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Strength Charatirazation and Cost Efficeincy of Using Palm Kernel Shell in Lightweigth Concrete for Pavement Works

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ABSTRACT
Costs of construction materials in Nigeria tends to be very high and the need to reduce environmental pollution has necessitated research into the use of waste materials, such as agro-industrial waste to replace traditional materials used in concrete production for pavement work. This work gives an account of the study conducted on the comparative of the density, strength and cost of Control Concrete and Palm Kernel Shell Concrete (PKSC) where Palm Kernel Shell (PKS) were used to fully replace crushed granite in the mix. The control concrete and PKSC cube were produced from a selected mix 1:1:2 and water-cement ratio 0.5 and tested according to provision of BS 12390-2 (2000), BS1881-125 and BS EN 12390-3 (2000) and eventually evaluated for road work suitability. Control concrete and PKSC of dimension 1.0 x1.0 x 0.05m were produced using the selected mix ratio. The cost incurred in producing the control concrete and PKSC were estimated and analyzed to determine the disparity. The results show that compressive strength and density of PKSC were lower than that of control concrete. Control concrete has a density and compressive strength of 2637.0 kg/m^3 and 33.8 N/mm^2, while PKSC has a density and compressive strength of 1985.2 kg/m^3 and 20.9 N/mm^2 respectively at 28 days hydration period. The cost/m^3 of producing control concrete was ₦27, 800 which was higher than ₦23, 566.67 cost of producing PKSC. The compressive strength of PKSC met the BS EN 206-1 recommended minimum strength requirement of 15 N/mm^2 and density not less than 800 kg/m^3 for structural light weight concrete (SLWC) for pavement work with 13.4% saving cost. The use of PKS waste as a replacement to traditional aggregates shall promote waste management and it will go a long way in cost reduction of concrete production.
***KEY WORDS**: PKS, PKSC, Density, Compressive Strength, lightweight concrete*

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I. INTRODUCTION

Pollution and waste management created by agro-wastes is a major problems in Nigeria. These waste pose environmental hazards and have adverse effects on the ecosystem at large. The quantity of these waste created in Nigeria is increasing over the years due to population increased, and economic growth. Some of these wastes are corn stalk, palm kernel shells, sugarcane bagasse, drops and culls from fruit, and vegetable. The continuous production of palm kernel shell waste promotes environmental pollution and nuisance with reference to its disposal. Palm kernel shells are underutilized and are usually abandoned as waste materials or used in a small scale as fuel in cooking and materials for filling potholes. Therefore, disposing them off beneficiary to mankind should be a welcome idea.

Palm kernel shell is cheap and available in large quantities in Nigeria**.** Desk review reveal that the main palm oil producing states in Nigeria include Anambra, Enugu, Imo, Abia, Ogun, Ondo, Oyo, Edo, Cross River, Ekiti, Akwa-Ibom, Delta and Rivers. Other palm oil producing state are kwara, and Kogi.

Concrete is an old and universal building material (Miller, *et al*.., 2004). It is a construction material made traditionally with fine aggregates, cement, water and coarse aggregates and may contain chemical admixtures. The continues demand for concrete worldwide using traditional materials in construction has drastically reduced natural stone deposits, which give rise to irreversible damage to our environment (Alengaram *et al*, 2013). As a consequence, researchers has made attention on the use of waste as feasible materials for construction. Furthermore, one of the greatest challenge of road construction is the total cost of construction. This cost depend on individual material which had led to poor quality of many project.

Researchers have extensively worked on this materials and found it lightweight aggregate. Among these researchers are Yusuf and Jimoh, **(**2011**),** Okechukwu peter oti, (2015), (Olutoge, 1995), D. O. Oyejobi, *et* *al*., (2012). The work of Yusuf and Jimoh, **(**2011**)** affirms that the Nigerian PKSC met the criteria as light weight concrete while the PKSC at mix ratio of 1:1.5:3 satisfied the specifications for rigid pavement. Typical concrete compressive strength classes used for road pavement are between 20N/mm^2 to 40N/mm^2. Similarly, D. O. Oyejobi, *et al.*, (2012), conclude that compressive strength of PKSC after 28 days hydration period satisfied British Standard recommended minimum strength of 15N/mm^2 for structural lightweight concrete at concrete mix of 1:1½:3. The partial replacement study carried out by Okechukwu peter oti, (2015) revealed that crushed granite could be replaced in concrete with Palm Kernel Shell up to 25%. The work of (Olutoge, 1995) revealed that density of PKSC was 740kg/m^3. Generally, it was recommended by British Standard that density of light weight concrete should not be less than 800 kg/m^3 and not more than 2000 kg/m^3 (BS EN 206-1). Very little is known about the cost of production of PKSC. Also many studies have investigate PKS as light weight aggregate using different nominal mixes but little or none has being done on nominal mix of 1:1:2.

This research work, strength characterization and cost analysis of using PKS as a replacement of coarse aggregate in lightweight concrete was investigated. The aim of this study was to determine the strength properties and compare the cost of a selected mix of control concrete and PKSC in pavement works. The objectives are: to determine physical properties of palm kernel shell (PKS); to determine the strength properties of the control concrete and PKSC; to produce control concrete and PKSC of 1.0m x 1.0m x 0.15m at 1:1:2 nominal mix and water-cement ratio of 0.5 and determine their cost and lastly to compare the strength and cost implication of using control concrete and PKSC in pavement work.

II. MATERIALS AND METHOD

The materials used for the experiment include: cement, granite, fine aggregate, palm kernel shell and water. Palm Kernel Shell (PKS) was sourced from Arandun town, Irepodun local government area of Kwara State. The town is located at the southern region of Kwara State. The granite used was gotten from Kafad Quarry in Idofian town, Ifelodun local government area, Kwara State. However, the fine aggregate used was sharp sand, which was sourced from Kafad Block Industry located in Oke odo, Tanke area, Ilorin, Kwara State. Ordinary Portland Cement (OPC) produced by Dangote industries which conforms with BS EN 197-1: 2000 was procured from Oke-odo, Tanke, Ilorin, Kwara State. Potable water supplied by the University of Ilorin was used in mixing and curing concrete.

Palm kernel shell was washed with detergent to remove coated palm oil and mud particles which can have effect on the chemical reaction of hydration, and thoroughly rinsed with water to remove any film of detergent. It was then properly air dried in an open space. The physical properties of sieve analysis, specific gravity, water absorption capacity, water content and aggregate impact value of the aggregate (PKS) were determined in accordance with BS 812-103.1 (1985), BS 812-2 (1995) and BS 812-109:1990. Density and strength properties were determined in accordance with BS 1881–102 (1983), BS 12390-2 (2000), and BS

EN 12390-3 (2000). PKSC and control concrete of the dimension 1.0 x 1.0 x 0.15m were produce using volume batching at a nominal mix of 1:1:2 and water/cement ratio of 0.5. A container of a known volume were used to measure the equivalent concrete materials of cement, fine sand and coarse aggregate (i.e. granite and PKS) and water/cement ratio of 0.5 and the weight of each of the measured material were taken using a digital weighing balance. The cost/Kg of each material used were estimated for both the PKSC and the control concrete.

III. RESULTS AND DISCUSSIONS

3.1 Suitability Assessment of Physical Properties of a PKS as a Light Weight Aggregates

Fig 1 show the percentage of PKS passing set of sieve. The percentage passing sieve 8mm and 4.75mm BS sieves are 37.57% and 5.67%, respectively. These falls within the grading of 4.75 – 40mm, which satisfy the requirement for coarse aggregate in accordance with BS 882: 1992. The results also show that PKS has a wide range of particles from 4.75 to 8mm and fineness modulus of 2.43. The specific gravity (SG) and water absorption of PKS was found to be 1.482 and 19.133% respectively. SG falls within the specified range of 1.14 and 1.62 specified for lightweight aggregate (LWA). The water absorption capacity of PKS was greater than that of normal weight aggregate with a value of 0.76%. With this, it can be said that PKS is an organic material with large presence of internal pores on its surface that absorb more water to increase its mass when soaked in water for 24 hours which result in high water absorption capacity. The water absorption capacity, however, falls within the specified range of 14 – 33% for LWA. This implies that for a dry PKS aggregate, more quantity of water will be required; this should be considered when designing the water/cement ratio so as to have a workable mix. The PKS is therefore recommended to be soaked before being used in concrete production. The result of moisture content of PKS shows that PKS has a moisture content of 14%. This implies that saturated PKS will contribute 14% water to the mix, thereby, occupying a volume in excess of PKS. Aggregate is required to be in a basic state of saturated and surface-dry condition.

The results of Aggregate Impact Value (AIV) of PKS show that PKS has AIV value of 5.63%, which is less than the maximum value of 10% specified for normal weight aggregate. This indicates that PKS is exceptionally strong. This means that PKS is a good shock absorbing material.

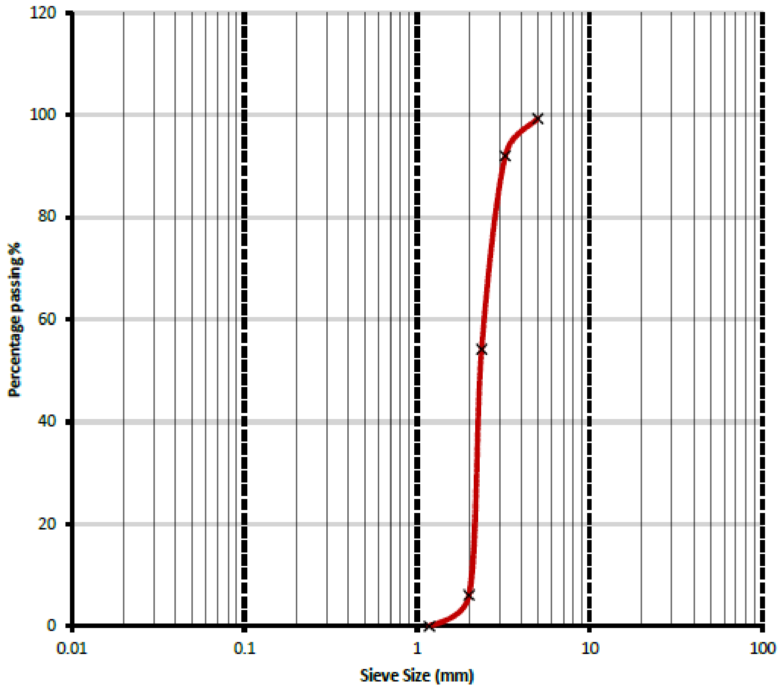

Fig 1 Particle Size Distribution curve of PKS

3.2 Mechanical Properties of Control Concrete and PKSC
Density of Control Concrete and PKSC

Fig 2 presents the results of density of control concrete and PKSC. The density of control concrete and PKSC show similar trend and increases with curing days. For instance control concrete has a density of 2459.3Kg/m^3 and 2637.0 Kg/m^3 at 7 and 28 days of curing, respectively, while PKSC has a density of 1866.7Kg/m^3 and 1985.2 Kg/m^3 at 7 and 28 days of curing, respectively. Density of control concrete was higher than the PKSC. Density of PKSC less than 2000 Kg/m^3 as specified by British Standard Specifications.

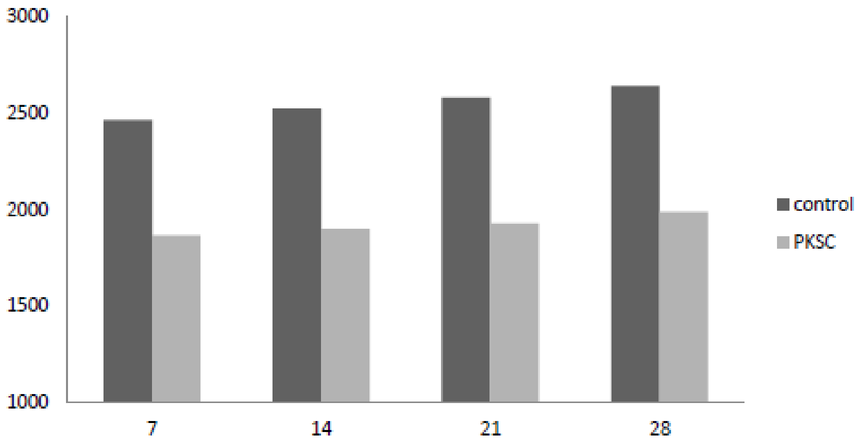

Fig 2 Density variation between Conventional Concrete and PKSC

Compressive Strength of Control Concrete and PKSC

Fig 3 shows the results of compressive strength of control concrete and PKSC. Compressive strength increase as number of cure days increased. Moreover, control concrete has compressive strength of 20N/mm^2 and 33.8N/mm^2 while PKSC has a 10.7N/mm^2 and 20.9N/mm^2 as 7 and 28 days respectively. PKSC met British Standard specification for minimum strength of 15 N/mm^2 for lightweight concrete.

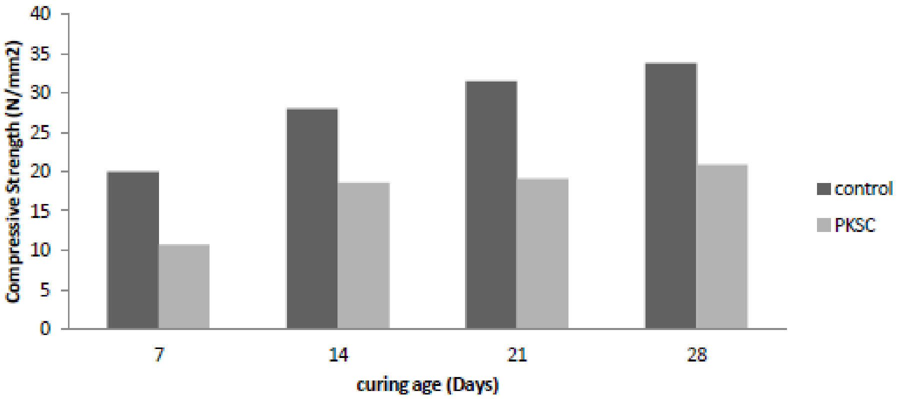

Fig 3 Compressive strength variation between Control Concrete and PKSC

3.3 Cost Analysis

Fig 4 presents the results of cost of the producing 1.0 x 1.0 x 0.15 m = 0.15 m^3 of control concrete and PKSC. It was determined using the prices of materials obtained from market survey for cost of construction materials in Ilorin, Kwara State as at 30^{th} of June, 2020. The total cost of materials used for control concrete was 4,161.2 while that of PKSC was 3,602.3. The results show that the cost of producing PKSC was lower than the cost of producing control concrete. This variation in cost was greatly affected by the fact that PKS was sourced at low cost. Percentage cost saving when PKSC was used as a replacement for crushed granite in concrete mix was 13.4%.

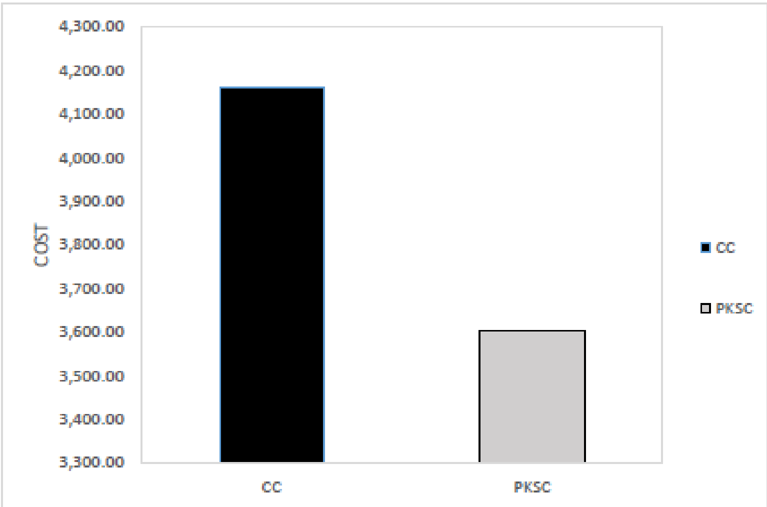

Fig 4 Cost variation between Conventional Concrete and PKSC

IV. CONCLUSION AND RECOMMENDATION

Based on the outcome of the study, the following conclusions were drawn:

- The SG, AIV, water absorption, of PKS were 1.48; 5.63; 19.133% respectively. These falls within the limit range of British Standard specifications as a lightweight aggregate. This implies that PKS is suitable for use as lightweight aggregate
- The density and Compressive Strength of PKSC were 1985.2 kg/m^3 and 20.9 N/mm^2 while that of control concrete were 2637.0kg/m^3 and 33.8 N/mm^2 after 28 days of curing.
- The cost/m^3 of producing PKSC was 13.4% less than the cost of producing control concrete
- The compressive strength and Density of control concrete was higher than that of PKSC but PKSC met the British Standard Specification for minimum strength of 15 N/mm^2 for lightweight concrete. PKS met all the specification as a replacement of coarse aggregate in concrete and cheaper than conventional aggregate in road wok.

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