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Evaluating the Suitability of using Periwinkle Shells as Partial Replacement of Bida Natural Gravel in Concrete Production

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ABSTRACT
This Research work investigate the suitability of using Periwinkle Shells (PS) to partially replace Bida Natural Gravel (BNG) in concrete production. Tests were carried out to determine the physical properties of the fine aggregates, BNG and PS. Mechanical properties of the concrete produced using BNG as coarse aggregate and partially replace with PS where also determined. The Department of Environment (DOE) British method of concrete mix ration for 0.5 water/cement ratio was used to obtain the mix ratio of 1: 2.17: 4.02. A total of 72 specimens consisting of 60 number of concrete cubes of sizes 150mm×150mm×150mm and 60 number of concrete prisms (beam) of sizes 500mm×100mm×100mm with different percentages by weight of BNG/PS as coarse aggregates in the order of 100:0%, 95:5%, 90:10%, 85:15% and 80:20% were cast and cured for 7, 14, 21 & 28 days after which their compressive and flexural strengths were determined respectively. The concrete developed in this research work has slump ranging from 19 – 35mm, compressive strength ranging from 11.61 – 20.40 N/mm^2 and flexural strength ranging from 3.1 – 12.7 N/mm^2. This is an indication that concrete produced with periwinkle shell as partial replacement for Bida Natural Gravel can be used for structural application in structures such as in the construction of beams, columns and in foundation of buildings.

Keywords: *Compressive strength, Density, Flexural strength and Periwinkle Shell.*

1.0 INTRODUCTION

The Continuous use of Bida Natural Gravel (BNG) as coarse aggregate in concrete production due to its availability and cost effectiveness in comparison with crushed granite around Bida town in Niger State Nigeria and its environ has led to some environmental problems connected with frequent utilization of these stone deposits (non-renewable source) which in turn results to some in balance in the eco-system. Alabi Adekola et al. (2015). The Bida basin is bounded to the North and South by the Precambrian basement rocks. The largest portion of the basin occurred at the southern half of Niger State Nigeria which form the central part of the basin, the buried Precambrian basement complex is directly overlain by rounded to sub-rounded coarse conglomerates, clay-sand pebbles admixtures and cross- stratified sand stones locally with scattard pebbles, cobbles and boulders. It has become imperative to provide alternative materials that can replace the natural deposit stones (BNG). Research has shown that 70 – 80% of the total volume of concrete is occupied by aggregates (coarse and fine) which has a great influence on the performance and general properties of the concrete. The use of waste natural materials has been identified as potential alternatives to conventional aggregates. This study is to investigate the suitability of using Periwinkle Shell (PS) as partial replacement to Bida Natural Gravel in concrete production. To investigate the performance of concrete in terms of workability, Compressive and Flexural strength upon addition of PS as a partial replacement for BNG as coarse aggregate. The result investigate with a view to possibly integrate it as one of the components in concrete production will open a new horizon in agro-concrete research and at the same time offer alternative to preserve natural coarse aggregate. Even though, research works have been conducted in the past on various type of waste and agricultural residual materials based on their potential to be used as coarse aggregate. Such as, Date seeds, Crushed Coconut Shell, Crushed animal bones, Expanded polystyrene beads, Ceramic scraps, Broken tiles to mention but few.

The unsustainable use of BNG as course aggregate in concrete production for building of structures has called for serious concern. BNG being a non-renewable natural resource is prone to depletion if no

long run. Osakwe *et al* (2015). In developed countries, the construction industry has identified the use of waste natural materials as potential alternatives to conventional aggregates by reducing the size of structural members. This has brought immense change in the development of high rise structures using light weight concrete residual materials for partial replacement of conventional aggregates (which are non-renewable) in the production of concrete. This will make concrete production a sustainable and environmentally friendly material in the long run. This study therefore sought to proffer answer to the following questions

a) By what percentage can Periwinkle Shell (an agricultural waste) be used to replace Bida Natural Gravel in concrete production?
b) What will be the effect of Periwinkle Shell on the concrete produced in terms of mechanical properties?

2.0 Materials and Method

2.1 Materials

The materials used for this research work are as follows;

i. Cement; The cement was purchased from the Usmaniyya stores Nigeria Limited located at Kpakungu Minna, Niger state, where cement is kept on a raised platform and adequately protected from external damage by weather. The cement referred to in this work is the Ordinary Portland Cement (Dangote Cement) produced in accordance with NIS 87:2004: Part 1 and classified as CEM 1 of the standard.

ii. Natural Sand (Fine aggregate); The sand was collected from River Kpakungu in Minna Nigeria free from clay, loam, dirt's or organic matters and also conforms to the grading requirement in zone 4 (BS 882:1987).

iii. Water; The water for mixing and curing was clean, free from deleterious materials and fit for drinking as recommended by NIS 87: 2004.

iv. Periwinkle Shells (PS); They were obtained from the stock dump at Kono boue in Khana local government area of River state, Nigeria; they were washed and dried

v. Bida Natural Gravel (BNG); This natural stones are generally reddish brown in colour and predominantly round in shape were obtained from Bida town in Niger state , Nigeria. They were equally washed and dried before being used for the research work.

2.2 Method

2.2.1 Aggregate Characterization

The following tests were carried out on the aggregates; Seive analysis, Specific gravity, and Bulk density (Compacted & Uncompacted)

2.2.2 Mix Design

The Department of Environment (DOE) method of mixed design for 0.50 water-cement ratio was used in this research to arrive at the mix ration of 1: 2.17: 4.02.

Mixing of the concrete was done mainly by hand with the aid of a shovel. The fine aggregate was first poured on the flat platform and mixed with cement. Bida Natural gravel (BNG) was then added followed by the appropriate percentage of Periwinkle shell (PS) and the mixture mixed thoroughly. The procedure was immediately followed by the addition of quantity of the required clean water and the whole constitutes mixed together until an even paste was obtained.

The slump test which measures the workability of the concrete was taken; the slum apparatus was cleaned and the wider surface placed on the steel plate supported with legs. The apparatus was then filled with concrete in three layers and each layer was given 25 blows using a 16mm diameter tamping rod. The top of the apparatus was then smoothened and was gently lifted and placed on the plate near the concrete. The difference in height between the top of the apparatus and the collapsed concrete was measured to obtain the slump value as shown in Table ii .Moulds of sizes 150 x 150 x 150 mm for the cubes and sizes 500 x 100 x 100 mm for the beam were cleaned and oiled before each casting. Batching of materials was by weight using the mix ration of 1: 2.17: 4.02 with water/cement ration of 0.5. The BNG as coarse aggregate was partially replaced with PS (BNG:PS) in the order of 100:0%, 95:5%, 90:10%, 85:15% & 80:20%.table The concrete cube and beams were demolded after 24 hours and the hardened specimens transferred to a curing tank. The specimens were removed after 7, 14, 21 and 28 days from the day of casting and dried at room temperature for 2 hours and crushed to obtain the compressive and flexural strength of the cubes and beams respectively.

3.0 RESULTS AND DISCUSSION

3.1 Aggregate Characterization

The Densities of the concrete cube and beams, Specific gravity, Sieve analysis, Bulk density (compacted &

Uncompacted) of fine aggregates, Bida natural gravel and periwinkle shell are shown on the Tables I - VIII below.

The Specific gravity of fine Aggregates and BNG are 2.66 and 2.86 which lies within the range for natural aggregates given as 2.5 – 3.0 (Neville 2000). Also Specific gravity of Periwinkle Shell is 1.3 which is lower than that of the natural aggregates and an indication that it is lighter than most natural aggregates The bulk density of the PS and BNG are 563kg/m^3 and 1726kg/m^3 respectively. The low bulk density of PS is an indication that light concretes can be produced with them.

The Table also shows that the values of the compressive and Flexural strengths of the cubes and beams after 28days of curing of the PS-BNG concrete reduced from 20.24 to 13.8 N/mm^3 and 6.1 to 3.7 N/mm^3 with increase in percentage of Periwinkle content respectively.

TABLE I: SPECIFIC GRAVITY OF MATERIALS USED

MATERIALS USED	SPECIFIC GRAVITY
FINE AGGREGATE	2.66
BIDA NATURAL GRAVEL	2.86
PERIWINKLE SHELL	1.30

TABLE II: SLUMP TEST

% REPLACEMENT	SLUMP (MM)
0	35
5	33
10	34
15	20
20	19

TABLE III: DRY DENSITY OF CUBES

% REPLACEMENT/AGE OF CURING	7days	14days	21days	28days
0	2469	2478	2499	2510
5	2453	2464	2479	2486
10	2440	2439	2475	2481
15	2410	2321	2392	2423
20	2356	2262	2382	2394

TABLE IV: DRY DENSITY OF CUBES KG/M^3

% REPLACEMENT/AGE OF CURING	7days	14days	21days	28days
0	2493	2567	2573	2581
5	2467	2553	2557	2561
10	2439	2453	2461	2478
15	2428	2436	2440	2452
20	2419	2431	2436	2445

TABLE V: COMPRESSIVE STRENGTH OF CUBES N/mm^2

% REPLACEMENT/AGE OF CURING	7days	14days	21days	28days
0	16.6	18.61	19.5	20.24
5	15.40	16.2	17.6	18.44
10	14.1	15.00	15.9	16.81
15	12.0	12.9	13.68	14.44
20	11.6	12.0	12.5	13.80

TABLE VI:FLEXURAL STRENGHT OF BEAMS N/mm^2

% REPLACEMENT/AGE OF CURING	7days	14days	21days	28days
0	4.2	4.7	5.6	6.1
5	3.7	4.2	5.1	5.7
10	3.2	3.5	4	4.8
15	11.9	12.1	3.2	3.9
20	12.0	12.7	3.1	3.7

TABLE VII: COMPACTED AND UNCOMPACTED BULK DENSITY OF MATERIALS USED

MATERIALS USED	UNCOMPACTED (kg/m^3)	COMPACTED (kg/m^3)
FINE AGGREGATE	1662	1754
BIDA NATURAL GRAVEL	1726	1901
PERIWINKLE SHELL	563	648

TABLE VIII: SEIVE ANALYSIS FOR SAND

Sieve sizes	Mass of seive	Mass of seive + sample	Mass retained	% Mass	Cumulative	Cumulativ
(mm)	(g)	(g)	(g)	retained	% Retained	% Passin
5.00	477.2	478.5	1.3	0.26	0.26	99.74
3.35	467.9	471.9	4	0.8	1.06	98.94
2.36	433.8	443.2	9.4	1.88	2.94	97.06
2.00	417.6	427.3	9.7	1.94	4.88	95.12
1.18	384.6	431.8	47.2	9.44	14.32	85.68
850µ	351.7	402.3	50.6	10.12	24.44	75.56
600µ	467.8	559.9	92.1	18.42	42.86	57.14
425µ	435	546.2	111.2	22.24	65.1	34.9
300µ	382.4	436.4	54	10.8	75.9	24.1

150μ	420.4	526.2	105.8	21.16	97.06	2.94
75 μ	400.1	410.3	10.2	2.04	99.1	0.9
Pan	297.1	301.6	4.5	0.9	100	0
Total			500	100	527.9	

TABLE IX: SEIVE ANALYSIS *FOR BIDA NATURAL GRAVEL*

Sieve sizes (mm)	Mass of seive (g)	Mass of seive + sample (g)	Mass retainer (g)	% Mass retained	Cumulative % Retained	Cumulative % Passing
20.00 mm	1433.3	1433.3	0	0	0	100
14.00 mm	1371.1	1635.5	264.4	26.44	26.44	73.56
10.00 mm	1324.4	1648.1	323.7	32.37	58.81	41.19
6.30mm	1310.8	1651.1	340.3	34.03	92.84	7.16
5.00mm	1447.7	1501.1	53.4	5.34	98.18	1.82
3.35mm	1296.8	1311.7	14.9	1.49	99.67	0.33
Pan	804	807.3	3.3	0.33	100	0
Total	.0		1000	100	475.94	

TABLE X: SEIVE ANALYSIS FOR PERIWINKLE SHELL

Sieve sizes (mm)	Mass of seive (g)	Mass of seive + sample (g)	Mass retainer (g)	% Mass retained	Cumulative % Retained	Cumulative % Passing
20.00	1433.3	1433.3	0	0	0	100
14.00	1371.1	1374.4	3.3	0.33	0.33	99.67
10.00	1324.4	1943.4	619	61.9	62.23	37.77
6.30	1310.8	1678.4	367.6	36.76	98.99	1.01
5.00	1447.7	1447.7	0	0	98.99	1.01
3.35	1296.8	1296.8	0	0	98.99	1.01
Pan	804	812.6	8.6	0.86	100	0
Total			1000	100	459.53	

3.0 CONCLUSION

From the results obtained, and the tests carried out on the concrete developed using PS as partial replacement for BNG, the following conclusions can be reached.

i. The Specific gravity, Uncompacted bulk density, Compacted Bulk density for PS were found to be 1.3, 563kg/m^3 and 648 kg/m^3 respectively.

ii. The Slump, compressive strength, Flexural strength and density of concrete containing PS ranges from 19 to 35mm, 11.6 – 20.24N/mm^3, 3.1 to 12.7N/mm^3 and 2262 to 2581kg/m^3.

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