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Analyses of some Engineering Properties of Isan - Ekiti Soil, Southwestern Nigeria

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ABSTRACT
Today, all over the World, soil plays major role in Civil Engineering works or construction. Its thorough assessment is impossible if its Engineering properties were overlooked. The aim of this study is to analyze some Engineering properties of lateritic soil deposited in Isan – Ekiti, South-western Nigeria. Soil samples collected from the study area were subjected to Atterberg Limits, CBR and Grain Size laboratory tests. It is observed that the LL, PL, PI, SL and CBR values varied from varied from 41.10 to 57.50%, 24.60 to 35.50%, 14.80 to 22.70%, 0.32 to 0.61 and 4.38 to 30.21% respectively for all the soil samples. It could be generally observed all the soil samples were classified as granular soil material with mainly silty or clayey gravel and sand constituent materials with some stone fragments. Their general rating as sub-grade materials is "Excellent to good". They were grouply classified as A – 2 – 7 and were only good for sub grade filling materials. There is need for further study on deposited materials around the study area for good base and sub base courses materials.

Keywords: *Atterberg Limits, Engineering properties, Grain Size Analysis, Soil, Sub grade.*

I. INTRODUCTION

In Civil Engineering works, soil is indispensable and governs everything. Therefore, it must be thoroughly assessed to know its properties and study its best usage. At times, soil is being replaced in order to bring best out of the project. This usually results in seeking for construction materials from burrow pit, since huge amount of money will be used in stabilization process of the available soil in order to suit the construction purpose. It is highly significant to have cheap construction materials so that there will be availability of basic infrastructures for people globally especially developing countries. The cost of construction is alarming with majority of the population becoming poorer in developing countries especially Nigeria. This is due to the fact that most developing countries are poor, agricultural based and have low standard of living. Nevertheless, it is compulsory for those countries to have access to better infrastructure. Thus, there is need to use available resources for the improvement of the standard of living of people in a country like Nigeria. Nevertheless, everything must be considered along with soil when it comes to Civil Engineering works (Adetoro & Dada, 2017a).

All structures are built on soil for stability. Any defects in the soil properties that makes it unfit for construction purpose will require its disposal, replacement or improvement of its Engineering performance for optimal use. The formal could be expensive and requires the use of heavy equipment if the burrow pit location is far among others. The latter, which is improvement of engineering performance of soil, could be done using stabilizing agents / additives (Adetoro & Dada, 2017a)

In tropical and sub-tropical climates countries such as Nigeria, lateritic soils are required or used in different Engineering works, which are good for roads subgrade and other pavement layers. Though, there are some cases where a lateritic soil may contain large quantity of clay minerals, which will reduce its strength and durability under load especially in moisture's presence [2].

Any deficiency in soil properties usually accompanied by awkward problems in Civil Engineering works. Most soils within some important Civil Engineering projects are not suitable for their construction purpose, therefore, cut or haul to spoil. The result is acquisition of burrow pit materials which could be costly at the end of the day if it far away from the project [3]. Universally, past researches showed that roads failure usually occur 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].

Presently, assessment of soil is impossible if its Engineering properties is overlooked. In any Civil Engineering construction, soil underneath and surrounding any foundation plays significant role in effective functioning of the project. Thus, the need to acquire knowledge about soils' Engineering properties is paramount [5].

The piece of study sought to assess or analyse some Engineering properties of Isan Ekiti soil in south-western part of Nigeria, Ekiti State precisely. The Engineering properties looked into were mechanical and performance ones. There is substantial deposit of lateritic soil in the study area. If the soil is found suitable, it will help in accessibility and availability of good lateritic soil materials for road construction in the area. The tests to be carried out are Atterberg Limits (Mechanical properties), California Bearing Ratio (CBR – Performance properties) and Grain Size analyses (Mechanical properties). It will also help in provision of data for Engineers, Planners, Designers and Contractors.

A. Study Area

The study area is Isan-Ekiti, Oye Local Government Area (LGA), Ekiti State - a state in western Nigeria declared as a state on 1st October, 1996 alongside five others by the military under the dictatorship of General Sani Abacha. The state, carved out of the territory of old Ondo State, covers the former twelve local government areas that made up the Ekiti Zone of old Ondo State. On creation, it had sixteen Local Government Areas (LGAs), having had an additional four carved out of the old ones. One of these sixteen LGAs is Oye LGA, which is surrounded by Kwara State in the North, Ikole LGA in the East, Ileje-Meje / Ido-Osi LGAs in the West and Irepodun / Ifelodun LGA in the South as shown in Fig. 1 [8]

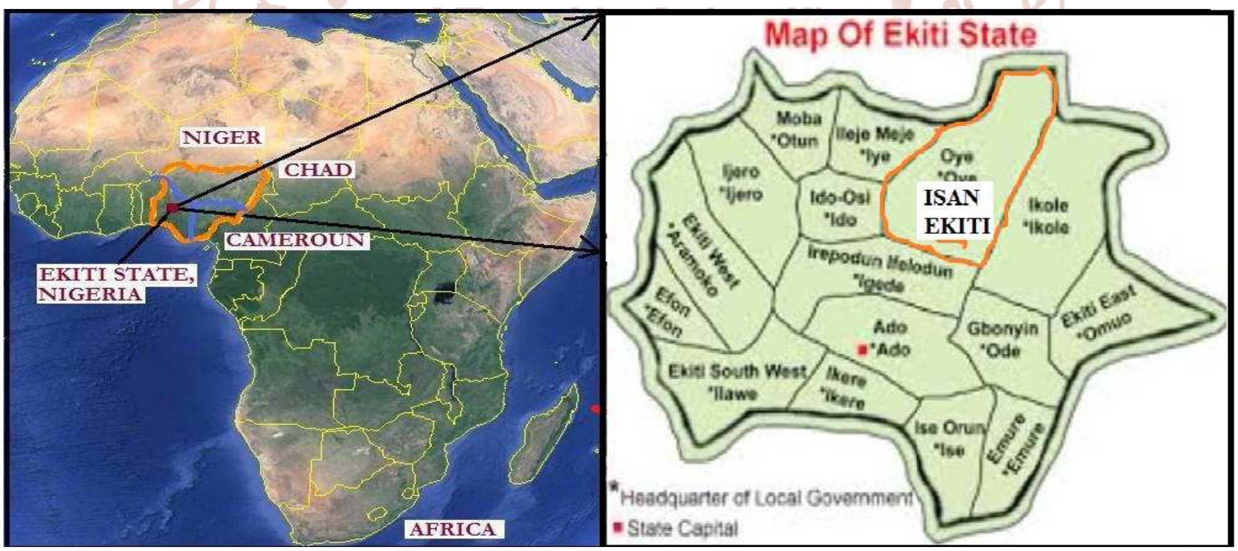

Figure 1: Location of the Study Area- Isan-Ekiti, Ekiti State (Source: [10])

Isan – Ekiti is located on Latitude 7^0 55'N and Longitude 5^0 19'E. 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 schist's 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 course in texture. The geological nature of the study area and its increased urbanization make it more vulnerable and of public Health concern when it comes to water quality ([1], [8]).

The Study area is within the tropical climate of South-western Nigeria with two distinct seasons namely rainy season (April–October) and dry season (November–March). Its Temperature is between 21° and 28 °C with high humidity. The south westerly wind and the northeast trade winds blow in the rainy and dry (Harmattan) seasons respectively [8].

B. Atterberg Limits Tests

These comprises of Liquid Limits (LL), Plastic Limit (PL), Plasticity Index (PI) and Shrinkage Limit tests. Another name for these set of tests is *Consistency Limits Tests*. They were carried out on the soil sample(s) in other to analyze the samples natural reactions with water. The results were always compared with rekmown standards specified values e.g. [6] and [9] standards specified values ([1], [4]).

C. California Bearing Ratio (CBR) Test

This is a penetration test used for acquisition of relative value(s) of shearing resistance of road pavement layers materials. It is a dimensionless index conducted in a standard laboratory or on the field during construction. It is usually used method of soil evaluation for pavement design especially in tropical and subtropical countries like Nigeria [5].

D. Grain Size Distribution Test

It is used in analyzing particles or grains distribution, grouping of the particles into sizes and relative proportion by mass of soil types for the samples (i.e. clay, sand and gravel fraction). It is mostly suitable for fill material. The results are always classified according to [6] ([4]).

II. MATERIALS AND METHODS

Soil samples were collected from four pits dug within the study area (Namely Sample A, B,C and D) at depth between 1.00m and 2.00m 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.

Moulding of test specimens was started as soon as possible after completion of identification. All tests were performed to standards as in [7]. Their features were also examined. The tests carried out on the samples were Atterberg Limits and Grain Size Distribution. The results were compared to the standard specified values and grouped in accordance with [6] and [9].

III. Results and Discussion

Table 1 showed Grain size analysis test results for the soil samples. It is observed that the results showed that all the soil samples have percentages finer than 0.075mm fractions less than 35% (i.e. < 35%), which ranges between 16.2 and 33.7%. They have more than required quantities of silt / clay (i.e. less than required quantities of between 7 and 14%).

Table 1: Grain Size Analysis Test Results for the Soil Samples

SAVE	% PASSING				LIMITS		SOIL CLASSN.				SOIL TYPE
No. (mm)	A	B	C	D	LOWER	UPPER	A	B	C	D	
12.5	100	100	100	100	100	100					
9.5	99.5	99.4	86.5	92.6	87	97	18.3	6.4	34.4	9.6	GRAVEL
4.25	91.5	96.4	68.8	88	65	82					
2.36	81.2	93	52.1	83	50	65	47.5	63.7	35.9	50.7	SAND
1.18	70.3	87.2	42	80	36	51					
0.6	58.4	77.8	33.7	74.3	26	40					
0.3	44.3	65	25.8	62.4	18	30					
0.15	34.6	56.7	20.2	50.5	13	24					
0.075	33.7	29.3	16.2	32.3	7	14	33.7	29.3	16.2	32.3	SILT/CLAY

Soil samples A and D have required quantities of sand (i.e. 43 to 51%), while soil samples B and C have more and less than required quantities of sand respectively. For Gravel, only sample C has the required quantity (i.e. 32 to 37%), while others have less than required quantities. The quantities of silt / clay present in the soils were in descending orders of A > D > B > C. The quantities of sand present in the soils followed the descending orders of B > D > A > C. While C > A >D > B were in descending order for Gravel quantities present in the soil samples.

Generally, all the soil samples could be classified as granular materials.

Table 2 showed Atterberg Limits and CBR tests results for the soil samples. It is observed that the Liquid Limit (LL), Plastic Limit (PL), Plasticity Index (PI), Shrinkage Limit (SL) and CBR values varied from 41.10 to 57.50%, 24.60 to 35.50%, 14.80 to 22.70%, 0.32 to 0.61 and 4.38 to 30.21% respectively for all the soil samples.

Table 2: Atterberg Limit Tests and California Bearing Ratio (CBR) Results for the Soil Samples

TEST	SAMPLES CODE			
	A	B	C	D
LIQUID LIMIT (%)	41.10	45.80	53.00	57.50
PLASTIC LIMIT (%)	26.30	24.60	30.30	35.50
PLASTICITY INDEX (%)	14.80	21.20	22.70	22.00
SHRINKAGE LIMIT (%)	0.61	0.32	0.48	0.55
CBR (5mm)(%)	6.26	4.38	10.36	30.21

From Table 1, all the soil samples have percentages finer than 0.075mm fractions less than 35% (i.e. < 35%). From Table 2, all the LL values for the soil samples were greater than 40%. While all the soil samples have the PI values greater than 11%. Hence, according to [6], their general rating as sub-grade materials is "Excellent to good" materials. Their percentage ranges of sand and gravel were 35.9 – 63.7% and 6.4 – 34.4% respectively. These results implied that the soils have large contents of sand and gravel materials. They are likely to have significant constituent materials of Silty or Clayey Gravel and Sand soils and grouply classified as A – 2 - 7 soils.

Generally, all the soil samples met the required specification for sub grade course materials (i.e. LL ≤ 80%, SL ≤ 0.8%, PI ≤ 55% and CBR > 3%), thus suitable for sub grade course materials. No soil sample met the required specification for base and sub base course materials (i.e. LL ≤ 35%, SL ≤ 0.6%, PI ≤ 12% and CBR >= 80%).

IV. CONCLUSION

From the above piece of study, it could be concluded that all the soil samples were generally classified as granular soil material with mainly silty or clayey gravel and sand constituent materials with some stone fragments. Their general rating as sub-grade materials is "Excellent to good". They were grouply classified as A – 2 – 7 and were only good for sub grade filling materials. While the large deposit of lateritic materials were good as sub grade filling materials, the vicinity of the study area should still be searched for good sub base and base course materials. Thus, further study should be carried out.

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