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Engineering Geological Properties of Soil Subgrade of Ilawe-Ikere Ekiti Proposed Highway Alignment, Southwestern Nigeria

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Abstract: This study examines the engineering geological properties of the soil subgrade along, the proposed Ilawe-Ikere Ekiti highway alignment. Engineering geological mapping showed that thick mantle of soil along the proposed road alignment is underlain by older granite rock. Outcrops of the grayish, fine to coarse-grained granite were mapped in some localities in the area. Disturbed soil samples collected were subjected to several laboratory tests including clay mineralogy, natural moisture content, grain size, specific gravity, consistency limits, linear shrinkage, compaction and California bearing ratio tests. Petrographic analysis of thin section of older granite rock was carried out. XRD diffractograms revealed prominent Kaolinite peaks and subdued illite peaks, the natural soil moisture range from 2.0-2.8%, liquid limit from 36.0-43.0%, plastic limit from 15.8-20.5%, linear shrinkage from 2.10-2.60% and specific gravity from 2.66-2.74. The compaction characteristics of the soil indicated dry densities ranging from 1910-2050 kg m^{-3} at optimum moisture content of 15-18.2%. Petrographic study of the older granite thin section revealed the presence of biotite, amphibole, muscovite, quartz, pyroxene, plagioclase and opaque minerals in the rock. The engineering geological data obtained showed that the soil is good for all civil construction work including road subgrade.

Key words: Engineering, geological properties, propsed highway, construction work, pyroxene

INTRODUCTION

Ilawe-Ekiti and Ikere-Ekiti are 2 densely populated headquater towns in Ekiti Southwest and Ekiti South local government councils, respectively. The occupation of the inhabitants in the two towns is predominantly farming. The farm products in the area include cocoa beans, forest reserver colanut, plantains, banana, beans, cocoyam, palmoil and kernel pepper, vegetable etc.

The needs to transport these important food items to market centres have prompted the government of Ekiti State to initiate the idea of linking the two communities with a good road network. It is also the wish of the government in power in Ekiti State to network these 2 communities by a good road as one of the means of gaining political strength in the two communities. It is a general belief that networking the 2 communities with a good road will enhance civilization, development of small scale cottage industries, sourced primarily from agricultural products and improved income and purchasing power of the farmers and the community dwellers. As local government council headquater towns, much emphasis is laid by government authorities on self-reliance as a veritable tool for development and community empowerment.

In an unstable typical third world economy, there is the need to over stretch limited fund available for such development as road construction. Therefore, there is a dire need for proper preconstruction site investigation work to enable engineers understand the necessary construction expedients and essential rock and soil data acquired from detailed study of the proposed highway alignment. This important need informed this investigation so that the design engineers responsible for designing the road would have required information for designing the road appropriately.

MATERIALS AND METHODS

The investigation was carried our both in the filed and in the laboratory. The field based investigation involved mapping the road alignment and observing the rock and soil conditions and the general nature of the environment where the road is routed. Distrubed soil samples were taken from critical section of the alignment where difficulties are suspected. These disturbed soil samples were taken to the laboratory and subjected to different tests which range from natural moisture content, Alterberg limits, linear shrinkage, specific granity, compaction, California Bearing Ratio (CBR) and X-Ray

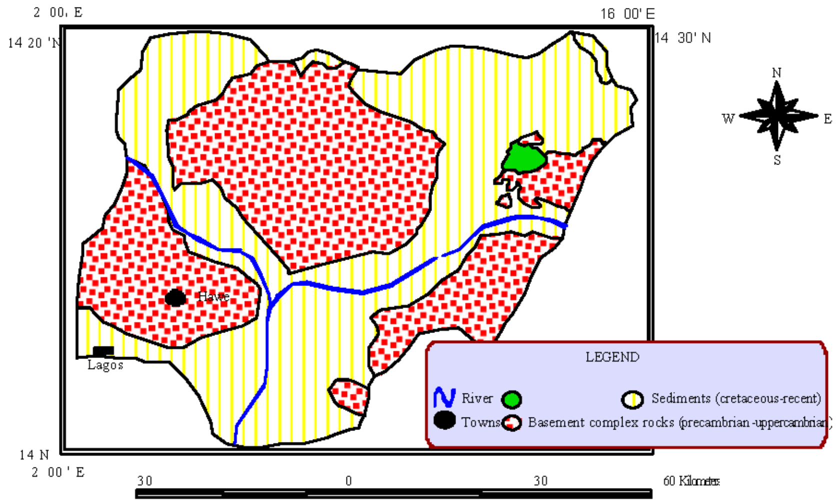

Fig. 1: Simplified geological map of Nigeria

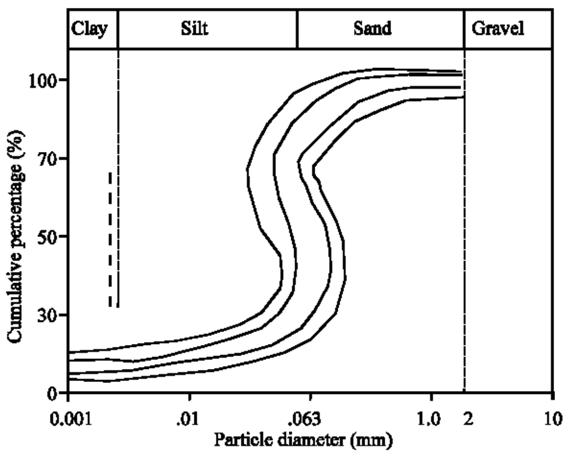

Fig. 2: Particle size distribution curves for the studied soil samples

Diffraction (XRD) analysis. All the tests were performed in accordance with the procedures specified by the American Society for Testing and Materials and the british standard institution (ASTM, 1979; BS, 1377, 1975). Petrographic study of thin sections of the rock samples was carried out using the polarizing microscope in the laboratory. The minerals were identified using their optical properties. Modal analysis of the minerals were also done.

Physical setting and geology of the study areas: The study area in Southwestern Nigeria is indicated in Fig. 1. Ilawe-Ekiti is situated within the basement complex environment of the crystalline rocks in Nigeria (Rahaman and Malomo, 1983; Jegede, 1999). At Ilawe, the basement complex rocks include granites, granite gneisses and quartzite ridges but the road alignment studied traversed granite terrain, which occurs in many places as plutons along the periphery of the road alignment. Petrographic studies showed that the mineralogy of the granite include biotite, amphibole, muscovite, quartz, pyroxene, plagioclase and opaque as shown in Table 1. The structural features exhibited by the rocks include folds, faults and joints.

RESULTS AND DISCUSSION

Texture and consistency: The textural envelopes for the studied soil are shown in Fig. 2. The envelopes indicated a uniformly graded soil with the absence of gravelly soil fractions. However, reasonable amount of sandy fraction size in the soil indicated strength increase emanating from quartz formed from weathering of the older granite rock. All the soil samples plot within inorganic clays of intermediate plasticity region in the casagrande plasticity chart (Casagrande, 1947) (Fig. 3).

Moisture-density relationship: The compaction characteristics of the studied soils are shown in Fig. 4. Four curves were selected to show the relative variation in moisture/density relation. The dry density of the soil range from 1910-2050 kg m^{-3} while the optimum moisture content range from 16-16.6%. Since the moisture content is relatively minimal, the soil is considered good for construction purpose.

Linear shrinkage and specific gravity: The results of the linear shrinkage and specific gravity values are both presented in Table 1.

Table 1: Summation table for subsoils engineering properties

Location	Natural moisture content	Consistency limit: Liquid limit (%)	Plastic limit (%)	Plasticity index (%)	Linear shrinkage	Specific eravity	Compaction: MDD (kg m^{-3})	OMC kg m^{-3}(%)	CBR (%)	Unified classification
I L 1	2.3	42.8	20.5	22.3	2.40	2.74	2020	18.2	89	CI
I L 2	2.5	43.0	15.8	27.2	2.60	2.66	2050	16	86	CI
I L 3	2.8	43.0	19.9	23.1	2.10	2.71	1910	16.6	83	CI
I L 4	2.0	36.0	16.0	20	2.50	2.70	2030	15	81	CI

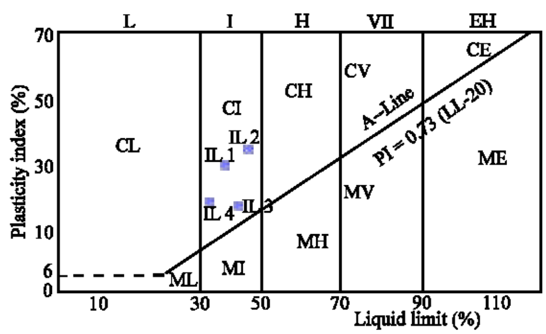

Fig. 3: Casagrande's plasticity chart for studied soil samples

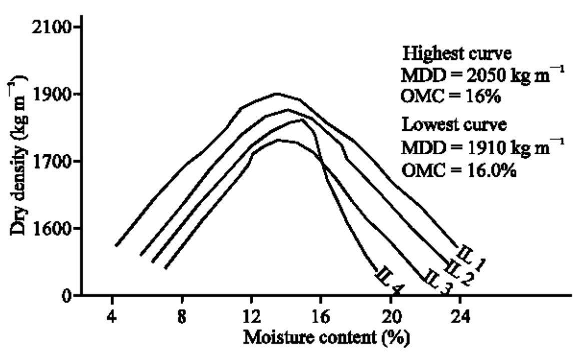

Fig. 4: Moisture density relationship for granite derived sbsoils along llawe-lkere road

It is observed from the table that the linear shrinkage values vary from 2.10-2.60. Soils with linear shrinkage value above 8 would be inactive and inexpansive. Such soil would not present field compaction difficulties (Brink *et al*., 1982; Jegede, 1994, 2004). The occurrence of abundant Kaolinite in the soil further confirms this assertion, as revealed by the clay mineralogical test results (Fig. 5). The modal analysis shown in Table 2 suggested that the Kaolinite in the soil specimen must have emanated from the decomposition of the feldspars in the parent older granite during weathering.

The specific gravity test results showed that the specific gravity values range from 2.66-2.74. The reason

Table 2: Modal analysis of granite

Minerals	1st count	2nd count	3rd count	Total	Modal %
Biotite	3	3	2	8	10
Amphibole	3	2	3	8	10
Muscovite	9	8	8	25	33
Quartz	2	3	3	8	10
Pyroxene	3	2	2	7	10
Plagioclase	6	7	7	20	25
Opaque	1	1	1	3	2
				79	100%

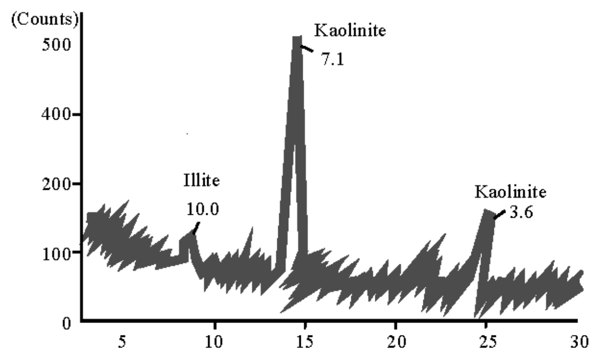

Fig. 5: Diffractogram for the clay (<2 micron) fraction of the studied soil sample

for the relatively high specific gravity values is because of abundant quartz in the parent older granite rock as revealed by the modal analysis result, which is shown in Table 1.

It is believed that the occurrence of abundant quartz in the soil will impart some strength into the soil thereby increasing the bearing capacity of the soil.

California bearing ratio: The graph indicating the California bearing ratio of the soil is shown in Fig. 6. The unsoaked CBR values of the soil range from 81-89%. Although an unsoaked CBR value of 50 is considered adequate for subgrade soil materials, however, these obtained CBR values support earlier facts that the soil is considered suitable for construction purposes. (Jegede, 2000).

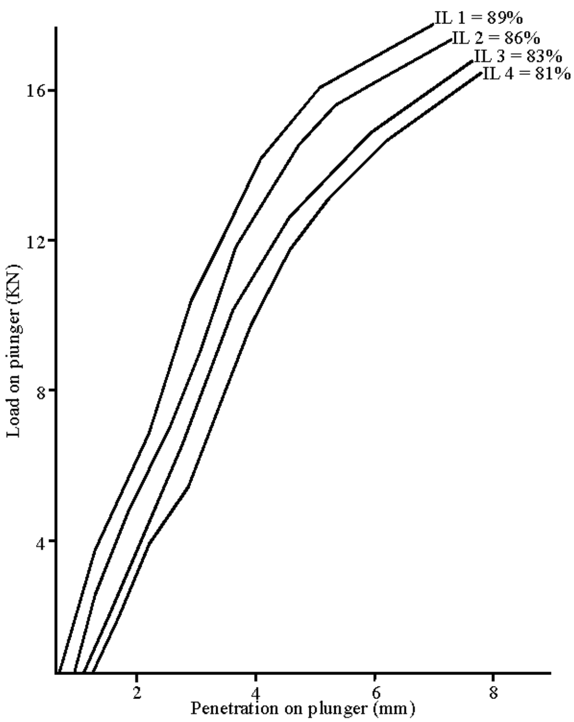

Fig. 6: CBR curve for studied granite-derived subsoils

CONCLUSION

All structures regardless of the material of which they are constructed rest ultimately upon soil and rocks. Consequently, the design of the foundations and the settlement behaviour of the completed structure depends on the engineering geological properties of the underlying material and on its action under the stress imported by the foundation. The laboratory geotechnical tests results and field information collected on the rocks in the area both support that the soil is suitable for construction works. Granite is a competent rock when it is not weathered nor fractured, low linear shrinkage values with high unsoaked CBR values attested to the fact that the subsoil along the alignment of the proposed road will be suitable for the entire road construction and other civil works in the area.

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