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Research article

MECHANICAL STABILIZATION OF A DELTAIC CLAYEY SOIL USING CRUSHED WASTE PERIWINKLE SHELLS.

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ABSTRACT.

Mechanical stabilization of a deltaic clayey soil using crushed waste periwinkle shells was examined. The crushed waste periwinkle shells were subjected to standard geotechnical engineering testing before using it to blend with the soil, in order to examine its influence on the geotechnical engineering properties of the soil.

This paper demonstrates the effect of the crushed waste periwinkle shells on the modification of the plasticity, swell potential, compaction characteristics and CBR values of the soil. The results show that an otherwise marginal deltaic clayey soil can be mechanically stabilized with the addition of crushed waste periwinkle shells.

Keywords: Mechanical stabilization, Periwinkle shells, Plasticity, Compaction, CBR.

INTRODUCTION.

Most of the Niger Delta area, Nigeria, which is undergoing rapid industrialization, consist of soils that lack certain attributes for suitability as construction materials. They are either treated chemically or blended with other materials to stabilize them for geotechnical engineering use. Traditionally, Portland cement and hydrated lime are used for the soil stabilization. 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).Literature review, reveals that periwinkle and oyster shells have been used in concrete and other areas of civil engineering; but no technical information on the assessment of the utilization of crushed waste periwinkle shells for geotechnical engineering applications in Nigeria.

The study is to identify the geotechnical engineering properties of crushed waste periwinkle shells from Iloabuchi, in Diobu, Port Harcourt, Nigeria, and assess its potential in geotechnical engineering applications.

This paper therefore describes the initial laboratory tests of a planned extensive testing programme to assess the effectiveness of the crushed waste periwinkle shells as an alternative stabilizer. The tests were performed at the Civil Engineering Department laboratory of the Rivers State University of Science and Technology, Port Harcourt, Nigeria by Miss Esenwa Ifechukwude Cynthia as her dissertation in partial fulfillment of the requirement for her award of the B.Sc degree by the University.

Table 1: Properties of the Deltaic Clayey Soil.

Characteristics	Value/Classification
Moisture content	15.75
Liquid limit	38.50
Plasticity index	21.50
Linear shrinkage	9.70
Particle density	2.67
Percentage <0.002	28.90
Grading Modulus	0.22
Unified soil classification	CI
Activity	0.74
Heave classification	Medium

Table 2: Properties Of Periwinkle Shells.

Characteristics	Value/Classification
Moisture content	11.50
Liquid limit	Non-Plastic
Plasticity index	Non-Plastic
Linear shrinkage	0.00
Particle density	3.03
Percentage <0.002	4.50
Grading Modulus	0.95
Unified soil classification	SC
Activity	0.00
Heave classification	Low

Figure 1: Waste Periwinkle Shells.

Figure 2: Crushed Waste Periwinkle Shells.

Table 3: Influence of adding crushed waste Periwinkle Shells on the Grading Characteristics/Classification.

Periwinkle shell content by weight (%)	Percentage passing 0.002mm sieve	Grading Modulus	Unified soil classification	Activity	Heave classification
0	28.90	0.22	CI	0.74	Med
10	22.10	0.30	CL	1.00	Med
20	17.50	0.41	CL	1.00	Med
30	15.75	0.46	CL	1.00	Med
40	15.80	0.50	SC	1.00	Med
50	12.78	0.60	SC	1.00	Med
60	12.40	0.70	SC	1.00	Low
70	6.75	0.78	SC	1.00	Low
80	6.77	0.81	SC-SM	1.00	Low
100 **(Pure Crushed Periwinkle Shells)**	4.50	0.95	SC	0.00	Low

EXPERIMENTAL STUDY/RESULTS.

The soil 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 Illoabuchi in Diobu, Port Harcourt, Nigeria. Fig 1 shows typical picture of the periwinkle shells. They were crushed to particles (Fig 2). The particle size distribution analysis revealed that 96% passed through the 600µm sieve and about 17% passed through the 75µm sieve. Table 2 shows a summary of the physical characteristics of the crushed waste periwinkle shells.

The variation of periwinkle content with liquid limit and plasticity index is shown in fig 3. It is clear from the figure that periwinkle content is inversely proportional to the liquid limit and plasticity index. Fig 4 shows the rate of variation of liquid limit and plasticity index. The influence of the periwinkle content on the grading characteristics and final classification of the mixtures is shown in table 3. With increasing periwinkle content, the soil is transformed from intermediate plasticity clay to a sandy clay. The initial soil classification CI changes to SC. Fig 5 shows that the swell is inversely proportional to the periwinkle content. The swell in this study refers to the increase in the vertical height of the sample during the soaking of CBR moulds.

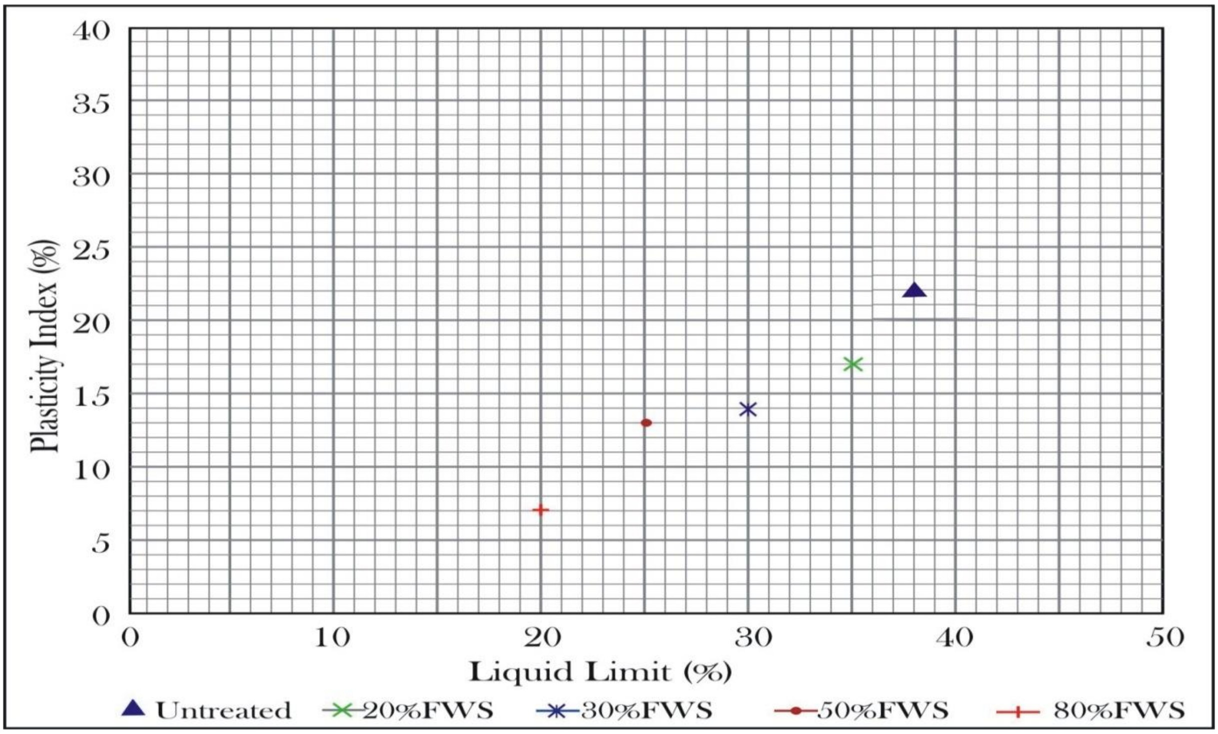

Figure 3: Influence of the addition of periwinkle shells on the variation of liquid limit and plasticity index.

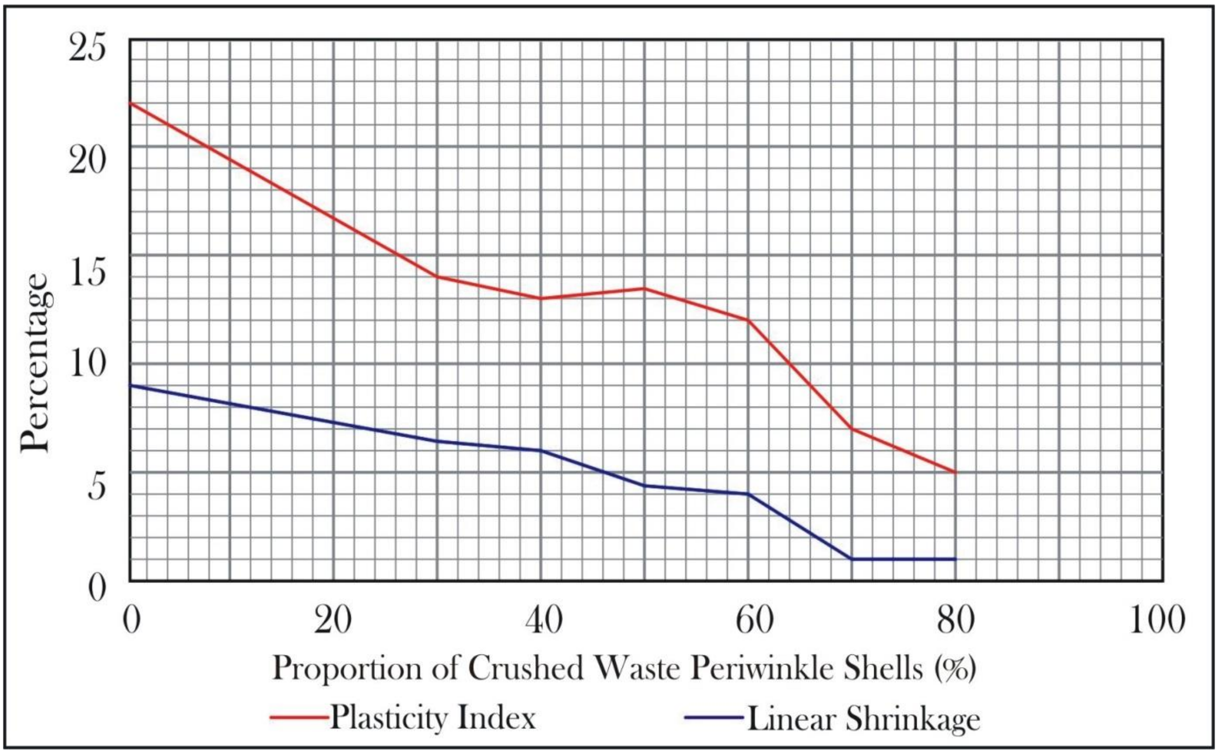

Figure 4: Rate of variation of liquid limit and plasticity index

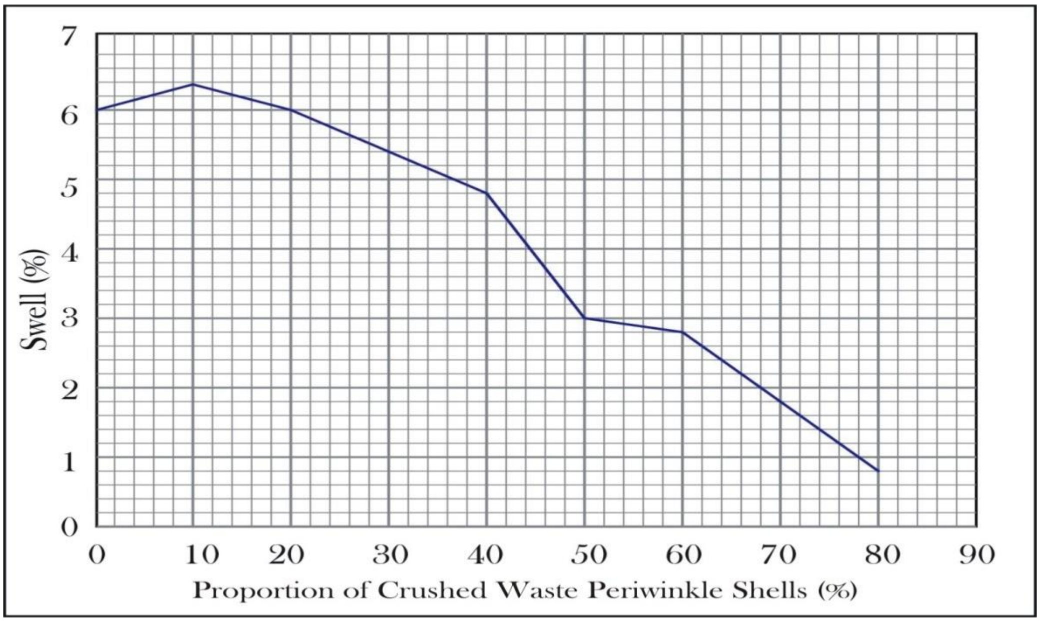

Figure 5: Influence of crushed waste periwinkle shells on swelling of deltaic clayey soil.

The effect of periwinkle content on the maximum dry density is shown in fig 6. It is clear from the figure that the optimum value of the maximum dry unit weight was obtained at about 20% periwinkle content; and at about which point, the minimum optimum moisture content was obtained in fig 7.

The variation of CBR with periwinkle content is shown in fig 8. There is no significant change in the CBR with an increase in periwinkle content up to about 48%. Thereafter, the CBR increased linearly with periwinkle content. A higher proportion of periwinkle content is therefore required in order to realise the benefits of its use as a stabilizing agent. The CBR results show that the rating of the soil is slightly improved from being rated as poor to a medium rating as a sub-grade material when a higher proportion of the crushed waste periwinkle shells is used.

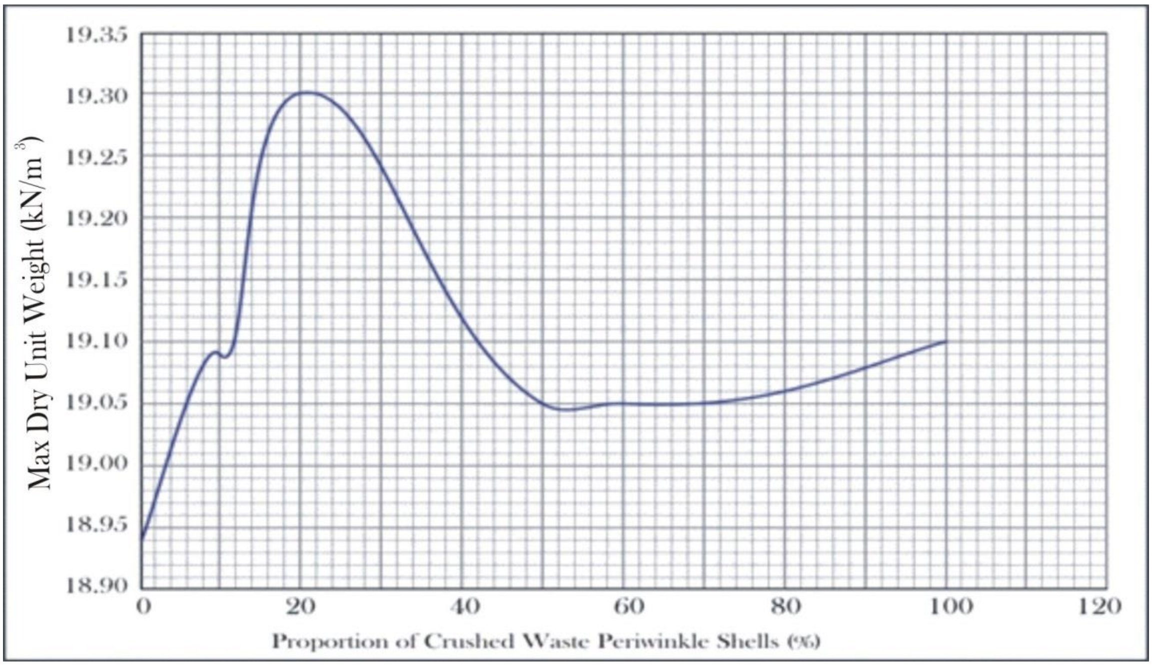

Figure 6: Effect of the proportion of crushed waste periwinkle shells on maximum dry unit weight of deltaic clayey soil.

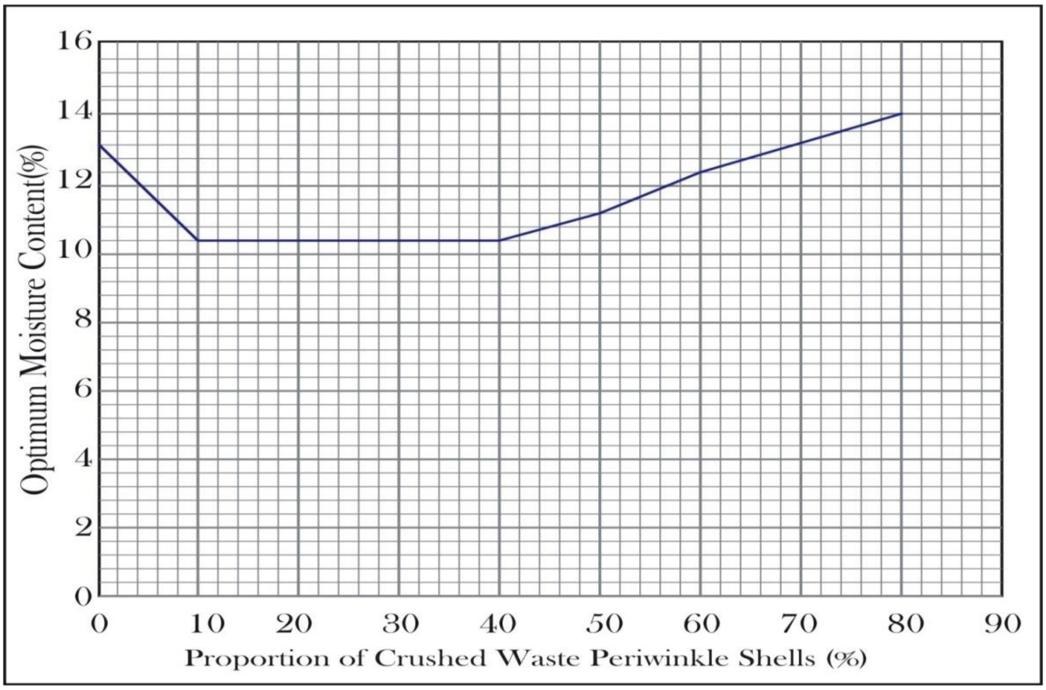

Figure 7: Variation of optimum moisture content with crushed waste periwinkle shells.

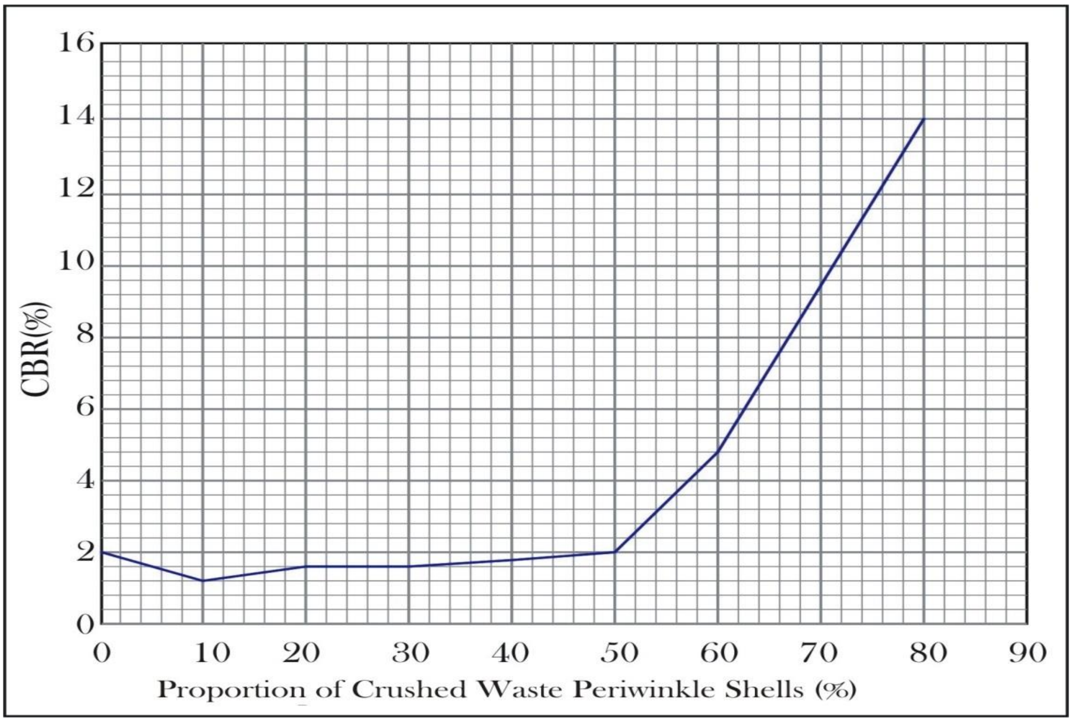

Figure 8: Effect of the proportion of crushed waste periwinkle shells on the CBR of deltaic clayey soil.

DISCUSSION AND CONCLUSIONS.

It is clear from this investigation that up to about 5 to 6t of periwinkle shells are discarded each day in Port Harcourt and about 3000t is annually disposed in waste facilities, out of which some are sold by periwinkle shell traders for some building/ civil engineering construction for some temporary works. Increasing the engineering use of the periwinkle shells would be beneficial as it would contribute towards the alleviation of the environmental impact.

There is a significant reduction of the liquid limit, plasticity index and swell with the addition of the periwinkle shells. The results of the compaction tests demonstrate that these changes slightly improve the physical properties with respect to strength as indicated by the CBR test results. However, a higher proportion of the crushed waste periwinkle shells, over 48% is required to achieve higher increases in load bearing values, for soil with an initial low CBR value. It is suggested that an addition of small quantities of other additives should significantly increase the achievable strength at lower proportions of the crushed waste periwinkle shells. Reducing the plasticity index of the soil at lower periwinkle content is of much benefit as it renders the clayey soil easier to handle during construction.

It is concluded that crushed waste periwinkle shells has the potential to perform as a mechanical soil stabilizer or for the purpose of soil modification. Consistency in the quality of periwinkle shells may be of concern as any variation in waste management processes could have an effect on the characteristics of the periwinkle shells. This is considered one of the major priorities for further research.

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