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Assessment of Engineering Properties of Ado-Ekiti to Ikere-Ekiti Road Soil, Southwestern Nigeria

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Abstract
All over the world, conditions of any road largely depend upon its Engineering properties. The aim of this study is to assess the Engineering properties of Ado-Ekiti to Ikere-Ekiti road soil. Soil samples were taken from ten locations within the study area, subjected to laboratory tests (which are Grain Size and Atterberg Limits tests) and the results analyzed. The results showed that that the Liquid Limit (LL), Plasticity Index (PI) and Shrinkage Limit (SL) values varied from 23 to 41.1%, 5.8 to 25.2% and 0.1 to 0.7% respectively for all the soil samples. Most of the soil samples were generally and grouply classified as granular and A – 2 materials with mainly silty or clayey gravels and sand constituent materials. All the soil samples were good as subgrade materials, while few ones were good as base and subbase materials. There is need for immediate rehabilitation of the road.

Keywords: Atterberg Limits, Base, Grain Size Analysis, Engineering properties, Subbase, Subgrade

1. Introduction
The failure of highway in Nigeria, especially those constructed after the independence (in 1960) have been of great concern. Despite various rehabilitation efforts, several segments of those highways still fail perpetually. Much of the nation's resources that could have been channelled into the provision of education, health and other social facilities are expended on these rehabilitations. Thus, become an annual ritual and a big financial burden on various tiers of government. Road failures are not limited to any particular geological setting. Failures have been recorded on all formations [5].
The performance of a pavement depends on the quality of its sub-grade and sub-base layers. As the foundation for the pavement's upper layers, the sub-grade and sub-base layers play a key role in mitigating the detrimental effects of climate and the static and dynamic stresses generated by traffic. Therefore, building a stable sub-grade and a properly drained sub-base is vital for constructing an effective and long lasting pavement system [5].
In addition to stability and drainage requirements, the sub-grade and sub-base must be designed and constructed to exhibit a high level of spatial uniformity measured using engineering parameters. Several environmental variables (e.g. temperature, moisture etc.) must also be taken into account, since these variables have both short and long term effects on the geotechnical characteristics of the soil [5].
Generally, previous researches showed that roads failed due to negligence of road maintenance, inadequacies in design and poor workmanship, poor soil properties like low CBR and high liquid limits among others [1, 4].
The aim of this research work is to assess some engineering properties of Ado-ekiti to Ikere-ekiti road soil, Southwestern Nigeria. The tests to be carried out are Atterberg Limits and Grain Size analyses. This will help in acquisition of data about condition of the road, thus proffer solution to its problem. These data would also be available for Engineers, Planners, Designers and Contractors.

1.1 Study area
The study area is along Ado Ekiti – Ikere Ekiti road connecting Ado – Ekiti and Ikere – Ekiti Local Government Areas (LGAs) together. It is about 14.4 km and lies within Latitude 7^0 30^1

7.500^0 N and Longitude 5^0 14^1 5.233^0 E as shown in fig. 1. Geologically, its landscape consists of ancient plains broken by steep sided outcropping dome rocks situated within tropical climate of Nigeria and underlain by metamorphic rocks of the Precambrian basement complex of Southwestern Nigeria, which are very ancient in age as shown in fig. 2. These basement complex rocks showed great variations in grain size and in mineral composition. The rocks are quartz gneisses and schists consisting essentially of quartz with small amounts of white mizageous minerals. In grain size and structure, the rocks vary from very coarse-grained pegmatite to medium-grained gneisses. The rocks are strongly foliated and occur as outcrops. The soils derived from the basement complex rock are mostly well drained, having medium to coarse in texture. The geological nature of the study area and its increased urbanisation make it more vulnerable and of public health concern when it comes to water quality [2, 3, 9].

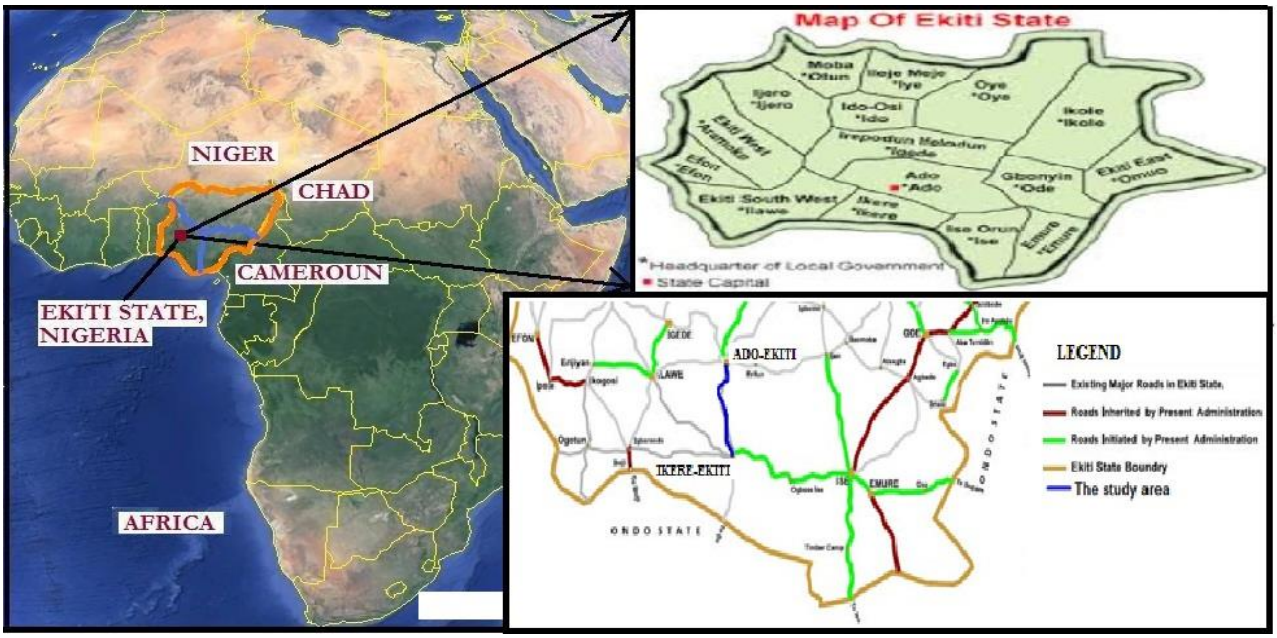

Fig1: Location of the study area

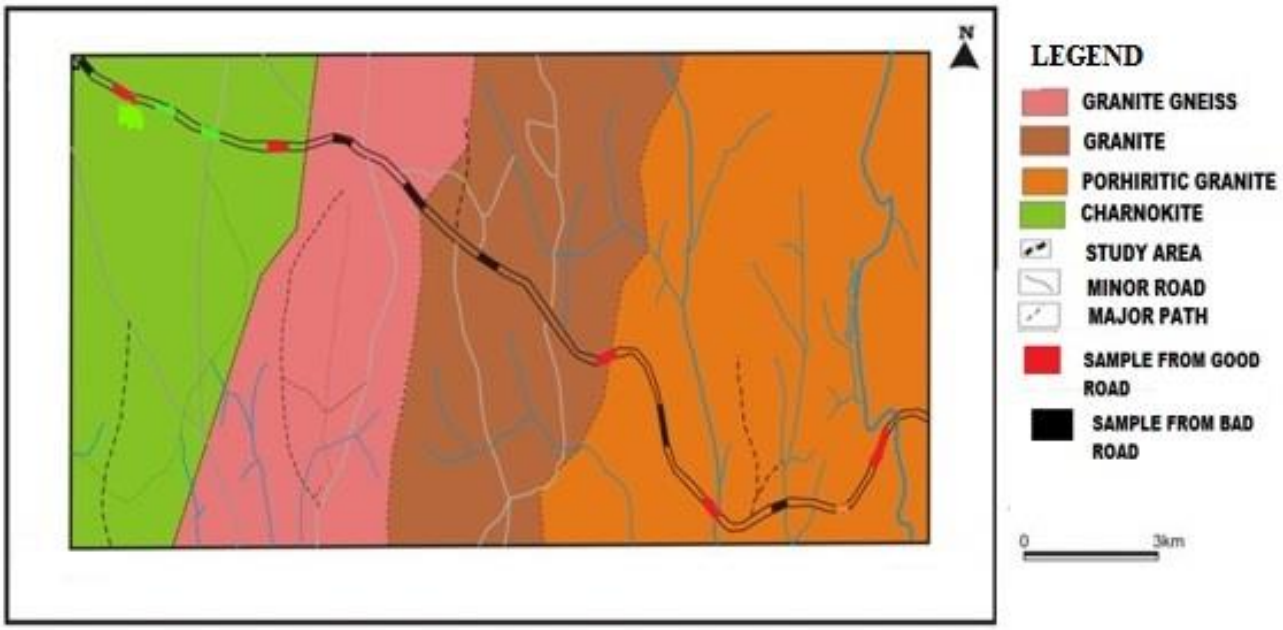

Fig2: eology of the study area

1.2Atterberg limits tests

This is a set of tests, which can also be called *Consistency Limits Tests*. These set of tests are Liquid Limits (LL), Plastic Limit (PL) and Shrinkage Limit tests. Plasticity Index is derived from the limits by subtracting PL from LL (i.e. PI = LL – PL). The tests are always conducted on the soil sample(s) for the purpose of analysis of the samples natural reactions with water. They are also used for classification of soils, assessment of mechanical properties of Earthworks Materials, Volume Change potential and desiccation. The results were usually compared with test proven [7, 10] and other standards / specified values [6].

1.3Grain size distribution test

Analyses of soil particles or grains distribution, soil particles grouping into sizes and relative proportion by mass (i.e. clay, sand and gravel fraction) were carried out using this test. It is mostly suitable for fill material. The

results are usually grouped in accordance with [7] and other classification methods / charts / codes [6].

2. Materials and methods

The whole stretch of the road was visually inspected and soil samples were taken from ten pits (i.e. locations) dug within the study area at depth between 0.50m and 1.5m after topsoil removal using method of disturbed sampling. The soil samples collected were stored in polythene bag to maintain its natural moisture contents. The samples were then taken to the laboratory where the deleterious materials such as roots were removed. The samples were air dried; pulverized and large particles were removed. The coordinates of collected soil samples locations were taken using GPS. The details of the soil samples were as shown in Fig. 3 and Table 1. Moulding of test specimens was started as soon as possible after completion of identification. All tests were performed to standards in accordance with [8]. Their features were also examined. The tests carried out on the samples were Grain Size Distribution and Atterberg limits. The results were compared to the standard specified values and grouped in accordance with [7, 10].

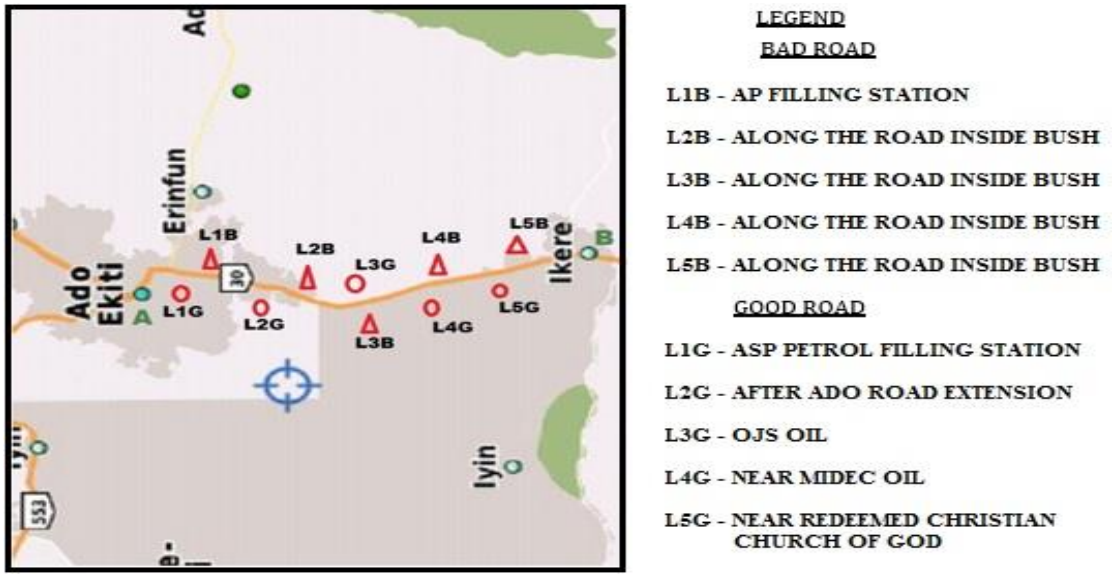

Fig3: Topographical map of the sampling locations

Table 1: The details of the soil samples

SAMPLE CODE	LOCATION	DESCRIPTION	COORDINATES
L1B	1	Sample from Bad portion of the Road near AP Filling Station	Lat. 7^0 33' 21"N Long. 5^0 12' 50"E
L2B	2	Sample from Bad portion of the Road inside bush along the Road	Lat. 7^0 32' 36"N Long. 5^0 13' 07"E
L3B	3	Sample from Bad portion of the Road inside bush along the Road	Lat. 7^0 32' 07"N Long. 5^0 13' 13"E
L4B	4	Sample from Bad portion of the Road inside bush along the Road	Lat. 7^0 31' 35"N Long. 5^0 13' 19"E
L5B	5	Sample from Bad portion of the Road inside bush along the Road	Lat. 7^0 31' 09"N Long. 5^0 13' 24"E
L1G	6	Sample from Good portion of the Road near APS Petrol Filling Station	Lat. 7^0 33' 39"N Long. 5^0 12' 45"E
L2G	7	Sample from Good portion of the Road after Ado Road exit	Lat. 7^0 32' 47"N Long. 5^0 13' 03"E
L3G	8	Sample from Good portion of the Road near OJS Oil	Lat. 7^0 31' 54"N Long. 5^0 13' 15"E
L4G	9	Sample from Good portion of the Road near Midec Oil	Lat. 7^0 31' 33"N Long. 5^0 13' 12"E
L5G	10	Sample from Good portion of the Road near Redeemed Church of God	Lat. 7^0 31' 10"N Long. 5^0 13' 26"E

Results and discussion

Field assessment from the visual inspection showed that the study area is unkempt. There are presence of cracks, depression, potholes and ruts on the road's surface, which could be as results of poor drainage system and pavement layers' failure. There were also presences of wear and tear on the pavement asphaltic surface due to aging. The whole drainage systems along the road are blocked and begging for desiltation / cleaning. The shoulders are mostly overgrown with vegetation. Generally, there are needs for rehabilitation and maintenance of the road or study area.

Table 2 showed Grain size analysis test results for the soil samples from the bad portion of the road. It is observed that all the soil samples have large quantities of silt / clay except L2B (i.e. between 7 and 14%). For the required sand (i.e. 43 to 51%), L1B and L2B have more than required while L3B, L4B and L5B have less than required quantities. For Gravel, it is only L5B that is within the required limits (i.e. 32 to 37%).

Table 2: Grain size analysis test results for the soil samples from the bad portion of the road

SIEVE	% PASSING					LIMITS		SOIL CLASSN.					SOIL TYPE
No. (mm)	L1B	L2B	L3B	L4B	L5B	LOWER	UPPER	L1B	L2B	L3B	L4B	L5B	
12.5	100	100	100	100	100	100	100						
9.5	97.52	98.46	98.06	95.58	92.70	87	97	9.14	16.98	24.86	12.52	34.66	GRAVEL
4.25	93.18	93.34	86.1	90.18	74.92	65	82						
2.36	88.38	81.48	73.2	83.06	58.04	50	65	60.02	71.50	26.44	31.96	36.36	SAND
1.18	77.26	66.00	66.3	76.54	48.04	36	51						
0.6	61.44	45.82	60.00	70.34	39.52	26	40						
0.3	44.22	25.58	54.2	62.88	31.78	18	30						
0.15	36.24	14.52	49.86	55.36	25.66	13	24						
0.075	28.36	9.98	46.76	51.10	21.68	7	14	28.36	9.98	46.76	51.10	21.68	SILT/CLAY

Table 3 showed Grain size analysis test results for the soil samples from the good portion of the road. It is observed that all the soil samples have more than required quantities of silt / clay except L2G (i.e. less than required quantities of between 7 and 14%). For the required sand (i.e. 43 to 51%), L1G and L2G have less than required while L3G, L4G and L5G have more than required quantities. For Gravel, L1G have more than required, L2G have more than required, while others (i.e. L3G, L4G and L5G) have less than the required limits (i.e. 32 to 37%). Generally, the quantities of silt / clay present in the soils were in descending orders of L4B > L3B > L3G > L1B > L5G > L5B > L1G >L4G > L2B > L2G. The quantities of sand present in the soils follow the descending orders of L2B > L5G > L3G > L1B > L4G > L1G > L5B > L2G > L4B > L3B. While L2G > L1G > L5B > L3B > L4G > L2B > L5G > L4B > L1B > L3G were in descending order for Gravel quantities for the soils.

Table 3 : Grain size analysis test results for the soil samples from the good portion of the road

SIEVE	% PASSING					LIMITS		SOIL CLASSN.					SOIL TYPE
No. (mm)	L1G	L2G	L3G	L4G	L5G	LOWER	UPPER	L1G	L2G	L3G	L4G	L5G	
12.5	100	100	100	100	100	100	100						
9.5	93.50	92.60	99.36	97.28	100	87	97	35.46	52.60	5.66	23.58	13.90	GRAVEL
4.25	74.92	59.80	95.96	86.94	94.66	65	82						
2.36	58.04	40.00	93.70	73.70	86.10	50	65	37.96	35.20	61.72	56.36	61.76	SAND
1.18	48.04	22.28	89.20	60.86	74.12	36	51						
0.6	39.52	18.36	74.89	44.64	60.50	26	40						
0.3	31.78	13.36	54.96	31.06	47.68	18	30						
0.15	25.66	8.10	39.24	22.16	34.62	13	24						
0.075	20.08	4.80	31.98	17.34	24.34	7	14	20.08	4.80	31.98	17.34	24.34	SILT/CLAY

From Tables 2 and 3, all the soil samples (except L3B and L4B) have percentages finer than 0.075mm fractions less than 35% (i.e. < 35%). From Table 4, all the Liquid Limit (LL) values for the soil samples (except L2B) were less than 40%. While all the soil samples (except L3B, L4B and L5G) have the Plasticity Indices (PI) values greater than 11%. Hence, general rating as sub-grade materials for L3B and L4B samples in accordance with AASHTO (1986) is fair to poor materials. Their percentage ranges of sand and gravel were 26 - 32% and 12 - 25% respectively. These results implied that the soils have large contents of silty / clay materials. They are likely to have significant constituent materials of silty soils and grouply classified as a – 4 soil.

While general rating as sub-grade materials for the remaining soil samples (i.e. L1B, L2B, L5B, L1G, L2G, L3G, L4G and L5G) in accordance with AASHTO (1986) is excellent to good materials. Their percentage ranges of sand and gravel were 31 - 72% and 5 - 53% respectively. These results portrayed that the soils have large contents of granular materials. They are likely to have significant constituent materials of silty or clayey gravel and soils; grouply classified as A – 2 (i.e. A – 2 – 4 to A – 2 – 7) soils.

Table 4: Atterberg limit tests results for the soil samples

ATTERBERG LIMITS	SAMPLES CODE									
	L1B	**L2B**	**L3B**	**L4B**	**L5B**	**L1G**	**L2G**	**L3G**	**L4G**	**L5G**
LIQUID LIMIT (%)	32.90	41.10	21.90	33.70	23.90	35.60	33.80	39.70	33.40	23.00
PLASTIC LIMIT (%)	18.80	15.90	11.50	27.30	10.60	15.80	17.80	15.10	12.70	17.20
PLASTICITY INDEX (%)	14.10	25.20	10.40	6.40	13.30	19.80	16.00	24.60	20.70	5.80
SHRINKAGE LIMIT (%)	0.40	0.10	0.60	0.30	0.10	0.60	0.60	0.50	0.70	0.60

Table 4 showed Atterberg Limits tests results for all the soil samples. It is observed that the Liquid Limit (LL), Plasticity Index (PI) and Shrinkage Limit (SL) values varied from 23.0 to 41.1%, 5.8 to 25.2% and 0.1 to 0.7% respectively for all the soil samples. Generally, all the soil samples met the required specification for subgrade course materials (i.e. LL $\leq$ 80%, SL $\leq$ 0.8% and PI $\leq$ 55%), thus suitable for subgrade course materials. Only L3B, L4B and L5G soil samples met the required specification for base and subbase course materials (i.e. LL $\leq$ 35%, SL $\leq$ 0.6% and PI $\leq$ 12%).

Conclusion

Conclusions from the above study are:

1. The L1B, L2B, L5B, L1G, L2G, L3G, L4G and L5G soil samples were generally classified as granular soil material with mainly silty or clayey gravel and sand constituent materials with some stone fragments. While L3B and L4B soil samples were generally classified as silty or clay material with mainly silty constituent materials.
2. L1B, L2B, L5B, L1G, L2G, L3G, L4G and L5G soil samples have group classifications of A – 2 (mainly A – 2 – 4, A – 2 – 6 and A – 2 – 7) while L3B and L4B soil samples have group classifications of A – 4.
3. All the soil samples were good as subgrade materials. Though L1B, L2B, L5B, L1G, L2G, L3G, L4G and L5G soil samples were better (i.e. excellent to good).
4. Only L3B, L4B and L5G soil samples were good as base and subbase materials.
5. The road failure is due to lack of maintenance and bad drainage system.

It is recommended that the road should be rehabilitated immediately. There should be room for periodic and seasonal maintenances of the whole road by the Federal and State Governments.

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