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GEOTECHNICAL ASSESMENT OF SOME FAILED SECTIONS ALONG GOMBE-POTISKUM HIGHWAY; NE-NIGERIA

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Abstract

The research is focused on soil samples obtained from some failed sections along Gombe –Potiskun Road the area of investigation is between Doho to Tongo, kwami L.G.A. Gombe State of about 17 to 62km. The engineering properties of soils were investigated by conducting laboratory test and compared with standard in which six sample pits were dug and samples were collected for geotechnical determination. Soils taken at Doho were treated as sub-base material while those taken from other points were treated as sub-grade materials. The results obtained from the geotechnical tests performed indicate that the MDD ranges from 1.400 to 1.97gm/cm^3 the OMC has the maximum result of 24% and minimum value of 7.9% for compaction and moisture content. The soils recorded 0% and 13% as the minimum and maximum CBR values after 24 hours (sub-base) and 48 hours (sub-grade) soaking respectively. The test conducted revealed that maximum value of 76.0% and 38.5% and minimum value of 12.3% were obtained for liquid limits (LL%) and the plasticity index of the samples ranges from 11.2% to 53.3%. The soils were classified as **GM, ML and S** because of variations in properties and different points of sampling. The soil samples from Doho is made up of sandy materials (inorganic) and are seen as suitable engineering materials while those obtained at Tongo where the road terribly failed composed mainly of shale, silt (organic) mixed with small gravels are unsuitable materials.

Keywods: Geotechnical, Liquid-limits, Plasticity Index.

Introduction

Gombe-Potiskum highway is an important getaway that link most parts of the North-Eastern Nigeria with the famous Ashaka Cement Company which is located about 9 km off the Gombe-Potiskum after Bajoga town. This road is exposed to heavy duty trucks conveying cement products to the various parts of NE-Nigeria and even the country at large. The road had undergone several rehabilitations in the past by the Federal Ministry of works, Petroleum Trust

Fund (PTF) and recently by the Federal Road maintenance Agency (FERMA); but there are still some portions of the road that experience recurrent failures. These failures may be due to poor pavements design or weakness of the soil and/or inadequate geotechnical investigation.

In this work an attempt was made at establishing the geotechnical properties of the area by conducting some geotechnical investigation along the road as well as a geological mapping of the area.

Physiography and Geology of the area

The study area (Fig 1) is part of Gombe Sheet 36 NE which encompasses some settlements in Kwami and Funakaye Local government areas of Gombe State (Doho, Mallam-Sidi, Kurugu, Dukul and Tongo) these are some of the settlements traverse by the road. Doho and Tongo lies between the latitudes $10^0$25’34.5’’N to $10^0$44’02’’N and longitudes $11^0$12’11.5’’E to $11^0$21’42’’E and has chainage ranging from 17+850 to 62+765(this is where most of the sampling was conducted).

The study area (Gombe–Potiskum Highway) is located in the North- South trending Gongola Basin (Gongola Arm) of the Upper Benue Trough in the North-Eastern Nigeria. The most recent information on the origin of the Benue Trough of which the upper Benue trough is a part was given by Guiraud (1989). He considered it to be due to a position of set of pull-apart basins associated with NE-SW inherited transcurrent faults (Benkhelil, 1982, Benkhelil and Robinean, 1983; Maurin et al 1986). The area is characterized by sediments deposited from Upper Cretaceous to Tertiary age with varying depositional environments ranging from transitional to marine environments (Carter *et al* 1968, Benkhelil 1982). The area shows different formations which include Yolde Formation, Pindiga Formation, Gombe Formation and Keri-Keri Formation (Carter *et al* 1968; Benkhelil 1989). The formations in the area of investigation are characterized by shales (Fika shale), sandstone Gombe sandstone and Gulani sandstone intercalated with clay.

The drainage pattern of the area is predominantly dendritic with streams, mostly seasonal, flowing towards the East.

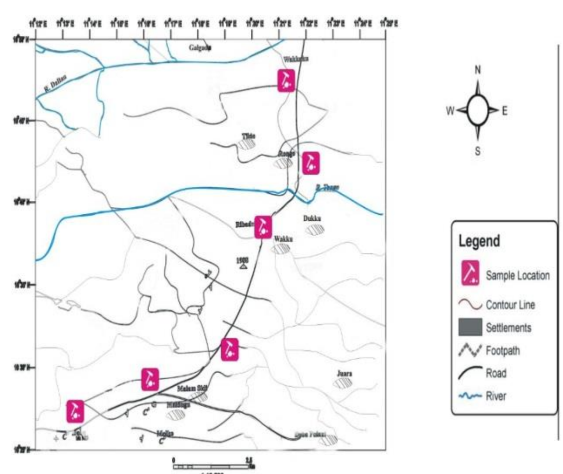


Figure 1: The study area

Methodology

Disturbed soil samples were collected at a depth of about 1.5 m along the road at six

(6) different locations, some of the samples were taken Sub-grade and sub-base materials on the road, while others were taken some few metres away from the road. These samples were then taken to the TRIACTA NIGERIA LTD Laboratories for geotechnical analysis and evaluating the physical properties of the soil. These analysis were based on the British Standard code BS1377 1990. Part 1-5 as well as the American Association of State Highway and Transport Officials AASHTO Codes.

Table1: GPS Coordinates and chainages of the sampling points

Pit No	Northern	Eastern	Elevation (m)	Depth (m)	Chainage
1.	10^0 44’02.0’’	$011^0$21’42.2”	439	1.0	62+765
2.	$10^0$44’10.5’’	$011^0$21’43.4”	335	1.5	62+525
3.	$10^0$44’21.6”	$011^0$21’35.9”	340	1.5	56+580
4.	$10^0$39’46.4”	$011^0$21’54.8”	318	1.0	50+100
5.	$10^0$25’38.6”	$011^0$21’14,0”	483	1.5	17+900
6.	$10^0$25’34.5”	$011^0$21’11.5”	487	1.5	17+850

Table 2: Optimum Moisture Content Result

Pit no.	1	2	3	4	5	6
Moisture content (wt %)	11.1	24	17.8	7.8	10.0	9.9

Table 3 Atterberg Limit Result

Pit no.	1	2	3	4	5	6
Liquid limit (LL %)	35.5	76.0	38.5	23.0	12.3	
Plastic limit (PL %)	25.5	22.5	15.3	11.8	N.P	N.P
Plasticity index (PI %)	10.5	53.5	23.2	11.2	N.PI	N.PI

* Pits no. 5 and 6 could not record PI as a result of difficulty in rolling the two samples

Table 4: Compaction Test Result

Pit no.		1	2	3	4	5	6
BSL	MDD(mg/gm)	1.85	1.400	1.62	2.1	1.87	1.97
	OMC (%)	11.1	24	17.8	7.9	10.0	9.9

Table 5: CBR test Result

Pit no.	1	2	3	4	5	6
CBR (%)	0	7	1.1	0	8.7	13

The following geotechnical studies are performed: Sieve analysis; Optimum moisture content; Atterberg limits with the exception of shrinkage limit, compaction test and CBR. This research is restricted to the following geotechnical tests such as Compaction Test CBR test; PH value, specific gravity (GS), PSD test, and Atterberg limits test. Table 1 is the GPS coordinates of the sampling points.

Results and Interpretations

The results obtained from the laboratory analysis conducted on the samples for the following tests; Sieve analysis, Atterberg limits, moisture contents, CBR and compaction (MDD) are presented and discussed in this section.

Optimum Moisture Content Results

The variation in the moisture content of the soils is presented in Table 2.

Atterberg Limit Result

The variation in the liquid Limit, plastic limit and plasticity index are presented in the Table 3.

Compaction Test Result

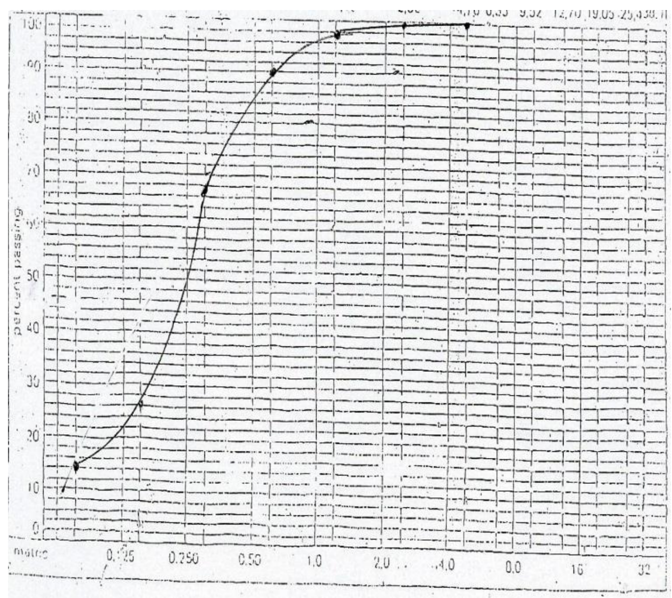
The variation in optimum moisture content (OMC) and maximum dry density (MDD) with efforts of compaction is presented in Table 4.

California Bearing Ratio (CBR)

The variation in the CBR is presented in Table 5.

Data Interpretation

Interpretation of Sieve Analysis Result



The pit no.1 soil is classified as A-3-6 based on AASHTO soil classification system with group index value of one (1). The soil is made up of sandy-silty material mixed with minute gravels and is grey-brown in colour. The pit no.2 has the highest group index value of 50, composed of silty-sand and small gravels. It belongs to A-2-6 AASHTO soil class and it shows brown to pale yellow colour.

Pits no.3 and 4 have A-2-7 AASHTO soil class mainly made of shaley sand. They display dark grey-brown colour but have different GI values of 18 and 0 respectively.

Pits no.5 and 6 are both classified as A-2-3 AASHTO soil class which are reddish in colour and composed of sandy laterite and their GI value was found to be zero.

Interpretation of Optimum Moisture Content Result

Pit no.2 has the highest moisture content of 24 % consisting of silty- sand with small gravels while pit no.4 has the lowest moisture content of 7.9 % which is made up of shale and sandy materials.

Interpretation of Atterberg Limit Test Result

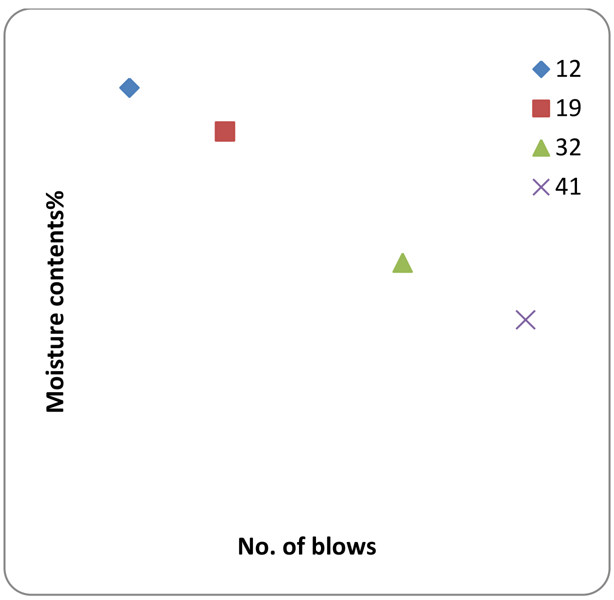


Figure 3: Liquid limit graph for pit no.3

The pits no.1, 2, 3, 4 and 5 have the liquid limit ranging from 12 % to 76.0 % and plasticity index of ranging between 10.5 % and 53.5% which shows that the measure of expansion is high. Pit no.5 does not record plastic limit while liquid and plastic limits could not be obtained in pit no.6 after adequate blowing on Casa-Grande apparatus. Therefore plasticity index was not recorded for both sample from pits 5 and 6 due to difficulty in rolling of the samples. All samples treated were less than 80 % for liquid limit but sample 2(76.0 %) was greater than 50 % as per desired limit.

Interpretation of Compaction Test Result

Figure 4: MDD and OMC graph for pit no.1

The optimum moisture content (OMC) generally increased with increase in percentage of water while the maximum dry density (MDD) also increased with increase in effort of compaction.

Interpretation of California Bearing Ratio Result

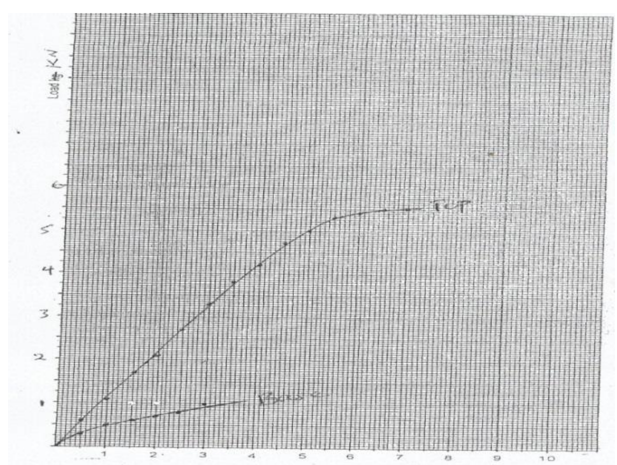


Figure 5: CBR graph for pit no.6

Pits no. 1 and 4 recorded 0% of CBR after 48 hours soaking, pit no.2 recorded 7% and pit no.3 has 1.1% after 48 hours soaking in which they were treated as sub-grade materials.

Pits no.5 and 6 were treated as sub-base soil recording CBR of 8.7% and 13% after 24 hours soaking. Thus, samples 2, 5 and 6 did not get penetrated by the CBR Marshall tester and are stronger than the other samples collected i.e 1, 4 and 3 respectively. Based on the specification limits all the samples treated are less than 30% after 24 and 48 hours soaking for materials treated as sub-grade(1, 2, 3 and 4 samples) or as sub-base(5 and 6 samples).

Summary and Conclusion

Summary

This analysis shows that the soils obtained are generally inorganic and belong to **GM, ML and S** groups of the Unified Soil Classification Scheme. From Doho (samples 5 and 6) to Tongo (samples 3 and 4) where the road is relatively stable the liquid limit ranges between 12.3 % and 38.5 % while before Tongo (sample 3 and 4) to after Tongo (samples 1 and 2) where the road experienced much failures the liquid limit was found to be 76.0 % as well as plasticity index of 53.5 % and a group index of 50.

The OMC of the soils generally increased with increase in percentage of water from 7.9 % to 24 % and MDD also increased with increase in the compactive effort which is between 1.40 % and 1.97 %.

Samples 1 and 4 have 0 % CBR values which were both taken on the road pavement while the remaining samples which were obtained 5m away from the road have CBR values ranging from 1.1% to 13 % meaning they are stronger than those recorded as 0 %.

Conclusion

On the basis of the result of the analysis carried out in this research, the following conclusions were made:

1. The soils were found to be predominantly sandy soil, shaley, silty with mixture of some minute gravelly materials. Optimum moisture content of 9.9 % to 24 % makes the soil to have relative expansion and shrinkage and the force of attraction between the particles is low or increase in inter-particles to move past one another and denser state of packing.
2. CBR result indicates that, the soil is relatively strong especially at Doho compared to those obtained at Tongo.
3. The presence of shaley and silty materials before Tongo and after Tongo makes the material poor for road construction resulting in failure of the road.
4. The samples collected at Doho may be suitable Subbase materials.

Based on the group index the materials obtained from samples 2, 3, 5 and 6 indicate fair to good characteristic index properties except sample 1 and 4 which exhibit poor characteristic index properties.

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