ASSESMENTS OF SOILS INDEX PROPERTIES OF EKITI-STATE DISTRICTS SOILS, SOUTH WESTERN NIGERIA FOR ROAD WORKS

Akinwamide Joshua Tunbosun[1], Jacob Odeh Ehiorobo[2], Osuji Sylvester. Obinna[3] Akinwamide Oluwayinka Glory[4]

[1,4]Department of Civil Engineering, Faculty of Engineering, The Federal Polytechnic, Ado Ekiti, Ekiti State, Nigeria

[2,3] Department of Civil Engineering, Faculty of Engineering, University of Benin, Benin City, Edo State, Nigeria.

*Corresponding author: akinwamidejoshua2@gmail.com

ABSTRACT

The index properties of soil of Ekiti State were evaluated in this study. The study area was divided into three Senatorial Districts. A total of 160 samples were obtained per district. Laboratory tests such as: Natural Moisture Content (NMC), Specific gravity, Grain size analysis, Consistency tests were carried out, the results obtained classified the soils of Ekiti State Central Districts into four classes as A-2-4, A-2-6, A-2-7 and A-7-5. and Southern Districts into Eight as A-2-4, A-2-5, A-2-6, A-2-7, A-4, A-5, A-6 and A-7-5 while Ekiti Northern Senatorial Districts were classified into Six classes thus A-2-4, A-2-5, A-2-6, A-2-7, A-6 and A-7-6. The geotechnical implication of these results is that Ekiti Central Districts soils have more geomaterials for construction of base course and sub- base courses materials compared to other districts soils, which are more of sub -base and sub-grade materials which may require stabilization to improve their engineering properties. From the foregoing its established t the soils found in the study area are adequate for Civil engineering works particularly samples from Ekiti Central Districts soils while other districts will also be adequate if treated with additives to improve their geotechnical properties.'

Key words: *Ekiti Senatorial Districts, Classification of soils, Index properties.*

1. INTRODUCTION

Soil index properties are the properties of soil that help in identification and classification of soil. These are properties of soil that indicate the type and condition of the soil and provide a relationship to structural properties. Soil index properties are used extensively by engineers to differentiate between the various kinds of soil within a broad category (ELE, 2013). A good knowledge about a site including its subsurface conditions is very important in its safe and economic development. It is therefore an essential preliminary to the construction of any civil engineering work such as roads, buildings, dams, bridges, foundation, etc., (Adeyeri, 2015). It is unfortunate to note that in developing countries likes Nigeria only few investors in the construction industry take time to execute subsoil investigation prior to commencement of construction activities on their projects. The result is the calamitous consequences such as failure or collapse of buildings and other massive engineering structures which often cause untold hardship and sometimes even loss of lives and properties. Many attempts have been made of recent to study the geotechnical properties of soils around Ekiti State in southwestern Nigeria particularly in the Northern and Central area of Ekiti State where strength properties were evaluated (Bayowa et al., 2014, Okunade 2007; Oladapo and Ayeni, 2013; Owolabi and Aderinola, 2014; Talabi et al, 2013; Adeyeri et al,2017; Osuji and Akinwamide 2018. They all opined that The lateritic soils are suitable for dam, earth fill, subgrade, sub base and base course materials in civil engineering construction project However, few attempt has been made to evaluate the index properties of lateritic soil found within the three districts of Ekiti state, Nigeria. This research will consequently consolidate the data requirement for a website based geotechnical database management system for Nigerian soils as proposed by Okunade (2010).

2. METHODOLOGY

Ekiti State is a southwestern state in Nigeria, situated within the tropics. It is located between longitudes 40°51' and 50°45' east of the Greenwich meridian and latitudes 70°151' and 80°51' north of the Equator, it has a total land Area of 6, 353Sq km. By 2006 Census, the population of Ekiti State was 2,210 957 with its state capital located in Ado-Ekiti. It ranks 31st in term of area in the country. It lies South of Kwara and Kogi State, East of Osun State and bounded by Ondo State in the East and in the south with 16 Local Government Councils. Ekiti State belong to the Precambrian Basement Complex of Southwestern Nigeria. It is drained by many rivers/streams flowing dendritically towards the major rivers, among them are river Elemi, Ose and Ogbese respectively. These zones are known for a high humidity [60 – 80%] and average annual rainfall (1500mm). The materials used in this study include the geological maps of the areas, global positioning system device (GPS), other materials include, field notebook and data sheets, sample bags, sample labels, trowel, spade and scoop. During these fieldworks four hundred and eighty (480) disturbed soil samples were collected from borrowed pits found within the three Senatorial Districts of Ekiti State at the average depth of 2 m from the ground surface and analyzed for various index, geochemical Index properties and soil strength tests were analyzed in The Federal Polytechnic Ado-Ekiti (FPA) geotechnical laboratory according to procedures and methods proposed by British Standard BS1377 (1990), The tests provide data from which soils were classified.

3.0 RESULTS AND DISCUSSION

3.1 Natural Moisture Content Test Results.

The engineering properties of fine-grained soils are strongly dependent on water content (*Sridharan, 2012*). The results of the NMC % evaluated for this research are shown in table 3.1 - 3.3 from each of the senatorial districts respectively. The results for NMC varied between 1.4 to 29.47 %, 1.9 to 34 % and 1.1 to 33 % for Southern, Northern and Central senatorial districts respectively. From the foregoing the values are fairly high considering the period when the test was conducted, indicating the soil potential for water retention, a property of fine grain soils. The engineering implication of the above results reveal that the Central senatorial districts materials show preferred suitability for engineering construction works than southern and Northern senatorial soils. Underwood (1967) proposed that soils with Natural Moisture Content (NMC) of 5%-15% are suitable/favorable engineering materials, NMC of 16%-19% are marginal favorable engineering materials and soils with NMC values ranging from 20%-35% are unfavorable engineering materials.

INDEXPROPERTIES	DIVISION OF THE DISTRICTS AND RANGE S OF VALUES		
	SOUTHERN	NORTHERN	CENTRAL
NMC (%)	1.4 to 29.47 %	1.9 to 34 %	1.1 to 33 %
GS	1.87 to 2.60,	1.9 to 2.58	2.17 to 2.90
LL(%)	32.5 -63	35 – 68	21- 55
PI	8.5 -25	11 -28	7.5 -22
%Pass Sieve 200	15 to 55 %,	2.9 to 45 %	2.00 to 37 %.

3.2 Specific Gravity (Gs) Test Results.

This test was carried out in accordance with BS 1377 (1990) the results of the specific gravity (Gs) test varied between 1.87 to 2.60, 1.9 to 2.58 and 2.17 to 2.90 as showed in the table 3.1 for Southern, Northern and Central senatorial districts respectively. The results showed a slight variation in the values of the Gs of soils obtained within the three senatorial districts of Ekiti State. Its noteworthy that sample from Ekiti central showed a higher value compare to other location, which indicate a better degree of laterization which make the soils of this region more suitable for construction purpose according to (Que et al, 2008) that specific gravity is closely linked with the mineralogy and/or the chemical composition of the soil. (De Graff-Johnson, 1972), recorded that the higher the specific gravity, the higher the degree of laterisation. Furthermore, the larger the clay fraction and the alumina concentration, the lower is the specific gravity. Thus, Ekiti central senatorial districts appear to be the most evolved samples in term of laterization (ferruginization) process. Specific gravity test is an important index property of soils that is closely linked with mineralogy or chemical composition [Oyediran and Durojaiye, 2011] and also reflects the history of weathering (Tuncer and Lohnes, 1977). It is relatively important as far as the qualitative behavior of the soil is concerned [Raj, 2012] and useful in soil mineral classification, for example iron minerals have a larger value of specific gravity than silicas [Bowles, 2012]. Based on the study, (Roy and Dass, 2014) found that increase in specific gravity can increase the shear strength parameters (cohesion and angle of shearing resistance). Roy (2016) observed that increase in specific gravity also increases the California Bearing Ratio strength of the subgrade materials used in road pavement design.

3.3 Grain Size Analysis Tests Results

The results of the grain size fraction distribution curves of the studied soils samples were presented in tables 3.1 and figure 3.1 to figure 3.3 for Southern, Central and Northern senatorial districts respectively. Many of the zones had a very high percentage finer than 0.075 fractions that is > 35% which classifies the soils in the study area as clay of high compressibility (CH) and silty gravelly soils for Southern, Northern and Central senatorial districts respectively. the percentage of fines (% passing sieve 200) has significant effect on the performance of the base / sub-base materials excess fines will result in the reduction in maximum dry density and increases the susceptibility to weakening from water infiltration or ingress (Garg 2009). The results showed that the number of fines found in the soil samples are quite similar (greater than 70 %) The "well graded" curve represents a non-uniform soil with a wide range of particle sizes that are evenly distributed. The Fine Content varies between 15 to 99 %, 2.9 to 65 % and 2.00 to 67 %. The wide variation observed in these results might be due to the reason opined by various previous researchers that grain size distribution data are extremely varied and erratic (Moh, and Mazhar., 1969; Winterkorn, and Chandrashekharan, 1951; Vallerga and Rananandana. 1969; Lohnes et al, 1971). The reason for this is enumerated in details by different researchers (Terzaghi, 1958, Gidigasu, 1971). When soils are manipulated, their engineering properties vary a lot. Pre -testing drying causes variations in some parameters of soils and this behavior is always attached to the dehydration of the colloidal hydrated oxides occurring in these soils. Densification of a well-graded soil causes the smaller particles to move into the voids between the larger particles (Naresh and Nowatzki 2006). As the voids in the soil are reduced in the soil samples, the density and strength of the soil may increase. In contrast, poorly graded or uniform soils are composed of a narrow range of particle sizes. (Akinola and Obasi, 2004) reported that the type of clay that formed is not only a function of the nature of parent rock but also the intensity of weathering and the length of time during which it occurred. The fine-grained fractions dominate the composition of the studied soils, in comparison with coarse content fractions particularly for samples from southern and northern districts. Based on the Unified Soil Classification System (ASTM, 2000) soils with percentage of fines that range between 15 -35% are said to be very clayey. In the present study, the fines fall above the specified range which is well pronounced in the southern and northern districts of the studied area.

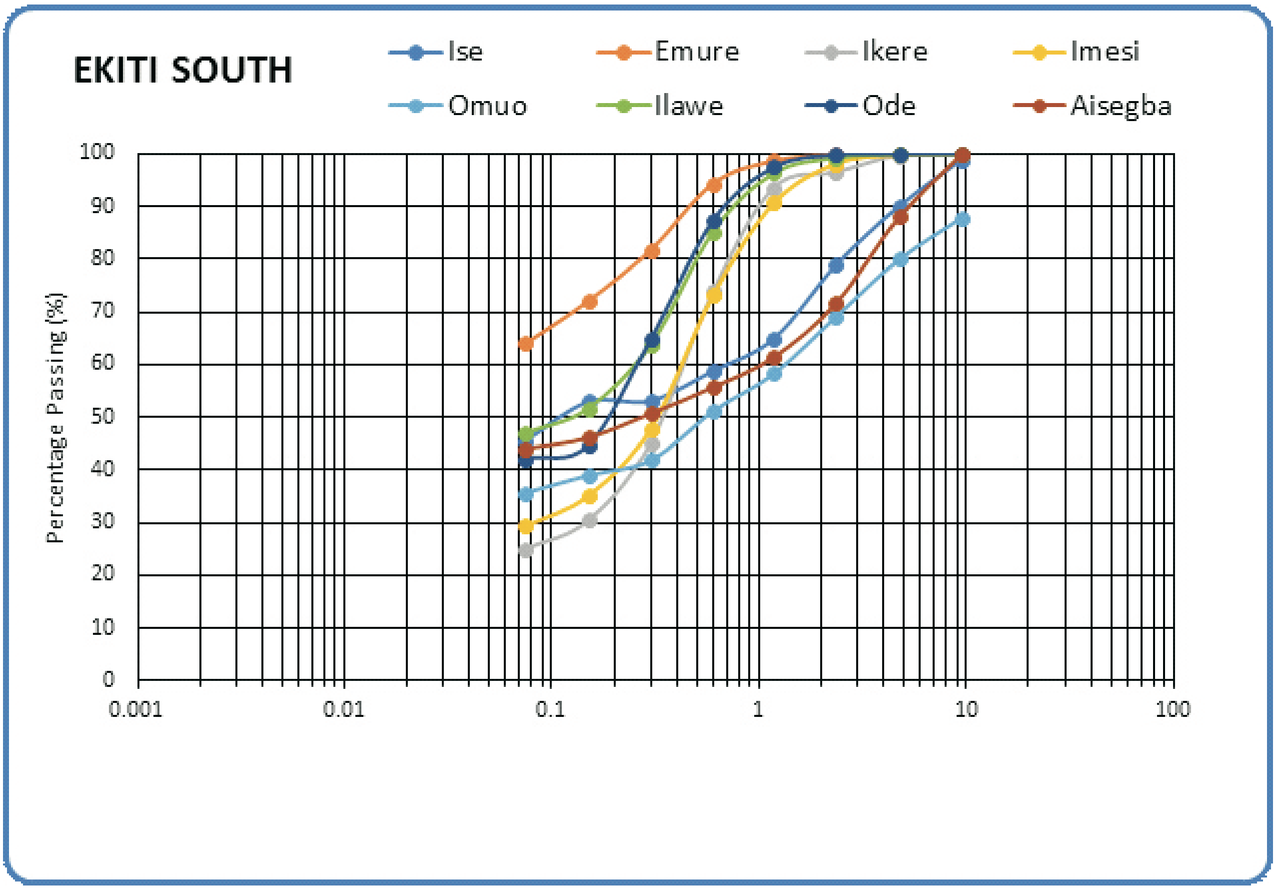

Figure 3.1: Some Graph of Ekiti Southern Senatorial Districts (ESSD) Sieve Analysis

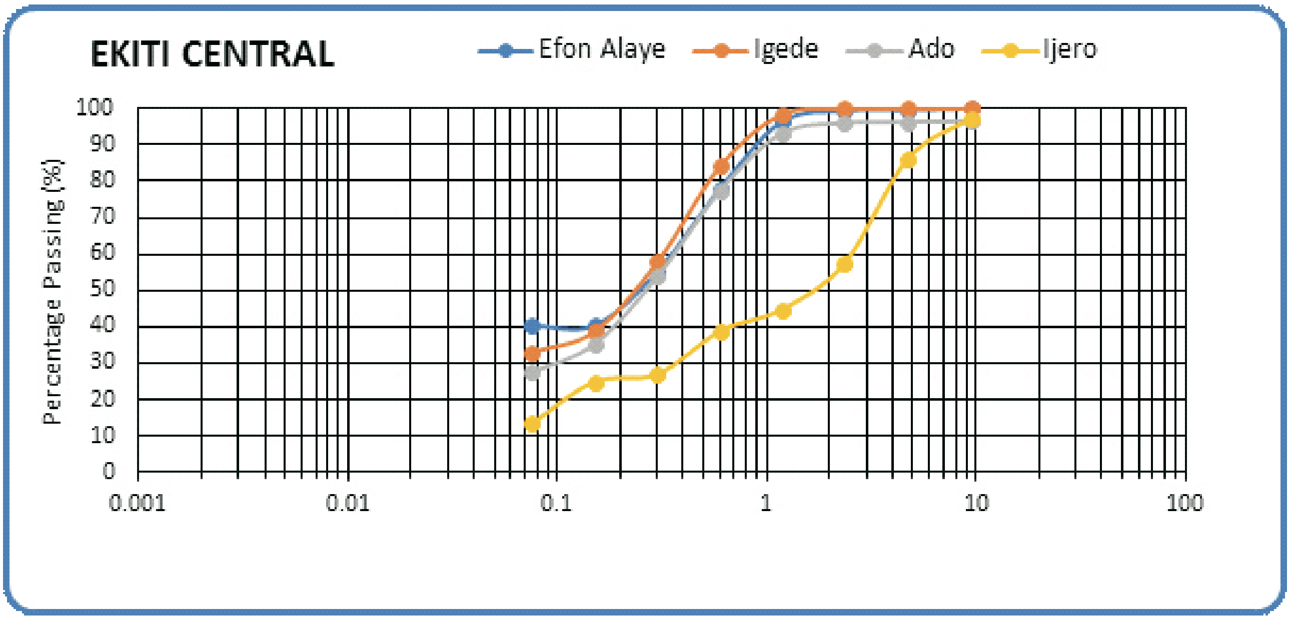

Figure 3.2: Some Graph of Ekiti Central Senatorial Districts (ECSD) Sieve analysis.

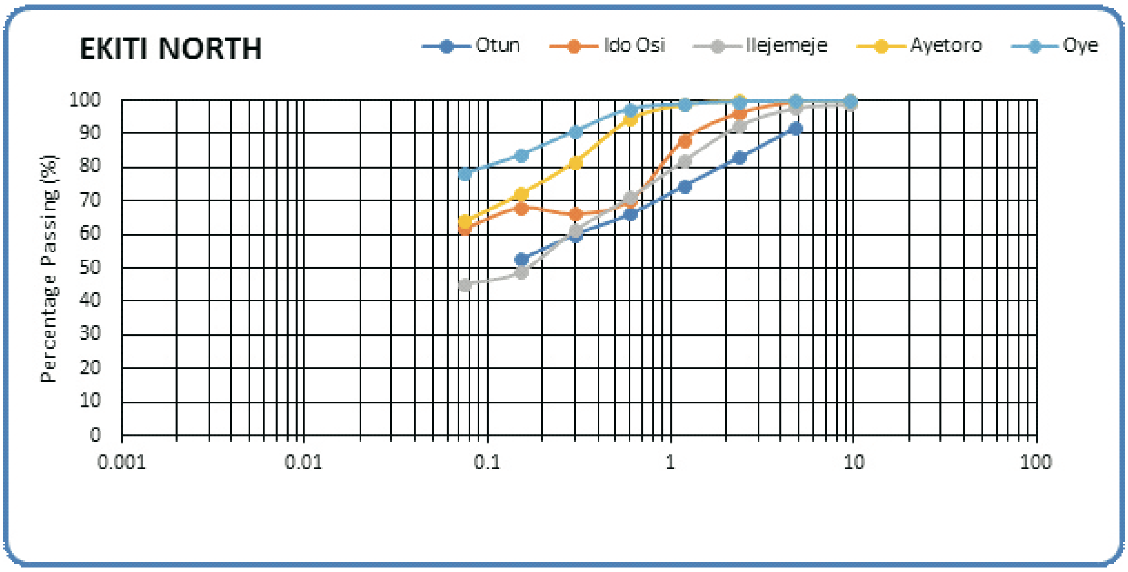

Figure 3.3 : Some Graph of Ekiti Northern Senatorial Districts (ESND) Sieve Analysis

3.4. Consistency Tests Results

The results of liquid limit (LL %) and Plasticity index (PI %) evaluated on all the trial pits within the three senatorial districts varied between 16.7 – 71 % and 2.4 – 59 % respectively are shown in Table 3.1 and figure 3.4 to figure 3.6 for southern, northern and central districts respectively. The results showed that Soils from South has their liquid limit (LL%) and Plasticity Index (PI %) ranging between 16.7 – 53.5 % and 3.62 – 34 % respectively while Northern districts values varied between 21-66 % and 5.08 – 59 % (FMW, 1997) recommend liquid limits not greater than 80% for sub- grade and not greater than 35 for sub base and base course materials. Also, plasticity index not greater than 55% for sub-grade and not greater than 12% for both sub-base and base course. According to (Ola ,2013) asserted that the larger the PI % value the greater the engineering problems associated with using the soil as an engineering material such as foundation support for residential building, roads, subgrades etc. (Ola ,1983) used the classification of plasticity index values to relate the swelling potentials stating that clay soils with less than 25 % of plasticity index tend to possess low to medium swelling potential. From the analysis carried out it can be concluded that the plasticity index (PI %) values obtained revealed that Northern, Southern and some part of Central districts will pose serious settlement challenges in engineering construction works within the study area.

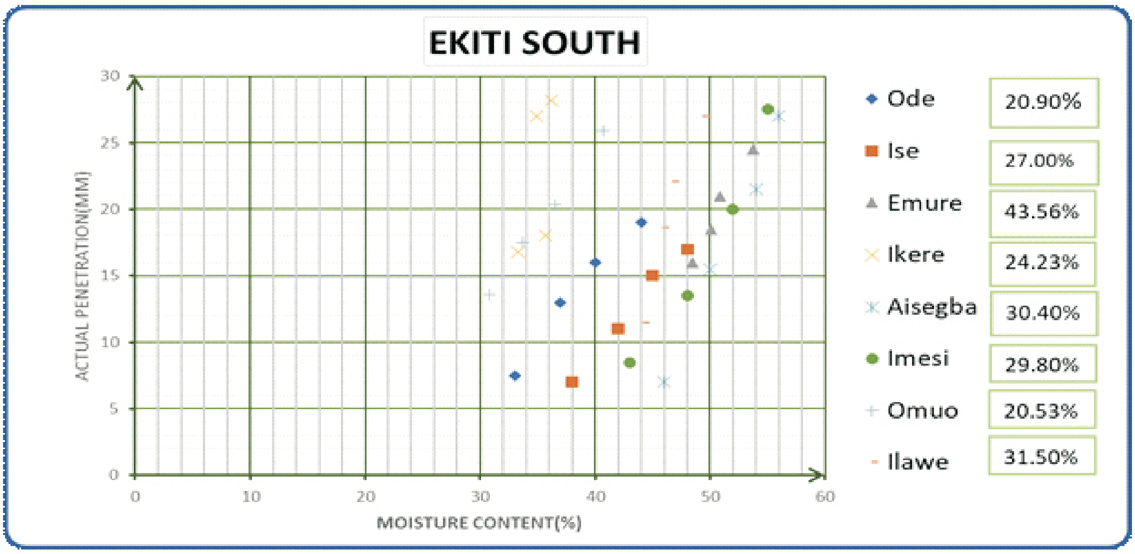

Figure 3.5: Some Graph of Ekiti Southern Senatorial Districts (ESSD) Liuid Limit graph

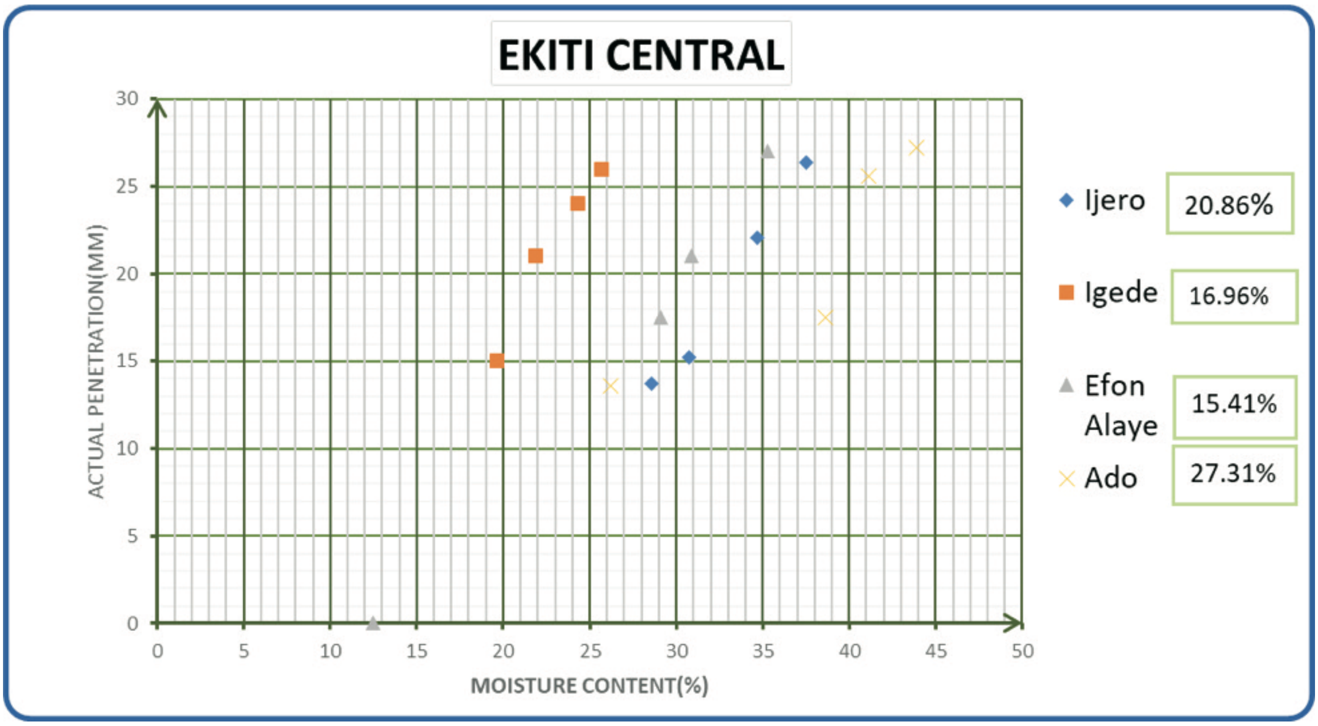

Figure 3.6 : Some Graph of Ekiti Central Senatorial Districts (ECSD) Limit graph

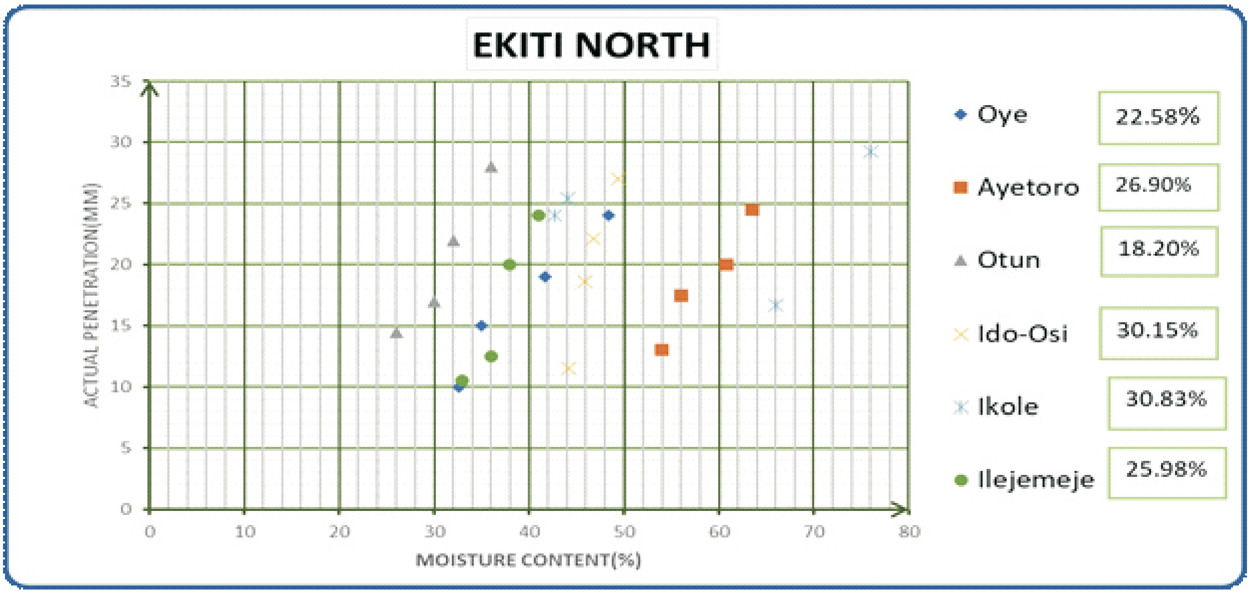

Figure 3.6 : Some Graph of Ekiti Northern Senatorial Districts (ENSD) Liqquid Limits

3.5 Classification of Soils within the Senatorial Districts

Soil Classification is the grouping or classing of soils with a similar range of parameters (chemical, physical and biological) into units that can be geo-referenced and mapped (Das, 1995). The performance of soil under external loads is dependent mainly on its grain size and arrangement of particles. It is therefore very necessary to study the size, shape and gradation of) soil particles. Soil is grouped based on the size of their particles. The purpose of soil classification is to arrange various types of soils into classes according to their geotechnical parameters. The present research works was classified based on AASHTO and USCS classification system. The results of Central Senatorial Districts classified the soils into four classes as clay of low compressibility (CL) clay of high compressibility (CH) f according to

(USCS,1986) and A-2-4, A-2-6, A-2-7 and A-7-6 for AASHTO classification system. From the foregoing, the soils classified some as low plasticity, Sandy gravelly clay, clayey soils and others as medium compressibility soils which agree with (Osuji and Akinwamide, 2018) findings. and Southern Senatorial Districts samples were classified into Eight as A-2-4, A-2-5, A-2-6, A-2-7, A-4, A-5, A-6 and A-7-5 which describe soils in the study area as Clay gravelly sand silty clay materials according to USCS while Ekiti State Northern Senatorial Districts were classified into Six classes thus A-2-4, A-2-5, A-2-6,A-2-7, A-6 and A-7-6 respectively. The classification tests perform on the soils sample from the three districts showed that Ekiti Central Districts soils has more geomaterials for construction of base course and sub- base course materials compared to other districts soils which are more of sub -base and sub-grade materials which may require stabilization to improve their engineering properties.

4.0 CONCLUSIONS

The assessment of index properties of Ekiti State soils was evaluated, the results of the tests reveal the following:

i. The results of the NMC reveal that the Central Senatorial Districts materials show preferred suitability for engineering construction works than southern and Northern senatorial soils which showed a high NMC value.

ii. Its noteworthy that sample from Ekiti central showed a higher value of Gs compare to other location, which indicate a better degree of laterization which make the soils of this region more suitable for construction purpose.

iii. The results of grain size analysis showed that the number of fines found in the soil samples are quite similar (greater than 70 %).

iv. The plasticity index (PI %) values obtained revealed that Northern, Southern and some part of Central districts will pose serious settlement challenges in engineering construction works within the study area.

v. The classification analysis according to AASHTO and USCS classified the soils of Central Senatorial Districts into four classes as clay of low compressibility (CL) clay of high compressibility (CH) and A-2-4, A-2-6, A-2-7 and A-7-5. and Southern Senatorial Districts into Eight as A-2-4, A-2-5, A-2-6, A-2-7, A-4, A-5, A-6 and A-7-5 while Ekiti Northern Senatorial Districts were classified into Six classes thus A-2-4, A-2-5, A-2-6,A-2-7, A-6 and A-7-6.

5.0 RECOMMENDATION

It's recommended that good drainage facilities should be provided for soils within the Northern and some part of Southern district if they are to be used for any construction purpose that will mitigate loss of strength due to high sensitivity of the soils in these area to moisture changes. This research work will provide information for Engineers and Contractor to properly apply these materials for construction work and will prevent possible delay and additional expenses during construction of earth works particularly at the preliminary stage of the project.

REFERENCES

Adeyeri, J.B. (2015) *Technology and Practice in Geotechnical Engineering*: IGI Global Publishers: Advances in Civil and Industrial Engineering (ACIE) Book Series; Pennsylvania, USA

Akinola, O. O., Obasi, R. A. (2014). Compositional Characteristics and Industrial Potential of The Lateritic Clay Deposit in Ara-IjeroEkiti Areas, Southwestern Nigeria. International Journal of Scientific & Technology Research, Volume 3, 8:305 -31

ASTM D 2488-00,' Standard Practice for Description and Identification of soils (Visual -Manual Procedure),' American Society for Testing and Materials, 2000

Bayowa, O.G. Olorunfemi, O.M. Akinluyi, O.F. & Ademilua, O.L. (2014). A Preliminary Approach to Groundwater Potential Appraisal of Ekiti State, Southwestern Nigeria. Int. J. of Sci.and Tech. Vol. 4, No. 3, pp. 48-58.

Bowles J.E, Engineering Properties of Soils and their Measurements, 4 th edition, McGraw Hill Education (India) Private Limited, New Delhi, 2012.

De Graff Johnson (1972). Lateritic gravel evaluation of road construction. *J soil Mech Div Amst Soc Civil Eng, 98*, 1245–1265.

Dias, R. D., (1995). Proposta de Metodologia de Definição de Carta Geotécnica Básica em Regiões Tropicais e Subtropi-cais, Rev. IG, São Paulo, volume especial, 51-55.

ELE International, Chartmoor Road, Chartwell Business Park, Leighton Buzzard, Bedfordshire, LU7 4WG

Federal Ministry of Works and Housing (1997). *Nigerian General Specification for Roads and Bridges (Revised Editio*n) **2** 137-275

Garg, S. K. (2009). *Soil Mechanics and Foundation. Engineering* (7th ed., pp. 673–683). New Delhi:

Gidigasu, M. D. (1971). The importance of soil genesis in the engineering classification of Ghana soils. Eng. Geol. 5:117-161

Gidigasu, M. D. (1983). Development of acceptance specifications for tropical gravel paving materials. *Eng Geo, 19*, 213–240.

Lohnes, R. A., R. 0. Fish and T. Demirel. (1971). Geotechnical properties of selected Puerto Rican soils in relation to climate and parent rock. Geol. Soc, Am, 82:2617-2624

Moh, Z. C. and F. M. Mazhar. (1969). Effects of method of preparation on index properties of lateritic soils. Proc. of Specialty Session on Engineering Properties of Lateritic Soils, 7th Int. Conf. Soil Mech. Found. Eng., Mexico City 1:23-25.

Okunade, E.A. (2007). Eng. Properties of Lateritic Adobe Bricks for Local Bldg. Construction and Recommendations for Practice. J. of Eng. and Applied Sci. Vol. 2 No 9. 1455-145

Okunade, E.A. (2010). Design and Implementation of a Web-Based Geotech. Database Mgmt. System for Nigerian Soils. Modern Applied Sci. Vol. 4. No. 11. pp. 36-42. British Standards 1377. (1990). Methods of tests for soils for civil engineering purposes, London

Ola S.A (2013) Essentials of Geotechnical Engineering, first edition . University Press PLC, Ibadan, Nigeria, Pp 68-69

Ola, S.A. (1983): Geotechnical Properties and Behavior of Some Nigerian Lateritic Soils In S.A Ola Ed. Tropical Soils of Nigeria In Engineering Practice. A.A. Balkama Netherlands, pp.61-84

Oladapo, M. I. and Ayeni, O.G. (2013). Hydro geophysical Investigation in Selected Parts of **Irepodun** LG. Area of Ekiti State, SW Nigeria. J. Of Geol. and Ming Research. Vol. 5, No 7, pp. 200- 207

Osuji O.S and Akinwamide J.T. (2018). Physico-Chemical Properties of Lateritic Soils in Ado-Ekiti, South Western Nigeria. Universal Journal of Environmental Research and Technology, Volume 7, Issue 1: 10-18.

Owolabi, T .A. and Aderinola, O .S. (2014). Geotech. Evaluation of Some Lateritic Soils in Akure South, Southwestern Nigeria. Electronics J.of Geotech.*Eng.* Vol. 19, pp. 6675-6687

Oyediran, A. and Durojaiye, H.F., 2011, Variability in the geotechnical properties of some residual clay soils from south western Nigeria., IJSER., 2 (9), 1-6.

Que, J., Wang, Q., hen, J., Shi, B., & Meng, Q. (2008). Geotechnical properties of the soft soil in Guangzhou College City. *Bull Eng Geol Environ, 67*, 479–483

Raj P.P, Soil Mechanics and Foundation Engineering, Dorling Kindersley (India) Pvt. Ltd., New Delhi, 2012

Roy, S. and Dass, G., 2014, Statistical models for the prediction of shear strength parameters at Sirsa, India., I. Journal of Civil and Structural Engineering., 4(4), 483-498.

Roy, S., 2016, Assessment of soaked California Bearing Ratio value using geotechnical properties of soils., Resourcesand Environment., 6(4), 80-87

Sridharan, 2012 *Engineering Behaviour of Fine-Grained Soils a Fundamental Approach** Thirteenth IGS Annual Lecture delivered on the occasion of its 32nd Annual General Session held at Bombay. Pg. 447 – 464

Talabi, A. O., Ademilua, O. L., Ajayi, O. Z. And Oguniyi, S. O. (2013). Preliminary Geophysical Evaluation of Orin Bauxite Deposit, SW Nigeria. J. of Emerging Trends in Eng. and Applied Sci. Vol. 4, No 3, pp. 432437

Terzaghi, K. (1958). Design and performance of Sasumua Dam. Inst. Civil Engineers Proc. 9:369-395.67. Topping, J. 1957. Errors of observation and their treatment.

Tuncer, E.R. and Lohnes, R.A., 1977, An engineering classification for basalt-derived lateritic soils., Eng. Geol., 4, 319– 339.

Underwood, L.B. (1967): Classification and identification of shales. J. soil Mech. Found. Div. ASCE, 93 (11), pp.97-116.

Vallerga, B. A. and N. Rananandana. (1969). Characteristics of lateritic soils used in Thailand road construction. Highway Research Record 284:86-103.

Winterkorn, H. F. and E. C. Chandrashekharan. (1951). i.aterite soils and their stabilization. Highway Research Board Bull. 44:10-29