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GEOTECHNICAL INVESTIGATION OF CLAYEY-SOIL: A CASE STUDY OF SELECTED SPOTS IN ITESIWAJU LOCAL GOVERNMENT AREA, NIGERIA.

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Abstract

Itesiwaju, the study area, is a prominent Local Government Council in Oyo State of Nigeria. A detailed geotechnical investigation was carried out on deposition of clayey-soil in the selected study area through physical observation, field survey and laboratory analysis in line with existing Standards. Seven (7) popular towns (Otu- the Council's Headquarter, Ipapo, Igbojaye, Okaka, Komu, Oke-Amu and Baba-Ode) were considered in the sampling exercise. A representative sampling point was taken from each of the major towns in the study area, all of which revealed well graded soil particles (Gravel-between 7 and 25%, Sand-11 to 18% while Fines ranged from 64 to 78%). Grading the samples with the American Association of State Highway and Transportation Officials (AASHTO)'s Standard, it was discovered that the particles all belonged to A-4, A-5, A-6 and A-7 group. Also, the Plasticity Indices of samples from Ipapo and Komu fell into A-7-6 group, while the rest belonged to A-7-5 group. Samples from Oke-Amu, Komu and Baba-Ode have low swelling potentials while those from Ipapo, Okaka, Otu, and Igbojaye have medium swelling potentials when compared with Standards. All samples were of high plasticity values when measured with Casagrande's plasticity chart. In addition, all analysed samples have relatively high moisture contents, low dry densities and considerably moderate California Bearing Ratio (CBR) values. These are all pointers to the fact that the clay material contents in the study area are high, pure, and plastic which are useful for industrial applications.

Keywords: California Bearing Ratio (CBR), Moisture Content, Plasticity Index, Swelling Potential.

Introduction

Itesiwaju is one of the thirty-three (33) Local Government Areas in Oyo State (See figure I). It came into existence in December 1996, having being carved out of the old Iseyin Local Government Area (Itesiwaju Local Government, 2002). The local government lies in the savannah belt in the Oyo North part of Oyo State between Latitudes 8.05 and 8.45°N, and Longitudes 3.20 and 3.60°E (Duze and Ojo, 1982). It is bounded in the Northern part by Atisbo Local Government, Eastern region by Oyo West Local Government, Southern part by Iwajowa and Kajola Local Government Areas and at Western side by Okpara Forest Reserve (Refer to Figure II). Some notable physical features of the Local Government include rivers like Atan, Oyan, Kojuoba, Otu, Titiale, Ofiki, Owarin, Okaka; Trunks A, B and C roads; Okpara Forest Reserve; Highlands (mountain and hills); Lowlands (plains, lakes etc); physical structures like buildings, dams and other monuments. The principal towns in Itesiwaju Local Government are Otu (the headquarter), Okaka, Komu, Igbojaye, Ipapo, Oke-Amu and Baba-Ode. These towns are however surrounded by numerous villages and hamlets. The predominant occupation of the settlers is farming; a few others are engaged in the civil service, petty trading etc (Akinfenwa, 2005). Most farmers in the study area are faced with challenges such as credit facilities, lack of machineries, storage facilities, subsidies, etc (Adedokun, 2005). For administrative convenience, the council is divided into Ten (10) wards distributed as follows: Otu (2); okaka (2); Ipapo (2); Oke-Amu (1); Igbojaye (1); Komu (1); Baba-Ode (1). In the same vein, the sampling for the geotechnical investigation was based on ward allocations. Representative samples were therefore taken each from the seven major towns. The broad aim of this research is to investigate the extent of clay deposits in the study area. The specific objectives therefore include:

(i) Location of major clay deposit in the study area.
(ii) Determination of the clay content or constituents of the area to ascertain purity or otherwise of such.
(iii) Laboratory analysis of clay sample from the study area for classification, chemical content, compatibility and strength.

The Methodology

(a) Preliminaries:

For the investigation exercise, a thorough field work was embarked upon. A reconnaissance survey of Itesiwaju Local Government was carried out (Figure 1). Based on the feasibility study of the area, major

sampling stations were identified (Figure 2). In all seven (7) stations at varying distances to Otu (headquarter), were selected as shown in Table I.

(b)Clayey-Soil Deposition per station:
During the field trip to the seven (7) stations, major areas naturally endowed with clayey-soil deposition were identified. The areas even though scattered all over the concerned towns, were all easily accessible (Figure 2). These were summarily presented in Table II.

(c)Field Trip Report on Sampling Stations:
(i) Logistics of Sampling Exercise:

The sampling exercise was carried out on the field at the seven selected stations all over the local government area, each sampling point taken from the seven major towns. The exercise was done under the auspices of the Council's management/authority who provided additional human resources and other necessary logistics. The Councilor of each Administrative Ward led the research crew to their respective territories/communities who in turn gave very warm reception to the team. Some of the tools employed for the sampling exercise included digger, sieve, spade, boring auger, steel tape rule, head-pans, sacks, strings etc.

(ii) Collection of Samples:

At each station of major clay deposits, an excavation was carried out until soil profile was ascertained. Whenever the clay soil layer was reached, the sampling was carried out in-situ. The first sample portion taken from each site was about 2kg and was kept in air-tight black cellophane nylon. A bigger sample portion of about 7-8kg was equally taken from each site and placed in fertilizer sacks.

(iii) Sampling Reports:

As earlier mentioned, there are several places where clay is deposited in large quantities all over the Local Government Area. The scope of this work was however limited to seven (7) notable stations located one at each of the major towns. The representative sites, their soil profiles and remarks were as shown in Table III.

(d)Laboratory Analysis:

In all, about 12kg clay samples each from the seven (7) stations were collected and transported to the Geotechnical Laboratory for analysis. The standard method in accordance with British Standard (BS 1377:1975 Methods of test for soils for Civil Engineering purposes) was adopted in the anlysis. Tests conducted include Particle Size Distribution, Liquid Limit, Plastic Limit, Plasticity Index, Moisture Content, Compaction and Carlifornia Bearing Ratio (CBR).

Laboratory Test Results And Discussion:
The results of the Laboratory analysis carried out on the samples from all the stations are as presented below:

(a) Grain-Size Analysis:

As indicated in Table IV, the percentage of gravel, sand, and fines were determined on each sample. For all the samples, the gravel proportion ranged between 7 and 25%, the sand was between 11 and 18% while the fine ranged from 64 to 78%. This is a pointer to the fact that the samples were well graded. When the result is compared with the American Association of State Highway and Transportation Officials (AASHTO) Standard Soil Classification Table, as reproduced in Table V, it was observed that all the samples belong to either A-4, A-5, A-6 or A-7 group. This therefore means that the study area contains High Silt-Clay materials.

(b) Liquid Limits, Plastic Limits and Plasticity Indices:

The Liquid Limits of Samples A,B,C,D,E,F and G are 42, 53, 45, 50, 52, 43 and 51 percentages respectively (Table VI refers).

Relating the results with the AASHTO Standard Soil Classification Table (Table V), it was observed that the liquid Limits were all of either A-4, A-5, or A-7 group. Based on the Plasticity indices, the samples belong to the A-6 or A-7. Meanwhile, samples A and F (i.e samples from Ipapo and Komu) fall to A-7-6 (as Plasticity Index > LL-30) leaving other samples to A-7-5 group. Again, comparing the results with the Standard Table on Criteria for Determining the Potential Expansiveness of soils, as presented in Table VII, it was observed that samples B, F, and G (from Oke-Amu, Komu and Baba-Ode) have Low Swelling Potential (Plasticity Index < 15%) while others (Sample A, C, D and E from Ipapo, Okaka, Otu, and Igbojaye respectively) all have Medium Swelling Potential (Plasticity Index values between 15 and 25%). In addition, when the values are related with Casagrande's Plasticity Chart, it was discovered that all the samples have high Plasticity Values (Liquid Limits > 40%). It should be noted however that High Plasticity Value corresponds to High Clay Content.

(c) Moisture Contents and Dry Densities:

Table VIII summarizes the values of Optimum Moisture Contents (OMCs) and Maximum Dry Densities (MDDs) obtained after analyzing the samples. It is observed that the OMCs ranged from 8.3-14.5%, while the MDDs were of values between 1.95 and 2.21 g/cc. All the samples therefore have Relatively High Moisture Contents and Low Dry Densities.

(d) California Bearing Ratio (CBR) Results:

The values of the soaked CBR obtained from all the samples are generally low and ranged between 18 and 24% (See Table IX). The CBR values, when

compared with the standards indicate an acceptable value for building purposes (although very poor as road construction sub-grade and sub-base materials).

Conclusion

Clayey soil is abundantly deposited all over certain portions of Itesiwaju local government council area. These areas include Olowa, Akolude, Oloori, Aara, Alafara, Koro Pupa, Basorun, just to mention a few. The material contents of the selected areas are quite high, pure and desirable. This research work therefore strongly recommends a profitable application of this natural resource for the benefit of mankind. An Industry for mass-production of clay-bricks could be cited in the local government area. An extension of such factory would enhance gainful usage of clay materials as found in production of clay rubbed slabs, electric hot-plate bases, ceramics, plates, modernized local pots, fire kilns moulds for silver- and black-smith works, earth-dam embankments and a host of others.

Table 1: Approximate distance of sampling station's to councils headquarter.

Station	Town	Approximate Distance to Headquarter (in Km)
1	Ipapo	22
2	Oke-Amu	24
3	Okaka	5
4	Out	0 (Reference Station)
5	Igbojaye	31
6	Komu	37
7	Baba-Ode	40

Table II: Clayey-soil deposition per station at a glance

Station	Town	Location of Clay Deposit	Description of Clay Deposit Area
1	Ipapo	Olowa	Along Okaka Road
		Olorombo	Off Owode Road
		Alamo	Gbonkan Area
		Adigun Farm	Along Iseyin Road
2	Oke-Amu	Akolude	Off Ikere-Dam Road
		Adebayo	Near Alaraba Village
		Alaganran	Along Ikere-Dam Road
		Cassia	Near Alaganran Village
		Aaya	Along Ikere-Dam Road
3	Okaka	Oloori	Along Ipapo Road
		Alamo	Along Temidire Road
		Okaka River side	Along Alaga Road
		Agelu	Behind Celestial Church
4	Otu	Aara	Along Ilero Road
		Alapa Meta	Off Komu Road
		Ongobi	Off Ilero Road
		Ibu-Olodo	Off Okaka Road
5	Igbojaye	Alafara	Along Ilero Road
		BAT Area	Along Komu road
		Iwele	Off Komu Road
		Basorun	Behind Primary School
6	Komu	Koro-Pupa	Along Bausa Road
		Koro-Adekunle	Along Ilepa Road
		Aiyekeke	Along Atogun Road
		Odo-Akuko	Off igbojaye Road
7	Baba-Ode	Basorun	Behind Maternity Centre
		Bale Area	Along Kosebaja Road
		Koro-Pupa	Off Asaju Road
		Arigidana	Along Ilero Road

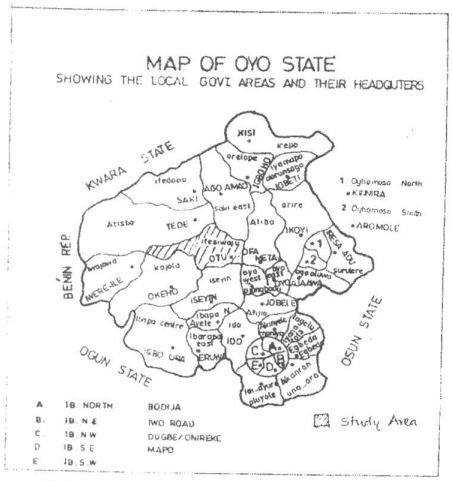

FIGURE 1: Map of Oyo State showing the 33 Local Government Areas

FIGURE 2: Administrative Map of Ifesiwaju Local Government Area indicating the sampling stations

Table III: Detailed field trip report

Sampling Date	Station	Representative Site	Sample Label	Sampling Depth (m)	Soil Profile	Remarks
6-1-2005	Ipapo	Olowa	A	1.40	Humus soil, disintegrated parent material and clay	Pure clay material deposit in very large quantities.
6-1-2005	Oke-Amu	Akolude	B	1.00	Top soil and clay	Pure clay material deposit in very large quantities.
6-1-2005	Okaka	Alamo	C	1.20	Top soil and clay deposit	Pure clay material deposit in very large quantities.
7-1-2005	Out	Aara	D	1.45	Organic residue and clay	Pure clay material deposit in very large quantities.
7-1-2005	Igbojaye	Alafara	E	1.05	Humus and clay	Pure clay material deposit in very large quantities.
8-1-2005	Komu	Aiyekeke	F	0.90	Top soil and clay	Pure clay material deposit in very large quantities.
8-1-2005	Baba-Ode	Basorun	G	1.40	Organic residue and clay	Pure clay material deposit in very large quantities.

Table IV: Grain/particle size distribution of the samples

Location /Sample number	A	B	C	D	E	F	G
Gravel (%)	13	9	25	12	10	8	7
Sand (%)	15	18	11	12	18	17	15
Fines (%)	72	73	64	76	72	75	78

Table V: AASHTO soil classification system

	Granular Materials (35% or less passing No. 200)							*Silt-Clay Materials (More than 35% passing No.200)*			
General Classification	A-1			A-2				A-7			
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5 A-7-6
Seive analysis, percent											
Passing No.10 (2.00mm)	50 max	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
No.40(425 µm)	30 max	50 Max	51 min	.....	.....	.....	.....	.....	.....	.....	.....
No.200 (75 µm)	15 max	25 Max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction Passing No.40 (425 µm)											
Liquid Limit	.....	.....	.....	40 max	41 max	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity Index	.....	6max	N.P	10 Max	10 max	11 min	11 min	10 max	10 max	11 max	11 min
Usual types of Significant constituent Materials	stone fragments, Gravel and sand		Fine Sand	Silty of Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General rating as subgrade				Excellent to good				Fair to poor			

Source: Adewoye et.al (2004)

Table VI: Results of the Atterberg limits of the samples

Location /Sample number	A	B	C	D	E	F	G
Liquid Limit (%)	42	53	45	50	52	43	51
Plastic Limit (%)	26	41	30	34	35	29	39
Plasticity Index (%)	16	12	15	16	17	14	12

Table VII: Criteria for determining the potential expansiveness of soils

Plasticity Index	Swelling Potential
0-15	Low
15-25	Medium
25-35	High
>35	Very High

Table VIII: Optimum moisture contents and dry densities of the samples

Location /Sample number	A	B	C	D	E	F	G
Optimum Moisture Content (%)	8.3	9.3	8.7	8.5	13.2	13.5	14.2
Maximum Dry Density (g/cc)	2.10	1.95	2.21	1.98	2.05	2.14	2.20

Table IX: Results of the CBR tests of the samples

Location /Sample number	A	B	C	D	E	F	G
CBR Values	20	18	21	20	24	21	20

References

Adedokun, S.A (2005) 'Briefs on Agricultural Practices in Itesiwaju Local Government Area' An Unpublished Material from office of Supervisory Councillor For Agriculture. P.2.

Adewoye, A.O., Adegbola, A.A., Bolaji, A.A., and Opebiyi, D.F. (2004) 'Engineering Properties of Foundational Materials of Oyo-OgbomosoRoad, in Southwestern Nigeria'.Science FocusVol 9, p. 46.

Akinfenwa, M.I (2005) 'Itesiwaju Local Government of Oyo State of Nigeria at Nigeria' An Unpublished Text of Local Government Chairman's Address. P.5.

British Standard Institution (1975) 'Method of Soil Tests for Civil Engineering purposes BS 1377. London, British Standard Institution.

Duze, M and Ojo, A (1982) 'Senior School Atlas'. Macmillan, Nigeria, 1st ed. p 13. bmknmn Itesiwaju Local Government (2002) 'History of Itesiwaju Local Government' An Unpublished Text from the Information Unit of Itesiwaju Local Government p. 3.