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IMPACT OF PARTIAL REPLACEMENT OF GRANITE WITH PERIWINKLE AND PALM KERNEL SHELLS ON CONCRETE STRENGTH

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Concrete has been universally known as conventional building material, which has great effect on walling unit of building production and its component. This experimental study sought the strength parameter of concrete produced with partial replacement of granite with 25% of Periwinkle and 25% Palm kernel shells respectively for future intending use.12 concrete cubes were produced with design mix of 1: 1½: 3 concrete and they were cured for 7, 14, 21 and 28 days to attain maximum strength. Physical properties conducted on the materials were specific gravity (SG), water absorption (WA), grain size distributions, dry and bulk density and mechanical property was also determined through compressive strength to analyze the strength parameter of the concrete. The outcome of the mean strength of three concrete cubes produced, revealed that it increased as the age of concrete progresses from 9.93 N/mm^2 at 7 days, to 12.35 N/mm^2 at 14 days, 13.73 N/mm^2 at 21 days, and as high as 14.93 N/mm^2 at 28 days respectively. Therefore, a design mix of 1: 1½: 3 of concrete produced with 25% Periwinkle and 25% Palm kernel shells is advised to be used for lightweight concrete and non-load bearing components in building especially pedestrian, non-motorable way, kerbs for cost effective and waste reduction.

Keywords: Concrete production, Mechanical property of concrete, Non-load bearing components, Physical properties of concrete.

1 INTRODUCTION

Concrete is a constituent construction material (Ede *et al.* 2017) that its standard cannot be compromised for cost reduction. But the rising production cost of concrete has always been an issue of concern to many low-income earners. One of the reasons why developing countries are still suffering from housing deficit is the high cost of production, particularly cost of materials is always on increase level every day. Ogunbayo *et al*. (2016) noted that in Nigeria prices of rented accommodation have grown over 12.8% the universal inflation rate, thereby limiting the effort of stakeholders to make affordable housing availability. In order to cater for housing demands, construction industry have to look inward on some locally source non-conventional building materials that could be developed to serves the same purpose as conventional material.

Waste management is one of the areas that could be harnessed to provide needed succor once the economic value of some of the materials considered as wastes are fully determined. This pointed attention of this research work on the use of some of marine and agricultural waste products in line with goal 11 of Sustainable Development Goals (SDGs) that encourage use of locally source building materials in protection of climate and ensure housing are affordable for all. A call for sustainable, environmentally friendly and cost-effective building materials has increase research focus on some available agricultural waste for the intending uses as non-conventional building material. Palm tree is one of the cash crops grown majorly in the tropical regions around the world, while palm kernel shells comes as an agricultural waste product gotten from palm oil production. As such, they are generated in large quantities within the area where the tree is available (Olanipekun *et al.* 2006). Palm kernel shells are mostly used with firewood for domestic cooking in some area, while other shells are piled up as waste products adding to environmental pollution (Ndoke 2006). Olanipekun *et al.* (2006), and Osei and Jackson (2012) noted that concrete strength produced with palm kernel shells gain strength gradually as the age of concrete increases. Olusola and Babafemi (2013) obtained 18.13MPa of lightweight concrete at optimum use of 50% palm kernel shells replacement. Also, a good lightweight concrete could be gotten if 25% (1: 1: 2) coarse aggregate is partially replace with palm kernel shells.

Periwinkle is one of the seafood located in Badagry, Port-Harcourt, Calabar, Ikot-Abasi and other coastal cities in Nigeria (Dauda *et al.* 2018). However, periwinkle shells become a waste once the small greenish-blue marine snail has been eaten. The shell possesses brittle, strong tough quality. Agbede and Manasseh, (2009), Otunyo *et al.* (2013) and Soneye *et al.* (2016) studied the limit at which periwinkle shells could be partially replaced with coarse and fine aggregates in Sancrete block and concrete production. Oluwatuyi *et al.* (2018) and Rahgozar *et al.* (2018) recommended the use of milled eggshell and Rice Husk Ash as eco-friendly stabilizer for lateritic soil. Joshua *et al.* (2015) posit the use of 10% of palm kernel nut ash (PKNA) as pozzolanic in partial replacement of cement. In line with this background this experimental study sought the strength parameter of concrete produced with partial replacement of 50% of granite, 25% of Periwinkle and 25% Palm kernel shells for intending usage in concrete production and other building components.

2 MATERIALS AND METHODS

This research got periwinkle and palm kernel shells for the study from Badagry in Lagos State. Both the periwinkle and palm kernel shells were washed separately with warm water in order to get rid of unwanted particles and periwinkle oysters from the shells. The shells were sun dried after washed to be ready for concrete production. Both the river sand and granite were gotten from quarry site, Abeokuta, Ogun State respectively. 42.5 N grade of Ordinary Portland Cement (OPC) gotten from vendor shop at Ota town, was in line BS EN 933-1 (1998) standard. However, this study used clean water as specified in BS EN 100 (2002). Design mix of 1: 1½: 3 was batched by volume because periwinkle and palm kernel shells have lesser weights compared with granite. The physical properties' tests conducted were grain size distributions, water absorption, dry and bulk density BS EN ISO 10545-3 (1997). While mechanical property was determined through compressive strength. The experiment adopted 0.5 water/cement ratio, mixing of the concrete materials and casting of 150 mm^3 concrete cubes were done manually. 12 numbers of 150 mm^3 concrete cubes were casted and compacted in three layers, each layer compacted 25 times using 25 mm diameter of tapping rod to ensure that all the pure spaces within the concrete cubes were eliminated. This process was followed by complete emersion of concrete cubes into curing tank for 28 days. Tools used for manual production of concrete include wheelbarrow, head pan, shovel, curing tank, 150 mm x 150 mm x 150 mm concrete cubes mould. Apparatus used are manual sieve shaker for the grain size distribution, digital weighing balance, thermostical oven and digital compression testing machine Model YES-2000, 2000KN

Max.Capacity, manufactured in July 2010 were used for the experiment (Figure 1). Dimension tolerance as reported in (Ajao *et al* 2018, Ogundipe *et al.* 2018b) studies was considered when the experiment was carried. Also, safety precaution and recommendations of (Ogundipe *et al.* 2018a, Ogundipe *et al.* 2018b) were strictly comply with.

Figure 1. Compression testing machine.

3 RESULTS PRESENTATION

Table 1 showed the results of specific gravity (SG) and water absorption (WA) for granite, river sand, periwinkle, and palm kernel shells. The value of SG and WA of (1.51, 8.7%); (1.38, 5.67%) were recorded for PKS and PS, respectively. The water absorption value shows the percentage of porosity the aggregate possesses, it will also determine the water cement ratio for any concrete mix-design produced with these materials. The SG value did not meet the 2.5 – 3.0 recommended for normal weight aggregate, the value generated indicate that both the periwinkle palm and kernel shells are suitable as lightweight aggregate, this corroborate with Olanipekun *et al.* (2006) and Olusola and Babafemi (2013). However, the value of SG and WA (2.66 and 2.62) for granite and river sand are within the standard value 2.5 – 3.0 BS EN ISO 10545-3 (1997).

Table 1. Specific gravity and water absorption.

Physical properties	Granite	Palm kernel shells	Periwinkle shells	Sand
Aggregate Size (mm)	20	20	20	4.75
Specific Gravity (SG)	2.66	1.51	1.38	2.62
Water absorption	3.83	8.7	5.67	3.65

3.1 Density

The result presented in Table 2 showed that the concrete has average bulk density of 2222 kg/m^3 at age 7 days, 2388 kg/m^3 both for 14 days and 28 days respectively.

Table 2. Density of concrete cubes made with 50% granite, 25% Periwinkle and 25% Palm kernel.

S/N	Dry Mass (kg)	Age (days)	Cube Volume (m^3)	Average Bulk Density (kg/m^3)	Mean Bulk density (kg/m^3)
1	7.5	7	0.003375	2222	
2	8.0	14	0.003375	2388	2333
3	8.0	28	0.003375	2388	

3.2 Grain Size Distribution

Figure 2 and 3 presented the results of grain size distribution obtained from the experience. River sand coefficients of curvature (CC) = 1.78, coefficients of uniformity (CU) = 11.42; Granite has CC = 1.50, CU = 4.04; Periwinkle CC = 1.02, CU = 1.36; and Palm kernel (CC) = 0.89, = 1.35. A CC of 11.42 and 4.04 for river sand and granite, meant that the grain size distributions of river sand and granite used are well graded as noted in Vandevelde (2008) and Ogunbayo *et al.* (2018).

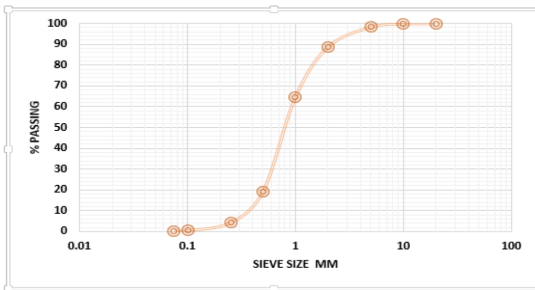

Figure 2. Grain size distribution river sand.

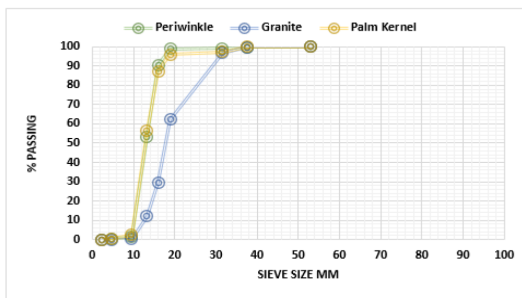

Figure 3. Grain size distribution Granite, Periwinkle and Palm kernel.

3.3 Compressive Strength

Table 3 revealed gradual increase in mechanical properties of concrete cubes tested, at the age of 7 days the concrete attains 9.93 N/mm^2, followed by the result of 14 days 12.35 N/mm^2. However, on the 21 days the concrete has gained 13.73 N/mm^2 before the maximum strength was attained at 28 days 14.93 N/mm^2. The result showed an increase in mechanical property of concrete, as the age of concrete progresses.

Table 3. Compressive Strength of Concrete procedure with 50 % granite, 25% of Periwinkle and 25% Palm kernel shells.

Age of Concrete	Size of Concrete Cubes (mm^3)	Cube 1 N/mm^2	Cube 2 N/mm^2	Cube 3 N/mm^2	Mean Value N/mm^2
7	150	9.7	9.93	10.2	9.93
14	150	14.2	11.4	11.9	12.35
21	150	14.5	15.2	11.49	13.73
28	150	16.3	13.57	14.92	14.93

4 FINDINGS AND DISCUSSIONS

This experimental study sought the strength parameter of concrete produced with partial replacement of 50% of granite, 25% of periwinkle and 25% palm kernel shells for intending future usage in concrete production with reliable and stable strength for walling units and other building components. The result of concrete strength gotten from this study is an improvement on findings of (Olanipekun *et al.* 2006, Osei and Jackson 2012, Olusola and Babafemi 2013). Other concerned researcher limited their effort on the combination of two components viz: Granite and periwinkle or Granite and palm kernel shells but this study went further to combine three components together. Therefore 50% of Granite is combined with 25% palm kernel and 25% periwinkle shells respectively to produce lightweight concrete at a design mix of 1: 1½: 3. Approximately 15 MPa of concrete was produced from the above materials and the result revealed an increase in mechanical property of concrete, as the age of concrete progressed, until 28 days when optimum strength of 14.93 N/mm^2 was recorded. The concrete maintained average density of 2222 kg/m^3 at age 7 days after complete immersion in curing tank. However, the density increased at age 14 days to 2388 kg/m^3 and maintained this same density up to the 28 days of curing. The results of water absorption and specific gravity for palm kernel and periwinkle shells fell below the required standard BS EN ISO 10545-3 (1997). The effect of these on concrete is an indication that both materials have tendency of absorbing lesser water from water cement ratio used for concrete production. The grain size distributions showed that only granite and river sand used for the experiment are uniformly graded.

5 CONCLUSION AND RECOMMENDATION

The physical and mechanical parameters of lightweight concrete palm kernel and periwinkle shells were experimented for possibility of adoption for construction purposes. Palm kernel and periwinkle shells are known as waste products, they have lesser density compared to that of granite. The combination of these three different coarse aggregate materials proved to be more suitable for the production of lightweight concrete. As it was observed from the results of grain size distributions of palm kernel and periwinkle shells, the materials have a reliable co-efficient of curvature with possibility of producing a more homogeneity aggregate performance and avoid a concrete having honeycomb. The aggregate with small grain sizes can fuse well into one another to improve the strength parameters of the concrete. This tends to provide cost effectiveness and waste reduction, because periwinkle and palm kernel shells currently constitute waste materials in any regions where they are found. Therefore, any effort to consider these materials as future green economy scale of producing concrete will go a long way in meeting the SDGs goal 11 for the production of locally non-conventional building materials. It will also be useful for the production of non-load bearing walling units and other lightweight elements like pedestrian, non-motorable way and roadside kerbs. The most importance aspect of this study is to promote the use of PKS and PS wastes as partially replacement of conventional materials in concrete production, thereby resulting into cost and waste reduction in the society.

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