GEOTECHNICAL STUDY OF ADO – IJAN EKITI ROADWAY UNDER VARIED CONDITIONS

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ABSTRACT

The development of a nation is largely dependent on the availability of good and sustainable Transportation infrastructure. The constant pavement defects and failures experienced on Ado-Ijan Ekiti road way can be related to several causes. The need to address this becomes imperative. Samples were picked from different locations at varying depths (0.5, 1.0 and 1.5 m), and were analyzed in the geotechnical laboratory. The tests include; specific gravity, sieve analysis, California bearing ratio (CBR), Atterberg Limit tests and Compaction tests. The result of the geotechnical investigations shows that the soil materials were well graded but had a low bearing capacity. Most of the soil had no plasticity as required by the FMW&H. It was concluded that the engineering and geological investigation showed that the defects present on the road way is not due to traffic loading but rather low bearing capacity and plasticity of the soil at sub base and base course levels.

KEYWORDS: Geological, Investigation, Traffic, Engineering And Geotechnical study & Ado-Ijan Ekiti Road

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1. INTRODUCTION

Highways are vitally important to a country's economic development. The construction of a high quality road network directly increases a nation's economic output by reducing journey times and costs, making a region more attractive economically. Road infrastructure plays a significant role in the growth and development of settlements. The ADO-EKITI – IJAN-EKITI ROAD is an 18 km asphaltic pavement. The road was constructed mainly to ease the movement of people and also to enhance the tap of agricultural produce from some interior agricultural areas of Ekiti State linked by this road. Though being a minor single lane road it is also a Federal Government Road.

Geotechnical surveys of the entire high way pavement are essential because of poor conditions of the road network in Nigeria; they are used to predict the performance of the road over a long time. Though indications of road failure abound, but the failures found on this road are very much similar in character and shape with little disparity in their different causes. The few failures associated with this road include pot—holes, stripping of wearing surface, gulley erosion, vegetation encroachment, narrow pavement width etc. A very high percentage of the roadway has lost its wearing course. Finally, though an important assessment and study of this road has been done in this report, still no complete coverage of road failures and possible solutions is claimed or was attempted.

2. MATERIALS AND METHODS

2.1 Materials

Soil Samples were collected from five different trial pits and at 3 depths (0.5m, 1.0m and 1.5m). Samples were air dried for 2 weeks and unwanted materials like shrubs and twigs were removed. The coordinates of the locations are as

presented in Table 1. Borehole water fit for drinking purpose was used for this survey.

Table 1 : Latitude and Longitude of the various Locations

Ado-Ijan Road			
Location	Latitude	Longitude	Elevation (m)
1	7°36'8.79"N	5°18'52.94"E	375
2	7°36'8.62"N	5°19'39.43"E	355
3	7°37'23.84"N	5°23'19.77"E	383
4	7°37'27.74"N	5°23'12.67"E	383
5	7°37'25.63"N	5°24'13.07"E	387

2.2 Methods

The geotechnical properties of the constituent's material lateritic soil was determined in order to ascertain the suitability of the materials. Laboratory tests were conducted on the soil samples in conformity with British Standard (BS 1377, 1990).

The laboratory tests carried out on the natural soil include particle size distribution, Atterberg limits, compaction, CBR (California Bearing Ratio). The geotechnical properties of the soil were determined in accordance with British Standard Institute (1990a). California bearing ratio (CBR) tests were prepared at the optimum moisture contents (OMC) and maximum dry densities (MDD) – British standard light of the soil. The CBR tests were conducted as specified by the Nigeria General Specifications (1997) for road and bridges works, where the compacted specimens were cured for six days and soaked for one day before testing at a constant loading rate.

2.2.1 Specific Gravity

The specific gravity of the soil sample gotten at various chainages used was determined using a pycnometer (stopper bottle having a capacity of 50 ml) as specified by ASTM Standard Test Method for Specific Gravity of Soils (D 854-92, 1995). The specific gravity value is an average of two tests; individual determinations differed from the mean by less than 0.02.

2.2.2 Atterberg Limit Test

Plastic Limit and Liquid Limit (Cone Penetration Method) were conducted on the soil sample passing 0.425mm (No. 40) sieve in accordance with BS:1377 – part 2, 1990 (Arora, 1997) in order to determine the stage at which the soil ceases to be plastic and to determine the water content at which the soil changes from liquid state to plastic state.

2.2.3 Sieve Analysis Test

This test is carried out to analyze the soil particles according to their aggregate. It is used to characterize soil particles greater than 75µm. Soil sample was collected and kept in the oven at 105°C after which wet and dry sieving was carried out.

2.2.4 compaction Test

Modified AASHTO, West African Standard and Standard proctor method of compaction was employed for the base course, sub base and sub grade respectively. This was carried out according to British Standard code of practice (BS1377:1990) to determine the optimum moisture content (OMC) and Maximum Dry Density (MDD) of the soil sample and to improve its strength.

2.2.5 California Bearing Ration Test

The California Bearing Ratio test is conducted to evaluate the suitability of the sub-grade and the materials used in the base and sub-base of a flexible pavement. The penetration load is expressed as a percentage of the standard loads at the respective penetration level of 2.5mm or 5.0mm. Soaked C.B.R for 24 hours was carried out on the sub grade materials and unsoaked C.B.R was carried out on base and sub base materials.

$$CBR\ Value = \frac{Penetration\ Load * Proving\ Ring\ Factor}{Standard\ Load} * 100$$

3.RESULTS AND DISCUSSIONS

3.1 Specific Gravity

The specific gravity values of the claysoils at various locations are shown in Table 2.

Table 2: Specific Gravity Test Results at all Locations

Depths	Location 1	Location 2	Location 3	Location 4	Location 5
Base	2.63	2.60	2.61	2.56	2.53
Sub-Base	2.61	2.73	2.58	2.57	2.53
Sub-grade	2.62	2.63	2.53	2.55	2.56

From the table above, with the specific gravity of 2.5-2.7, the surveyed route is said to have a high amount of quartz materials. With the specific gravity of an iron-rich laterite of 2.75-3.0 which denotes the material on the route is not good enough.

3.2 Sieve Analysis

Table 3 below shows that the soil samples had higher percentage of granular materials at the base course level (i.e. <35%, According FMW&H standard) which varied between 7.8-22.16%. Table 4 shows that for the base course (Location 1-5), the percentage passing sieve 200 varied between 8.72-19.86% for sub-base (Location 1-5) which meets the requirements specified for sub base (i.e. <35%) (According FMW&H standard). From Table 5, it is observed that the percentage passing sieve 200 varied between 11%-22.84% for sub-grade (Location 1-5) which meets the requirements specified for sub grade materials (i.e. <35%, According FMW&H standard).

Table 3: Summary of Sieve Analysis test results on Base at all locations

Sieve Size (mm)	% Passing of Soil Samples				
	Location 1	Location 2	Location 3	Location 4	Location 5
9.50	72.70	100.00	97.82	97.56	99.82
4.75	56.38	99.12	95.10	92.94	95.58
2.36	50.34	96.54	93.76	90.18	93.94
1.18	46.50	90.06	89.02	81.16	84.88
0.60	37.92	75.52	78.50	65.92	67.42
0.30	21.10	46.52	52.32	44.08	53.84
0.15	11.02	20.52	25.36	21.52	33.38
0.075	7.80	12.94	16.26	13.10	22.16

Table 4: Summary of Sieve Analysis test results on Sub Base at all locations

% Passing of Soil Samples					
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Sieve Size (mm)	Location 1	Location 2	Location 3	Location 4	Location 5
9.50	75.14	87.38	97.48	99.10	97.06
4.75	58.64	65.98	94.46	95.76	95.04
2.36	52.38	49.12	93.00	91.52	92.60
1.18	48.66	41.92	87.26	82.34	84.18
0.60	39.32	33.44	75.98	68.78	70.72
0.30	22.20	17.28	48.84	46.80	46.70
0.15	12.46	8.26	23.10	29.22	22.38
0.075	8.72	6.12	14.32	19.86	13.24

Table 5: Summary of Sieve Analysis test results on Subgrade at all locations

Sieve Size (mm)	% Passing of Soil Samples				
	Location 1	Location 2	Location 3	Location 4	Location 5
9.50	88.66	88.64	98.22	97.86	99.68
4.75	79.48	70.72	95.64	93.12	98.10
2.36	67.74	52.48	94.50	88.86	95.58
1.18	60.18	44.92	90.12	81.92	85.54
0.60	48.80	36.18	78.00	64.44	71.96
0.30	28.34	20.86	50.84	42.10	51.46
0.15	16.78	12.24	27.28	22.66	31.90
0.075	11.44	9.00	18.76	13.88	22.74

3.3 Atterberg Limit Tests

Table 6: Atterberg Test Results for Base, Sub base and Sub grade at all Locations

Locations		LL (%)	PL (%)	PI (%)	Shrinkage Limit	% Passing Sieve 200
1	Base	18.44	0.00	18.44	0.00	7.80
	Sub Base	20.76	0.00	20.76	0.00	8.72
	Sub grade	25.49	18.79	6.21	3.57	11.44
2	Base	24.14	17.49	6.65	2.14	12.94
	Sub Base	19.42	0.00	19.42	0.00	6.12
	Sub grade	22.62	0.00	22.62	0.00	9.00
3	Bse	21.78	0.00	21.78	0.00	16.26
	Sub Base	21.28	0.00	21.28	0.00	14.32
	Sub grade	26.96	14.39	12.57	2.14	18.76
4	Base	21.93	0.00	21.93	0.00	13.10
	Sub ase	20.1	0.00	20.1	0.00	19.86
	Sub grade	29.03	12.02	17.01	2.86	13.88
5	Base	24.11	12.66	11.45	2.14	22.16
	Sub Base	23.72	10.59	13.13	2.87	13.24
	Sub grade	23.0	10.15	12.85	5.71	22.74

Figure 1: Graph of Penetration against Moisture Content at Location 3

From Figure 1 it can be deduced that at 20mm penetration, the moisture content at the subgrade (1.5m depth) is 28% which connotes with the FMW specifications and with a plasticity limit of 14.39% which is less than the specified not greater than 55%, qualifying the soil for subgrade material. It can also be deduced that at 20mm penetration, the moisture content at the sub-base (1.0m depth) is 22.5% which implies with the FMW specifications but with no plasticity implying the soil is sandy which makes it unfit for a sub-base material. From the graph it can be deduced that at 20mm penetration, the moisture content at the Base course (0.5m depth) is 23.5% which implies with the FMW specifications, but with no plasticity i.e. soil is sandy, disqualifies it for a base course material.

3.4 Compaction Test

The graph of dry density was plotted against moisture content for each location to determine their MDD and OMC. Modified AASHTO, West African Standard and Standard proctor method of compaction was employed for the base course, sub base and sub grade respectively.

Table 7: Summary of Compaction test results on Base, Sub base and Sub grade at all location 1

Location 1	Base	Sub-Base	Sub-grade
MDD (kg/m^3)	2170	2280	2050
OMC (%)	14.5	9.7	12.2

Table 8: Summary of Compaction test results on Base, Sub base and Sub grade at all location 2

Location 2	Base	Sub-Base	Sub-grade
MDD (kg/m^3)	2075	2280	1960
OMC (%)	16	9.9	15

Table 9: Summary of Compaction test results on Base, Sub base and Sub grade at all location 3

Location 3	Base	Sub-Base	Sub-grade
MDD (kg/m^3)	2030	1960	1840
OMC (%)	16	16	11.5

Table 10: Summary of Compaction test results on Base, Sub base and Sub grade at all location 4

Location 4	Base	Sub-Base	Sub-grade
MDD (kg/m^3)	2050	2030	1760
OMC (%)	14	18	16

Table 11: Summary of Compaction test results on Base, Sub base and Sub grade at all location 5

Location 5	Base	Sub-Base	Sub-grade
MDD (kg/m ³)	2070	1980	1785
OMC(%)	14	15.5	16

Figure 2 : Graph of the Dry Density against Moisture Content at Location 3

From the graph in Figure 3, it can be deduced that the maximum dry density (MDD) of the subgrade (1.5m depth) is 1840 kg/m³ which does not imply with the Federal Ministry of Works specification of MDD not < 1750 kg/m³. It can also be deduced that the maximum dry density (MDD) of the sub-base (1.0m depth) is 1960 kg/m³ which implies with the Federal Ministry of Works specification of MDD not < 2000 kg/m³. From the graph it can be deduced that maximum dry density (MDD) of the Base course (0.5m depth) is 2030 kg/m³ which does not imply with the Federal Ministry of MDD not < 2000 kg/m³.

3.5 California Bearing Ratio Test (CBR)

Table 12: California Bearing Ratio Results for all Locations at Base, Sub base and Sub grade

Soil Samples	CBR
Location 1	26.18
	10.39
	6.89
Location 2	21.79
	9.14
	6.79
Location 3	11.3
	10.8
	7.3
Location 4	10.07
	10.2

	9.94
Location 5	10.07
	12.46
	11.5

4. CONCLUSION AND RECOMMENDATIONS

From the results of the geotechnical tests carried out on the soil materials, it can be discovered that the soil, though being well graded, failed in most engineering properties like plasticity limit, bearing capacity which are required for a suitable highway material. The soil in most subgrade and sub base areas had no plasticity indicating that the soil there had high sand constituents and very low compaction coefficients.

This research has given a better insight on road failure problems in not only Ekiti state but also in Nigeria. This survey helped know the performance of the Ado-Ijan road. And from the survey the following recommendations can be drawn; Suitable drainages should be constructed to resolve the problems of flooding and washing away of the pavement and also the disposition of foundational layers. Need for excavation of the subsurface materials, the topsoil at depth of about five meters especially areas where surface water have accumulated along these sections of the road and be replaced with competent soil material excavated to be used as road embankment.

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