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# Modern Approaches to Road Construction Using Geotechnical Characterization of Soil

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***Abstract*—Geotechnical investigation is one of the effective means of detecting and solving pre and post construction problems. Design of the various pavement layers is very much dependent on the strength of the sub grade soil over which they are going to be laid. Sub-grade strength is also depending on the basic properties of the soil. Sub-grade strength is mostly expressed in terms of CBR (California Bearing Radio) weaker sub grade essentially requires thicker layers where as strong sub grade goes well with thinner pavement layers. The pavement and the sub grade mutually must sustain the traffic volume. British standard institution encodes the exact design strategies of the pavement layers based upon the sub grade strength. The sub grade is always subjected to change in its moisture content due to rainfall, capillary action, overflow or rise of water table. For an engineer, it's Important to understand the Change of sub grade strength due to variation of moisture content. This research work is an attempt to understand the basic geotechnical properties of sub grade such as grain size distribution (sieve analysis), compaction, natural moisture content, atterberg limits, specific gravity and California bearing radio test. All analyses were carried out in accordance with the British standard institution. The geotechnical properties of soils and their suitability for road construction have been evaluated for selected sites in Mairi place. The moisture content of the samples ranges from 4.5 to 8.2% with average values ranging from 4.77 to 8.0% the maximum dry density ranged from 1.77 to 2.23 g/cm$^3$ while the optimum moisture content ranged from 9.50 to 12.71% and the soil samples were classified as fine sand. This geotechnical information obtained will serve as base line information for future road foundation design and construction in the study area.***

***Keywords—Geotechnical, sub grade, Soil, Road Construction***

## I. INTRODUCTION

Soil is that thin layer of the earth made up of a mixture of mineral and organic materials, water and air formed from the underlying rocks plant and animal material by various physical, chemical and biological processes. Soil can be defined in various ways but to civil soil is any un cemented or weakly cemented accumulation of minerals particles formed by the weathering of rock (Johnny, 2010). This gives soil characters need to be measured instead of being specified; therefore, it is not surprising that soil behavior is highly non-linear and irreversible. Furthermore, it must be realized that the voids of pores between particles are filled with water and air (Lancellotta, R.2009)

## II. NATURAL MOISTURE CONTENT (NMC)

Moisture content of a soil is very important in civil engineering; one of the most important uses is in the construction of a sub grade of a road, where density of the compacted sub grade is dependent upon the moisture content of the soil (Holtz and Kovaes 1981). This help us to understand the behavior of soil in various scenarios, so as to assess the suitability of the soil for the required application, or if needs any form stabilization. So the moisture content W, of soil is defined as ratio water usually expressed as percentage of the weight of water to the weight of a dry soil. Using equation 2.0 the moisture content can be determined

[Mc =- mc/md x 100] 2.0

Where ww is weight of water, wd is weight of dry soil and mc is moisture content. (Akosim and Ayadele,2010) conducted investigation on the characteristics soil of Sambisa Game reserve, Borno state in 2010, the result of investigation shows that the textual composition was dominated by sand in all habit types which has low moisture content. The soil of the reserve varied from sandy to sandy loam which has good moisture content. Furthermore, there was no investigation on determine the natural moisture content of soil Mairi ward

## III. SOIL PARTICLE SIZE OR GRAIN SIZE DISTRIBUTION

The size distribution is often of critical importance to the way the material performs in use soil texture is one of the important properties of soil maps and is defined as relative proportion of clay, sand silt content. Soil texture has extremely significant influence on the physical and mechanical behavior of the soil (Marc and Jacques, 2011). The primary mineral components of any soil gravel, sand, silt, and clay. Organic material can also be present in soil samples. Gravel and sand are classified as coarse grained soils, while inorganic silt and clay are classified as fine grained soil, (Sidi et al, 2015). Particles size limit for defined gavel, sand, silt, and clay used in different classification scheme are given in table 2.1 and 2.3 provide the briutish standard of classification of soil. although and investigation was conducted by (Maidugu et al 2011) at the following locations bolori ward, shehuri north, limanti ward, gwange ward, gamboru ward, bulumkutu ward polo ground national stadium and teacher village in 2017. The result obtained shows that the soils at 7 locations are sand, the soil at the national stadium and teachers village have the silt and clay and the soil at Polo ground is clay. But investigation was not conducted to determine the grain size of soil at mairi ward

Classification of soil with accordance to the systems (Civil Engineering, reference)

**SYSTEM DATE GRAVEL SAND SILT CLAY**
(mm) (mm) (mm) (mm)

Bureau of
Siol 1890 1-100 0.05-1 0.005-0.05 <0.005

soils
Atterberg 1905 2-100 0.2-2 0.002-0.2 <0.002

MIT 1931 2-100 0.06-2 0.002-0.06 <0.002

USDA 1938 2-100 0.05-2 0.002-0.05 <0.002

Unified or

(USCS) 1953 4.75-75 0.075-4.75 <0.075

ASTM 1967 4.75-75 0.075-4.75 <0.075

AASHTO 1970 2-75 0.075-2 0.002-0075 0.001-0.002

BS 1990 2.60 0.06-2 0.06-0.002 <0.002

Table 1.1 British standard classification of soil according to (BS1990)

TYPES OF SOIL GROUPS SUB-CLASSES OF SOIL GROUP SIEVE SIZE
Very coarse soil Boulders >200mm
Cobbles 60-200mm
G Coarse 20-60mm
Gravel Medium 6-20mm
Coarse soil fine 2-6mm
S Coarse 0.6-2.6mm
Sand Medium 0.2-0.6mm

Fine 0.06-0.2mm
M Coarse 0.02-0.06mm
Find soil Silt Medium 0.006-0.02mm
Fine 0.002-0.006mm
C Clay <0.002MM

COMPACTION

Proper soil compaction is essential for any type of construction. It is very important because it provides the necessary flat base which provides the crucial support for the buildings, various construction foundations, roads, pavements and any other construction structures (Glanville, 1952), The process of compaction gives the soil higher resistance and greater stability Compaction is the process of densification soil by reducing air voids, The degree of compaction of a given soil is measured in terms of its dry density (Marc and Jacques, 2011). The dry density is maximum at the optimum moisture content. A curve is drawn between the moisture content and the dry density to obtain the maximum dry density and the optimum moisture content. In Table 2.5 different class of soil are provided with their relative range of maximum dry density and the optimum moisture content. Investigation was conducted in Maiduguri to determine the compaction Characteristic of soil by (Umara, 2013). Investigation was not conducted to determine the compaction Characteristic of soil at Mairi ward

Table 1.2: Coefficient of curvature Cc and coefficient uniformity Cu (civil engineering reference manual)

| Soil | Cc | Cu |
|---|---|---|
| Gravel | >4 | 41-3 |
| Fine sand | 5-10 | 1-3 |
| Coarse sand | 4-6 | - |
| Mixture of silt, sand and gravel | 15-300 | - |
| Mixture of clay, sand, silt, and gravel | 25-1000 | - |

Table 1.3 classification of differed soil with their maximum dry density and optimum moisture content civil engineering reference manual

| Class Group Symbol | Description | Range maximum dry densities | Range of optimum moisture | Recommended Percentage of proctor Maximum Class (%) |
|---|---|---|---|---|
| GW | well-graded, clean gravels, Gravel-sand mixtures | 125-135 | 11-8 | 97 94 90 |
| GP | Poorly graded clean gravel, Gravel-sand mixtures | 115-125 | 14-11 | 97 94 90 |
| GM | Salty gravels, poorly graded Gravel-sand silt | 120-135 | 12-8 | 98 94 90 |
| GC | Clayey gravels, poorly graded Gravel-sand-clay | 115-130 | 14-9 | 98 94 90 |
| SW | Well-graded clean sands Gravelly sand | 110-130 | 16-9 | 97 95 91 |
| SP | Poorly graded clean sands, sand Gravel mix | 100-120 | 21-12 | 98 95 91 |
| SM | Salty sands, poorly graded sand- Silt mix | 110-125 | 16-11 | 98 95 91 |
| SM-SC | Sand-silt-clay mix with slightly Plastic fines | 110-130 | 15-11 | 98 96 92 |
| SC | clayey sands, poorly graded Sand-clay mix | 105-125 | 19-11 | 99 96 92 |
| ML | Inorganic silts and clayey silts | 95-120 | 24-12 | 100 96 9 |
| ML-CL | Mixture of organic silt and clay | 100-120 | 22-12 | 100 96 92 |
| CL | Inorganic clays of low to medium | 95-120 | 24-12 | 100 96 92 |
| OL | Organic silts and silt-clays low Plasticity | 80-100 | 33-21 | - 96 93 |
| MH | Inorganic clayey silts, elastic silts | 70-95 | 40-24 | 97 93 |
| CH | inorganic clays of high plasticity | 75-105 | 36-19 | - - 93 |
| OH | Organic and salty clays | 65-100 | 45-21 | - 97 93 |

PROCTOR TEST

Soils are compacted to increase stability and strength, enhance resistance to erosion, decrease / permeability, and decrease compressibility. This is usually accomplished by placing the soil in layers of a few inches to a few feet thick, and then mechanically compacting the layers. Compaction equipment cans density the soil by static loading and impact. The specification given to the grading contractor sets forth the minimum acceptable density as well as a range of acceptable water content values.

The basic laboratory test used to determine the maximum dry density of compacted soils is the Proctor test. The dry density of the soil sample can be found from Eq. 2.3 as the maximum dry density, or density at 100% compaction and Eq. 2.4 is used to determine bulk density.Where DD is dry density, pb is bulk density and w moisture content.

When soil, is compacted with a given compacting effort in moulds with increasing moisture content (MC) it is observed that the dry density rises to a maximum, before it starts to decrease giving a curve when plotted against the MC V

Soils close to the optimum water content require less compactive effort to achieve the required relative compaction.

**CALIFORNIA BEARING RATIO TEST**

The CBR testing was an initiative by the California Department of Transport. The testing has use in road construction as well as in the development of airstrips and pavements. The CBR rating was developed for measuring the load-bearing capacity of soils used for building roads. The CBR can also be used for measuring the load-bearing capacity of unimproved or airstrips or for soils under paved airstrips. The harder the surface, the higher the CBR rating.

The California bearing ratio (CBR) test is used to determine the suitability of a soil for use as a base or sub-grade in pavement. The test measures the relative load required to cause a standard (19.3 $cm^2$) plunger to penetrate a water-saturated soil specimen at a specific rate to a specific depth. The resulting data will be in the form of millimeter of penetration versus load in kilo Newton. (Walkley and Black 2005). This data can be plotted. If the plot is concave upward the steepest slope is extended downward to the x-axis. This point is taken as the zero penetration point, and all penetration values are adjusted accordingly. CBR results are used to determine factors like the material thickness to be used so that when the newly constructed roads are ready for use, any load can be passed by the heavy vehicles with their cargos Table (2.6) shows a typical range of CBR Values to be obtained.

Table 1.4: typical CBR Values (Civil Engineering Reference Manual)

| SOIL GROUP SYMBOLS | RANGE OF CBR |
|---|---|
| GW | 40-80 |
| GP | 30-60 |
| GM | 20-60 |
| GC | 20-40 |
| SW | 20-40 |
| SP | 10-40 |
| SM | 10-40 |
| SM-SC | 5-30 |
| SC | 5-20 |
| ML | 15 |
| ML-CL | - |
| CL | <5 |
| OL | <10 |
| MH | <10 |
| CH | <15 |
| OH | <5 |

**ATTERBER LIMIT TESTS (ALSO CALLED CONISTENCY LIMITS)**

The Atterberg limits are a basic 'measure of the critical water contents of a fine-grained.

The knowledge of the soil consistency is important in defining or classifying a soil type or predicting soil performance when used a construction material. The soil consistency is a practical and an inexpensive way to distinguish between silts and clays (Jackson, 1990)

A soil can behave like a solid, semi-solid, plastic solid, or liquid, depending on the water content. The water contents corresponding to the transitions between these states are known as the Atterherg limits. Each, of the Atterberg limits varies with the clay content, type of clay mineral, and ions contained in the soil sample (Marc and Jacques, 2011). Tests that determine two of these Atterberg limits the plastic limit and the liquid limit are frequently used to classify soils.

The plastic limit (PL or wp) is the water content corresponding to the transition between the semi-solid and plastic state.

The liquid, limit (LL or Wl) is the water content corresponding to the transition between the plastic and liquid state. A third limit that is occasionally used in soils engineering is the Shrinkage limit (SL or ws), which the water content is corresponding to the transition between a brittle solid and a semi-solid (Brady and Well, 1999)

An investigation was conducted by (Jackson, 1999) to determine the Atterberg limit on soil sample in Biu local government area and (Medugu et al, 201 1). But investigation was not conducted to determine the Atterberg limits of soil at main ward.

**LIQUID LIMIT TEST**: - is performed with a Special apparatus. A soil sample is placed in a low container and the sample is parted in half with a grooving tool. Container is dropped a distance of 10 mm repeatedly until the sample has rejoined for a length of 13 mm. The liquid t is defined as the water content at which the soil rejoins. The test is repeated at different water contents, and the water content corresponding to the liquid limit is found by interpolation usinga flow curve

**PLASTIC LIMIT TEST**:- consists of rolling a soil sample into a 30mm thread. The sample will crumble at that diameter when it is at the plastic limit. The sample is remolded to remove moisture and rolled into a thread repeatedly until the plastic limit is reached. The water content is determined for plastic limit

**PLASTICITY INDEX (PL):-** The difference between the liquid and plastic limits is known as the plasticity index, PT. The plasticity index indicates the range in moisture content over which the soil is in a plastic condition. In this condition it can be deformed and still hold together without crumbling. A large plasticity index (i.e., greater than 20) shows that considerable water Can be added before the soil becomes liquid. The equation below is used to determine the plasticity index.

**SHRINKAGE LIMIT (SL):-** is the water content at which further drying out of the soil does hot decrease the volume of the soil. Below the shrinkage limit, air enters the voids and water content decreases are not accompanied by decreases in volume. The test consists of drying a brick of soil to remove all removable water, and then adding water until all the voids are filled.

**SHRINKAGE INDEX, SI**: The difference between the plastic and shrinkage limits is known is the shrinkage index, SI.
The shrinkage index indicates the range in moisture content over which the soil is in a semi-solid condition. The equation below is used to determine the shrinkage limit.

$$SI=PL-SL \qquad 2.6$$

**LIQUIDITY INDEX (LI):** The consistency of clay means the water content relative to the Atterlerg limits, This is represented by the liquidity index, LI. liquidity index indicates that the water content is between the plastic limit and the liquid limit, a liquidity index greater than one indicates that the water content is above the liquid limit The equation below is used to determine the liquidity index.

SHEAR STRENGTH
One of the main characteristics of soils is that the shear deformations increase progressively when the shear stresses increase, and that for saliently large shear stresses the soil may eventually fail. In nature, or in engineering practice, dams or embankments for railroads or highways may fail by part of the soil mass sliding over the soil below it. The knowledge of shear strength is very important in the design of foundations the evaluation of bearing capacity soils, for the design of embankments for dams, roads, pavements and excavations. The analysis of the stability of the slope is done using shear strength and In the design of earth retaining structures like retaining walls, sheet pile coffer dams, bulks heads, and other underground structures. Other important effect may be the load on the structure, such as the water pressure against a road, dam r the groundwater level in the dam (Grath, 1989). The two main ways of determining shear are direct shear and triaxial stress test. Table 2.7 provides standard range of values for Characteristics of soil samples. But investigation was not conducted to determine the bear strength of soil at main ward.

**DIRECT SHEAR TEST:**
The direct shear test is a relatively simple test used to determine the relationship of shear strength to consolidation stress (Adeyemi and Oyeyemi 2000). In this test, a disc of soil is inserted into the direct shear box. The box has a top half and a bottom half that can slide laterally with respect to each other A normal stress is applied vertically, and then one half of the box is moved laterally relative to the other at a constant rate. Measurements of vertical and horizontal displacement and horizontal shear load are taken (Grath, 1989). The test is usually repeated at three different vertical normal stresses.

**TRIAXIAL STRESS TEST**
The triaxial test is a more sophisticated method than the direct shear test for determining the strength of soils (Grath, 1989). Triaxial testing of soil is an important aspect of construction where the relationship between stress and strain on an undisturbed soil sample is examined by subjecting it to different drainage conditions and stress levels. In the triaxial test a cylindrical sample is stressed completely around its peripheral surface by pressurizing the sample chamber. It is advisable to use the direct shear box to determine the shear strength of soil sample classified s find sand.

Table 1.5: strength characteristics of soil specimen (civil engineering reference manual)

| Group symbol | cohesion (as compacted), (kpa) | cohesion (saturated) (kpa) | Effective stress Friction cc sat angle ϕ |
|---|---|---|---|
| GW | 0 | 0 | >438° |
| GP | 0 | 0 | >437° |
| GM | - | - | >434° |
| GC | - | - | >431° |
| SW | 0 | 0 | 38° |
| SP | 0 | 0 | 37° |
| SM | 1050 | 420 | 34° |
| SM-SC | 1050 | 300 | 33° |
| SC | 1550 | 230 | 31° |
| ML | 1400 | 190 | 32° |
| ML-CL | 1350 | 460 | 32° |
| CL | 1800 | 270 | 28° |
| OL | - | - | - |
| MH | 1500 | 420 | 25° |
| CH | 2150 | 230 | 19° |
| OH | - | - | - |

**SPECIFIC GRAVITY**
Specific gravity of a soil particle depends on the gravity of the parent rock. Specific gravity is defined as the ratio of the weight of a given volume of soil solids at a given temperature to the weight of an equal volume of distilled water at that temperature both weight being taken. This means the ratio of the unit weight of soil particles to the unit weight of water at some known temperature (usually $4^0$C), and ranges numerically from 2.60 to 2.80 (Paul and Radnor 1979).

Its significance is to determine the density, bearing capacity of the materials. The normal range is 2.65 to 2.67 for sand, 2.67 to 2.70 for salty sand, 2.70 to 2.80 for organic clay, 2.75 to 3.00 for soils with micas or iron and for organic soil it varies but it may be <2.00. With the aid of Equation 2.7 the specific gravity of the soil samples can be known.

**MATERIALS AND METHOD**
The field aspects involved collection of soil samples from main ward is shown in Figure 2.1 and 2.2) in Maiduguri, Borno State, Nigeria. The study site was chosen cause of a proposed road project that commences from Mairi along Bama road to Muna garage. The samples were tested to investigate the suitability of the soil as sub-base materials.
The laboratory aspect of the project comprises natural moisture content, sieve analysis, compaction, California Bearing Ratio (C.B.R.), Atterberg limits and specific gravity. All the aforementioned tests are therefore, presented subsequent pages.

Soil sample were collected through disturbed sample method collection and were brought in to ie laboratory and were tests were conducted to determine it shear strength, moisture content, compactive characteristics, atterberg limits and specific gravity tests were conducted. All the test were conducted according to BS 1.377 (1990) and AASHTOT193.

**MOISTURE CONTENT (NMC)**

The moisture content W, of soil is defined as the ratio of water usually expressed as percentage f the weight -of water to the weight of a dry soil grain. The aim of this test is to determine the natural moisture content present in the soil sample the. Using following equipment

- Small containers (Tins)
- Digital weighing balance
- Oven

The soil samples were brought into the laboratory in an air-tied container to conserve it natural -ire content of the soil. The weights of containers were measured using the weight balance the soil sample was placed in the container. The total weight of the sample and container measured. The measured weight of the container plus the sample was recorded. The s with the container was placed into the oven for 24 hours so as to dry the moisture out weights of the dried sample were recorded. This process was repeated at least three times for each sample to get the average moisture content in each, sample. Equation 1.0 was used to the moisture content (MC) of the soil. The results obtained in this test are presented in chapter four.

**SIEVE ANALSYSIS**

The need for sieve analysis was o determine the grain size distribution and it workability. The objective is to determine the particle or grain size ‘distribution of the soil samples. The apparatus listed below were used to conduct the sieve analysis

Set of sieves
Scoop
Pan
Weir brush
Digital weigh balance

An Air dried soil sample of 500g was weighed after all the lumps have been broken own. The soil sample was placed in to the sieve and then placed on the sieve shaker for ten (10) minutes. The weight of soil sample retained on each sieve was weighted and the percentage of particle retained on each sieve was plotted graphs presented in chapter four.

**COMPACTION TEST**

Compaction is the process of densification soil by reducing air voids. The degree of compaction a given soil is measured in terms of its dry density. The dry density is maximum at the at the optimum water content.

The test is targeting the compaction characteristics of a soil specimen. Proctor compaction test method was used in this study. The following enumerated instruments are victimized in this test.

- Compaction mould with the capacity 954 cm3
- Rammer weighs 2.6 kg
- Detachable base plate
- Collar
- Oven
- Weighing balance
- Straight edge
- Large mixing pan
- Spatula
- Graduated jar
- Mixing tools

Equipment used in conducting compaction test.

The mould was clean and dry, the rammer and the base plate was greased lightly with oil. About 3000g of air dried soil sample was weighed on weighing balance and he Weigh of the mould must be noted. The Collar was attached to the mould and the mould was placed on a solid base.

Water was measured using graduated jar, although the water added is 3% of the weight of soil sample that was weight was placed into a mixing pan and mixed it. The mixed sample place into the mould in 3 equal layers, the first layer was about one third of the sample.

The Soil sample that was weight was placed into a mixing pan and mixed it. The mixed sample were place into the mould in 3 equal layers, the first layers was about one third of the sample.

The remain sample was covered so as to prevent moisture loss, while the sample in the mould was compacted by using 25 blows of the rammer falling from the height of 310mm, the blow were ensured to be uniformly distributed over the surface of the layer, this applies to the second and third layers.

The collar was removed and the excess soil projecting above the top of the mould was trim off using a straight edge while still covering the remaining soil sample in the mixing pan. The mould with the soil sample was weigh and then the soil was removed from the mould, few sample soil was taken for determination of moisture content from the top, middle and bottom portions of the sample. The soil samples were placed in an oven for 24 hours at 105°C.

After the 24 hours the dry sample was weighted and the mass was recorded. This above process repeated several times until the soil was fully saturated. When the soil sample was fully saturated the weight of the soil sample will decree. Equation 2.0 and 2.1 was used to determine the maximum dry density (MDD) and the optimum moisture content (OMC) of the soil sample

**CALIFORNIA BEARING RATIO (CBR) TEST**

California bearing ratio (CBR) test was used to determine the suitability of a soil for use as a jib-base or sib-grad in pavement. The aim of test was to determine the California bearing ratio f the soil samples. The equipment used for this test is shown as Fig. 3.7.

(1) CBR mould, inside diameter of 150 mm, total height of 175 mm, with detachable extension collar of 50 mm hight, and detachable base plate
(2) Rammers, of 4.5 kg
(3) Slotted masses with a hole in the centre.
(4) Mixing pan
(5) Scoop
(6) CBR loading machine

The mould was clean and dry, the rammer and the base plate was greased lightly with oil. About 6000g of air drie4 soil sample was weighed on weighing balance and the weight of the mould must be noted. The Collar was attached to the mould and the mould was placed on a solid base.

Water was measured using graduated jar, although the water added is 6% of the weight of sample.

The sample mixed was place into the mould in 5 equal layers. The remaining sample was covered so that the moisture dose not reduces. The sample in the mould was compacted by g it 55 blows of the rammer weigh 4.5 kg fall from the height of 650 mm, the blow was uniformly distributed over the surface of the layer, likewise all the remaining layers. The collar removed and the top of the mould is trim off excess projecting soil above using a straight edge while still cover the remaining soil sample in the mixing pan.

The mould containing the specimen Placed with the base plate in position but the top face exposed, on the 1over plate of the loading machine. To prevent upheaval of soil into the hole of surcharge mass, a 2.5 Kg annular mass was to be placed on the soil surface prior to seating penetration plunger. The penetration plunger was sit place at the centre of the specimen to establish full contact between the plunger and the specimen. Applying the load on the plunger d keeping the rate of penetration as 1.25 mm/minute. At the end of the test the plunger was raised and the mould was removed from the loading machine as well as the sample in the mould.

This above process was also done for CBR soaked; the soil samples are soaked and kept in water for 24 hours and 48 hours. The result of this test is given.

**ATTERBERG LIMIT TESTS**

The water contents corresponding to the transitions between these states arc known as the Atterberg limits. The plastic limit (PL or wp) is the water content corresponding to the transition between the semi-solid and plastic state.

The liquid limit (LL or wi) is the water content corresponding to the transition between the plastic and liquid state. A third limit that is occasionally used in soils engineering is the shrinkage limit (SL or ws), which the water content is corresponding to the transition between a brittle solid and a semi-solid.

The liquid limit test is performed with a casagrande apparatus. The soil sample is placed in a shal1ow container and the sample was parted in half with a grooving tool. Container was dropped at a distance Of 10 mm repeatedly until the sample has rejoined. The liquid limit was defined as / the water content at which the soil rejoins at 10-20, 20-30,30-40 blows. The test was repeated at different water contents, and the water content corresponding to the liquid limit is found by interpolation using a flow curve

The plastic limit test consists of rolling a soil sample into a (30 mm) thread. The sample will at that diameter when it is at the plastic limit. The sample is remolded to remove moisture and rolled into a thread repeatedly until the plastic limit is reached. The water content is determined for three such samples, and the average value is the plastic limit.

The shrinkage limit, SL, is the water content at which further drying out of the soil does not decrease the volume of the soil. Below the shrinkage limit, air enters the voids and water content decrease is not accompanied by decrease in volume. The test consists of drying soil to remove all removable water, and then adding water until all the voids are filled. The difference between the plastic and shrinkage limits is known as the shrinkage index, SI. The shrinkage index indicates range in moisture content over which the soil is in a semi-solid condition. The soil sample e placed in the mould an4 in to oven for 24 hours at 105°C. The spec between the soil and the mould was measured.

**SPECIFIC GRAVITY**

The aim of this test was to determine the specific gravity of soil fraction by density bottle. The apparatus required to conduct the test are density bottle, weigh balance and wash bottle with distil water. Firstly, the density bottle was cleaned and dried; the weight of the empty bottle was 1dng Wi. Dry soil sample was taken about 20 g was transferred to the bottle and the weight of the bottle and soil was recorded as W2. The weight of bottle, soil samples, water recorded as W3 the weight of bottle, water was recorded as W4. Equation 3.0 was employed to determine I specific gravity soil samples. The result of this test is present.

CONCLUSION

Investigation was carried out in determining the geotechnical characterization of soil for road construction. Based on the investigation, the following conclusions were drawn.

All the desirable properties mentioned above have been confirmed by the tests. The natural moisture content and compaction tests results of soil sample are within the requirement, which assures the soil samples are good for the sub-grade material. This is also backed by the sieves analysis, California bearing ratio (CBR), and specific gravity tests.

RECOMMENDATIONS

Based on the investigations of the study, the following recommendations are proffered.

it is recommended that laboratory tests be carried out on borrow pit materials to be used for construction of roads so as to know their suitability for the intending purposes which would or could reduce cost of maintaining such roads in the long run if proper materials are selected or used that could make roads stand the test of time.

Resident engineers and contractors should always work in strict adherence to codes of ethics of engineering profession so as to achieve or maintain best practices.

REFERENCES

AASHTO Standard specifications for transportation materials and methods of sampling and testing, 15th Edition, 1990 B.S 1924(1990).Methods of tests for stabilized soils, British standard institute, London

Adeyemi,G.O and Oyeyemi, F.(2000).Geotechnical properties of Ibadan Expressway, South western Nigeria, Bullentin of Engineering Geology and environment(2000),59:39-45.Available on http://link.spriner.com/article_/10.1007/sl100649900016page-1

Akosim,B and Ayodele ,I.(2010) Research on expansive black tropical clay areas of Maiduguri Gamboru wulgo Road in Borno state of Nigeria. Technical report on Road Design and constructions 317 unpublished 1979

Glanville W .H(1952) Soil mechanics for Roads Engineers Department of scientific and industrial research,Road research laboratory London

Holtz R D and kovaes W D (1981) ''An introduction to geotechnical engineering ''Prentice Hall (chapter 3) internet.