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Comparative Analyses of Performance Properties of Ekiti State Soil, Nigeria

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***Abstract* — It is hard to overlook the importance(s) of soil in construction of structures and other aspect of Civil Engineering practices. All structures are built on soil for stability. Thus, this soil of a thing must be thoroughly assessed to know its properties and study how to bring best out of it. One of the characteristics of soil to be assessed or studied is its performance properties. The aim of this study is comparative analyses of performance properties of Ekiti State soil. Soil samples collected from the study area were subjected to laboratory tests (i.e. Compaction test). The results of the tests carried out on the soil samples showed that the soil samples of Emure and Ise-Orun LGAs have the highest ranges of Maximum Dry Density (MDD) values and were best suitable materials for subgrade, subbase and base courses materials. Though their moisture content values were higher than the specified values. The soil samples of Efon - Alaaye LGA were all suitable for subgrade course materials and some of them (A and B) were suitable materials for subbase and base courses materials. Though their moisture content values were higher than the specified values. The soil samples of Gbonyin, Ido-Osi, Ijero and Oye LGAs were not suitable for subgrade, subbase and base courses materials. Their moisture content values were also higher than the specified values.**

Keywords—Civil Engineering, Compaction, Moisture Content, Performance properties, Soil.

I. INTRODUCTION

When it comes to Civil Engineering construction, every human being knows that soil is indispensable and everything depends on it. Thus, this soil of a thing must be thoroughly assessed to know its properties and study how to bring best out of it. One of the characteristics of soil to be assessed or studied is its performance properties. In a means to bring best out of it, soil is being replaced or stabilized. This usually results in seeking for expensive materials from far away burrow pit. At times, huge amount of money is used in stabilization process of the available soil in other to suit the construction purpose ([9]).

It is of utmost importance to have affordable amounts of construction materials in making available basic affordable structures for the people of the world especially that of Third World conutries. The cost of construction materials continue rising with majority of the population becoming poorer in those countries especially Nigeria. This is so alarming to the people of those countries and the whole world. Because most of these Third World countries are poor, agricultural based and their standard of living is nothing to write home about ([8]).

However, it is compulsory for those people to have access to better infrastructure. Based of this fact, the need for the use of all available resources and wastes for the improvement of the standard of living of people in a country like Nigeria is of paramount importance. But whatever it is, everything must be considered along with soil when it comes to Civil Engineering construction ([8]).

It is hard to overlook the importance(s) of soil in construction of structures and other aspect of Civil Engineering practices. All structures are built on soil for stability. If there is any deficiencies in the properties of soil that makes it unfit for structure to be built on it, there is need to either excavate the soil or improve its Engineering performance for optimum use. The formal is expensive and requires the use of heavy equipment. The latter which is improvement of Engineering performance of soil could be done through the use of stabilizing agents / additives ([11]).

The overall cost of improving soil properties with the use of conventional additives could be high and unaffordable, but if locally available additives are found suitable for stabilizing soil, this will reduce the cost of improving the soil properties. These locally available additives could be agricultural wastes, industrial wastes, domestical wastes etc. Most of these wastes are hazardous to man and environment. Even burning them can deplete the ozone layer ([11]).

Past research works of many authors such as [8], [9], [10], [11], [12], [13], [14], [15], [16], [17] etc. among others looked into improvement of soil through the use of locally available additives.

In this study, comparative analyses of performance properties of Ekiti State soil would be assessed. It would be of utmost help in getting Engineering information about Ekiti State soil and in knowing the capability of Ekiti State soil as construction materials.

STUDY AREA - the study area is Ekiti State as shown in fig 1 - a state in western Nigeria, declared a state on 1 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. Ekiti State is one of the thirty-six states that constitute Nigeria ([1], [2]).

The State is mainly an upland zone, rising over 250 meters above sea level. It lies on an area underlain by metamorphic rock. It is generally undulating country with a characteristic landscape that consists of old plains broken by step-sided out-crops that may occur singularly or in groups or ridges. Such rocks out-crops exist mainly at Aramoko, Efon-Alaaye, Ikere-Ekiti,Igbara-odo- ekiti and Okemesi-Ekiti. The State is dotted with rugged hills, notable ones being Ikere-Ekiti Hills in the south, Efon-Alaaye Hills on the western boundary and Ado-Ekiti Hills in the centre ([1], [2]).

The State enjoys tropical climate with two distinct seasons. These are the rainy season (April–October) and the dry season (November–March). Temperature ranges 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. Tropical forest exists in the south, while savannah occupies the northern peripheries ([1], [2]).

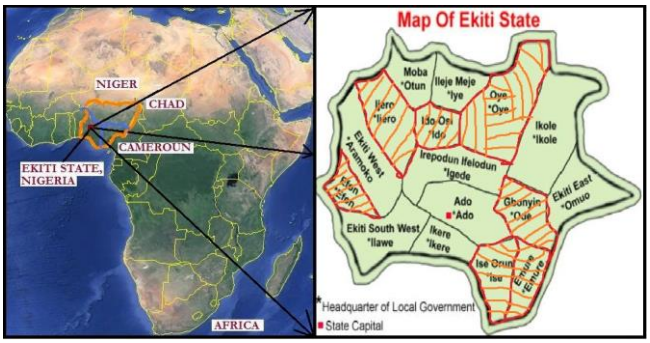

Fig. 1: Location of the Study area – Ekiti State [4]

II. MATERIALS AND METHODS

SOIL SAMPLE COLLECTION AND ANALYSIS - Soil samples were collected from pits dug within the study area (from seven different LGAs namely Efon Alaaye, Emure, Gbonyin, Ido / Osi, Ijero, Ise-Orun and Oye – Ekiti as shown in Fig. 1) at depth of 0.75 - 1.2m in its disturbed state. 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 [5]. 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 [6] and [7].

PERFORMANCE PROPERTIES - *of a soil have to do with Dry density, Moisture content and California Bearing Ratio (CBR) tests of the soil. This test measures the dry density of the compacted soil in relationship to moisture content depending on the manner of the compaction effort. Compaction influences the shear strength and compressibility of the soil and is frequently used in earthworks and road construction. Primarily used as a rapid test to determine the moisture suitability of earthwork materials at the construction phase. Calibration lines are usually determined through a range of moisture contents in the laboratory* ([5]).

The moisture content value is used to quantify the compactive effort to produce near full compaction and can be correlated with shear strength and CBR value. It is also used for the evaluation of sub-grade strength in road design. The test measures the load required to cause a plunger to penetrate a specimen of soil. Although an arbitrary test, it is an indirect measure of strength. Not suitable for materials with more than 25% of particles larger than 20mm ([5]).

COMPACTION TEST – *This test (s) is carried out on soil samples (treated and untreated state) in other to determine the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of the soil samples* ([8], [12]).

CALIFORNIA BEARING RATIO (CBR) - *is a penetration test used in acquiring 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 commonly used method of soil evaluation for pavement design especially in tropical and subtropical countries* ([8], [12]).

In this study, Compactive efforts of Performance properties (i.e. Dry Density and Moisture Contents) would be considered.

III. RESULTS AND DISCUSSION

Table 1: Compaction Test Results for the Natural Soil Samples of Emure and Ise-Orun LGAs

SOIL SAMPLE	A	B	C	D	E	F	G	H	I	J
MDD (Kg/m^3)	2201.87	1911.27	2462.15	2266.86	2202.07	2020.40	2167.36	2195.04	2044.00	2200.00
OMC (%)	14.05	17.08	11.62	10.74	10.20	10.95	11.32	9.88	12.50	9.10

Table 1 showed results of Compaction tests for the natural soil samples of Emure and Ise-Orun LGAs. The results showed that all the soil samples have Maximum Dry Density (MDD) values varied from 1911.27Kg/m3 to 2462.15Kg/m3 respectively. These soil samples met the required specification for subgrade course materials (i.e. MDD > 1760kg/m3), base and subbase course materials (i.e. MDD > 2000kg/m3) except soil sample B ([6], [7]).

Thus, they could be suitable for subgrade, base and subbase course materials. The Optimum Moisture Contents (OMC) values also varied from 9.10% to

17.08%. This portrayed that the moisture content in the study area remains very high compared to specified values ([6], [7]).

Table 2: Compaction Test Results for the Natural Soil Samples of Efon - Alaaye LGA

SOIL SAMPLE	A	B	C	D	E	F
MDD (Kg/m^3)	2012.00	2088.00	1964.00	1962.00	1970.00	1930.00
OMC (%)	9.50	12.50	9.10	10.00	9.10	11.70

Table 2 showed results of Compaction tests for the natural soil samples of Efon – Alaaye LGA. The results showed that all the soil samples of Efon - Alaaye LGA have Maximum Dry Density (MDD) values varied from 1930Kg/m3 to 2088Kg/m3 respectively. These soil samples met the required specification for subgrade course materials (i.e. MDD > 1760kg/m3). All the soil samples except A and B did not meet specifications for base and subbase course materials (i.e. MDD > 2000kg/m3) ([6], [7]).

Thus, they could be suitable for subgrade course materials. Soil samples A and B could also be suitable for subbase and base course materials. The Optimum Moisture Contents (OMC) values also varied from 9.10% to 12.50%. This portrayed that the moisture content in the study area remains very high compared to specified values ([6], [7]).

Table 3: Compaction Test Results for the Natural Soil Samples of Ido - Osi LGA

SOIL SAMPLE	A1	A2	B1	B2	C1	C2	D1	D2
MDD (Kg/m^3)	1512.00	1413.00	1498.00	1398.00	1439.00	1489.00	1397.00	1489.00
OMC (%)	14.00	16.00	18.70	16.30	14.80	13.30	15.00	14.70

Table 3 showed results of Compaction tests for the natural soil samples of Ido - Osi LGA. The results showed that all the soil samples of Ido - Osi LGA have Maximum Dry Density (MDD) values varied from 1397Kg/m3 to 1512Kg/m3 respectively. These soil samples did not meet the required specification for subgrade course materials (i.e. MDD > 1760kg/m3), base and subbase course materials (i.e. MDD > 2000kg/m3) ([6], [7]).

Thus, they are not suitable for subgrade, subbase and base course materials. The Optimum Moisture Contents (OMC) values also varied from 13.30% to 18.70%. This portrayed that the moisture content in the study area remains very high compared to specified values ([6], [7]).

Table 4: Compaction Test Results for the Natural Soil Samples of Gbonyin LGA

SOIL SAMPLE	1	2	3	4	5	6	7	8
MDD (Kg/m^3)	1580.00	1680.00	1460.00	1720.00	1690.00	1740.00	1640.00	1600.00
OMC (%)	14.30	13.30	16.20	16.20	12.50	13.50	15.60	12.80

Table 4 showed results of Compaction tests for the natural soil samples of Gbonyin LGA. The results showed that all the soil samples of Gbonyin LGA have Maximum Dry Density (MDD) values varied from 1460Kg/m3 to 1740Kg/m3 respectively. These soil samples did not meet the required specification for subgrade course materials (i.e. MDD > 1760kg/m3), base and subbase course materials (i.e. MDD > 2000kg/m3) ([6], [7]).

Thus, they are not suitable for subgrade, subbase and base course materials. The Optimum Moisture Contents (OMC) values also varied from 12.50% to 16.20%. This portrayed that the moisture content in the study area remains very high compared to specified values ([6], [7]).

Table 5: compaction Test Results for the Natural Soil Samples of Ijero LGA

SOIL SAMPLE	1	2	3	4	5	6
MDD (Kg/m^3)	1575.00	1463.00	1689.00	1644.00	1519.00	1666.00
OMC (%)	14.30	16.20	12.50	15.60	13.60	12.40

Table 5 showed results of Compaction tests for the natural soil samples of Ijero LGA. The results showed that all the soil samples of Ijero LGA have Maximum Dry Density (MDD) values varied from 1463Kg/m3 to 1689Kg/m3 respectively. These soil samples did not meet the required specification for subgrade course materials (i.e. MDD > 1760kg/m3), base and subbase course materials (i.e. MDD > 2000kg/m3) ([6], [7]).

Thus, they are not suitable for subgrade, subbase and base course materials. The Optimum Moisture Contents (OMC) values also varied from 12.40% to 16.20%. This portrayed that the moisture content in the study area remains very high compared to specified values ([6], [7]).

Table 6: Compaction Test Results for the Natural Soil Samples of Oye LGA

SOIL SAMPLE	1	2	3	4
MDD (Kg/m^3)	1651.63	1871.37	1742.53	1552.94
OMC (%)	18.00	16.22	11.59	14.97

Table 6 showed results of Compaction tests for the natural soil samples of Oye LGA. The results showed that all the soil samples of Oye LGA have Maximum Dry Density (MDD) values varied from 1552.94Kg/m3 to 1871.37Kg/m3 respectively. All the soil samples (except soil sample 2) did not meet the required specification for subgrade course materials (i.e. MDD > 1760kg/m3), base and subbase course materials (i.e. MDD > 2000kg/m3) ([6], [7]).

Thus, they are not suitable for subgrade, subbase and base course materials. However, soil sample 2 is only suitable as subgrade course materials. The Optimum Moisture Contents (OMC) values also varied from 11.59% to 18.00%. This portrayed that the moisture content in the study area remains very high compared to specified values ([6], [7]).

IV. CONCLUSION

From the results of the study shown above, the following conclusions were drawn:

1. The soil samples of Emure and Ise-Orun LGAs have the highest ranges of MDD values and all of them (except soil sample B – suitable for subgrade course materials only) were best suitable materials for subgrade, subbase and base courses materials. Though their moisture content values were higher than the specified values.

2. The soil samples of Efon - Alaaye LGA were all suitable for subgrade course materials and some of them (A and B) were suitable materials for subbase and base courses materials. Though their moisture content values were higher than the specified values.
3. All the soil samples of Gbonyin, Ido-Osi, Ijero and Oye LGAs were not suitable for subgrade, subbase and base courses materials (except soil sample 2 of Oye LGA which was suitable for subgrade course materials only). Their moisture content values were also higher than the specified values.
4. The soil samples of Ido-Osi LGA have the lowest ranges of MDD values while the soil samples of Efon-Alaaye LGA have the lowest ranges of OMC values.
5. Emure and Ise-Orun LGAs have the highest MDD values while Gbonyin LGA has the lowest MDD value.
6. Ido-Osi LGA has the highest OMC value while Efon-Alaaye, Emure and Ise-Orun LGAs have the lowest OMC value.

Further research work should be done on this study in other to ascertain any other suitable hidden properties of the soil especially on Performance properties.

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