The Study of Periwinkle Shells as Fine and Coarse Aggregate in Concrete Works

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***Abstract*—For a country like Nigeria and indeed the third world countries at large, to be able to achieve a sustainable infrastructural development particularly in the area of housing in the nearest future, low cost building materials especially those readily available within each geo political areas must be exploited and used to make housing affordable for all and sundry. The inflationary trend in the Nigeria economy escalated the cost of building materials to the extent that many of the conventional building materials are no longer affordable for the construction of low cost housing. This research presents the study of the suitability of periwinkle shells as fine and coarse aggregate in construction works. Experimental and statistical approach was adopted in this project. Physical and mechanical properties of periwinkle shells and crushed granite were determined and compared. A total of sixty (60) concrete cubes of size 150 x 150 x 150 mm with different percentages by weight of crushed granite to periwinkle shells as fine and coarse aggregate in order of 0%, 10%, 30%, 50% and 100% inclusion of periwinkle shells were cast, tested and their physical and mechanical properties were determined. Compressive strength test showed that 30% replacement of granite by periwinkle shells and 30% replacement of sharp sand by periwinkle fine aggregate were satisfactory without compromise in compressive strength requirement for a mix ratio 1:2:4. Also, the cost analysis shows a 24% savings in cost when periwinkle shells are used holistically (100%) as coarse aggregate and 6.8% savings in cost when 30% are used to replace granite as coarse aggregate.**

Keywords—periwinkle shells, mechanical properties, concrete, compressive strength, fine aggregate, coarse aggregates

I. INTRODUCTION

The inflationary trend in the Nigeria economy escalated the cost of building materials to the extent that many of the conventional building materials can no longer be used for construction of low cost housing. The need to produce durable and low cost building components using local building materials and simple technologies is of great importance. This will enhance employment opportunities and conserve foreign exchange. In order to cut down on cost of construction, researchers have concentrated on using natural occurring materials as substitutes to the conventional cost of building materials.

Concrete being the most popular material used for construction of buildings has cement, fine aggregates, coarse aggregates and water as its main components. The most expensive constituent is cement and in terms of quantity, the most demanding are fine and coarse aggregate. Thus, it is necessary to look for locally available materials that would substitute for these aggregate in concrete wholly or partially without compromising strength. The choice of the locally available materials depends on three main factors of strength, economy, compatibility and availability [1]. For this reason a possible alternative is found in periwinkle shells.

Periwinkles are a group of marine snails. Their shells are typically mottled gray, white, and black and taper to a straight-sided or rounded cone with an obtuse point as shown in below. Periwinkles inhabit the littoral zone, the region between low and high tides. Although they must live near the ocean and spend part of their time underwater, they prefer to be partially exposed to air. In the riverine areas of Nigeria, periwinkles are extremely useful. Apart from the fact that the snails are been consumed as food, their shells are also useful for; soil stabilization, concrete production, beads production, poultry birds feeds, decorations etc. The reasons favoring the extensive usage of periwinkle shells as concrete materials are; the shells are hard, apart from being hard, they are generally light materials suitable for the riverine, they are readily available in sizeable quantity, they have good bonding properties with cement and sand and are less expensive when compared to crushed stones (granites). Efforts have been made and continue to be made within and outside Nigeria to investigate the suitability of these shells as coarse aggregates in concrete. [2-4] investigated the suitability of the shells as coarse aggregates using varying mix designs, design mixes and also varying the percentage of periwinkles shells in the concrete from 0% -100% periwinkle shells. From their findings the characteristics strength of the 28 days concrete produced at 100% periwinkle shells ranges from 11.77N/mm^2 to 15.65N/mm^2.

So much efforts by researchers have been spent on the possible use of the shell as coarse aggregate but little or no effort has been made on the possibility of using the shell as fine aggregate either wholly or partially in structural concrete. Consequently, this work seeks to investigate the suitability of the shells as fine aggregates as well as coarse aggregate and in an attempt to do this, series of test such as; flakiness, Los Angeles abrasion,

specific gravity & absorption, impact value, elongation and grading will be carried out. Also two different types of fresh concrete will be made; periwinkle coarse aggregate shell (PWCS)

with granite concrete and periwinkle fine shell (PWFS) with granite concrete with varying percentage of periwinkle shell (coarse and fine) from 0 – 100% respectively.

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II. MATERIAL AND METHODOLOGY

The materials required for this work are Periwinkle shells (coarse and fine), Aggregates (coarse and fine), Cement and Water. The periwinkle shells used in this work were the remains after the shells were cooked and the edible part removed. This periwinkle shells were obtained from Oyingbo market in Ebute Metta, Lagos state. The (PWS) were thoroughly washed and sundried to remove impurities. Hand - picking of further impurities was done before the material was taken to the laboratory for tests. However, some of the shells meant for fine aggregates were grounded using los Anglos abrasion machine at the laboratory. Batching of the materials in this work was done by weight. The weighing scale was used in measuring out the weights of the constituents materials. Considering the quantity of work to be done, baromix machine was used. The mixing was done in such a way that the coarse aggregates were first introduced into the mixer followed by the fine aggregate; little water was added first before the cement was introduced into the mixer. This was then followed by a gentle introduction of more water into the mixer until a visible and consistent concrete was attained. The concrete was then discharged into a wheelbarrow in order to convey the concrete to a spot where the slump and the fresh density of the concrete was taken.

A. *Casting Curing and Crushing*

The standard mould by dimension (150 x 150 x 150) mm3 was used in the casting of cubes. For each percentage replacement of periwinkle shell either as fine aggregate or as coarse aggregate, six cubes were prepared. In order words, this means six cubes each of 0%, 10%, 30%, 50%, & 100% PWFS and 0%, 10%, 30%, 50%, & 100%, PWCS. Consequently, a total of 60 cubes were prepared. The cubes were allowed to set properly before the moulds were loose and the cubes transferred to a curing tank at an ambient temperature of 25% ± 2 degrees Celsius. Crushing was done concurrently with curing of cubes at age 3, 7, 28 and 56days respectively with their corresponding strength recorded.

III. RESULTS AND DISCUSSION

A. *Sieve Analysis Test Results*

The results of the sieve analysis are presented in in Fig. 1 and 2. Aggregates from both PWFS and PWCS failed to satisfy the grading limits of BS 882: 1992 for aggregates. On one hand PWFS failed to enter the grading limits of BS sieve size 1.18mm and that of 600µm, lagging behind the lower boundary limits by 7.2% and 1.8% respectively. On the other hand PWCS also failed to satisfy the grading limits of sieve size 5mm shooting beyond the limits by 2.6%. On the contrary, the results of “3/4”, “1/2” and Quarry Dust falls within the envelope adequately. However, the fact that PWFS and PWCS aggregates failed to satisfy the grading limits completely does not render the aggregates unfit for concrete production. This is so because there are no known grading limits for periwinkle aggregates and secondly, from experience, some aggregate failed to enter the grading envelope yet their 7 and 28 days cubes strength proves okay.

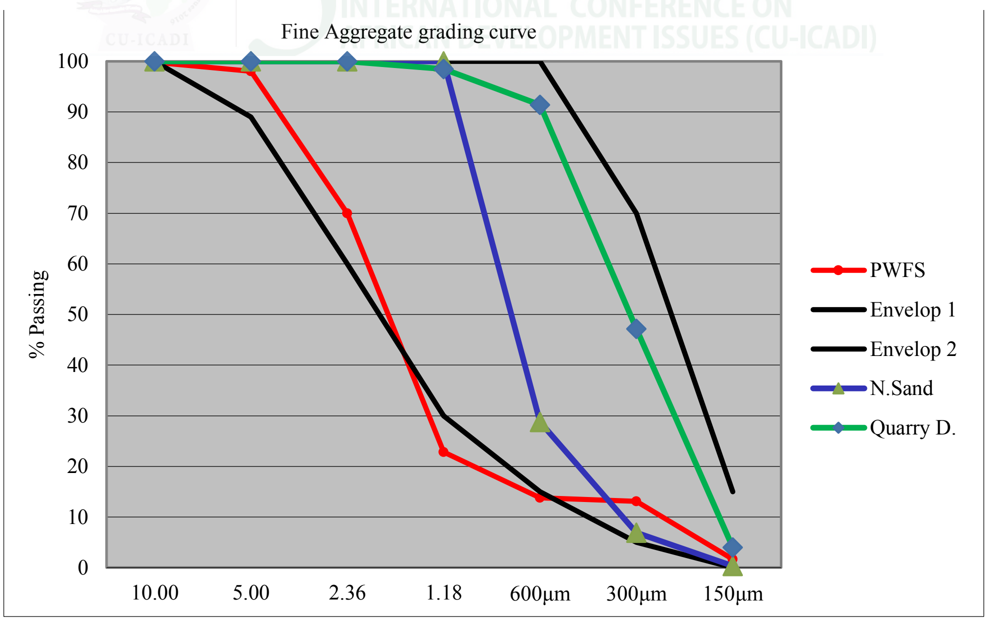

Fig. 1. Shows the Fine Aggregate grading curve

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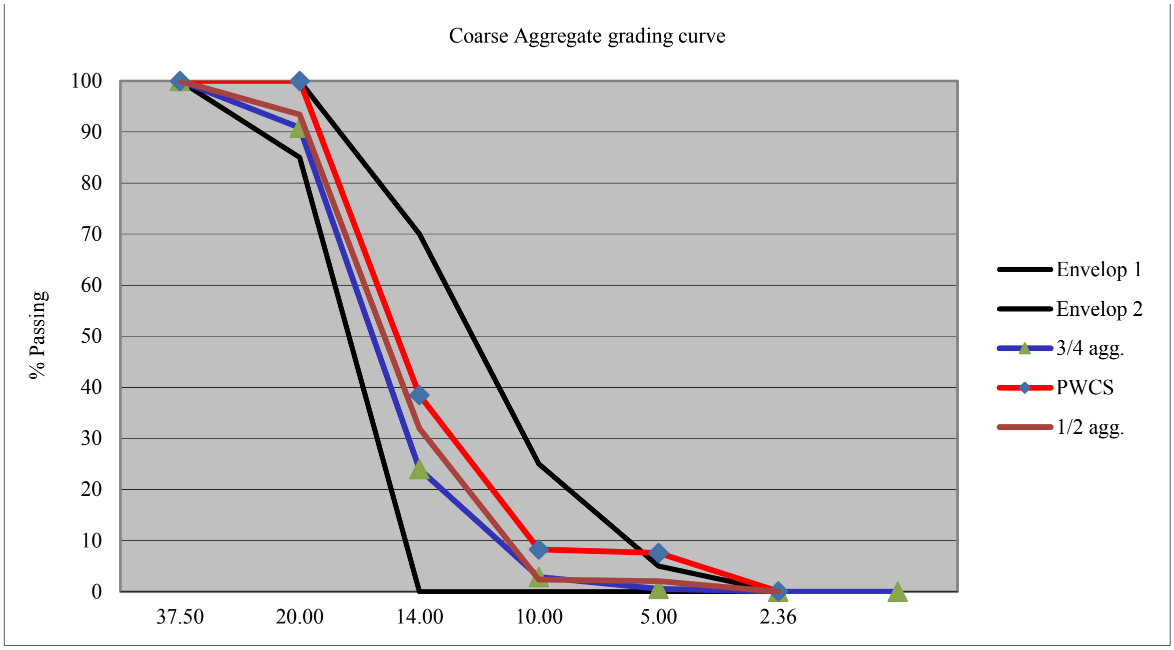

Fig. 2. Shows the Coarse Aggregate grading curve

B. Compressive Strength.

The slump, density and compressive strengths of PWCS and PWFS were obtained. For each percentage replacement i.e 100%, 50%, 30%, 10% and 0% six cubes each were prepared. The cubes were tested at age 3, 7, 28 and 56 days. For curing age 3 and 7, two cubes were crushed and the average strength taken. While for curing age 28 and 56 days one cube each was crushed. The slump increases with a reduction in the percentage replacement of PWCS and PWFS aggregates in concrete. Figure 3 compares the effects of PWCS with that of PWFS aggregates on the compressive strength of concrete. From the charts, similar compressive strengths were obtained at 100% PWCS and PWFS i.e between 2.67N/mm2 and 8.9N/mm2. These results are short of the expectation at 28 and 56 days. This implies that whenever the shell is used wholly either as PWFS and PWCS aggregates in concretes the strength at 28 days and 56 days is most likely going to be up to half of designed strength. The low strength when the shells are used wholly could be linked to the high water absorption ability of the shells. Material that has high water absorption by implication encourages more water to be added to concrete during mix and the moment the designed water is exceeded by a certain percentage the proposed designed grade will fail. It is better for the water to be reduced slightly in as much as consistency and workability are enhanced in the course of production. The results at 10% replacement for PWCS aggregates and PWFS aggregates is close to that of 0% i.e control design mix, meaning that the results are good at this level of replacement. At 30% replacement, both PWCS & PWFS concrete passed but the coarse shell concrete showed a better characteristics strength property. However, at 50% replacement both PWFS and PWCS failed to attain the targeted strength of 20N/mm2, with the coarse shell showing a better result.

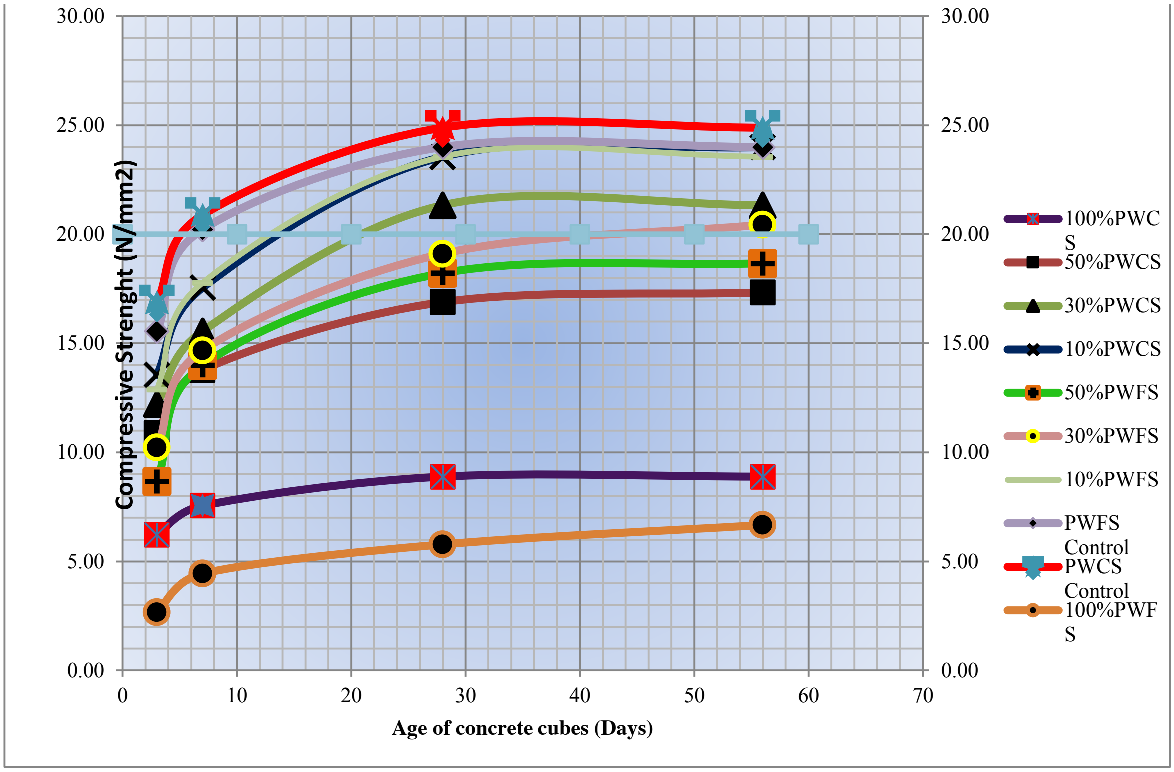

Fig. 3. Compressive Strength vs. age of concrete chart

IV. Conclusion

At the end of this research work, the following conclusions were arrived at:

- As the percentage replacement of PWCS and PWFS increases from 0% to 100% the slump decreases that is the workability decreases.
- Concrete made with 100% PWCS- aggregates are lighter than the normal granite chippings concrete, that is as percentage of granite chippings increases the density of concrete produced increases.
- PWCS and PWFS were able to attain the design compressive strength of 20N/mm^2 at 30% inclusion as aggregate in concrete works.
- The two specimens PWFS and PWCS concrete exhibited a low characteristics strength less than 10N/mm^2 when used holistically that is at 100 percentage replacement.
- There is a saving in cost of 6.8% when 30% of periwinkle shells are used with 70% of granite as coarse aggregate.

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