International Journal of Medical Science and Applied Biosciences
ISSN: 2545-5893(Print) 2545-5877 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

Geotechnical Properties of Landmark University Lateritic Soil Stabilized with Cassava Peel Ash

[1]Gana A.J; [2]Adewara Sunday O.; [3]Aremu Charity. O & [1]Oluwatomisin A.G
[1]Department of Civil Engineering, Landmark University, Omu-Aran, Kwara State
[2]Department of Economics, Landmark University, Omu-Aran, Kwara State
[3]Department of Agriculture, Landmark University Omu-Aran, Kwara State
Email: phildebo123@gmail.com

ABSTRACT

This research work investigated the geotechnical properties of lateritic soil stabilized with cassava peel ash. The natural soil sample was gotten from Landmark University, Omu-Aran, Nigeria, and were subjected to preliminary soil tests such as natural moisture content, specific gravity and atterberg limit at its natural state. Engineering tests such a direct shear test, permeability and unconfined compressive strength tests were also carried out on the lateristic soil at their natural states and at when the cassava peel ash were added to the soil at varying proportions of 0,2,4,6,8 and 10% by weight of soil. The result of the strength tests showed that cassava peel ash enhanced the strength of the interitic soil. The unconfined compressive strength improved from 16.7kN/m^2 at natural state to 298.7 kN/m^2 at 10% cassava peel ash. The cohesion values also increased from 63 kN/m^2 at natural state to 115 kN/m^2 at 8% cassava peel ash. The coefficient of permeability values of the modified soil indicates its potential as an embankment fill material with good drainage capacity. The microstructural images of the natural soil and stabilized soil also gave an indication to the effect of cassava peel ash on the soil fabric. Cassava peel ash has a promising potential for stabilizing and improving the properties of lateritic soil.

Keywords: Geotechnical properties, Landmark University Lateritic Soil, Cassava Peel Ash

INTRODUCTION

Marginal and weak soils, including soft clays, muck, organic deposits, and loose sand, are often unsuitable for construction due to their poor engineering properties. Lateritic soils are generally used for road construction in Nigeria. Lateritic soil in its natural state generally have low bearing capacity and low strength due to high content of clay. When lateritic soil contains a large amount of clay materials its strength and stability cannot be guaranteed under load especially in the presence of moisture. It has been stated that laterite is a residual of rock decay that is red, reddish brown and yellowish in colour and has a high content of oxides of iron and hydroxides of aluminum and low proportion of silica when lateritic soil consists of high plastic clay, the plasticity of the soil may cause cracks and damage on pavement, road ways, building foundations or any other civil engineering construction projects. The improvement in the strength and durability of lateritic soil in the recent time become imperative, this has geared up researchers toward using stabilizing materials that can be source locally at a very low cost. These local materials can be classified as either agricultural or industrial wastes. The ability to blend the naturally occurring lateritic soil with some chemical additives to give it better engineering properties in both strength and water proofing is very essential. Over the years, cement and lime have been the two main materials used for stabilizing soils. These materials have rapidly increased in price due to the sharp increase in the cost of energy and high demand for them. Thus has hitherto prevented third world countries like Nigeria in providing good road for its citizen particularly rural dwellers that are mostly agriculturally dependent. Clay soils usually have the potential to demonstrate undesirable geotechnical properties such as low bearing capacity, high compressibility, shrinkage and swell characteristic and high moisture susceptibility (Sakr *et al.*, 2009). Several methods have been adopted to improve the geotechnical properties of such soils so that the stability and serviceability requirements can be met. Among these methods, stabilization of the clayey soils using different additives can basically be considered, because the replacement of the unsuitable soil with good quality soils becomes more uneconomical and non-ecological practice. In addition, cement stabilization is nowadays not related to its production (al-swaidani et al; 2016).

The needs for adequate provision of transportation facilities are enormously increasing with increase in population and also the maintenance of the existing one. Highway engineers are faced with the problem of providing very suitable materials for the highway construction. Owning to this fact, continuous researches have been carried out and still being carried out by individuals, firms and institution on ways to improve the engineering properties of soils. The most available soil do not have adequate engineering properties to really bear the expected wheel load. So, improvisation have to be made to make these soils better. These lead to the concept called soil stabilization which is the alteration of soils to enhance their engineering properties in order to allow in-situ construction. It is any treatment applied to soil to improve its strength and reduce its vulnerability to water ingression, if the treated soil is able to withstand the stresses imposed on it by traffic under all weather conditions without deformation, then it is generally regarded as stable. This definition applies irrespective of whether the treatment is applied to a soil in situ or the soil has been removed and placed in a pavement or embankment (O' Flaherty, 2002). Soil stabilization can be a beneficial method in treating the chemical and physical features of soft soils with different additives (Sabih *et al*; 2011). The two most common additives used in soil stabilization are cement (Davidson, 1961) and lime (Negi *et al*; 2013). Other recycled materials that have potential to stabilize soils when used alone or in combination with other additives include plastic waste (mallikarijuna and mani, 2016), fly ash (Edit *et al*; 2006), rice husk ash (Alhassan, 2008), coconut husk ash (Oluremi *et al*; 2012), corn cob ash (Jimoh and apampa, 2014), baggase ash (Osinubi *et al*; 2009), groundnut shell ash (Oriola and Moses, 2010,) bamboo leaf ash (Amu and Adetuberu, 2010).

The use of recycled materials to stabilize marginal soils offers a viable alternative from economical, technical, and environmental standpoints. Recycled materials provide an attractive alternative to traditional engineering construction materials such as asphalt, concrete, natural aggregate and others. This is due in part to their suitable engineering properties, which allow them to be used as substitute materials in several transportation and geotechnical application. Equally important, recycled materials offer both economic and environment incentives. In addition to a lower cost in comparison to traditional materials, their use has the potential to alleviate landfill problems as well as avert costs typically associated with their disposal. It has been observed that Portland cement, by the nature of its chemistry, produces large quantities of CO_2 for every ton of its final product which contribute to the melting of the ozone layer covering the earth surface.

International Journal of Medical Science and Applied Biosciences
ISSN: 2545-5893(Print) 2545-5877 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

Therefore, replacing proportions of the Portland cement in soil stabilization with agricultural waste material like cassava peels ash will reduce the overall environmental impact of the stabilization process. Cassava peels (CP) is a by- product of cassava processing either for domestic consumption or industrial uses. Cassava peel constitute between 20-35% of the weight of tuber, especially in the case of land peeling. Based on 20% estimate, about 6.8 million tons of cassava peel is generated annually and 12 million tones are expected to be produce in the year 2020. Indiscriminate disposal of cassava peels due to gross underutilization as well as lack of appropriate technology to recycle them is a major challenge, which results in environment problems. Thus, there is need to search for alternative methods of making use of cassava peels. Therefore, the purpose of this study was to investigate the impact of cassava peel Ash on the stabilization of lateritic soils.

Cassava processing produces large amount of waste and is generally considered to contribute significantly to environmental pollution (FAO, 2001). A cassava starch production unit processing 100 tons of tubers per day has an output of 47 tons of fresh by-products, which may cause environmental problems when left in the surrounding of processing plants or carelessly disposed of (Aro *et al*; 2010). In Nigeria, for example, cassava waste are usually left to rot away or burnt to create space for the accumulation of yet more waste heaps. The heaps emit carbon dioxide and produce a strong offensive smell (Aro *et al*; 2010; Adebayo, 2008). Cassava peels (large amount of cyanogenic glucosides) and pomae (large amount of biodegradable organic matter) may cause surface water pollution especially if they are stored under heavy rain or simply disposed of in surface waters (Pandey *et al*; 2000; Barana *et al*; 2000). This study presents a simply way of recycled cassava peel through burning into ash and using it as a soil stabilizer in the field of civil engineering as reinforcing materials. Reinforced soil construction is an efficient and reliable technique for improving the strength and stability of soils. The technique is use d in a variety of application, ranging from retaining structure and embankments to subgrade stabilization beneath footings and pavements.

MATERIALS

Lateritic Soil (Site Description and Sampling)

The lateritic soil sample was taken from the front of the mandate lodge at landmark university, Omu-aran, Nigeria. The area lies at a geographical coordinate of 8.1402° N and 5.0963° E with an elevation between 495 and 543 meters above sea level.

The method used in the sample collection of the laterite soil is the trial pit method. One undisturbed block sample and several disturbed samples were collected from one location at the site. A trial pit is simply a hole dug in the ground that is large enough for a ladder to be inserted, thus permitting a close examination of the sides. With this method, relatively undisturbed samples of soils were collected. T he depth of the trial pit was 1.2m (4ft) and about (1.2m) 4ft x (1.2m) 4ft wide. The pit was sunk by hand excavation with the aid of spade and digger.

Cassava Peel Ash (Sourcing and Processing)

Cassava peel is an agricultural waste from the cassava processing industries. Large quantity of fresh cassava peels was collected in sack bags from the recently commissioned cassava processing plant of landmark university farms, Nigeria. The cassava peels was washed and sun dried on a large clean mat for three days and finally milled into powder using the milling machine. The ash cassava peels powder. The oxide composition of CPA is presented in Table 3.1.

Table 1 Oxide composition of cassava peel ash (source: Edeh *et al*; 2014)

Oxides	SiO_2	CaO	K_2O	Fe_2O_3	Al_2O_3	SO_3
Concentration (%)	12.5	24.0	44.8	2.59	-	3.83
Oxides	TiO_2	P_2O_5	MnO	Ag_2O	BaO	LOI
Concentration (%)	0.95	4.32	0.19	4.61	0.76	1.34

PREPARATION OF STABILIZED SOIL MIX

The cassava peel ash was added to the clay soil at varying percentages of 0, 2,4,6,8 and 10% by weight of the soil. These quantities fall in the range of those used in provision studies (Pourakbar *et al*; 2015). The cassava peel ash and the clay soil was thoroughly mixed to make stabilize sample homogenous. The stabilized soil were stored in containers and cured at room temperature for 3 days to allow for equilibrium to occur before starting the analysis.

EXPERIMENTAL PROGRAMMES

Various test methods have been adopted in research and practice to assess the efficiency of using cassava peel ash as soil stabilizer. Such assessment tests include the following:

MOISTURE CONTENT DETERMINATION

The oven-drying method is the definitive procedures used in standard laboratory practice. The moisture content of the lateritic soil sample was determine according to BS1377:1990 part 2:3 and it was carried out in the geotechnical laboratory of Landmark University.

ATTERBERG LIMIT TEST

The Atterberg limit is a basic measure of the nature of a fine grained soil, depending on the moisture contents of the soil. It was determine on the lateritic soil sample and stabilized lateritic soil sample according to BS1377:1990 part 2:4 & 2:5 and it was carried out in the geotechnical laboratory of Landmark University.

DENSITY

Density is expressed in terms of mass density and it was determine on the lateritic soil sample in accordance to BS1377:1990 part 2:7 which was carried out in the geotechnical laboratory of Landmark University. The bulk density of a soil is the mass per unit volume of the soil deposit including any water it contains. The dry density is the mass of dry soil contained in a unit volume. Both are expressed in Mg/m^3, which is numerically the same as g/cm^3.

International Journal of Medical Science and Applied Biosciences
ISSN: 2545-5893(Print) 2545-5877 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

SPECIFIC GRAVITY

This is a property of the mineral material forming soil grains; it was determine on the lateritic soil sample in accordance to BS1377:1990 part 2:8 and carried out in the geotechnical laboratory of Landmark University.

SIEVE AND HYDROMETER ANALYSIS (PARTICLE SIZE DISTRIBUTION)

This would be done on the lateritic soil sample in accordance to BS1377:1990 part 2:9 and was carried out in the geotechnical laboratory of Landmark University.

UNCONFINED COMPRESSIVE STRENGTH TEST

Unconfined compressive test which would be determine on the lateritic soil sample and stabilized lateritic soil sample according to BS1377:1990 part 7:7 using the tri-axial machine in the geotechnical laboratory university.

DIRECT SHEAR TEST

The direct shear test was determine on the lateritic sample and stabilized lateritic soil sample according to BS1377:1990 (part 7:4) using the shear box apparatus in the geotechnical laboratory of Landmark University. Since there were no arrangements for measuring pore pressure in the shear box apparatus, the test will be conducted as a drained test only. The horizontal shear force will be applied at a constant rate of strain of 5mm/min.

HYDRAULIC CONDUCTIVITY

The hydraulic conductivity will be measured on the clay sample and stabilized clay samples using the rigid wall permeameter under falling head condition as recommended by BS1377:190 (part 6) in the geo technical laboratory of landmark university.

DETERMINATION OF MICRO STRUCTURAL COMPOSITION

Scanning electron microscope (SEM) test was performed on the lateritic, cassava peel ash and stabilizer lateritic sample to determine their micro structural composition.

RESULT AND DISCUSSION

CLASSIFICATION TESTS

The result of the classification tests which include the natural moisture content specific gravity, density, particle size distribution and atterberg limit test are presented and discussed below.

Natural moisture content

The result of the tests to determine the natural moisture contents of soil sample is presented in the table 4.1. The test was done in four trials and average natural moisture content of the soil was calculated as 10%.

Table 2: Natural Moisture Content of Lateritic Soil.

Weight of can (g)	Weight of wet sample + can (g)	Weight of dry sample + can (g)	Moisture content (%)
13.5	28	26.5	12
13.5	32.5	31	9
13.5	29	27.7	9
13.5	30.5	29	10
			10

Specific gravity

The result of the specific gravity which describes how heavy the soil sample is compared to water is presented in t able 4.2. The tests which was done in triplicate showed that the average specific gravity was 2.35. This specific gravity value of the soil falls within the range for clay materials such as halloysites, whose range of specific gravity is 2-2.55.

Table 3: Specific gravity of lateritic soil.

Trials	1	2	3
Weight of empty pycnometer. (M_1)	16.0g	16.0g	16.0g
Weight of pcynometer + soil sample (M_2)	32.0g	35.0g	30.0g
Weight of pcynometer + soil sample water (M_3)	76.5G	78.0G	76.0G
Weight of pcynometer + water only. (M_4)	67.5g	67.5g	67.4g
Specific gravity = $\frac{M_2M_1}{(M_2-M_1)-(M_3-M_4)}$	2.29	2.24	2.56
Average	2.35		

DENSITY

The result of the ratio of the mass to the volume of the soil otherwise referred to as density is presented in table 4.3. The test was done in triplicate and the average bulk density of the lateritic clay soil sample was calculated as 1,130.52km/m^3

Table 4: Bulk density of lateritic soil

Trial	1	2	3
Weight of empty mould (kg)	4.338	5.046	4.949
Weight of mould + soil (kg)	5.402	6.146	6.007
Weight of soil (kg)	1.064	1.100	1.058
Volume of mould (m^3)	0.00095	0.00095	0.00095
Bulk density (kg/m^3)	1,120.00	1,157.89	1,113.68
average	1,130.52 km/m^3		

PARTICLE SIZE DISTRIBUTION

All soils are made up of particles of various sizes, it is convenient to classify them in terms of these characteristics. This is done by the observation of the particle-size distribution of a given weight of soil. This would show what percentage (by mass) of each size is present in the materials. The resulting distribution is sieve analysis in table 4.4 and plotted on the chart alongside the hydrometer analysis in figure 4.1. From figure4.1. it could be deduced that percentage of soil in the soil sample was 66.90% while the percentage of silt and clay in the soil sample were 11.50% and 21.60% respectively.

International Journal of Medical Science and Applied Biosciences
ISSN: 2545-5893(Print) 2545-5877 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

Table 5 particle distribution result of the lateritic soil

Sieve size (mm)	percentage passing
4.75	100.00
2.36	96.20
2	99.70
1.18	89.55
0.6	6.50
0.5	60.90
0.425	49.45
0.212	41.90
0.150	36.80
0.075	33.10
Pan	0.00

Particle size distribution analysis curve of the Lateritic Soil Sample

ATTERBERG'S LIMITS TEST

The result of the Atterberg limit test on the lateritic soil sample showed that the liquid limit was 53.2, the plastic limit was 25.6 and the plasticity index was 27.6. From the particle size distribution curve in figure 4.1, 33.1% of the soil passed through sieve no. 200. The soil sample could therefore be classified as an A-2-7 soil according to the American association of highway transportation officials (AASHTO) and as a SC (Clayed sand) soil according to the unified soil classification System (USCS).

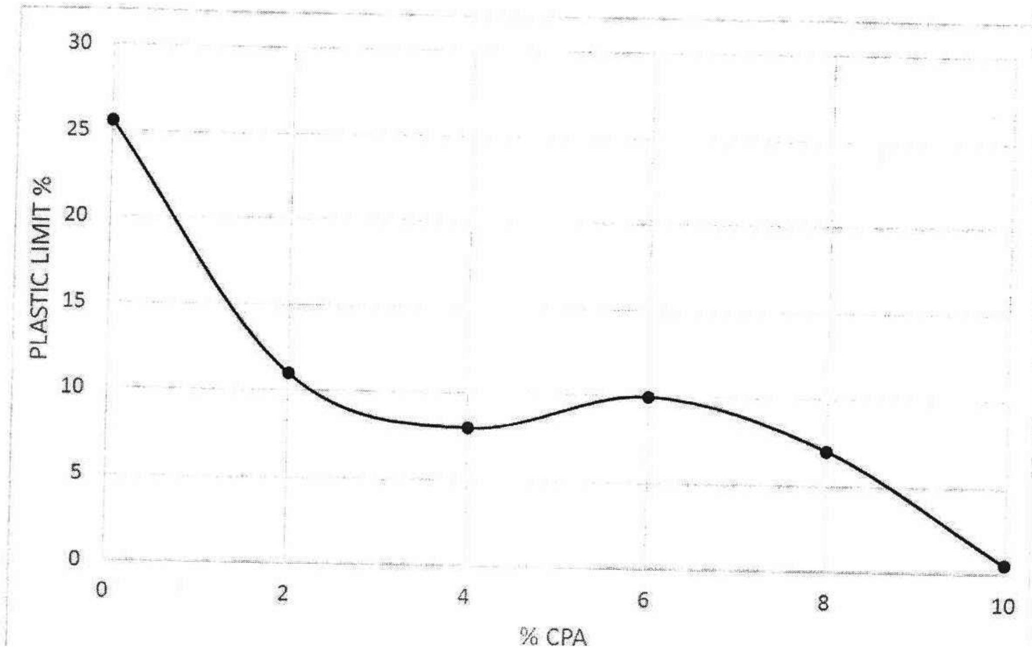
Results of Atterberg's Limit Tests on Stabilized Soil Samples

The moisture content of a soil sample is necessary in accessing the suitability of the sample as a highway material. The results of the atterberg limit tests carried out on the stabilized soil sample to access the efficiency of the stabilizing blinder used is presented in this section. Cassava peel ash (CPA) was used to stabilize the lateritic soil. The results are shown in table 4.5 and plotted in figure 4.2-4.4 for the liquid limit (LL), plastic limit (PL) and plasticity index (PI) respectively.

Table 6 Liquid Limit (LL), plastic limit (PL) and plasticity index (PI) of CPA stabilized lateritic soil samples.

% CPA	LL	PL	PI
0	53.2	25.6	27.6
2	52	11	41
4	48	8	40
6	43	10	33
8	33	7	26
10	15.1	0.5	24.6

Variation of LL with % of CPA addition.



Variation of PL with % of CPA addition.

From the results displayed in figure 4.2-4.4. it showed all the atterberg limits and index including the liquid limit (LL), plastic limit (PL) and plasticity index (PI) decreases with an increase in cassava peel ash added to the soil samples. The only exceptions to these were the plastic limit at 6% CPA addition and the plasticity index at 2% CPA addition. This decrease may be due to flocculation and agglomeration arising from action exchange reactions where Ca^{+} in the additives reacted with ions of lower valence in the clay structure. The results of the atterberg limit tests results showed that all the modified soils met the requirements of the Nigeria General specification of maximum plasticity (PI) index of 30% and liquid limit (LL) of a maximum of 50% for a subgrade material in road construction.

RESULTS OF UNCONFINED COMPRESSIVE STRENGTH TEST (UCS) ON STABILIZED SOIL SAMPLES

The results of the unconfined compressive strength (UCS) test tests carried out on the stabilized soil sample to access the efficiency of the stabilizing blinder (CPA) used is presented in this section. The UCS values of lateritic soil mixed with varying proportions of cassava peel ash are reported in table 4.6 and plotted in figure 4.5.

Table 7 UCS values for various CPA addition

% CPA	UCS (KN/M^2)
0	163.7
2	200.3
4	206.2
6	245.6
8	280.9
10	298.7

International Journal of Medical Science and Applied Biosciences
ISSN: 2545-5893(Print) 2545-5877 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

Variation of UCS values with varying% of CPA addition

The results in figure 4.5 showed that the addition of CPA to lateritic soil from 0% to 10% increased the UCS value of soil from 163.7 KN/M^2 (UCS of natural soil i.e. at 0% CPA) to 298.7 KN/M^2 (UCS of 10% CPA stabilized soil). From chemical viewpoint with geotechnical consideration, when the stabilizing blinder (CPA) was mixed with lateritic soil, reactions occur via two distinct processes (i) ion exchange reaction known as modification and (ii) lateritic soil-CPA pozzolanic reactions known as stabilization. These mechanism are responsible for the improvement in the UCS of soil-CPA mixtures. The UCS value of 10% CPA stabilized soil (298.7 KN/M^2) which is the highest in this research work, falls short of the UCS value of 1710 kn/m^2 specified by TRRL (1977) for base materials stabilization using ordinary portland cement. This value also fails to meet the requirement of 687-1373 KN/M^2 for sub-base as specified by Ingles and Metcalf (1972).

RESULTS OF DIRECT SHEAR TEST ON STABILIZED SOIL SAMPLES

The direct shear tests is used to measure the shear strength properties of the soil. It was used to determine the effect of stabilizing blinder (CPA) on the shear strength of the lateritic soil. The cohesion and angle of internal friction values gotten from the direct shear test on soil mixed with varying proportions of CPA are reported in table 4.7, while the cohesion and angle of internal friction are displayed on figures 4.6 and 4.7 respectively.

Table 8 Cohesion and angle of internal friction for various CPA additions.

% CPA	Cohesion (KN/M^2)	Angle of internal friction (°)
0	63	35
2	70	30
4	100	19
6	110	16
8	115	13
10	90	8

Variation of angle of internal friction values from direct shear test with varying % of CPA addition.

The results in figure 4.6 showed that adding of CPA from 0% to 8% increased the cohesion values of the soil from 63 KN/M^2 (cohesion value of natural soil) to 115 KN/M^2. The increase in the cohesion value could be attributed to the cementitious nature of the CPA, which results in bonding between the soil particles. However, the cohesion values later decreased to 90 KN/M^2 with 10% CPA addition. The angle of internal friction in figure 4.7 showed that adding of CPA from 0% to 10% decreased the angle of internal friction values of the soil from 35° (angle of internal friction value of natural soil) to 8°. The angle of internal friction value depends on both the frictional properties of the individual particles and interlocking between particles. The decrease in this value could be due to change in the gradation and void ratio of the stabilized sample with CPA addition.

RESULTS OF PERMEABILITY TEST ON STABILIZED SOIL SAMPLES

Permeability is an engineering property of soil which measure the rate of flow per unit area under hydraulic gradient. The result of the permeability test using falling head method on the CPA stabilized lateritic soil sample are reported in table 4.8 and plotted in figure 4.8.

Table 9 Coefficient of permeability values foe various CPA addition.

% CPA	Coefficient of permeability (cm/s)
0	0.463×10^{-6}
2	0.471×10^{-6}
4	0.563×10^{-6}
6	0.827×10^{-6}
8	1.24×10^{-6}
10	0.448×10^{-6}

Variation of coefficient of permeability values with varying % of CPA addition.

The results of the coefficient of permeability displayed in figure 4.8 showed that adding of CPA from 0% to 8% increased the coefficient of permeability value of the soil from 0.463×10^{-6} cm/s (coefficient of permeability value of natural soil) to 1.24×10^{-6} cm/s. The increase in the coefficient of permeability value could be attributed to change in the shape, size and void ratio of the stabilized soil samples. However, the coefficient of permeability values later decreased to 0.448×10^{-6} cm/s with 10% CPA addition. The coefficient of permeability value of the CPA-lateritic soil mix indicates its potential as an embankment fill material with good drainage capacity.

RESULTS OF MICROSTRUCTURAL ANALYSIS ON STABILIZED SOIL SAMPLES

Micro structural analyses (using the scanning electron microscope [SEMI] were performed on the lateritic soil, the cassava peel ash and the lateritic soil stabilized with 2% and 10% CPA and shown in figure 4.9a and b showed the micrograph of the lateritic soil at different magnifications. The lateritic soil sample consists of closely knitted fabrics of clay (agglomerate) as shown in figure 4.9a. at a higher magnification figure 4.9b showed that the soil sample contains some void spaces. The micrograph of the CPA showed that it contained a fine closely knitted fabrics as shown in figure 4.10. However the micrograph of the lateritic clay soil stabilized with 2% and 10% CPA displayed in figures 4.11 and 4.12 indicate that the soil particles were bonded more closely than the natural lateritic soil sample and the void spaces were filled with the CPA. This micro structural also explain an increase in the mechanical (strength) properties of the stabilized samples.

CONCLUSIONS

The study was conducted to stabilize lateritic soil using cassava peel ash (CPA) as a stabilizing blinders. A series of laboratory tests that included basic geotechnical tests on the collected lateritic soil sample, permeability and strength tests were performed on the sample mixtures to evaluate the effectiveness of the stabilization process. Based on the laboratory tests, the following conclusions were drawn:

- The lateritic soil sample collected was an A-2-7 soil according to the American association of highway transportation officials (AASHTO) and as a SC (clayed sand) soil according to the unified soil classification system (USCS). The lateritic soil natural moisture content was 10% and specific gravity of 2.35 and a bulk density of 1,130.52 kg/m^3. Atterberg limits were 53.3% and 25.6% respectively for the liquid limit and plastic limit.
- The plasticity of the syabilized samples initially increased and later decreased with increase in the stabilizing blinder content, a decrease in soil plasticity gives an indication of a more stable soil with marked increase workability.
- The strength of the stabilized soils gotten from the UCS and cohesion values of the varying amount of stabilizing binder on the soil showed that the strength of the sample were increased with an increase in the amount of stabilizing binder added. The cohesion values however, decrease with the 10% CPA addition.
- The coefficient of permeability value of the CPA-lateritic soil mix increase with an increase in the stabilizing binder content, this indicates its potential as an embankment fill material with good drainage capacity.

RECOMMENDATION

As a result of the outcome of this research work, it is recommended that various method of utilizing agriculture wastes should be devised instead of disposing them into the dumpsite and landfill. Extensive research can also be done on the usage of this agriculture wastes alongside primary stabilizing agents like cement to investigate their suitability in improving soil properties.

CONTRIBUTION TO KNOWLEDGE

This research work had established the extent to which agriculture wastes (cassava peel) can be burned in to ashes and used to improve the geotechnical properties of lateritic soil. An improvement in the index and strength properties of soil by addition of CPA will help to find an application for waste materials. This will also give other researchable an idea on the exploration and utilization of several other waste products found in the environment. This will bring about a better environment and low cost soil improving agents.

REFERENCES

Adebayo, A. O. (2008). Using cassava waste to the raise goats. Project 2008-4345. World Bank Development Marketplace.

Adegbola, A. A; & Asaolu, V. O. (1989). Preparation of cassava peels for use in small ruminant production in Western Nigeria. Toward Optimum Feeding of Agricultural By-products to Livestock in Africa Preston, TR, Nuwanyakpa, MY (Eds.), 109-115.

Adu-amankwa, B. (2006). Profitability analysis of pilot plant utilizing waste cassava peels and pulp as substitute for maize in animal feed formation. Journal of Science and Technology (Ghana), 26(3), 90-97.

Alhassan, M. (2008). Potentials of rice husk ash for soil stabilization. Assumption University Journal of Technology, 11(4), 246-250.

Al-Swaidani, A; Hammoud,1; & Meziab, A. (2016). Effect of adding natural pozzolana on geotechnical properties of lime-stabilized clayed soil. Journal of Rock Mechanics and geotechnical engineering, 8(5), 714-725.

Amu, O.O; & Adetuberu, A.A. (2010). Characteristics of bamboo leaf ash stabilization on lateritic soil in highway construction. International Journal of Engineering and Technology, 2(4), 212-219.

Amu, O.O; Ogunniyi, S. A; & Oladeji, O. O. (2011). Geotechnical properties of lateritic soil stabilized with sugar case straw ash. American Journal of Scientific and Industrial Research, 2(2), 323-331.

Aro, S. O; Aletor, V. A; Tewe, O. O; & Agbede, J. O. (2010). Nutritional potentials of cassava tuber wastes: A case study of a cassava starch processing factory in south western Nigeria. Livestock Research for Rural Development, 22(11), 42-47.

Arum, C; & Olarewaju, A. J. (2005). Quality control in civil engineering construction. In proceeding of the 3rd national civil engineering conference of the Nigerian institution of civil engineering on the strategies for enhancing the civil engineering profession in Nigeria (pp. 63-69). Nigeria institution of civil engineers, Akure, Ondo State Nigeria.

Babu S. G.L. and Chouksey S. K; (2011). Stress-strain response of plastic waste mixed soil, waste management journal, 31,481-488.

Barana, A.C; & Cereda, M. P. (2000). Cassava wastewater (manipueira) treatment using a two-phase anaerobic biodigester. Food science and technology (campinas), 20(2), 183-186.

Bello, A.A. (2011) influence of compaction delay on CBR and UCS of cement stabilized lateritic soil. Pacific journal of science and technology, 12(2):87-98.

Bello, A.A (2013). Introduction soil mechanics I,Tony Terry prints, Lagos.

Bello, A. A; Ige, J. A. and Ayodele. H. (2015). Stabilization of Lateritic Soil with Cassava Peels Ash, British Journal of Applied Science and Technology, 7(6):642-650.

Bergaya, F; & Lagaly, G. (2006). General introduction: clays, clay minerals, and clay science. Development in clay science, 1,1-18.

British Standards institution (1990): british standard method of test for soils for civil engineering purpose: classification tests. Lomdon, BS1377.

Choudhary A. K; Jha J.N. and Gill K.S; (2010.). A study on CBR behavior of waste plastic strip reinforced soil, emirates journals for engineering research, 15(1), 51-57.

Consoli NC, Montardo JP, Prietto PDM and Pasa GS. (2002). Engineering behavior of sand reinforced with plastic waste, journal of geotechnical and geo environmental engineering, ASCE; 128(6):462-472.

Davidson, D.T. (1961). Soil stabilization with cement (No. 194-198). Iowa state university of science and technology.

Das, B.M. (2008). Advance soil mechanics, third ed. Taylor & Francis Group.