GEOTECHNICAL ASSESSMENT OF NANKA AND OGWASHI ASABA FORMATIONS FOR ROAD CONSTRUCTION IN SOME PART OF ANAMBRA STATE SOUTHEASTERN NIGERIA

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Abstract

The impact of the Nanka and Ogwashi - Asaba Formations for Road construction has been analysed. Analysis on Formation reveals that liquid limit ranges from 20% - 48% with a mean value of 34.4%, plasticity index ranged from 9% - 27% with an average of 17%, while the linear shrinkage ranges from 9% - 27% with a mean value of 8.5%. The grain size analysis showed that the amount of fines ranges from 16%-54%. maximum dry density(MDD) from 1.91Mg/m^3 - 2.19Mg/m^3 with a mean value of 1.99% while optimum moisture content (OMC)ranged from 7% to 13% with a mean value of 10.9%. California Bearing Capacity(CBR) between 44% - 139% with a mean value of 73.6% for unsoaked CBR while the soaked CBR ranged from 16% - 32% with an average of 23%, which is good for sub-base, base course and sub grade respectively. However, only sample OG is suitable for base-course while S1 and OB are suitable for subgrade. Based on AASHTO classification, the samples (soil) are classified as A-2-6(good) except OGB, TRO and ANW samples that are A-6(poor), A-7(poor) and A-2-7(good) respectively. The Particle Density of the soil lies between 2.57 and 2.70.

Nevertheless, samples OGB and TRO can be improved with stabilizing agent. Nanka and Ogwashi – Asaba Formations in Anambra State can be adjudged suitable for sub-grade, sub-base and base materials, mostly sub grade and sub-base materials. This geotechnical information obtained will serve as base-line information for future road construction materials.

KEYWORDS: Geotechnical properties, Nanka Formation, Nigerian specification. Ogwashi – Asaba Formation, Road Construction, Sub-base and Sub-grade.

1. Introduction

Due to economic growth and rapid development in Nigeria, road network is considered very essential to a great extent; they are complementary to other modes of transportation and are challenged by infrastructural defects. According to [7] One of the factors responsible for these failures as adjudged by professionals include lack of in depth knowledge of the geotechnical properties of soil which is a precondition for its use in civil engineering construction either as a construction material or foundation for super structures. [24] have reported of incessant failures in roads and highways for which local shale had been utilized both as part of the pavement structure and as aggregates.

The understanding of soil behavior in solving engineering and environmental issues as swelling soil especially expansive lateritic soils that can cause significant damage to road construction and other engineering application is the sole aim of geotechnical engineering [1], [17]. A pre-construction geotechnical evaluation of lateritic soils is necessary to mitigate structural failures [7]. For a material to be used as either a base course or sub-base course depends on its strength in transmitting the axle-load to the sub-soil and or sub-grade. The structural strength of road pavements depends directly on the strength of subgrade, sub base, base course, thickness and composition of pavement structure.

The aim of this research is to determine geotechnical properties of Nanka and Ogwashi Asaba Formations in some parts of Anambra state for use as road constructional material.

The study area lies within longitudes $6^{o}48´$E to $6^{o}57´$ E and Latitude $6^{o}00´$N to $6^{o}18´$N (Fig 1). Figure 1 also shows the sampling point's distribution from which ten samples were collected and tested for suitability as road construction materials. This study is focused in the southern part of Anambra Basin. The Anambra Basin was formed following the Santonian tectonic pulse on a sub-basin formed by the differential subsidence of the fault block in the southern Benue Trough. It was a deltaic complex filled with a lithostratigraphic unit akin to those of the Cenozoic Niger Delta [20]

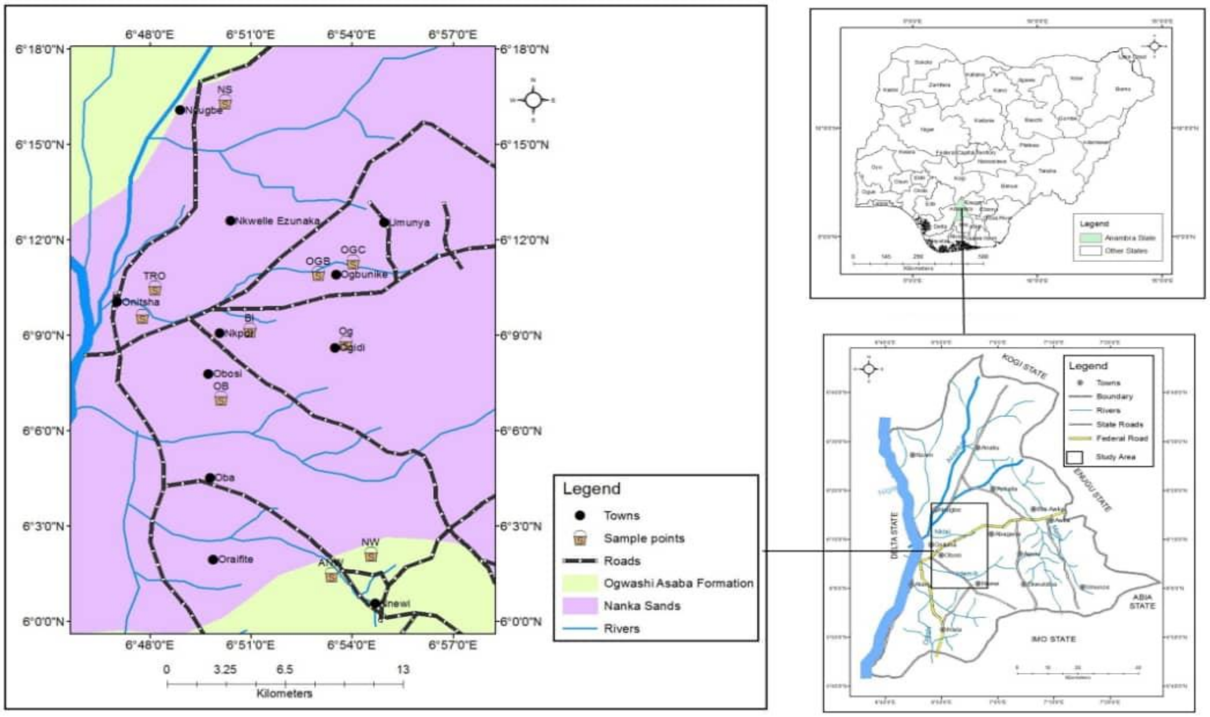


Fig. 1: Geologic Map of the Study Area Showing the Sampling Points Distribution.

The Nanka and Ogwashi –Asaba Formations underlie the study Area. Eocene rocks that outcropped in southeastern Nigeria have been classified under the Ameki Group and comprises the Ameki Formation, Nanka Sands and the Nsugbe Sandstone. Nanka Sand consists of a distinct unit of sands, shale-siltstone and finely laminated shale. The sand subunits comprises of uncemented, medium to coarse grained and pebbly quartz sand, with thickness varying from 50 to 90m [25]

The Oligocene – Miocene Ogwashi Asaba Formation consist of interbedded successions of lignite, shale, sandstone, siltstone, and claystone facies. It is the outcropping equivalent of the Agbada Formation in the subsurface Niger Delta [3], [5], [19]. The depositional environment has been interpreted by [2] as being continental.

Ogwashi–Asaba Formation is identified within the Anambra Basin and also referred to as the Lignite "series" [17]. The formation is assigned the late Eocene-Oligocene age [11], [8]. Table 1 shows the lithostratigraphic framework of Anambra basin [13]. The aim of this research is to determine suitability of some of the Nanka and Ogwashi – Asaba Formations in Anambra State for road construction.

This Formation is identified within the Palaeocene Anambra Basin (Afikpo geosynyncline) according to [12]. The formation is characterized by alternation of clays, sands, grits and lignites [9], [21]. The formation occurs mainly in Benin, Asaba, Onitsha and Owerri areas [18], [13] and Table 1 suggested Oligocene–Miocene age for this formation, but palynological results by the work of [8] assigned a Middle Eocene age to the basal part.

Table1: Lithostratigraphic Framework of Anambra Basin (after Nwajide, 1990)

AGE		ABAKALIKI-ANAMBRA BASIN	AFIKPO BASIN
30 my	Oligocene	Ogwashi-Asaba Formation	Ogwashi-Asaba Formation
54.9 my	Eocene	Ameki/NankaFormation/Nsugbe Sandstone	Ameki Formation
60 my	Paleocene	Imo Formation Nsukka Formation	Imo Formation Nsukka Formation
73 my	Maastrichtian	Ajali Sandstone Mamu Formation	Ajali Sandstone Mamu Formation
83 my	Campanian	Nkporo/ Owelli Formation/Enugu Shale	Nkporo Shale/Afikpo Sandstone
87.5 my	Santonian	Non-deposition	
88.5my	Coniacian	Awgu Group (Agbani Sandstone/Awgu Shale)	
93 my	Turonian	Ezeaku Group)	Ezeaku Group (Incl Amaseri Sandstone)
100 my	Cenomanian- Albian	Asu River Group	Asu River Group
	Aptian Baremian Hauterivian	Unamed Units	
	Precambrian	Basement Complex	

*my = million years.

2. Materials and Methods

Two methods were used in this research which consists of both field and laboratory procedures. Ten samples were collected from different locations from Nanka and Ogwashi – Asaba Formations occurring area in Anambra State for assessment for road construction (Table 2). Samples were collected within the depth of 1.5m and 3.5m and packed in polythene bags for laboratory analysis. These samples are herein designated as S1, B1, OGC, OGB, OB, OG, TRO, NS, NW and ANW. The test conducted includes particle density test, sieve analysis test, Atterberg limits test, compaction test and California bearing ratio test (CBR). Prior to testing, the soil were air-dried and broken into smaller fragments, care being taken not to reduce the sizes of the individual particles. Particle density is the ratio of the density of the soil to the density of water was carried out using pyconometer. It gives an idea about the suitability of soil as a construction material; higher value of specific gravity gives more strength for roads and foundations [26]. Particle size distribution was carried out by mechanical method using an automatic shakers and a set of sieves. Particle size distribution curve (gradation curve) represents the distribution of particles of different sizes in the soil mass [27]. Soil containing particles with high angularity possess high strength to compare with less or no angular particles.

The liquid limit and plastic limit tests were carried out on air-dried samples that passed 0.425 mm (BSI No. 36) sieve using Casagrande apparatus for identification and classification of soils also determine its plasticity. CBR tests were performed on compacted samples in both unsoaked and soaked conditions, following the procedure of [22] to determine the strength of subgrade soil for construction of pavement. However, soaking was done overnight (24 hours) in a water-filled bathtub, as suggested by [15]. All tests were carried out in accordance with British standard code of practice (BS1377:1990 and ASTM128 for road construction for civil engineering purposes:

Table 2: Details of the Samples Collected

SAMPLE SYMBOL	LOCATION	LATITUDE	LONGITUDE
SI	Shoprite, Onitsha	6° 9'25.85"N	6°47'41.65"E
BI	Nkpor	6° 8'59.79"N	6°50'0.08"E
OGC	Ogbunike Cave	6°11'9.96"N	6°53'58.98"E
OGB	Ogbunike	6°10'38.35"N	6°53'0.32"E
OB	Obosi	6° 6'59.71"N	6°49'59.80"E
OG	Ogidi	6° 8'34.57"N	6°53'29.32"E
TRO	Trans Nkisi	6°10'12.24"N	6°48'3.54"E
NS	Nsugbe	6°16'2.92"N	6°48'59.96"E
NW	Nnewi	6° 0'37.58"N	6°54'36.97"E
ANW	Akamili, Nnewi	6° 0'29.40"N	6°54'36.49"E

3.0 Results and Discussions

Particle Density

Table 3 shows the summary of the data obtained from the Specific gravity test carried out. The specific gravity of the tested samples lies between 2.57 and 2.70; these values are suitable in accordance with [23] which states that the standard values for specific gravity of soils ranges between 2.60Mg/m^3 and 2.80Mg/m^3. Except sample TRO which is lower than the specified range and it is an indication of coarse soil. Lower Specific gravity value indicates a coarse soil, while higher values indicate a fine grained soil.

Table 3: Summary Result of Particle Density of the Soil

SAMPLE	PARTICLE DENSITY (Mg/m^3)
S1	2.60
B1	2.64
OGC	2.63
OGB	2.61
OB	2.62
OG	2.70
TRO	2.57
NS	2.63
NW	2.63
ANW	2.64

Particle Size Distribution

The percentage of material passing through no 200BS sieve ranges between 16% - 54%. According to Federal Ministry of Works general specification requirements for roads and bridges (1997), samples S1, B1, OGC, OB, NS, NW, ANW and OB can be deduced as suitable for sub-grade, sub-base and base materials as the percentage by weight finer than N0 200BS test sieve is less than 35% (Table 4). Based on the percentage of clay/silt, sand and gravel contents samples S1, B1, OGC, OB, NS and NW can be classified as A-2-6, OG as A-2-7, and OGB as A-6 while ANW is A-2-4 (following AASHTO classification system). These are shown in figure 2 to 3.

Table 4: Summary of Particle Size Distribution/Classification

SAMPLES	**S1**	**B1**	**OGC**	**OGB**	**OB**	**OG**	**TRO**	**NS**	**NW**	**ANW**
CLAY/SILT (%)	28	24	28	54	29	23	45	16	31	19
SAND (%)	72	76	56	46	71	47	55	84	69	81
GRAVEL (%)	0	0	16	0	0	30	0	0	0	0
CLASSIFICATION	A-2-6	A-2-6	A-2-6	A-6	A-2-6	A-2-7	A-7	A-2-6	A-2-6	A-2-4

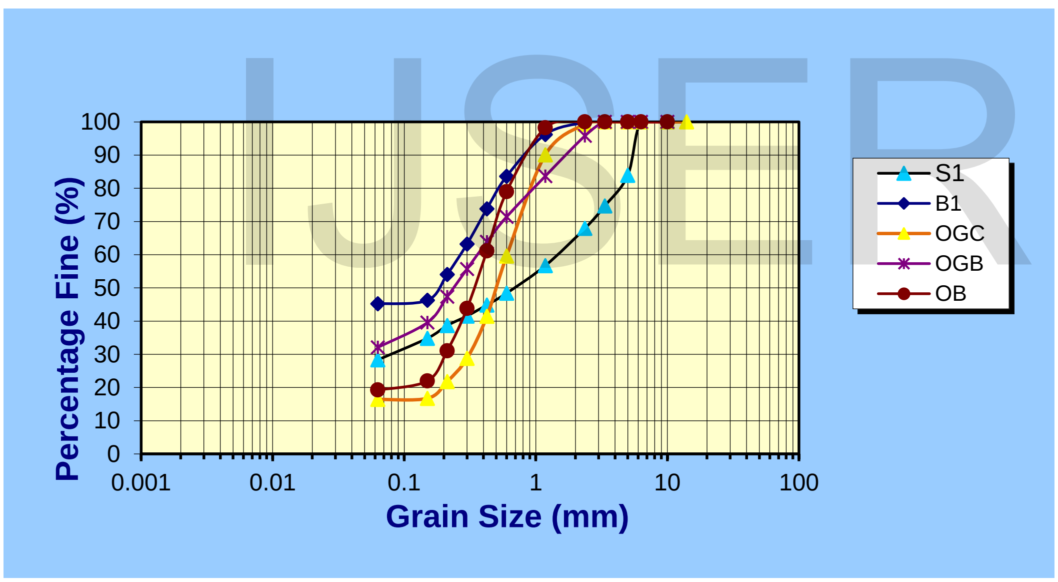


Fig. 2: Granulometry Curve for S1, B1, OGC, OGB AND OB

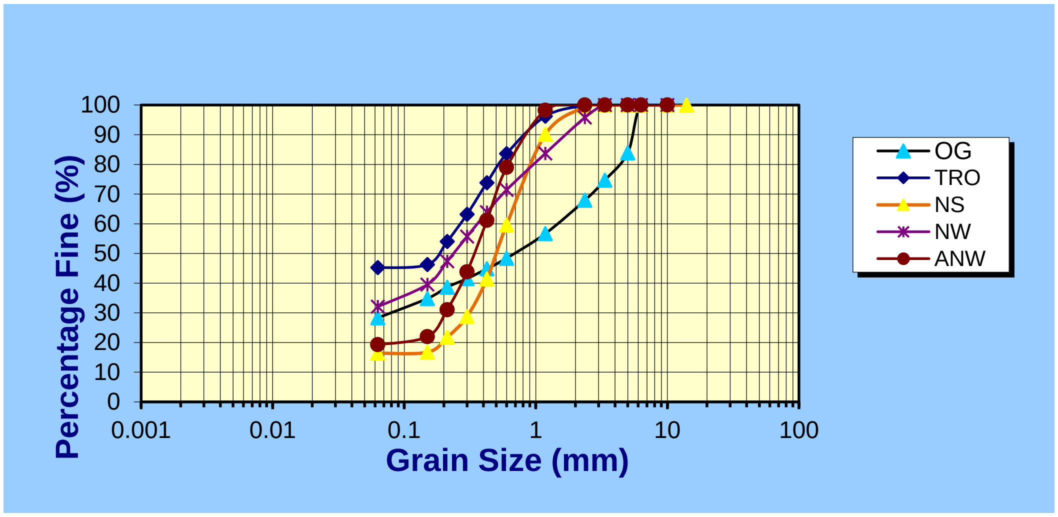


Fig. 3: Granulometry Curve for OG, TRO, NS, NW AND ANW

Atterberg Limit Results

The Atterberg limit result ranges from 20% - 44% of liquid limit, plastic limit ranges from 11% - 23%, plasticity Index ranges from 9% - 27% while the linear Shrinkage ranges from 6% - 10% (Table 5) which indicates that sample OGC, OB, OG and TRO are of medium plasticity while sample S1, B1, OGB, NS, NW and ANW are of low to medium plasticity as shown in Fig.4 and 5. According to the [10] which specified a liquid limit of < 35%; plasticity index < 12% and linear shrinkage <8% for sub-base and base-course materials, only sample ANW falls within the standard for sub-base and base-course materials.

Table 5: Summary Result of Atterberg Limits

SAMPLES	S1	B1	OGC	OGB	OB	OG	TRO	NS	NW	ANW
LIQUID LIMIT (%)	30	34	36	34	38	44	48	28	32	20
PLASTIC LIMIT (%)	14	19	18	17	18	23	21	12	21	11
PLASTIC INDEX (%)	16	15	18	17	20	21	27	16	11	9
LINEAR SHRINKAGE (%)	8	9	9	8	9	10	10	6	10	6

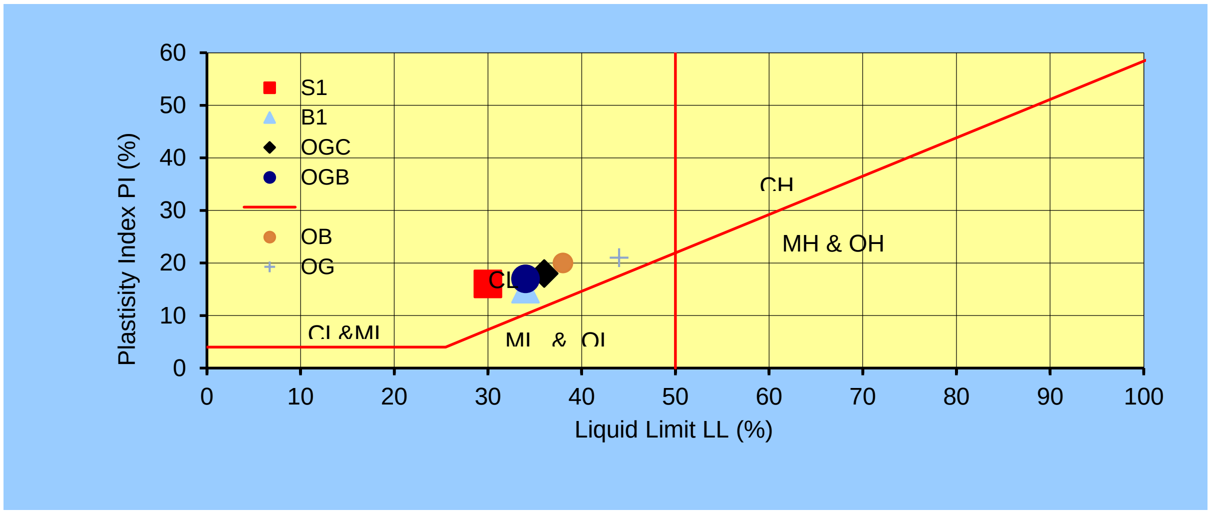


Fig. 4: LL-PI Curve for S1, B1, OGC, OGB, OB AND OG

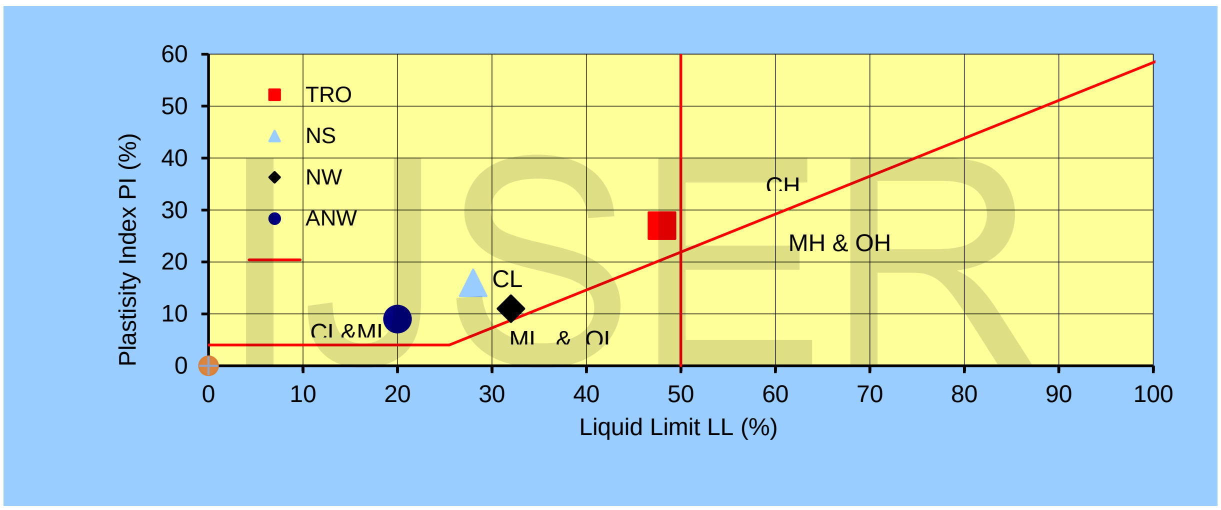


Fig. 5: LL-PI Curve for TRO, NS, NW, AND NWA

Compaction

The maximum dry density for the samples varies between 1.83Mg/m^3 and 2.19Mg/m^3 while that of optimum moisture content ranged from 7.0% to 13.0%. The summary of the results is shown in table 6. Figures 6 to 15 show the behaviour of the soil during compaction. According to [14] the ranges of values that may be anticipated when using the standard proctor test methods are: for clay, maximum dry density falls between 1.44Mg/m^3 and 1.685Mg/m^3 and optimum moisture content may fall between 20-30%. For silty clay maximum dry density is between 1.6Mg/m^3 and 1.845Mg/m^3 and optimum moisture content ranges between 15- 25%. For sandy clay maximum dry density usually ranges between 1.75 and 2.165Mg/m^3 and optimum moisture content between 8 and 15%. Looking at the results of the soil samples, it could be deduced that they are sandy clay.

Table 6: Summary of Compaction Results

SAMPLES	S1	B1	OGC	OGB	OB	OG	TRO	NS	NW	ANW

MAXIMUM DRY DENSITY (Kg/m^3)	1.95	2.04	1.93	2.03	1.97	1.95	1.83	2.19	2.11	1.91
OPTIMUM MOISTURE CONTENT (%)	12.5	10.0	13.0	12.0	10.0	12.0	13.0	7.0	10.7	9.0

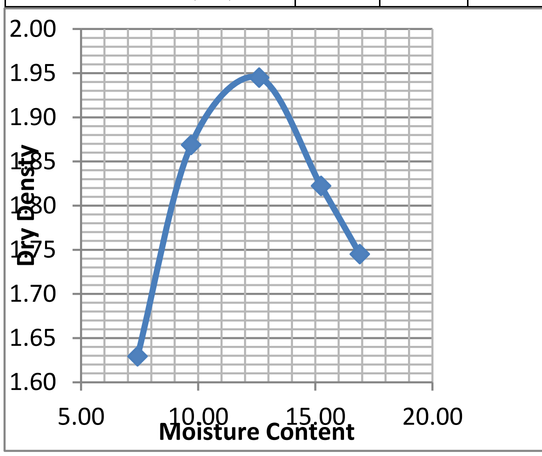


Fig. 6: COMPACTON GRAPH FOR S1

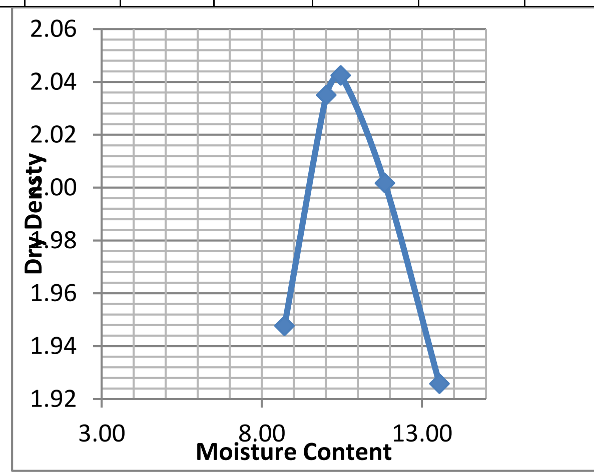


Fig. 7: COMPACTON GRAPH FOR B1

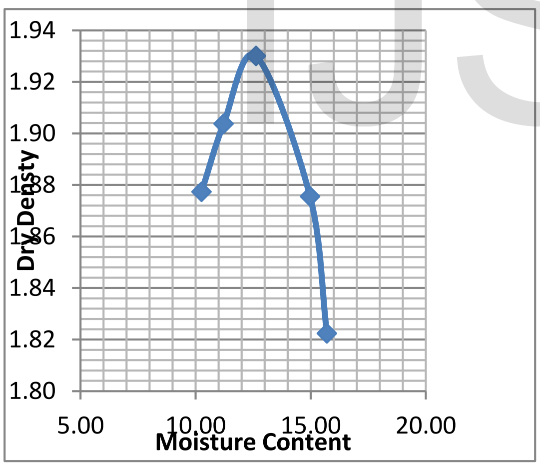


Fig. 8: COMPACTON GRAPH FOR OGC

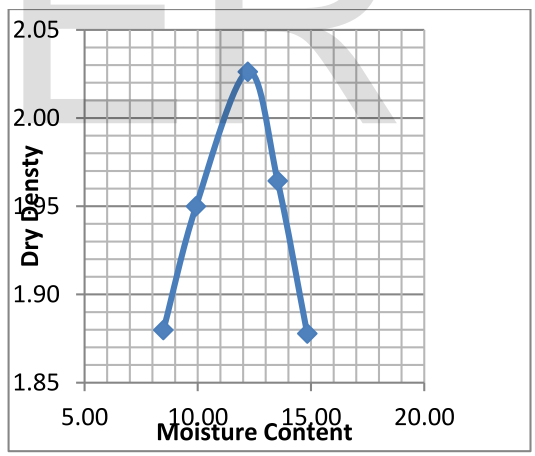


Fig.9: COMPACTON GRAPH FOR OGB

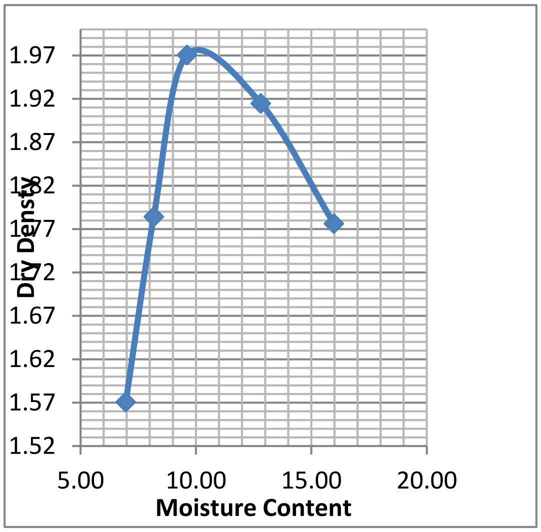


Fig. 10: COMPACTON GRAPH FOR OB

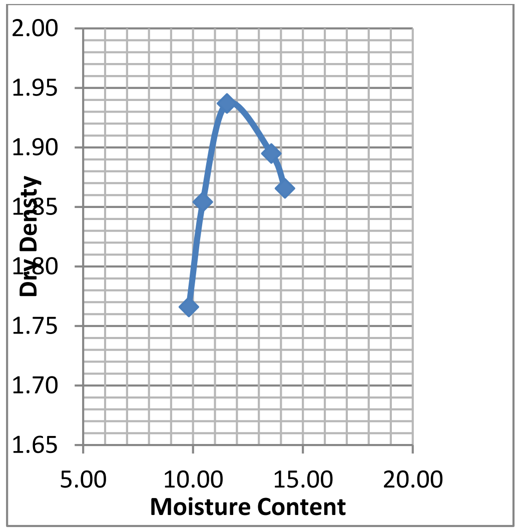
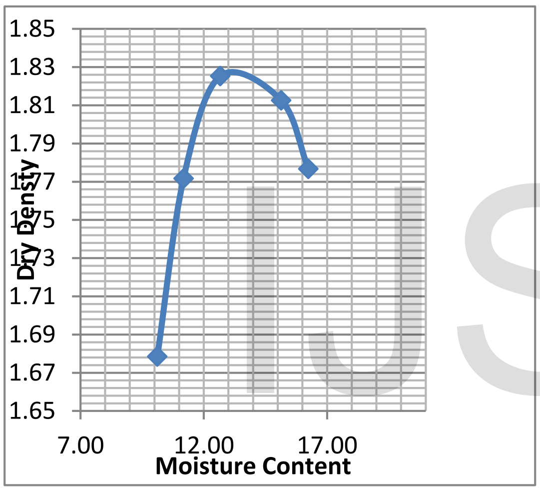


Fig. 11: COMPACTON GRAPH FOR OG



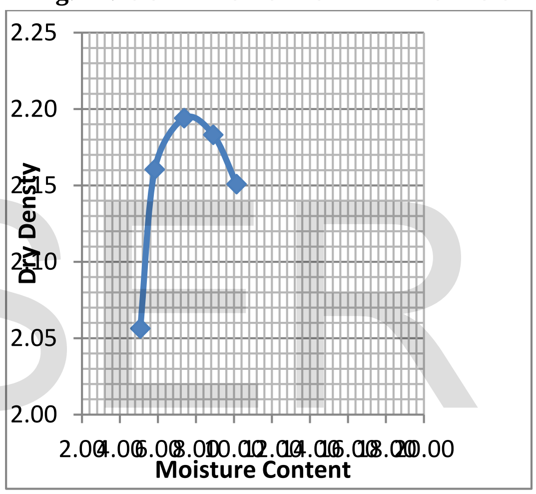


Fig. 12: COMPACTON GRAPH FOR TRO **Fig. 13:**

COMPACTON GRAPH FOR NS

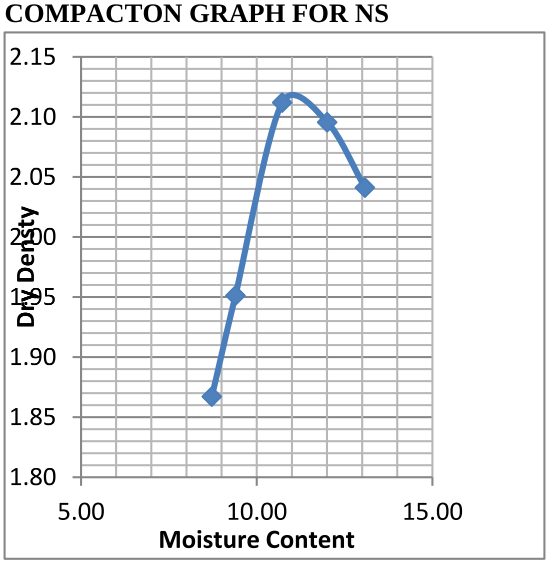


Fig. 14: COMPACTON GRAPH FOR NW

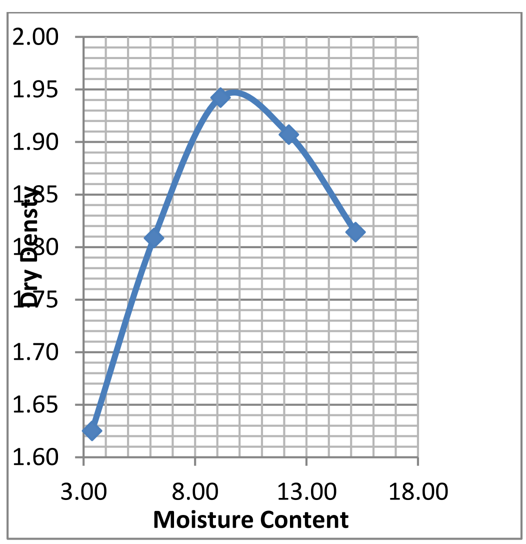


Fig.15: COMPACTON GRAPH FOR ANW

California Bearing Ratio

The unsoaked CBR value for the samples ranges from 44% - 139% while soaked CBR ranges from 16% - 32%. From the Federal Ministry of works and housing, (1997) recommendation of >10 % for sub-grade; >30% for sub-base; >80% for base-course, it can be deduced that soaked CBR samples S1, OB and ANW are suitable for sub-grade while unsoaked CBR samples B1, OGC, OGB, TRO, NS, and ANW are suitable for sub base. It is only OG sample that is good for base course. The summary of the CBR results are shown in Table 7 while figures 16 to 25 shows the graphs for the CBR.

Table 7: Summary of CBR Results

SAMPLE	CBR @ 2.5m		CBR @ 5.0m		Accepted CBR (%)	CBR Mode
	Top	Bottom	Top	Bottom		
S1	14.61	16.24	16.37	15.94	16	soaked
B1	75.51	50.34	80.57	56.01	68	unsoaked
OGC	43.03	66.58	76.48	69.48	72	unsoaked
OGB	19.49	38.97	35.55	46.32	44	unsoaked
OB	11.37	7.47	27.25	13.79	21	soaked
OG	128.29	149.40	134.64	134.64	139	unsoaked
TRO	48.39	59.27	49.55	53.86	54	unsoaked
NS	41.41	41.90	70.88	53.32	62	unsoaked
NW	63.33	79.57	72.17	79.17	76	unsoaked
ANW	43.84	21.11	29.73	25.85	32	soaked

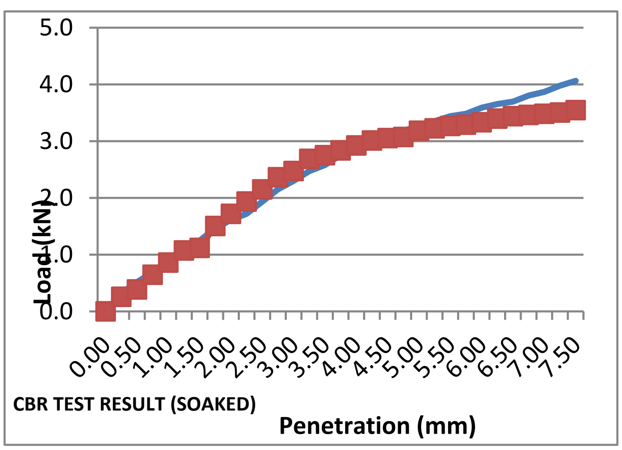


Fig. 16: CBR GRAPH FOR S1

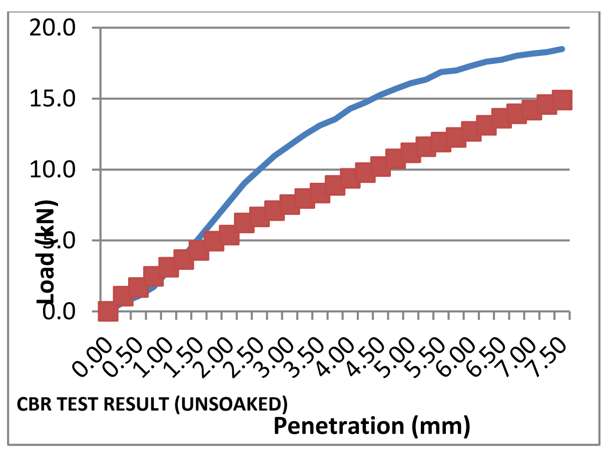


Fig. 17: CBR GRAPH FOR B1

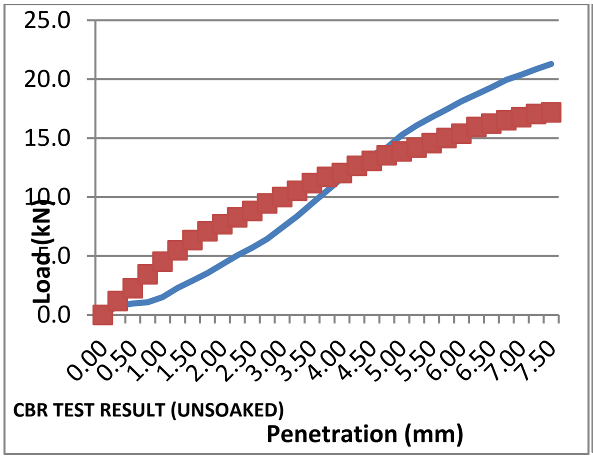


Fig.18: CBR GRAPH FOR OGC

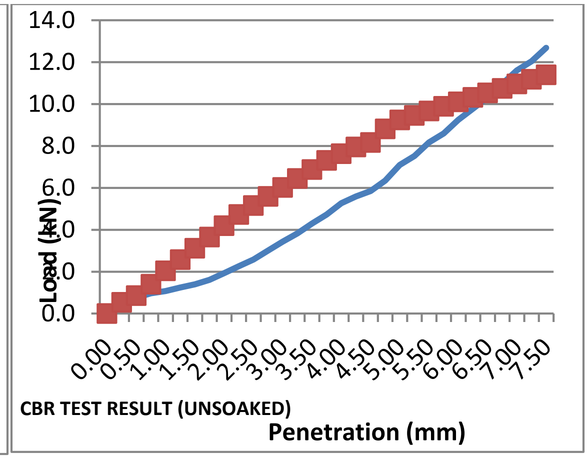


Fig.19: CBR GRAPH FOR OGBUNIKE (OGB)

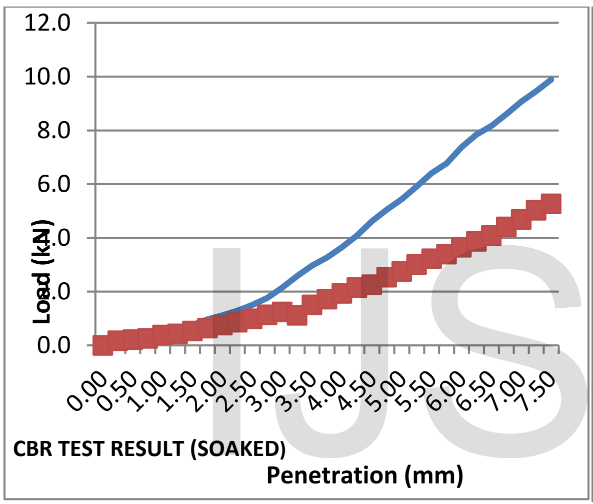


Fig.20: CBR GRAPH FOR OB

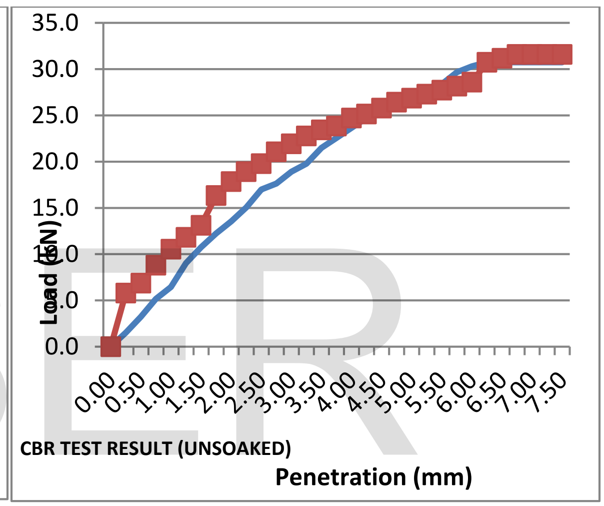


Fig. 21: CBR GRAPH FOR OG

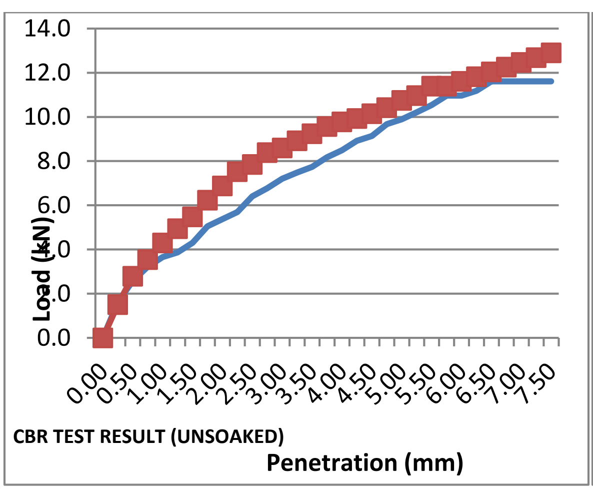


Fig. 22: CBR GRAPH FOR TRO

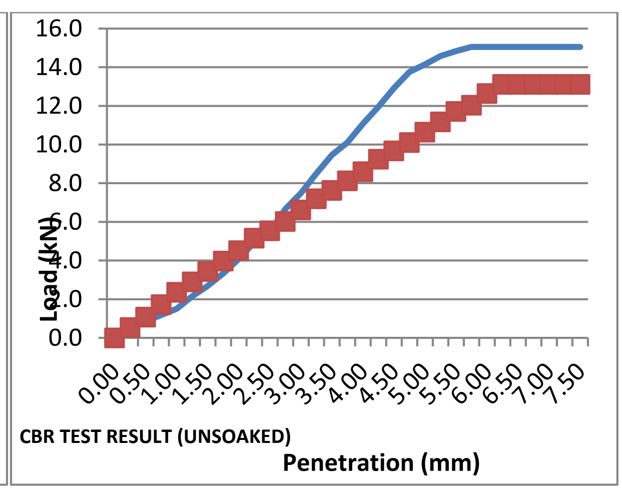


Fig. 23: CBR GRAPH FOR NS

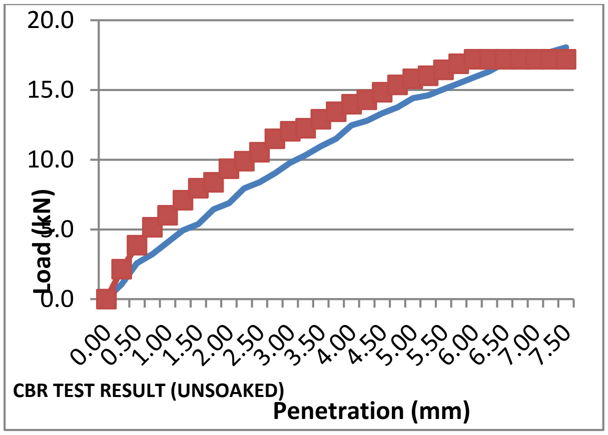


Fig. 24: CBR GRAPH FOR NW

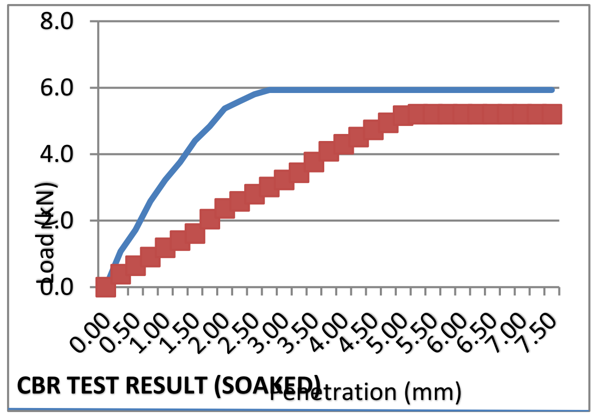


Fig. 25: CBR GRAPH FOR NW

4. Conclusions

Soil deposits derived from Nanka and Ogwashi - Asaba Formations in some parts of Anambra state, southeastern Nigeria are being used in road construction projects in and around the study area. Most of the samples evaluated have well-graded particles-size distribution curves, OGB and TRO have fines more than 35% passing 200BS sieve, while the remaining samples have less than 35%. Using AASHTO soil classification system, sample OGB and TRO are classified as A-6(poor) and A-7(poor) respectively. The study area has low to medium plasticity which is one of the qualities of good materials used for construction of roads. Most of the samples are suitable for subgrade and sub-base while only OG is suitable for base course. It is recommended that all the sub grade and sub base samples should be stabilized with either cement, sand; crushed stone (gravels) of ½ and 3/4-inch size in order to meet the base course requirement and also geo-engineering confirmatory test be carried out before embarking on road construction.

5. Acknowlegment

The authors wish to thank Mr. Kenneth Chinagbaogu Okeke and Mr. Ben Owope for their encouragement and support, also Anambra State Materials Testing Laboratory, Awka's management and staff for testing the study samples.

6. Competing interests

The authors declare that they have no competing interests.

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