STRUCTURAL PROPERTIES OF SNAIL SHELL ASH CONCRETE (SSAC)

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ABSTRACT

The excruciating cost of cement has been constituting serious threat to the provision of safe, adequate and affordable housing for low income earners in Nigeria. Consequently, the search for cheaper alternate materials has become imperative. It is against this backdrop that this work investigated the potentials of snail shell ash (SSA) as partial replacement of cement in concrete. Towards this end, graded levels of snail shell ash (0%, 5%, 10%, 15%, and 20%) all passing through 75um sieve were used to prepare 1:2:4 concrete mix of water cement ratio of 0.5. Mechanical and physical properties of the resulting SSA blended concrete, such as workability, water absorption, density and compressive strength were determined in accordance with British Standards BS1881. The results showed that at 20% SSA replacement, the concrete has the lowest water absorption rate of 0.12% and the highest of 0.74% respectively, at 20% and 5% SSA% replacement. Furthermore, average density at 28days was shown to be 2376.30 Kg/m^{3}while 28days compressive strengths were 23.92N/mm^2 and 24.63N/mm^2 respectively, at 15% and 20%SSA replacement. The study concluded that after 28days of curing, SSA concrete could be used as normal weight structural concrete provided that application level of SSA does not exceed 20%.

Keywords- *Cementitious, Compressive Strength, Snail Shell Ash, Water Absorption, Workability.*

I. INTRODUCTION

Snail Shell is a waste product obtained from the consumption of a small greenish blue marine snail, which rests in a V shaped spiral shell, found in many coastal regions. These shells are very strong, hard and brittle material. These snails are found in the lagoons and mudflats of the coastal areas, the people in this area consume the edible part as sea food and dispose the shell as a waste product, but a large amount of these shells are still disposed off as waste. This invariably heightens the nuisance value of the huge deposits of solid waste which dot major towns and cities in this part of the globe. Studies have shown that every year, seafood industry alone generates over 100 million pounds (45.3 million kg) of waste that is strictly from shellfish and crustaceans [12].Most of these are ultimately sent to landfills. Therefore, there is growing concern on how to redress the deplorable situation so that more land space could be retrieved from landfills for more useful and productive ventures. Towards this end, great effort is being geared at recycling these and other agricultural waste for alternative uses in concrete works and thus convert wastes to wealth. In fact, abundant evidence exists suggesting that the chemical make-up of these shells demonstrates reasonable pozzolanic and strength properties when applied as aggregate in concrete production. [13, 14] in separate experimental studies opined that the Snail Shell Ash (SSA) exhibits strikingly similar properties with Ordinary Portland Cement (OPC), a position supported by the findings of [13] who posited that the phyico-chemical and mechanical properties such as composition; specific gravity compressive strength and tensile strength of both snail shell ash and OPC are similar. In light of the above, many researchers and built-environmentalist have interestingly indicated that ash of agricultural wastes could be used as a tool for curbing incessant collapse and high cost of building, when properly applied as partial substitute of cement in concrete [15].The persistence of structural collapse which has been widely attributed to high cost of OPC and the compelling need to make housing more affordable prompted the present research.

II.RESEARCH METHODOLOGY

A. Materials and Methods

The African giant snail shells were obtained from unauthorized dumpsites located at the shore of a lagoon in Badagry; a local market at Lusada and at Beam Hotel in Ilaro (7.389ºN, 3.909ºE) respectively, all within Ogun State in the Southwest of Nigeria . The shells were washed, cleaned, sun dried and crushed into finely ground powder using commercial milling machine. In this form, the powder passed through a 75um sieve. The crushed snail shell was calcined in an electric muffle furnace fitted with a temperature control device in the concrete laboratory of the Federal Polytechnic Ilaro, Nigeria (7.469ºN, 3.905ºE). The temperature ranged between 650ºC and 800ºC for about 45 minutes, at optimum temperature of 800ºC crushed snail shells turned to white powder. After, the chemical composition of oxides of snail powder was carried out using the X-ray fluorescent at the Geo-chemical laboratory in Ibadan, Oyo State Nigeria. Other materials used were cement, fine and coarse aggregate and water. The cement used was of grade 30 ordinary Portland cement in Nigeria in accordance with the Nigerian Standard Organization specification for cement use for general purpose. Water was obtained as free from any impurities that could affect the integrity of the resultant mix which was obtained from the Concrete Laboratory of the Department of Civil Engineering, Federal Polytechnic, Ilaro (7.102ºN, 3.330ºE) Ogun State, Nigeria.

Figure 1: Broken and Burnt Snail Shell (Before Sieve)

Figure 2: Snail Shell Ash (After Sieve)

XRF (X-ray Fluorescent) test was carried out and the table I below shows the chemical composition of oxides in snail shell ash.

Chemical Constituents (Samples)	**Percentage Composition (%)Snail Shell Ash (SSA)**	**Percentage Composition (%)Cement**
SiO_2	1.38	19.99
Al_2O_3	1.52	4.78
Fe_2O_3	2.53	3.57
MnO	0.02	
CaO	88.2	63.73
P_2O_5	0.07	0.10
K_2O	1.40	0.70
TiO_2	0.01	
MgO	0.30	1.90
Loss on Ignition (LOI)	4.57	2.41
Total	100	

Table 1 (Chemical composition of oxides in Snail shell Ash)

	0%	5%	10%	15%	20%
CEMENT	18	17.1	16.2	15.3	14.4
F A	36	36	36	36	36
C A	72	72	72	72	72
SSA	0.00	0.90	1.8	2.7	3.6
WATER	9.00	8.55	8.10	7.65	7.2

Table 2(Batch Weight of materials (kg) for each mix)

B. Particle Size Distribution

The sieve analyses of both fine and coarse aggregates were carried out in accordance with BS 1377-2, 1990.

SIEVE SIZE	WEIGHT RETAINED	CUMULATIVE RETAINED	PERCENTGE RETAINED	PERCENTAGE PASSING
9.5	0	0	0	100
4.75	4.1	4.1	2.05	97.95
2.36	9	13.1	6.55	93.45
1.18	64	77.1	38.55	61.45
600	45.7	122.8	61.4	38.6
425	36.6	159.4	79.7	20.3
300	29	188.4	94.2	5.8
200	11	199.4	99.7	0.3
150	0.4	199.8	99.9	0.1
75	0.2	200	100	0
TRAY	0			

Table 3 (Particle Size Distribution of fine aggregates (sand))

SIEVE SIZE	WEIGHT RETAINED	CUMULATIVE RETAINED	PERCENTAGE PASSING	PERCENTAGE RETAINED
25.4	0	0	100	0
19	15.1	15.1	92.45	7.55
13.2	29.4	44.5	77.75	22.25
10	94.5	139	30.5	69.5
7.5	39	178	11	89
1.18	22	200	0	100
TRAY	0			

Table 4 (Particle Size Distribution of coarse aggregates (granite))

C .Setting time of cement and SSA

The initial and final setting of cement and SSA were in accordance with BS 12

SAMPLES	INITIAL SETTING TIME	FINAL SETTING TIME
Dangote (OPC)	40minutes	4hours 40minutes
Snail Shell Ash	49minutes	6hours 40minutes

Table 5 (Setting time of cement and SSA)

SSA%	Weight (kg)	Density (kg/m^3)
0	8.20	2429.63
5	8.15	2414.81

10	8.10	2400.00
15	8.05	2385.19
20	8.02	2376.30

Table 6 (Density of SSA concrete at 28days)

	Weight (g)	Weight (g)	% Water Absorption
% Replacement	Before	After	
0%	8100	8200	1.24
5%	8090	8150	0.74
10%	8060	8100	0.49
15%	8040	8050	0.12
20%	8010	8020	0.12

Table 7 (Water absorption of concrete Cubes at 28 days)

	Curing days			
Replacement level (%)	7 Stress (N/mm^2)	14 Stress (N/mm^2)	21 Stress (N/mm^2)	28 Stress (N/mm^2)
0	19.54	21.05	23.48	25.17
5	18.33	20.25	20.75	21.42
10	16.88	21.58	21.00	23.00
15	15.52	16.97	21.50	23.92
20	17.17	21.29	22.71	24.63

Table 8 (Compressive Strength Test Results)

D. Workability test

The workability of both control and concrete containing Snail shell ash were determined by the slump test method in accordance with 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 with BS 1881: Part 114: 1983.

Density = Mass/Volume

F. Water absorption test

The weight of the cubes were weigh after demoulding and also 28 days curing in water in order to ascertain water absorption rate and which was carried in accordance with (BS 813-2; 1995)

Water absorption rate = (Final weight of cubes after curing - Initial weight of cubes before curing) / Initial weight of cubes before curing.

G. Compressive strength

The cubes were cured in water for 7days, 14 days, 21 days and 28 days. The compressive strength was carried on 150mm x150mm cubes after days of curing in accordance with (BS 1881- 116, 1983)

Compressive strength = Compressive Force/ Cross section Area (N/mm^2)

III.RESULTS AND DISCUSSIONS

A. XRF Analysis of Snail Shell Ash (SSA)

It was presented in Table I that silicon IV oxide (SiO_2), Iron II oxide (Fe_2O_3) and Al_2O_3 (5.43%) did not add up to (50%) class C pozzolan and (70%) class F pozzolan so shell snail ash neither belongs to class C or F pozzolans in accordance with (ASTM C618, 2008) but has 88.2% CaO so it is not a natural pozzolans.

B. Sieve Analysis of Coarse Fine and Aggregates.

It was observed that coarse aggregates had Coefficient of uniformity (C_u) of 1.57 and coefficient of curvature (C_c) of 1.29 as shown in Fig 1 below. Since C_u is less than 3 so the coarse aggregate is uniform and C_c falls between 0.5 and 2. The coarse aggregate is well graded in accordance with BS 1377-2, 1990.

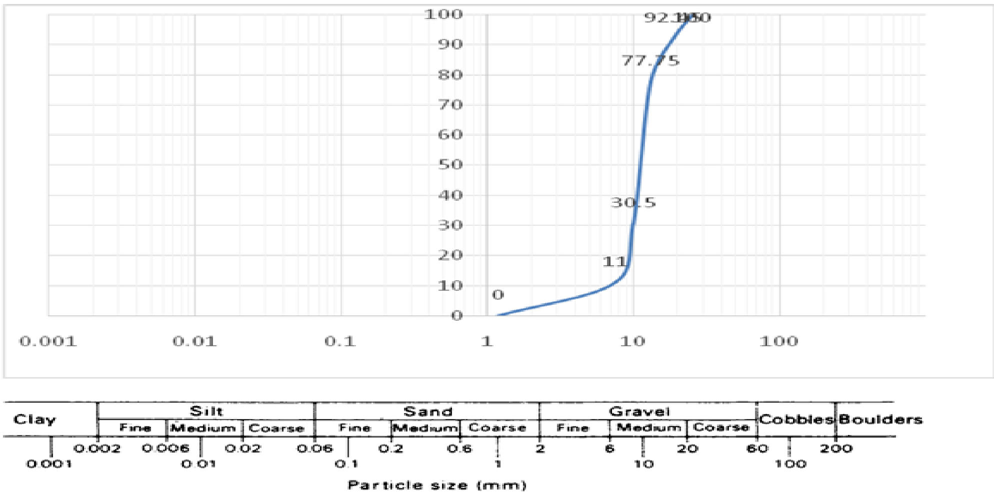

Figure 1: **ParFFigure 1: Particle Size Distribution of Coarse Aggregates**

The fine aggregate (sand) has coefficient of uniformity (C_u) of 3.33 and coefficient of curvature (C_c) of 0.83 as shown in Fig 2 below. Since C_u is greater than 3 so the fine aggregate is not uniform and C_c falls between 0.5 and 2. The fine aggregate is un- uniform well graded in accordance with BS 1377-2, 1990.

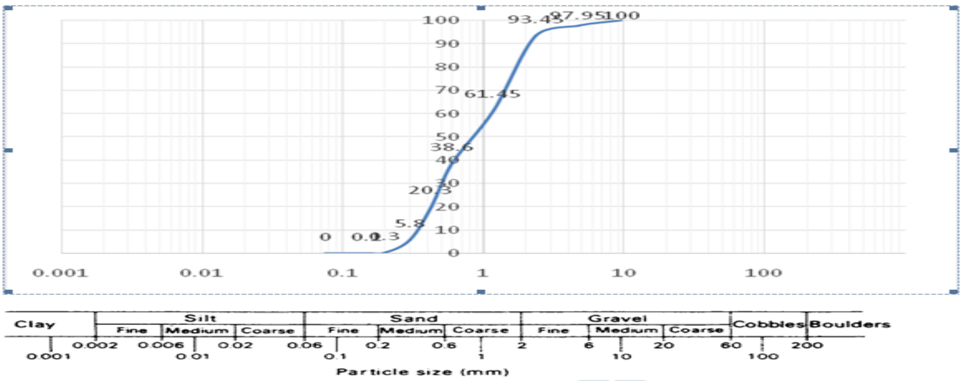

Figure 2: Particle Size Distribution of fine Aggregates

C. Initial and final setting time of cement and Snail shell ash

The initial and final setting time of cement and snail shell ash fall within the limit of initial and final setting of cement in accordance with BS 12, 1978.

D. Effect of SSA on Workability.

The height of slump for control was 14mm which is a true slump. At 5% replacement of snail shell ash in concrete the slump height declined to 10mm, then declined at 10% replacement to 8mm and reduced to 6mm at 15% and maintained the same height of slump at 20% replacement as shown in Figure 3. It can be deduced that the higher the snail shell ash in concrete the less workable the concrete. This was due to the fact that the snail shell ash cannot take in water as that of cement because of its greasing and smoothen surface.

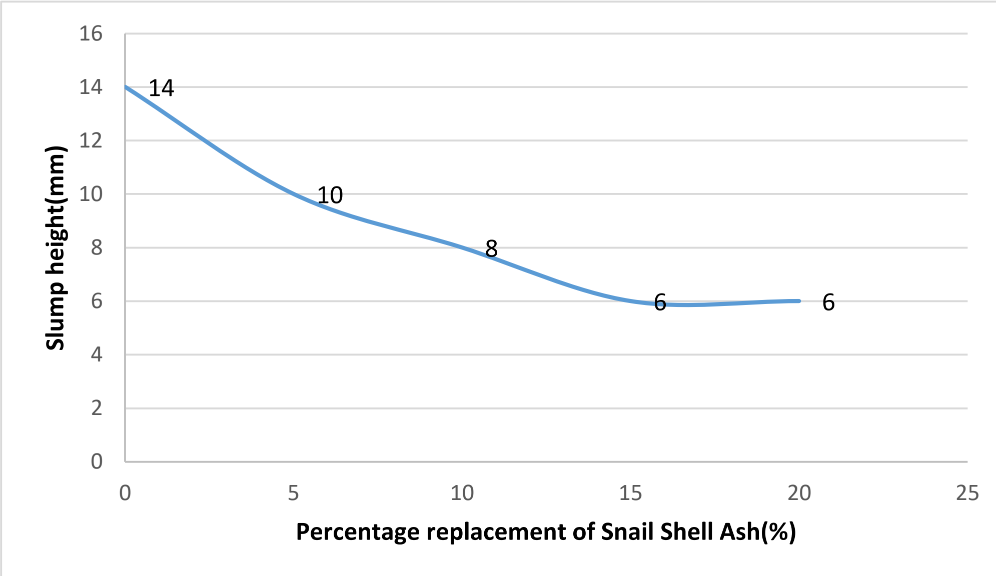

Figure 3: Graph of Percentage replacement of Snail Shell against Slump height.

E. Density

Density of SSA concrete at 28 days decreased as snail shell ash increased in concrete i.e the higher the SSA in concrete the lower the density. The density from 0 to 20% at replacement level of step 5% produced density of 2429.63, 2414.81, 2400, 2385.19 and 2376.30Kg/m^3 respectively as illustrated in Table VI. This reduction occurred because specific of SSA is less than specific gravity of cement.

F. Water Absorption

The concrete cubes at 28days curing were weighed after demoulding.It was observed that the 0% snail shell ash has water absorption of 1.24% and that 5% snail shell ash concrete has the highest water absorption rate of 0.74% while 10% has 0.49%, 15% and 20% has the lowest absorption rate of 0.12%. It was shown that increase in snail shell ash led to decrease in water absorption of concrete as shown in Table VII. The water absorption for concrete with snail shell powder at 5% is good according to concrete Society, United Kingdom, concrete quality is classified as good if the saturated water absorption is between 0.89% and 3%. In conclusion, the replacement levels from 5 to 30% of concrete with snail ash were all good.

G. Compressive Strength

Compressive strength for 28 days at 0%, 5%, 10%, 15% and 20% are 25.17N/m^2, 21.42 N/m^2, 23.00 N/m^2, 23.93 N/m^2 and 24.63 N/m^2 respectively. The higher the snail shell ash in concrete the higher the compressive strength as shown in figure 4 below. The optimal compressive strength at 20% SSA in concrete for 28 days was 24.63N/mm^2.The reason for this increase is higher chemical composition of CaO in snail shell ash.

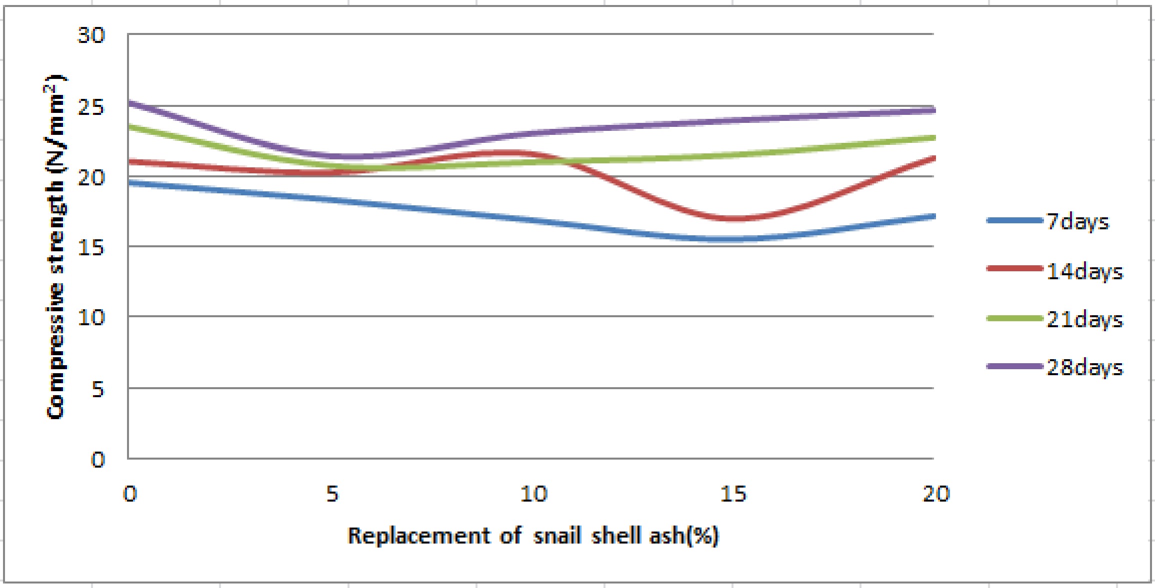

Figure 4: Compressive Strength against Snail Shell ash content.

Cost Implication

Quantity of cement saved

Assuming 50kg of cement is used.

5% x 50 = 2.5Kg

10% x 50 = 5 kg

15% x 50 = 7.5kg

20% x 50 = 10kg.

Cost of cement saved

A bag of cement cost #2500.

5% x2500 = # 125.00

10% x 2500 = #250.00

15% x2500 = #375.00

20% x 2500 = #500.00

If 20% substitute of snail shell ash in concrete will save 10kg of cement and #500 and produced maximum compressive strength of 24.63N/mm^2 compared to normal strength of 25N/mm^2.It means 40kg of cement and 10kg of snail shell ash will be used.

IV.CONCLUSIONS

This experimental study showed that snail shell ash (SSA) is not naturally pozolanic despite its high CaO composition and the striking similarities with OPC. The snail shell ash content is inversely proportional to the workability of SSAC as indicated by the slump test. This trend is replicated in water absorption, where the highest and lowest values respectively, occurred at 5% and 20%SSA application. The average density (2400Kg/m^3) and compressive strength 24.63N/mm^2 at 28days of the Snail shell ash concrete favorably compared with that of normal weight structural concrete.

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