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A Study on the Performance of Crushed Clam *(Egeria Radiata)* Shells (CCS) As Partial Replacement Material for Fine Aggregates in Concrete

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***Abstract*--The scarcity and high cost of conventional construction materials to the average people in the society has challenged researchers to look for low cost construction materials that are abundantly available in our environment. This study presents the performance of CCS as a constituent material in a concrete as partial fine aggregate replacement. Physical and mechanical properties of CCS and the fresh and hardened concrete were determined. Concrete specimens of 100x100x100mm, 100x100x500mm and 100mm diameter by 200mm height were constructed as cubes, beams and cylinders respectively. The crushed Clam shells were used to replace the fine aggregates at 0%, 10%, 20%, 30% and 40% replacement levels with a mix ratio of 1:2:4 and w/c ratio of 0.5. The slump test method was used to ascertain the workability of the concrete. Compressive, splitting tensile and flexural strengths and density of the concrete were evaluated after 7, 14, 21, and 28days curing period at the different percentage replacement levels. In all, the maximum strengths of 20.31, 2.47, 1.92N/mm2 were obtained at 10% replacement as compressive, splitting tensile and flexural strengths respectively in 28 days curing period. The range of values for the density is 2610, 2650, 2540, 2590, and 2510Kg/m3 for 0-40% replacement level respectively at 28 days curing. Increase in percentage of CCS in the concrete let to a reduction of the density, compressive, splitting tensile and flexural strengths respectively. But in all cases, the strength increased with increasing curing age. Replacement level of 10 -20% was found appropriate for the construction of normal and lightweight concretes.**

***Keywords*-- Clam shells, compressive, fine aggregates, flexural, and splitting tensile strength**.

I. INTRODUCTION

Concrete is the most common material used in the construction of buildings, roads, pavements bridges etc. hence, highly demanded in large quantity in the construction industry.

Concrete constitutes cement, water, and aggregates. But the high cost of these constituent materials has called for research into locally available materials such as agro-wastes that can be used to substitute conventional construction materials like river sand solely or partially. The practice of using agricultural and industrial waste materials in the construction industry will not only help to reduce the cost of construction, but will also enhance the mitigation of non biodegradable pollutants from our environments.

So many communities in coastal areas worldwide in southern Nigeria and other are littered with different seashells such as periwinkle, Clam (*Egeria radiate*), oyster shells etc in large quantities as waste materials. Many communities have started to use these wastes shell as construction materials to replace granites or river sand in concrete productions without any reliable data on the appropriate use of these materials in structural elements of buildings (Elijah 2009). The fear of unexpected structural deformations and buildings collapses makes it necessary to study the strength characteristics of any material from which a load bearing component is made. (Benham et al 1983). *Egeria radiata* is a marine organism that is endemic to the West African sub region. It is a member in the group of bivalve mollusk. It is the only Clam in the family of Donacidae that is normally found in fresh water. This organism is very nutritious and widely eaten by the people in Southern Nigeria. After consuming the edible flesh of the *Egeria radiata*, the shells are normally discarded in different dumpsites in these communities. Hence, communities such as Korokorosei, Ayama, Ondewari, Ikebiri, Olugbobiri etc in Bayelsa State have heaps of Egeria radiata shells as waste materials in different locations in their communities.

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Malu et al, 2009 showed that, the percentage mean concentrations of the various oxides in the *Egeria radiata* shell are FeO_3, CaO, MgO, MnO, TiO_2, NiO, CuO, ZnO, SiO, ZrO, P_2O_5 and PbO. The analysis revealed that, Calcium Oxide (CaO) is the predominant metal oxide with 95.54±0.05%. Magnesium oxide is the next dominant oxide with 2.52±0.02% and other metallic oxides found in lower quantity.

Amaziah et al., 2013 made an exploratory study of crushed periwinkle shells (CPWS) as partial replacement for fine aggregates in concrete. The study revealed that strength development in the CPWS-River sand concrete was not compromised only at 50:50 CPWS:River sand proportion for the 1:2:4 mix with cube strength of 18.67N/mm2, which is classified as lightweight 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 aggregates in concrete. The investigation revealed the 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

Olutoge 2010 investigated the suitability of sawdust and palm kernel shells as replacement for fine and coarse aggregates in production of reinforced concrete slabs. He concluded that, 25% sawdust and palm kernel shell substitution reduced the cost of concrete production by 7.45%.

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

This study is carried out to investigate the strength characteristics of Crushed Egeria radiata shells on the workability, compressive strength, flexural strength and the density respectively.

II. Research Methodology

A. Concrete Materials

The Clam shells were sourced from a dumpsite in Korokorosei community in Southern Ijaw Local Government Area of Bayelsa State, Nigeria. They were washed and Sundried for five days before crushing to a fine aggregate size with a machine at the Opolo market in Yenagoa, Bayelsa State. The Elephant brand of cement packaged in 50kg bags was used. It was sourced from the Bodija market in Ibadan, Oyo State. Crushed granites used were sourced from a quarry in Ibadan. River sand was also sourced from the Bodija market in Ibadan. Clean borehole water free from visible impurities was used.

B. Methods

1 *Bulk Density Crushed Clam Shells:* The bulk density of the Clam shells was carried out in accordance with the method in BS 812, 1995 part 2.

2 *Specific Gravity of Crushed Clam shells:* The specific gravity of the crushed Clam shells was carried out by the pycnometer test method in accordance with BS 1377, (1990)

3 *Mixing Proportions and Concrete Production:* The control mixing ratio used is 1:2:4 and water - cement ratio of 0.5. Batching of materials was done by weight. Moulds of 100x100x100mm, and 100x100x500mm were used to prepare the cubes and beams respectively. Moulds of 100mm diameter and 200mm height was used for the cylinder and lubricated prior to the mixing of the concrete. 60 cubes, 60 cylinders and 60 beams hence making a total of 180 concrete specimens were prepared with replacement levels of 0%, 10%, 20%, 30%, and 40% of CCS for River sand. The concrete was properly mixed by a shovel before casting in the lubricated moulds. The concrete was prepared in accordance with BS1881 (1983). The concrete specimens were removed from the moulds after 24 hours of casting and cured in water for 7, 14, 21 and 28 days respectively before testing. The mix proportions are shown in Table 1 as follows.

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Table I
Mix Proportions Per Cube Of Ccs Concrete

%CCS	River Sand	CCS	Cement	Granite
0%	0.69	-	0.34	1.37
10%	0.621	0.069	0.34	1.37
20%	0.552	0.138	0.34	1.37
30%	0.480	0.207	0.34	1.37
40%	0.410	0.276	0.34	1.37

Table II
Mix Proportions Per Prism Of Ccs Concrete

%CCS	River Sand	CCS	Cement	Granite
0%	3.43	-	1.71	6.86
10%	3.06	0.34	1.71	6.86
20%	2.72	0.68	1.71	6.86
30%	2.38	1.02	1.71	6.86
40%	2.06	1.37	1.71	6.86

4 *Workability test:* The workability of the concrete containing CCS as partial replacement for River sand was determined by the slump test method in accordance to BS 1881: Part 102

5 *Density:* The concrete cubes were weighed before testing to ascertain the density of the concrete at different times of testing. This was done in accordance to BS 1881: Part 114: 1983.

6 *Splitting tensile strength test:* The splitting tensile strengths of the 100mm by 200mm concrete cylinders were tested in accordance to BS 1881-117 (1983) by using the digital machine that automatically evaluated the load and displayed the splitting tensile strength on the screen.

7 *Compressive strength test:* The compressive strengths of the concrete cubes were tested in accordance to BS 1881-116 (1983) by using a Digital compression machine which automatically evaluates the compression load and displays the result on the digital screen

Plate 1 Compressive strength test

8 *Flexural Strength*: The flexural strengths of the 100mm by 100mm by 500mm concretes were tested in accordance to BS 1881-118 (1983) using the digital flexural testing machine that automatically evaluated the load and displayed the flexural strength on the screen.

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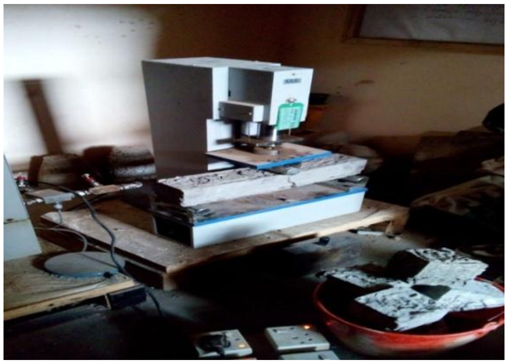

Plate 2. Flexural strength test set-up

III. Results And Discussions

1 Bulk Density and Specific Gravity of CERS: The bulk density and specific gravity of the crushed *Egeria Radiata* shell used for the study was 1420kg/m^3 and 2.60 respectively, while the bulk density and specific gravity for River sand was 1460kg/m^3 and 2.62 respectively. This implies that CCS can be a good replacement material for River sand in concrete casting.

2 Workability: The workability of the concrete was obtained through the method of slump test. The result of the slump test is presented in Table 3. The slump test showed that, the workability of the concrete decreased with increasing CCS content. The slump decreased from 60mm at 0% to 35mm at 40% CCS replacement level. The decrease in the slump is due to the increased specific surface area of the concrete on addition of CCS, hence needing more water to produce a workable concrete.

*3 Density :*The density of the concrete cubes increased with the increase in the curing days and reduced with increased CCS content. The density of the concrete at 28 days curing period were 2610, 2650, 2540, 2590, 2510kg/m^3 at 0%, 10%, 20%, 30%, 40%, replacement level of RS by CCS respectively. (Table 4)

4 Compressive Strength: The compressive strength results of standard cubes are compiled in Table 5 and Figure 1 presents the effect of CCS on the concrete. The compressive strength results at 28 days curing period for the samples with 0 – 40% CERS were 23.7, 20.31, 18.31, 15.82 and 13.94N/mm^2 respectively. The control cube showed an increase in compressive strength from 11.94N/mm^2 at 7 days to 23.7N/mm^2 at 28 days. Also, 10% replacement had increased compressive strength from 10.41N/mm to 20.31N/mm^2. The 20% replacement also gave 18.73N/mm^2 at 28 days curing. These results are equivalent to grades 20 and 15 concretes respectively.

5 Flexural strength: Table 6 shows the flexural strength test results, and Figure 2 shows the effects of the CCS on the flexural strength of the concrete. It is seen from the test results that, for the control beam, the flexural strength increased from 1.14N/mm^2 at 7 days to 2.19N/mm^2 at 28days curing period. However, the strength of the 10% replacement by CCS showed increase in flexural strength from 1.08N/mm^2 at 7 days to 1.92N/mm^2 at 28 days. Similarly, the 20% replacement by CCS showed an increase from 0.71N/mm^2 at 7 days to 1.64N/mm^2 and 30% replacement with CCS gave a flexural strength of 0.72N/mm^2 to 1.43N/mm^2. It is seen that the flexural strength of the concrete was not compromised at the 28 days curing for a lightweight concrete in accordance with BS 1881 Part 4 (1970).

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IV. TABLES AND FIGURES

Table III
Workability Test Results

%CCS	Slump(mm)
0%	60
10%	57
20%	49
30%	37
40%	35

TABLE IV:
Density Test Results Of CCS:RS Concrete In KG/M³

%CCS	7days	14days	21days	28days
0%	2440	2450	2450	2610
10%	2470	2520	2600	2650
20%	2490	2430	2480	2540
30%	2460	2540	2550	2590
40%	2440	2440	2540	2510

TABLE V
Compressive Strength Test Results Of CCS:RS Concrete

%CCS	7days (N/mm^2)	14days (N/mm^2)	21days (N/mm^2)	28days (N/mm^2)
0	11.94	15.53	20.65	23.7
10	10.18	12.27	18.77	20.31
20	10.41	12.37	17.92	18.73
30	9.41	11.39	13.0	15.82
40	8.08	9.99	12.19	13.94

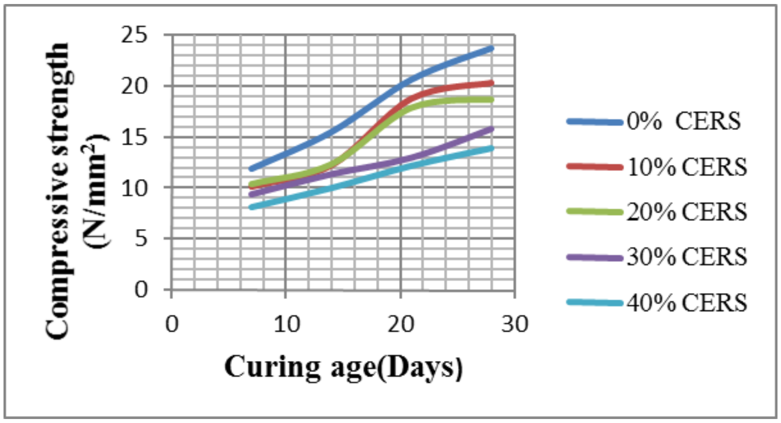

Figure 1: Effect of CCS on the compressive strength

Table VI:
Flexural Strength Test Result Of CCS:RS Concrete

%CCS	7days (N/mm^2)	14days (N/mm^2)	21days (N/mm^2)	28days (N/mm^2)
0	1.14	1.73	2.07	2.19
10	1.08	1.22	1.53	1.92
20	0.71	1.02	1.27	1.64
30	0.72	0.94	1.23	1.43
40	0.66	0.81	0.96	0.96

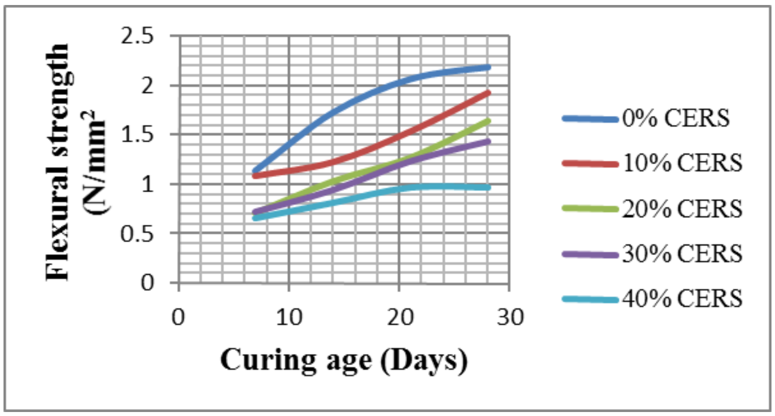

Figure 2: Effect of CCS on the flexural strength

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Table VII
Splitting Tensile Strength Test Result Of CCS:RS Concrete

%CCS	7days (N/mm^2)	14days (N/mm^2)	21days (N/mm^2)	28days (N/mm^2)
0	1.60	1.93	2.53	3.02
10	1.17	1.85	1.95	2.49
20	0.79	1.11	1.75	2.07
30	0.76	1.14	1.51	1.90
40	0.40	0.85	1.36	1.68

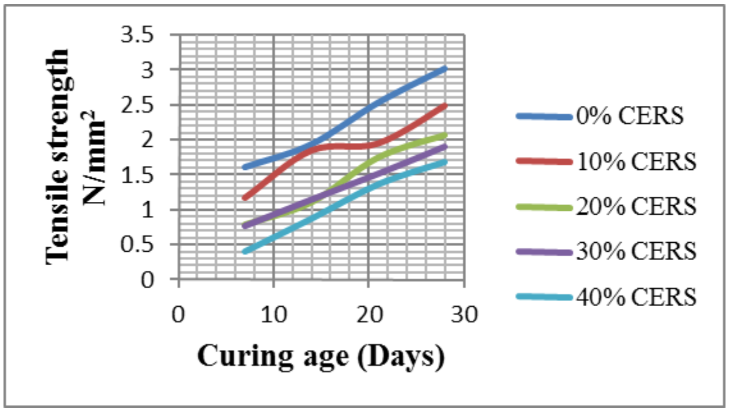

Figure 3: Effect of CCS on the Splitting tensile strength

V. Conclusions

1. Crushed Clam (*Egeria radiata)* shells (CCS) can be used as partial replacement for fine aggregates (river sand) in concrete casting in areas were the Clam shells are in abundance.
2. The test result also showed a decrease in the workability of the concrete as the percentage replacement of the crushed Clam shells (CCS) for river sand increases.
3. The 28days compressive strength at 0%, 10%, 20%, 30%, 40% are 23.7, 20.31, 18.73, 15.82, 13.94N/mm^2 respectively while the flexural strengths values are 2.19, 1.92, 1.64, 1.43, 0.96N/mm^2 respectively for a mix ratio of 1:2:4.
4. 10% replacement does not compromise the strength of the concrete as a grade 20 concrete, while 20% replacement produced a grade 15 concrete.

VI. Recommendation

1. The effect of crushed Clam shells on the concrete should also be studied beyond 28 days curing age to obtain the long term strength development of this concrete at 10%, 20%, 30%, 40% replacements
2. The effect of concrete admixtures on the Clam shell concrete should also be investigated.
3. The government should be approached to come up with policies to intensify the use of Egeria radiata shells in the construction industry

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