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Evaluation of Index Properties of Black Cotton Soil Stabilised with Plantain Peel Powder

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Abstract: ***Evaluation of index properties of black cotton soilstabilized with plantain peel powder (PPP) evaluated. Black Cotton Soils are a type of expansive soil which are basically susceptible to volumetric changes, with the changes in moisture. This is due to the presence of mineral montmorillonite, which as an expansive lattice. There are various materials that may be used as stabilizers but now in this research an attempt was made by stabilizing with plantain peel powderBlack cotton soil was obtained from Yola Adamawa state Nigeria which was stabilised in (0, 2, 4, 6, 8, 10) % proportion respectively. Laboratory test such as: Natural Moisture Content (NMC) , Specific gravity(Gs), Grain size analysis, Liquid Limit (LL) , Plastic Limit(PI), Linear Shrinkage (Ls), All the test were carried out in accordance with the British Standard code of practice (BS1377:1990). The laboratory preliminary tests on the soil results showed that the %passing sieve 200 is greater than 35% while Gs, LL, PI, Lsand NMCgave 2.6, 48 % , 20 %, 14 % and 14 % respectively. AASHTO and USCS soils classification system classified the soils as A-7-5 for (AASHTO) and CH materials which describe the soil as Clay of High Compressibility. The effect of PPP on the index properties showed that the LL % , PI % and Ls % varied between 48 and 32 for LL %, varied between 28 and 13 for PI % and varied between 14 and 7.5 for Ls % for (0, 2, 4, 6, 8, 10) PPP admixture which indicate that the higher the PPP the lower the clay content and the better the index properties examined. It was concluded that with the addition of PPP admixtures enhanced the index properties of the black cotton. Thus Plantain Peel Powder (PPP) can be used as a stabilizing agent for road works***

Keywords: Admixture, Black cotton, Index properties, *Plantain Peel Powder, stabilization*

1. Introduction

Soil index properties are the properties of soil that help in identification and classification of soil (Emmanuel et al 2017). These are properties of soil that indicate the type and conditions of the soil and provide a relationship to structural properties. Soil index properties are used extensively by engineers to discriminate between the different kinds of soil within a broad category (ELE, 2013).A good knowledge about a site including its subsurface conditions is very important in its safe and economic development. It is therefore an essential preliminary to the construction of any civil engineering work such as roads, buildings, dams, bridges, foundations, etc., (Adeyeri 2015).It is unfortunate to note that in developing countries like Nigeria only few investors in the construction industry take time to execute subsoil investigation prior to commencement of construction activities on their projects. The result is the calamitous consequences such as failure or collapse of buildings and other massive engineering structures which often cause untold hardship and damage and sometimes even loss of lives and propertiesSeveral highways pavement in Nigeria roads arefailing due to lack of use of soil with adequate engineering strength. So the need for improvement ofthe engineering properties of soil has been aparamount concern to the transportation engineers.The ability to blend the naturally abundant lateriticsoil with somechemical reagent to give it betterengineering properties in both strength and waterproofing has been of paramount importance to the transportation engineers.Black cotton soils are a type of expansive soils which can be found anywhere in the world but they are basically confined to semi–arid and arid regions of the tropical zones. These areas are naturally characterized by marked dry and wet seasons with low rainfall, poor drainage and high afternoon temperatures. The climate condition is such that the annual evaporation exceeds the precipitations (Chen, 1988). They are found in the north-eastern part of Nigeria Cameroon, Lake Chad, Sudan, Ethiopia, Kenya, South Zimbabwe, South Africa and other Eastern African countries. They are also found in India, Australia, South- Western USA and Israel (Ola, 1978; Tomlinson, 1999.Ola, 1978) reported 70 % montmorillonite in the Nigerian black cotton soils. Generally, black cotton soils have comparatively high percentage of clay, more than 90 % with substantial proportions of silt and sand. Their organic content is low and they are alkaline in composition with a pH greater than 7.0. The soil is black to grey in colour and it contains a very high percentage of humus (i.e., 3 to 15 %).Warren and Kirby (2004) refer to black cotton soils as ―swelling soils‖, ―heaving soils‖ and ―volume change‖ soils. Sahel (1993) describes expansive clay formations as being favoured by the geology, climatic condition and the environment of extreme disintegration, strong hydration and restrained leaching. Expansive soils swell and shrink considerably with changes in moisture content Due to the problems associated with these soils, road and building construction on this type of soil demand special knowledge which is in the hands of relatively small group of experts (Ibrahim, 1983). An engineering definition of these soils is ―a dark grey or black soil with a high content of clay usually over 50 % in which montmorillonite is the predominant clay mineral and which commonly expansive (Morin, 1971. Nowadays, considerable attention has been paid to the utilization of alternative materials, which bear higher engineering quality than traditional materials and are financially affordable. Soil is one of the most important materials used in a variety of construction projects including earth canals and earth dams. The fact that soil may provide all the resistance characteristics necessary for a project illustrates the importance of various methods used to

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improve soil quality. Clay soil is widely used in most of the construction projects. Clay soils, particularly soft clay soils, have good plastic properties so that increased moisture results in their decreased shear strength, compressive strength and volume changes. These damages typically take an irreparable toll on structures, which further clarifies the importance of soil improvement.

Plantain (*Musa* spp.) occupies a strategic position for rapid food production in Nigeria. It is ranked third among starchy staples. In Nigeria, plantain is produced in large quantities in Edo, Delta Ogun and Ondo states. Other producing states are Rivers State, Cross River, In Nigeria, plantain is produced in large quantities in Edo, Delta Ogun and Ondo states. Other producing states are Rivers State, Cross River, Imo, Anambra, Lagos, Kwara, Benue, Plateau, Kogi . The country's output doubled in the last 20 years. Production, which is concentrated in the Southern part of the country, still remains largely in the hands of small scale farmers who, over the years, have ingeniously integrated it into various cropping systems (Akinyemi et al, 2015). Plantain production in Africa is estimated at more than 50% of worldwide production. The majority (82%) of plantains in Africa are produced in the area stretching from the lowlands of Guinea and Liberia to the central basin of the Democratic Republic of Congo. West and Central Africa contribute 61 and 21%, respectively (FAO, 2006). It is estimated that about 70 million people in West and Central Africa derive more than 25% of their carbohydrates from plantains, making them one of the most important sources of food energy throughout the African lowland humid forest zone (Swennen, 1990). Nigeria is one of the largest plantain producing countries in the world (FAO, 2006). It has been estimated that Nigeria generates 20 kg of municipal solid waste per capita annually [FAO, 2013], and which has continued to increase with increasing population [FIDA, 2013]. Biogas technology has played and will continue to play a role in waste management [GUARDIAN, 2013]. Biogas production may therefore be a profitable means of reducing or even eliminating the menace and nuisance of urban wastes in many cities in Nigeria [IISD, 2013]. Plantain, banana and rice constitute major food crops in Nigeria. As a result, large quantities of wastes are often generated from the peels and husks. Indiscriminate disposal of these wastes and their concomitant decomposition often produce noxious gases such as hydrogen sulphide, ammonia etc., which pose serious environmental hazards. The aim of this study is to evaluatethe effect ofindex properties of black cotton soil Stabilized with plantain peel powder.

1.1. Laboratory Test

The following laboratory tests were conducted on the samples: Atterberg limits test, specific gravity test, sieve analysis test, hydrometer test, bulk density and natural moisture content test, prior to preparing the test specimens, the materials were oven-dried and broken into smaller fragments, care being taken not to reduce the sizes of the individual particles.

1.2. Particle Size Gradation

This test was carried out in accordance with wet sieving BS 1377 [1990] test 7a standard. The British Standard (BS) Sieves used, adequately covered the range of aperture size for the soil. A 2 mm sieve was nested in a 63 micron sieve without the lid. The soil was placed little at a time on the 2mm sieve and washed on a sink with a jet of clean water. The whole of the material retained on each sieve was allowed to drain and then carefully transferred to a tray and placed in the oven to dry at temperature of 105 to 110°C overnight. The dry soil was then passed through a nest of the complete range of sieves to cover the size of particles present down to 63µmsieve. The operation was carried out on a mechanical sieve shaker. The Percentage Weight retained and the Percentage Passing in the sieves were determined. The percentage passing was then plotted against sieves numbers

1.3. Natural Moisture Content

This test was carried out in accordance with BS 1377 [1990], test 1 A standard. A sample container was weighed to 0.01gand the weight was recorded as m1. The soil material to be tested was then added, both container and soil were weighed and the value was recorded as m2. The container with sample was then placed in the oven for 24 hours at a controlled temperature of 105°C, after which it was transferred to the desiccators to cool. The oven dried and cooled sample was the weighed and the value recorded as m3. The Natural Moisture Content was then determined as weight of water over weight of dry soil.

1.4. Specific Gravity

This test was carried out in accordance with BS 1377 [1990] standard. Three density bottles were washed, dried, cooled and weighed to the nearest 0.001g and recorded as (W1).Sample of appropriate mass (50 to 150g) was obtained by quartering down the original sample after passing a 2 mm BS sieve. Each bottle with the soil was weighed and recorded as(W2). Distilled water was added to each bottle so that the soil was covered and the bottle half full. The soil, bottle and water was weighed and recorded as (W3). The bottles were cleaned out and filled completely with distilled water and placed in the constant temperature bath until attainment of bath temperature. The bottle and distilled water was weighed and recorded as (W4).The specific gravity, Gs was calculated as = (W2-W1) / (W4-W1) - (W3-W2).

1.5. Atterberg Limits Test

The determination of liquid limit was carried out in accordance with American Society of the International Association for Testing and Materials (ASTM) methodD423 standard. About 250 g of soil sample from thoroughly mixed portion of soil material, passing 0.425 mm was placed\ in a porcelain dish and mixed with 15 to 20 ml distilled water by alternately and repeatedly stirring, kneading and chopping with spatula. Further water increment of 1 to 3 ml was added and the process repeated until sufficient water has been thoroughly mixed with the soil. A portion of the mix was

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pressed into the cup using a spatula and carefully spread into position while avoiding entrapment of air bubbles. The liquid limit was taken as the moisture content corresponding to 25blows. Similarly, for plastic limit determination, the test was carried out in accordance with BS 1377 [1990] test 3 standard .About 20 g of soil sample, passing 0.425 mm sieve was used for the test. The sample was thoroughly mixed with distilled water and kneaded for about 10 minutes to form a plastic ball. The ball was molded between the fingers and rolled between the palms, such that the warmth from the hand slowly dried it. The thread was then rolled between the fingers and a glass plate using steady pressure which reduced the diameter to about 3mm, the pressure was maintained until the thread crumbled. This crumbling point is the plastic limit.

1.6. Linear shrinkage test

This test was carried out in accordance with BS 1377 [1990] test 5 standard. About 150 g of air dried soil passing 0.425mm sieve was used. The mould was cleaned, dried and a thin film of silicone grease was applied to the inner surface to prevent soil sticking to the mould. The soil was placed on a glass plate and mixed properly using distilled water for about10 minutes until a homogenous paste of about the liquid limit was achieved. The length of the bar of soil was measured using a venire caliper, both top and bottom surfaces. The mean of the two lengths was taken as the dry length.

2. Results and Discursion

2.1 Grain size analysis

Figure 3 and Table 3 shows the graph of grain size analysis performed on the black cotton soil which has a very high percentage finer than 0.0075 fractions that is >35%.Hence, the soils are describe as (A-7-5) a Clay of high compressibility (CH).the implication of the result shows that soil of higher clay content are regarded as unsuitable material in road works which will require stabilization for strength improvement

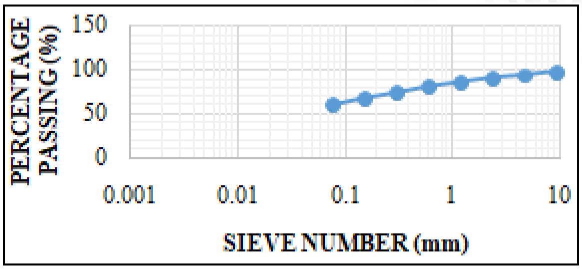

Figure 3: Graph of grain size analysis

Table 3: Grain size analysis of the Black cotton soil

Sieve number(mm)	Weight (gm)	%Ret	% passing
9.5	10	2.0	98
4.75	20	4.0	94
2.36	15	3.0	91
1.18	25	5.0	86
0.6	20	4.0	81
0.3	35	7.0	74
0.15	30	6.0	68
0.075	40	8.0	60

2.2 Consistency Limit test

Table 1and 2 shows the results of liquid limit (LL %), and plasticity index (PI %) evaluated on the Natural soil and on the stabilized soil which gave 48 % and 20%respectively at natural state of the soil while the stabilized varied between 48-32% and 20-13% respectively for (0-10) % PPP admixture addition, the results indicate that the higher the PPP the lower the clay content and the better the index properties examined as showed in figure 1 and 2. Federal Ministry of Works (FMW) general specification requirements for roads and bridges (1994) recommend liquid limit not greater than 80% for sub-grade and not greater than 35% for sub-base and base course. Also, plasticity index not greater than 55% for sub-grade and not greater than 12% for both sub-base and base. From the foregoing, the soils fall within these specifications. The above analysis showed that the PPP has enhance the index properties of the black cotton soil. Thus making the unsuitable material suitable for sub-grade, sub-base and base course and earth fill materials.

Table 1: Summary results for preliminary tests of the Black cotton soil (index properties)

NMC (%)	GS	%Passing sieve200	LL (%)	PL (%)	PI (%)	LS (%)	Classification	
							AASHTO	USCS
14	2.60	60	48	20	28	14	A-7-5	CH

*NMC (Natural Moisture Content). * GS (Specific Gravity). * LL (Liquid Limit). * PL (Plastic Limit) * PI (Plasticity index). * LS (Linear Shrinkage)

Table 2: Summary results for consistency test of the PPP blended with black cotton soil

% of PPP Addition	Liquid Limit (LL%)	Plastic Limit (PL%)	Plasticity Index (PI%)	Linear Shrinkage (LS%)
0	48.0	20.0	28.0	14.0
2	40.0	18.0	22.0	12.5
4	39.0	19.0	20.0	11.0
6	35.0	17.0	18.0	10.0
8	33.0	17.0	16.0	9.0
10	32.0	19.0	13.0	7.5

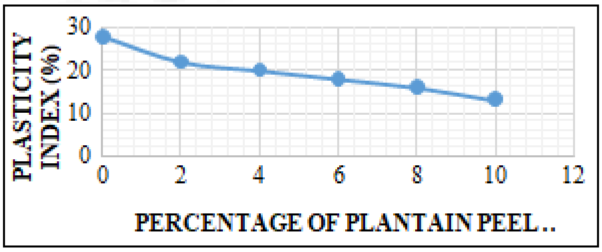

Figure 1: Graph of Plasticity index against percentage of PPP addition

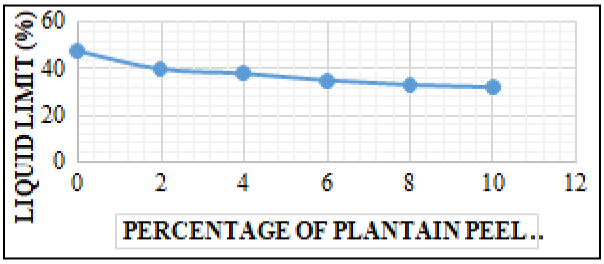

Figure 2: Liquid Limits results against percentage of PPP addition

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3. Conclusion

The index properties of black cotton from Yola Adamawa State stabilized with PPP has been evaluated.Samples of undisturbed soil were obtained for laboratory tests. The results of the tests at the natural state of sample shows that it has percentage of fine greater than 40%, The soils sample were grouped as (CH) and A-7-5 respectively. This classify the soils as Clay of high compressibility. The black cotton soil was stabilized with PPP, the results varied between 48-32% LL and 20-13% PI respectively at (0-10) % proportion of the PPP admixture addition

4. Recommendation

A black cotton soils stabilized with PPP are suitable for dam, earth fill, subgrade, sub base and base course materials in civil engineering construction project.

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