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EVALUATION OF PALM KERNEL SHELL AS A PARTIAL REPLACEMENT FOR COARSE AGGREGATE IN CONCRETE

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ABSTRACT

The possibility of complete depletion of aggregates resources in the near future cannot be overemphasized. Rising construction costs and the need to reduce environmental stresses to make construction sustainable has necessitated research into the use of alternative materials, especially locally available ones which can replace conventional ones used in concrete production. Therefore, this study evaluated the strength of concrete produced using Palm Kernel Shell (PKS) as a partial replacement for coarse aggregate. Cement, sand, coarse aggregate, and palm kernel shell were used for the production of concrete. The ratio of these materials is 1:2:4 by volume batch and a total of 60 cubes were cast for compressive strength test with dimensions of 150 mm x 150 mm x 150 mm. The size of coarse aggregate which was used for the study passed through 16 mm sieve and retained on 12.5 mm sieve. The coarse aggregate was replaced by PKS of 0%, 5%, 10%, 15%, and 20%. All the samples were cured for 7 days, 14 days, 21 days, and 28 days before the compressive strength was determined. After these tests were carried out, the results were used to compare with the control sample. The results indicated that 5% partial replacement of coarse aggregate with palm kernel shell in concrete is good without heavily affecting the strength of concrete. Therefore, palm kernel shell is not a good substitute for crushed stone aggregates in concrete.

1. INTRODUCTION

Nigeria is a developing country, and for the continuous growth of this country, we need continuous development and leading factor for the development is infrastructure. The infrastructure involves a large amount of concrete, which is very costly and the cost is increasing day by day. Rising construction costs and the need to reduce environmental stresses to make construction sustainable, has necessitated research into the use of alternative materials, especially locally available ones which can replace conventional ones used in concrete production. Concrete is the world's most consumed man-made material (Naik, 2008). Its great versatility and relative economy in filling a wide range of needs have made it a competitive building material (Sashidar and Rao, 2010). Concrete production is not only a valuable source of societal development, but it is also a significant source of employment (Naik, 2008). Production of concrete relies to a large extent on the availability of cement, sand and coarse aggregates such as granite, the costs of which have risen astronomically over the past few years. Despite the rising cost of production, the demand for concrete is increasing. The negative consequences of the increasing demand for concrete include depletion of aggregate deposits, environmental degradation and ecological imbalance (Short & Kinniburg, 1978).

The possibility of complete depletion of aggregates resources in the near future can therefore not be overemphasized. The use of replacement materials for conventional ones should not only contribute to construction cost reduction and drive infrastructural development but also contribute to reduce stress on the environment and make engineering construction sustainable to help transform the building and construction sectors of national economies (Zemke & Woods, 2009). Palm kernel shell (PKS) is hard, carbonaceous, organic by-products of the processing of the palm oil fruit. PKS consists of small size particles, medium size particles and large size particles in the range 0-5 mm, 5-10 mm and 10-15 mm (Alengaram et al., 2010). Palm kernel shell (PKS) is obtained as crushed pieces after threshing or crushing to remove the seed which is used in the production of palm kernel oil (Olutoge, 2010). Palm kernel shell (PKS) is an agricultural waste obtained during the processing of palm oil. Agricultural wastes have advantages over conventional materials in low-cost construction (Abdullah, 1997). The use of waste material in construction contributes to the conservation of natural resources and the protection of the environment (Ramezanianpour, Mahdikhani & Ahmadibeni, 2009). Ndoke (2006) investigated the suitability of palm kernel shells as a partial replacement for coarse aggregates in asphaltic concrete.

In Nigeria, the annual generation of PKS as reported by Ndoke (2006) is about 1.5 million tons. A proposal for its use, particularly in regions where they are abundant, can enhance the realization of ‘Affordable Housing for All’ agenda of past Nigeria government (Olawuyi *et al.,* 2012). Previous studies have shown that PKS is suitable as a granular filter for water treatment, coarse aggregate in plain, lightweight, and normal weight concretes, and as a road building material. Palm kernel shell (PKS) is organic waste materials obtained from crude palm oil producing factories in Asia and Africa (Alengaram et al., 2010). Olutoge (2010) investigated the suitability of sawdust and palm kernel shell as a replacement for fine and coarse aggregate in the production of reinforced concrete slabs. He concluded that 25% sawdust and palm kernel substitution reduced the cost of concrete production by 7.45%. He also indicated the possibility of partially replacing sand and granite with sawdust and palm kernel shell in the production of lightweight concrete slabs. Olanipekun (2006) compared concrete made with coconut shells and palm kernel shells as a replacement for coarse aggregates and concluded that coconut shells performed better than palm kernel as a replacement for conventional aggregates in the production of concrete. The aim of this study is to evaluate the strength of concrete produced using Palm Kernel Shell (PKS) as a partial replacement for coarse aggregate.

2. MATERIALS AND METHODS

2.1 Materials

The cement and fine aggregate used was ordinary Portland cement. The fine aggregate was sourced from Iree, Osun State, Nigeria and conforms to the requirements of BS 12(1996) and BS 882(1982) respectively. The PKS used was obtained from Obaagun, Osun State, Nigeria. The PKS and fine aggregate/sand were thoroughly flushed with water to remove impurities that could be detrimental to concrete. The PKS and fine aggregates were sun-dried and kept in waterproof sacks. The granite (coarse aggregate) used for the study was 12 mm size. It was sourced from a quarry along Ikirun – Ijabe Road, Obaagun, Osun State, Nigeria. The water used for the study was obtained from a well. The water was clean and free from any visible impurities. It conforms to BS 3148 (1980) requirements.

2.2 Methods

The study utilized a mix ratio of 1:2:4, batched by volume and a total of 60 cubes were cast: 12 cubes for each percentage replacement of each mix. The coarse aggregate was replaced by PKS of 0%, 5%, 10%, 15%, and 20% by weight of the conventional material. The samples were removed from the mould after 24 hours and placed in a curing tank for 7 days, 14 days, 21 days, and 28 days before the compressive strength and compacting factor test was carried out. The casting was done in iron moulds measuring 150 mm x 150 mm x 150 mm internally. The samples were made in accordance with BS 1881(1996). Moulding and curing of samples were done at the Soil Mechanics and Materials laboratory of the Department of Civil Engineering, Osun State Polytechnic, Iree, Nigeria.

3. RESULTS AND DISCUSSION

3.1 Workability

The results obtained from the compacting factor test are presented in Table 1. The workability decreases with increase in the percentage replacement of coarse aggregates by palm kernel shells which was due to increase in the specific surface as a result of the increase in the quantity of palm kernel shells, thus requiring more water to make the specimens workable. Since granite is denser than palm kernel shells, replacement by an equal mass of palm kernel shells leads to a larger increase in volume than replacement by an equal volume of granite. Increase in the quantity of shells increases the specific surface area, thereby more water would be required. It can be seen from Figure 1 that the workability reduces as the palm kernel shell content increases.

Table 1: Results from the Compacting Factor Test

PKS Replacement (%)	0	5	10	15	20
Compacting Factor	0.87	0.85	0.83	0.81	0.79

3.2 Compressive Strength

The results of the compressive strength of volume-batched concrete are shown in Table 2. The effects of replacement of granite with palm kernel shell on the compressive strength of the samples are shown in Figure 2. It is seen that the compressive strength decreases as the palm kernel shell content increases. The compressive strength is maximum at 0% replacement and minimum at 20% replacement. The compressive strength reduces as a result of the increase in percentage replacement of granite. The specific area increases due to percentage increment in palm kernel shell content thereby requiring more cement paste to bond effectively with the shells. The bonding is inadequate because the cement content remains the same. The strength of a concrete depends to a large extent on good bonding between the cement paste and the aggregates.

Table 2: Compressive Strength of Volume-Batched PKS (Nmm^{-}2)

Age at testing (days)	Palm Kernel Shell Replacement (%)				
	0	5	10	15	20
7days	15.06	12.11	9.60	8.54	6.07
14days	18.65	14.92	13.43	12.36	7.22
21days	19.51	15.48	14.48	13.84	7.16
28days	21.26	16.29	15.40	14.22	10.24

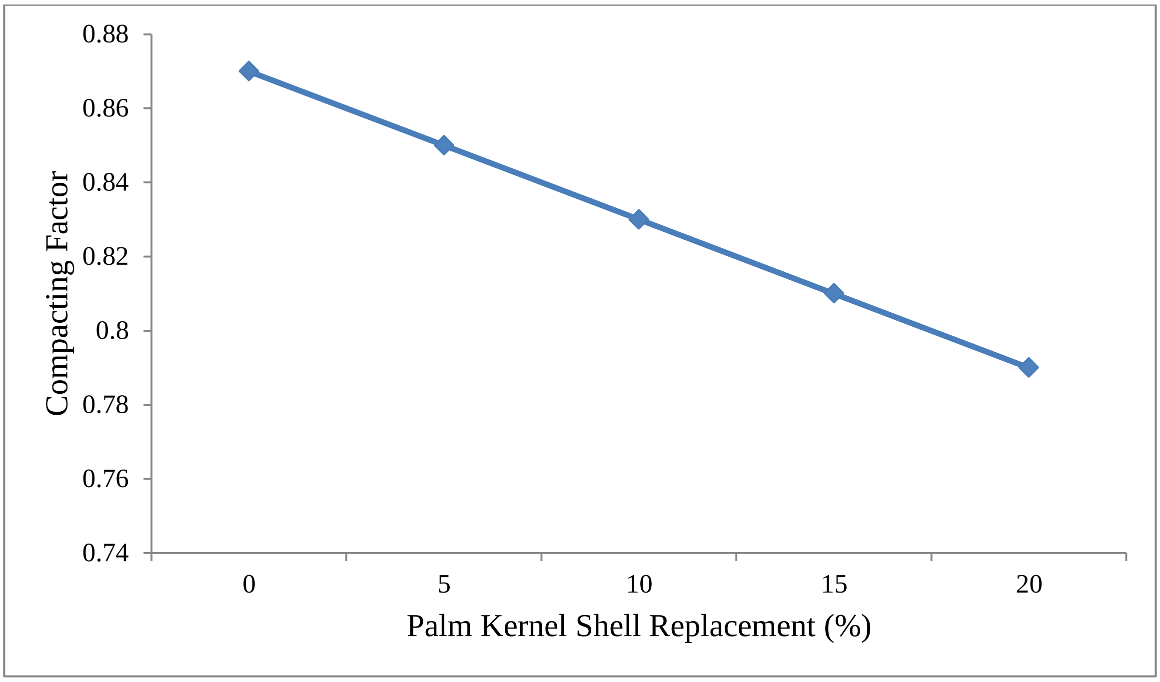

Figure 1: Variation of Compacting Factor with Palm Kernel Shell Content

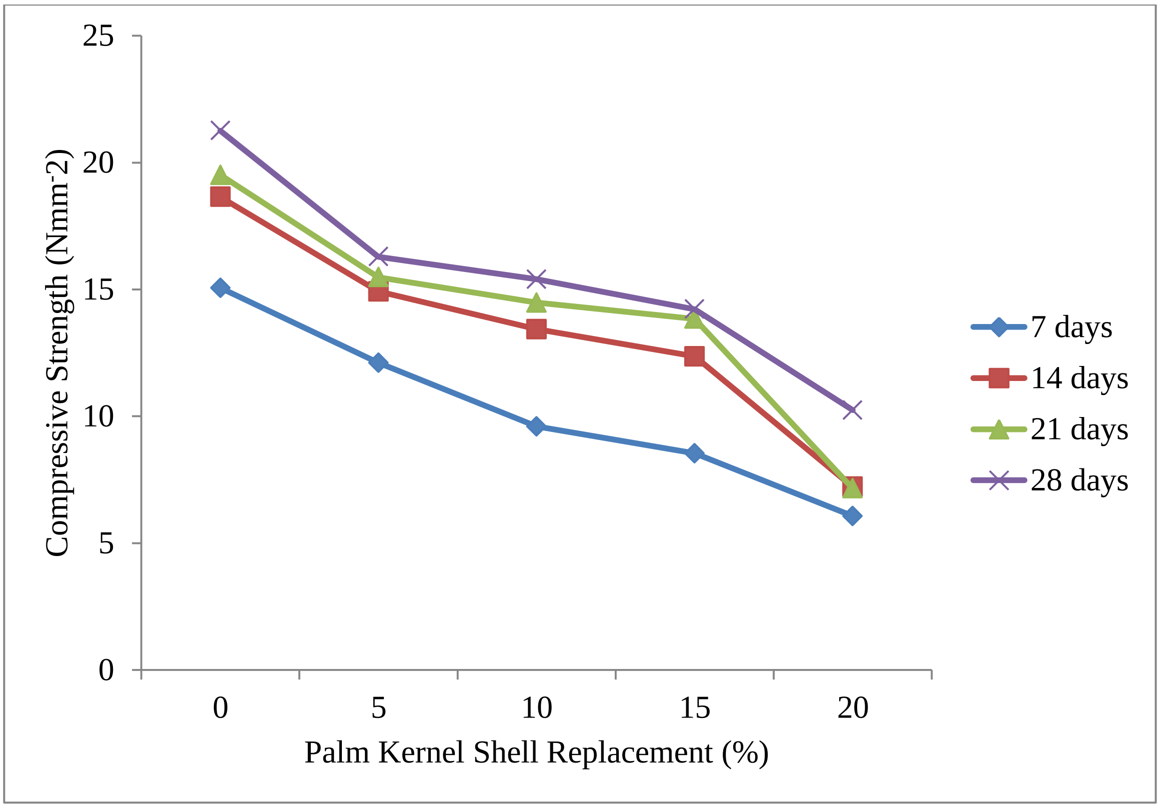

Figure 2: Variation of Compressive Strength with Palm Kernel Shell Content

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The following facts emerged from the study:

(1) Based on the results obtained, 5% partial replacement of coarse aggregate with palm kernel shell in concrete is good without heavily affecting the strength of concrete. Therefore, the optimum percentage of PKS replacement in concrete is 5% by weight of the conventional material.

(2) The use of palm kernel shell in concrete can solve the problem of environmental damage which can be caused by their disposal.

(3) There are potential cost reductions in concrete production using palm kernel shells as a partial replacement for crushed granite.

4.2 Recommendations

(1) Further studies are needed in various topics related to effective utilization and best incorporation techniques of waste materials in concrete.
(2) Government and researchers should integrate efforts toward preparing and implementing a sustainable solid waste management plan.

5. ACKNOWLEDGEMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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