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Variability in the geotechnical properties of a lateritic soil from south western Nigeria

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Abstract Four bulk soil samples of lateritic soil from the subgrade of the stable flexible highway pavement at Awosun village, near Ile-Ife, Nigeria, were investigated to determine the variation in geotechnical properties within a horizontal distance of 39 m. The California bearing ratio and uniaxial compressive strength were found to vary significantly over this short length. The importance of detailed and thorough sampling of lateritic soils is emphasized for proper evaluation of highway subgrade soils.

Keywords Laterite · Highway sub-base · California bearing ratio · Uniaxial compressive strength · Nigeria

Résumé Quatre échantillons de sols latéritiques utilisés pour la couche de forme d'une chaussée d'autoroute près du village d'Awosun dans la région d'Ile-Ife (Nigéria) ont été testés afin de déterminer la variation de leurs propriétés géotechniques sur une distance de 39 m. L'indice CBR et la résistance à la compression simple ont été déterminés et il est apparu des variations significatives de ces paramètres. On en déduit que la variabilité naturelle des sols latéritiques dans les zones tropicales doit être prise en compte de façon plus précise dans les techniques d'échantillonnage de ces matériaux.

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Mots clés Latérite · Couche de forme · CBR · Résistance à la compression simple · Nigéria

Introduction

The geotechnical properties of lateritic soils have been investigated by a number of researchers in southwestern Nigeria. Balogun (1982) studied some physical, geochemical and geotechnical properties of laterite borrow material in the Shagamu—Iperu area and found significant differences between some index properties of air-dried and oven-dried soil samples. He also noted that the grading and plasticity characteristics meant the soil could be used for highway sub-base material although the CBRs were lower than the recommended specification. Malomo et al. (1983) investigated the "peculiar characteristics" of some southwestern Nigerian soils and concluded they were mechanically stable but slightly thermally unstable. Ogunsanwo (1989) reported some geotechnical properties of five genetically different lateritic soils from southwestern Nigeria, noting the variations in their cohesion. Olukoga (1990) attributed the failure of a section of the flexible pavement on the Ile-Ife highway to the low specific gravity (indicative of a low degree of laterization), CBR and high water absorption capacity of the subgrade material.

Owolabi (1991), in his study of lateritic sub-base soils along the Ile-Ife/Sekona Oshogbo road, reported that soil samples compacted at the modified AASHTO level possessed better geotechnical properties than those compacted at the West African level. Adedeji (2001) established a fairly strong correlation between the energy of compaction and geotechnical properties of a banded gneiss-derived lateritic soil from Ago-Iwoye, southwestern Nigeria. However, little research has been carried out on

Table 1 Grain size distribution parameters

Test no.	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Amount of fines	Uniformity coefficient
1	13.0	41.8	26.2	19.0	54.8	142.3
2	13.0	39.8	29.2	18.0	52.8	134.6
3	5.5	46.8	22.7	25.0	52.3	60.0
4	6.0	47.0	23.0	24.0	53.0	39.0
5	8.0	49.5	22.5	20.0	57.5	30.0
6	8.0	49.1	24.9	18.0	57.1	37.0
7	3.0	53.2	20.8	23.0	56.2	30.0
8	3.0	54.2	20.8	22.0	57.2	22.4
Average	7.4	47.7	20.8	21.1	55.1	61.9

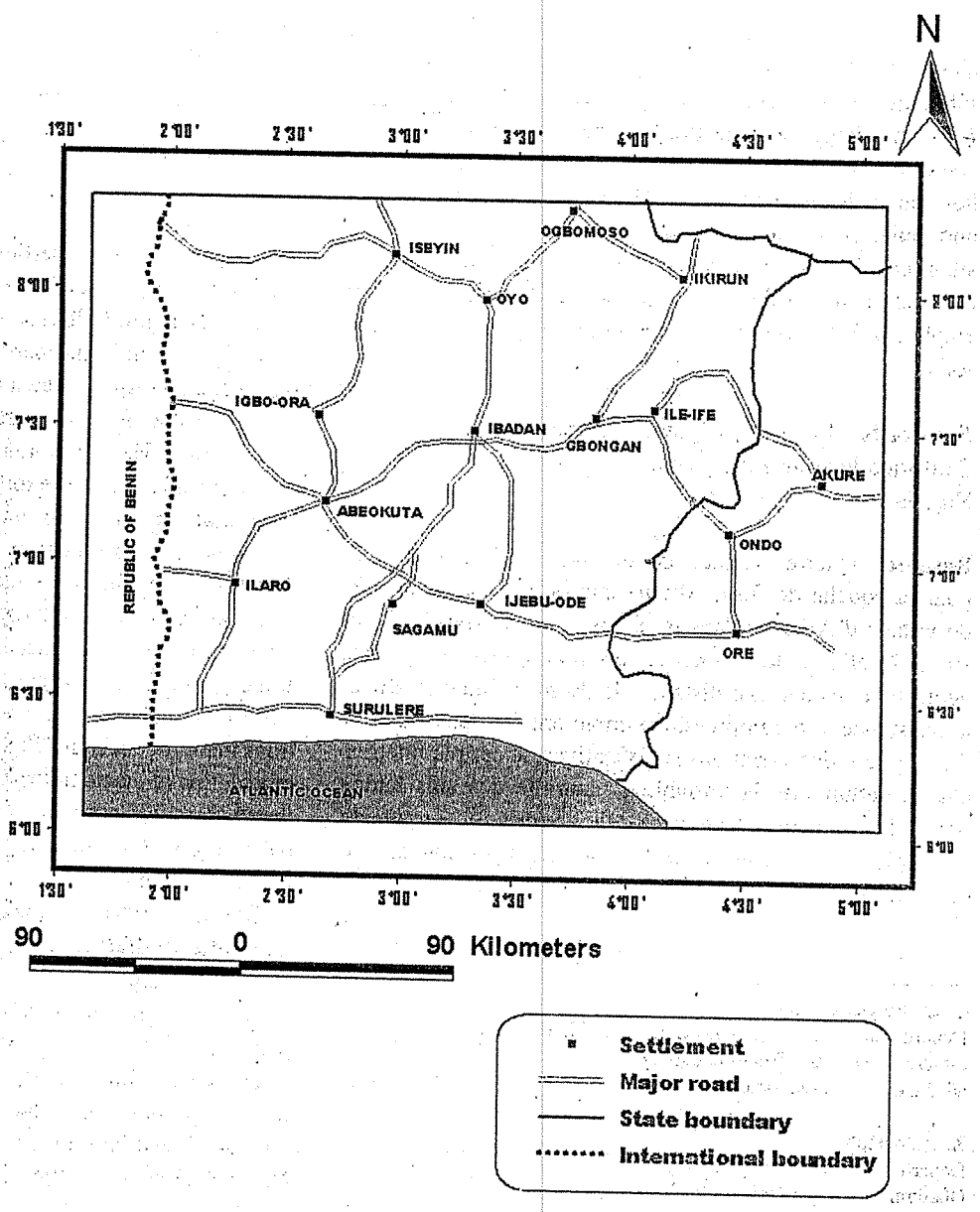

Fig. 1 Map of parts of south western Nigeria showing Ile-Ife near the study location

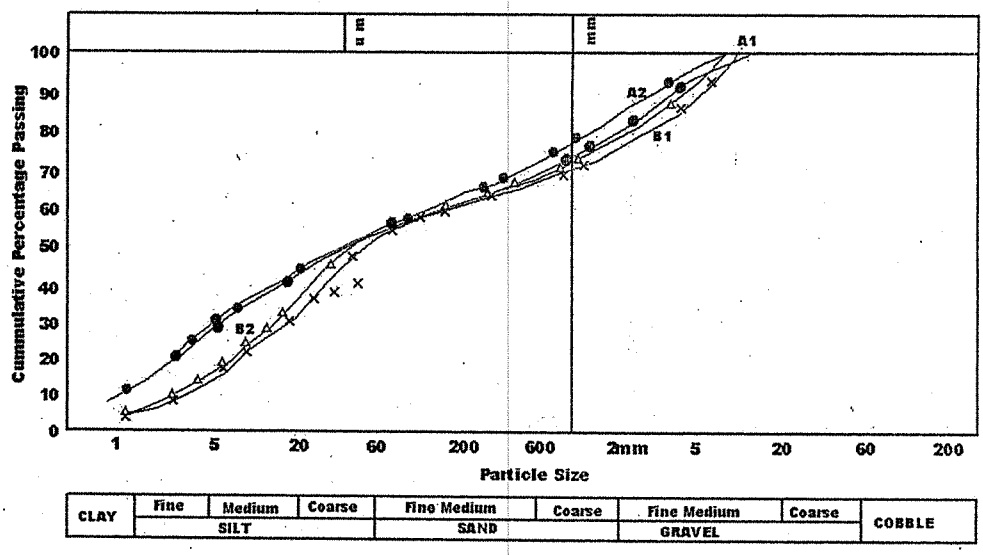

Fig. 2 Particle size distribution curves for samples *A1*, *A2*, *B1* and *B2*

the degree of variation in the geotechnical properties of closely spaced samples of lateritic soils in southwestern Nigeria. This paper discusses the geotechnical properties of four samples of pegmatite-derived lateritic soil obtained within a horizontal distance of 39 m, i.e. approximately 13 m apart.

The study area

The sampling location (latitude 7°40′, longitude 4°10′) is adjacent to Awosun village, about 8 km from Ile-Ife (Fig. 1). The topography is fairly flat and the flexible road pavement is quite stable. Although no rock outcrops in the vicinity of the sampling location, generally the bedrock in this area is a migmatite gneiss/pegmatite, consisting of alkali feldspars, quartz and micas (mainly muscovite). The derived soil is generally sandy silty lateritic clay.

Materials and methods

The four bulk soil samples were taken at Awosun village at a depth of 1.0 m, similar to the placement level of the adjacent flexible highway pavement. Each bulk sample was then divided into two and air-dried for a period of two months prior to being tested. The tests carried out (generally following BS 1377 (1975) included grain size distribution, liquid limit, plastic limit, linear shrinkage, compaction at the modified AASHTO level, CBR and unconfined compression. Samples for grain size analysis were soaked in a weak calgon solution to facilitate disaggregation during wet sieving.

Results and discussion

Classification tests

The results of the grain size distribution analysis are summarized in Table 1 and the grading curves presented in Figs. 2 and 3. The average amounts of clay, silt, sand and gravel size particles are 7.4, 47.7, 23.8 and 21.1%, respectively. The average uniformity coefficient of 62 is indicative of a well graded soil and hence a good highway sub-base and sub-grade material.

The results of the liquid and plastic limit tests are summarized in Table 2. The average values of liquid limit, plastic limit and plasticity index are 45, 22 and 23%, respectively. Philip (1952) cited in Wahab (1997) indicated that any lateritic soil having a liquid limit in excess of 30% and plasticity index above 12 should be rated poor for use under bituminous surfacing. However, the Federal Ministry of Works and Housing (1974) specified a maximum liquid

Table 2 Plasticity characteristics

Test no.	Liquid limit (%)	Plastic limit (%)	Plasticity index	Linear shrinkage (%)
1	46.0	19.6	26.4	7.3
2	46.0	19.7	26.3	7.3
3	49.5	22.3	27.3	7.4
4	54.5	26.0	28.5	7.5
5	39.0	23.5	15.5	7.6
6	41.6	25.5	16.0	8.7
7	44.5	22.7	21.9	8.7
8	39.0	15.7	23.3	8.0
Average	45.0	21.9	23.1	7.8

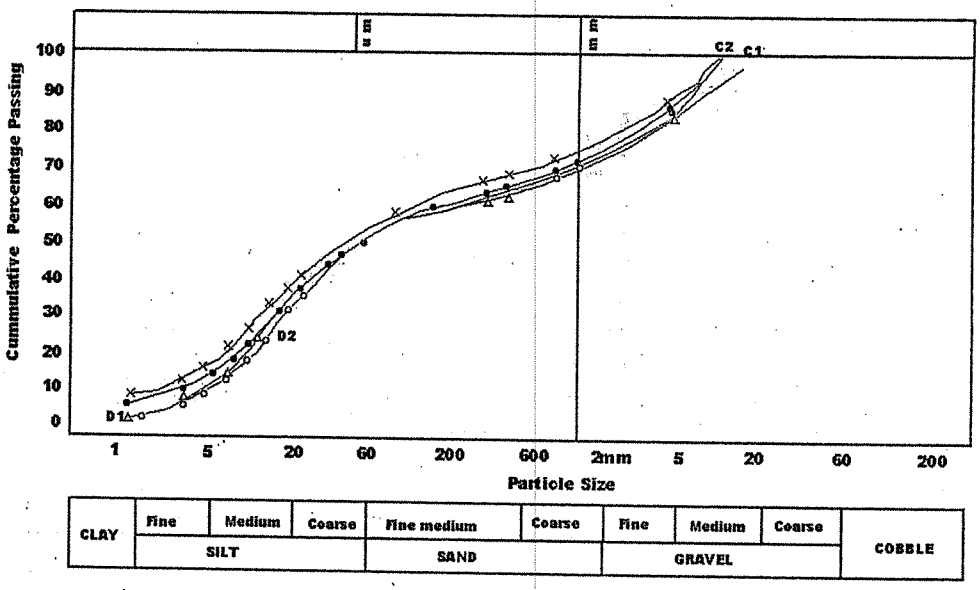

Fig. 3 Particle size distribution curves for samples *C1*, *C2*, *D1* and *D2*

limit of 40% and a maximum plasticity index of 20 for highway subgrade material.

The Casagrande chart classification (Fig. 4) places virtually all the soil samples in the medium plasticity/compressibility region. Placement of axle loads on a flexible highway pavement constructed on this soil would not therefore be expected to cause any significant deformation—the flexible pavement adjacent to the sampling location is devoid of waves.

The soil falls into Group A-7-6 of the AASHTO classification system suggesting a poor subgrade material. The fact that the highway pavement placed on this soil is very stable indicates that there is a need for engineers working in tropical areas to exercise some caution in the application of specifications designed for temperate zones.

The linear shrinkage of the samples varied from 7.3 to 8.7%. The average value (7.8%) is less than the maximum of 8% recommended by Madedor (1983), hence based on

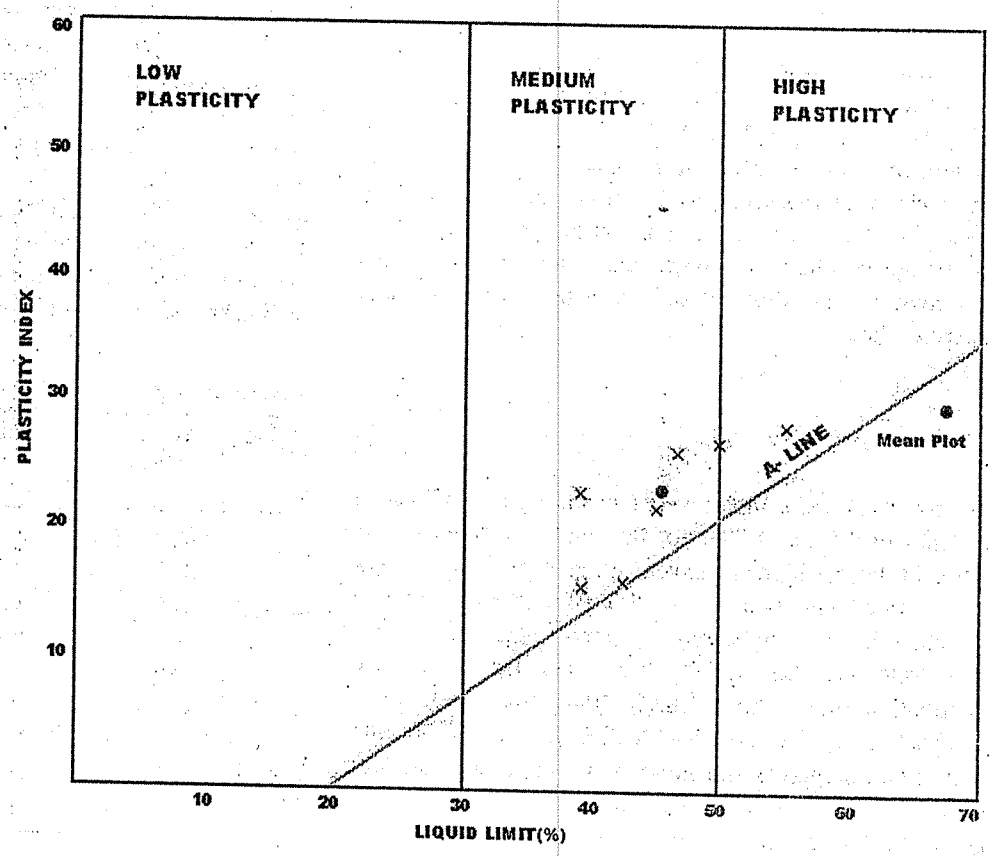

Fig. 4 Casagrande chart classification of the soil samples

variability in the mineralogical, chemical and hence geotechnical properties of lateritic soils, even within a restricted area.

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