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Prognostication of Performance of the Fresh and Hardened Concrete Made With Palmkernel and Periwinkle Shell as Partial Replacement of Coarse Aggregate at Varying Proportions

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***ABSTRACT** : This study evaluated the performance of concrete which its coarse aggregate component was partially swapped with the periwinkle shell (PWS) and palmkernel shell (PKS) at certain percentages. A total of 36 concrete cubes of sizes 150 by 150 by 150 mm3 with different percentages by weight of crushed granite to PWS and PKS as coarse aggregate with respective ratios of 100:0, 80:20 for each were cast and tested after 7, 21, and 28 days of curing. A comparative analysis of periwinkle shells and palmkernel shells on the mechanical property were performed to determent the effect of the aggregate nature and sizes on the weight, workability and compressive strength of the concrete. The results showed that the compressive strength of the 28 days PKS and PWS with 20% replacement were 9.1N/mm2 and 13.1N/mm2 respectively and that of 28days of granite concrete without replacement was 15.8N/mm2. This means that the compressive strength of natural, PKS and PWS concrete increases as the curing days increases. The compressive strengths of the concrete made of natural concrete were greater in all numbers of curing days compared to that of PKS and PWS concrete. Meanwhile, the compressive strength of the concrete made with 20% of periwinkle shell is great compared to that of 20% palmkernel shell for all the curing ages. The result shows that the weight of concrete made of natural concrete before curing of 7 days, 21days and 28days respectively differs and heavier than the concrete made of 20% of PKS and PWS replacement. It is also observed that the weight of concrete made with 20% of PKS is lighter comparable to that of 20% of PWS and control after 28 days of curing. This means that substituting the granite with PKS and PWS as aggregate produces a light weight concrete which is more durable with a considerable higher economic benefits and PKS concrete is more economically viable compared to the natural concrete and periwinkle shell concrete.*

***KEYWORDS:** Effect of aggregate sizes, mechanical properties, palm kernel shells (PKS), periwinkle shells (PWS)*

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I. INTRODUCTION

Portland cement concrete is defined as a composite of fine and coarse aggregates, bonded together by a cementitious material in a wet state and gets hardened over time after mixing. Rocco [1] defined concrete as a composite material made of aggregates bonded together by moistened cement which hardens over time. As a composite material, concrete is composed of a mixture of cementitious material, fine aggregates (e.g. sand) and coarse aggregates (e.g. stones) mixed with water, and with or without the addition of admixtures; which hardens over time. Concrete can be used as plain concrete or reinforced concrete for construction, to build durable and long-lasting structures [2]. Aggregates and ordinary portland cement are most vital components of concrete. The cement reacts with the water in the mix to form a hard matrix that binds the aggregates together into a durable and strong material used for different purposes [3]. Cement is currently used cementitious material over others like lime, for the production of concrete while the aggregate give stability, volume and improve the mechanical properties of the concrete [4]. Aggregates are granular (grainy or coarse) materials, which include as sand, crushed ceramics, gravel, iron blast-furnace slag, or crushed hydraulic-cement concrete, crushed stones, used with a hydraulic cementitious material to produce either concrete [7].

Mechanical properties of concrete include all the physical properties that a concrete mixture exhibits upon the when forces are applied on it such as hardness, modulus of elasticity, compressive strength and fatigue limit. The compressive strength of concrete is usually influenced by some factors including; water-cement ratio, aggregate size, degree of compaction, shape and can also be affected by age, type of material, and the process of curing, water cement ratio, size of aggregate, type of aggregate, and some other parameters [5]. The compressive strength of concrete is usually influenced by some factors including; water-cement ratio, aggregate size, degree of compaction and shape. Conventionally, aggregate gradation plays an important role in concrete mixing and about 65-70% volume of concrete will be occupied by natural aggregates (both coarse aggregates and fine aggregates). Structural engineers pay keen attention to the compressive strength of concrete as the major mechanical property of concrete before commencing the erection of any concrete-based structure [6].

Aggregates are granular (grainy or coarse) materials, which include as sand, crushed ceramics, gravel, iron blast-furnace slag, or crushed hydraulic-cement concrete, crushed stones, used with a hydraulic cementitious material to produce either concrete [7]. Various reports have predicted that concrete production will increase up to 18 billion tons per year by 2050, which represents a significant consumption of the scarce natural resources [8]. Due to the increasing demand for concrete, its costs of production have increased as a result of the scarcity of these aggregates used for its production. Annually, the construction industries use large quantities of naturally occurring aggregates, which has led to the depletion of raw materials and degradation of the ecosystem [16]. The production of these aggregates also constitute a number of environmental hazards: natural coarse aggregates are obtained from natural resources like stone by quarrying rocks which is the use of heavy explosives that have negative impacts on humankind. The high-frequency sound generated from heavy machinery involved during mining and crushing of stones in a free environment is the primary cause of noise pollution [18]. According to [8], the level dust that is often released during the process of quarrying cause induced air pollution, causing a high level of risk of breathing and general health problems. The dust produced through quarrying also have negative effects on the plant and animal lives in the surrounding. The impacts of blasting will negatively affect human health. Uncontrolled blasting in mines may lead to earthquakes and alter the landscape. The process of quarrying also leads to the depletion of the ozone layer and causes harm to the ecosystem.

In a bid to reduce the cost of construction, in order to provide for low-cost housing for the large populace, the use of locally-available substitutes to granitic chippings in concrete-making has to be more seriously investigated [17].This calls the need to use improved aggregate which entails replacement with other agricultural materials such as coconut shell, periwinkle, palm kernel ash and palm frond ash [9] that leads to the reduction in amount of cement and water required for concrete production. This is because aggregate allows the volume below the concrete to become a void, or at best, to be filled with finer particles of sand and cement only and results in a weakened area [10]. In addition, the littering of agricultural waste such as palm kernel shell and periwinkle shell indiscriminately has been a source environmental hazard and pollution. To secure the future generations, alternative sustainable coarse aggregate has become an urgent need in the construction industry and many scholars have carried out so many research works on the use of alternative materials as coarse aggregates.

According to some recent studies, the utilization of agricultural waste materials as development materials has some advantages, which includes, maximizing the cost of construction, sparing in vitality, and security of the environmental condition [11, 12]. Coconut shell was found to be one of the fundamental sources of contamination issues as rural garbage [13, 14]. Palm kernel shell consists of small, medium and large sizes of particles in the range 0-5 mm, 5-10 mm and 10-15 mm respectively; they are degradable waste products obtained as a byproduct of palm fruit after being processed for palm oil [15].

This study will significantly save the nature and the ecosystem at large by putting a stop to the massive use of natural resources as aggregates in concrete. The study will also decrease the rate of airborne and waterborne diseases in our society and improve the quality of concrete by reducing the weight of concrete for construction, decline the chances of natural disaster occurrence and preserve our natural resources. Therefore, in line with previous studies on the replacement of granite with more sustainable agricultural waste materials, this study will focus on the use Periwinkle shell and Palm kernel shell by examining the effects of aggregate sizes on the mechanical properties of concrete considering different replacement characteristics for the conventional granite.

A. The Use of Periwinkle Shell and Palm Kernel Shell as Replacement for Coarse Aggregate

In the coastal communities worldwide, Periwinkle (Tympanotonus fuscatus) is a major source of proteins and other vital minerals in most food consumed by the people in such places. These aquatic species known for their nutritional value, have shells which are the sources of environmental deterioration because they are indiscriminately littered in the environment. Periwinkle shell is an agricultural waste product that is commonly found in the coastal communities and it is known for generating a high level of waste in the environment. They constitute a great deal of environmental problems because they are relatively non-degradable. The absence of a proper waste management program leads to the blockage of drainages, resulting in flooding [19]. It also forms voids in the soil when they become weak, thereby making the soil unfit for foundation. Many of these environmental problems could be solved by using the periwinkle shells as primary production materials, especially in concrete making and the diagram of periwinkle shells and palmkernel shell is presented in the Fig. 1 and 2 respectively [19].

On the other hand, palmkernel shell consists of small, medium and large sizes of particles in the range 0-5 mm, 5-10 mm and 10-15 mm respectively; they are degradable waste products obtained as a byproduct of palm fruit after being processed for palm oil [15]. The socio-economic imparts of Palm kernel shell include the management of environmental pollution as it provides environment-friendly way of disposing Palm kernel shell, motivation for expand oil palm production by the producing areas, leading to increase in farmers earnings, economic incentive of the growing community and the countrys gross domestic product (GDP)[20]. The chemical composition of Palm kernel shell was observed to vary due to several factors which include species or varieties, climate, geographical location, origin of operation, treatment and processing methods [21]. The use of palm kernel shell as a complete replacement for coarse aggregate for concrete production is a positive development towards achieving a sustainable concrete production as it requires little or no energy for production unlike the crushed stones, which demands a significant amount of energy during extraction and processing, resulting in the emission of CO_2.

Fig. 1: Periwinkle shells

Fig. 2: Palm kernel shell

Ibearugbulem [22] have categorized periwinkle shells as lightweight class of coarse aggregates according to the specifications of ASTM specifications for concrete. The study in [23], explored the use of periwinkle shells as coarse aggregates in concrete works and came to a conclusion that about 42.5% replacement of crushed granite with periwinkle shells by weight still gives concrete with permissible compressive strengths. Osarenmwinda et al. [24] also investigated the potentials of using periwinkle shell as coarse aggregate for lightweight concrete and found that concrete produced with different cement-sand-periwinkle mixes had compressive strength values ranging from 14.00 N/mm2 to 25.67 N/mm2 at 28 days of age. The results of the above studies suggest a high potential of using of periwinkle shells as coarse aggregate for making concrete.

Mohamed eta al. [25], in their research investigated the proportioning of the mixture lightweight concrete made with oil palm kernel shell with a batch of 1:1.6:0.96 and 1:1.53:0.99 for CS: PKS (cement: sand: Palm kernel shell) ratio with cement content of 450kg/m3 which gave a minimum of 20mm slump, with density in the range of 1800 and 1900kg/m3 and a minimum compressive strength of 15N/mm2. Research by Yusuf et al. [26] on the structural application of lightweight concrete incorporated with palm kernel shells using a mix ratio of 1:1:2 and a water-cement ratio of 0.5. Palm kernel shell made concrete beam at 28 days of age gave a flexural strength of 2.883N/mm2 and deflection of 0.947mm showing a total resistance of 3981N to load. Elnaz et al. [27] compared the effects of cockle and palm kernel shell on pervious concrete pavement.

II. MATERIALS AND METHOD

A. Cement and Water

An Ordinary Portland Cement was used as the binding material for this experiment (Elephant Superset Cement), and was obtained from a retail shop in Umuahia. Clean potable water from the Civil Engineering Workshop in Federal University Owerri, Imo State Nigeria, and taps to ensure continuous hydration and conform to the specification of BS EN 1008 was used for both specimen preparation and curing. In line with the specification, the water used was free from reactive elements such as reactive ions and impurities to guarantee the quality of concrete.

B. Fine and Coarse Aggregate

All aggregates were free from dust as dust may affect the bond between the aggregate and cement particles. The sharp sand were used as the fine aggregate for this experiment and was obtained from the Otammiri River, which is situated in Owerri L.G.A of Imo state, Nigeria. Normal coarse aggregate used for this practical was well selected from the set of granite sold at Abakiliki, Ebonyi State; it was free from detrimental coatings of dust and clay. Periwinkle shell (PWS) will be obtained from restaurants and other small rivers in the rural places where they can be found. Palm Kernel Shell was obtained from a local oil mill in Umuahia and local restaurants respectively, wash them thoroughly and sun-dry them for the laboratory tests. Particle size distribution of these elements was determined to know their grading. They were used to produce different sets of concrete which was cured for different number of days after which the strength of the concrete cubes and tested using destructive test method. Then, a comparison was made between the strength of the normal concrete and the other concretes produced with the agricultural wastes, to check if they are suitable for construction.

C. Experimental Design Program

This experimental investigation aimed at determining the effects of aggregate sizes on the mechanical properties of concrete considering different replacement characteristics of cement from 0-40**%** on the physical and mechanical behavior and with water cement ratio of 0.5. The experimental investigation were carried out on the fresh and hardened concrete samples and rheological and mechanical characteristics of the concrete was evaluated.

Concrete mix design was employed to enable the proportioning of available materials to produce concrete of desired strength thereafter, different proportions of granite replacement with periwinkle and palmkernel shell was done at constant cement, sand and water to produce concrete having the specified properties. In this research thirteen different mixes were prepared employing 6.3mm size natural gravel. This will be achieved, by determine the concrete weight, water-cement ratio and compressive strength of normal cement-concrete and those made with palm kernel shell and periwinkle shell as the coarse aggregate at 20% replacement. Thus, experimental test for sieve analysis, specific gravity, setting time, slump test and compressive strength test was performed to determine the particle size distribution of materials, weight, workability and mechanical property of the concrete. The above experiments will be carries out according to the experimental design tabulated below.

Table 1: Experimental design for the mix of the concrete composite

S/N	Granite (%)	Palm Kernel Shell (%)	Periwinkle Shell (%)	Experimental Run
1	100	0	0	Control (100% Granite)
2	80	20	0	20% PKS
3	80	0	20	20%PWS

III. RESULTS AND DISCUSSION

A. Sieve Analysis

The result of sieve analysis for fine aggregate of 400 grams, graphite-coarse aggregate of 1000 grams, PKS coarse aggregate of 400 grams and PWS coarse aggregate of 500 grams by weight are presented in Fig. 3, 4, 5 and 6 respectively as the particle size distribution curve graph. The particle size distribution curve can be used to compare different soils, it shows the size ranges of particles found in the soil and also shows whether they are well-graded or not.

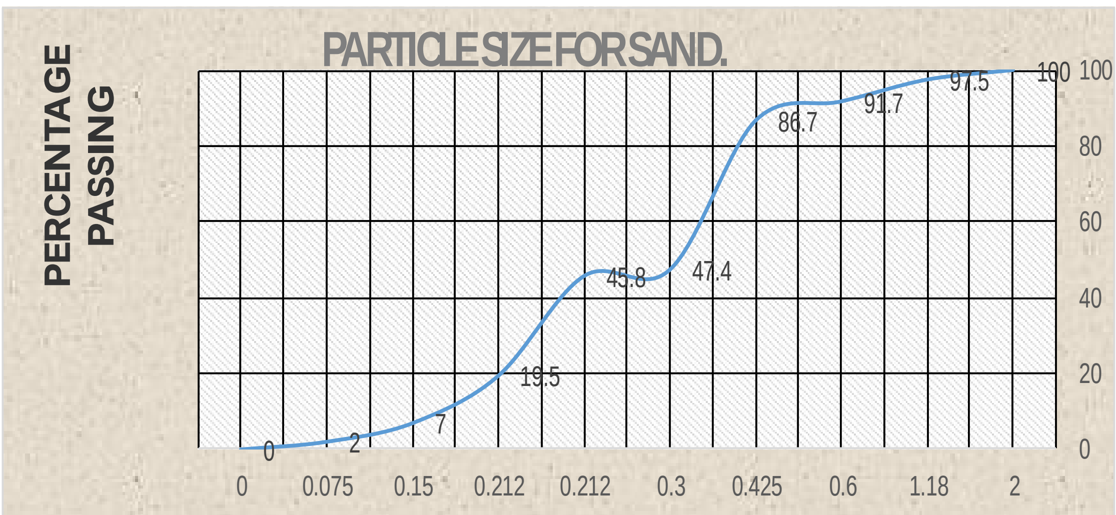


Fig. 3: Particle size distribution curve for fine aggregate 400g by weight

The weight of the sieve retained, percentage retained, cumulative percentage and percentage passing were calculated for all the sieve. The value of percentage of sieve passing is plotted against the particle size of the material to be sieved. According to Nigerian Standard by Federal Ministry of Works and Housing (F.M.W & H-2013), specification requirement in clauses 6201 and 6252, material passing the 425µmsieve shall have a liquid limit of not more than 35% and a plastic index (P.I) of not more than 12% as determined by American Society for Testing Materials Method. The fine aggregate used for this study satisfies its condition which makes it suitable as a subbase material. The sieve analysis of fine aggregate used for the study as presented in Fig. 3 shows that characteristics fraction passing sieve number 200 is classified as A-3 with less than 10% passing through the sieve no 200. This implies that the soil is a fine sand. The result in the Fig. 3 shows that as the size of sieve decreases from 2 to 0.075, the average percentage passing in the sieve decreases 100 to 7. According to unified soil classification system flowchart for coarse-grained soils and the result gotten in Fig. 4 above, it shows that coarse aggregate has group symbol GW and group name well-graded gravel.

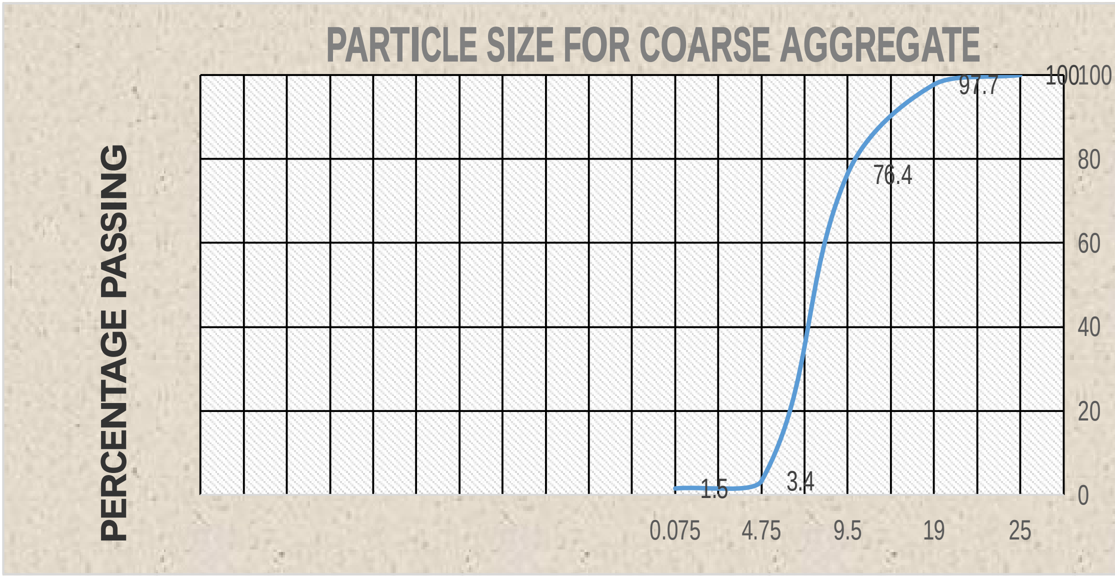


Fig. 4: Particle size distribution curve for coarse aggregate 1000g by weight

The sieve analysis of coarse aggregate test is a fundamental and essential test for all coarse aggregate in the field laboratories and is known as the gradation test. With the help of analysis of coarse aggregate test, we can determine the particle size distributions within a given sample for aggregate specifications verification with design requirements and production control requirement. The result in the Fig. 4 shows that as the size of sieve decreases from 25 to 4.75, the average percentage passing in the sieve decreases 100 to 3.4. According to unified soil classification system flowchart for coarse-grained soils and the result gotten in Fig. 4 above, it shows that coarse aggregate has group symbol GW and group name well-graded gravel.

The result in the Fig. 5 shows that as the size of sieve decreases from 25 to 4.75, the average percentage passing in the sieve decreases from 100 to 0.68. From Fig. 5, it is observed that according to unified soil classification system flowchart for coarse-grained soils and the result gotten, PKS aggregate has group symbol GW and group name well-graded gravel.

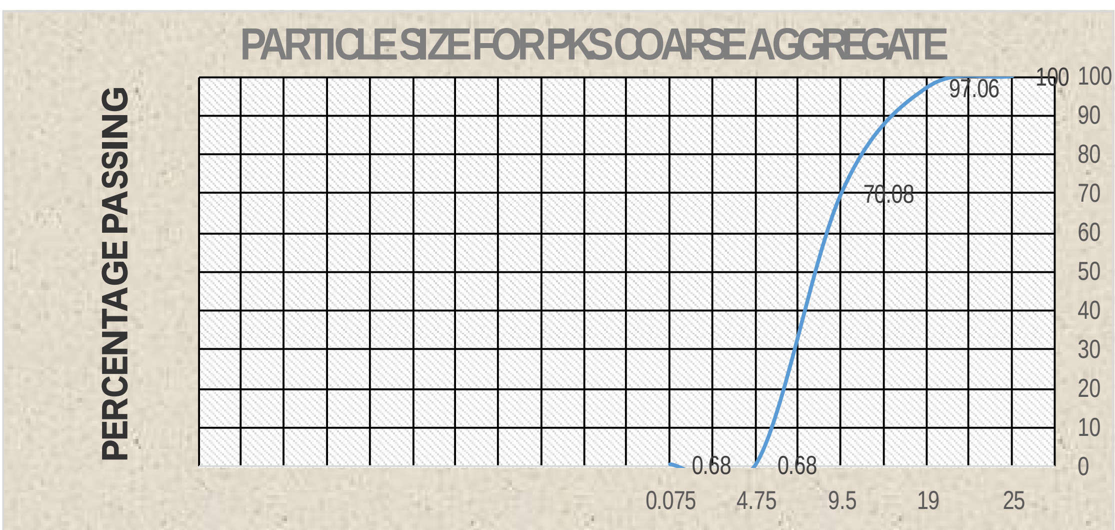


Fig. 5: Particle size distribution curve for PKS coarse aggregate 500g by weight

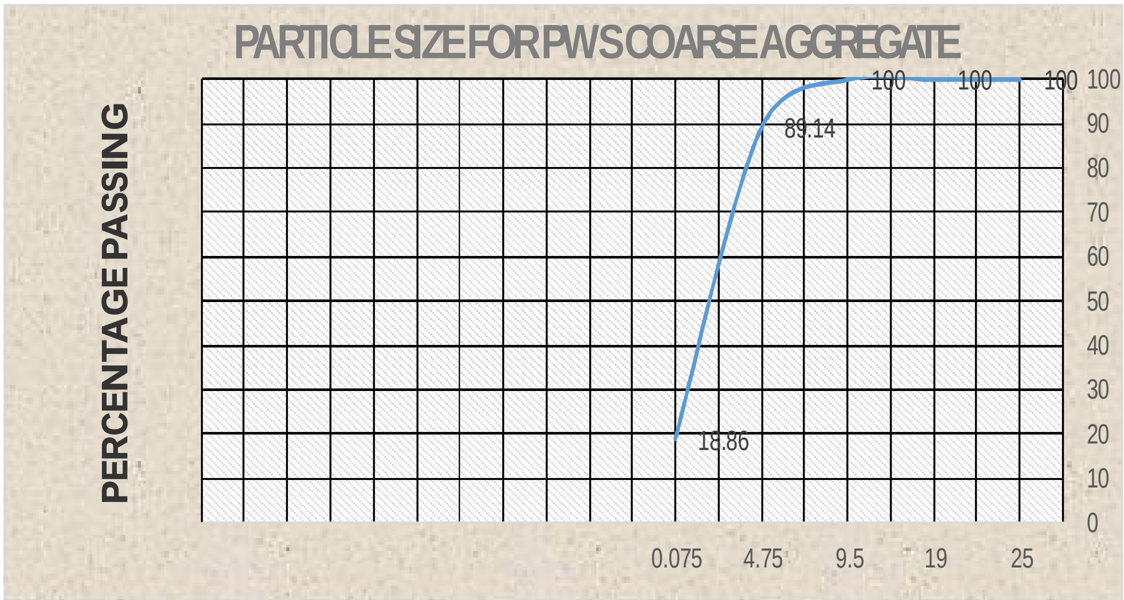


Fig. 6: Particle size distribution curve for PWS coarse aggregate 500g by weight

The result in the Fig. 6 shows that as the size of sieve decreases from 25 to 4.75, the average percentage passing in the sieve decreases from 100 to 89.14 Considering the unified soil classification system flowchart for coarse-grained soils and the result gotten from Fig. 6, the coarse aggregate has group symbol GW and group name well-graded gravel with Sand.

B. **Specific Gravity**

The equation of specific gravity as state below was used to calculate the value of specific gravity for the cement, fine and coarse aggregate. This was achieved by substituting the weight the bottle, soil and distilled water as stated in the established equation. The calculated specific gravity of fine aggregate at 200 grams by weight of the aggregate is 2. The specific gravity of a fine aggregate is approved to be satisfactory when the value between is between 2.3 to 2.8. This implies that the result gotten according to the below table is satisfactory. The specific gravity of Portland cement must have the least value, by this we can ensure that cement is at least 3.1 heavier than water of same volume, and it sinks in water because the specific gravity is greater than 1. The result showed that the pores in the cement are filled with moisture.

Specific gravity $GS = \frac{W2-W1}{(W4-W1)-(W3-W2)}$

Where: W_1 = weight of empty bottle
W_2 = weight of empty bottle + soil
W_3= weight of empty bottle + soil + distilled water
W_4 = weight of empty bottle + distilled water

C. **Aggregate Impact Test**

Aggregate impact value (AIV) test indicates the toughness of aggregates. The higher the AIV the more aggregates get broken during impact and lower the toughness or weak aggregate.

Aggregate impact value = $\frac{M2}{M1}$ X 100%

Where; M_1 = weight of a specimen
M_2 = weight of fraction passing 2.36mm sieve
M_2 = 68.0g
M_1 = 593.6g

Average Value = $\frac{68.0}{593.6} \times 100$ **= 11.46%**

The aggregates having elongation index values not greater than 15% are generally considered suitable for pavement construction. The result gotten from AIV is 11.46% which makes the aggregate suitable for construction.

D. Slump Test

The concrete slump test can be classified according to the nature of concrete fall. The slump concrete takes various shapes and according to profile of slumped concrete and the slump is termed true, shear or collapse slump. Only a true slump is of any use in the test. The slump result for control concrete is 30mm which shows that the concrete has a low workability mixes having slumps between 10-40mm are typically used for foundations with light reinforcement. The slump result for the concrete made with 20% replacement periwinkle shell is 20mm which shows that the concrete has a very dry mixes having 0-25mm are typically used in construction of pavements or roads, this shows that the addition of PKS improves the soil strength, causing the water to dry and low workability. The slump result for the concrete made with 20% replacement PWS is 20mm which shows that the concrete has a very dry mixes having 0-25mm are typically used in construction of pavements.

Table 4. Slump value

Specimen	Slump value(mm)
A	30
B	20
C	20

Note: Specimen: A – Natural Concrete
B – Concrete with palm kernel shell (PKS)
C – Concrete with periwinkle shell (PWS)

E. Weight of Concrete before and after Curing

The result of the weight of concrete cubes for the control mix and 20% PKS and PWS replacement before and after curing were presented in the Fig. 7 and 8 respectively. The weight of Type 1, Type 2 and average weight of concrete before and after 7 days of curing gave 7.146kg, 7.386kg and 0.086kg respectively. Also, the weight of Type 3, Type 4 and average weight of concrete before and after 21 days of curing gave 7.895kg, 8.540kg and 0.097kg respectively. While, the weight of Type 5, Type 6 and average weight of concrete before and after 28 days of curing gave 8.435kg, 7.681kg and 0.094kg respectively. Generally, the result in the Fig.s showed that all the numbers meet up to residential concrete standard except Type1.

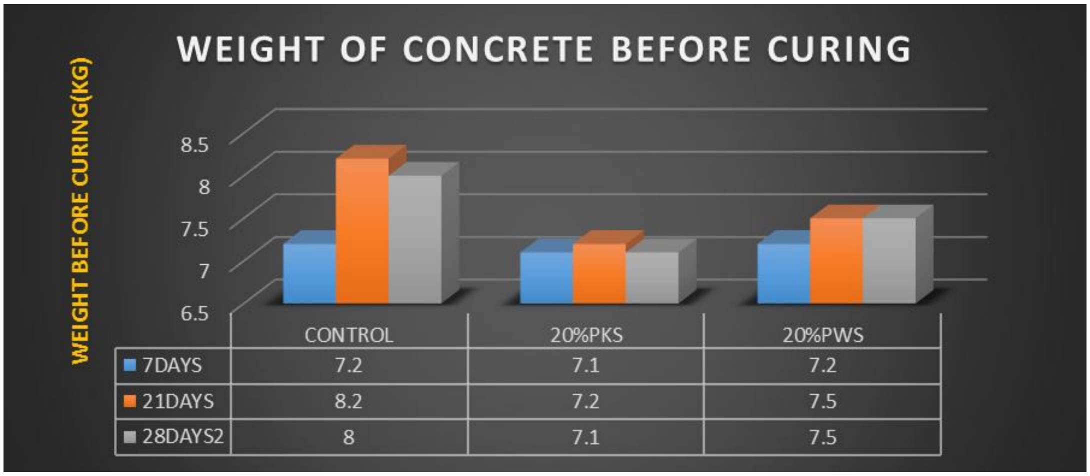
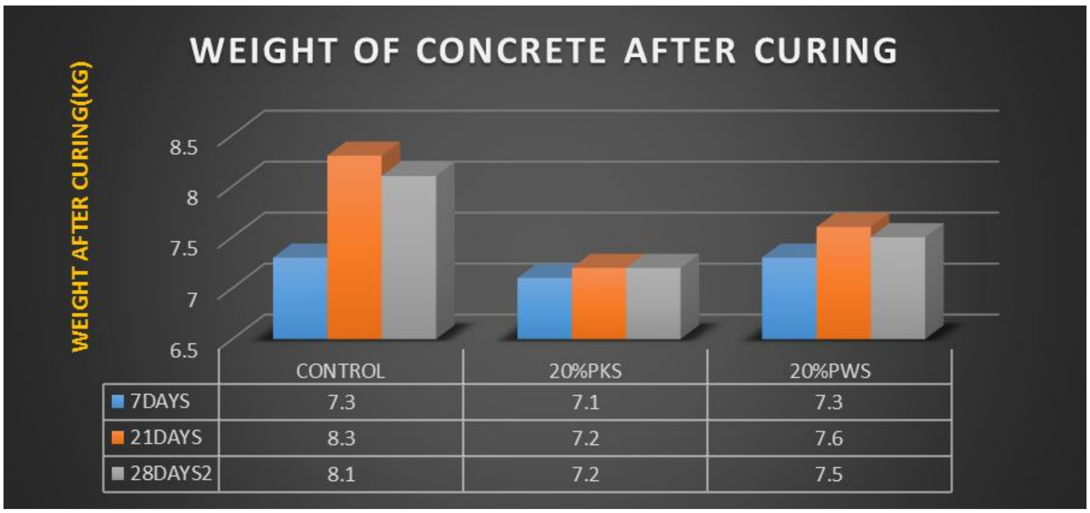


Fig.7: Weight of concrete before curing (kg)

The result in the Fig.7 showed that the average weight of concrete with 20% replacement of PKS before and after 7days, 14days and 28 days of curing is 0.05kg, 0.12kg and 0.05kg respectively. The result in the showed that the weight of concrete made of natural aggregate (control) before curing of 7days, 21days and 28days respectively differs and heavier than the concrete made of 20% of PKS and PWS replacement. This means that substituting the granite with PKS and PWS as aggregate produces a light weight concrete which is more durable with a considerable higher economic benefits. Also, the weight of the concrete after 21 days is maximum and higher than 7 and 28 days for normal concrete and concrete made with PKS. The weight of concrete made with 20% of PKS before curing have the same weight at the 7days and 28days of curing and lighter to the one of 21days. The showed that the concrete made of PKS is very light compare to that of PWS made of the same percent (20%). The weight of concrete made with 20% of PWS before curing have the same weight at 21-28 days and heavier than the one of 7days before curing. Generally, the weight of concrete made of PWS is heavier than that of PKS after 28 days of curing.



	CONTROL	20%PKS	20%PWS
7DAYS	7.3	7.1	7.3
21DAYS	8.3	7.2	7.6
28DAYS2	8.1	7.2	7.5

Fig. 8: Weight of concrete after curing (kg)

The result in the Fig. 8 showed that the average weight of concrete with 20% replacement of PWS before and after 7days, 14days and 28 days of curing is 0.04kg, 0.08kg and 0.14kg respectively. The weight of the concrete made of natural aggregate without replacement (control) after the curing of 7days, 21days and 28days respectively differs and heavier than that of 20% of PKS and PWS except that of 7days curing which has the same weight as that of 7 days of 20% of PWS. The weight of the concrete made with PWS increase as the period of curing increase from 7 to 28 days of curing. The weight of concrete made with 20% of PKS is lighter compare to that of 20% of PWS and control after curing of 7, 21, and 28 days respectively. The weight of concrete made with 20% of PWS at 7, 21, and 28 days of curing is heavier compare to that of 20% PKS and lighter than that of control exception of 7days curing that has the same value as that of control. The weight of the concrete made of natural aggregate without replacement (control) after the curing of 7days, 21days and 28days respectively differs and heavier than that of 20% of PKS and PWS exception of the one of 7days curing which has the same weight as that of 7 days of 20% of PWS. The weight of concrete made with 20% of PKS is lighter compare to that of 20% of PWS and control after curing of 7, 21, and 28 days respectively. The weight of concrete made with 20% of PWS at 7, 21, and 28 days of curing is heavier compared to that of 20% PKS and lighter than that of control exception of 7days curing that has the same value as that of control.

F. Water Absorption of Concrete

The result in the Fig.9 shows that the water absorption increases from 7 days to 21 days and decrease at 28 days for the natural concrete used as control mix. It is observed that at 20% replacement of the palm kernel shell (PKS), the water absorption increases rapidly from 7days to 21days and decrease rapidly at 28 days. Meanwhile, after the 20% replacement of the cement with the periwinkle shell (PWS), the water absorption increases simultaneously from 7 days to 28 days. This means that the concrete made with 20% of periwinkle shell has a greater water absorption capacity at 28 days of curing compared to that of natural aggregate without replacement (control) and palm kernel shell (PKS) made with 20% replacement. The concrete made with 20% of palm kernel at 21 days of curing has a greater water absorption capacity compared to that of natural aggregate without replacement (control) and periwinkle shell (PWS) made with 20% replacement. Also, the natural concrete has a great water absorption capacity at 7-21 days of curing and decrease at 28 days compared to that of PKS and PWS made with the same 20% replacement.

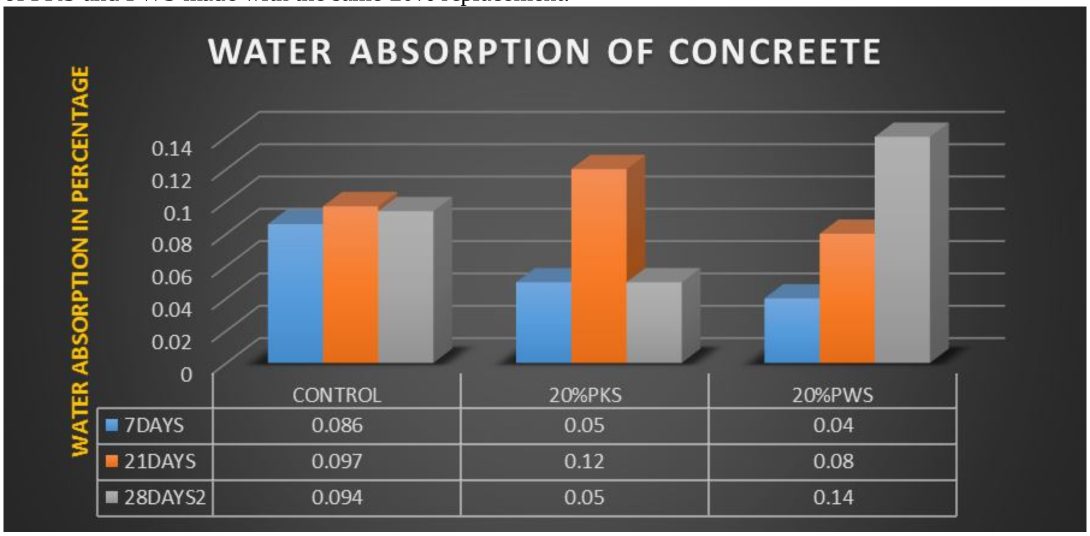


Fig. 9: Water Absorption for Concrete at 7-28days Curing

G. Compressive Strength of Concrete

The result which is presented in the Fig. 10 showed that the concrete compressive strength for control mix vary from 2200psi (15 MPa) which is about 230kg for residential concrete to 4400psi (30 MPa) which is about 460kg for higher commercial building. Here, the presence of 20% PKS caused a decrease in strength in all the types thereby making the concrete not suitable for construction. The results shows that the addition of 20% PWS increases the concrete strength, from Type 2 to strength increased rapidly making the concrete suitable for residential construction and has the highest value at Type 6.

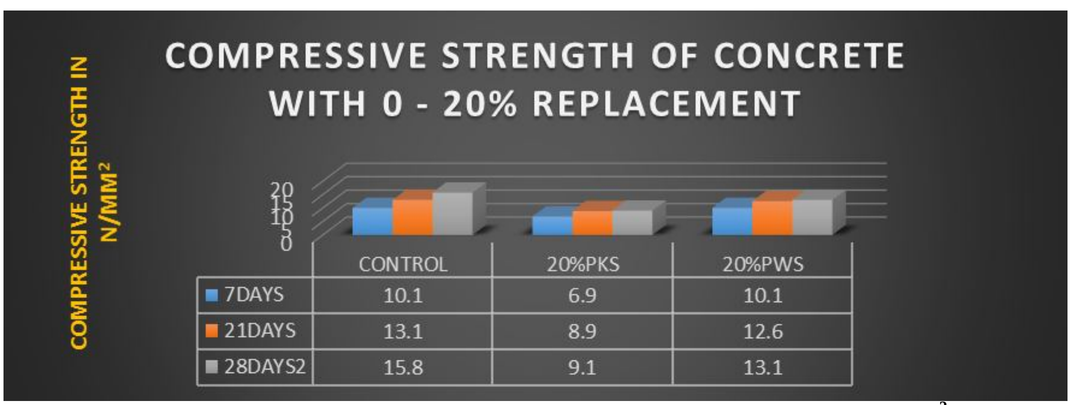


Fig. 10: Compressive Strength of Concrete at 7-28 Days Curing (N/mm^2)

The result in the Fig. 7 showed that the compressive strength of the concrete made of natural aggregate without replacement (control) increases simultaneously at higher rate from 7day to 28days of curing. At 20% replacement of Palm kernel shell (PKS), the compressive strength of the concrete increases at the low rate from 7days to 28 days of curing. At 20% replacement of periwinkle shell (PWS), the compressive strength of concrete increases at high rate from 7 days to 28 days of curing. The compressive strength of concrete made of natural aggregate, 20% of PKS and 20% of PWS increased as the curing days increased. The compressive strengths of the concrete made of natural aggregate without replacement (control) were greater in all number of curing days compared to that of 20% of PKS and 20% PWS replacement. The compressive strength of the concrete made with 20% of periwinkle shell is great compare to that of 20% palmkernel shell.

IV. CONCLUSION

Mining and the entire process of the production and use of coarse aggregates (gravel) have been proven harmful and problematic to human inhabitants. To reduce harm, risk and management of these industrial wastes, the potentials effects of PKS and PWS as replacement for gravel were investigated. The following conclusion can be drawn from the research

i. The soil was classified to be A-3 under USCS classification.
ii. Coarse aggregate has group symbol GW and group name Well-graded gravel for both PWS and PKS.
iii. The aggregates having elongation index values not greater than 15% are generally considered suitable for construction. The result gotten from AIV is 11.46% which makes the aggregate suitable for construction.
iv. The compressive strength increases at 20% PWS and decreases at 20% PKS. This shows that additives like PWS and PKS can be used for partial replacement on concrete.

Mining and the entire process of making gravel have been proven harmful and problematic to human inhabitant to reduce harm, risk and management of industrial waste, it's recommended to invest industrial waste such as PWS and PKS into construction. This research have proven the fact that PKS and PWS can be used as replacement material in concrete. However, it is also recommended to extend the use of higher proportion of PKS. This will help establish how much of the admixture could be used to improve the soil grading.

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