm kernel shell ash (PKSA) in furnace at foundry section of Faculty of Engineering, Oyo State College of Agriculture and Technology, Igboora. The ashes produced was used as cement replacement of concrete mix 1:2:4 in 0%, 5%, 10% and 20% respectively. The concrete were casted with cement, sand and aggregate with the mixture of PKSA in appropriate proportion. The total of twelve cubes were casted for each percentage to determine the concrete compressive strength at 7, 14, 21 and 28 days. The total cubes crushed was 48 in number and water/cement ratio of 0.5 was used. The result indicated that the concrete compressive strength and density generally increased with the increase in the curing days and reduced with the increase in the PKSA contents but the PKSA replacement between 10-15% is recommended for optimum strength.

Keywords: Pozzolans; Palm kernel shell (PKSA); Compressive; Concrete; Strength

Introduction

Nigeria is the fifth largest palm oil producing country, with 1.5% or 1.03 million metric tons to the world total output, according to the United States Department of Agriculture (USDA, 2007). This necessitated the presence of many palm oil industries in Nigeria and availability of palm kernel shell which is the waste of these industries has no value except for using for cooking fire in some rural areas. Though this idea is being discouraged because of hazard due to pollution from the fire.

The researchers have worked on ways of using the Palm Kernel Shell Ash (PKSA) as pozzolans material as partial replacement of cement in concrete production, and if this is utilized optimally, it will reduce the cost of concrete and also enhance safe and sustainable environment.

The use of pozzolans in the production of concrete is not a new development or trend in the construction industry. At the outset, the use of pozzolans for building works was necessitated by the need to find a material that can bind sand and gravel together in the

presence of water, and also give the required strength when used for residential and public construction (Kartini 2011; Guiherme *et al*, 2008). A pozzolans is a siliceous or siliceous and aluminous material which possesses little or no cementitious property but in a finely divided form and in the presence of water, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties (Dipayan, 2007).

Ordinary Portland cement is the most common type of cement used in construction around the world. It is used as a basic ingredient for concrete, sandcrete, mortar, stucco and non-specialty grouts. According to (Adepegba, 2000) the annual Portland cement required in Nigeria is about 8.2 million tons and only 4.2 million is produced in Nigeria, about 3.6 million tons or more is being imported to meet up with this requirement. If an alternative material to replace cement fully or partially in construction works can be produced locally, the amount of cement required will reduce, hence reducing the quantity of cement needed which will reduce the cost of construction. This leads people to start searching for alternative conventional building material to cement that will be cheaper and

accessible, and one of the alternative materials discovered during the research was the Palm Kernel Shell Ash.

The demand for cement will be met by the use of cementing materials in other to reduce the green gas emission (Bentur, 2002). Most industrial wastes such as silica fume, fly ash and furnace slag and recently agricultural wastes such as pozzolanic materials such as palm kernel shell ash (PKSA), rice husk ash (De sensall, 2006) are introduced into concrete. The silica present in these materials reacts with the $\text{Ca}(\text{OH})_2$ released during the hydration of cement and forms additional calcium silicate hydrate (C-S-H) which improves the durability and the mechanical properties of concrete such as good thermal insulation properties and better fire resistance (Igarashi, *et al.*, 2005)

Palm kernel shell ash is not a common construction material but it has the potential to be used for construction. It is a by-product of palm oil mills. After palm oil is extracted from the palm fruit, both the palm kernel shell and the palm oil husk are burned as fuel in the boiler of the palm oil mill. Generally, after combustion about 5% palm kernel shell ash (PKSA) by weight of solid wastes is produced (Abdullah, *et al.*, 2006). The ash produced varies in tone of color of grey shades.

The physical characteristics of PKSA is very much influenced by the operation mode of the palm oil factories, and it has been observed that the utilization of palm kernel shell is minimal and unmanaged while its quantity increases annually and most of the palm kernel shell (PKS) are disposed as waste in landfills causing environmental problems (Tanqchirapat, *et al.*, 2007). After burning, an ash by-product is produced. As a solution to the disposal of the ash derive from the palm oil, research studies have been carried out to examine the feasibility of using the ash as a cement replacing material (Tay and Cheong 1995). Due to high silica oxide content found in palm kernel shell ash (PKSA) chemical composition, which met the pozzolanic properties criteria, it has the potential to be used as cement replacement or as filler to produce strong and durable concrete (Hussin and Awal, 1997).

Material and methods

Materials

The palm kernel shell used for this study was bought from Towoowo market in Igboora, Oyo State (Fig1), the collected sample was burnt to ashes with the furnace at the foundry section of faculty of

Engineering, Oyo State College of Agriculture, Igboora, and was sieved with sieve No 100 (0.15mm). The ordinary Portland cement (Elephant Cement) that conforms with BS EN 197 (2011) was bought from the Igboole area of Igboora, Oyo State and was used as a binder for the concrete production. The Fine and Coarse Aggregate used were sourced from a construction site at the Oyo State College of Agriculture and Technology while the water used was obtained from a borehole at fishery department of the College



(a) Palm kernel Shell



(b) Palm kernel Shell Ash

Fig. 1: Production of Palm Kernel Shell Ash

Preparation of sample

Ordinary Portland cement were replaced with PKSA at 5, 10 and 20% by weight of cement to cast the concrete moulds of 150 x 150 x 150 using 1:2:4 mixing ratio by weight and the water to cement ratio of 0.5. The mixture without the PKSA that contains 100% cement was also done serving as the control mixture. The specimens (Fig. 2) were prepared for the compressive strength and density using 150 x 150 x

150 concrete moulds of total area of 0.0225m² and total volume of 0.00375m³ in accordance with British Standards. The concrete moulds were casted and compacted with 25 blows at three layers, the concrete cubes were removed from the moulds after 24 hours of casting and were placed in plastic containers filled with water for the curing of the concrete cubes. The compressive strength and density tests were taken after curing periods of 7, 14, 21 and 28 days.



(a) Mixing of the Concrete

(b) Casting of the Concrete Moulds

Fig. 2: Production of PKSA Concrete Moulds

Table 1 Mix proportions (kg)

Mix ID	PKSA %			
	0%	5%	10%	20%
Cement	13.89	13,2	12.5	11.1
Fine Aggregate	27.78	27.78	27.78	27.78
Coarse Aggregate	55.56	55.56	55.56	55.56

Results and discussion

Physical properties

The specific gravity of the palm kernel Shell Ash was determined as 1.98 which was less than that of cement (3.15).

Fig 3 shows the grading curve of the PKSA indicated that its falls within the sand zone of the particle size

distribution curve stretching from fine to mild sand region. The result shows that PKSA has more than 50% of particles in the fine zone region. The material falls within the category of fine sand that is zone 4 of the grading curve according to SNI-T-15-03 (1990).

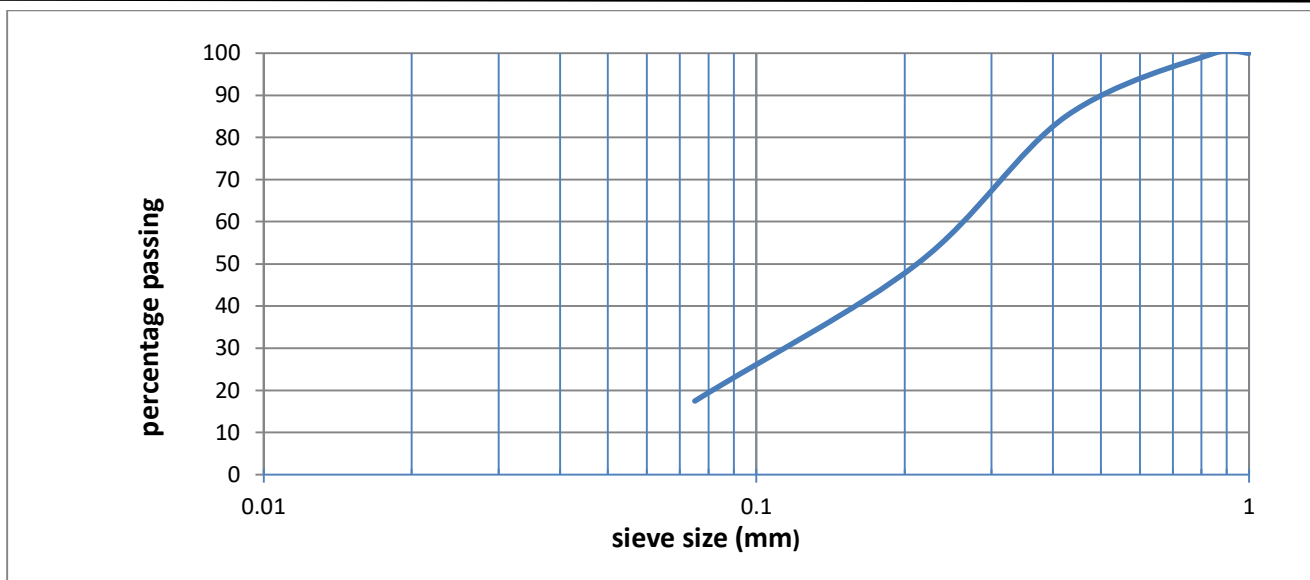


Fig. 3: Particle Size Distribution Curve for Palm kernel Shell Ash.

Fig 4 shows the result for the sieve analysis test on the fine aggregate (sand) used for the production of concrete, the coefficient of uniformity (C_u), and coefficient of curvature (C_c) obtained from the figure in accordance with BS 1377 (1990) were 3.0 and 0.4

respectively, The material falls within the category of mild sand, that is zone 3 of the grading curve according to SNI-T-15-03 (1990), it is poorly graded and it suitable for the concrete production.

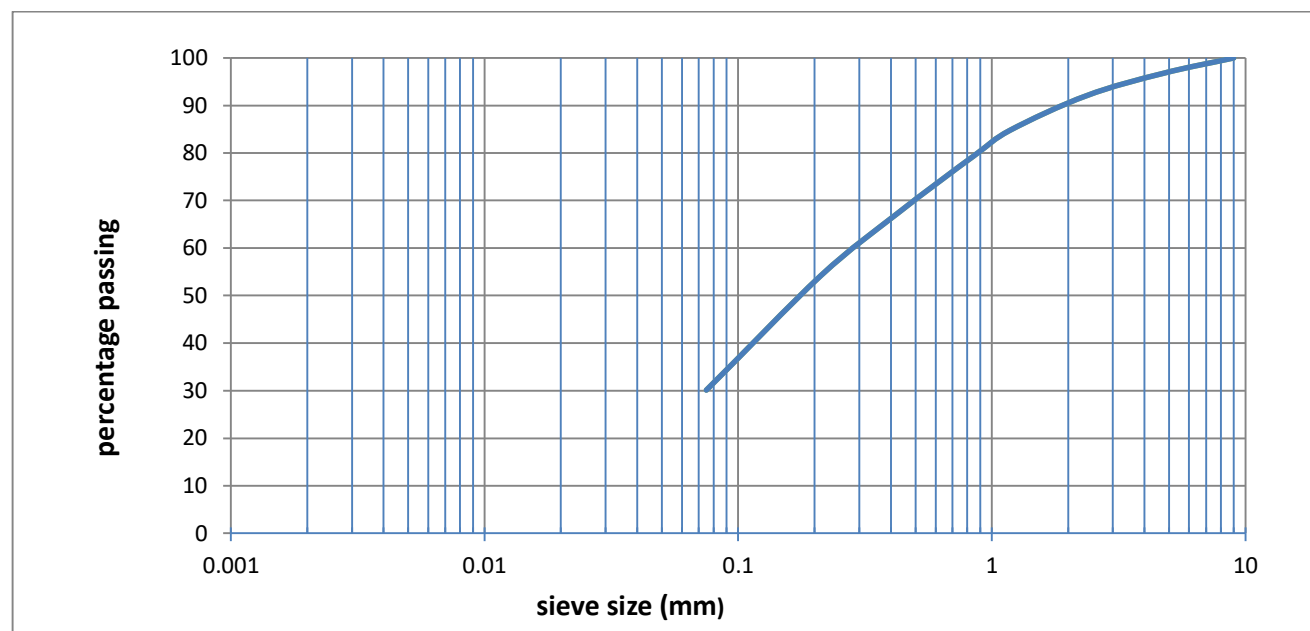


Fig. 4: Particle Size Distribution Curve of Fine Aggregate (Sand)

Density

The effect of PKSA replacement on the density of concrete at different curing periods is shown in fig.5. The result shows that the density of the PKSA concretes generally decreased with an increased in the percentage of PKSA and increased with curing age, with the highest value at 28 days. The density for 14

and 21 days curing are closely related with a significant gap from that of 7 and 28 days respectively. There is significant difference between the density of 7 days compared to other curing ages. The increase with age is attributed to the size $\frac{3}{4}$ down of coarse aggregate fraction of the concrete because it is majorly responsible for the density of the concrete.

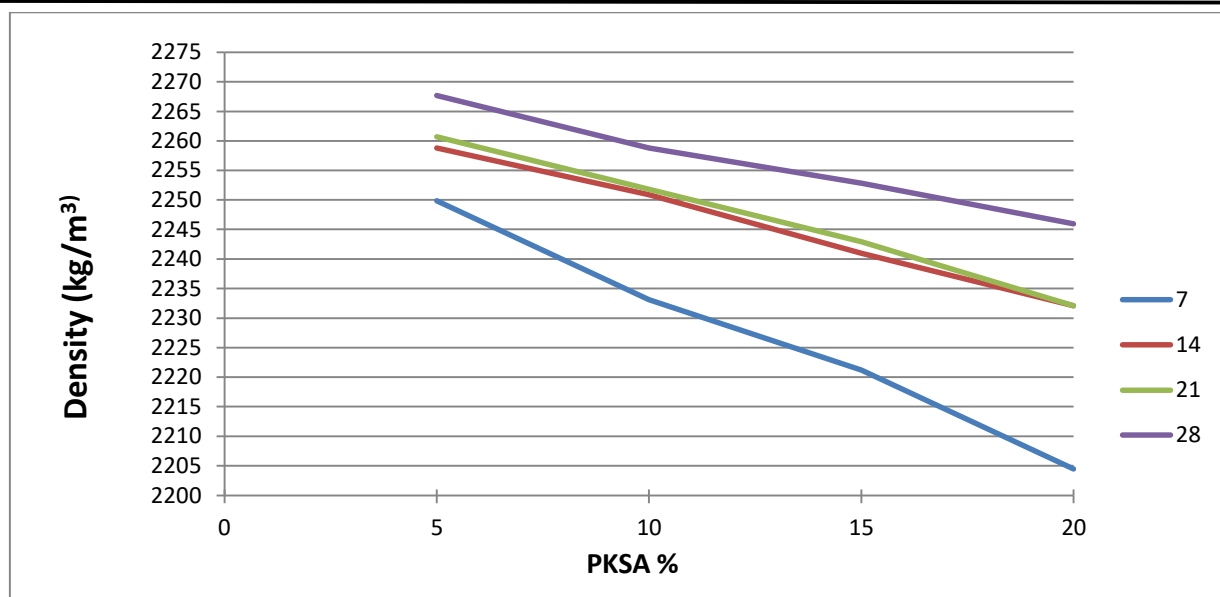


Fig. 5: Effect of the PKSA on the density of the concrete cubes

Compressive strength

The effect of the compressive strength on PKSA is shown in the figure 6. The results from the figure indicate that the compressive strength of the concrete increased with the curing age and decreased with the increase in the PKSA.

The result at 7 days showed that compressive strength decreases with the increase in the PKSA percentage and 0% has highest value being the control mix.

At 14 days of curing, similar trend was observed with a significant difference between the 5 and 10% PKSA replacement. The trend at 21 and 28 days of curing is similar with others as the compressive strength decreased with increase in the percentage of PKSA, it also shows a significant difference between 5 and 10% replacement.

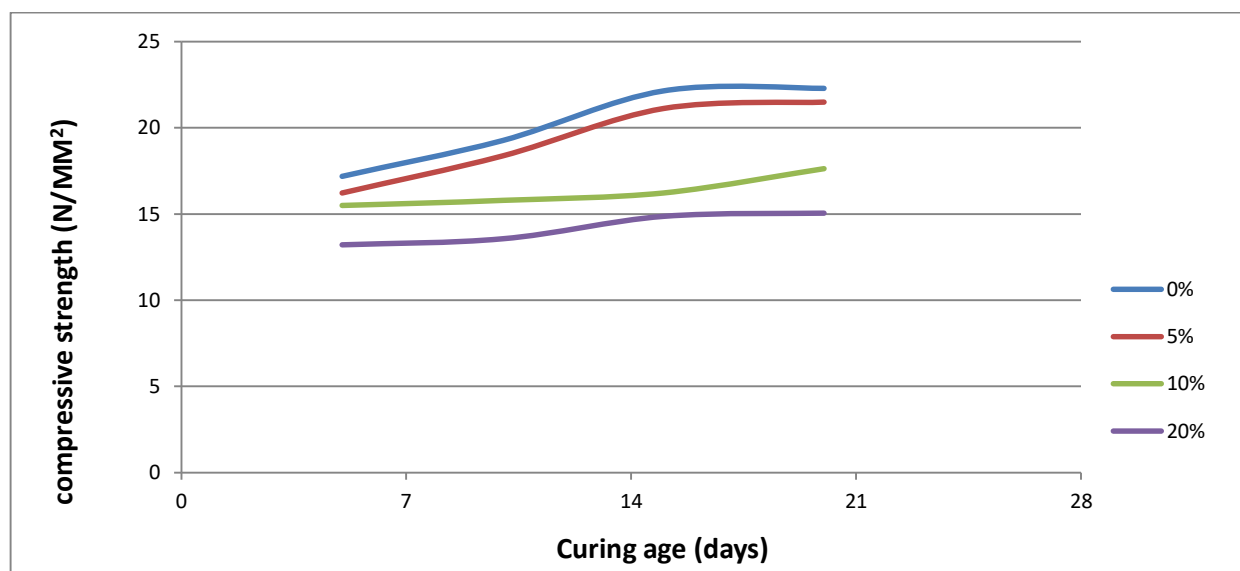


Fig. 6 Effect of the PKSA on the compressive strength of the concretes cubes

Conclusion

Based on the result of the various tests conducted on the effect of PKSA on the compressive strength of the concrete cubes, the following conclusions were made from the study.

1. Palm kernel shell ash (PKSA) is a good pozzolanic materials, since the result of the concrete

compressive strength showed that its aid the hydration of concrete when its silica content chemically combined with the Calcium hydroxide content of the cement.

2. The compressive strength of the concrete cubes generally increased with the curing period and reduced with an increase in the PKSA content of the

concrete. The strength increased significantly after 5% PKSA replacement for 14, 21 and 28 days curing age.

3. The density of the concrete also increased with increase in the curing days, and decreased with an increase in the PKSA replacement. The value of density for the curing age at 14 and 21 days are closely related with a significant difference with that of 28 days.

4. The use of 5-10% PKSA replacement is therefore recommended for various concrete use in buildings and other civil engineering construction works because of its closer strength compared to the control value, which contains 100% ordinary Portland cement.

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