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Investigating the Suitability of Snail Shell Ash as Partial Replacement for Soil Cement Stabilization

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***Abstract*—*Snail shells is a waste product which is obtained from the eating of a small greenish-blue marine snail, which is found in a V shaped spiral shell, found in many deltaic regions. These shells are a very strong, hard material. These snail are found in the creeks and mudflats of the delta areas, the people in this area eat the edible part as sea food and dispose the shell as a waste product, but a large amount of these shells are still disposed of as waste and with disposal already constituting a problem in area where they cannot find any use for it, and had led to large deposits having accumulated in many places over the years. It is with this understanding that this experimental study seeks to investigate into the suitability of snail shell ash as partial replacement for ordinary Portland cement in concrete The engineering properties considered are Optimum Moisture Content, Maximum Dry Density and California Bearing Ratio. The changes in these properties of the soil cement with the addition of snail shell ash waste in different proportions were evaluated. It is observed that the above properties have optimally improved by adding snail shell ash waste. This study shows that snail shell ash can be satisfactorily used as a stabilizing agent for sub-grade layers and sub-base layers of a flexible pavement*.

***Keywords*—** *Snail shell ash, cement, Atterberg limit, California bearing ratio, maximum dry density*.

I. INTRODUCTION

Stabilization is the treatment of natural soil to improve its engineering properties and thus making it more stable. It is required when the soil available for construction is not suitable for the intended purpose. The construction of infrastructures like roads, bridges, buildings within such areas normally undergo foundation problems. And this foundational problems occur as a result of the expansion of the poor soils. Expansive soils are characterized by swelling when wet for example laterite. Whenever this poor soils are encountered, a probable solution must be sought for; some of the options we are normally faced with are: abandoning the poor soil, removing the poor soil and replacing it with a suitable one. Soil stabilization is usually the most probable method used especially in cases when it would be expensive to acquire new sites to replace the poor ones, it involves treating the soil with admixtures and chemical additives. Hence, there is a major challenge to search for a material that is readily available at a low cost which is environment friendly and can be used totally or partially to replace cement.

Research has shown that most materials that are rich in amorphous silica can be used in partial replacement of cement. It has established that amorphous silica which is found in pozzolanic materials (snail shell ash).

Due to the bad state of the Nigerian economy, engineering materials are not more readily available. The high cost of construction materials like cement has increased the cost of construction. Unlike other engineering materials; it has become very important for the construction and maintenance of structures in every country.

1.1 Objective

- The identification of snail shell as an effective stabilizing material by a certain percentage of cement in the stabilized soil with snail shell ash.
- Identification of snail shell ash as possible replacement for industrial cement in road construction which will help reduce snail shell wastes found in large quantity especially in coastal communities as a means of pollution control in the environment.
- It will also reduce cost of construction.

1.2 Soil Stabilization

Soil stabilization may be defined as any process aimed at maintaining or improving the performance of a soil as a construction material. [1] Defines soil stabilization as the mixing and compacting of soil with some quantities of binders. Soil stabilization is used to reduce the permeability and compressibility of the soil mass in earth structure, [2] and raising the bearing capacity of the soil. The different types of conventional binders used as stabilizing agents are; cement, lime, bitumen, resins, chloride etc. and some of these have given satisfactory performance in the field, but due to high cost and shortage of these materials agricultural waste is been looked into as possible or partial replacement. Some of these waste are quarry dust obtained as waste in quarry site, egg shell ash, palm kernel ash, palm bunch ash, coconut shell ash, saw dust ash etc. [3] made a feasibility study on the use of periwinkle, snail and oyster shells as admixtures in cement to improve the strength of concrete. [4] Investigated the strength properties of palm kernel shell ash concrete by using PKSA as a partial replacement for cement. [5] Used coconut shall ash as a partial replacement for OPC (ordinary Portland cement) in concrete production

II. MATERIAL

2.1. Portland Cement (P.C.)

Portland cement is the common type of cement in general use around the world, used as a basic ingredient in the production of concrete, and mortar. It developed from other types of hydraulic line gotten from limestone (Body). The

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major chemical components of PC are tricalcium silicate $(CaO)_2$, (SiO_2), and tricalcium aluminate $(CaO)_3.Al_2O_3Fe_2O_3$). The most common use of OPC is in the production of concrete as cohesive material of structural elements such as panels, beams, stairs, damns, foundations and column [6]

2.2 Snail Shell Ash

Snail shells is a waste product which is obtained from the eating of a small greenish-blue marine snail, which rests in a spiral shell shaped, found in many Deltaic regions. These shells are a very strong, hard material. These snail are found in the creeks and mudflats of the delta areas, the people in this area eat 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 and which is constituting a problem in area where they cannot find any use for it as waste and large deposits have accumulated in many places over the year.

2.3 Soil

Soil is any uncemented or weakly cemented accumulation or material particles formed by the weathering of rocks and contains void spaces between particles, what are filled by water and air [7] Soil is said to be residual if the present location of the soil is that in which the original weathering of the present rock occurred. Otherwise, the soil is referred to as transported.

Laterite is a soil group which is formed under weathering systems productive of the process of laterization i.e. the decomposition of ferroalumino silicate mineral, leaching of the combined silica and base and the permanent decomposition of sesquioxide within the prefilled [8]. The Soil Sample was gotten from a construction site situated at Rumuchi in Rumuekini in Rivers state Nigeria. The soil is reddish brown in colour and it has a plastic limit of 24% and a liquid limit of 20.8%. Materials used are cement, snail shell ash, laterite soil and water. Cement is a grey powder made by grinding together a mixture of limestone and clay which is then heated at a temperature of 1,450 degree Celsius. The cement used for this project is the local brand of cement known as Dangote 3x Cement. It is available in any cement retail store in Nigeria. The cement is of the grade of 42.5 ordinary Portland cement and conforms to BS EN 197-1:2000 standards for cement production.

III. Experimental Procedure

In this project the snail shell waste was collected from different dump site in and around choba. The snail shell was washed thoroughly and dried, after which it was grinded. This grinded material was sieved using a 75um BS Test sieve to achieve a smooth, uniform and fine particle. The ash was found to be hydroscopic hence the ash was stored in an air-tight container. The chemical analysis or composition of snail shell ash was done by [9] adopting X-ray fluorescence technique in which the snail shell ash is made into standard tablet from the samples of cement to get the chemical analysis of the snail shell ash. The chemical analysis of the snail shell ash is shown table 2. The soil used is locally available and its properties were tested in the laboratory. The results are given in table 2. As per USC soil classification it is seen that the local soil is clayey silt. The properties of snail shell ash waste are given in Table. The soil is stabilized by partially replacing cement content in increasing order of 1%, 2%, 3%.4%, 5%, 6% and 7% of snail shell ash by weight of the soil. The Optimum moisture content, maximum dry density and CBR values for the soil – snail shell ash mixture is determined in the laboratory for each percentage by Standard Procter and CBR testing Machine. The results are shown in tables 3 and 4.

TABLE 1. Properties of the laterite soil.

Properties	Value
Liquid limit	24%
Plastic limit	20.8%
Plastic index	3.2
Specific Gravity	2.58

TABLE 2. Chemical composition of snail shell ash.

Constituent	Description	% in Snail Shell Powder
CaO	Calcium Oxide	51.09
LOI	Loss on ignition	40.54
SiO_2	Silica	0.60
Al_2O_3	Alumina	0.51
MgO	Magnesium oxide	0.69
SO_3	Sulphur oxide	0.19
Na_2O	Sodium oxide	1.20
K_2O	Potassium oxide	0.12
TiO_2	Titanium dioxide	0.03
Cl	Chlorine	0.034
Fe_2O_3	Ferrous oxide	0.56
P_2O_5	Phosphorus perioxide	0.21
Mn_2O_3	Manganese oxide	0.02

IV. Results and Analysis

TABLE 3. Summary of the proctor compaction result.

Stabilization ratio	Optimum moisture content (%)	Maximum Dry Density (kg/m^3)
Soil + 7% cement + 0% snail shell ash	19.0	1.78
Soil + 6% cement + 1% snail shell ash.	19.0	1.78
Soil + 5% cement + 2% snail shell ash	21.0	1.83
Soil + 4% cement + 3% snail shell ash	20.8	1.68
Soil + 3% cement + 4% snail shell ash	22.0	1.71
Soil + 2% cement + 5% snail shell ash	19.75	1.80
Soil + 1% cement + 6% snail shell ash	25.0	1.71

Graphs are plotted to show the variation of OMC, MDD and CBR for different percentages of snail shell ash in Figure 2 to 3. It is seen that there is increase in OMC values and slight decrease in MDD values as percentage of snail shell ash is increased. The CBR value also shows a decrease if percentage of snail shell ash is increased. The soil considered for study is having a low CBR which can be increased to the required value satisfying traffic characteristics by adding snail shell ash , if silt clays and sandy clays to be used as sub-grade soil. It is seen from the results that the locally available soil

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which is having a very low CBR value can be used as sub-grade by adding 2% cement and 5% snail shell ash by weight of soil.

The sieve analysis test conducted showed that the soil was retained at 1.18mm sieve size. The soil classification of the soil is clayey silt (USC) classification and A-2-5 soil on the AASHTO soil classification system.

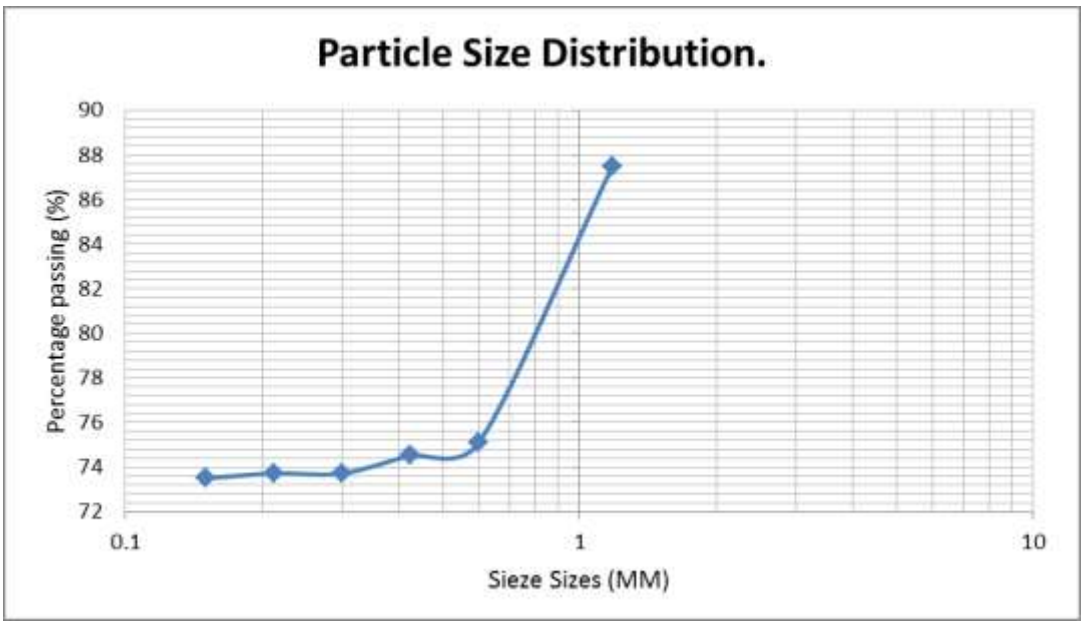

Fig. 1. Chart showing the relationship between percentage passing and sieve sizes.

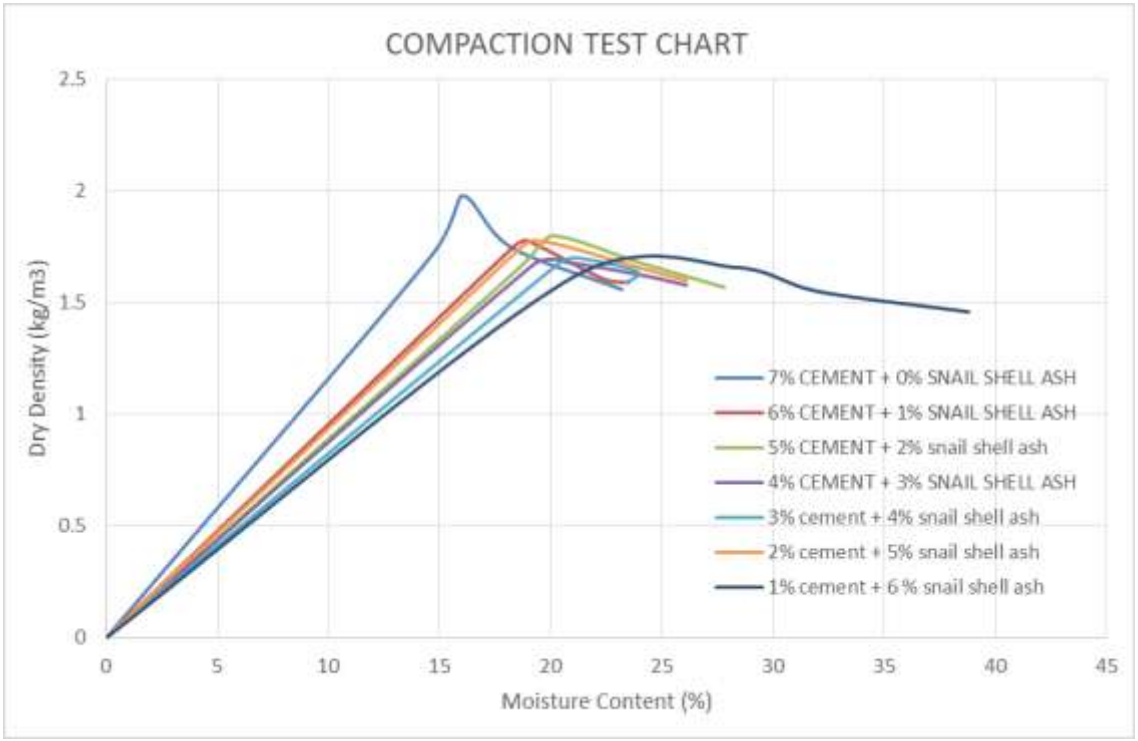

Fig. 2. Variation of MDD and OMC for different percentage of cement and snail shell ash.

TABLE 4. California bearing ratio test (C.B.R) result.

Soil Sample with stabilization ratio	C.B.R. Value
7% Cement + 0% Snail shell ash	19%
5% Cement + 2% Snail shell ash	20%
2% Cement + 5% Snail shell ash	12%
1% Cement + 6% Snail shell ash	8%

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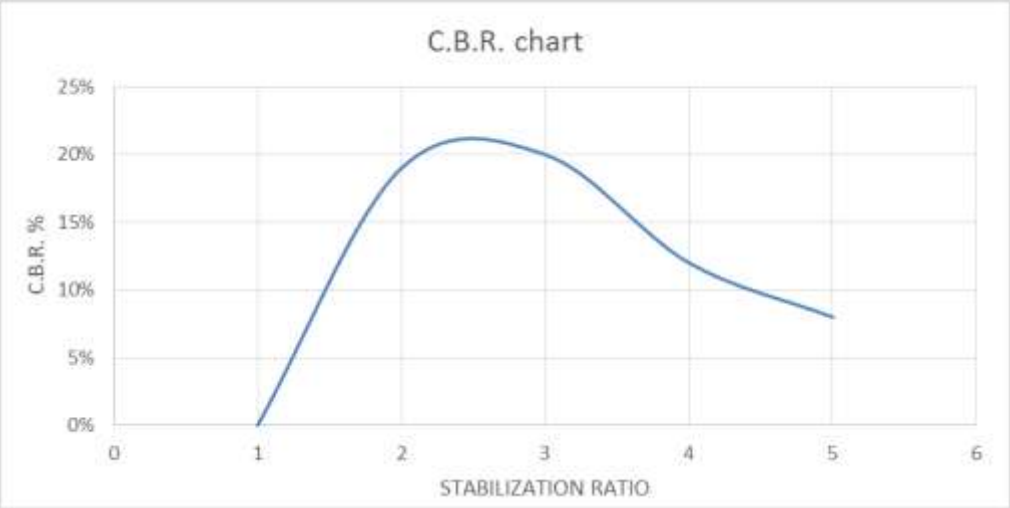

Fig. 3. Graph showing the C.B.R. values for different percentage of snail shell ash.

According to BS: 1377 the C.B.R. standard for laterite soil to be used for subgrades under Highway Engineering is between 5%-15% and from test results the C.B.R. test the soil sample with their different stabilization ratio are adequate for subgrade use.

V. CONCLUSION

Based on the study conducted, following the methodology and results obtained in the previous chapters, the following conclusion can be made regarding the partial replacement of cement soil stabilization with snail shell ash:

1. Cement has shown that it is a better stabilizing agent than that Snail shell ash in all areas of engineering properties except for maximum dry density(MDD) and Optimum moisture content(OMC) where Snail shell ash proved to be better
2. However, Snail shell ash can be used for the stabilization of soil where very high subgrade performance is not required or necessary.
3. Cement quantity as small as 2% and 5% of snail shell ash a additive is found to be sufficient for stabilizing laterite soil. This stabilization ratio (2% cement and 5% snail shell) gave us a C.B.R. value of 12% which is within the range recommended for construction.
4. From the forgoing investigation it would appear that snail shell ash perform satisfactorily as a cheap stabilizing agent for laterite soil for subgrade purposes.

The construction cost can be reduced to a large extent if locally available materials are used. In the flexible pavement construction the main constituent is soil, which comprises the base layer and sub-base layer. If the locally available soil is having a very low CBR value, it can be treated with locally available materials to improve its quality. In this study it has seen that snail shell ash when mixed with the locally available soil improved the engineering properties of soil, especially MDD and CBR.

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