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Investigation of the Strength and Workability of Composite Material (Palm Kernel Shells and Rice Husks) As Substitute to Granite in Concrete

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Abstract **Original Research Article**

This work investigates the suitability of a composite material (palm kernel shells-rice husks), as substitute to granite in concrete based on the compressive strength and workability of concrete. The aggregates were batched by volume in a ratio of 1:2:3, and water-cement (w/c) of 0.5. The percentage replacement of aggregates by palm kernel shells-rice husks composite was varied from 0% to 100% at intervals of 25%. The slump test was used to determine the workability of the fresh concrete. The compressive strengths of cured concrete cubes of sizes, 150mmx150mmx150mm were determined at 7days (2.74 N/mm^2), 14days (5.93 N/mm^2), 21days (7.63 N/mm^2) and 28days (9.18 N/mm^2) respectively. The result showed that the composite mix of $P_{75}R_{25}$ at 28-day curing period produced the best value of compressive strength 9.18N/mm^2. Thus, the result obtained from this study revealed that replacement of granite aggregate in concrete making with composite material of palm kernel shells and rice husks in batched volume proportion of 1 part of cement to 2 parts of sand to 3 parts of composite materials is adequate for construction of farm buildings when compared with normal weight aggregate one.

Keywords: Compressive strength, Workability, Palm Kernel Shell, Rice Husk and Concrete.

1.0 Introduction

Concrete is the most versatile heterogeneous construction material and the impetus of infrastructural development of any nation (Olutoge *et al.*, 2012). Concrete is a composite inert material comprising of cement, coarse, fine aggregates and water at different mix ratios. The use of concrete as building material is always in high demand. Good durability and workability of concrete makes it convenient for construction industry players. However, the high density of concrete will result in increased dead load on building structures because of use of steel reinforced concrete. The use of lightweight aggregates as lightweight concrete is an option to reduce the dead load on a building,

especially for high-rise buildings (Zulkarnain *et al.*, 2014). Continuous increase in the cost of construction is one of the major challenges the construction industry is encountering as well as quality discharge of great number of developmental projects, and as such projects are dependent on some factors of production, which is the cost of materials (Williams *et al.*, 2014). The rising cost of construction and the need to re-use some agro-wastes so as to reduce environmental stresses and make construction sustainable, has necessitated researches into the use of alternative materials, especially locally available ones which can replace conventional ones used in concrete production. There is need to get substitute materials, which are cheaper and durable. It is found that palm kernel shells have few users, and the remaining unused shells are left on the environment as pollutants and with time they decay to cause greenhouse effect, which is harmful to living organisms. It is on this backdrop that many attempts have been made to use palm kernel shells as concrete aggregates for lightweight concretes (Osei and Jackson, 2012). But the disposal of abundant palm kernel shells and rice husks agro-wastes by re-use as concrete aggregates needs to be studied. Palm kernel shells and rice husks are generally common agricultural waste materials from palm nuts and rice processing respectively. For this reason, many people have made attempts to find alternative use for these materials in abundance. It is hoped that the findings of this study would help construction industries to make good use of local agro-based materials such as palm kernel shells and rice husks in concrete production. The use of such replacement materials would not only contribute to construction cost reduction and drive infrastructural development, but also contribute to resource control measure to reduce stress on the environment, and avail engineering/construction technology the needed aid to transform the building and construction sectors of national economies, for the realization of global poverty reduction. Finally, it would reveal the potential characteristics of palm kernel shells and rice husks composite that would enhance its use as coarse aggregates for concrete production.

2.0 Materials and Methods

The materials used in this study include the following:

Palm kernel Shells (PKS) and Rice Husks (RH) as composite aggregates: The PKS were obtained from a mill at Mgbirichi community in Ohaji/Egbema Local Government Area of Imo State, Nigeria. The shells were put in basket, in batches and thoroughly flushed with water to remove impurities that could be detrimental to concrete. Also, the rice husks were obtained from Bende Town, in Bende Local Government Area of Abia State., Nigeria. Both materials were sun dried and kept in waterproof sacks.

P Fig. 1(a): Rice Husks

P Fig. 1(b): Palm Kernel Shells

Granite: 20mm size of granite sourced, from a quarry site at Okigwe, Imo State, Nigeria was used for this study.

Sand: The sand was sourced from Otammiri River at Federal University of Technology, Owerri, Nigeria. It was thoroughly flushed with water to reduce the level of impurities and organic matters and later sundried and kept in close doors, to prevent it from trapping any moisture that could cause bulking of aggregates so as to conform to the requirements of British Standards 882(1982).

Cement: Ordinary Portland cement manufactured by Dangote Cement Company was used, and it was sourced from Ihiagwa market, Owerri, Nigeria and conformed to the requirements of British Standards 12(1996) as stated in the manual of manufacturer and the cement pack.

Water: The water used for the study was obtained from a borehole at Federal University of Technology, Owerri, Nigeria. According to Oparaocha *et al.*, (2010), the water was clean and free from any visible impurities and it conformed to British Standards 3148(1980) requirements.

Table 1: Comparison of Properties of Aggregates

Properties	GRANITE	PKS	RH
Thickness (mm)	20	3.30	2.50
Bulk density (kg/m^3)	1650	970	940
Specific gravity	2.69	1.74	0.98
Water absorption for 24 h (%)	0.78	12.03	93.10

2.1 Batching and Mixing of Materials

The aggregates used for the experiment were batched by volume with a measuring tray in a ratio of 1:2:3 and water-cement (w/c) ratio of 0.5. The percentage replacements of aggregates by rice husk-palm kernel shell composite were 0%, 25%, 50%, 75% and 100%; this was done to determine the proportion that would give the most favorable result.

Fig. 2: Concrete mix

2.2 Casting and Curing of Samples

Molds of 150 x 150 x 150mm sizes were used and the cubes were molded on the same day which was done in accordance with British Standards 1881-108 part 122. The samples were demolded after 24 hours and kept in a curing tank for 7, 14, 21 and 28 days respectively.

2.3 Testing of Concretes

All tests were carried out at the structural/materials testing laboratory of the Civil Engineering Department, Federal University of Technology, Owerri, Nigeria. The tests include workability tests (using slump cone) and compressive tests, using automatic universal testing machine (WE-600B).

Fig. 3: Automatic Universal Testing Machine (WE-600B)

3.0 Results and Discussion

The workability tests results as shown in table 2 on the respective samples showed that the % composite mix of PKS and RH ($P_{75}R_{25}C$) needs more water as a result of its high-water absorption capacity, while the Normal Weight Aggregate Concrete (NWAC) showed true slump by falling within the recommended range. But that of Palm Kernel Shell-Rice Husk (PKSRH) was quite workable, but did not show true slump because of the absorption of some water.

Table 2: Workability test of NWAC and PKSRHC

S/No	Sample	W/C Ratio	Degree of workability (Slump) in Mm
1	NWAC	0.5	13
2	$P_{75}R_{25}C$	0.5	3

Note: NWAC=Normal Weight Aggregate Concrete (Granite), PKSRHC = Palm Kernel Shell-Rice Husk Concrete, $P_{75}R_{25}C$= % composite mix of PKS and RH

Table 3: Summary of Average Compressive Strength Test

TEST (N/mm^2)	7 Days	14 Days	21 Days	28 Days
NWAC	9.33	11.10	12.50	17.33
$P_{75}R_{25}C$	2.74	5.93	7.63	9.18

The Table 3 shows the compressive strength test of normal weight aggregate concrete and palm kernel shell-rice husk for 7 days, 14 days, 21 days and 28 days respectively. The results indicate that the compressive strengths of both concretes increased as the curing periods increased, with normal weight aggregate concrete having higher compressive strength than palm kernel shell-rice husk concrete. The compressive strength values gotten for various curing days was plotted using bar chart as shown in figure 1.

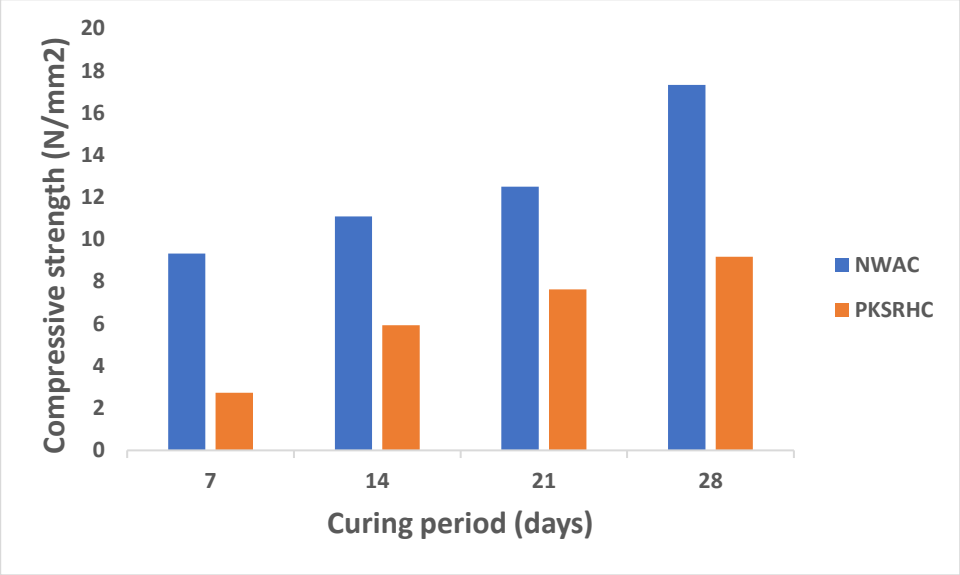

Fig. 4: Average compressive Strength of NWAC against PKSRHC

The average densities of the cubes produced with palm kernel shell-rice husk are 1501kg/m^3, 1729 kg/m^3, 2084kg/m^3 and 2262 kg/m^3 after each curing period, which concurred with Mannan and Ganapathy (2002) in classifying the concrete as semi light-weight concrete, which is a concrete with weight of 1842 to 2082kg/m^3.

4.0 Conclusion

This study shows that the use of PKS and RH as composite can be beneficial in concrete production. It can serve as lightweight aggregates in the production of plain lightly reinforced concrete. The PKSRH concrete is excellent and also workable as well as consistent. The hardened palm kernel shell-rice husk concrete produced enough strength that will help make it suitable for a wide range of uses. However, the compressive strength values of the normal weight aggregate concrete are almost twice that of palm kernel shell-rice husk concrete, which is normal as PKSRH composite is lighter. The specific gravity of PKS and RH aggregates are relatively low compared to the range of values for different coarse aggregate as a result of the high amount of voids within the particles. Therefore, it can be concluded that there are potential cost reductions in concrete production using palm kernel shells-rice husks composite as partial replacement to obtain a desired strength in building construction projects.

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