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MINERALOGICAL AND GEOTECHNICAL CHARACTERISTICS OF SOME SUBGRADE SOILS IN A SECTION OF THE IBADAN/ILE-IFE EXPRESSWAY, SOUTHWESTERN NIGERIA

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ABSTRACT

Air-dried soil samples collected from horizons that form the placement levels at five locations near Gbongan/Oshogbo junction along the Ibadan/Ile-Ife highway, Southwestern Nigeria were studied. The most abundant clay mineral in the soil samples is Kaolinite while other minerals include quartz, illite, chlorite and vermiculite. Although the soils fall into the Group A5 of the American association of State Highways and Transportation Officials Classification System, which indicates poor to fair subgrade soils, their Plasticity and strength characteristics (in terms of California Bearing Ratio (CBR) and unconfined Compressive Strength) are typical of those of good subgrade soils. Fairly strong correlation coefficients of 0.955 and 0.844 were established between the amounts of Kaolinite and CBR and the amount of Kaolinite and unconfined compressive strength respectively. The respective mathematical relationships were $Y=0.14X + 31.07$ and $Y=0.28X-33.63$ where Y and X are the amounts of Kaolinite and CBR/unconfined compressive strength

respectively. The observed remarkable stability of the pavement in the study area can thus be attributed to the preponderance of Kaolinite in, and high strength of, the subgrade soils.

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INTRODUCTION

The almost 80-Kilometre Ibadan/Ile-Ife expressway is an important highway in southwest Nigeria. It serves as a link not only between the western and eastern part of Nigeria but also between the western and some parts of northern Nigeria. As a result of the busy nature of the road, the Federal Military Government some years ago awarded a contract for its dualization, and it was recently commissioned.

Ajayi (1) noticed that failure of a section around Majeroku along the Ibadan-Ile-Ife highway was due to the founding of the pavement on saprolite rather than on the much stronger laterite horizon. Adeyemi (2) established some positive correlations between the strength characteristics (in terms of California Bearing Ratio CBR and unconfined compressive strength) and the amount of kaolinite in some subgrade soils along sections of the Lagos-Ibadan expressway. He also discovered that the degree of stability of the flexible highway pavement increased with the amount of kaolinite in, and strength of, the subgrade soils.

Although Ayangade (3) who investigated some geotechnical properties of highway subgrade soils along Gbongan/Oshogbo road in southwestern Nigeria did not notice any clear-cut relationship between some engineering index properties (such as the plasticitiy) of subgrade soils and the degree of stability of the pavement, he established a fairly strong positive link between the degree of stability of the pavement on the one hand, and the CBR and unconfined compressive strength on the other.

Some positive correlations between the degree of stability and the strength characteristic of subgrade soils were noticed along some sections of the Ibadan end of the Lagos-Ibadan highway (4).

However, there is no recorded investigation on the mineralogical characteristic of subgrade soils in any section of the Ibadan-Ile-Ife highway. It is on the basis of this consideration, that the mineralogical and geotechnical characteristics of subgrade soils along the highway was investigated. This was with a view to esbtablishing geological and geotechnical bases, if any, for the observed stability of the pavement.

The study area of about 1 km long is ½ km east and west of the Gbongan/Oshogbo junction along the Ibadan-Ile-Ife expressway, Southwestern Nigeria (Fig. 1). Although rocks do no outcrop in the vicinity of the study area, available geological report shows that the area is underlain by migmatite-gneiss complex which comprises quartzite and quartz schist, biotite and biotite-hornblende gneiss (5).

MATERIALS AND METHODS

Bulk samples were collected at depths that correspond to the pavement levels of the pavement from five locations in the study area. The samples were air-dried for a period of four weeks prior to the execution of laboratory investigations.

Mineralogical analysis was carried out by use of X-ray diffractometer in the Geology Department of the Obafemi Awolowo University, Ile-Ife. X-ray diffraction technique involves placing a powdered clay sample in a beam of X-rays which is diffracted through characteristic angles by the crystal lattice of the clay mineral (6). The calculated interplanar spacing on each diffractogram was compared with standard values compiled by the American Society for Testing and Materials (ASTM). The highest computed d-spacings were eventually employed in clay mineral identification (7). Estimation of the percentage of each mineral species was carried out by dividing the area covered by the strongest peak of each mineral with the sum of the areas covered by the strongest peaks of all the identified minerals.

Highway geotechnical properties such as grain size distribution analysis, plasticity, CBR and unconfined compression tests were carried out on air-dried samples in the Civil Engineering Department of the Obafemi Awolowo University. Both the CBR and unconfined compression tests were determined for samples compacted at the optimum moisture content of the modified American Association of State Highways and Transportation Officials (AASHTO) level. This level of compaction was adopted because most southwestern Nigerian lateritic soils are not over-compacted at the level (2). The geotechnical tests were carried out by following the procedures stipulated in the British Standards 1377 of 1975 (8). However, modifications of the procedures were made to take care of the peculiar nature of lateritic soils. One of such characteristisc is the aggregation of particles by sesquioxide of iron. The resultant false particles were disaggregated by soaking the soils in weak calgon solution for at least 24 hr during which time the soil was regularly squeezed and agitated.

In order to simulate conditions which operate at sites, CBR of both the unsoaked and soaked samples were determined. This was meant to assess the extent to which ingress of water would reduce the strength and increase the volume of subgrade soils.

RESULTS AND DISCUSSION

Results of mineralogical and geotechnical investigations are presented and discussed in this section. Although several determinations were made for each parameter, only those that were adjudged reliable after statistical treatment are presented here. Emphasis is placed on the comparison of obtained results with some existing standard specifications for highway subgrade soils. This is with a view to ascertaining the mineralogical and geotechnical bases for the stability of the pavement in the study area.

Mineralogical characteristic

Table 1 shows the relative abundance of the identified minerals obtained as a result of qualitative and quantitative interpretations of the X-ray diffractorgrams obtained for the soils (Fig. 2).

Quartz and kaolinite are present in all the soils. Quartz exhibits the least variation among the identified minerals. This suggests that only one parent rock underlies the studied soils since

Table I. Clay mineralogical characteristic of the studied soils

Sample	% Quartz	% Kaolinite	% Illite	% Vermiculite	% Chlorite
A	60.71	14.79	2.82	21.68	-
B	59.09	16.67	1.52	22.73	-
C	57.35	36.02	6.64	-	-
D	23.77	63.82	-	6.31	6.11
E	67.36	32.64	-	-	-
Range	23.71 – 67.36	14.79 – 63.82	1.52 – 6.64	6.31 – 22.73	-
Mean	53.66	32.79	3.66	16.91	6.11
C.V.	31.93	60.17	72.72	54.36	-

C.V. = Coefficient of variation in %

Table II. Some engineering properties of the studied soils

Sample	AF (%)	% Clay	LL (%)	PL (%)	PI	LS (%)
A	59.0	7.6	51.5	37.0	14.5	7.4
B	53.0	9.0	50.0	38.9	11.1	7.8
C	57.0	7.5	47.5	37.2	10.3	6.9
D	55.2	7.5	43.5	36.2	7.3	6.8
E	60.8	8.6	48.7	37.7	11.0	7.2
Range	53.0 – 60.8	7.5 – 9.0	43.5 – 51.5	36.2 – 38.9	7.3 – 14.5	6.8 – 7.8
Mean	57.0	8.04	48.24	37.4	10.84	7.22
C.V.	5.38	10.84	6.68	2.67	23.66	5.57

AF = Amount of fines
PL = Plastic limit
LS = Linear shrinkage
LL = Liquid limit
PI = Plasticity index
C.V. = Coefficient of variation (%)

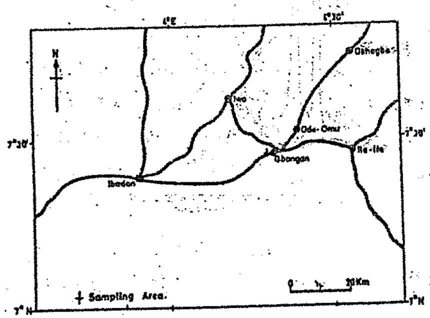


Fig. 1. Location map

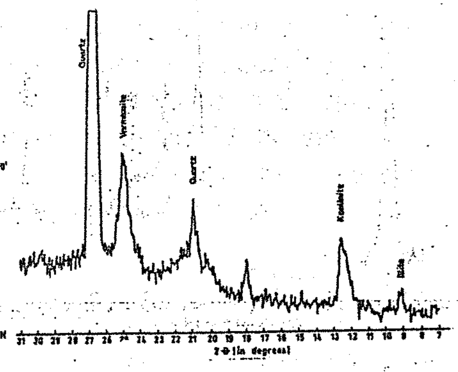


Fig. 2A. X-ray diffractogram of the studied soil.

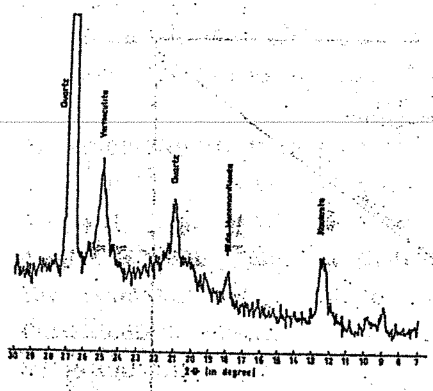


Fig. 2B. X-ray diffractogram of the studied soil.

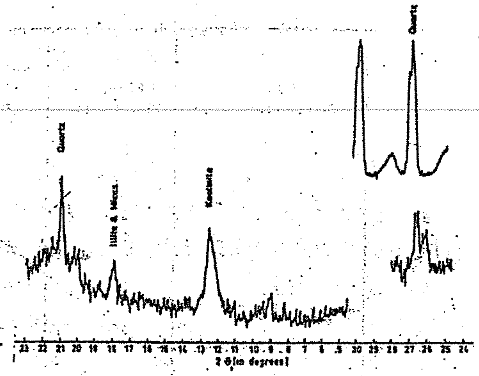
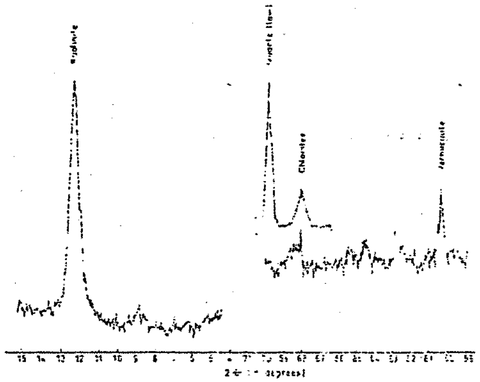


Fig. 2C. X-ray diffractogram of the studied soil.



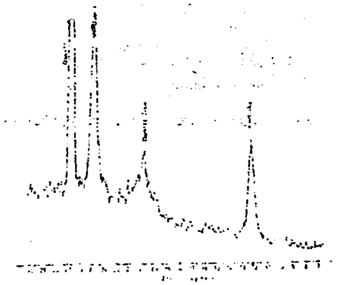


Fig. 2D. X-ray diffractogram of the studied soil.

Fig. 2E. X-ray diffractogram of the studied soil.

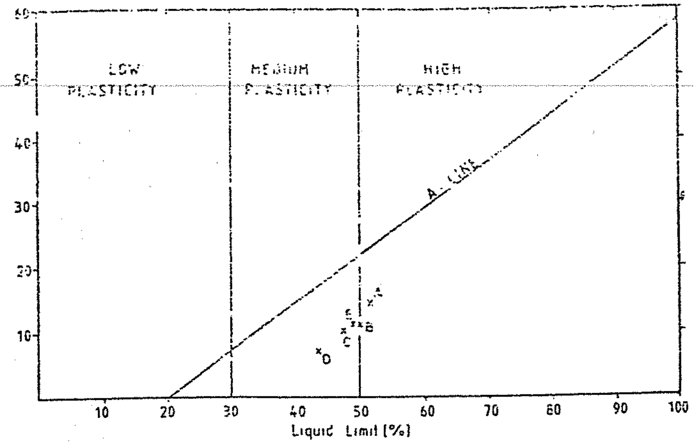


Fig. 3. Casagrande chart classification of the studied soils

the amounts of quartz in residual soils often reflect what obtains in parent rocks.

The dominant clay mineral is kaolinite. This implies that the environment is well drained. Soils which major clay mineral is kaolinite are known to exhibit little expansion in the presence of water and low shrinkage upon exposure to dryness. Kaolinite forms very stable clay because of its tight inexpandable structure which resists the introduction of water into its crystal lattice. The mean value of 32.79% is by far less than the 53.8% and 87.91% obtained for soils below fairly stable and very stable pavement respectively along some sections of the Lagos/Ibadan expressway (2).

Vermiculite is another important clay mineral in the studied soils. The mineral is known to lose water readily on heating but unlike montmorillonite, its interlayer spacing does not expand beyond 15A on addition of water (9). It is thus not as hydrophilic as montmorillonite which was not noticed in any of the studied soils. The absence of montmorillonite is in agreement with the findings of Ogunsanwo (10) and Adeyemi (2) who investigated, inter-alia, the mineralogical characteristics of some residual soils in southwestern Nigeria.

Engineering index properties

The studied soils are generally well graded. The amounts of fines are fairly high but the soils are moderately plastic (Fig. 3 and Table II). Based on grain size distribution and plasticity characteristics, the soils can be classified into Group A-5 of the AASHTO classification system. This means that they are poor to fair subgrade soils.

Although the values of the Liquid limit are higher than the maximum value of 30% stipulated by the Federal Ministry of Works for highway sub-base soils, the value of plasticity index are generally less than the maximum value of 12 recommended by the Ministry. The plasticity index is generally lower than the maximum value of 25 based on French recommendation for road construction in tropical Africa (11). Since the plasticity index is generally less than 25. the soils would exhibit low to medium swelling potential (12).

The linear shrinkage is generally less than the maximum value of 8% for sub-base soils (13). Since the values of linear shrinkage are generally less than 10% the soils would not pose any field compaction problem (14).

California bearing ratio (CBR) characteristic

Table III shows that the studied subgrade soils would suffer appreciable reduction in strength if there is ingress of water below the pavement. This is because the percentage reduction in strength as a result of soaking of the compacted samples ranged between about 45 and 56. It is therefore necessary to ensure good drainage at the study area. This has been taken care of by the road contractor.

The unsoaked and soaked CBR values are generally less than 80% and 30% recommended for highway sub-base and subgrade soils respectively by the Federal Minister of Works. However, the values satisfy the stipulated figures of 0-7% and 7-20% recommended for highway sub-base and subgrade soils respectively (15).

Unconfined compressive strengths

Table IV shows a fairly high increase in strengths of compacted samples after being cured for 48 hr. The percentages increase range from about 25 to 47. Thus under good drainage condition, the strengths of the subgrade soil would improve appreciably with time.

There is no existing specification of values of unconfined compressive strength of soils compacted at the optimum moisture content of any given level of compaction for highway subgrade soils. However, the values obtained for the studied soils are not

Table III. CBR of the studied soils compacted at the optimum moisture content of the modified AASHTO level

Sample	Unsoaked CBR (%)	Soaked CBR (%)	% Reduction in the strength
A	10.88	5.94	45.40
B	11.56	5.21	54.93
C	13.53	7.52	46.42
D	14.50	7.48	48.41
E	12.63	5.56	55.98
Range	10.88-14.50	5.21-7.48	45.40-55.98
Mean	12.62	6.29	50.23
C.V.	11.56	6.21	9.77

Table IV. Unconfined compressive strengths of samples compacted at the OMC of the modified AASHTO level.

Sample	Uncured q_u (KN/m_2)	Cured q_u (KN/m_2)	% Increase in strength
A	160	210	31.25
B	186	273	46.77
C	280	361	28.93
D	288	360	25.00
E	272	356	30.88
Range	160 – 288	210 – 361	25.00 – 46.77
Mean	237.2	312	32.57
C.V.	25.12	21.84	

C.V. = Coefficient of variation (%)
q_u = Unconfined compressive strength

Nigeria. Unpublished B.Sc. (Civil Engineering) project, Obafemi Awolowo University, Ile-Ife, Nigeria. 1992.
4. Adeyemi, G. O. and Oyeyemi, F. Geotechnical basis for failure of sections of the Lagos-Ibadan expressway, southwestern Nigeria. Bulletin of the Engineering geology and the Environment. 59 : 39 – 45. 2000.
5. Jones, H. A. and Hockey, R. D. The geology of parts of southwestern Nigeria, Explanation of 1:250,000 sheets Nos. 59 and 68, Geological Survey of Nigeria Bulletin. 11 : 101. 1964.
6. Hurlbut, C. S. (Jr) and Klein, C. Manual of Mineralogy. 19th Edition. John Wiley and Sons. P. 432. 1971.
7. Chen, P. Table of key lines in X-ray powder diffraction patterns of minerals in clays and associated rocks. Indiana. P. 88. 1977.
8. B. S. 1377 Methods of testing of soils for civil engineering purposes. British Standard Institute. 1975.
9. Gidigasu, M. D. Laterite soil engineering, Elsevier, Amsterdam. P. 554. 1976.
10. Ogunsanwo, O. Basic geotechnical properties, chemistry and mineralogy of some laterite soils from southwestern Nigeria. Bulletin of the International Association of Engineering Geology, Paris. 37 : 131-135. 1988.
11. Simon, A. B., Giesecke, J. and Bidlo, G. Use of lateritic soils for road construction in North Dahomey, Engineering Geology, Amsterdam. 7 ; 197 - 218. 1973.
12. Ola, S. A. Geotechnical properties of an Attapulgite clay shale in Northwestern Nigeria. Engineering Geology, Amsterdam. 19 : 1-13. 1982.
13. Madedor, A. O. Pavement design guidelines and practice for different geological areas in Nigeria. In Ola, S. A. (ed.). Tropical soils of Nigeria in Engineering practice, A. A. Balkema (publishers), Rotterdam, Netherland. PP. 291-297. 1983.
14. Gidigasu, M. D. Review of identification of problem laterite soils in highway Engineering. Transport Research Board, Washington. 497 : 96 - 111. 1973.
15. Asphalt Institute Soil Manual Maryland, United States of America. P. 176. 1961.

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CHEMICAL ANALYSIS AND MORPHOLOGICAL PROPERTIES OF TWO SPECIES OF MELIACEAE IN PULP AND PAPER MAKING

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ABSTRACT

Chemical analyses were carried out on two Nigerian wood species, Cedrela odorata and Melia azadarach and their pulping potentialities investigated. Cedrela gave the following results on analysis: basic density 691.99 kg/m^3, pH 6.27, 20% solubility in 1% NaoH solution, 12.1% solubility in hot water, 15.5% solubility in cold water. Melia gave the following results on analysis: basic density 563.9kg/m^3, pH 4.54, 20% solubility in 1% NaoH, 20.6% solubility in hot water and 15.7% solubility in cold water. The wood species were also screened for their fibre properties. Melia had a fibre length of 1.40mm, fibre diameter of 31.29μm, Runkel ratio of 0.90, while Cedrela had a fibre length 1.10mm, fibre diameter of 28.54μm and Runkel ratio of 0.91. Melia gave a pulp yield of 42.6%, Cedrela gave 40.00% yield on sulphate cook. On soda cook, Melia gave 40.00% pulp yield, Cedrela gave 38.52%. On the acid cook Melia gave 25.2% yield while Cedrela gave 20.00% pulp yield.

INTRODUCTION

Pulp and paper production constitute an important Industry in any Nation's economy. As food is important to a nation, so pulp and

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