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IMPROVEMENT OF CLAY SOIL CHARACTERISTIC USING RICEHUSK ASH AND LIME

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ABSTRACT

The characteristic of clay soil was improved in this research work. This was done in order to check the issue of strength variation, high plasticity, moisture absorption which affects the performance of clay when used for construction purposes. This research was confine to moisture content, specific gravity, C.B.R, compaction, consistency and compressive strength of clay soil. In this research different percentage of rice husk ash and lime were added as stabilizer for improving the characteristics of clay. 2%, 4%, 6%, 8% and 10% of rice husk ash and lime were added respectively. The laboratory test results revealed 6.0%-12% moisture content, 1.0-2.9 specific gravity, 37.83%-60.90% C.B.R, 71.66KN/m^2-139.55KN/m^2 share stress, 21%-42% liquid limit, 9.7%-27.4% plastic limit, 10.4%-13.3% shrinkage limit, 7.2%-32.2% plasticity index, 1.52g/cm3-1.73g/cm3 maximum dry density, relationships which corresponded with the following percentage of additive 2%, 4%, 6%, 8%, and 10%. For better performance the clay soil of rice husk ash and lime should be used as stabilizer in order to ensure good stability and workability of clay soil.

Keywords: Strength Variation; Clay Soil; Rice Husk Ash; Compressive Strength; Laboratory Test;

INTRODUCTION

The success of any construction project depends on the strength and soundness of any under-laying soil. Graham. (1984). The usability of soil create significant effect on structure which are permit with effective techniques and design, chemically treated lime and Ash from rice husk can transform unstable soil into stabilized soil which are classified into pavement design. Construction of structures is an important aspect of Civil engineering profession and it aim is to provide a firm, strong structure to better the lives of people.

Soil stabilization can be defined as the process of treating natural soil to improve performance, strength and reduce the vulnerability of water as construction materials.

The stabilization of soil plays a significant role by changing the characteristic of the soil to produce a long-term permanent strength and stability. Graham (1984).

However, the purpose of soil stabilization is to improve soil strength and other properties and to lower water.

With the above purpose, it can be achieved by the application of the following method which include the mechanical and chemical methods of stabilization, the mechanical method involve the process of improving the gradation of the soil while chemical method is the process of injecting and mixing of chemicals substances into the soil. The type of chemicals agents used in the stabilization of soil includes; Portland cement, sodium chloride, calcium chloride, Asphalt, paper mill waste, ash from rice husk.

In stabilization with lime and ash from rice husk, clay soils are transformed chemically into a natural cement structure of calcium silicate aluminates. Due to the pozzolanic nature of these two substances clay soil can be treated to a varying degree, depending on the objectives that are to be considered. The least amount of treatment is used to dry and modify soil temporarily.

A greater degree of treatment supported by testing, design and proper construction techniques produces permanent structural stabilization of soil.

STATEMENT OF PROBLEM

The major problems of clay soil are due to the following listed below;

a. High moisture absorption
b. High plasticity
c. Compressibility
d. Instability
e. Variation in strength.
f. Swelling.

These problems are noticed by depression of structure, lateral movement and swelling of pavement in the presence of water even under moderate wheel loads. However there is need to modify it to improve its engineering properties for better usage by the construction industries, these benefits enhances construction, save time and money.

AIM

The aim of this research work is to improve the geo-chemical engineering properties of clay soil to produce long-term permanent strength and stability.

OBJECTIVES

The objectives are as follows;

- To make use of locally available soil and other materials.
- To improve the strength of the sub-grade.
- To evaluate the effect of the admixture on the index and engineering properties of stabilized clay soil.

- To determine the optimum additive content of the additive that results in desired improvement in properties.
- To ascertain the effect of the additive on the properties and the C B R value of the clay soil.
- To verify the strength value obtained at the optimum percentage of the additives.

SIGNIFICANCE OF THE STUDY

This research is of paramount importance to structural engineer, building designer and users in various states mentioned, it makes it easy to checkmate the issues of swelling pavement, differential settlement in both pavement and building construction.

SCOPE OF THE STUDY

This project is to determine, generally on how to improve the engineering properties of clay soil to stop swelling and failing when used in construction works or projects.

LIMITATION OF THE STUDY

This research work is limited to preliminary test and the main test. These tests include the follow;

a. Natural moisture content test
b. Specific gravity test
c. Consistency (Atterberg limit) test
d. Compaction test
e. C.B.R test
f. Unconfined Compression Test (UCT)

LITERATURE REVIEW

This chapter encompasses a review of the definition of soil and some of the research result on clay soil that has been published.

Geo-technical engineers classified soil as either cohesive or granular. Granular soil(sometime refers to as loose particle soil), it is formed from loose particles without strong inter-particle force e.g. gravel and sand, cohesive soil (clay, silt, clayey) which are formed from particles bound together, the particle are flashy and sheet-like and retains a significant amount of absorbed water on their surfaces.

The ability of the sheet-like particle to slide relatively to one another gives cohesive soil the property known. GRAHAM W. (1984)

GENERAL AND PHYSICAL CHARACTERISTIC OF CLAY SOIL

Clay soil is predominantly black, Gregg and red in color, as the nature implies, it has more clay content with little silt and sand particle. The clay particles are not visible, it is hard to crumble and stick to the hand when dry, it is also smooth when felt between the fingers. Little A. L. (1969).

Clay soil exhibit poor engineering properties, this includes high plasticity, poor workability, low strength values are excessive expansion.

Water as a physical characteristic of soil which attracts the passage of traffic, this is due to the penetration of water and it is a property that is due to the presence of mineral in clay, soil many of which are water absorbing.

CLASSES OF CLAY MINERAL AND CHEMICAL COMPOSITION

The minerals comprise of clay which are as a result of chemical weathering of rocks particles and hydrate of aluminum, manganese, silicate, iron which are generally combined together in a way as to create a sheet-like structure. These sheets are built from two basic units, the tetrahedral unit of silica, iron or magnesium. The main dimension of clay particles is usually less than 0.002mm and the different types of mineral have been created from the same manner in which these structures are slicked together.

Clay minerals are sub-divided into:

a. Montomorillionic group
b. Kaolinite group
c. Illite group. LITTLE A. L. (1969)

MONOTOMORILLONTE GROUP

The mineral that falls under this group has similarities with the illite group however, in the tetrahedral sheet, some of the silica are replaced by iron, magnesium, and aluminum, this mineral exhibit very high water absorption, shrinkage characteristics and swelling. Bentonite is also a member of this mineral group and is usually formed from the weathering of volcanic as magma due to its large expansive properties when mixed the water, it is much in demand as a in the sealing of leaks in reservoirs and tunnels, it is also used as a drilling mod for bored soils. LITTLE A. L. (1969)

ELITE GROUP

The elite group consist of a series of octahedral sheet of sandwich between two different tetrahedral sheet of silicon and aluminum, in the octagonal sheet, silicon is partially replaced by aluminum, illite absorb more water than kaolinite and have higher swelling and shrinkage characteristics. LITTLE A. L. (1969)

KAOLINITE GROUP

This group is the most dominant, part of the residual clay deposit are made from large stalks of alternating single tetrahedral sheet of aluminum. The structure of kaolinite is very stable and strong both absorb with water. They have low swelling and shrinkage characteristics to water content variation. LITTLE A. L. (1969)

SOIL STABILIZATION

This is simply known as the process of improving any unstable soil in many instances soil that are unsatisfactory in their natural state can be altered through stabilization to make them suitable to a degree where they can be used in construction works.

Civil engineering projects located in areas with soft or weak soil have traditionally incorporated improvement of soil properties by using various methods. Soil stabilization is to use for variety of engineering works, the most common application being in the construction of roads and pavements, where the main additive is increase the strength or stability of the soil and reduce the construction cost by making best use of the locally available materials.

Over the times, cement and lime were the two main materials used for stabilizing soil; these materials have rapidly increased in price due to the sharp increase in the cost of energy. Thus the use of agricultural wastes such as rice husk ash (RHA) will considerably reduce the cost of construction and as well reduced the environmental hazards they causes. Rice husk is an agricultural waste obtained from milling of rice. Hence rice husk is used for upgrading of soil, normally the rice husk ash (RHA) is added together to a small amount of cement or lime or both can be added together for more efficiency.

Soil stabilization can also be achieved through mechanical means, soil stabilization is generally classified under two broad classes which are:

i. Mechanical stabilization
ii. Chemical stabilization.

These can also be further sub-divided into:

i. soil-aggregate
ii. soil- cement
iii. soil-lime
iv. soil-rice husk ash
v. soil-bituminous material.

The choice of stabilization method depends largely on the type of soil, property of the soil to be determined through the basic laboratory test or the availability of stabilizers and economy at hand also matters. HAKEEN K. L. (2004).

STABILIZATION METHODS

MECHANICAL STABILIZATION

This is the most widely used method because it enhances the use of locally available material. Broadly mechanical stabilization implies the stability of a material under a given set of moisture conditions rather than maintaining the load bearing capacity under varying moisture conditions.

This include the grading(blending) of materials, coarse grained and fine grained soil to obtain moisture processing some degree of internal friction plus cohesion and provide a material that is workable during placement.

Generally the principal of grading soil may be applied to the improvement of soil of low bearing capacity adding to them materials having a particle size of low bearing capacity adding to them material having a particle size that are lacking e.g. sand can be added to clay soil and vice versa. LITTLE A. L. (1969)

FACTORS AFFECTING MECHANICAL STABILIZATION

i. Mechanical strength of aggregate: In a well proportion and thoroughly compacted mechanically stabilized roads a low mechanical strength is permission on aggregate.
ii. Mineral composition of the material: Experiences suggest that almost any material that is resistant to weathering will be suitable for use as aggregate on mechanical stabilization, all kinds of natural rocks, gravel, sand and artificial materials e.g. slab, shale, wood ash, etc. have been used with success likewise low

graded materials e.g. laterite, lime rock etc. mineral composition of silt and clay in particle presence in found undesirable.

iii. Particle size distribution (Grading): To achieve mechanical stabilization it is necessary to have a well-proportioned material containing some clay binders for coarse materials. It is usually assumed that particle size distribution given the greatest dry density has the greatest internal friction, although this has not been proven experimentally. GRAHAM W. (1984)

CHEMICAL STABILIZATION

This is simply the increase in stability of a given material by the introduction of chemicals materials e.g. lime, cement, bitumen and resinous compounds so as to improve on the strength property of the material, chemical stabilization can be further be classified base on the kind of chemical employed. LITTLE A. L. (1969)

CEMENT STABILIZATION

This is thoroughly compacted mixture of polarized soil and cement between 5%-15% by weight of cement added to the soil (sand or clay) respectively to produce a material (soil-cement) which is stronger and more durable than untreated soil, having the appearance of very dense soil. It is hard with limited resistance to wear.

Faced with the concrete skyline of an urban landscape few people would guess that cement faces its toughest challenges underground-in oil and gas wells were environmental conditions are far more severe than any encountered on the earth's surface. Recently sophisticated computers modeling have been introduced to simulate and optimize the cementing operation. Data recorded while pumping the cement are analyzed to judge whether the cement has been correctly placed. Cement evaluation logs and other casted whole logs can indicate the strength of the set cement and whether it is bonded to the casting. The outcome of a cementing job however depends ultimately on choosing the appropriate cement and additives to suitable with particular well conditions. WIKIPEDIA (2007)

CEMENT ADDITIVES

Today's well cements have to withstand an enormous range of well depths and conditions. In permafrost zones, the cement must withstand below freezing conditions, while in thermal recovery wells or geothermal fields they must endure temperatures above 350 degree Celsius. They must contend with weak formations, formations that might cause lost circulation and corrosive and pressured formations fluids. How can cement be formulated to accommodate such varied condition? The answer lies in additives which came in eight main varieties.

Normally cement additives can number up to or more than 100 but they can be grouped into eight main categories;

i. **ACCELERATORS:** reduce cement setting time and speed up the development of compressive strength. They are commonly used in shallow, low-temperature wells.
ii. **RETARDERS:** Extend cement setting time and allow sufficient time for slurry placement in deep well.
iii. **EXTENDERS:** reduce cement density and may also reduce the amount of cement needed for a job. Low density cement is needed for cementing weak formations which would otherwise break down and cause lost circulation.
iv. **WEIGHTING AGENTS:** Increase cement density. These are used for cementing high pressure formations which might become unstable if slurry density were too low.
v. **DISPERSANTS:** reduce the Viscosity of cement slurry and ensure good mud removal during placement.
vi. **FLUID-LOSS CONTROL AGENTS:** control water loss from the cement into the formation.
vii. **LOST-CIRCULATION CONTROL AGENTS:** reduce the loss of cement slurry into weak or muggy formation. Loss of

cement may be necessitating a costly remedial cementing operation.

viii. **SPECIAL ADDITIVES:** such as antifoam agents and fibers are manufactured for specific cementing tasks such as the prevention of foaming that might lead to a loss in hydraulic pressure.

CHEMICAL COMPOSITION OF CEMENT

The raw materials used for the manufacture of cement consist mainly of lime, silica, alumina and Iron oxide. These oxides interact with one another in the Kiln at high temperature to foam more complex compounds. The relative properties of these oxides compositions are responsible for influencing the various properties of cement; in addition to rate of cooling and fineness of grinding. The table 1 below shows the approximate oxide composition limits of ordinary Portland cement.

Table 1: Chemical Composition of Cement

OXIDE	Percent Content %
CaO	60-67
SiO2	17-25
Al2O3	3.0-8.0
Fe2O3	0.5-6.0
MgO	0.1-4.0
Alkalis(K2O3Na2O)	0.4-1.3
SO3	1.3-3.0

WIKIPEDIA (2007)

LIME STABILIZATION

The addition of lime to soil results to the decrease in the density of soil, change the plasticity proportion of the soil and increase its strength, these changes are as a result of chemical reaction which the altercation of water film surrounding the clay minerals depends on the change, hydration of attraction ion and sizes, the calcium ion (lime) is divalent types of bond and serves in turn decrease in plasticity and result in a more open and granular structure.

The second stage is the process in which lime changes soil due to flocculation of soil particles. The amount of lime used in construction is 5%-10% by weight, it should be noted that the percentage result in the concentration of calcium ion is greater than the quantity needed.

The third stage is a process whereby the lime affects soil by the reaction of lime on soil components to form chemical; the two principal components of the soil which reacts with lime are silica and alumina. This reaction is a long term, one result in greater strength, if the mixture of lime soil are cured for a period of time, " this reaction is known as pozzolanic action".

In spite of minimizing swelling and improving the plasticity and workability, the following benefits are incurred from stabilizing with lime

- Enhance effect on Atterberg limit
- Drying off of mixture in excess of optimum
- Improve workability
- Water proofing properties imparted on lime stabilized clay soil
- Increase in optimum moisture content and reaction in optimum density which is desirable properties
- Increase C.B.R value as well as increase in strength with age. NELSON AND MILLER(1992)

RICE HUSK ASH STABILIZATION

Rice husk is one of the most widely available agricultural wastes in many rice producing countries around the world. Globally approximately 600 million tons of rice paddies are produced each year. On average 20% of the rice paddy is husk giving an annual total production of 120million tones. In majority of rice producing countries much of the husk produced from processing of rice is either burnt or dumped as a waste product. Burning of rice husk (RH) in ambient atmosphere leaves a residue called rice husk ash (RHA). For every 1000kg of paddy milled about 220kg (22%) of husk is produced and when this husk is burnt in the boilers about 55kg (25%) of RHA is generated.

Rice husk is a pozzolanic material that could be potentially used in soil stabilization through it is moderately produced and readily available. If tested on clayey soil by mixing with different percentage of rice husk ash, the additive when added 9% decrease the liquid limit by(11-18%) and the plastic index decrease by about (32-80)% and it causes the reduction in the maximum dry unit weight and also the optimum moisture content is increased. ROY.A (2014)

PROPERTIES OF RICE HUSK ASH

Rice husk contains 75-90% of organic matters such as cellulose, lignin etc. and rest mineral components such as silica, alkalis and trace elements. A typical analysis of rice husk is in table 2. The content of each of them depends on rice variety, soil chemistry, climate conditions and even the geographic localization of the culture. Rice husk is unusually high in ash compared to other biomass fuels in the range 10-20%. The ash is 87-89% silica highly porous and light weight, with a very high external surface area. Presence of high amount of silica makes it a valuable material for use in industrial application. Other constituents of RHA such as K_2O, Al_2O_3, CaO, MgO, Na_2O, and Fe_2O_3 are available in less than 1% ref. various factors which influence ash properties are incinerating conditions (temperature and duration), rate of heating, burning, techniques, crop variety and fertilizer used. The silica in the ash undergoes structural transformation depending on the conditions of combustion such as time and temperature (Wikipedia 2007).

Table 2: Properties of Rice Husk Ash

PROPERTY	RANGE
Bulk density (kg/m cube)	96-160
Hardening (Mohr's scale)	5-6
Ash %	22-29
Carbon %	35
Oxygen %	31-37
Hydrogen %	4-5
Nitrogen %	0.23-0.32
Sulphur %	0.04-0.08
Moisture	8-9

WIKIPEDIA (2007)

APPLICATION OF RICE HUSK ASH

RHA has got numerous applications in silicon based industries substantial research has been carried out on the use of RHA as mineral admixture in the manufacture of concrete. RHA in amorphous form can be used as a partial substitute for Portland cement and as an admixture in high strength and high performance concretes. When mixed in a certain percent with cement in a soil the MDD is decreased while the OMC is increased with increase in RHA content. Normally this can be explained that the decrease in MDD is because of replacement of soil and presence of RHA in it and increase in OMC with increase of RHA is because of quantity of free silt and clay fraction and coarse materials with larger surfaces area are formed.

RHA can also be used for other uses such as:

i. RHA can be used in steel industry as an insulator
ii. RHA can be used in ceramic and refractory industry because of its insulating properties
iii. RHA is used as a means of silica source contain in ash. ROY A. (2014)

HOW IT IMPROVES

- ✓ Plasticity reduction
- ✓ Reduction in moisture-holding capacity
- ✓ Swell reduction

MATERIAL AND METHOD OF RESEARCH

METHOD OF SAMPLE COLLECTION (CLAY SOIL)

The sample was collected from a dug pit of about 1.5m depth at Gonigora, Kaduna state.

Some of the sample (clay soil) for the research was kept in an air tight polythene bag to determine the natural moisture content of the soil sample (clay).

NATURAL MOISTURE CONTENT DETERMINATION

This is referred to as the mass of natural water which can be removed from the soil, usually by heating at 105 degree Celsius and expressed as a percentage of the dry mass in its form. Measurement of soil moisture content is very important since it gives an indication of water holding capacity of the soil sample.

The moisture content test was conducted in accordance with B.S 1377(1990).

ATTERBERG LIMIT TEST

Moisture content determine the state of grained soil and its behaviors as seen by the sliding abilities the aim of determining the state of soil under the action of water content and it is achieved by Atterberg limit and plasticity index.

a. LIQUID LIMIT DETERMINATION

The liquid limit test was conducted in accordance with B.S 1377 (1975).

b. **PLASTIC LIMITS DETERMINATION**
   The plastic limit test was conducted according to the B.S 1377 (1975).
c. **SHRINKAGE LIMIT**
   The shrinkage test was conducted according to B.S 1377(1990)

SPECIFIC GRAVITY TEST
The determination of specific gravity test is conducted according to the B.S 1377(1975).

COMPACTION TEST
The compaction test was conducted according to B.S 1377(1990) and the B.S 1924(1990).

CALIFORNIA BEARING RATIO (C.B.R) DETERMINATION
It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25mm/min. to that required for the corresponding penetration of a standard material. The California Bearing Ratio Test (CBR Test) is a penetration test developed by California State Highway Department (U.S.A) for evaluating the bearing capacity of sub grade soil for design of flexible pavement.

The test was conducted according with the B.S 1377 (1990).

UNCONFINED COMPRESSION TEST
Unconfined Compression Test (UCS) is a simple laboratory testing method to assess the mechanical properties of rocks and fine-grained soils. It provides measures of the un-drained strength and the stress-strain characteristics of the soil. The unconfined compression test is often included in the laboratory testing program of geo-technical investigations, generally when dealing with rocks.
The test was conducted according to the BS 1377 (1990).

DISSCUSSION OF RESULT

From Table 3A, it was observed that the natural moisture content of the clayey soil increased from 3% to 12%, with the addition of 2% to 10% rice husk ash and lime.

From Table 3A, it was observed that the U.C.S value of the soil at the increased from 71.66 KN/m^2 to 139.55KN/m^2 with the addition of 2% to 10% rice husk ash and lime

From Table 3A, it was observed that the soil had high CBR strength on the addition of 10% of rice husk and lime.

As shown in plotted graph in appendix A3, A3 and A4 the clay soil had better bearing values at 10% of rice husk ash and lime was added making the clay soil better at bearing load.

CONCLUSION

From the result of the test carried out on the natural state of the clayey soil, it was observed that the soil had low bearing capacity, high moisture content, high dry density and shrinkage limit of 42% liquid limit, making it unsuitable for construction purpose, most clay soil of this type needed stabilization

For the stabilized soil, properties of the clayey soil improved from poor to high bearing strength which is needed for construction purpose.

From the test carried out it, was noticed that the clay soil is an A-6 kind of soil with regards to AASHITO classification, thus for good performance of the soil it should be stabilized with 2%-10% of rice husk ash and lime in order to achieve high load bearing capacity.

RECOMMENDATION

Based on the major findings on table 3A, the following recommendations were made.

1. That 2%-10% of rice husk ash and lime should be used to stabilize A-6 clayey order to achieve better engineering properties.
2. The rice husk ash and lime stabilized soil can be used for filling on road and low cost housing.
3. That rice husk ash and lime should be used as stabilizing agent to encourage local production of these materials
4. That further research work should be carried out on clay soil with the addition of percentage of rice husk ash and lime above 10%.

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TABLE 3 A1: Summary of Laboratory Test Results

Civil & Water Engineering Laboratory services Division

S/NO.	SAMPLE Mix / description	O.M.C TEST	N.M.C TEST	CONSISTENCY LIMITS TEST				B.S. COMPACTION TEST		CBR TEST	SHARE BOX (UCS)
		O.M.C. (%)	N.M.C. (%)	LL (%)	PL (%)	PI (%)	LS (%)	M.D.D. (g/CM^3)	S.G	CBR VALUE (%)	KN/M^2-
1	Clay soil	16.0	6.0	42.0	9.8	32.2	12.0	1.67	2.9	37.83	71.66
2	2% RHA + L	18.5	8.9	21.0	13.8	7,2	13.0	1.67	2.6	47.6	102.37
3	4% RHA + L	21.5	8.0	37.0	27.4	9.6	11.4	1.53	1.8	57.0	121.13
4	6% RHA+ L	18.0	3.0	17.0	9.7	7.3	10.4	1.57	1.5	58.2	125.60
5	8% RHA +L	17.5	9.5	26.0	18.5	7.5	13.3	1.73	1.0	59.5	129.79
6	10% RHA +L	22.0	12.0	28.0	19.9	8.1	12.0	1.52	2.2	60.9	139.55

SEE THE GRAPHS BELOW IN FIG A2, A3 ,AND A4 FOR THE ABOVE

References to this paper should be made as follows: Salihu Andaa Yunusa; et al (2016), Improvement of Clay Soil Characteristic using Ricehusk Ash and Lime. *J. of Agriculture and Veterinary Sciences,* Vol. 8, No. 2, Pp. 32 – 52.