

STABILIZATION OF CLAY SOIL USING CALCIUM CARBIDE RESIDUE (CASE STUDY OF ANGWAN PAMA KADUNA SOUTH LOCAL GOVERNMENT AREA OF KADUNA STATE)

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ABSTRACT

This study covers the investigation of the engineering properties of calcium carbide residue stabilized clay soil. It was aimed to determining the suitability of using calcium carbide residue to stabilize a clay soil to ascertain whether it can be economically for use as a construction material for sub base, bases, embankment fills. Samples were collected in angwu- pama Kaduna south local government area and laboratory test were conducted to determine the physical and geological properties of the soil. The strength of the soil had increased considerable by addition of 2%, 4% and 6% of a stabilizer (calcium carbide residue). From the analysis of result obtained in this study, the natural moisture content (NMC) of the soil is very high (i.e 34.27). the consistencies limit and the sieve analysis test result for proper classification of the soil and the effect of calcium carbide residue on the consistency limit parameter, the soil in its natural state has liquid limit of 37.00 and plasticity index of 24.84 and has about 42.9% of its entire material passing through B.S Sieve No. 200s which is accordance with AASHTO soil classification system as an A -6 soil (i.e highly clay soil) which make the soil a poor material for construction. A remarkable value of 2.37 was obtained for it specific gravity value at 0% calcium

carbide residue by weight of soil. With the adding 2% - 4% calcium carbide residue, the value was decrease to 2.27 - 2.24 of soil which was the value of one of the most active soil and by adding 6% there was an increase in the value of the soil of specific gravity which was recorded to be 22.8% of clay soil and this confirm with that of lateritic soil described in BS. 1924. The compaction test show that the M.D.D and O.M.C recorded for the control sample was 1.96(g/cm³) and 22.82%. There was a decrease in value recorded with addition of the stabilizer, for consolidation test conducted, there was an increase in cv, mc, and pc value between 2%, 4% calcium carbide residue and was a drop in 6% of calcium carbide residue by rate of soil. It was found that stabilization of clay soil with 2% to 4% calcium carbide residue were the most economical and hence improves the properties of the soil.

Keywords; Soil Stabilization; Calcium Carbide; Construction Material; Soil Classification;

INTRODUCTION

Soil is the most readily available construction material at any sites, which carries the load and forms the foundation. It is likely to be the most economical material on earth as a construction material.

Soil can be considered as a layer of disintegrated rock material laying on the surface of the earth. The soil is classified into two main groups. Residual soil and transported soil. Residual soil are soil developed in place from the rock or parent material where as transported soil are residual soil that been eroded and redeposit by wind, ice or water. Witezak (1975).

Soil stabilization refers to the procedure in which a special soil, a cementing, calcium carbide, lime or other chemical material is added

to a natural soil to improve one or more of its properties. Zamr Bin Chik (2007)

Laterite soil is unique soil which occur in some tropical region normally are high in iron and aluminum. The predominant characteristic of a life rite clay is that in an engineering senses it has a very low density with a corresponding highly moisture content in its natural states.

Therefore upon removal from a cut and placement in to a fill, it often reverts to a liquid state and becomes extremely difficult to work.

In tropical areas, the heavy rainfall causes weathering of igneous or leaching of clay soil. This continuous washing may dissolve and removed some of the minerals resulting in a red colored soil of low density. This soil appeal to be firm, and steep cuts can be made on to them. However these soils contain large amount of water. When used as a construction material, these soils become soft and unstable and very unsatisfactory. Et'al Verson A. (1973)

The reason why the cost of housing even in rural area has risen substantially are included: the storage of building material to meet the demand of building industries, high cost of labour and economic situation all these factors necessitate the need to look critically at locally available raw material with a view to determine the extent to which completely raw materials in building construction

Clay soil particle are quite small and have diameters of less than 0.002mm. Clay are silicate minerals that are synthetically formed by crystallization and precipitation of products of both minerals that is weathering and dissolution and sedimentary processes clay particle are so tiny that they becomes tightly packed, such that clays have little or no pores space or void between clay particle are micros

topic, yet form tremendous surface areas that allow a large amount of water to bind to clay particles. So, clay are resistant to water flow, but, when wet, it hold and retain much water. Zamr Bin Chick (2007) and (Korn and Fang (1975).

Stabilization is one of the several technique available to the Civil Engineer in solving not all, most of the soil problems as it affects road, dam and building structures. Its selection for any of such problem should be based on comparisons with alternative methods, as it will best suite the problem at hand.

The needs for stabilization are:

1. For dust control on very dusty road project
2. For a high quality base construction
3. For boarder line base mineral with high plasticity
4. For control of moisture evaporation on a soil layer (retarding the moisture).

Stabilization techniques involve the following methods:

REMOVAL OF POOR MINERAL FROM THE BED OF THE FORMATION LEVEL

This soil could be replaced with some selected quality minerals.

BYPASSING OF BAD SOIL (CLAY/SILT) DEPOSIT

This method is applicable where the total area of deposit is so large and deep that pilling will be very expensive, therefore, the site is rerouted if cost will be lowered.

Adequate compaction of layer (sub-base/sub-grade) to a very high density. While the internal frictional force characteristics is associated to the coarse particles.

Stabilization may therefore be defined as the process of treating natural soil in a manner as to maintain after, or improve the performance of the soil and the construction material.

Soil play the most important part in civil engineering, this cannot be over emphasized since all project are sited on earth. It is very necessary for an engineer to have knowledge of soil and its properties with specific reference to tropical areas, a substantial fractia of existing soil material with unique tropical problems. The improvement of such formation consist of these soil types to bring them with acceptable limits in term of good quality for sub-base cause for pavement design and for strong foundation suitability.

Soil stabilization a general term for any physical, chemical, biological or combined method of changing a natural soil to meet an engineering purpose^s improvements include increasing the weight bearing capabilities and performance of in-situ subsoil, sand, and other waste materials in order to strengthen road surface. In certain regions of the world, typically developing countries and now more frequently in developed countries, soil stabilization is being used to construct the entire road. In the past, soil stabilization was done by utilizing the binding properties of clay soils, cement- based products such as soil cement, and /or utilizing the "rammed earth" technique (compaction) and lime. Some of the green technologies are enzymes, surfactants, biopolymers, synthetic polymers, co-polymer based products, cross linking styrene acrylic polymers, tree resins, ionic stabilizers, fiber reinforcement, calcium chloride, calcite, sodium chloride, magnesium chloride and more some of these new stabilizing techniques crate hydrophobic surfaces and mass that prevents road failure from water penetration or heavy frosts by inhibiting the ingress of water into the treated layer.

However, recent technology as increased the number of traditional additives used for soil stabilization purpose^s such nontraditional

stabilizers include polymer based styrene acrylic polymers that significantly improves the load-bearing capacity and tensile strength of treated soil. Copolymer based product, fiber reinforcement, calcium chloride, and sodium chloride.

Traditionally, widely accepted types of soil stabilization techniques uses products such as bitumen emulsion which can be used as a binding agent for producing asphalt. However, bitumen is not environmentally friendly and becomes brittle when its dries out. Portland cement was been used as an alternative to soil stabilization. However this can often be expensive and is not a very good "green" alternative cement fly ash, lime fly ash (separately, or with cement or lime), bitumen, tar, cement kiln dust (CKD), tree resin and ionic stabilizers are all commonly used stabilization against. Sibel Pamuklu (1991).

PROBLEM STATEMENT

Due to the uneven distribution of soil over the surface of the earth, coupled with the economical importance attached to the construction process, and also the continuous problem of dealing with procedures and techniques by which otherwise unsuitable soils may be improved by stabilizations. In many instance sub-grade soil that are unsatisfactory in their natural state can be altered by admixture, by the addition of calcium carbide residue, cement, lime bituminous minerals, aggregates or by proper construction and thus by made suitable for sub-grade construction. In its broadest sense, soils stabilization implies improvement of soil that it can be used for sub base, bases, dam embankment, road side or drain embankment and in some rare importance, surface courses, as in all engineering design problems the economics of the problem is light of the benefit derived from the stabilization process determine whether it is warranted.

In this study, calcium carbide residue is chosen as a stabilizer to clay soil so as to improve its physical and engineering properties.

AIMS AND OBJECTIVES OF THE STUDY

The aim of this study is to clearly observe the suitability of using calcium carbide residue to stabilize a clay soil to ascertain whether it can be economically for use as a construction material for sub base, bases, embankment fills etc) in comparison to the cost of bringing either forms of borrowed material (such as laterites)

THE OBJECTIVES OF THIS STUDY ARE:

1. To find out the extent to which the additive can be used to improve engineering properties of soil. When used to construct roads or mud house under an avoidable environmental condition e.g moisture content, that radiation etc.
2. To determine the content of used of calcium carbide residue that may be economically used to stabilize the lateritic soil.
3. To determine the suitability of using calcium carbide residue stabilized clay soil as a construction material.
4. To ensure adequate compaction of sub-grade to high density level

SIGNIFICANCE OF THE STUDY

Since the engineering professions is faced with the problem of dealing with different types of soil for construction purpose. This study will help to give insight on the rate or degree of improvement, the calcium carbide will have on specific engineering properties of clay soil samples to be used as sub-base, bases, embankment fills, and sub grade materials where selected materials no efficient quantity may not be available.

RESEARCH METHODOLOGY

In the course of compiling this project, various methods of investigation were employed and they include:

- Research from relevant textbook and engineering journals
- Consulting experts in related discipline within outside the school
- Consulting past-project on similar write-up
- Using personal home work, lecture notes and practical knowledge.
- Site visit

SCOPE/LIMITATION OF STUDY

The study is based on determining the natural moisture content of a soil sample (that is clay) obtained from water logged area during the last few days of rainy season well as some of its physical engineering properties and to also observe the degree of utterance time will have on these observed properties.

Therefore, the study is limited to the following list of tests,

1. Natural moisture content determination on soil sample
2. Atterberg (or consistency) limits test on the un-stabilized clay soil sample as well as stabilized soil sample.

Which comprises of the following:

- a. Liquid limit test
 - b. Plastic limit test
 - c. Strinkage limit test
3. Particle size distribution
 4. Moisture/density relationship determination of un-stabilized soil as well as stabilized soil sample by method of compaction
 5. Specific gravity tests
 6. Consolidation test

All this mentioned test will serve as the basic for the analysis to be carried out.

Civil Engineering is concerned with the identification and determination of the stability structure. Most of the problems of increasing the strength and stability of the natural soil in order to improve on its load bearing properties with view to determine life expectancy of project such as sub-base, base of loads, dams, rails, our filled pavement and allied construction are effaced by the design part of civil engineering.

Generally, the strength of the sub-grade determines the thickness or types of sub-grade pavement layers, which the engineer specifies to transmit traffic loading to the sub-grade.

The process entails the sampling analysis combined with a good soils classification and the term "soils stabilization" the process whereby unstable soil is term of strength are improved in order to meet the requirement of stability and the strength for the used in high way construction.

There are several methods soils stabilization in which all has in common, the fact, the materials added to the natural soil to produce design traffic loading. This research is based on specified method of stabilization of disturbed soil. It involves a series of basic standardized laboratory test to determine soil properties. The advice of stabilization method depend on the properties of soil, determined through the basic laboratory test, availability of stabilizers, traffic condition as well as the overall economic this research fetched the amount of kilograms, the stabilizing material and stabilizer, the strength would proportion of stabilizer, the strength would be improved which would increase the traffic loading of the base of the sub-base.

TECHNIQUES IN STABILIZATION

Soil stabilization is a process whereby the properties and characteristics of soil are altered to improve its engineering, performance.

It may be a temporary measure to permit the construction of a facility, or a pavement measure to improve the performance of the completed in various ways according to the nature of the process involved. The material added and the desired result on the basis of process we have mechanical, electrical, chemical and thermal stabilization. Gronko (1974).

MECHANICAL STABILIZATION

This method involve the subjection of soil mass to force, with produce a decrease on voids ratio, thereby causing an increase in permeability. There are many techniques, which can be used to increase mechanically the density of soil. For instance blasting method, the use of various types of rollers vibration action Andrew W.P (1995).

ELECTRICAL STABILIZATION (ELECTRO OSMOSIS)

The electro osmosis process is based upon the fact that when a direct electrical current is passed through a saturated soil, the contained in the soil moves towards the attitude. If water is removed at the cathode and it is not replace at the anode consolidation is include the soil decrease in volume and the strength of the soil is increased. Granko (1974)

BITUMINOUS STABILIZATION

This method involves the principle of adding bituminous material to improve the strength of the soil. Bitumen emulsion, cut back bitumen and road tar are being used effectively as soil stabilizing agent. These materials increases the strength of the soil by binding the particles together and also acts as a water and so maintaining the

strength of the stabilized soil materials. A range of 2-4 percent bitumen is sufficient to give a substantial strength of heavy cohesive soil. Andrew W.P (1995)

CHEMICAL STABILIZATION

This is another method of stabilization where by cement, calcium carbide, lime, bitumen or various chemicals are used to bind the particles of the soil, so as to provide an increase in the soil strength and improved properties (Andrew W.P (1995). It is important to note that when the soil has been treated in the manner stated above, it cases to be part of the sub grade than part of the whole of the pavement. The procedure of chemical stabilization can be accomplished in three fundamental ways called suspension, solution and emulsion (Andrew W.P (1995).

CLAY SOIL CLASSIFICATION (GENERAL DEFINITION)

A clay soil as defined by BSCS is a cohesive soil comprising 35-100% fines where they clay particles predominate to produce cohesion, plasticity and low permeability. The description of a clay soil is commonly given in the following order.

Strength/ mass structure/colour/soil name/of plastic/ with other structure Depending on the proportion of mixture of the soil particles the name could be given as follows:

Clay salt clay

Sandy clay (sand 35-65%)

Very silty clay

Very sandy clay (sandy 65%+)

A clay soil may contain some relatively appreciable amount of silt particles and is termed "salty clay". Although this may contain the same mineralogical properties as that or clay but there are certain distinction in colour, odour, degree of plasticity and either related

physical and chemical properties. In relatively all cases, a clay soil is formed silt material as formed though the physical and mechanical weathering process there by retaining most of the mineral consistent of the parent material. However, in a simple field identification test, salty clays are harder than silts when based to crushed between fingers but so far than moderate plastic clay. (Korn and Fang (1975).

Clay particles are almost always, hydrates i.e. surrounded by layer of water molecules called absorbed water this is due to the pore pressure between the soil particles, which is function of its permeability or its property of movement of water molecule through the soil mass. (Korn and Fang (1975)

GENERAL AND PHYSICAL CHARACTERISTICS OF CLAY SOIL

Generally when 50 percent of the deposit consists of particles 0.002m and smaller, the deposit is termed as "clay soil" with this relative percentage the large soil particles are suspended in a fine grained soil matrix where 80 to 90 percent of the deposit material is smaller than the No 200 sieve (0.075mm), as little as 5 to 10 percent clay good the soil a cohesive label. [Korn and Fang (1975).

Seldom does a pure clay deposit exist naturally it is nearly always contaminated with silt and /or fine sand particles as well as colloidal (<0.001) sizes. Collides, sometimes called rock flour, are the bi-product of rock abrasion and do not possess clay mineral properties even though the size range is similar (Korn and Fang (1975).

A complete description of the structure of a fine-aggregate cohesive soil required knowledge of both the inter- particles forces and the geometrical arrangement of fabric of the particles. It is nearly impossible to measure the inter particles force field surrounding clay particles directly, therefore, the fabric is the principal focus in studies of cohesive soils. (Korn and Fang 1975).

Recent studies of clay soils with scanning electronic microscope (SEM) shows the individual clay particles to be aggregated or flocculated together in submicroscopic fabric units, which are called domains by numerous researchers (Young and Sheeran 1975, Collins and MC Gown, 1975) Domains in turn group together to form submicroscopic groups clusters.

These grouping are due to the antiparticle forces acting on the small basic units. Cluster group together to form peds and group of peds of macroscopic size.

Non scientific terms for the peds includes soil "crubs" aggregates. Peds and other macro structure features such as joint and fissures constitute the macro fabric soil structure [Korn and Fang (1975)].

Microstructure is more important from a fundamental than form an engineering view point, but it is useful as aid in the general understanding of soil behavior. The microstructure of clay is the complete geological history of that deposit, including both stress changes and environmental conditions during deposition. These geological imprints lead to affect the engineering response of the clay very considerably. Recent research on the clay microstructure suggests that the greatest single factor of influencing the final structure of clay was the electrochemical environment existing at the time of deposition (Korn and Fand (1975)).

Flocculated structure, or aggregations, of varying degree of packing appears to be particularly sensitive to whether the depositions took place in a marine, brackish or fresh water environment. The ion concentration in this water would range from high in the case of marine to low in fresh water. The degree of packing also appears to be influenced to a large degree of packing also appears to be influenced to a large degree by clay mineralogy as well as by the

amount and angularity of the fine sand to silt grain present. Silt particles in a cohesive deposit have been observed to have thin skins of apparently well-oriented clay particles. Both silt and clay particles/ aggregation often contain thin films of amorphous materials (organic, silica or iron compound) on their surfaces. Leaching into or out of these fine grained deposits may change the soil characteristics considerably as the peds and cluster become coated or the amorphous materials are leached Avery (Korn and Feng (1975)).

GEOTECHNICAL PROPERTIES AND CLASSIFICATION OF CLAY SOIL

As mention in the early course of our discussion, clay particles are almost always hydrated i.e. surrounded by layers of water molecules called absorbed water, (section 2.2). This layer is often at least two molecules thick, or simply the double layer. This water is attracted and/or contains metallic ions. A diffusion of the absorbed cations form the clay minerals extend outward from the surface of the clay into the absorbed water layer. The effect of this to produce a net charge near the mineral particles and charges at a greater distance. This diffusion of cations is a phenomenon very similar to the atmosphere where the diffused material is water molecules.

The suspended soil water always produced by minerals are alkaline (PH.7) due to the negative charges on the mineral units. A few exceptions may occasionally occur when the mineral are contaminated with amorphous substances. Due to these charges the H ions in water and the Vander waals forces, and the small size of the particles, they tend to become attracted together in collision in a solution. To avoid flocculation especially in the laboratory a dispersed oil water suspension may be neutralized, addition of an alkaline material such as sodium hydroxide (NaOH) will cause very rapid freshly flocculated clay, in these circumstances, can be easily dispersed back into solution by shaking, indicating that the inter-

particles attractions are far less than the shaking forces. After a clay has been standing sometimes, however, dispersion is not easily accomplished indicating thyrrotrophic (strength gain with aging) affect.

As regard to these effects, cation exchanges (i.e calcium exchange) can be used to finish clay soil where it becomes defective by mixing the clay with calcium carbide, the process is termed "stabilization" though the shear strength of given compacted cohesive soil depends on the density and moisture content at the time of shear (DR. HANS .F. WINTR KORN AND HSAI-YANG FANG). Where the effective strength parameter C and Q of such soils may be determined in the laboratory by "slow" shear test and the small sample is permitted to drain during shear, these soils are so impermeable that under field conditions their strength for a considerable length of time after placement depends on un-drained or partially drained conditions.

The pore water pressures developed while the oil is being subjected to shear are of great importance in determining the strength of such soil. Before the theory of pore water pressure where well understood, the resistance of a compacted cohesive soil to penetration which can now be explained by pore pressure theory. An illustration given by Dr. HANS and HSAI-YANG in their book of foundation engineering handbook for the resistance shown by a compacted silly clay at different conditions of placement under proctor standard compaction effort. It was noted that the soil place at co percent moisture content (3.3 percent dry of option) at 1665.87kg/m^3 resist penetration (2900PSI), very well, i.e it has high shear strength. This is attributable to high negative pure water pressure (capillary pressure in the voids (Korn and Farg (1975).

SOIL CALCIUM CARBIDE STABILIZATION

As name implies, it is another method of improving the soil strength by used of ordinary calcium carbide. Calcium carbide is used widely

for stabilization due to its important role and advantage over the other method.

ADVANTAGES OF SOIL CALCIUM CARBIDE STABILIZATION

- i. Availability: Calcium carbide is always available in the country.
- ii. Less care and control: Less care is involved in using the calcium carbide. It also does not require much control.
- iii. Simplicity use:-This produced in mass and so the problem of searching is not much encountered.
- iv. Information: There is always availability of information on calcium carbide treated soil more than other soil stabilization.

To the machine which will be used in pursuing the soil in mixing calcium carbide. Heavy soils will also make mixing to prove difficult. However, it has been known from experienced highway engineers that a good result of stabilization could be obtained when the liquid limit is greater than 4.5% and plastic limit greater than 20%. Robert (1975).

TYPES OF ADMIXTURE

Admixtures are chemical substances or materials which alter the properties and characteristics of soil when added to improve its engineering performance. These include calcium carbide, cement, lime, Bitumen material, aggregate depressant and asphalt. When soil material are treated with any of these admixture the soil or base material strength and bearing capacity and may increase while water sensitivity and volume change during wet to dry cycles decrease.

REASON FOR USING ADMIXTURE IN STABILIZATION

- i. To reduce plasticity index of the soil
- ii. To increase the strength of the pavement structure
- iii. To control moisture
- v. To cut down required pavement thickness

- vi. Control dust
- vii. To construct of superior bases to lend stiffness to the pavement and resistance against fatigue failure.

MINERALOGICAL AND CHEMICAL COMPOSITION OF CLAY SOIL

Clay minerals are predominately silicates of aluminum and /or iron and magnesium. Some of them also contain alkaline and or alkaline earths as essential components. These minerals are predominantly crystalline in the atoms composing them are arrange in indefinite geometrical pattern. Most of the clay minerals have sheet or layered structures. Chester's are books of sheet like units or bundles of tube or fiber units soil masses generally contain a mixture o several clay minerals named for in predominating clay minerals with varying among of the non clay minerals. (Korn and Fang 1975).

Clay minerals are very small (less than 2mm) and vary electrochemically active particles, which can be seen using, and electronic microscope only with difficulty. The clay minerals exhibit characteristic of affinity for water or and resulting plasticity not exhibited by other materials even though they may be of clay size or smaller. For example, finally ground quarter does not exhibit plasticity when wetted. It should be noted that any fine-grained "clay" deposit is likely to contain both clay minerals and wide range of particle size of other materials which are essentially "filler" (Korn and Fang (1975).

The principal sources of clay minerals are the chemical weathering of rock, which contains:

- orthoclase feldspar
- Plagio clase feld spar
- mica (muscovite)

All of which may be termed complete aluminum silicates. However, according to grin (1968), clay minerals can be formed from almost any rock as long as sufficient alkaline earths present to affect the necessary chemistry (Korn and Fang (1975).

Weather action on rock produces a very large number of clay minerals with the common property of affinity, but in widely different amounts, for water some of the common clay minerals are:

- a. **KAOLINITE:** this is a modification of "Kauling" meaning high ridge of hill Jauchau fu china, where a white Kaolinete clay was obtained several countries past.

Engineers used the term to describe a clay group characterized by low activity. The Kaolinite structural units consist of alternating layers of silica tetrahedral with the tips imbedded in an allumina (gibbsite) octahedral. (i.e-a fundamental building block of clay mineral structure). The alternating layers produces what is sometimes called a 1:1 basic unit. The resulting flat sheet unit is about 7A thick and extends infinitely (relative to 7A) in the other two dimensions. The Kaolinite cluster is a slacking of 70, 60, 100 or more of these. 7A sheet as a book with hydrogen bonds and vander walls forces at these interface. The resulting formula is approximately. $(OH)_8Al_4Si_4O_{10}$ (Korn and Fang 1975).

- b. **ILLITE:** illite is generally term for a clay group discovered in illions. These clay minerals are or the general equation.
 $(OH)_4KY$ (sising ALY) ALS mag 6. Feb) 020.

Where Y is between 1 and 1.5. Illite is derived principally from muscovite (mica) and Biotites and is sometimes called mica clay. The Illite clay mineral consists of an Octaphedral layer of gibbsite sand watched between two layers of silica tetrahedral. This precedes a 1:2 mineral with the additional

difference that some of the silica positions are filled with aluminum atoms and potassium ions attached between layers to make up the charge deficiency. This bonding results in a less stable condition than for Kaolites and thus the activity of illite is greater.

Vermiculite is a clay mineral in the illite family which is similar except for a double molecular layer of water between sheets interspersed with calcium and or magnesium ions and substitution of brucite for gibbsite in the octahedral layer. Illite and fomiculite clay sand clay shale are widely used in making light weight aggregates (sometimes called expanded shale or vermiculite). The vermiculite is particular expands considerably on high heating because the water layers quickly turn to steam with resulting large expansions. Illite clays lead to be found in area of moderate rainfall, as in the central Unites States, England and Europe.

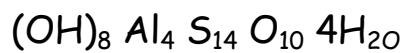
The bounding combination, of hydrogen and water waals forces results in considerable strength and stability with little tendency for the interlayer to take on water and well (activity) and result in mineral bond on the order of 500 to 1000 a thick. Kaolinite is the least active of the clay mineral as well as being directly formed as a by product or rock weathering.

Another 1:1 mineral of the Kaonite family is halloysite. i.e differs from Kaolinte by being more randomly stacked, so that a single molecule of water may enter between the 7-A single molecule of water may enter between the 7-A units, given the equation. $(OH)_8 Al_4 S_{14} O_{10} 4H_{20}$

The halloysite differs from kaolinite in that the elemental sheets are ruled into tubes, dehydration by heat on the order of 60 to 700C and even air drying. These processes with often

permanently alter halloysites either reducing approximately kaolinite. The engineering properties of halloysite are considerably different from those of kaolinite, and since even air-drying may affect the chemistry, which is indirectly measured by the Atterberg limits, great care is necessary in obtaining realistic sample for the Atterberg limits and hydrometer analysis. Kaolinite and halloysite clay are widely used for china ware due to the absence of iron and subsequent iron discoloration of farming at high temperatures. (Korn and Fang 1975).

- c. **MONTECORINITE:** This is the name of giving to a clay mineral found at Montmorillon, France with the general formula.



When H₂O is the interlayer (layers) of absorbed water the term smectite is also used for this clay mineral group.

The montmorillonite clay mineral is made sheet like units ordered also as a 1:2 unit, the inter sheet bonding is mainly due to the van der Waals forces and is, very weak relative to hydrogen or other ion bonding. Various substitutions take place, including Al for Si in the tetrahedral and Mg, Fe, Li, or Zn, for Al in the octahedral layer. These exchange result in a relatively large net unbalanced negative charge on the mineral, with resulting large cations exchange capacity and affinity for water H⁺ ions in the absence of metallic ions.

Bentonite is a montmorillonitic clay mineral which is particularly active in terms of swelling in the presence of water and has been widely used in drilling oil wells and in soil exploration as a drilling mud and as clay goat. Bentonite is somewhat variable in its properties depending on the sources and amount of weathering of the parent volcanic material.

Weathering of the parent volcanic material.

Weathering of montmorillonite clay minerals often produces kaolinite clay, and in areas where weathering has progressed both materials are usually present.

Montmorillonite is found in the more acid regions of the world as in the western United States, Australia, New Zealand and southern Africa (Korn and Fang (1975)).

WHAT IS CALCIUM CARBIDE

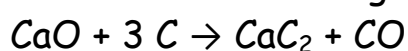
CALCIUM CARBIDE: is a chemical compound with the chemical formula of CaC_2 . Its main use industrially is in the production of acetylene and calcium cyanamide.

The pure material is colorless, however pieces of technical-grade calcium carbide are grey or brown and consist of about 80-85% of CaC_2 (the rest is CaO (calcium oxide), Ca_3P_2 (calcium phosphide), CaS (calcium sulfide), Ca_3N_2 (calcium nitride), SiC (silicon carbide), etc.). In the presence of trace moisture, technical-grade calcium carbide emits an unpleasant odor reminiscent of garlic.

Applications of calcium carbide include manufacture of acetylene gas, and for generation of acetylene in carbide lamps; manufacture of chemicals for fertilizer; and in steelmaking.

PRODUCTION OF CALCIUM CARBIDE

Calcium carbide is produced industrially in an electric arc furnace from a mixture of lime and coke at approximately 2000 °C. This method has not changed since its invention in 1892:



The high temperature required for this reaction is not practically achievable by traditional combustion, so the reaction is performed in an electric arc furnace with graphite electrodes. The carbide

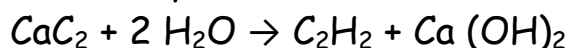
product produced generally contains around 80% calcium carbide by weight. The carbide is crushed to produce small lumps that can range from a few mm up to 50 mm. The impurities are concentrated in the finer fractions. The CaC_2 content of the product is assayed by measuring the amount of acetylene produced on hydrolysis. As an example, the British and German standards for the content of the coarser fractions are 295 L/kg and 300 L/kg respectively (at 101 kPa pressure and 20 °C temperature). Impurities present in the carbide include phosphide, which produces phosphine when hydrolysed. This reaction was an important part of the industrial revolution in chemistry, and was made possible in the USA as a result of massive amounts of inexpensive hydroelectric power produced at Niagara Falls before the turn of the 20th century. The method for the production in an electric arc furnace was discovered in 1892 by T. L. Willson and independently by H. Moissan in the same year.

CRYSTAL STRUCTURE

Pure calcium carbide is a colorless solid. The common crystalline form at room temperature is a distorted rock-salt structure with the C_2^{2-} units lying parallel.

PRODUCTION OF ACETYLENE

The reaction of calcium carbide with water, producing acetylene and calcium hydroxide, was discovered by Friedrich Wohler in 1862.



This reaction was the basis of the industrial manufacture of acetylene, and is the major industrial use of calcium carbide.

Today acetylene is mainly manufactured by the partial combustion of methane or appears as a side product in the ethylene stream from cracking of hydrocarbons. Approximately 400,000 tonnes are produced this way annually (see Acetylene Preparation).

In China, acetylene derived from calcium carbide remains a raw material for the chemical industry, in particular for the production of polyvinyl chloride. Locally produced acetylene is more economical than using imported oil.^[11] Production of calcium carbide in China has been increasing. In 2005 output was 8.94 million tons, with the capacity to produce 17 million tons.

In the USA, Europe, and Japan, consumption of calcium carbide is generally declining. Production levels in the USA in 1990s were 236,000 tons per year.

CARBIDE LAMPS

Calcium carbide is used in carbide lamps. Water dripping on carbide produces acetylene gas, which burns and produces light. While these lamps gave steadier and brighter light than candles, they were dangerous in coal mines, where flammable methane gas made them a serious hazard. The presence of flammable gases in coal mines led to miner safety lamps such as the Davy lamp, in which a wire gauze reduces the risk of methane ignition. Carbide lamps were still used extensively in slate, copper, and tin mines where methane is not a serious hazard. Most miners' lamps have now been replaced by electric lamps.

Carbide lamps are still used for mining in some less wealthy countries, for example in the silver mines near Potosí, Bolivia. Carbide lamps are also still used by some cavers exploring caves and other underground areas, although they are increasingly being replaced in this use by LED lights.

Carbide lamps were also used extensively as headlights in early automobiles, motorcycles and bicycles, but have been replaced entirely by electric lamps.

THE USE FOR CALCIUM CARBIDE

Calcium carbide is a chemical compound containing calcium & carbide, with a chemical formula of CaC_2 . Pure calcium carbide is colorless, but most of the material is produced industrially, & is impure, giving it a black or grayish-white color, depending on the quality. The main use for calcium carbide is in the production of the flammable gas acetylene.

It is necessary to produce calcium carbide industrially, because it is not naturally occurring in giant amounts. High temperatures, on the order of 3630 degrees Fahrenheit (2000 degrees C) are necessary to produce the material. It is made in a kind of furnace called an electric arc furnace, which can reach temperatures much hotter than those that are obtained through simple combustion. The basic chemical method used to make the material has not changed since it was discovered in 1888.

When any grade of calcium carbide comes in to contact with water, a chemical reaction immediately begins, which yields new compounds, of which is acetylene, a useful flammable gas. This is the principal modern use of calcium carbide. Countries such as China use giant amounts of acetylene as an industrial fuel, chiefly because it is cheaper to make & use domestically than to import petroleum for the same purpose. Oddly, acetylene may even be used to speed up the ripening of fruit; in the same way that ethylene is used.

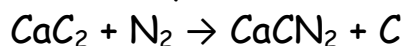
It finds most of its makes use of in manufacturing various chemical substances. Another important use of calcium carbide is in the manufacturing of steel. Calcium carbide helps in desulfurization of any kind of iron and acts as an important fuel in the process of steelmaking. This procedure can extend to any amount of scrap formulized in to liquid iron. This of work much depends on the estimated budget. Calcium carbide also acts as a powerful deoxidizer in the work of the process of ladle treatment.

Calcium carbide is used in the production of calcium cyanamid by means of reacting it with nitrogen in a high temperature. Calcium cyanamid is further used for production of high quality fertilizers. Calcium carbide is used in carbide lamps. For carbide lamps acetylene is added along with water for ignition. Carbide lamps are extensively used in copper, slate and tin mines. They are now being replaced by electric lamps but are still popular for adventures and scientific expeditions in caves. They are widely used in vintage cars for their sophisticated look.

Of the lesser known applications of acetylene gas is present in a unusual industry sector. Commercial fruit farmers usually pick their crops before they are fully ripe because green fruit is simpler to ship. Prior to sale, the green fruit is exposed to either ethylene or acetylene gas which acts as a hormone stimulator hastening the ripening process. In several Asian countries, the fruit is basically placed under bowls along with a couple of lumps of raw calcium carbide (cas NO.75-20-7) where moisture in the air causes the release of acetylene gas.

PRODUCTION OF CALCIUM CYANAMIDE

Calcium carbide reacts with nitrogen at high temperature to form calcium Cyanamide:



Calcium Cyanamide is used as fertilizer. It is Hydrolysed to Cyanamide, H_2NCN .

STEEL MAKING

Calcium carbide is used:

- In the Desulfurisation of iron (pig iron, cast iron and steel)
- As a fuel in steelmaking to extend the scrap ratio to liquid iron, depending on economics.
- As a powerful deoxidizer at ladle treatment facilities.

METHODOLOGY

SITE VISIT

To obtain the clay soil sample for this study, the site was visited in order to ascertain the following information.

- i. **THE GEOLOGY OF THE AREA:** The site is relatively flat and marshy (i.e water lodged) and contains predominantly clay soil with some noticeable organic constituents but in a relatively small quantity.
- ii. **THE ACCESSIBILITY TO THE SITE:** the site is not quite far from Ungwan Parma Kaduna south local government area of Kaduna state. Although, the part to the actual site of collection is not quite accessible to cars, but it is to foot and motor cycles.

SAMPLING COLLECTION

The clay sample was obtained at Ungwan Parma Kaduna South Local Government Area of Kaduna State during the period of the wet season.

Instruments such as diggers, polythene bags, shovels and measuring tape were taken from the school laboratory of Department of Civil Engineering to the site of collection.

A trial pit from the sample is to be collected was dug at a width of 1m x 1m and a depth of 0.5m after which the sample were collected into four separate bags and some relatively small portion of the collected sample was put in an air tight polythene bag so as to obtain its natural moisture content. The samples in the four bags were then taken to the school laboratory of department of civil engineering and spread out to dry completely before the required laboratory tests were conducted.

The calcium carbide residue used was obtained from Panteka market which serves as a stabilizing agent. After the sample has been

observed to be completely dry, different laboratory test, which shall be discussed in the later part of this chapter, were conducted on the soil sample. The test conducted on both the un-stabilized clay soil sample (i.e control sample material) as well as the stabilized sample at different percentage of the dry weight say, 2 percent, 4 percent, and 6 percent, in order to determine the relative effect of calcium carbide residue on some of engineering properties of the samples like its consistency limit (i.e, plastic limit, liquid limit, plasticity index as well as its shrinkage limit), optimum moisture content and maximum dry density.

The particle or grain size distribution of the soil sample was also determined for control sample material (i.e. un-stabilized sample) and the stabilized soil at different percentage of the dry weight as stated and consolidation of the soil sample will be determined, just like the way everything is stated in the earlier part of this section

LABORATORY TEST ON SOIL

The laboratory tests conducted on the soil sample were based on the British standard method of testing both stabilized and un-stabilized soil sample (BS 1377-1990 PART 1-9) method of test for soils Civil Engineering purposes.

PRESENTATIONS AND ANALYSIS OF RESULT

TABLE 1: MAGNESIUM TEST

No	Initial	Final	Difference	Computed Ma
1	0.0	9.8	9.8	695.8
2	9.8	20.0	10.2	725.2

TABLE 2: CHLORINE TEST

No	Initial	Final	Difference	Computed Ma
1	19.5	27.5	8.0	568.00
2	27.5	30.5	3.0	213.00

*Stabilization of Clay Soil using Calcium Carbide Residue
(Case Study of Angwan Pama Kaduna South Local Government Area of Kaduna State)*

TABLE 3: SUMMARY OF TEST RESULTS

% Calcium carbide residue	N.M.C%	Specific gravity (g/cm ³)	Atterberg limits				% Passing B.S sieves NO.7 (2.40mm)	Compaction classification		Consolidation			Soil group and classification
			L.L (%)	P.L (%)	P.I (%)	S.L (%)		O.M.C %	M.D.D g/cm ³	Cv(m ² /year	Mv m2/KN	Pc(m)	
0	34.27	2.37	37.00	24.84	12.16	3.70	42.9	22.82	1.96	2.900	0.00618	0.00036	Silty clay A-6 Clay soil A-2-4
2		2.27	31.00	29.79	1.21	5.26	32.5	14.81	1.74	3.332	0.00420	0.00027	Clay soil A-2-4
4		2.24	23.00	15.14	7.86	6.06	30.2	22.32	1.68	4.812	0.00611	0.00056	Clay soil A-2-4
6		2.28	19.00	11.32	7.68	7.60	35.0	21.01	1.55	3.005	0.00686	0.00040	Clay soil A-2-6

TABLE 4: AASHTO SOIL CLASSIFICATION SYSTEM

General classification	Granular materials 35% or less passing No 200)						Slit - clay (More than 35% passing No 200)				
	A-1		A-3	A-2			A-4	A-5	A-6	A-7	
Group classification	A-1a	A-1b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5; A-7-6
Sieve analysis Percent passing No 10 No 40 No 200	50 max 30 max 15 max	50 max 25 max	51 max 10 max	35 max	35 max	35 max	35 max	36min	36max	36max	36max
Characteristic of Fraction passing No 40 liquid limit plasticity index	6 max	N.P	41 max 10 max	40 max 10 max	40 max 11 max	41 max 11max	40 max 10 max	41 max 10 max	41 max 10max	40 max 11min	41 max 11 min
Group index	0		0		0		4 max	8 max	12 max	16 max	20 max
Usual types of significant constituent materials	Stone fragments, gravel and sand	Fine Sand	Silty or clayey gravel and sand				Silty soils			Clay soils	
General ration as sub grade	Excellent to god						Fair to poor				

DISCUSSION OF RESULTS

From the analysis of result obtained in this study, the natural moisture content (NMC) of the soil is very high (34.27%). Table 3 show the consistency limit and the sieve analysis test result for a proper classification of the soil and the effect of calcium carbide residue on the consistency limit parameter, the soil in its natural state has a liquid limit of 37.00 and plasticity index of 24.84 and has about 42.9% of its entire material passing through BS sieve No 200s in accordance with AASHTO soil classification system in Table 4 as an A-6 soil (highly clayey soil) which make the soil a poor material for construction. But as the percentage of calcium carbide residue used in the stabilization of soil increase (2% - 6%), the L.L began to decreases (31% to 23%), it P.L experienced an increase at 2% calcium carbide residue by weight of soil and a relative drop 4% calcium carbide residue by weight of soil, then another relative drop at 6% calcium carbide residue by weight of the dry soil which implied that there is constantly drop in the plastic limit values in table 3. The plasticity index (P.L) on the other hand witnessed an uneven increase at 2% calcium carbide by weight of soil then an appreciable increase at 4% - 6% calcium carbide residue by weight of soil. The shrinkage limit (S.L) values were also observed to be increasing in a relatively proportional manner, as show in the table 3.

Judging by this trend of observation, the calcium carbide residue is improving the strength of the soil with the percentage increase of calcium carbide residue by weight of soil which according to the AASHTO soil classification range from 2% - 6% A-2-4 soil which is (clayey soil) and is a good construction material.

The value of the specific gravity (GS) of the soil was obtained to be 2.37 and by adding 2%- 4% calcium carbide residue, the value was decrease to 2.27 - 2.24 by adding 6% there was an increase in the value of the soil specific gravity which was recorded as 2.28 as show in table 3.

From table 3, the result of compaction test show that the M.D.D and O.M.C recorded for the control sample 1.96 (g/cm³) and 22.82% respectively. Decrease in value was record with an addition of the stabilizer. For the 2% calcium carbide residue by weight of soil, the values of O.M.C and M.D.D was decreases to 1.74 (g/cm³) and 14.81% and there was a little increase in 4% and 6% of calcium carbide residue of O.M.C and M.D.D respectively which was shown in the table 3 this show that the incensement of the % of stabilizer improved the compaction properties of the soil. Lastly, for consolidation test conducted, there was an appreciable increase in cv, mv and pc values between 2% - 4% calcium carbide residue by weight of soil, there was rate at which the maximum CV, MV and Pc value were recorded and finally a drop was recorded at 6% calcium carbide residue by rate of soil, the result were show in table 3 and the appendices.

From the study, it was found that the engineering properties of the clay soil were best improved on the addition of 4% -6% of calcium carbide residue to the dry weight of the soil.

CONCLUSION

The choice of admixture for soil stabilization depends on the type of admixture to be used, its availability, economy involved and the type of soil one is working on. Base on the results obtained from this study, it was clear that the addition of calcium carbide residue at different rates has been observed to have improved the soil's undesirable engineering properties such as permeability, compressibility, plasticity, swelling and shrinkage.

A remarkable value of 2.24 was obtained for its specific gravity value at 4% calcium carbide residue by weight of soil, which was the value of one of the most active clay material. (i.e montmorillonite) and this confirm with that of lateritic soils described in BS.1924.

The consistency limits were obtained to be LL = 23.00% P.L = 15.14 and PI = 7.86% for the 4% of the calcium carbide residue though a decrease was observed at every increase in the quantity of calcium carbide residue added, thereby indicating an improvement in the soils engineering property as a construction material.

RECOMMENDATION

There is an appreciable increase in the strength of the soil when stabilized with calcium carbide residue. The increase in engineering properties as a construction material is proportional to the calcium carbide residue content in most cases. Based on the study that has been carried out, It is here by recommend that calcium carbide residue stabilization of the soil with 4% calcium carbide residue by weight of soil of calcium carbide residue was found to be suitable and more economical as it could be used as a replacement for laterite as a construction material.

The soil stabilization with 4% calcium carbide residue can be suitable as a fill material for an earth dam, embankment construction as it has been observed to have a continued gain in strength.

It can also be used as sub-base construction materials. Also it is recommended that similar studies should be conducted using the same soil type but by increasing the % of calcium carbide residue to be 10%, 20%, 30%, 40% and 50% using different types of samples and locally available stabilizers.

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