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EXPLORATORY STUDY OF CRUSHED PERIWINKLE SHELL AS PARTIAL REPLACEMENT FOR FINE AGGREGATES IN CONCRETE.

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ABSTRACT

An exploratory study of crushed periwinkle shell (CPWS) as partial replacement for fine aggregate in concrete was carried out. Mechanical and Physical properties of the CPWS and fine aggregate (river sand) were determined and compared. Concrete cubes of 1:2:4 and 1:3:6 by weight of cement were prepared in the laboratory, using the following proportions, 0:100, 30:70, 50:50 and 100:0 CPWS to fine aggregate (river sand). 14, 21 and 28 days compressive strength test were carried out on the concrete cube. The CPWS had an average moisture content of approximately 11.65%, the highest amongst the aggregates. Physical examination of the CPWS particles showed that the grains were angular in shape with rough surface texture. The sieve analysis test revealed that the particle sizes were fine aggregates with about 98.8% passing through the British sieve No. 4 (4.75mm). The CPWS had a bulk density of 1504kg/m^3, while that of the river sand was 1636kg/m^3. The workability test revealed that the slump values decreased in the concrete mixture as the quantity of CPWS increased. It was also discovered that the compressive strength decreased with increased percentage of replacement of the river sand with CPWS. The control (highest) 28 days compressive strength of the concrete produced with zero percent CPWS and 100% river sand was 24.89N/mm^2. 28 days compressive strength of concrete cubes with 50% CPWS and 50% river sand for mix proportion of 1:2:4 was 18.00N/mm^2.From the results of this exploratory study, it can be safely stated that CPWS can be used as a partial replacement of river sand in the production of light weight concrete in areas where the periwinkle shells are in abundance. The purpose of the study is to explore the possibility of turning waste to wealth. A significant factor is that concrete will be produced cheaper in areas with large population of periwinkle shells, while the environment that these periwinkle shells are usually dumped will become better protected.

Key Words: periwinkle shell, river sand, coarse aggregate, workability, compressive strength, concrete.

INTRODUCTION:

The ingredients of normal concretes world-wide are cement, water, fine and coarse aggregates. This mixture when placed in mould or formwork and allowed to cure becomes hard like stone. The hardening is caused by chemical reaction between the water and cement. The fine and coarse aggregates bond with cement and strengthen after curing.

The strength, durability and other features of this conglomerate material depend on the properties of the mix, properties of its constituents, the method of compaction and other controls during placing, curing etc. All concretes made with lightweight aggregate exhibit a higher moisture movement than is the case with normal weight concrete Neville, (2005).

Fine and coarse aggregates are the two major types of aggregates normally used in concrete production. Fine aggregate is generally natural sand and is graded from particles of 5mm in size down to the finest particles but excluding dust. Coarse aggregate is natural gravel or crushed stone usually larger than 5mm and usually less than 16mm in ordinary structure Olufemu et al, (2009).

Over the years, large quantities of periwinkle shells have accumalted in many parts of the country such as Bori, Western Ijaw, Burutu, Agoro, Ogalaga and Lotugbene. Periwinkle shells are obtained from periwinkle. Periwinkles are marine mollusks (gastropods) with thick spiral shells. As they grow, gastropod shells follow a mathematically regular pattern. Thus, as they increase in size, they retain their basic form. The mollusk produces this spiral shape by continually adding shell to the edge, coiling around an imaginary axis running straight through the shell. The resulting shell becomes a strong compact home for the mollusk inside. The major families of periwinkle include the Litorinae family. They are common in North America and European shores and are widely distributed in the littoral drifts and sand banks. The major species available in the lagoon and mudflats of Nigeria's Niger Delta, between Calabar in the east and Badagry in the west, are *Tympanostomus spp*. and *Pachmellania spp,* Dahunsi, (2003).

Periwinkle shells have been used by the people of the coastal states, for instance, in Rivers State of Nigeria for over 30 years been used as conglomerate in concrete reinforcement. These shells have been used for many purposes, for example at homes, soak-away, slabs and road construction. The cost of these shells was more than 10 times cheaper than that of gravel Neville, (2005).

Many experimental works have been carried out to improve the properties of the concrete by adding new materials; the materials may be natural materials or recycled materials or synthetic materials. Olufemi et al, (2009), carried out a study on the suitability of periwinkle shell as replacement for river gravel in concrete. The study concluded that periwinkle shells can be used as partial replacement for river gravel in normal construction works especially in places where river gravel is in short supply and periwinkle shells are readily available.

For low and medium strength workable concrete, smooth round gravels are usually to be preferred, but for high crushing strength or flexural strength, concrete made with angular and rough or crystalline

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crushed rock e.g. granite, carboniferous limestone may demonstrate a benefit for all workable concrete, natural rounded sands are preferable to crushed stone fines, Murdock et al, (1991).

Olufemi et al, (2009), investigated the suitability of periwinkle shell as partial replacement for river gravel (coarse aggregate) in concrete. The study discovered that concrete cubes with periwinkle shells alone as coarse aggregate were lighter and of lower compressive strengths compared to those with other periwinkle: gravel properties. The 28-day density and compressive strength of periwinkle were 1944kg/m^3 and 13.05N/mm^2. Density, workability and compressive strength of periwinkle concrete increased with increasing inclusion of river gravel. The study finally concluded that periwinkle shells can be used as partial replacement for river gravel in normal construction works especially in places where river gravel is in short supply and periwinkle shells are in abundance.

Dahunsi, (2003) also carried out a study on the properties of periwinkle-granite concrete. It was discovered that periwinkle shells can be used as a partial replacement for granite in normal construction works and that the strength development in periwinkle-granite concrete is similar to those of conventional granite concrete.

Yang et al, (2005), studied the effect of oyster shell substituted for fine aggregates in concrete characteristics. . Crushed oyster shells, an industrial waste, were substituted for fine aggregate in concrete. The investigation revealed that oyster shell did not cause reduction in the compressive strength of concrete at 28 days. It was also discovered that development of compressive strength was faster as substitution rate of oyster shell increased, Yang et al, (2005).

This study investigated the partial replacement of fine aggregate (river sand) with crushed periwinkle shells in concrete.

MATERIALS AND METHOD

Specific Gravity of Cement and Aggregates:

The pyconometer test method BS:1377, (1990) was used to obtain the specific gravity of the cement, river sand, CPWS, and gravel.

Bulk Density:

The Bulk density of the cement, river sand, CPWS and gravel was obtained using BS 812, (1995) Part 2 method.

Moisture Content:

The gravimetric method was employed to determine the moisture content of the river sand, CPWS and gravel.

Gradation Test:

Sieve analysis BS:410 (1969) , was carried out on the river sand, CPWS and gravel. For the CPWS, the crushed periwinkle shells were washed, oven dried before passing them through the various sieves.

Workability Test:

Slump test was carried out to determine the workability of the concrete made with partial replacement of fine aggregate (river sand) with CPWS.

Compressive Strength Test:

Metal moulds measuring 150mm x150mm x 150mm were used to cast the concrete cubes. A total of 32 cubes were prepared for the mix ratios of 1:2:4 and 1:3:6 by weight and proportions of (CPWS:River Sand), 0:100, 30:70, 50:50, and 100: 0. The samples were left to cure for 14, 21 and 28 days, respectively.

The concrete cubes were loaded to failure using compression machine in the laboratory. The tests were performed in a room with 90% humidity and room temperature of between 25^{o}Cand 29^{o}C.

The weight of each cube of concrete for the compressive strength test was 2.5kg.

Chemical Analysis:

Standard chemical analysis was conducted on the CWPS sample to determine the chemical properties.

RESULTS

Table 1: Specific Gravity of Cement, River Sand, Gravel and CPWS

Material	Cement	River Sand	Gravel	CPWS
Specific Gravity (Gs)	3.14	2.64	2.57	2.10
Bulk Density (Kg/m^3)	1223	1636	1291	1504
Moisture Content %	-	7.8	2.76	11.65

Table 2(a): Sieve Analysis of River Sand

Sieve (No)	Sieve Size (mm)	Mass Retained	% Retained	% Passing
No 4	4.75	2	0.4	99.6
No 8	2.36	4	0.8	98.8
No 16	1.18	11	2.2	96.6
No 30	0.600	84	16.8	79.8
No 50	0.300	194	38.8	41
No 100	0.150	156	31.2	9.8
No 200	0.075	42	8.4	1.4
pan		7		

Total Weight = 500g

Table 2 (b) Sieve Analysis of CPWS

Sieve (No)	Sieve Size (mm)	Mass Retained	% Retained	% Passing
No 4	4.75	6	1.2	98.8
No 8	2.36	90	18	80.8
No 16	1.18	216	43.2	37.6
No 30	0.600	110	22	15.6
No 50	0.300	51	10.2	5.4
No 100	0.150	16	3.2	2.2
No 200	0.075	6	1.2	1
pan		5		

Total Weight = 500g

Scientia Africana, Vol. 13 (No.1), June 2014. Pp151-159
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Table 2 (c) Sieve Analysis of Gravel

Sieve Size (mm)	Mass Retained	% Retained	% Passing
19.00	19	1.9	98.1
13.22	80	8	90.1
9.50	342	34.2	55.9
6.7	375	37.5	18.4
4.75	130	13	5.4
3.55	20	2	3.4
pan	24		

Table 3: Slump Test Result for Various Mixed Proportions of River Sand and CPWS

Mix Ratio	CPWS/River Sand Ration (%)	Slump (mm)
1 : 2 : 4	0 : 100	31
1 : 2 : 4	30 : 70	76
1 : 2 : 4	50 : 50	3
1 : 2 : 4	70 : 30	7
1 : 3 : 6	0 : 100	0
1 : 3 : 6	30 : 70	0
1 : 3 : 6	50 : 50	0
1 : 3 : 6	100 : 100	0

Table 4: Compressive Strength Test Results

Mix Ratio	CPWS: River Sand Ratio (%)	W/C Ratio	Compressive Strength (N/mm^2)		
			14 days (Average)	21 days (Average)	28 days (Average)
1 : 2 : 4	0 : 100	0.6	24.45	-	24.89
1 : 2 : 4	30 : 70	0.6	13.76	-	15.56
1 : 2 : 4	50 : 50	0.6	15.55	-	18.00
1 : 2 : 4	70 : 30	0.6	14.22	-	13.33
1 : 3 : 6	0 : 100	0.7	13.34	14.0	-
1 : 3 : 6	30 : 70	0.75	7.34	7.56	-
1 : 3 : 6	50 : 50	0.75	8.45	8.22	-
1 : 3 : 6	100 : 0	0.75	3.56	2.68	-

Table 5: Chemical Analysis of CPWS

S/No	Parameter	Test Method	Result	Standard
1	pH	ASTMD 51-77	6.41	>5
2	Specific Gravity	ASTMD 58	2.30	2.2 – 2.6
3	Carbonate (%)	BS 3921	0.73	1
4	Silica (%)	BS 1377	95.85	94 – 99
5	Ferric Oxide (%)	ASTMD 114	0.05	0.5
6	Salinity (%)	ASTMD 632	0.170	1
7	Aluminum Oxide (%)	BS 1377	0.028	0.05
8	Sulphure Trioxide (%)	BS 12	2.20	5.0
9	Silt Content (%)	BS 812	0.089	0.3
10	Organic Matters	BS 1377	2.37	5
11	Magnesium (%)	BS 1377	0.16	0.5

FIGURES

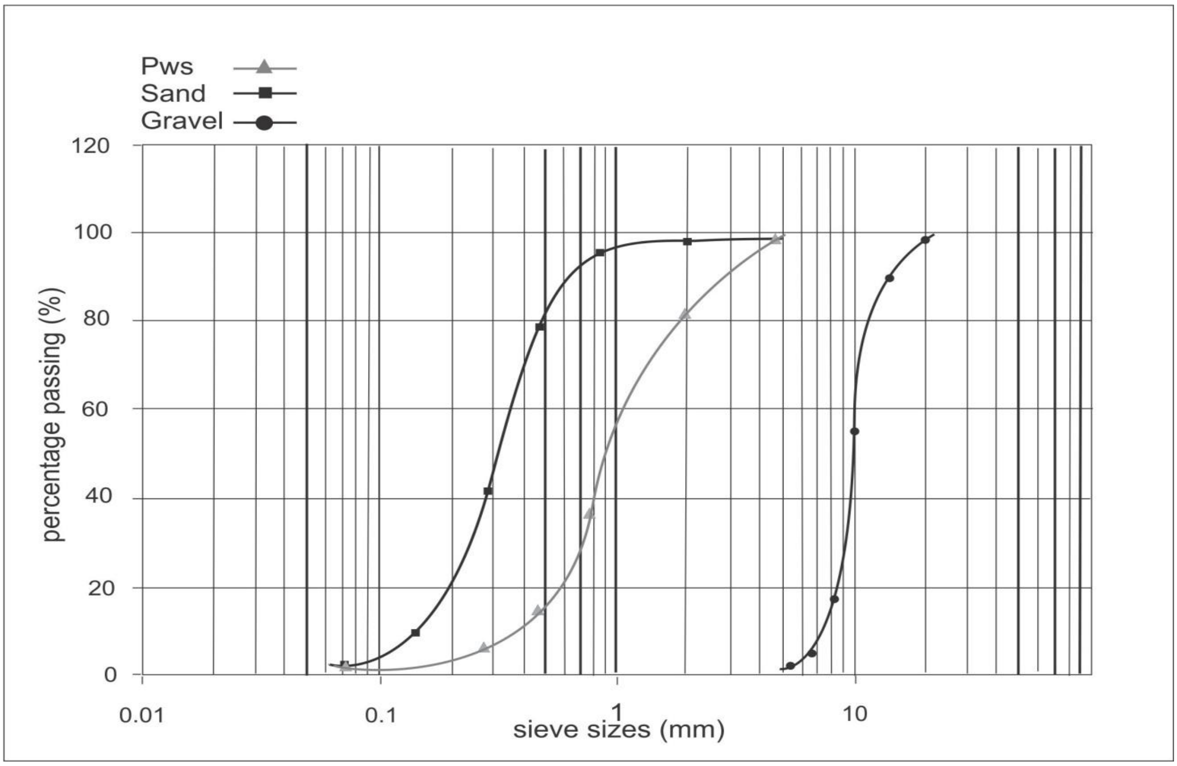

Figure 1 Particle Size Distribution Curve for Aggregates and CPWS fines

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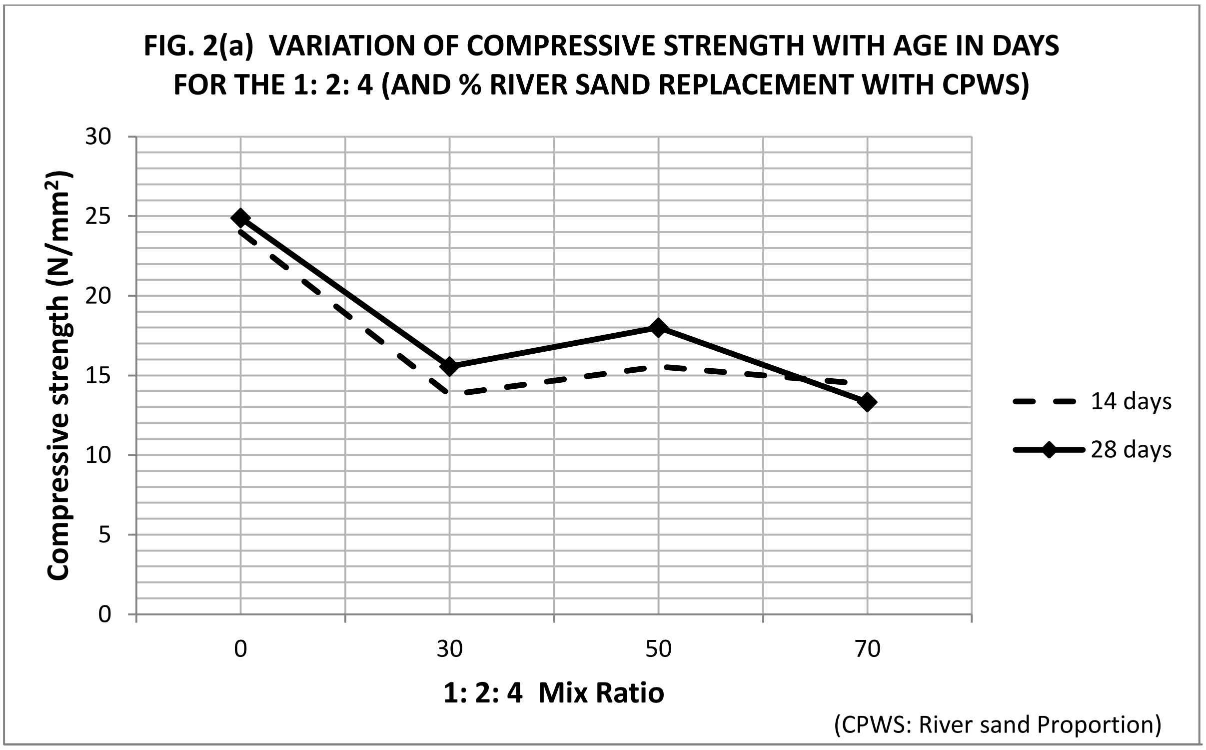

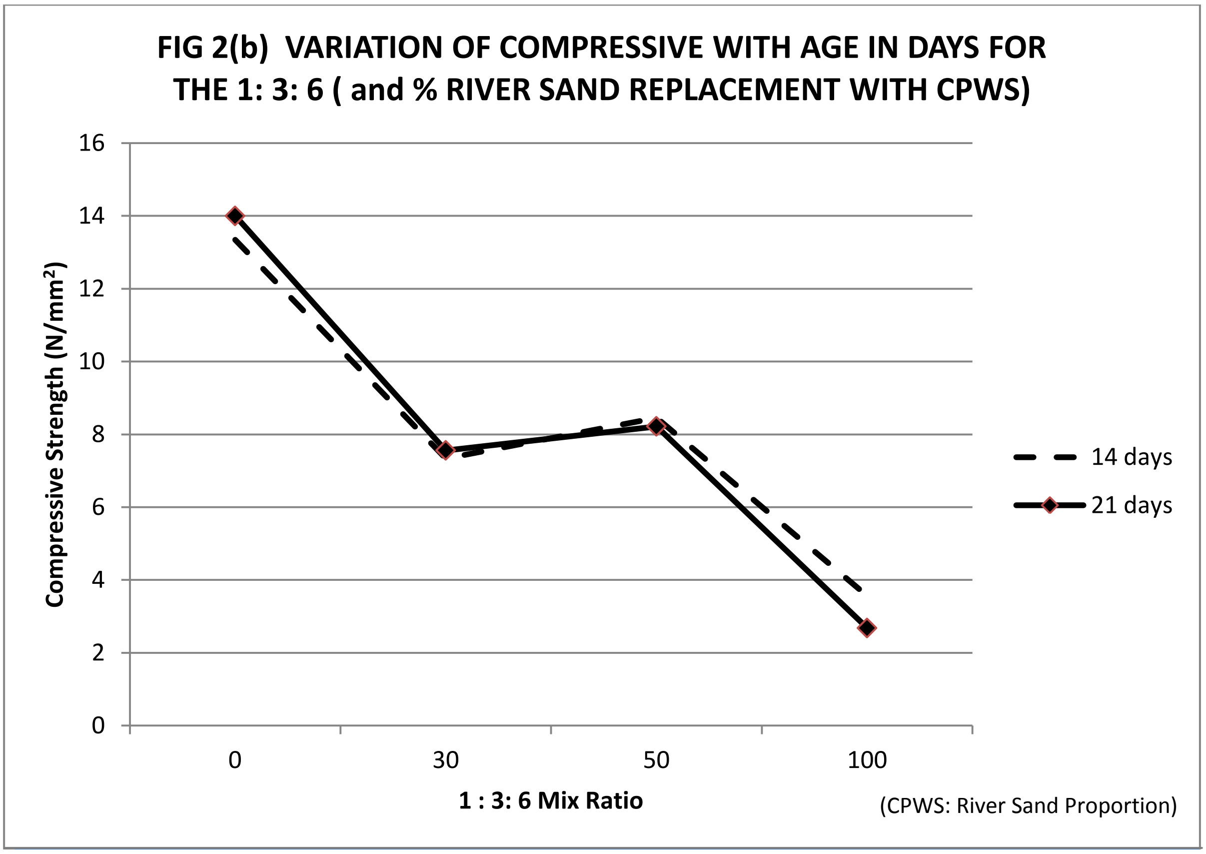

DISCUSSIONS

Specific Gravity of Cement and Aggregates;

From Table **1** it can be deduced that the CPWS has a lower specific gravity when compared to that of sand. The values of the specific gravity for CPWS and River Sand are 2.10 and 2.64 respectively.

Bulk Density;

Table 1 also, shows that the Bulk density of the CPWS is lower than that of the River Sand. The values of the bulk density for CPWS and River Sand are 1504kg/m^3 and 1636kg/m^3 respectively.

Moisture Content:

Furthermore, Table 1 shows that the moisture content of the CPWS is higher than that of the River Sand 11.67% and 7.8 % respectively. The high water content of the CPWS was responsible for the absorption of water from the concrete mixture which was responsible for the reduced workability of concrete with CPWS as against that without CPWS.

Gradation Test Analysis;

From f**ig 1,** it can be observed that 98.8% of the CPWS particles passed through the No 4 sieve, while about 99.6% of the river sand particles passed through the No 4 sieve, while only 5.4% of the gravel passed through the No. 4 sieve. This confirms the fact that the CPWS and River Sand are fine aggregates. The particle size distribution curves shown in Figs 1 shows that the both the River Sand and CPWS are well graded fine aggregates.

Workability Test;

The slump value increased from 31mm at CPWS: River Sand proportion of 0:100 to 76mm for the CPWS: River Sand proportion of 30:70, for the 1:2:4 mix ratio. At CPWS: River Sand, proportion of 50:50 the slump decreased to 3mm, and increased to 7mm for the CPWS: River Sand proportion of 70:30.

The slump value was zero for the 1:3:6 mix ratio for all the various proportions of CPWS: River Sand. The 76mm slump value at 30:70 CPWS : River Sand proportion for the 1:2:4 mix ratio is considered as medium workability This is expected as a result of the fact that the quantity of the River sand has increased in the mix.

Compressive Strength;

Figs 2 (a) – (b), show that there was a general increase in strength, with progressive increase in curing age. The compressive strength of the concrete made with various proportions of the CPWS/River Sand decreased with increase in the proportion of CPWS. For both the 1:2:4 and 1:3:6 mix ratios there was a sudden increase in the compressive strength at 50% CPWS : 50% , with a value of 18.00N/mm^2 obtained for this mix ratio and proportion of CPWS and River Sand at 28 days. This values compare favourably with compressive strength values of light weight concrete. As expected the compressive strength of 24.89N/mm^2 for the CPWS: River Sand (0:100) proportion, which is the control is the normal average value of the strength of concrete at 28 days.

The following conclusions were drawn from the result of the study:

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1) CPWS can be used as a partial replacement of river sand in the production of light weight concrete in areas where the periwinkle shells are in abundance. This practice will mitigate the environmental problems arising from indiscriminate dumping of the periwinkle shells after extracting the edible part for human consumption.
2) The workability of the CPWS-River Sand concrete deceased with increasing content of CPWS.
3) The strength development in CPWS-River Sand concrete is appreciably close to those of conventional fine aggregate concrete only at 50:50 CPWS:River Sand proportion for the 1:2:4 mix with a cube strength value of 18.67N/mm^2. This can be classified as structural light weight concrete.

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