Comparative Study on Cementitious Content of Ground Mollusc Snail and Clam Shell and their Mixture as an Alternative to Cement

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Abstract *Snail and clam shells are waste materials from Snail and Clam after removing the edible part. They are often dumped as waste to the environment and causes environmental pollution. This research aimed at comparing admixtures from these waste shells as alternative to cement. Snail shell, Clam shell and Snail/Clam shell mixtures were used as partial replacement of cement in this work because of their pozzolan nature. The result from the experiment carried out showed that Snail/Clam shell mix mortar mould had better comprehensive strength compared to snail or clam shell mould respectively at partial replacements by weight (10-30%). The comprehensive strength of the mortar mould also decreases with increase shell ash content mixed with the cement. Maximum partial replacement by weight of cement with snail shell ash was obtained at 20% with comprehensive strength of 20 N/mm². Clam shell ash was at 25% with comprehensive strength 30 N/mm² while Snail/Clam shell ash mixture had comprehensive strength of 38 N/mm² at partial replacement of 25%. The initial and final setting times for the blended cement paste increases as the shell ash replacement increases with Snail shell ash blended cement having higher initial and final setting, followed by Snail/Clam mixture blended cement.*

Keywords — *Cementatious, Snail & Clam Admixtures, Compressibility strength, Setting time*

I. INTRODUCTION

Snail and Clam are small marine animals belonging to the group phylum Mollusca and class gastropod [1]. Their shells are produced as waste materials from the local consumption of these animals and also from food industries. These shells are often dumped as waste material to the environment due to poor waste management system in third world countries like Nigeria. With time these waste shells results in environmental pollution which becomes harmful to humans residing in these areas and also affects water ways inhabiting animals. One way of converting these waste shells to useful materials and also reduce environmental pollution is to use them as admixtures in the cement and concrete industries.

Admixture or Pozzolans are materials added as ingredient of concrete aside cement, aggregate and water before or during mixing [2] Admixture materials are obtained from natural materials or by products from other processes. Admixtures are known to improve the strength characteristics of cement, its workability, hardening properties and also reduce the cost of concrete construction [3].

Cement is used as binders to improve the strength of materials in construction and building works while concrete is the combination of cement, aggregate (gravel or granite, sand) and water used in construction.

In Nigeria the pricey nature of cement and other construction materials such as concrete has affected building and construction projects. This has made it difficult for the average Nigerian to build their homes, road, drainage etc., thus, the need for alternatives to cement such as admixtures from locally found natural materials is highly encouraged.

Research have shown that Pozzolan admixtures from different agricultural waste can be used as partial replacement of cement in construction such as sawdust ash [4], rice husk ash [5][6], cassava starch admixtures[7], snail shell ash and periwinkle shell ash [8] [9]. Their result showed that the admixtures improve the strength and hardening properties of the concrete, reduces possible environmental pollution and also reduction in the cost of construction.

The aim of this work is to study comparatively the effect of waste snail and clam shells and their mixture as cementatious content for the partial replacement of cement on the strength of concrete. Although works has been carried out on snail shells, Clam shell separately, to the best of my knowledge no work has been carried out on the combined strength characteristics of snail and clam shell as cementatious material compared to the their individual shells. In this research work, land snail was chosen in preference to water snail because of its availability in the Niger Delta Area of Nigeria, and it is mostly consumed locally in this region and generates most of the environmental pollution.

Snails are marine animal (phylum Mollusca and class gastropod), and belongs to the group of exoskeletons that contains rigid and resistant component that plays functional role like protection from temperature, support, feeding, acting, etc. They differ in sizes and nature but possess some

characteristics that distinguish them such as their coiled nature, feeding habits and pattern, shell hardness and content of calcium carbonate ($CaCO_3$). The content of $CaCO_3$ in snail shells allows for its use as partial replacement for ordinary Portland cement. The land snails are found in bushes and forests while sea snails are found in Rivers and sea same as Clam.

Clam is a bi-valve sea animal (having two shells) unlike snail which is uni-valve in nature. Clam is found in brackish deep water, in river bed and is a seasonal animal. It is a species of the molluscs and possesses rigid and resistant component that fulfil a set of functional role like protection from predators, support, feeding, acting, etc. They are consumed daily in diets in most homes in the south-south and south-eastern part of Nigeria.

Research has been carried out on the Strength Characteristics of Snail Shell Ash Blended Cement Concrete [10][11], snail shells has been used in cement mortars for masonry and plastering [12]. Research has also been carried out on clam shells as beach retaining wall [1]. Research has shown that Clam shell is richer in micro-nutrients compared to land snail, water snail and periwinkles shells [13]. And also research have shown that snail and clam shells contains the constituent of ordinary potland cement (OPCEM) which gives its strength, specifically calcium oxide (CaO) and silicon oxide (SiO2) [14]. This makes snail and clam a possible alternative for the replacement of the cement.

II. MATERIALS AND METHOD

The shell Admixtures were produce through the following steps. First, Snail and clam shells were collected from dumpsite at Amassoma in Southern Ijaw Local government Area of Bayelsa State in Nigeria. The shells were washed and impurities such as soil, dirt and other organic materials were removed and the shells sun-dried. The shells were cracked into smaller pieces and placed in a Vecter furnace at 800^{o}C to form ash. The ashes were then crushed and gently grind with mortar and pestle to powder form. Finally, A 300µm (micron) sieve mesh was used to produce fine powder (pozzolan) from the shell ash and stored in a bottle. Ordinary Portland cement used as binding agent together with sand was bought from a local shop.

The specific gravity of the shell ash sample were determined in accordance with British standard applying the equation [15]

$$\text{Spgr} = \frac{w_2 - w_1}{(w_2 - w_1) - (w_3 - w_4)} \qquad 1$$

Where, W_1 is the weight of an empty bottle with stopper, W_2 is the weight of the bottle filled with shell ash to about three quarter of the bottle, W_3 is the weight of the bottle filled with shell ash and water covered with stopper and W_4 is the weight of the empty bottle filled with water and stopper.

The bulk density of the waste shell ash sample was determined using the equation below:

$$\text{Bulk Density} = \frac{\text{Weight of substance}}{\text{Volume of substance}} \qquad 2$$

2.1 MORTAR CUBES PRODUCTION

The moulds of size 100mm X 50m X 50mm was used for casting of the mortar cubes in the form of bricks. The moulds were cleaned and oiled with used engine oil to enhance easy removal of the cubes after setting and to prevent damage of the test cubes. Cement to sand and water mix ratio of 1:3:0.5 was adopted due to the sand particle size [14]. The control block or mould (0% pozzolan) was mixed thoroughly by means of a hand trowel on a non-absorbent tray to obtain a homogenous mixture. The mix was then placed in a mold and allowed to set for a day before removing. The molding process was repeated for cement replacement with 10%, 20%, 30% and 40% of Snail shell, Clam shell and snail/clam shell mixtures respectively at equal ratio. The casted blocks was placed in water bath and cured for 7 days. The curing allows the blocks to maintain satisfactory moisture content.

2.2 COMPRESSIBILITY TEST

The compressive strength of the cubes was carried out at the end of the seven days curing period. The block cubes were removed from the curing tank and weighed before taken to a compressive strength machine with capacity 1000KN to determine their comprehensibility.

2.3 SETTING TIME

The initial and final setting time for the mould was done to determine the consistency of the mould as it sets after moulding. The initial set is taken as the as the time passed from when the paste was prepared to when it set. And the consistency test for the mould followed similar procedure by [15], at Civil Engineering Department laboratory in Niger Delta University Amassoma, Bayelsa State, Nigeria.

Figure 1 shows the materials and equipment used for the research: (a) Land snails, (b) Clams, (c) weighing balance (d) sieve (e) ground snail and clam shells (f) furnace (g) Curing bath with blocks (h) compressibility machine

Fig 1 Materials and equipment used

III. RESULTS AND DISCUSSION

Table 1 shows the average specific gravity and bulk density of the samples (snail shell ash, clam shell ash and ordinary potland cement) after three separate experiments.

Table 1 Specific gravity of the samples

Material	Specific gravity	Bulk Density (g/cm³)
Snail shell ash	2.47	1.26
Clam shell ash	2.54	1.32
Cement	3.15	1.30

Table 2 shows the compressibility strength test of the snail ash, clam ash, snail and clam ash mixture at 0 %, 10%, 15%, 20%, 25% and 30% replacement of cement by these pozzolans ashes. The data showed that the compressibility strength for the samples increases with increase with cement replacement and decreases after the maximum percent replacement has exceeded. The snail shell has maximum comprehensive strength at 20% replacement, Clam shell ash at 25% and Clam/snail shell mixture ash at 25% at a comprehensive strength of 40N/mm². Although the initial comprehensive strength of the samples was lower than that of the control (0% replacement). This is because of the slow process of pozzolans which allows for the hydration of the cement. The result from Table 2, showed that the mixture of Clam and snail had higher compressive strength at replacement 10 – 25 percent compared to snail or clam respectively. Clam and snail mixture has maximum comprehensive strength at 25% replacement of cement which makes it a better alternative to cement compared to snail or clam separately.

Table 2 Comprehensive test of shell ash

Shell ash	Percentage replacement (%)	Comprehensive strength (N/mm²)
Snail	0	48
	10	10
	15	15
	20	20
	25	15
	30	10
Clam	0	48
	10	18
	15	23
	20	26
	25	30
	30	15
Clam/Snail mixture	0	48
	10	20
	15	27
	20	32
	25	38
	30	30

Table 3: Initial Setting Time

Sample (%)	Snail (minutes)	Clam (minutes)	Snail & Clam (minutes)
0	100	100	100
10	110	105	108
15	120	110	112
20	130	125	125
25	145	130	135
30	160	145	153

Table 4: Final Setting Time

Sample (%)	Snail (minutes)	Clam (minutes)	Snail & Clam (minutes)
0%	160	160	160
10%	200	180	194
15%	215	200	208
20%	225	210	217
25%	238	225	232
30	245	230	237

Table 3 and 4 shows the initial set time and final set time for the paste. The data showed that both the initial and final set time increases with increased percentage replacement of cement with the shell ash. These increases can be attributed to the decrease in hydration due to increase shell content on the cement and also the amount of water needed to mix the paste.

IV. CONCLUSIONS

Snail shell, Clam shell and Snail/Clam shell mix can be used as partial replacement of cement in construction and in manufacturing because of their pozzolan nature. Snail/Clam shell mix mortar mould showed better comprehensive strength compared to snail or clam shell mould respectively at partial replacements by weight (10-25%). This can be attributed to the combined pozzolan properties of the individual shells. The comprehensive strength of the mortar mould also decreases with increase shell ash content mixed with the cement. The maximum partial replacement by weight of cement with snail shell ash is 20% with comprehensive strength of 20 N/mm², Clam shell ash at 25% with comprehensive strength 30 N/mm² and Snail/Clam shell ash mix at 25% with comprehensive strength 38 N/mm². The comprehensive strength of the mortar mould was observed to decreases with increase replacement of cement with the shell ash.

The initial and final setting times for the blended cement paste increases as the shell ash replacement increases. Snail shell ash blended cement had higher initial and final setting, followed by Snail and Clam mixture blended cement. Clam shell blended cement had the lowest initial and final setting time. This might be due to its bivalent nature and the large amount of calcium carbonate found on it compared to snail shell.

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