

# Evaluation of Index Properties of Lateritic Soils in Ado Ekiti Metropolis South Western, Nigeria

**Emmanuel. O. Eze<sup>1</sup>, O. S .Osuji<sup>2</sup>, Joshua .T. Akinwamide<sup>3</sup>**

<sup>1</sup>(Department of Civil Engineering, University of Benin, Edo State, Benin City Nigeria). [Emmanueldotezeatunibendotedu](mailto:Emmanueldotezeatunibendotedu) +2348035715904

<sup>2</sup>(Department of Civil Engineering, University of Benin, Edo State, Benin City Nigeria. +2348030726214).

<sup>3</sup>(Department of Civil Engineering, The Federal Polytechnic, Ado Ekiti, Ekiti State, Nigeria).

akinwande\_ [joshua@yahoo.com](mailto:joshua@yahoo.com).

## ABSTRACT

The aim of this research is to evaluate the index properties of lateritic soils in Ado Ekiti Area of Ekiti State, Nigeria. The areas will be divided into Five Zone viz:: Ado-poly, Ado-Ikere, Ado-Housing, Ado-Ilawe and Ado-Adebayo respectively for the sampling process. Eighteen soils samples were collected to cover Ado-Ekiti and environs in Ado Ekiti suburbs. The research comprise field data collections. ArcGIS 10.1 will be used for quantitative analysis of the field data. Measurement of depth at sample collection points will be taken using GIS, the geographic coordinate and other details using Global Positioning System (GPS) handheld instrument (Garmin 76). Laboratory test such as: Natural Moisture Content (NMC) , Specific gravity, Grain size analysis, Liquid Limit , Plastic Limit, Linear Shrinkage. The visual soil profile description of all trial pits investigated, reveal little variation within the soil strata. The laboratory results indicated that the particle size gradation for gravel ranged from 1 to 44 % , sand ranged from 26 to 77% and fines ranged from 8 to 46%; natural moisture content ranged from 1.1 to 18.7%; specific gravity ranged from 2.23 to 2.79; the bulk density ranged from 1134. to 1625. kg/m<sup>3</sup> , ; the liquid limit ranged from 25 to 65%, plastic limit ranged from 17 to 43%, plasticity index ranged from 10 to 30%; linear shrinkage ranged from 3.6 to 15.5%; According to America Association of State Highway and Transport Officials (AASHTO) soil classification and Unified Soil Classification System (USCS), all the samples can be classified as follows for all the five zone investigated : A-2-4, A-2-6, A-6 , A-7-5 for (AASHTO) and CL, MH and CH materials. This research work has provided data for engineers, designers and contractor for the use of this lateritic soils materials for construction work and has prevented possible difficulties, delays and additional expenses during construction due to inadequate geotechnical information within this metropolis It is recommended that all contractors should ensure that the testing and quality control of lateritic materials and project site within this area is done before the commencement of work on site

**KEYWORDS:** Linear shrinkage, plasticity index, subgrade

## 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 conditions of the soil and provide a relationship to structural properties. Soil index properties are used extensively by engineers to discriminate between the different kinds of soil within a broad category (ELE, 2013). A good knowledge about a site including its subsurface conditions is very important in its safe and economic development. It is

therefore an essential preliminary to the construction of any civil engineering work such as roads, buildings, dams, bridges, foundations, etc., (Adeyeri 2015). It is unfortunate to note that in developing countries like Nigeria only few investors in the construction industry take time to execute subsoil investigation prior to commencement of construction activities on their projects. The result is the calamitous consequences such as failure or collapse of buildings and other massive engineering structures which often cause untold hardship and damage and sometimes even loss of lives and properties. Many attempts have been made of recent to study the geotechnical properties of soils around Ekiti State in Southwestern Nigeria (Bayowa et al., 2014, Okunade, 2007; Oladapo and Ayeni, 2013; Owolabi and Aderinola, 2014; Talabi et al, 2013; Adeyeri et al, 2017). However, no previous attempt has been made to investigate the index properties of lateritic soil sequence in Ado Ekiti area of Ekiti State, Nigeria. Hence reason for this research arises to evaluate the soil index properties for the purpose of soil characterization of Ado Ekiti area lateritic soils of Ekiti State, Nigeria. (This will subsequently consolidate the data requirement for a web-based geotechnical database management system for Nigerian soils as proposed by Okunade (2010). Laterite as products of tropical weathering with red, reddish brown, or dark brown color, with or without nodules or concreting and generally (but not exclusively) found below hardened ferruginous crust or hard pan (Ola, 1983). The aim of this research is to determine the index properties of lateritic soil in Ado Ekiti local Government area, Southwestern Nigeria.

## LOCAL GEOLOGY OF THE STUDY AREA

The study involves collection of soil samples from borrow pits in Ado Ekiti using the method of Undisturbed and disturbed sampling. The areas are as shown in figure: 1) lies on latitude  $7^{\circ}15'$  North of the Equator and on longitude  $5^{\circ}15'$  east of the Greenwich Meridian. It stands on the altitude of about 370 meters above the sea level. The study area occurred within the Pre – Cambrian crystalline rocks of the Basement complex of Southwestern Nigeria (Rahamam, 1976). The predominant rock types in the study area are, Charnockites, granite gneiss and migmatitic rocks. The samples were taken at a depth of 1.1m from the surface.

## LOCATION MAP OF THE STUDY AREA



**Figure 1:** Map of Ekiti State showing Ado Ekiti Town (Oladipo et al,2013)

## MATERIALS AND METHODS

### Sampling

The samples used for the analysis were collected from eighteen (18) different locations within the area (Fig. 1). The eighteen (18) samples were designated as L1-01 to L11- 18. A disturbed method of sampling was employed in collecting the samples. Care was taken when collecting the samples to ensure that the analyzed samples are true representatives of the insitu materials. The samples were excavated with the Help of a hoe and a shovel. The samples were packaged in polyethylene bags, clearly labelled and sent to The geotechnical laboratory of the federal polytechnic Ado-Ekiti, South Western Nigeria for relevant laboratory tests.

### Laboratory Test

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

### Particle Size Gradation

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

### Natural Moisture Content

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

### Specific Gravity

This test was carried out in accordance with BS 1377 [1990] standard. Three density bottles were washed, dried, cooled and weighed to the nearest 0.001g and recorded as (W1). Sample of appropriate mass (50 to 150g) was obtained by quartering down the original sample after passing a 2 mm BS sieve. Each bottle with the soil was weighed and recorded as (W2). Distilled water was added to each bottle so that the soil was covered and the bottle half full. The soil, bottle and water was weighed and recorded as (W3). The bottles were

cleaned out and filled completely with distilled water and placed in the constant temperature bath until attainment of bath temperature. The bottle and distilled water was weighed and recorded as (W4). The specific gravity,  $G_s$  was calculated as  $= (W_2 - W_1) / (W_4 - W_1) - (W_3 - W_2)$

## Bulk and Dry Densities

These tests were carried out in accordance with BS 1377 [1990] test 16 standard. Bulk and dry densities are fairly easy determinations, which yield valuable insight on a soil's potential to support a structural foundation. These parameters were determined using soil cores. A hollow cylinder provided with a cutting edge was forced into the ground, then retrieved with a column of soil, preserved and taken to the laboratory where it was extruded into a cylindrical mould with a known mass and volume. It was weighed and the mass recorded. The

Moisture content was then determined as per (3). The bulk density was determined by dividing the mass of wet soil by the volume of the cylindrical mould while the dry density was determined as follows: Dry density,  $(\rho_d) = \rho_b \times 100 / 100 + m$  where,  $\rho_b$  = bulk density and  $m$  = moisture content (%)

## Atterberg Limits Test

The determination of liquid limit was carried out in accordance with American Society of the International Association for Testing and Materials (ASTM) method D423 standard. About 250 g of soil sample from thoroughly mixed portion of soil material, passing 0.425 mm was placed in a porcelain dish and mixed with 15 to 20 ml distilled water by alternately and repeatedly stirring, kneading and chopping with spatula. Further water increment of 1 to 3 ml was added and the process repeated until sufficient water has been thoroughly mixed with the soil. A portion of the mix was pressed into the cup using a spatula and carefully spread into position while avoiding entrapment of air bubbles. The liquid limit was taken as the moisture content corresponding to 25 blows. Similarly, for plastic limit determination, the test was carried out in accordance with BS 1377 [1990] test 3 standard. About 20 g of soil sample, passing 0.425 mm sieve was used for the test. The sample was thoroughly mixed with distilled water and kneaded for about 10 minutes to form a plastic ball. The ball was molded between the fingers and rolled between the palms, such that the warmth from the hand slowly dried it. The thread was then rolled between the fingers and a glass plate using steady pressure which reduced the diameter to about 3 mm, the pressure was maintained until the thread crumbled. This crumbling point is the plastic limit.

## Linear shrinkage test

This test was carried out in accordance with BS 1377 [1990] test 5 standard. About 150 g of air dried soil passing 0.425 mm sieve was used. The mould was cleaned, dried and a thin film of silicone grease was applied to the inner surface to prevent soil sticking to the mould. The soil was placed on a glass plate and mixed properly using distilled water for about 10 minutes until a homogenous paste of about the liquid limit was achieved. The length of the bar of soil was measured using a vernier caliper, both top and bottom surfaces. The mean of the two lengths was taken as the dry length

## RESULTS AND DISCUSSIONS

### Natural Moisture Content

Table 1 shows the results of natural moisture content of the soils in all the trial pits investigated which varied between 1.1 and 19.2%. The values are fairly high considering the time of test, indicating the soil potential for water retention, a property of fine grains.

### Grain size analysis

Figure 2 and 3 shows the graph of grain size analysis performed on all the trial pits investigated. Many of the samples had a very high percentage finer than 0.0075 fractions that is >35% varied between 13 and 30% for (Adebayo, Siumiloluwa, NTA and Falegan samples), 35-36% for (Christ school., and oke ila) & 42-78% for (Poly, Abuad, Dallimore, Gov.office, Basiri,) respectively. Hence, the soils are describe as Silty gravelly sandy soils for (Adebayo, Siumiloluwa, NTA and Falegan samples) while other location investigated were Clay of high compressibility respectively.

### Consistency limit tests

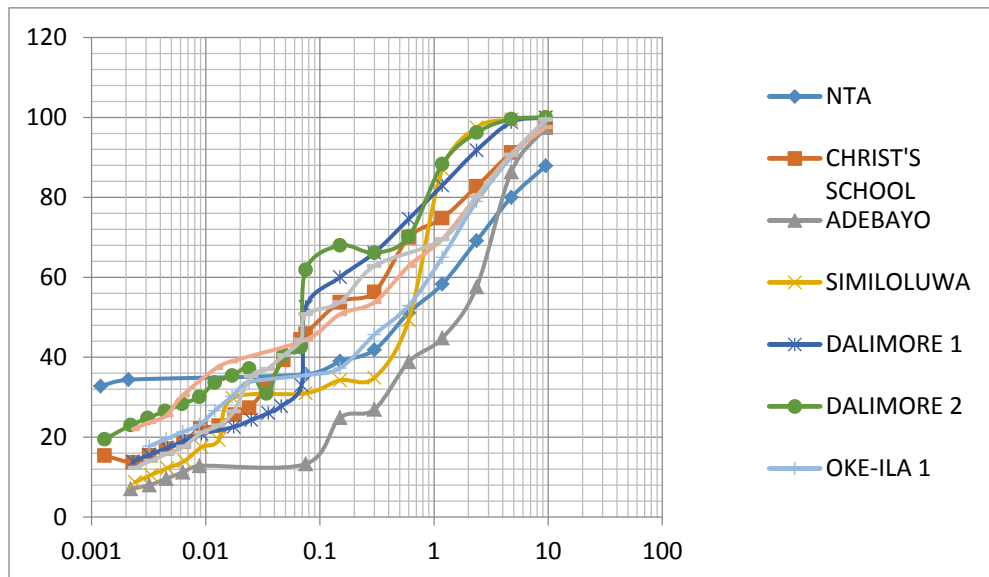
Table 1 shows the results of liquid limit (LL %), and plasticity index (PI %) evaluated on all the trial pits, which varied between 17-65% and 10-30% respectively. It was observed that soils from (Adebayo, Siumiloluwa, NTA and Falegan samples) has their liquid limit (LL %), and plasticity index (PI %) ranges between 17-37% and 10-12% respectively while Christ schl, okeila, poly, Abuad, Dallimore, Gov.office and Basiri) varied between 35-65% and 11-30%.. Federal Ministry of Works (FMW) general specification requirements for roads and bridges (1994) recommend liquid limit not greater than 80% for sub-grade and not greater than 35% for sub-base and base course. Also, plasticity index not greater than 55% for sub-grade and not greater than 12% for both sub-base and base. From the examined soil samples, the soils fall within these specifications, except for poly and Abuad that fell out of maximum specified. Thus making other location suitable for sub-grade, sub-base and base course and earth fill materials

### Ground Water Conditions

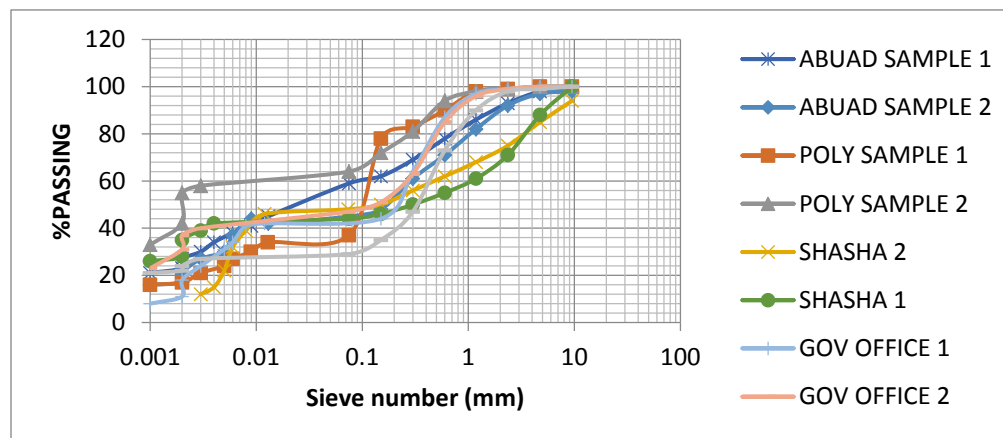
Ground water was not encountered in the test pit up to the depth excavated.

**Table 1:** Summary results of the soils index properties

LOCATIONS OF SAMPLES		NMC %	GS	LL%	PL%	PI%	SL%	$\rho_b$ kg/m <sup>3</sup>	%Passing			SOIL CLASSIFICATIO	
									0.075	0.6	2	AASH TO	USCS
A	<b>Poly 1</b>	15.8	2.23	58	28	30	05	1250	58.5	94	78	A-7-5	CL
	<b>Poly 2</b>	14.9	2.59	30	18	12	06	1429	45.5	92	71	A-6	CL
	<b>Abuad 1</b>	19.2	2.61	65	37	28	10	1153	78.4	100	98	A-7-5	MH
	<b>Abuad 2</b>	16.8	2.46	60	27	18	06	1250	64.1	99	94	A-7-5	MH
B	<b>Shasha 1</b>	13.7	2.79	53	33	19	10	1428	44.0	56	72	A-7-5	MH
	<b>Shasha 2</b>	11.6	2.39	52	30	22	10	1363	48.0	76	63	A-7-5	CH
C	<b>Gov. office 1</b>		2.56	43	21	22	09	1363	42.0	100	87	A-7-5	CL
	<b>Gov. office 2</b>	4.8	2.54	53	27	26	11	1395	47.0	99	85	A-7-5	CH
D	<b>Falegan</b>	1.1	2.60	37	25	12	07	1428	29.3	98	73	A-2-4	CL
E	<b>Dalimore 1</b>	12.7	2.36	50	28	22	07	1540	43	75	80	A-7-5	OL/ML
	<b>Dalimore 2</b>	18.7	2.30	43	12.5	31	7.7	1433	61	70.2	96.2	A-7-5	CH
F	<b>Oke-ila 1</b>	16.7	2.29	50	30	20	9.8	1600	41	78	83	A-7-5	ML
	<b>Oke-ila 2</b>	10.5	2.44	50	31	20	15.5	1134	35	65	80	A-2-6	OH
G	<b>Christ' sch</b>	12.2	2.41	35	21	14	05	1243	36	76	85	A-2-6	CL
H	<b>Basiri</b>	15.9	2.31	52	43	11	10	1255	44	62	80	A-7-5	MH
I	<b>Nta</b>	10.7	2.57	35	25	10	3.6	1577	25	68	79	A-2-4	ML
J	<b>Similoluwa</b>	9.5	2.33	25	15	10	4.9	1533	20	60	75	A-2-4	CL
K	<b>Adebayo</b>	8.2	2.66	27	17	10	05	1625	13	39	58	A-2-4	CL



**Figure 2:** grain size after hydrometer analysis



**Figure 3:** grain size after hydrometer analysis

**Table 2:** Showing Soil Profile and General Strata Description

Location of sample	From Depth Ranges (meters)	To Depth Range (meters)	Strata Description
Poly 1	0	1.1	Reddish brown, Indurated and multled ,Iron oxide mixed with Quartz grains
Poly 2	0	1.1	Greyish, Indurated and multled ,Iron oxide mixed with Quartz grains
Abuad 1	0	1.1	Greyish, plastic and indurated, more of clay mixed with little pocket of iron oxide
Abuad 2	0	1.1	Brownish, granular-indurated, Quartz mixed with organic matter
Shasha 1	0	1.1	Redish brown Non- indurated publish Iron stone, Quartz
Shasha 2	0	1.1	Reddish brown, Non- indurated peblish granular quartisitc pebbles
Gov. office 1	0	1.1	Dark greyish Sandy in appearance, non indurated, - iron oxide mixed with dirty Quartz
Gov. office 2	0	1.1	Dark greyish brown, fine sandy and non indurated, iron oxide mixed with dirty Quartz
Falegan	0	1.1	Reddish brown, Sandy Quartz, iron oxide and clay
Dalimore 1	0	1.1	Greyish, plastic and indurated, more of clay mixed with little pocket of iron oxide.
Dalimore 2	0	1.1	Reddish brown, Non- indurated peblish granular quartisitc pebbles
Oke- ila 1	0	1.1	Redish brown Non- indurated publish Iron stone, Quartz
Oke-ila 2	0	1.1	Brownish, granular-indurated, Quartz mixed with organic matter
Christ' sch	0	1.1	Dark greyish Sandy in appearance, non indurated, - iron oxide mixed with dirty Quartz
Basiri	0	1.1	Redish brown Non- indurated publish Iron stone, Quartz
Nta	0	1.1	Brownish, granular-indurated, Quartz mixed with organic matter
Similoluwa	0	1.1	Dark greyish Sandy in appearance, non indurated, - iron oxide mixed with dirty Quartz
Adebayo	0	1.1	Redish brown Non- indurated publish Iron stone, Quartz



**Table 3:** Showing details of samples co-ordinate and Soil sample locations

Soil sample location	Co-ordinates		Elevations
	EASTING	NORTHING	
Poly 1	005' 18.262"	07' 35.923"	372.9m
Poly 2	005' 18.312"	07' 35.879"	363.9m
Abuad 1	005' 18.682"	07' 35.957"	369.2m
Abuad 2	005' 18.782"	07' 35.954"	369.7m
SHASHA 1	005' 13.150"	07' 32.588"	375.6m
SHASHA 2	005' 13.258"	07' 32.288"	375.1m
Gov. office 1	005' 13. 688	07' 32.433"	378m
Gov. office 2	005' 13. 545	07' 32.365"	376m
Falegan	005' 11.923"	07' 37.028"	438.8m
Dallimore 1	005' 13.261"	07' 37.868"	442.6m
Dallimore 2	005' 13.205"	07' 37.940"	437.3m
Oke Ila 1	005' 13.782"	07' 38.050"	436.8m
Oke Ila 2	005' 13.936"	07' 38.284"	419.0m
Christ school	005' 12.667"	07' 37.979"	442.9m
Basiri	005' 11.675"	07' 43.473"	412.9m
NTA	005' 11.768"	07' 37.910"	464.1m
Similoluwa	005' 11.163"	07' 38.220"	437.2m
Adebayo	005' 14.240"	07' 39.734"	391.8m

## CONCLUSION

The characterization and index properties of lateritic soils in Ado-Ekiti of Ekiti State Capital have been evaluated. Trial pits 1.1m were excavated and samples of undisturbed soil were obtained for laboratory tests. The results of the tests reveal the following: most of the pits has percentage of fine greater than 40%, except few location which has percentage fines less than 35%. Ground water was not encountered. The soils sample were grouped as (CH, MH, and CL) and A-2-4, A-2-6, A-6 and A-7-5 respectively. This classify the soils as Clay of high compressibility, Clay of medium to high compressibility and Clay of low compressibility. The lateritic soils are suitable as dam, earth fill, subgrade, sub base and base course materials in civil engineering construction project.

## RECOMMENDATION

It is recommended that all contractors should ensure that the testing and quality control of lateritic soil materials is done before the commencement of earthworks on site and the adequate quality of construction as the construction project is being executed.



## REFERENCES

1. Adeyeri, J.B. (2015) *Technology and Practice in Geotechnical Engineering*: IGI Global Publishers: Advances in Civil and Industrial Engineering (ACIE) Book Series; Pennsylvania, USA
2. 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. *International Journal of Science and Technology (IJST)*. Vol. 4, No. 3. Pp. 48-58.
3. British Standards 1377 (1990) Methods of tests for soils for civil engineering purposes, London
4. ELE International, Chartmoor Road, Chartwell Business Park, Leighton Buzzard, Bedfordshire, LU7 4WG
5. Oladapo, M.I. and Ayeni, O.G. (2013) Hydrogeophysical Investigation in Selected Parts of
6. Irepodun/Ifelodun Local Government Area of Ekiti State, Southwestern Nigeria. *Journal of Geology and Mining Research*. Vol. 5(7). Pp. 200 – 207
7. Okunade, E.A. (2007) Engineering Properties of Lateritic Adobe Bricks for Local Building Construction and Recommendations for Practice. *Journal of Engineering and Applied Sciences*. Vol. 2(9). Pp. 1455-1459
8. Okunade, E.A. (2010) Design and Implementation of a Web-Based Geotechnical Database Management System for Nigerian Soils. *Modern Applied Science*. Vol. 4. No. 11. Pp. 36-42. Available: [www.ccsenet.org/mas](http://www.ccsenet.org/mas)
9. Omotosho et al (2012) Evaluation of some engineering properties of lateritic soil around Dall quarry, sango area, Ilorin, Nigeria, Department of geology University of Ilorin, Nigeria ISSN 0189-9546
10. Owolabi, T.A. and Aderinola, O.S. (2014) Geotechnical Evaluation of Some Lateritic Soils in Akure South, Southwestern Nigeria. *Electronic Journal of Geotechnical Engineering (EJGE)*. Vol. 19, Bund. R., Pp. 6675-6687. Available at [ejge.com](http://ejge.com).
11. Rahaman, M.A. (1989) Review of the basement geology of southwestern Nigeria. In: Kogbe, C.A., (ed) *Geology of Nigeria*, Rock View (Nig.) Limited, Jos, Nigeria, pp. 39-56.
12. Talabi, A.O., Ademilua, O.L., Ajayi, O.Z. and Oguniyi, S.O. (2013) Preliminary Geophysical Evaluation of Orin Bauxite Deposit, Southwestern Nigeria. *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS)*. Vol. 4 (3). Pp. 432-437



***Editor's note.***

This paper may be referred to, in other articles, as:

Emmanuel O. Eze, O. S. Osuji, Joshua T. Akinwamide: "Evaluation of Index Properties of Lateritic Soils in Ado Ekiti Metropolis South Western, Nigeria" *Electronic Journal of Geotechnical Engineering*, 2017 (22.07), pp 4261-4270. Available at [ejge.com](http://ejge.com).