International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 9, September 2016)

Performance of Clam (Egeria Radiata) Shell Ash (CSA) as a Substitute for Cement in Concrete.

F. A. Olutoge[1], S. E. Nwabueze[2], S. O. A. Olawale[3], B. E. Yabefa[4]
[1,2,4]Department of Civil Engineering, University of Ibadan, Ibadan Nigeria.
[3]Department of Civil Engineering, Osun State University, Osogbo, Nigeria

***Abstract*— Cement is a construction material required on daily basis by the construction industries in every society for the construction of shelters, roads, pavements etc. The high and increasing cost of cement used in these concrete works has made it unaffordable for owner-occupied housing in developing countries. Hence, the need to find alternative material as partial replacement to reduce high cost of construction. This study used an agro-waste material; Clam (*Egeria radiata*) shells: an environmental pollutant Clam Shell, reduced to Clam Shell Ash(CSA), which was used as partial replacement for Ordinary Portland cement at 0%,5%,10%,15%, and 20%. A total of one hundred and twenty (120) specimens were produced and cured in water for 7, 14, 21, and 28 days respectively. The chemical composition and specific gravity of the CSA together with properties such as compressive strength, split tensile strength and density were determined. The results showed that CSA contain major metallic oxides present in OPC, though in different percentages. The optimum compressive and split tensile strength were obtained from concretes produced with percentage replacement level of 5% CSA for OPC respectively at 28days curing period. The density of the concrete decreased with increasing CSA.**

***Keywords*— Concrete, Clam (*Egeria radiata*) Shell Ash, Compressive strength, Split tensile strength.**

I. INTRODUCTION

Cement is a major constituent of concrete basically required by the construction industry for the construction of buildings, roads, pavements etc. in all developed and developing countries. Concrete is a composite material which is made up of cement, aggregates, water, admixtures, and reinforcements. It has become very important in every country for the construction and maintenance of existing infrastructures. The increasing demand for cement has geometrically increased its cost, hence, making it unaffordable. Aho et al (2008) stated that, the high cost of construction materials like cement and reinforcement bars has increased the cost of construction. Also, the production process of cement has some major disadvantages such as the steady introduction of green house gases in large quantity to the environment.

Hence, there is a major challenge to search for a material that is readily available at low cost which is environment friendly and can be used totally or partially to replace cement in concrete production.

Research shows that, most materials that are rich in amorphous silica can be used in partial replacement of cement (Aho et al 2008). It has been established that, amorphous silica found in some pozzolanic materials react with lime more readily than that of crystalline form. (Nehdi et al 2003). Use of pozzolans can lead to increased compressive and flexural strength (Oyetola et al 2006)

In respect of the high cost and problems associated with cement, this work investigated the use of an agro-waste material called Clam (*Egeria radiata*) shells which were collected and burnt to form Clam shell ash (ERSA) and used as partial replacement of cement in concrete production. This will help to reduce the seashell wastes found in large quantity in the coastal communities (Elijah 2009) as a means of pollution control in the environment and also reduce the cost of construction. The Clam (*Egeria radiata*) is in the group of bivalve mollusks and the only fresh water Clam in the family of Donacidae endemic to the West African subregion. It is of both ecological and economic importance (Lawrence et al 1996). It is a gonochoristic specie which spawns once in a year during the peak of the rain season (June to October). The specie is abundant in many large rivers e.g. Volta (Ghana), Sanega (Cameroon), and Cross (Nigeria) rivers. It supports a rich and thriving artisanal fishery whenever it is found. Several aspects of its biology haven been documented e.g. general biology and gross anatomy (Purchon, 1964), population dynamics and fisheries (Etim and Brey 1994, Moses 1990).

Olutoge et al (2012) assessed the suitability of periwinkle shell ash (PSA) as partial replacement for (OPC) in concrete production. The result showed increased initial and final setting time on increasing PSA. The specific gravity of the PSA was less than OPC. And the compressive strength decreased with increasing PSA.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 9, September 2016)

Etuk et al (2012) made a feasibility study on the use of seashell ash as admixtures in concrete. Periwinkle, Oyster, and Snail shells were burnt at 800^{o}C and used as replacement for Ordinary Portland Cement at 0%, 10%, 20%, 25%, and 30%. The maximum compressive strength with percentage replacement level of 10% for PSA, 15% for OSA, and 20% for SSA were obtained.

Olutoge et al (2012) investigated the strength properties of palm kernel shell Ash concrete; by using the PKSA as a partial replacement for cement. 100% cement concrete of mix 1:2:4 and 0.5 water-cement concrete ratio was used as control. A total of 72 concrete cubes of size 150×150×150mm^3 with different volume percentage of PKSA to OPCt in the order of 0:100, 10:90 and 20:80 were cast and their physical and mechanical characteristics were tested at 7days, 14days, 21days, and 28 days time. The compressive strength test showed that 10% of the PKSA in replacement for cement was 22.8N/mm^2. Hence he concluded that, PKSA can be used as a partial replacement for cement at lower volume of replacement.

Utsev et al 2012 used coconut shell ash as partial replacement for OPC in concrete production. Concrete cube were produced using replacement level of 0, 10, 15, 20, 25, and 30 percent of OPC with CSA. A total of 54 cubes were produced and cured for 28days. The result showed that, the densities of concrete cube of 10-15% replacement was above 2400kg|mm^2 and the compressive strength increased from 12.45N/mm^2 at 7days to 31.78N/mm^2 at 28days curing, thus meeting the requirement for use in both heavy weight and light weight concreting.

The objective of this study is to investigate the strength properties of the ERSA concrete based on the workability, density, compressive strength, splitting tensile strength, and and some physical properties of the ERSA and its chemical analysis.

II. Research Methodology

A. Materials

The Elephant brand of Ordinary Portland cement (OPC) was used in this study. It was sourced from Bodija market in Oyo state, Ibadan Nigeria. This met the requirements of BS 12 (1996). Crushed Granites rocks with a maximum particle size of 20mm sourced from a quarry in Ibadan was used as coarse aggregates, and River sand with particle size of 4.75mm was used as fine aggregates in accordance with BS 812-103.2 1989. The sieve analysis result of the fine and coarse aggregates is shown in Table 2 and 3. Also, the water used in this study was clean borehole water free from every visible impurity.

The Clam shells used in this work were obtained in a dumpsite at Korokorosei community in Southern Ijaw Local Government Area of Bayelsa State, Nigeria. The shells were washed and dried for five days and burnt in an uncontrolled environment to form Clam shell ash (CSA). Then the ash was ground and sieved with 4.75µm sieve. Then the specific gravity and chemical properties of the CSA was determined as shown in Table 1. The chemical analysis of the CSA was carried out in the chemical laboratory in the Department of Agronomy, University of Ibadan, Ibadan, Nigeria.

Plate I. Clam (*Egeria radiata*) Shells

Table 1
CHEMICAL COMPOSITION OF ERSA AND OPC

Oxide	SiO_2	Al_2O_3	CaO	MgO	K_2O	Na_2O	MnO_2	Fe_2O_3	CuO	ZnO
CSA (%)	40.74	6.11	51.06	0.18	0.28	0.04	0.012	0.036	0.0006	0.0039

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 9, September 2016)

Table II
Sieve Analysis Of Fine Aggregate

Sieve size	Weight of Sieve	Sieve + Mat Retained(Kg)	Weight Retained(Kg)	%Retained	%Passing
4.75*mm*	492.5	499.7	7.2	1.81	98.19
2.36*mm*	431.0	465.7	34.7	8.71	89.48
1.18*mm*	393.9	490.1	96.2	24.16	65.32
850μm	377.5	427.4	49.9	12.53	52.79
600 μm	347.1	395.0	47.9	12.03	40.76
425 μm	342.2	383.8	41.6	10.45	30.31
212 μm	341.6	392.2	50.6	12.71	17.60
150 µm	323.0	352.9	29.9	7.51	10.09
75 μm	314.8	350.4	35.6	8.94	115
pan	488.6	453.2	4..6	1.15	-----

Table III
Sieve Analysis Of Coarse Aggregate

Sieve size	Weight retained	% Retained	Cumulative retained	% Passing
19.04mm	143.00	1.55	1.55	98.30
12.00mm	3174.00	34.56	37.20	65.10
10.00mm	4360.00	48.20	-	16.90
4.75mm	1506.00	15.69	-	0.00
Pan		100.00		

B. Specific Gravity of Clam Shells

The specific gravity of the Clam shells was carried out by the pycnometer test method in accordance with BS 1377, (1990)

C. Proportioning and Mixing of Concrete Constituents

The mix ratio considered in this study was 1:2:4 with a water-cement ratio of 0.5. Batching of the materials was done by weight. A total of 60 concrete cubes of 100mm and 60 cylinders of 100mm diameter with 200mm height, hence making a total of 120 concrete specimens were cast. CSA was used to partially replace OPC at a replacement level of 0%, 5%, 10%, 15% and 20%. The detail of constituents per cubic hundred millimeter of the concrete is shown in Table IV. All concrete ingredients were mixed in accordance with the procedure given in BS 1881-125: 1986.

Table IV
Mix Proportions (Per 100mm3) Of CSA Versus OPC Concrete

%CSA	Cement	CSA	River Sand	Granite
0	0.34	-	0.69	1.37
5	0.32	0.017	0.69	1.37
10	0.31	0.034	0.69	1.37
15	0.29	0.051	0.69	1.37
20	0.27	0.068	0.69	1.37

D. Workability test

The workability of the concrete containing Clam shells ash as partial replacement for cement was determined by the slump test method in accordance to BS 1881: Part 102: 1983

E. Density

The weight of each concrete cubes were obtained prior to testing to ascertain the density. This was done in accordance to BS 1881: Part 114: 1983.

F. Compression Strength

The compressive strength was determined on the 100mm concrete cubes by the application of the compression load of 3.0KN/s in accordance with BS 1881: Part 111: 1983. The compressive strength was tested after 7, 14, 21 and 28 days of curing in water.

G. Splitting Tensile Strength

The splitting tensile strength test of the concrete was done on the 100mm diameter by 200mm height cylinder specimen after 7, 14, 21 and 28 days of curing. The concrete cylinder was placed in the horizontal axis between the platens of the testing machine. The load was gradually applied until the cylinder split in to two halves.

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 9, September 2016)

The test was carefully done in accordance with BS 1881: Part 117 1983.

III. Results And Discussion

A. Specific Gravity of CSA

The specific gravity of the Egeria radiata shell ash (ERSA) is 2.08, which is less than 3.15 for OPC which it replaced.

B. Effect of CSA on Workability

The effect of the CSA on the workability of the concrete is shown in Table 5. Slump values of 59mm, 53mm, 43mm, 40mm and 37mm were obtained for the CSA replacement level of 0-20% respectively. The result shows a decrease in the slump values as the CSA increases. This is due to the increasing specific surface area of the concrete on increasing content of the CSA, hence more water is needed to produce a more workable concrete. The slump values are within the acceptable limit of a concrete with low workability.

C. Density

Table 6 shows the density test results of the concrete cubes. The results show that, the density increased as the curing days increased and reduced with increasing Clam shell ash replacement. Density of the concrete increased from 2520Kg/m3 at 7 days to 2600Kg/m3 at 28 days curing period for the 0% replacement of OPC by CSA. Also, density at 0% to 40% replacement level in steps of 10% gave value of 2600, 2710, 2630, 2590, 2540Kg/m3 respectively for the 28 days curing.

D. Compressive Strength

The strength development of the concrete cubes at the various curing days is given in Table 7, and Figure 1 shows the effect of ERSA on the compressive strength of the concrete cubes. The result shows that, the compressive strength increased generally with increased curing days and decreased with increasing content of Clam shell ash. The values of compressive strength at 28 days of curing were 22.56N/mm2, 18.55N/mm2, 12.68N/mm2, 10.14N/mm2, and 8.48N/mm2 for 0%, 5%, 10%, 15%, 20% replacement level of CSA for OPC respectively. Hence the optimal 28 days strength for OPC-CSA mix is recorded at 5% replacement level (18.55N/mm2)

E. Splitting tensile Strength

The results of the splitting tensile strength test of the concrete cylinders are presented in the Table 8 below. Figure 2 shows the effect of CSA on the tensile strength of the concrete. The results showed that, the tensile strength of the concrete increased with increased curing period and decreased with increasing Clam shell ash (CSA) content. Splitting tensile strength values at 28 days curing were 3.43N/mm2, 2.80/mm2, 2.34N/mm2, 2.20N/mm2, and 1.74N/mm2 for 0%, 5%, 10%, 15%, and 20% replacement level of CSA for OPC respectively. Therefore the maximum 28 days tensile strength for the OPC-CSA mix is obtained at 5% replacement level (2.80N/mm2) which does not compromise the strength of the concrete.

Table V
Slump Test Result

%CSA	Slump(mm)
0%	59mm
5%	53mm
10%	43mm
15%	40mm
20%	37mm

Table VI
Density Of The Concrete Cubes In KG/M3

%CSA	7days Density (Kg/m^3)	14days Stress (Kg/m^3)	21days Stress (Kg/m^3)	28days Stress (Kg/m^3)
0	2520	2410	2560	2600
5	2530	2550	2590	2710
10	2490	2560	2540	2630
15	2450	2460	2490	2590
20	2420	2460	2530	2540

Table VII
Compressive Strength Test Results

%CSA	7days Stress N/mm^2	14days Stress N/mm^2	21days Stress N/mm^2	28days Stress N/mm^2
0	15.43	16.38	19.98	22.56
5	13.16	15.18	14.92	18.55
10	8.74	11.15	12.44	12.68
15	6.45	7.25	10.66	10.14
20	3.36	5.48	6.35	8.48

International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 5, Issue 9, September 2016)

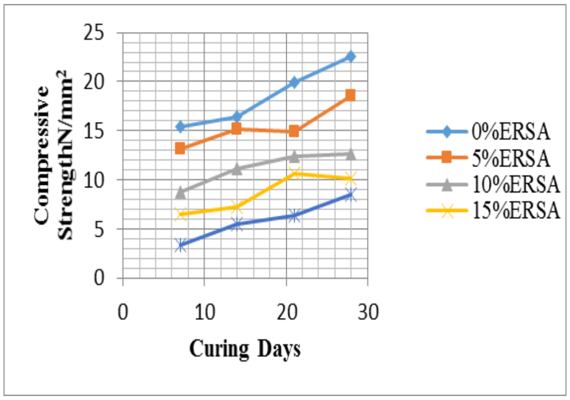

Figure 1 Effect Of CSA On The Compressive Strength

Table VIII
Split Tensile Strength Test Results

%CSA	7days Stress N/mm^2	14days Stress N/mm^2	21days Stress N/mm^2	28days Stress N/mm^2
0	1.96	2.56	2.80	3.43
5	1.64	2.09	2.26	2.80
10	1.51	1.90	2.17	2.34
15	1.35	1.62	2.03	2.20
20	1.20	1.35	1.60	1.74

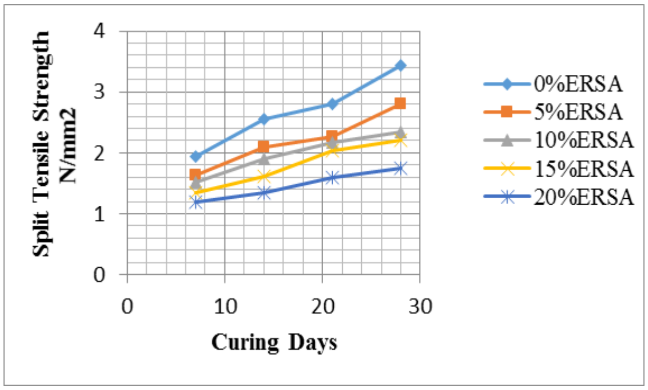

Figure 2 Effect Of CSA On The Split Tensile Strength

IV. CONCLUSIONS

The experimental results showed that Clam shell ash (CSA) is a good pozzolanic material which contains the required chemical constituents that makes up a pozzolan. The pozzolanic activity of CSA increases with increase in time.

Increase in Clam shell ash content in the concrete reduced the slump values. Hence, the concrete becomes less workable. This means that more volume of water is required to increase the workability when CSA content is increased.

The specific gravity of the Clam shell ash (CSA) was less than that of the Ordinary Portland Cement which it replaced, this implies that, a greater volume of cementitious material s will result from mass replacement

V. RECOMMENDATIONS

Appropriate technology should be properly developed to utilize this material, so that it will enhance the supply of cementitious material to the rural area of the country where these wastes are generated in large quantity, hence combating unhealthy disposal of these agricultural wastes.

It is also recommended that, the concrete curing should be extended beyond 28days to ascertain the long term strength development of ash modified concrete.

Other tests such as corrosion resistance, shrinkage, properties, and absorption rate should also be carried out on the Clam shell ash (CSA) concrete.

REFERENCES

[1] Aho, M.I and Utseve, J.T (2008). Compressive strength of sandcrete Blocks made with Rice Husk Ash as a partial Replacement for cement. Nigerian journal of Technology, Vol. 27, No. 2 pp 71-77.

[2] BS 12 (1996), Specifications for Portland Cement, British Standards Institute, London

[3] BS 1881: Part 102 Testing Fresh Concrete: Method for determination of slump, British Standards Institute, London, 1983.

[4] BS 1881: Part 116 Method for Determination of Compressive Strength of Concrete, British Standards Institute, London, 1983

[5] BS 1881: Part 117: Testing Concrete method for Determination of tensile splitting strength, British Standards Institute, London, 1983.

[6] BS 1881-125 Testing Concrete: Methods of mixing and sampling fresh concrete in the Laboratory, British Standard Institute, London.

[7] BS 1881: Part 114: 1983 Testing Concrete. Method for determination of density. British Standard Institute, London, 1983.

[8] Etuk , B. R, Etuk, I. F, Asuquo L. O; (2012). Feasibility of using sea shells Ash as Admixtures for concrete. Journal of Environmental Science & Engineering. Jan2012, Vol. 1 Issue 1 A, P121

[9] Elijah. I, Ohimain, Sunday Bassey and Dorcas D.S Bawo (2009). Used of sea shell for civil construction works in coastal Bayelsa State, Nigeria: A waste management perspective. Reseach Journal of Biological Science 4(9): 1025-1031, 2009.

[10] Nehdi, M., Dequette, J.E and Damatty, A. (2003). Performance of rice husk ash produced using a new technology as a mineral admixture in concrete. Cement and concrete Research Journal, 33(8); 1203-1210.

[11] Oyetola, E.B and Abdullahi, M.(2006): the use of rice husk ash in low cost sandcrete blocks production. Leonardo Electronic Journal of practices and Technology; 8:58-70

[12] Olutoge F. A, Oriyaomi M, Okeyinka .S. O (2012). Assesment of the suitability of periwinkle shell Ash (PSA) as partial replacement for ordinary Portland cement (OPC) in concrete. IJRRAS 10(3) 2012. Available at www.arpapress.com/volumes/vol10/ssue3/IJRRAS-10-3-08.pdf.

[13] Olutoge F.A, Quadri H.A, Olafusi O.S (2012); Investigation of the strength properties of palm kernel shell Ash concrete. Engineering technology and Applied Science Reseach Vol.2, No.6(2012).

[14] Purchion, R.D., (1964) A note on the biology of Egeria radiata L. (Bivalve: Donacidae). Pro. Malacology. Soc. London 35:251-271.

[15] Utsev, J.T, Taku J.K. (2012); Coconut Shell Ash as replacement of OPC in concrete production. International of scientific &Technology Research Vol.1 ISS2277-8616