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GEOTECHNICAL CHARACTERIZATION OF LATERITIC SOILS IN PARTS OF EJIGBO LOCAL GOVERNMENT AREA, SOUTHWESTERN NIGERIA

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ABSTRACT

Lateritic soils deposits over quartzites in Ejigbo Local Government Area, Southwestern Nigeria have been characterized in terms of geotechnical and engineering properties.

Ten lateritic soil samples were collected in test pits and were subjected to the following laboratory tests: natural moisture content, grain size analysis, atterberg limits, compressive strength and compaction in accordance with the procedures of the British Standard 1377 of (1990).

The result of specific gravity ranged from 2.58 to 2.70. The grain size analysis result showed that percentage passing No. 200 (75mm) ranged between 10 and 33%. The liquid, plastic limit and plastic index ranged between 16.70 to 46.5%, 11.80 to 31.80% and 4.35 to 26.79% respectively. The minimum dry density and optimum moisture content ranged between 1.81kg/m^3 to 2.19kg/m^3 and 8.60 to 16.40% respectively. California bearing ratio ranged between 6 to 29%.

According to AASHTO classification, the result showed that all the samples except samples 2,3and4 have CBR values that fall within the specification for the subgrade, which is 10% minimum for BS compaction and the liquid limit values did not exceed 30% except for samples 2,6 and 8 and therefore suitable for use as subgrade and subbase materials for road pavement constructions.

INTRODUCTION

Lateritic soils abound in most parts of the tropical world, particularly in humid tropical climates within 30^{0}N and 30^{0}S of the equator. This region probably contains, in a scientific and economic sense, the least developed areas of the world; hence the soils have not been studied as intensively as soils of the temperate climates (Adeyemi and Abolurin, 2000).

CIRIA (1988) has proposed the following definition for lateritic soils that is adopted for this study. It states "Laterite in all its form is a highly weathered natural material formed by the concentration of the hydrated oxides of iron and aluminium. This concentration may be residual accumulation or by solution, movement and chemical precipitation. In all cases it is the result of secondary physico-chemical processes and not of the normal primary processes of sedimentation, metamorphism, volcanism or plutonism. The accumulated hydrated oxides are sufficiently concentrated to affect the character of the deposit in which they occur.They may be present alone on an unhardened soil; as a hardened layer, or as a constituent such as concretionary modules in a soil matrix or a cemented matrix enclosing other materials." Lateritic materials constitute the major surfacial deposit of engineering materials in many parts of Australia, Africa and South America (CIRIA 1988).

Numerous quarries and roadside excavations that have been occurring in many areas of Southwestern Nigeria have helped one to know the significance of laterites as a road-building material. This great importance of laterites together with their varied properties which depend on many factors such as temperature, high humidity and rainfall, have made the study of laterites a subject of continuing interest.

The studied soil is located within Ejigbo Local Government Area, Southwestern Nigeria which falls within the tropical areas where the process of laterization requires conditions of temperature and rainfall that characterize the humid tropic and subtropical zones of the world. These soils are formed under weathering systems productive of the process of laterization, the most important characteristics of which is decomposition of ferro – allumino silicate minerals and permanent deposition of sesquioxides (i.e oxides of iron and aluminum – Fe_2O_3 and Al_2O_3) within the profile to form the horizon of material known as laterties (CIRIA, 1988; Gidigazu, 1976; Gidigazu and Kuma, 1987; Wooltorton, 1975)

However, researches have been carried out on the engineering and geotechnical properties of lateritic soils in Eastern Nigeria (Arumala and Akpokodge, 1987; Madu, 1976 and Aitsebaomo, 1998), Northern Nigeria (Ola, 1978; Ola, 1982 and Omange etal, 1990) and Southwestern Nigeria (Alao, 1982; Agbede, 1992; Ogunsanwo, 1989;

Oladeji and Raheem, 2002; Ogunsanwo, 2002; Agbede and Osuolale, 2005; Bello, 2000 and Tajudeen 2006). There exist no information, at least in published literature on the engineering and geotechnical properties of the lateritic soils of the study area. This scenario has therefore prompted the need for this research work to provide necessary data to meet this urgent and great need. Hence, this study intends to investigate the geotechnical and engineering characterization of the lateritic soil of the study area in order to provide geotechnical data for engineers, designers, contractors, planners and academics.

Description of Study Area

Ejigbo Local Government Area is surrounded by major towns in Oyo and Osun states and lies within latitude $4°05^1$ and $4°24^1$ and longitude $7°40^1$ and $7°\ 55^1$ of the equator as shown in Figure 1. It is surrounded in the north by Ogbomoso, which is about 33km away from it, and south by Ede, which is about 24km of away from it. The land area of the Local Government is about 502 square kilometers with a fairly undulating terrain and highest altitude of about 111.48m above the sea level with rocky subterrain in certain areas.

There exist two distinct seasons, namely: wet and dry seasons. The wet season starts in April and ends in October while the dry season starts in November and ends in April (Tajudeen, 2006)

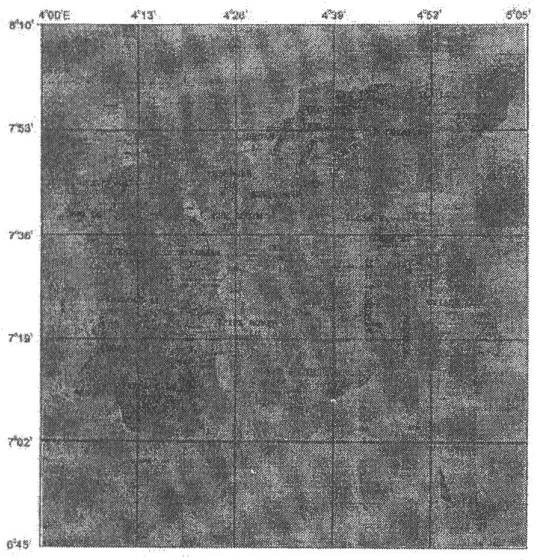

Fig 1 Local Government Map of Osun State

MATERIALS AND METHOD

Collection of Samples

A reconnaissance survey of the study area was conducted during which the soil samples were collected. The study location include; Ansar-ud-deen Grammar School, Ejigbo Local Government headquarter; Popo area, Ogunmado, Bara market, Ejibo central Mosque, Igbo Owa, General Hosipital, Gedu, Aiyegbogbo and Sagan as shown in Figure 2

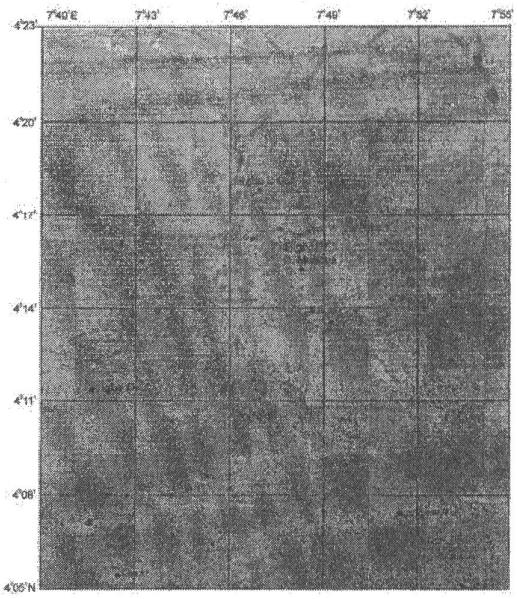

Fig 2 Topographic Map of Ejigbo Local Government

Preparation of Specimens

Trial pits of depth ranging from 1.0 to 1.5m were dug at the various locations in order to collect fairly disturbed samples in accordance with BS 1377 (1990) and Bowles (1988)

Test Procedure

The following test viz: sieve analysis, atterberg limit, compaction, California Bearing ratio, specific gravity and unconfined compressive strength were carried out on each of the disturbed samples. The procedures for the tests are as follows:

Sieve Analysis: Representative sample of approximately 500g was used for the test after washing and oven – dried. The sieving was done by mechanical method using an automatic shaker and a set of sieves.

Liquid Limit Determination: soil sample passing through 425μm sieve, weighing 200g was mixed with water to form a thick homogeneous paste. The paste was collected inside the casangrande's apparatus cup with a grove created and the number of blows to close it was recorded.

Plastic Limit Determination: Soil sample weighing 200g was taken from the material passing the 425μm test sieve and then mixed with water till it became homogenous and plastic to be shaped to ball. The ball of soil was rolled on a glass plate until the thread cracked at approximately 3mm diameter.

Compaction Test: Soil sample passing the 20mm BS sieve of about 7kg was used. The sample was mixed with suitable amount of water of 4% at the initial stage and later increased to 6%, 8%, 10% and 12% on subsequent tests. The soil was compacted using BS mould of 105mm diameter and 115.5mm height. The compaction was done in 3 layers. Each layer was compacted with 2.5kg rammer at 27 blows from a dropping height of 300mm. The Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) were determined from the graph of dry density against moisture content (Bowles, 1988 and BS 1377, 1990)

California Bearing Ratio (CBR): Fresh sets of oven – dried soil was mixed with about 5% of its weight of water. This was put in C.B.R mould in 3 layers with each layer compacted with 55 blows using 2.5kg hammer at a drop of 450mm (standard proctor test). The compacted soil and the mould were weighed and placed under C.B.R machine following the standard procedure. Load was recorded at penetration of 0.625, 1.9,2.25, 6.25, 7.5, 10 and 12.5mm.

Specific Gravity, Shrinkage Limit and Natural Moisture Content. The determination of specific gravity, shrinkage limit and natural moisture content tests followed the standard as outlined in BS 1377 of 1990.

RESULT AND DISCUSSION

Grain Size Distribution: The result of the grain size analysis is presented in Table 1. The result showed that most of the samples are well graded. The results of the well- graded samples show that the smaller particles filled the spaces between the larger particles, giving a dense mass interlocking particles with higher shear strength and low compressibility.

Atterberg Limits: The plastic limit of the samples 1, 3, 5, 6, 7, 8, 9 and 10 exhibits low swelling potential since their plastic index is within 0 – 15, sample 4 has a medium swelling potential since the value is not greater than 25, while sample 2 with value greater 25 has high swelling potential. The liquid limits of samples 1, 3, 5, 8, 9 and 10 ranged between 16 and 29% and therefore suitable for use as subgrade and subbase materials according to the guideline of Federal Ministry of Works of 1997 which states that liquid limit should not be greater than 30% for materials to be used for subgrade and subase. It also suggests plasticity index of 20% maximum. Thus all the studied samples fall within this specification except samples 2 and 4.

Compaction Test: the Optimum Moisture Content values of the samples fall within 8.6 and 16.4% while that of the Maximum Dry Density fall within 1.81 and 2.19 kg/m^3. These values are within the range of previous result obtained within some part of Southwesten Nigeria (Alao, 1982; Ogunsanwo, 1989; Oladeji and Raheem, 2002 and Agbede and Osuolale, 2005).

California Bearing Ratio: The result revealed that all the soil samples have CBR values that fall within the specification for the sub grade, which is 10% minimum for BS compaction.

The Unified Classification System was used to classify samples as SW, SC, SM, GC and GM. Samples1,5,6,7and 8 are classified as SW; samples 2 is classified as SC; samples 3 and 4 are classified as SM; sample 9 is classified as GC and sample 10 is classified as GM.

In the same vein, the result obtained from sieve analysis and atterberg limit test have helped in making reasonable classification according to AASHTO. Samples 1, 3, 6, 7, 8, 9 and 10 belong to group A – 2- 4, which implies that the soil samples could be rated as good for sub grade with good drainage characteristics. Samples 4 and 5 belong to group A – 2 – 6, which indicate that the samples could be rated as fair for the subgrade with fair drainage characteristics and a slightly volume change property. Sample 2 belongs to group A – 2 – 7, which indicates that the sample could be rated as fair sub grade rating with good to fair drainage and slight to medium volume change property.

CONCLUSION AND RECOMMENDATION

The geotechnical characterization of lateritic soils of parts of Ejigbo Local Government Area, Southwestern Nigeria have been investigated. The grain size distribution characteristics reveals that samples are well graded with the exception of samples 2 and 4. These samples (Clayey gravel and sand) are usually rated as excellent to good subgrade materials. The percentage passing through No 200 BS sieve ranged between 10 and 33% showing that the soil samples are coarse materials according to Unified Soil System (USS). Thus, the soil samples can be deduced as suitable for subgrade and base materials as their percentage by weight finer than No. 200 BS test sieve is not greater than 35%, according to Federal Ministry of Works and Housing (1972). Similarly, the low liquid limit and plasticity index qualify the soil samples except samples 2, 6 and 7 as good subgrade materials. This also makes the sample reasonably stable as embankment materials. Using AASHTO classifiation all the sample fall in A-2-4 except sample 2, thus rated as excellent to good subgrade materials. The values of the soaked California Bearing Ratio (CBR) show that the samples are very good as subgrade material. It can therefore be safely concluded that all the samples are suitable as subgrade materials for highway construction except sample 2 and most of the samples are also stable as embarkment materials.

Table 1: Summary of Atterberg Limit, Grain Size Analysis, and AASHTO Soil Classification of the Samples

Sample No	Atterberg's Limits			Grading % passing BS Sieve			Group Classification Index	of soils
	LL(%)	PL(%)	PI(%)	2mm 10	425μm 40	75μm 200	GI	AASHTO
1	28.00	23.29	4.71	54	34	18	0	A-2-4(0)
2	46.5	19.71	26.79	63	49	33	3	A-2-7 (3)
3	21.05	16.70	4.35	77	48	24	0	A-2-4 (0)
4	35.30	12.38	22.92	56	41	30	1	A-2-6 (1)
5	29.40	18.59	10.81	61	33	18	0	A-2-4 (0)
6	39.98	31.44	8.54	60	37	26	0	A-2-4 (0)
7	38.50	31.80	6.70	50	32	22	0	A-2-4 (0)
8	18.66	13.02	5.64	70	42	19	0	A-2-4 (0)
9	16.70	11.18	5.52	52	24	12	0	A-2-4 (0)
10	19.80	14.93	4.87	48	21	10	0	A-2-4 (0)

Table 2: Summary of Compaction, California Bearing Ratio and Unified Classification System.

Sample No.	Location	MDD (mg/m3)	OMC (%)	Soaked (CBR%)	USC	Remarks as embankment material.
1	A.U.D Gramms. Sch	2.01	9.4	21.97	SW	Very stable
2	Ejigbo L.G.H	1.81	16.4	6.09	SC	Reasonably stable
3	Popo Area	2.04	11.3	8.57	SM	stable when dense
4	Ogunmade	2.11	10.2	8.12	SM	Very stable
5	Ejigbo C. Mosque	2.07	9.2	12.35	SW	Very stable
6	Igboowa	2.10	8.9	15.18	SW	Very stable
7	General Hospital	2.08	8.8	18.44	SW	Very stable
8	Gedu	2.06	8.6	9.81	SW	Very stable
9	Aiyegbogbo	2.07	8.6	22.30	GC	Reasonably stable
10	Sagan	2.19	9.3	28.68	GM	Reasonably stable

It is recommended that further studies should be carried out on the lateritic soils in the studied Local Government area on an economic scale. This will one to know the exact quantity of laterites that are available in this area. It is to be noted that clay mineralogical tests have to be recommended for further studies. This enables one to know the degree of laterization considering the amount of total iron in terms of ferric oxide and the silica – sesquioxide of iron and aluminum molar ratio. Also, there is need for investigating lateritic soils from other parts of Nigeria. This would provide comprehensive data on geotechnical properties of the lateritic soils in Nigeria.

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