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Variability in Some Geotechnical Properties of Three Lateritic Sub-Base Soils Along Ibadan Oyo Road

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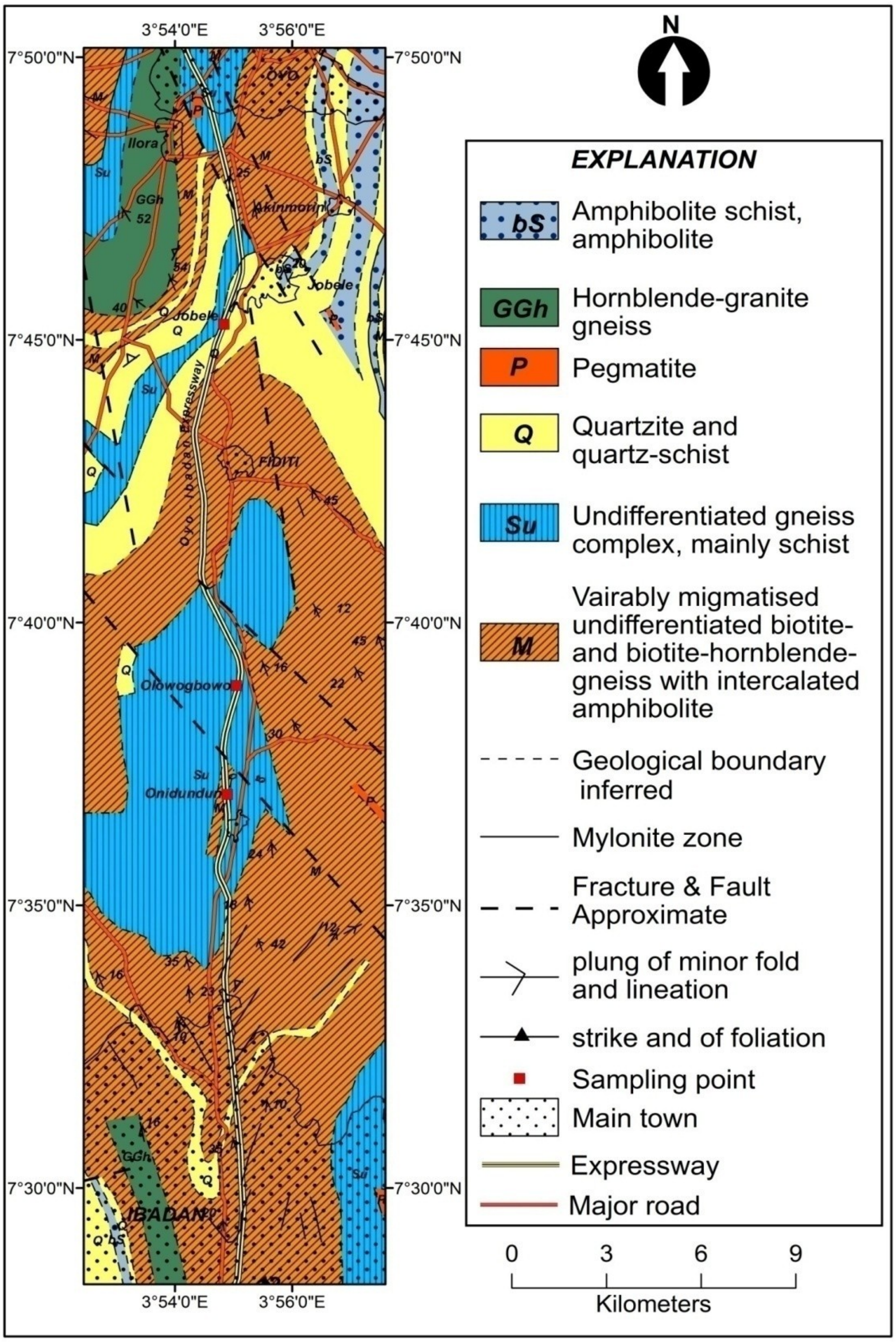
Abstract: *Geotechnical characterization of samples of three lateritic sub-base soils along Ibadan-Oyo highway was executed to establish the variability in properties of the soils. Parameters often used in the evaluation of highway sub-base soils, such as consistency (Atterberg) limits, Grain size distribution, Specific Gravity, California Bearing Ratio (CBR), permeability were considered. The determined Geotechnical properties of the tested soils varied from one location to the other along the highway. Laboratory analyses showed that some parameters such as maximum Dry Density the amount of fines and the unsoaked CBR exhibit high variability while others such as specific gravity, optimum moisture content (OMC) and permeability have low coefficient of variation.*

I. Introduction

Laterite soils are formed in the tropics where there is heavy rainfall during the wet season followed by humid dry season. Laterite soils are essentially the products of tropical weathering and are mainly used for construction purposes. The chemical composition morphological characteristics of these laterite soils are influenced by the degree of weathering to which the parent material has been subjected. Holland (1903) suggested that during the weathering of aluminous silicates in the tropics, the silica, alkalis and alkaline earths are removed in solutions while the alumina and ferric oxide become hydrated and remain behind. However, Ola (1977) stated that from engineering point of view, particularly where there is lack of adequate laboratory facilities, lateritic soils can be regarded as all products of tropical weathering with red, reddish brown or dark coloration . The geotechnical characteristics and field performance of most laterite soils are influenced considerably by genesis, degree of weathering, morphological characteristics, chemical and mineral composition as well as by the environmental conditions (Vargas, 1993; Terzaghi, 1958; Clare and Beaven 1962, 1965; Little, 1969; Gidigasu 1972, 1974, 1976). In the process of laterization, Maignem (1966) and Gidigasu (1976) cited in Ola (1976) have identified three major stages in the process of laterization. First, is decomposition which is characterized by physico-chemical brake down of primary minerals and the release of constituent elements. The second stage involves the leaching, under appropriate drainage conditions, of combined silica and bases and the relative accumulation or enrichment from outside sources of oxides and hydroxides of sesquioxides (mainly Al_2O_3 and Fe_2O_3, the most resistant component to leaching). The third stage is dehydration or desiccation which involves partial or complete dehydration of the sesquioide rich materials and secondary minerals. However, available data on geotechnical characteristics of laterite soils show that they range in performance from excellent to poor for engineering purposes. (e.g. Nixon and Skipp 1957;Bava1957; Lundgren 1969)



Method of Investigation

Both disturbed and undisturbed soil samples were collected from three abandoned borrow pits. The samples taken from each of the three sites (PA, PB, PC) were sent to the laboratory to determine properties such as:

1. Grain size distribution following the British Standard procedure 1377 of 1975.
2. Consistency (Atterberg) limits test
3. Linear Shrinkage
4. Optimum Moisture Content (OMC) and Maximum Dry Density (MDD)
5. Unsoaked (CBR)
6. Permeability

II. Results And Discussion

Table 1. Grain Size distribution parameters of samples from location PA

SAMPLE CODE	% CLAY	% SILT	TOTAL FINE	% SAND				GRAVEL
				COARSE	MEDIUM	FINE	TOTAL SAND	
PA1	32.5	25.3	57.8	6.8	14.2	8.0	29	13.2
PA2	32.4	24.1	56.5	6.1	13.3	11.7	31.1	12.4
PA3	34.9	27.8	62.7	5.8	14.3	12.4	32.5	4.7
PA4	37.3	26.5	63.8	5.5	15.1	11.2	31.8	4.4
PA5	38.1	29.2	67.3	4.4	13.7	10.9	29.0	3.7
PA6	34.2	29.9	64.1	3.8	15.9	12.2	31.1	4.8
PA7	36.6	29.0	66.4	3.9	13.7	11.1	28.8	4.8
PA8	37.3	29.5	66.8	4.2	14.0	10.7	28.9	4.4
PA9	32.2	25.5	57.7	3.1	16.9	15.3	35.3	7.0
PA10	38.0	26.6	64.6	4.4	16.1	11.6	32.0	3.3

Table 2 Grain Size distribution parameters of samples from location PB

SAMPLE CODE	% CLAY	% SILT	TOTAL FINE	% SAND				GRAVEL
				COARSE	FINE	MEDIUM	TOTAL SAND	
PB1	25.0	29.8	54.8	3.3	10.8	14.7	28.7	16.4
PB2	23.0	27.7	51.5	4.2	13.1	13.5	30.8	17.7
PB3	25.4	30.6	56.0	8.5	13.2	17.7	39.4	4.7
PB4	22.3	30.6	52.9	5.5	11.8	14.5	31.9	15.2
PB5	21.6	29.5	51.1	4.4	10.0	16.5	30.8	18.1
PB6	25.3	31.5	56.8	3.8	12.0	15.6	31.3	11.9
PB7	23.5	29.1	52.6	5.7	12.7	14.8	33.1	14.2
PB8	26.9	29.3	56.1	4.2	14.0	10.7	28.9	15.0
PB9	22.5	29.4	51.9	6.9	14.0	15.3	36.1	11.9
PB10	23.9	29.4	53.3	5.8 .	17.0	11.6	34.4	12.3

Table 3. Grain Size distribution parameters of samples from location PC

SAMPLE CODE	% CLAY	% SILT	TOTAL FINE	% SAND					GRAVEL
				COARSE	MED		FINE	TOTAL SAND	
PC1	49.6	18.4	68.0		3.3	10.8	14.7	28.7	3.2
PC2	46.8	19.6	66.4	4.2	12.6	13.5		30.3	3.3
PC3	45.1	19.6	64.7	4.5	13.2	15.4		33.1	2.2
PC4	49.6	21.4	71.0	3.3	11.8	11.9		27.1	1.9
PC5	44.4	19.5	63.9	4.4	10.0	15.1		29.5	6.6
PC6	44.3	21.4	66.5	3.8	12.0	15.6		31.3	2.2
PC7	43.3	19.5	65.5	3.7	14.3	14.8		32.8	1.7
PC8	42.2	22.2	64.6		4.2	14.0	15.2	33.3	2.1
PC9	43.7	22.2	65.9	4.8	12.8	13.4		30.9	3.2
PC10	35.8	26.2	61.9		5.8	17.0	11.6	34.4	3.7

Grain size; The system which has been adopted by the British Standard Institution is the one originally put forward by the Institute of Technology as the well-graded mixture, is one containing an assortment of particles covering a wide range of sizes (Leonard, 1976). Most of the engineering properties of coarse-grained soils are closely associated with the predominant particle size (e.g. Adeyemi 1995 cited in Gidigasu, 1976,).

Tables (1, 2 & 3), show that all grains in the soil samples are well represented in all samples from the three locations, an indication that all the samples are well- graded

Table 4 Consistency limits and Linear shrinkage of samples from location PA

Sample code	w L %	wP %	P I%	Linear shrinkage(%)
PA1	39 .0	21.2	17.8	10.0
PA2	40.1	23.2	16.9	10
PA3	41.1	22.2	18.9	10.7
PA4	37.9	21.1	16.8	9.3
PA5	37.8	21.1	16.7	9.3
PA6	37.9	22.1	15.8	9.3
PA7	41.2	23.2	18.0	10.0
PA8	37.8	21.2	16.7	9.3
PA9	39	21.1	18.0	10.0
PA10	42.3	23.3	19.0	10.7

wL = Liquid Limit; wP =Plastic Limit; PI = Plastic Index.

Table 5				
PB1	42.2	31.1	11.1	11.4
PB2	43.3	32.3	11.1	11.4
PB3	44.3	32.2	12.1	12.1
PB4	47.6	30.1	17.6	12.9
PB5	46.5	29.2	17.3	12.1
PB6	39. 0	29.2	9.9	10.7
PB7	48.7	33.2	15.6	12.9
PB8	43.3	29.2	14.1	11.4
PB9	41.2	30.3	10.9	11.4
PB10	38.9	28.2	10.8	10.7

Table 6 Linear shrinkage of samples at location PC

Sample code	w L(%)	w P (%)	P I (%)	Linear shrinkage
PC1	39	16.2	22.8	10
PC2	44.3	17.3	27.1	12.1
PC3	41	16.2	24.8	10.1
PC4	43.3	17.3	26	12.1
PC5	38.9	15.2	23.7	10
PC6	43.3	16.3	27.1	12.1
PC7	41.2	15.2	26.1	10.7
PC8	38.9	15.2	23.8	10
PC9	36.5	15.1	21.7	9.3
PC10	41.2	16.2	25	10.7

wL = liquid limit; wP = Plastic Limit; PI = Plasticity Index

III. Linear Shrinkage (L.S)

The linear shrinkage is an important parameter in the evaluation of soil as highway sub-base materials. Adeyemi (1995) cited in Gidigasu (1973) suggested that any soil with linear shrinkage below 10% as in samples e.g., at location PA (see table 4) would not pose a field compaction problem. (Tables 5 & 6) have higher linear shrinkages which is above 10% on the average. Madedor (1983) also suggest that a linear shrinkage below 8% indicates a soil that is good as a sub-base , no sample falls within the range.

Table 7
Coefficient of variation (CV) of geotechnical parameters of soil sample from location PA

Parameter	Mean	S.D	C.V(%)	
Unsoaked CBR	6.3	1.41	22.4	significant
Decrease OMC	5.8	1.2	22.03	significant
MDD (increase)	2.41	0.31	12.8	significant
Activity	0.47	0.05	10.85	significant
Amount of fines	48.6	4.2	8.65	Not significant
%Clay size fraction	0.36	0.025	6.93	Not significant
Plasticity Index	17.46	1.12	6.4	Not significant
Linear Shrinkage	9.86	0.55	5.6	Not significant
OMC	13.95	0.51	3.72	Not significant
K-. determined	1.46×10^{-6}	0.045	3.1	Not significant
Specific Gravity	2.71	0.037	1.3	Not significant
MDD(W A)	1918.7	4.29	0.22	Not significant

Table 8
Coefficient of variation (CV) of geotechnical parameters of soil sample from location PB

Parameter	Mean	S.D	C.V(%)	
MDD^{WA}	2064.0	597.78	28.90	significant
K determined	1.81×10^{-6}	0.461	25.4	significant
Amount of Fine	52.3	13.0	24.8	significant
Activity	0.69	0.157	22.8	significant
Plasticity Index	13.05	2.87	21.99	significant
Linear Shrinkage	11.7	2.4	20.5	significant
OMC	7.48	0.9127	12.2	significant
Unsoaked CBR	22.0	2.54	11.5	significant
OMC	10.96	0.70	6.5	Not significant
% Clay size Fraction	0.25	0.0141	5.66	Not significant
% increase in MDD	4.51	0.13	2.86	Not significant
Specific Gravity	2.74	0.02	0.73	Not significant

Table 9
Coefficient of variation (CV) of geotechnical parameters of soil sample from location PC

Parameter	Mean	S.D	C.V(%)	
Unsoaked CBR	10.8	1.55	14.34	significant
Activity	0.55	0.0588	10.69	significant
Amount of Fine	5.3	5.86	10.0	significant
Linear Shrinkage	10.99	1.04	9.53	Not significant
% Clay size fraction	0.45	0.0364	8.08	Not significant
Plasticity Index	24.8	1.72	7.3	Not significant
OMC	9.21	0.6460	7.01	Not significant
MDD	4.96	0.056	1.13	Not significant
Specific Gravity	2.75	0.0173	0.63	Not significant
MDD(WA)	1858.2	6.37	0.34	Not significant
OMC	16.11	0.039	0.24	Not significant
K determined	5.73*(E-6)	0.38	0.067	Not significant

Mean, Standard deviation and Coefficient of variation

The theory of statistical analysis is that if the coefficient of variation of any parameter is 10% and above, it is assumed that the variation is significant. Mean, Standard deviation, and Coefficient of variation are shown in (Tables 7, 8 &, 9), for samples at locations PA, PB & PC. Various geotechnical properties of soil samples at each of the three locations were evaluated and the levels of significant of coefficient of variation are shown in the tables. In summary, Out of the 12 tested parameters in each of the three locations, PA, PB and PC, Unsoaked CBR, OMC and the Activities are significant in terms of coefficient of variation; while the others are not very significant see (tables 7, 8 &9).

IV. Recommendation

Since important geotechnical parameters often utilized in evaluating highway construction materials, exhibit significant variability within the restricted sampling locations, field sampling of such soils should be very comprehensive in order to properly evaluate the soils for highway construction.

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