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Stabilization of Soil with Cassava Peel Ash – Lime Admixture

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Abstract
This project examined the geotechnical properties of lateritic soils modified with Cassava Peel Ash-Lime admixture with a view to obtaining a cheaper and effective road stabilizer. After collecting samples 1, 2 and 3 from three borrow pits meant for road construction works, preliminary tests was performed on the samples for identification and classification purposes, followed by the consistency limit tests. Engineering property tests (compaction, California bearing ratio (CBR) and Unconfined Compressive Strength) was performed on both at the stabilized and unstabilized states with the addition of 2, 4, 6 and 8% Cassava Peel ash and 1%, 2% and 3% lime contents. The results showed that the soil samples were well graded sand with fair to poor rating as subgrade material for pavement construction. However, the engineering properties of the samples were further improved with the addition of Cassava Peel Ash-Lime Admixture. This caused reductions in the PI of samples 1 from 9% to 1% and 6%. Optimum values of maximum dry densities (MDD) and shear strengths were obtained at 4% for sample 1 and 3, 6% at sample 2 CPA+Lime stabilization. MDD increased to 1.680, 1.680 and 1.920 Mg/m^3 respectively in samples A, B and C. We therefore concluded that Cassava Peel Ash-Lime Admixture has a good potential for improving the geotechnical properties of lateritic soils.
Keywords: Cassava peel ash, Compaction, California bearing ratio, unconfined Compressive Strength

1. Introduction

Engineering field described soil as, “the solid material that can be removed without blasting.” Soil is biologically defined as, “unconsolidated mineral or organic matter on the surface of the earth that has been subjected to and shows effects of genetic and environmental factors.”

The stability of structures founded on soil depends to a large extent on the interaction of the said soil with water. Some soils of the tropics absorb large amount of water during the raining seasons and do not allow easy passage of such water. This consequently results in a large volume increase which drastically reduces during the dry season. This phenomenon has substantial effect on structures founded on such soils. In the same vein, some lateritic soils have been found to be problematic in the course of construction due to their poor engineering properties such as high swelling and shrinkage response to water volume ratio, high permeability and compressibility of the soil mass, low bearing capacity especially in the foundation soil, etc. (Bello, 2007, 2013, Bello et al., 2015). Also, road bases built with soils that are not easily drained are affected by the development of pore water pressures which causes the formation of potholes and, eventually, the total failure of such roads. In an attempt to minimize these effects, such soils are subject to treatments aimed at either disallowing water into them or allowing easy passage (drainage) of water to prevent pore water development.

Stabilization has been defined as any process by which a soil material is improved and made more stable. It is also the treatment of natural soil to improve its engineering properties. Soil stabilization aims at improving soil strength and increasing resistance to softening by water through bonding the soil particles together, water proofing the particles or combination of the two (Sherwood, 1993). There are basically two principal methods of soil stabilization namely mechanical and chemical stabilization (Bello, 2011; 2013).

Cassava peel is an agricultural waste from cassava processing factory. Quicklime is a widely used chemical compound, it is a white, caustic, alkaline, crystalline solid at room temperature. Quicklime is relatively inexpensive. Both it and a chemical derivative (calcium hydroxide, of which quicklime is the base anhydride) are important commodity chemicals. Edeh et al (2014) and Bello et al (2015) have used Cassava peel ash as stabilizer, Sujit and Hussain, 2012 and Onyelowe, Okoafor, 2011 used lime as stabilization agent.

2. Materials and method

2.1 Materials

Lateritic Soil: The soil used in this study is known as lateritic soil. Three disturbed samples was obtained in Ilesa-West Local Government Area of Osun State. The location of the soil samples are: 7.639N and 4.754E. A study of the soil and geological maps of Nigeria after Akintola (1982) and Areola (1982), respectively, show that the study area lies within southwestern Nigeria basement complex which forms part of the African crystalline shield. The basement complex is composed predominantly of folded gneisses, migmatite, schist and quartzite of the Precambrian age. The soil samples were collected in large-to -medium-sized bags and thereafter transported to the Soil Mechanics Research Laboratory of the Department of Civil Engineering, Osun State University, Osogbo, Osun State. Each soil sample was spread and allowed to air-dry under laboratory conditions.

Soil Samples were varied with 2% CPA + 1% lime, 4% CPA + 2% lime, 6% CPA + 3% lime and 8% CPA using weight method.

Cassava Peel Ash and Lime: The cassava peel ash used was collected as refuse from a local processing factory in Oke-Baale, State of Osun, Nigeria. The peels were dried in open air, burnt to ash and eventually calcinated up to 700ºC in an electric furnace. The clinker was grinded to fine powder and passed through the 425μm sieve. Quicklime was used for this study.

2.2 Methods

Sieve analysis: Representative sample of approximately 500g will be used for the test after washing and oven-dried. The sieving will be done by mechanical method using an automatic shakers and a set of sieves.

Atterberg limit: This method will be used to determine the liquid limits and plastic limits.

I. Liquid limit: To perform this test, soil of at least 200g that passed through sieve number 40, placed on a glass plate then mixed with distilled water into a paste. A groove is then cut at the centre of the soil paste, with standard grooving tool. By the use of the cranked-operated cam, the cup is lifted and dropped, the moisture content, in percentage, required to close the distance along the bottom of the grove after 25 blows is determined.

II. Plastic limit: About 200g of soils that through sieve number 40 is as prepared in liquid limit. The soil is mixed with water to make it sufficiently plastic for rolling into a ball, which is then rolled out between hand and the glass to form a thread. The soil is said to be at its plastic limit when it begins to crumble at a thread diameter of 3mm. At this stage it is removed for moisture content determination.

Natural moisture content and specific gravity: The determination of specific gravity, and natural moisture content tests will follow the standard as outlined in BS 1377 of 1990.

California bearing ratio (CBR) test: is a penetration test for evaluation of the mechanical strength of road sub grades and base courses. It was developed by the California Department of Transportation before World War II. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material. The CBR test is fully described in IS: 2720 part 16 (1987).

Unconfined compression test: UCS test is performed in accordance with IS:2720 part 10 (1973). The sample sizes were of 38 mm diameter and 76 mm length. At the optimum moisture content (OMC) and maximum dry unit weight, the tests were performed.

3. Results and Discussion

Index Properties: Index properties of the soil such as natural moisture content, specific gravity, atterberg limit and particle size analysis tests were carried out on the soil samples and the summary of the preliminary test results for soil samples 1, 2, 3 are shown in Table 1. Sample 1 is classified as A-6, Sample 2 and 3 are classified as A-7-6. The Liquid limit for sample 1, 2 and 3 are 35.21%, 42.32% and 47.83% respectively, the Plastic limit for sample 1, 2 and 3 are 0%, 26.39% and 28.16% respectively and the PI for sample 1, 2 and 3 are 35.21%, 15.93% and 20.57% respectively. This result show that sample 2 and 3 have medium plasticity index.

Compaction: The summary of the compaction test result on the lateritic soil samples treated with CPA + lime using West African Standard compactive effort was shown in Table 2. The Optimum Moisture Content (OMC) of samples 1, 2 and 3 are 15.20%, 21% and 17.30% while the Maximum Dry Densities (MDD) are 1.610, 1.250, 1.884 Mg/m3 respectively. The MDD increased from 1.610 to 1.70 Mg/m3 at 8% CPA in Sample 1, from 1.250 to 1.682 Mg/m3 at 6% CPA + lime in Sample 2 and from 1.896 to 1.920 Mg/m3 at 4% CPA + lime in Sample 3. The optimum moisture contents (OMC) also reduced correspondingly in all the samples with the addition of CPA + lime admixture.

An increase in MDD is a good indication of improvement in soil property, whereas a reduction in OMC enhances the workability of a good soil. Osinubi (2001) further added that the decrease in OMC were as a result of self-desiccation whereby all the available water molecules were used up in the hydration reaction with consequent lower hydration and an incomplete hydration that affect the OMC.

California Bearing Ratio: Summary of the soaked CBR results of Sample 1, 2 and 3 are shown in Table 3. The results shows that the CBR values of samples 1 and 2 increased considerably with the addition of CPA + lime. The soaked CBR values attained for untreated lateritic soil are 2.4%, 4% and 10.28% for Samples 1, 2 and 3 respectively at WAS energy level. Peak value of 8.18% at 6% CPA +3% Lime was recorded for Sample 1, 8.94% at 4% CPA + 2% Lime was recorded for Sample 2 and 19.10 at 6% CPA + 3% Lime was recorded for sample 3. The increase in strength could be due to the presence of calcium which is required for the formation of CSH.

According to clause 6201 of Federal Ministry of Works and Housing (F.M.W & H) Specification Requirement, minimum strength for subgrade/fill shall not be less than 10% after at least 48 hours soaking, in light of this Sample 1 at 6% CPA + Lime, sample 2 at 4% CPA + Lime and 6% CPA + Lime is fit for subgrade/fill. The Samples didn't meet the CBR values specified by Federal Ministry of Works and Housing.

Unconfined Compressive Strength: Summary of the UCS results of Sample 1, 2 and 3 are shown in Table 4. The results shows that the UCS values of samples 1, 2 and 3 increased considerably with the addition of CPA + lime. The UCS values attained for untreated lateritic soil are 83.37, 101.58 and 124.68 kN/m^2 for Samples 1, 2 and 3 respectively at WAS energy level. Peak value of 314.22kN/m^2 at 6% CPA +3% Lime was recorded for Sample 1, 471.06kN/m^2 at 6% CPA + 3% Lime was recorded for Sample 2 and 851.98kN/m^2 at 6% CPA + 3% Lime was recorded for sample 3. The increase in strength could be due to the presence of calcium which is required for the formation of CSH.

4. Conclusion and recommendation

It was shown that the addition of Cassava Peels Ash – Lime Admixture improved the qualities of the soil samples by significantly reducing their plastic indices. This reduction in plasticity index signifies soil improvement and increase in workability of the soil samples. This also shows reduction in swelling index of the soil samples.

The addition of CPA + lime shows improvement in the engineering properties of the soil samples. Optimum moisture contents reduced to 18.15% at 6% CPA + 3% Lime in sample 2 and reduced to 14.4% at 4% CPA + 2% Lime in sample 3 while MDD increased to 1.70,1.68 and 1.92 Mg/m3 at 4%, 6% and 8% CPA + Lime addition in Samples 1, 2 and 3 respectively.

The soaked CBR values of samples increased to 8.18%, 8.94% and 19.1% at 6% CPA + Lime stabilization for sample 1, 2 and 3 respectively which means sample 1, 2 and 3 can be used as a subgrade/fill material at 6% CPA + 2% Lime admixture.

The study therefore concluded that Cassava Peels Ash – Lime Admixture has the potential to stabilize lateritic soils for highway construction effectively.

Based on this study, CPA + Lime showed substantial improvement on the strength properties of the CPA + Lime stabilized samples. Also it shows that CPA + Lime has potential to effectively stabilize lateritic soils with low California Bearing Ratio (CBR) for highway construction. CPA + Lime is economical as a stabilization material and it is good for subgrade/fill material for highway construction. CPA + lime admixture can be recommended at 4% CPA+2% lime and 6% CPA + 3% lime

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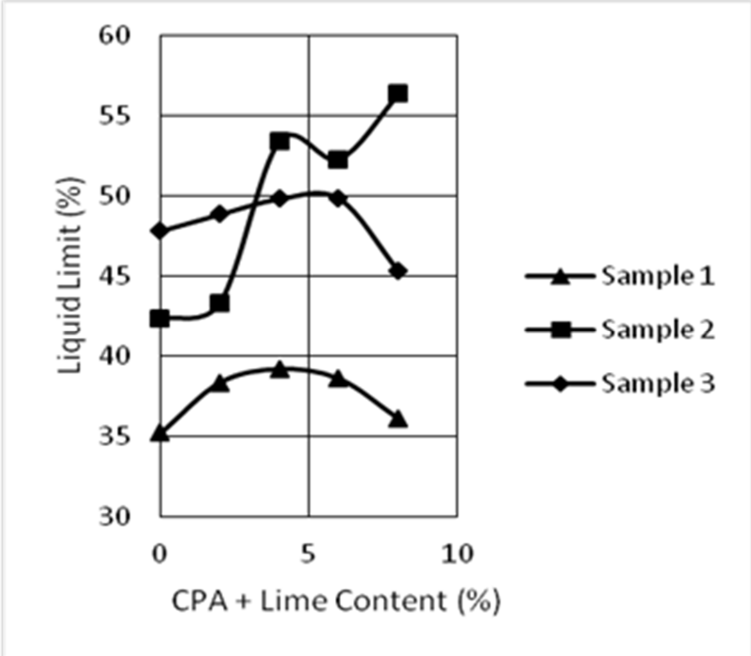

Fig 1: CPA + Lime Admixture on Liquid Limit of the Sample

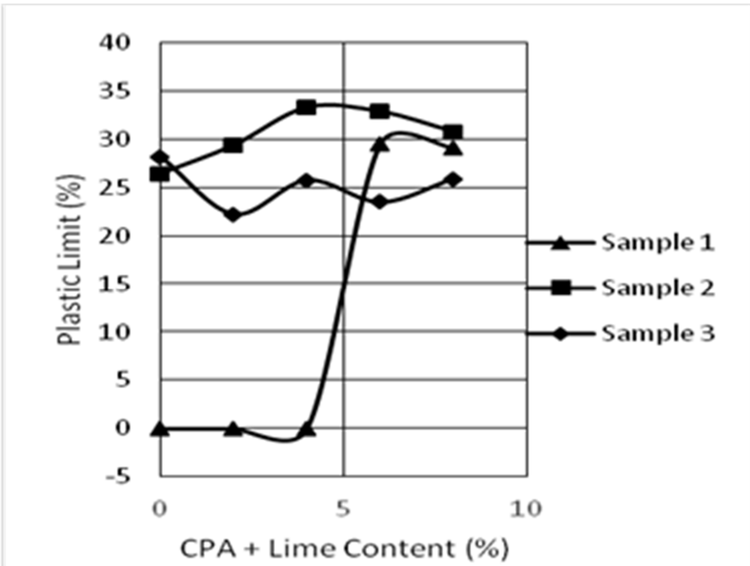

Fig 2: CPA + Lime Admixture on Plastic Limit of the Samples

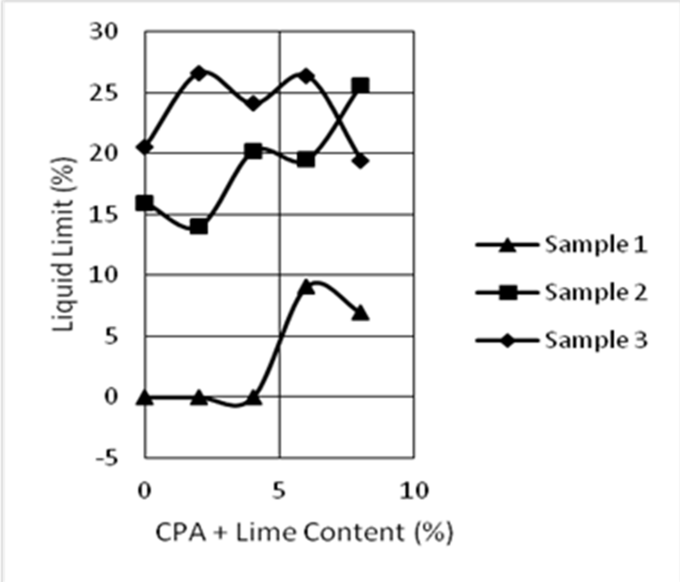

Fig 3: CPA + Lime Admixture on the Plasticity index of the Samples

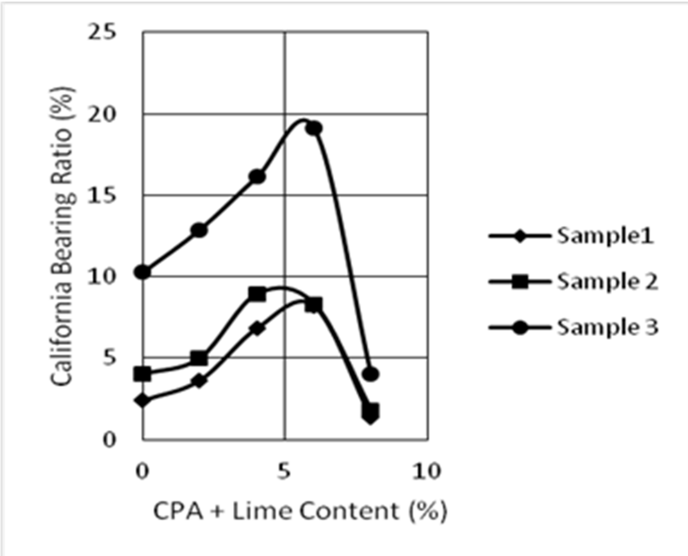

Fig 4: CPA-Lime Admixture on the CBR of the Samples

Table 1: Summary of the index properties of soil samples

Properties	**Sample 1**	**Sample 2**	**Sample 3**
Colour	Reddish Brown	Reddish	Brownish
Percentage passing BS NO 200 Sieve	48.67	66.67	42.00
Natural Moisture Content	13.64	15.42	13.33
Specific Gravity	2.60	3.00	2.58
Group Index	4	10	5
AASHTO Classification	A-6	A-7-6	A-7-6
USCS Classification	SC-SM	CH	SC
Liquid Limit (%)	35.69	42.32	47.83
Plastic Limit (%)	0	26.39	28.16
Plasticity Index (%)	35.69	15.93	20.57
Maximum dry Density (Mg/m^3)	1.61	1.25	1.90
Optimum Moisture Content (%)	15.2	21	16.55