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INFLUENCE OF SUBGRADE SOIL ON PAVEMENT PERFOMANCE: A CASE STUDY OF AGO-IWOYE – ILISHAN ROAD, SOUTHWESTERN NIGERIA

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ABSTRACT

Ago-Iwoye –Ilisan road is the major road that links Abeokuta the state capital of Ogun –state to Ijebu towns. The road has always been experiencing pavement failure, which occurs inform of cracks and potholes. Being the major road, the effect of the failure has negative impact on the soico-economic growth of Ijebu –areas. The primary objective of the study was to determine the influence of the geotechnical properties of the sub-grade materials on the pavement performance of Ago-Iwoye – Ilishan Road. Eleven (11) soil samples were collected at eight (8) different locations with the aid of hand auger and were air-dried before taken to the laboratory for determination of engineering properties. The Liquid limit and the Plastic limits ranged from 13.9 – 46.2% and 8.1 – 32.7%, with the Plasticity index from 10.6 – 15.9% and Shrinkage limit from 6.2 – 27.7% respectively. The soaked CBR values of the subgrade materials is between 67% and 75% compared with 30% minimum specified by FMWH, 1997.

The soils were classified by ASSHTO under the A-6 and A-7 category which shows that the soils are fair to poor as a sub-grade material and USCS classification shows that the soil falls into the SM and SC group.

The comparison of all the results with the Nigeria specification (Federal Ministry of Works and Housing general guidelines) for the sub grade materials along the Ago-Iwoye- Ilisian road show that the materials underlain the pavement do satisfy the Nigeria standard. Therefore, the perennial failure frequently experience along the road route is not significantly influenced by subgrade materials. Hence, influence of other factors such as poor drainage courses, level of groundwater table, variation of geologic materials along the road route and poor construction materials should be thoroughly addressed before embarking on future rehabilitation of the highway.

1. INTRODUCTION

A pavement section may be generally defined as the structural material placed above a sub-grade layer (Woods and Adcox, 2006). The characteristic of the soil bed over which the entire pavement system rests on represents subgrade soils (Mcghee, 2010).

Pavement failures are common features of Nigerian roads. Despite several rehabilitation attempts, the reason for their occurrence seems not to be well understood.

The sub-grade provides a foundation for supporting the pavement structure. As a result, the required pavement thickness and the performance obtained from the pavement during its design life will depend largely upon the strength and uniformity of the sub-grade. Hence, a thorough investigation of the sub-grade should be made so that the design and construction will ensure uniformity of support for the pavement structure and realization of the maximum strength potential from the particular sub-grade soils.

Ago-Iwoye –Ilisan road is the major road that links Abeokuta the state capital of Ogun –state to Ijebu towns. The road has always been experiencing pavement failure, which occurs inform of cracks and potholes (see Plate 1&2).Being the major road, the effect of the failure has negative impact on the socio-economic growth of Ijebu –areas. The primary objective of the study was to

determine the influence of the geotechnical properties of the sub-grade materials on the pavement performance of Ago-Iwoye – Ilishan Road.

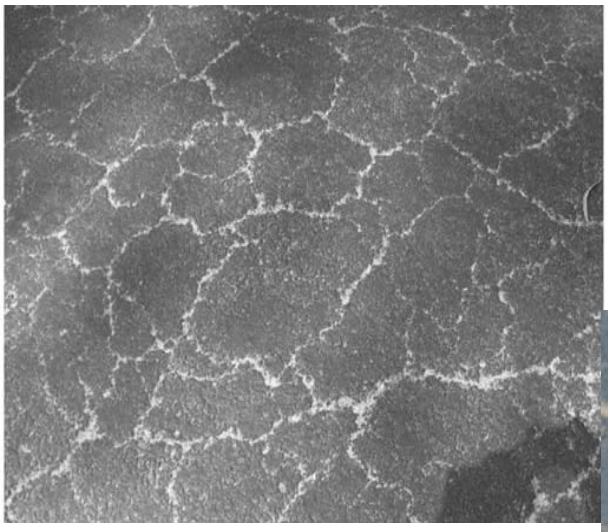

Plate 1: Cracks on the pavement of the study Highway

Plate 2: Cracks on the pavement of the study Highway

2. LOCATION OF THE STUDY AREA

The study area Ago-Iwoye – Ilishan road, is situated in the south-western part of Nigeria within latitudes $06^0 53'00"$-$06^0 57'00'$ and longitudes $3^0 44'00'$-$3^0 56'00'$ (Fig. 1.0). The road traverses Irolu, Ijesha-Ijebu, Oladele, Ajegunle settlements with other small villages. Akanni, (1991) stated that Ago –Iwoye - Ilishan road can be specifically placed in the humid tropical region. The rainy season ranges from mid-March to early November with double maxima of rainfall whose peaks occur in June and September while the dry season lasts from November to early March with the month of December and January relatively dry. The mean monthly rainfall varies from less than 50mm in January to over 200mm in June and July. A relatively lower amount of about 140mm in August is due to the little dry season or August break, which is the normal form of climatic condition throughout Nigeria. The vegetation of the area is characterized by the rain forest type influenced by human activities such as construction of roads and houses, farming etc. River Ome is the main river that forms the drainage. The river flows through a N-S direction, parallel or sub-parallel to the strike of the rock with dendritic drainage pattern.

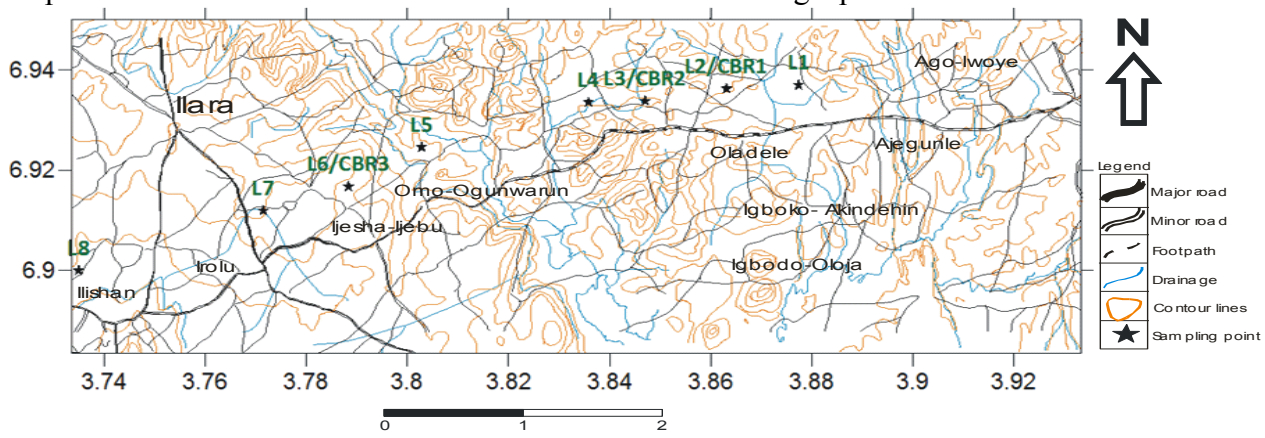

Figure 1.0: Location map of the study area

3. GEOLOGY OF THE STUDY AREA

The half of the study area falls within the Basement Complex of southwestern Nigeria and it is predominantly underlain by gneisses of various grades and suites. These rocks are porphyroblastic gneisses, Biotite gneisses, granite gneisses and banded gneisses. There is an occurrence of a massive intrusive body of quartz schist at the southern part of the area. Some other part of the study area falls within the Sedimentary terrain which is Ise formation of Abeokuta group as shown in Figure 2.

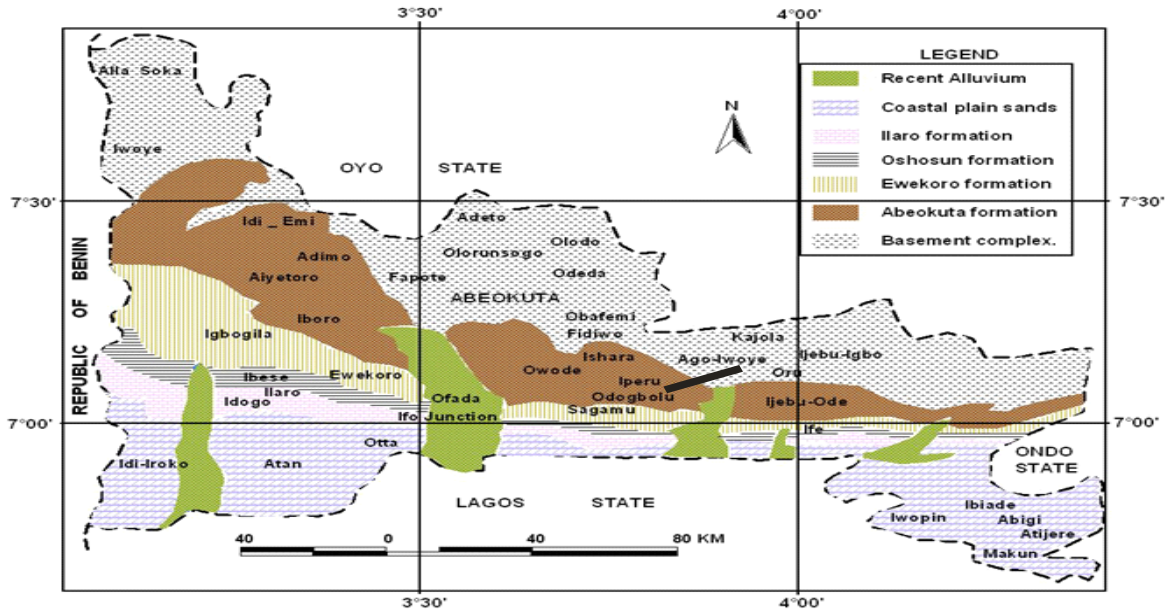

Figure 2.0: Geological map of Ogun State showing different areas (Adopted by Olurin *et al*., 2012).

4. MATERIALS AND METHODS

Eleven (11) samples were collected at eight (8) different locations with the aid of hand auger and digging tools for trial pits. The soil samples were air-dried before being subjected to the laboratory tests such as the grain size analysis, moisture content, consistency limits, compaction test and the California Bearing Ratio (CBR). The results of the grain size analysis were presented as grain size distribution curves, that is, plotting of percentage of soil passing against the grain size on a semi-log graph. Typical grain size distribution curves are shown at Fig. 3 (a&b).

The soils were classified by using the American Association of State Highway and Transport Official (AASHTO) and USGS methods. The AASHTO classification identified two major soil types along the road route which are A – 6 and A – 7 category which rated the soils fair to poor subgrade materials.

The USGS classification method identifies silty sand (SM) and clayey sand (SC) soil types along the road route. The laboratory tests were conducted accordance with the procedure specified by the American Society for Testing and Materials (ASTM 1289, 1979) and the British Standard Institute (BSI 1377, 1990).

5. RESULTS AND DISCUSSION

The results of the laboratory analysis of the soil samples were presented as distribution curves and summary of geotechnical properties of the subgrade soils. A typical distribution curve is as shown in figure 3.0 (a&b).

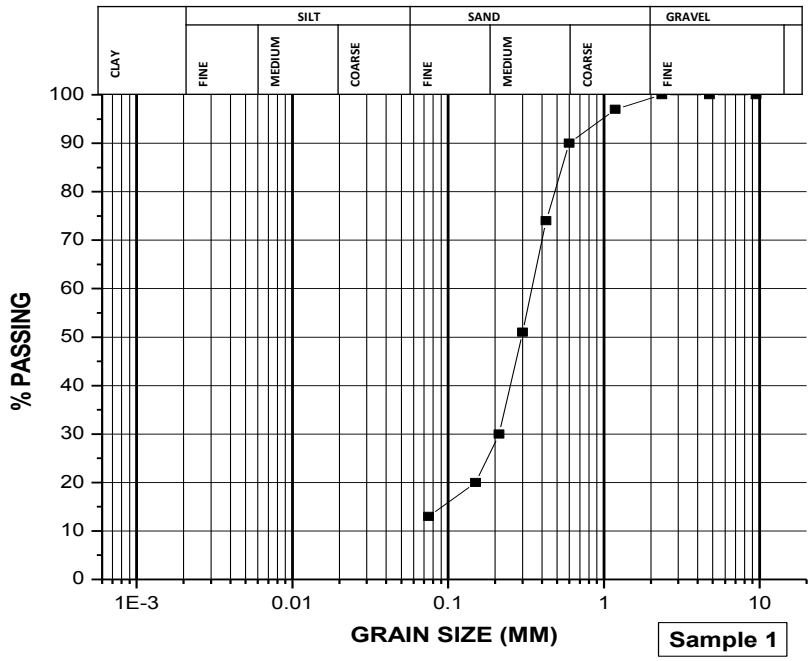

Figure 3a. Grain size distribution curve for Sample 1

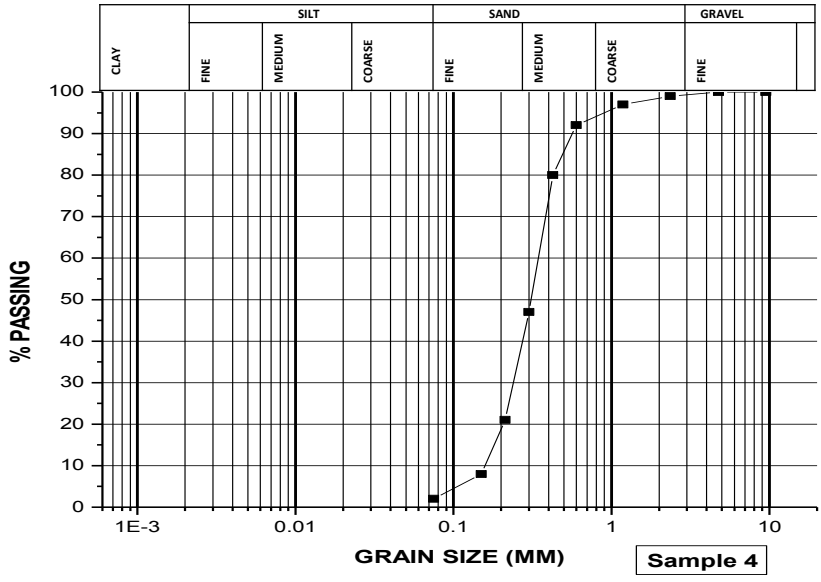

Figure 3b. Grain size distribution curve for Sample 4

Figure 3a shows the grain size distribution curve for sample 1 where the percentage of soil passing is plotted against the grain size (mm). This shows that percentage of coarse soil is 86%, while that of fine soil is 14%. For figure 3b, the percentage of coarse soil is 98% and fine soil is 2%. Table 1 shows the summary of the geotechnical properties of the subgrade soils. The values represent the average for three replicate of each sample tested.

The geotechnical properties of the subgrade soils along the highway route revealed that the liquid limit values ranges from 13.9% to 40.0% and plasticity index ranges from 10.6% to 15.9% against the FMWH, 1997 specify value of 40% maximum and 10% minimum for liquid limit and plasticity index respectively.

The soaked CBR values of the subgrade materials is between 67% and 75% compared with 30% minimum specified by FMWH, 1997. The laboratory maximum dry densities are between 1.47Mg/m^3 and 1.68Mg/m^3 while optimum moisture content ranges from 18.5% to 26.7%. These values are still within the acceptable values of FMWH, 1997 for good to fair subgrade materials. Averagely 75% of the samples satisfy the requirement that the LL and PI of sub-grade should not be more than 35 and 12% respectively (FMWH,1997).

6. CONCLUSION

The results of the subgrade soils investigation along Ago-Iwoye - Ilisian road revealed that the road pavement structures are underlain by are A – 6 and A – 7 category of soils, which rated the soils fair to poor subgrade materials. Averagely 75% of the samples collected satisfy the requirement that the LL and PI of sub-grade should not be more than 35 and 12% respectively. The soaked CBR values of the subgrade materials is between 67% and 75%. The CBR values are relatively high, which is an indication that the subgrade soils are good to fair for pavement structures.

The comparison all the results with the Nigeria specification (Federal Ministry of Works and Housing general guidelines) for the subgrade materials along the Ago-Iwoye- Ilisian road show that the materials underlain the pavement do satisfy the Nigeria standard. Therefore, the perennial failure frequently experience along the road route is not significantly influenced by subgrade materials. Hence, influence of other factors such as poor drainage courses, level of groundwater table, variation of geologic materials along the road route and poor construction materials should be thoroughly addressed before embarking on future rehabilitation of the highway.

Table 1: Summary of the Geotechnical result

TEST	SAMPLES										
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
% Finer(0.06mm)	14	18	15	2	4	10	2	4	23	18	7
% Finer (> 2mm)	86	82	85	98	96	90	98	96	77	82	93
Natural moisture content (%)	3.9	13.2	10.2	7.2	4.2	2.2	3.3	9.2	4.3	4.3	3.9
Liquid Limit (LL) %	23	46.2	29.5	13.9	18.7	20.6	30.0	26.0	40.0	41.7	32.1
Plastic Limit (PL) %	11.4	32.7	17.2	-	8.1	8.8	14.1	13.3	25.9	27.7	18.3
Plasticity Index (PI) %	11.6	13.5	12.3	13.9	10.6	11.8	15.9	12.7	14.1	14.0	13.8
Shrinkage Limit %	8.3	27.7	8.1	6.2	12.3	6.8	13.6	7.8	16.3	26.3	19.3
Maximum Dry Density (MDD) Mg m^{-3}	-	-	-	-	-	-	-	-	1.47	1.51	1.68
Optimum Moisture Content (OMC) %	-	-	-	-	-	-	-	-	26.7	18.5	21.8
California Bearing Ratio (CBR) %	-	-	-	-	-	-	-	-	71.9	69.6	75.0
AASHTO Classification	A-6	A-6	A-7	A-6	A-6	A-2-6	A-6	A-6	A-6	A-7	A-2-6
USCS classification	SM	SC	SC	SC	SM	SC	SC	SC	SM	SC	SM
Site condition	Unstb	Unstb	Unstb	Stb	Unstb	Stb	Sbl	Stb	Unsb	Stb	Stb

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