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PULVERIZED PERIWINKLE SHELL STABILIZATION OF A NIGERIAN LATERITIC SOIL

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ABSTRACT

Pulverized periwinkle shell (PPS) stabilization of Nigerian lateritic soil was investigated. Various amounts of PPS (2%, 4%, 6%, 8% and 10%) were added to the soil to study its effects on the particle size distribution, Proctor compaction characteristics, consistency limits, unconfined compressive strength (UCS), California Bearing Ration (CBR) and durability tests.

Test results show lower maximum unit weight, higher optimum moisture contents (OMC) reduction in clay fraction (CF) with increased PPS. 2% PPS treatment of lateritic soil yielded peak 7 days UCS and CBR values of 850 kN/m2 and 17% respectively, which are below 1,700 kN/m2 and 180% for UCS and CBR, respectively, recommended for adequate cement stabilization, it is concluded that PPS cannot be used alone as stabilizer but needs to be combined with other binding materials, such as fly ash.

Keywords: Periwinkle shell, Lateritic soil, Proctor Compaction, Consistency limits, CBR, Durability.

I. INTRODUCTION

Lateritic soils are mostly in the tropics with applications in pavements, embankments, low-cost housing road fills etc. Previous work on the geological study of laterites in Nigeria dwells mainly on their distribution, classification, depth extent, general nature and formation (Faniran 1970, 1972, 1974 and 1978, Adekoya et al 1978). Although much work has been done on the geotechnical study of laterites (Ola 1978, 1980a, 1980b and Alao 1983) most especially in connection with foundation problems, no attention has been paid to pulverized periwinkle shell stabilization of lateritic soils; where the soils may not meet the required specification. Stabilization means improving soil strength, bearing capacity, and durability under adverse moisture and stress conditions (Gidigasu 1976) by adding other soil, cement, lime, bituminous products, silicates and various other chemicals and natural or synthetic, organic and inorganic materials.However, industrial by-products, construction and demolition waste and other waste materials ordinarily considered as environmental problems, are gradually finding applications in soil stabilization (Nikraz 1999; Zaman et al 1992, Collins and Ciesielske 1994, Chun and Kao 1993, Edil et al 2002, Kleven et al 2000, FIRST 2004, Javed and Lovell 1995, Otoko G. R 2014a, 2014b, 2014c). Although PPS has been used in concrete and other areas of civil engineering; but no technical information on the assessment of the utilization of pulverized waste periwinkle shells for geotechnical engineering applications in Nigeria. This study is to identify the geotechnical engineering properties of pulverized waste periwinkle shells from Ilaobuchi in Diobu, Port Harcourt, Nigeria and assess its potential in geotechnical engineering applications.

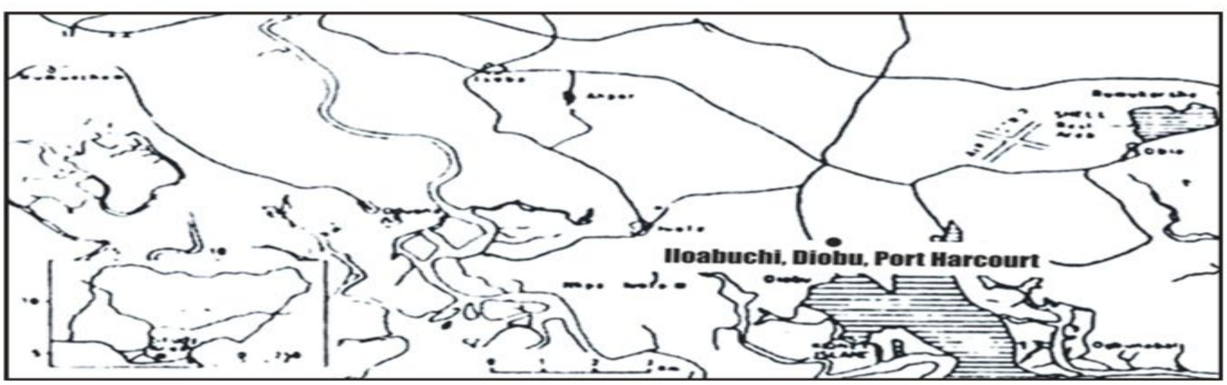

Figure 1: Map of the Niger Delta, Nigeria, showing the location of Iloabuchi, Diobu, Port Harcourt.

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II. SELECTION AND PREPARATION OF PPS

The waste periwinkle shells were obtained from Ilaobuchi, in Diobu, Port Harcourt, Nigeria, calcined at 700^{o}C, which falls within the range of 550^{o}C - 1100^{o}C suggested by Price (1975). It was then pulverized and sieved through the 45µm sieve which is a convenient basis of clarification of size (Smith and Halliwell 1979).

The criteria for soils that can be economically stabilized include soils with (i) Liquid limit less than 40% (ii) Plasticity index 16% and (iii) Percentage passing No. 200 BS sieve less than 50%. The properties of the selected lateritic soil are liquid limit 41.5%, plasticity index 16.5% and percentage passing to No. 200 BS sieve, 43.5%. The properties of the lateritic soil and PPS are given in table 1.

Table 1: Engineering Properties of Soil Sample/PPS

Tests	Test Results	
	Lateritic Soil	PPS
Natural moisture content	15.75	11.45
Liquid limit (%)	38.50	Non- Plastic
Plastic limit (%)	17.00	Non- Plastic
Plasticity index (%)	21.50	Non- Plastic
Special gravity	2.67	3.02
Percentage passing No. 200 BS sieve	28.90	4.65
Linear shrinkage	9.80	0.0
Unified soil classification	CI	SC

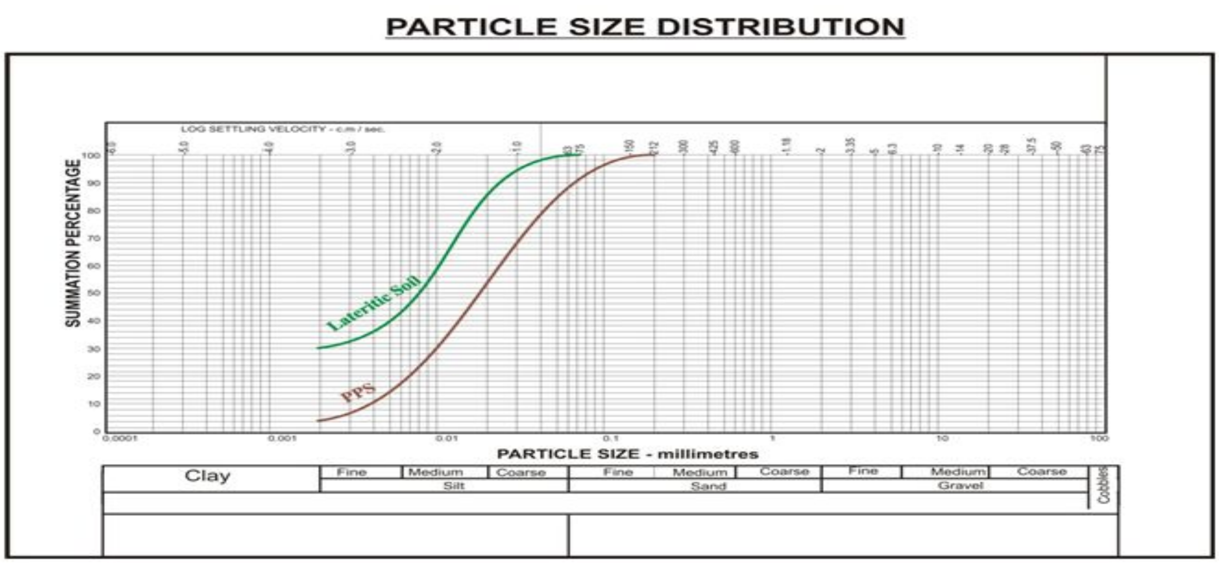

Figure 2: Particle size distribution curves for the lateritic soil and the PPS.

Figure 3: Waste Periwinkle Shells.

Figure 4: Pulverized Periwinkle Shells.

III. EXPERIMENTAL STUDY/RESULTS

The lateritic sample was collected from Emilaghan, Abua Central in Abua/Odua Local Government area of Rivers State, Nigeria. The geotechnical engineering properties of the soil are shown in Table 1.

The periwinkle shells were collected from Iloabuchi in Diobu, Port Harcourt, Nigeria, calcined at 700^oC pulverized and passed through 45µm sieve. The physical characteristics of the PPS is shown in table 1.

Compaction: Samples were air dried for one day and then moisture - unit weight relationship, unconfined compressive (UCS) and California Bearing Ratio (CBR) tests carried out, including Proctor compaction tests.

Strength: Samples of natural laterite and laterite stabilized with pulverized periwinkle shell were prepared and tested in accordance with BS 1377 (1990) and BS 1924 (1990), respectively. The unconfined compressive strength (UCS) tests were performed in cylindrical samples as shown in fig. 3. In the specimen preparation, the various amounts by dry weight of PPS (2%, 4%, 6%, 8% and 10%) were mixed with the natural laterite in the dry state, before addition of water to the respective OMCs. The soil - PPS mixture was compacted into a detachable mould, specimens removed and wrapped with polythene sheets to prevent moisture loss; before air curing them for 7, 14 and 28 days in the case of UCS, whereas for CBR, they were cured for 6 days and soaked in water for one day before testing in accordance with the provisions of the Nigerian General Specifications (1997).

Figure 5: Cylindrical Samples For UCS.

Durability: Specimens of the soil - PPS mixture were immersed in water for measurement of resistance to loss in strength rather than the ASTM (1992) method that are not effective in the tropics. The ratio of UCS of specimens wax - cured for 7 days, de - waxed and immersed in water for another 7 days to UCS of specimens wax - cured for 14 days, gave the resistance to loss in strength. These specimens were used for each UCS, CBR and durability tests and were waxed to prevent loss of water by evaporation and allowed to cure under controlled conditions.

IV. DISCUSSION OF RESULTS

The atterberg limits of the natural soils are summarized in table1, while the particle size distribution is shown in fig. 2. The soil is classified as CI while the PPS is classified as SC in the unified soil classification system - USCS (ASTM 1992).

Strength characteristics - UCS: UCS of compacted lateritic soil cured at 7, 14 and 28 days respectively is shown in fig. 6. The improvement in strength of soil - PPS mixture has been attributed to soil - PPS reactions. Reaction between SiO_2 and CaO in the PPS form cementitious compounds that bind the soil aggregates. Peak UCS values of 825, 830 and 950kN/m^2 were recorded at 2% PPS content for 7, 14 .

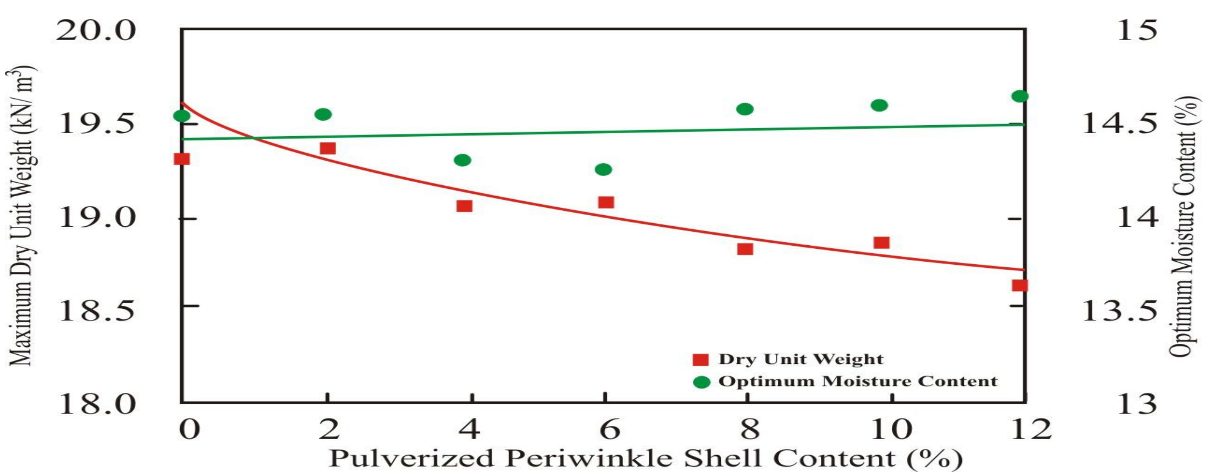

Figure 6: Variation of maximum dry unit weight and optimum moisture content with pulverized periwinkle shell content

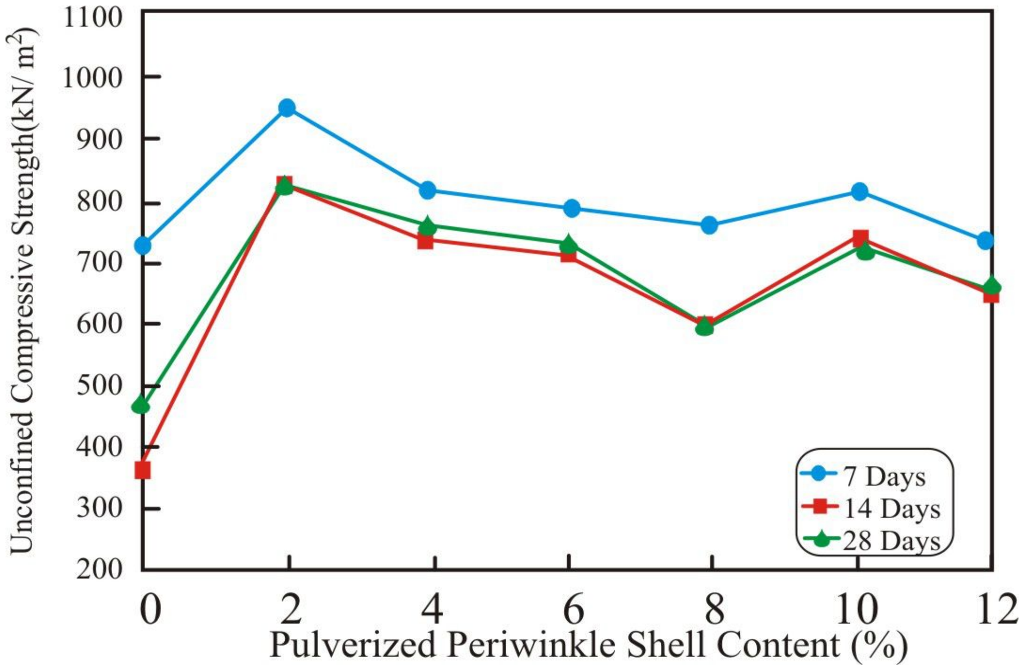

Figure 7: Variation of unconfined compressive strength with pulverized periwinkle shell content.

and 28 days curing periods respectively. Strength was directly proportional to age and inversely proportional to PPS content. These strength values are however less than the value of 1,700kN/m^2 recommended for cement stabilized soils by TRRL (1977).

California bearing ratio (CBR): CBR tests show peak value of 18% at 2% PPS content (fig. 7) decreased with PPS content up to 6% and increased later, but level the peak value obtained.

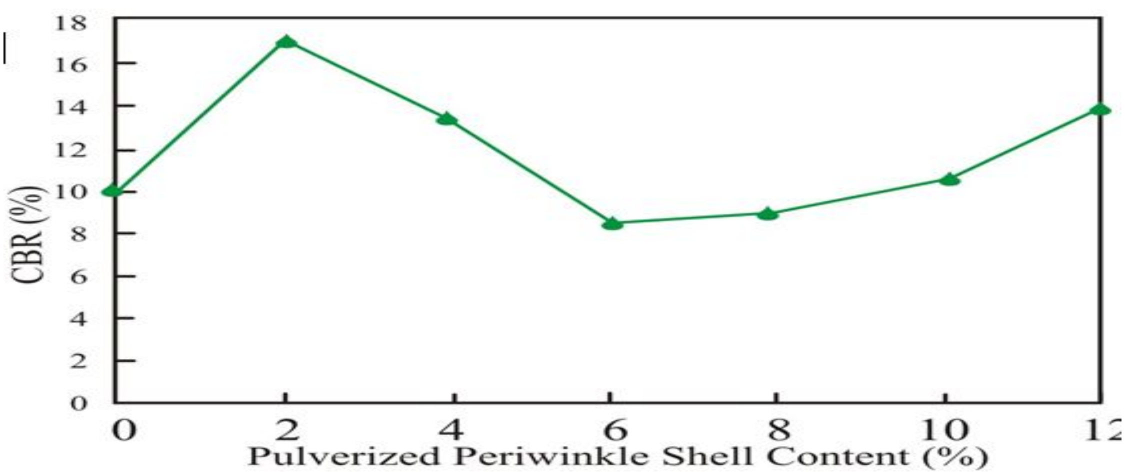

Figure 8: Variation of California Bearing Ratio with pulverized periwinkle shell content

Durability: The resistance to loss in strength as outlined previously is 10% (i.e 90% loss in strength), which is more than the maximum 20% allowable loss in strength for a 7 day curing and 4 day soaking period usually specified. This means that the specimens did not withstand the durability test. Therefore, it is necessary to combine PPS with other bonding materials such as fly ash, cement or lime to improve its durability.

V. CONCLUSION AND RECOMMENDATIONS.

The effects of PPS on the geotechnical characteristics of a lateritic soil is studied. It is concluded that the laterite is classified CI and the PPS classified SC in the unified soil classification system (USCS).

Lower maximum unit weight, higher optimum moisture contents (OMC) and reduction in clay fraction (CF) with increased PPS. 2% PPS treatment of lateritic soil yielded peak 7 days UCS and CBR values of 850 kN/m^2 and 17% respectively, which are below 1,700 kN/m^2 and 180% for UCS and CBR, respectively, recommended for adequate cement stabilization, it is concluded that PPS cannot be used alone as stabilizer but needs to be combined with other binding materials, such as fly ash.

VI. REFERENCES

[1] Adekoya, J.A, Irokanulo, B.G., & Ladipo, K *(1978). Report on the investigation for bauxite at Works Hills near Oju, Benue State. Unpublished Report Geol. Surv. Nigeria.*

[2] Alao, S. A. *(1983). Geology and engineering properties of laterites from Ilorin, Nigeria. Eng. Geol. 19: 111-118.*

[3] ASTM (1992).*Annual Book of Standards, Vol. 04.08. American Society for Testing and Materials, Philadelphia, PA.*

[4] BS 1377 *(1990). Methods of Test for Soil for Civil Engineering Purposes. British Standard Institute, London.*

[5] BS 1924 *(1990). Methods of Test for Stabilized Soils. British Standard Institute, London.*

[6] Chun, S C & Kao, H S. *(1993). A study of engineering properties of a clay modified by fly ash and slag. Proceedings, Fly ash for soil improvement, ASCE, Geotechnical Special Publication 36:89–99.*

[7] Collins, R J & Ciesielske S. K. *(1994). Production and use of industrial wastes. Sythesis of Highway Practice 199: Recycling and use of waste materials and by products in highway construction. Transportation Research Board, National Research Council, Washington DC.*

[8] Edil, T. B, Benson, C. H, Bin-Shafigue, Tanyu, Kim. W & Senol. *(2002). Field evaluation of construction alternatives for roadway over soft subgrade. Transportation research Record 1786, Natural research council, pp 36-48.*

[9] Faniran, A. *(1970). Landform examples from Nigeria. No.2. The deep weathering (duricrust) profile. Nigerian geographical Journal 13: 87-88.*

[10] Faniran, A. *(1972). Depth and pattern of weathering in the Nigerian Precambrian basement complex rocks areas: A preliminary report. In: Dessauvagie, T. F. J. & Whiteman, A. J. (Eds.), African Geology, Geol. Dept. University of Ibadan, Nigeria.*

[11] Faniran, A. *(1974). The depth, profile and significance of deep weathering in Nigeria. Journal Tropic geogr., 38: 19 – 30.*

[12] Faniran, A. *(1978). Deep weathering duricrust and soils in humid tropics. Savana 7 (1): 1 – 55.*

[13] FIRST (Foundry Sand Facts for Civil Engineers) *(2004). Federal Highway Administration report FHWA- IF-04-004.*

[14] Gidigasu, M.D. *(1976). Laterite Soil Engineering. Elsevier, Amsterdam. Ingles, O.G. and Metcalf, J.B. (1972). Soil Stabilization Principles and Practice. Butterworth, Sydney.*

[15] Javed, S & Lovell, C W. *(1995). Uses of waste foundry sand in civil engineering. Transportation Research Board Record, 1486:109–113.*

[16] Kleven, J R., Edil, T B & Benson, C H. *(2000). Evaluation of excess foundry system sands for use as subbase material. Proceedings of the 79th Annual Meeting, Transportation Research Board, Washington, DC.*

[17] Nigerian General Specification *(1997). Roads and Bridges, Federal Ministry of Works, Abuja.*

[18] Nikraz, H R *(1999). Properties and performance of lime kiln dust for stabilisation of soft clay. Proceedings, 12th Regional Conference for Africa on Soil Mechanics and Geotechnical Engineering, Durban.*

[19] Ola, S. A. *(1978). The geology and geotechnical properties of the black cotton soils of Northern Eastern Nigeria. Eng. Geol., 12: 375 – 391.*

[20] Ola, S. A. *(1980a). Permeability of three compacted tropical soils. Q. J. Eng. Geol. London., 13: 87 – 95.*

[21] Ola. S. A. *(1980b). Some foundation design problems in the Sokoto area of North-Western Nigeria. Proc. of the 7 regional Conference for Africa on soil Mech. And foundation Eng. Accra p 267 – 275.*

[22] Otoko, G. R *(2014a).Stabilization of Lateritic silty clays with common stabilizing agents. International Journal of Engineering Science and Research Technology. 3.(4), 1-8.*

[23] Otoko, G. R *(2014b).A review of stabilization of problematic soils. International Journal of Engineering and Technology Research. 2.(5), 1-6.*

[24] Otoko, G. R, Ephraim, M. E & Ikegboma, A. *(2014c). Reinforcement of a lateritic soil using oil palm fruit fibre . International Journal of Engineering and Technology Research. 2.(6), 1-5.*

[25] Price, W.H. (*1975). Pozzolans – a review. J. Amer. Concr. Inst., 72, No. 5, pp. 225-32.*

[26] Smith, M. A. & Halliwell, F. (*1979). The application of the BS 4550 test for pozzolanic cements to cements containing pulverized – fuel ashes. Mag. Concr. Res., 31, No. 108,pp 159 – 70*

[27]Transport and Road Research Laboratory *(TRRL) (1977). A guide to the structural design of bitumen-surfaced roads in tropical and sub-tropical countries, Road Note 31, H.M.S.O., London.*

[28] Zaman, M, Laguros, J G & Sayah, A. *(1992). Soil stabilization using cement kiln dust. Proceedings, 7th International Conference on Expansive Soils, Dallas.*