ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2521-0904 (Print)
ISSN: 2521-0440 (Online)
CODEN: EHJNA9

Engineering Heritage Journal (GWK)

DOI: http://doi.org/10.26480/gwk.01.2022.06.13

RESEARCH ARTICLE

TEXTURE AND CEMENT STABILIZATION OF DREDGED SAND USED FOR OGBIA - NEMBE ROAD, BAYELSA STATE, NIGERIA

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ARTICLE DETAILS

Article History:

Received 13 December 2021
Accepted 15 January 2022
Available online 19 January 2022

ABSTRACT

This paper is aimed at determining the texture, compaction, and cement stabilization properties of the dredged sand used in the Ogbia-Nembe road construction in Bayelsa State, Nigeria. Both field and laboratory studies were undertaken. Results from the laboratory tests revealed the various properties as follows: moisture content (41.3 – 58.2%), Liquid limit (45.5 – 50.5%), Plastic limit (26.2 – 33.7%), Plasticity Index (16.8 – 20.6%), Cu (2,15 – 3.16), Optimum moisture content (OMC) and Maximum dry densities (MDD) for the dredged sands are (9.2 – 9.4) and (1600 – 1620kN/m3 respectively. The OMC, MDD and California bearing ratio (CBR) of the sand-cement mixture are 10.2 – 12.6%, 1830 – 1880kN/m3, 177 -313% and 1140 - 2905kN/m2 respectively. The dredged sands are classified as A-3 according to the AASHO classification system. However, the average MDD of the dredged sand is 1620kN/m3 which is below the Federal Ministry of Works (FMW) specification for pavement construction, therefore the need for stabilization. Stabilization of the sand with 6% - 10% cement increased the MDD, CBR, UCS to 1880kN/m3, 313% and 2905kN/m2, respectively. The results of this study revealed that the minimum percentage of cement required to stabilize the dredged sand used for the construction of the road is 6%. Also, particle size of cohesionless soil affects the density and sand-cement stabilization is more economical than paying for additional maintenance cost if the pavement fails. This study also revealed that increasing the percentage of cement of a sample does make the soil brittle as well as increases the strength of the material/soil.

KEYWORDS

Compaction, texture, stabilization, soil, dredged sand, pavement

1. INTRODUCTION

The texture is a surface characteristic that has a very wide influence on pavement functional quality (Akpokodje, 2001). It is currently assessed by number of test methods. For stabilization purposes, soil may be differentiated into sub-grade (soil) stabilization and base stabilization (coarse-grained) on the basis of the fine content index. Soil stabilization is the permanent physical and chemical alteration of soils to enhance their physical properties. Stabilization is the process of mixing a stabilizer, for example cement, with a soil or imported aggregate to produce a material whose strength is greater than that of the original unbound material. Stabilization aims at improving on site materials to create a solid and strong sub-base and base courses (Youdeowei et al., 2020). Improvement of sub-grade has to do with blending and mixing materials with the soil in order to stabilize the subgrade (Otoko, 2014).

Soil-cement stabilization involves the pulverization, mixing and blending of material with a predetermined, quantity of cement at the Optimium Moisture Content (OMC) necessary for maximum density with the compaction equipment available, and its compaction do that density. Soil stabilization involves combining soils in such a way that when it is compacted under specified conditions and to the specified extent, it would undergo material change in its properties and would remain in its stable compacted state without undergoing any change under the effect of exposure to traffic (Onyelowe and Okafor, 2013). Water is necessary for soil cement to help obtain maximum compaction and for hydration of the cement. Potable water or other relatively clean water, free from harmful amounts of alkalis, acids or organic matter, may be used. Stabilization work can be carried out in layers to any required thickness. Not all materials can be successfully stabilized, for example if cement is used as the stabilizer, then a sandy soil is much more likely to yield satisfactory results than soft clay (Watson, 1994).

For soils to be stabilized with cement, proper mixing requires that the soil have a P1 of less than 20% and a minimum of 45% passing the 0.425mm (No 40) sieve. Most of the roads in the Niger Delta were constructed with locally available soil materials and this has led to widespread pavement failures in most of the completed roads. Since all the soils in Niger Delta are substandard for base course construction, suitable materials have to be transported for a very long distance. Under these conditions, it might be more economical to improve the properties of the local substandard materials by either stabilization or the use of new design and construction methods (Akpokodje, 2001).

Thus, new method must be adopted for new roads to increase the bearing capacity of the pavement. Stabilization with additives such as lime, lime fly ash, Portland cement, bituminous materials is gaining popularity in many parts of the world (Maranda and Safapan, 2009). The reason of soil cement stabilization is to bring soils to increase their natural strength by the addition of Portland cement. Widespread pavement failures resulting from faulty designs, lack of adequate drainage and good quality pavement soils is a critical constraint to government's determination to provide good road network in the Niger Delta. This paper, therefore, is aimed at determining the texture and compaction properties of dredged sand used to construct road and determining the strength of cement stabilized sands.

Quick Response Code	Access this article online	
	Website: www.enggheritage.com	**DOI:** 10.26480/gwk.01.2022.06.13

Cite The Article: Ukwoma, I.P; Akpokodje, E.G., Nwankwoala, H.O (2022). Texture and Cement Stabilization of Dredged Sand Used For Ogbia – Nembe Road, Bayelsa State, Nigeria. *Engineering Heritage Journal, 6(1): 06-13.*

2. Study Location

The study area lies between latitudes 4^0 55' and 5^0 05'N and longitudes 6015' and 6020'E. The study area is bounded by Delta State on the North, Rivers State on the East and then Atlantic Ocean on the Western and Southern Parts. The study area is located within the Niger Delta region. The topography of the area is essentially flat, sloping vary greatly seawards. A prominent feature of the rivers and creeks is the occurrence of natural levees on both banks, behind occur vast areas of back-swamp and Lagoon/lakes where surface flow is negligible (Youdeowei and Nwankwoala, 2012). This region has a very low water gradient, coupled with flat topography, soil properties and high rainfall in the wet season combined to create serious drainage problems. Along the coastline lies a long coastal Saline belt of active and abandoned beaches built by ocean currents and tides. This area is comparatively higher than the adjacent areas and its width varies from 1 to 10km. North of the mangrove swamp is the freshwater swamp which is in turn succeeded inland by dry areas that are not prone to periodical flood inundation [7, 8, 1] classified the geomorphological units into five, namely (Youdeowei and Nkwankwoala, 2012; Nwankwoala and Mzaga, 2017; Akpokodje, 2001):

1) Dry flatland and plains
2) Deltaic plains with abundant freshwater blackswamps
3) Freshwater swamps, meander belts and alluvial swamps
4) Active or abandoned coastal ridges
5) Saltwater or mangroves swamp.

Table 1: Geologic Units of the Niger Delta (Akpokodje, 1987).

GEOLOGIC UNIT	LITHOLOGY	AGE
Alluvium (General)	Gravel, Sand, Clay, Silt	Quaternary
Freshwater Backswamp meander belt	Sands, Clay, Some Silt, gravel	
Salt water Mangrove Swamp and backswamp	Medium-fine sands, clay and some silt	
Active/abandoned breach ridges	San, clay and some silt	
Sambreiro-Warri deltaic plain	Sand, clay and some silt	
Benin Formation (Coastal plain sand)	Coastal to medium sand, subordinate silt and clay lenses	Miocene-Recent
Agbada Formation	Mixture of sand, clay and silt	Eocene-Recent
Akata Formation	Clay	Paleocene

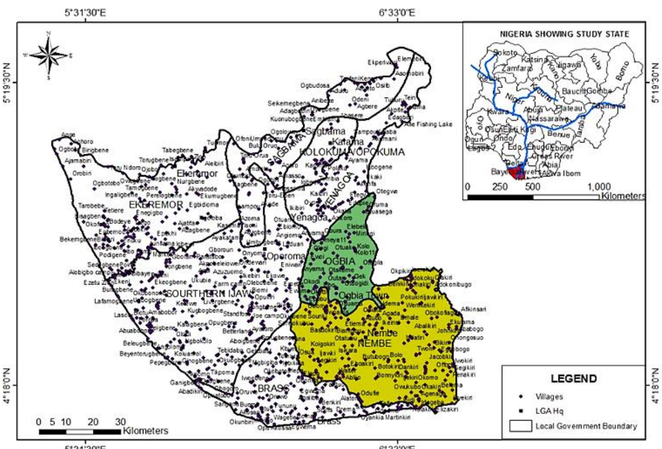

Figure 1: Map of the Study Area (Source: Digitalized from Ministry of Land and Survey, Yenagoa, Bayelsa State)

3. Methods of Study

3.1 Field Sampling

Samples were collected from the field; ten samples of natural superficial soils were collected at different depths while, eight samples of dredged sands were collected along the road. The dredged sands were collected along the road section at 2km interval and were stored in bags. The laboratory study was carried out in accordance with British Standard (British Standards Institution, 1990). The compacted CBR values for the sand with some percentages of cement were done, the mixture was wax and cured for six days; then soaked for 24hrs before testing.

Table 2: GPS coordinates of various Locations of the Natural Superficial Soils

Location	Depth (m)	GPS Coordinates	
		N	E
7km + 400	0.50	04^{0}37'33.36''	006^{0}20'45.72''
7km + 500	0.50	04^{0}37'29.88''	006^{0}20'46.98''
10km + 100	0.69	04^{0}36'08.64''	006^{0}21'01.56''
10km + 200	0.76	04^{0}36'06.84''	006^{0}21'02.94''
13km + 300	0.60	04^{0}34'44.82''	006^{0}22'00.84''
13km + 400	0.66	04^{0}34'42.00''	006^{0}22'01.68''
17km + 100	0.55	04^{0}33'02.10''	006^{0}22'57.90''
17km + 200	0.50	04^{0}33'00.66''	006^{0}23'00.96''
19km + 200	0.35	04^{0}32'46.92''	006^{0}23'41.22''
19km + 400	0.40	04^{0}32'49.38''	006^{0}23'43.26''

Table 3: GPS coordinates of various Locations of the Dredged Sands

Location	GPS Coordinates	
	N	E
7km +	04^{0}37'29.88''	006^{0}20'45.72''
9km +	04^{0}36'35.52''	006^{0}20'46.74''
11km +	04^{0}35'38.28''	006^{0}21'24.54''
13km +	04^{0}34'44.82''	006^{0}22'00.84''
15km +	04^{0}33'42.66''	006^{0}22'19.38''
17km +	04^{0}33'00.66''	006^{0}23'00.96''
19km +	04^{0}32'46.92''	006^{0}23'41.22''
21km +	04^{0}32'43.50''	006^{0}24'02.64''

Figure 2: Cross-section of the Road (N 04^{0}34'44.82'', E 006^{0}22'00.84'')

Figure 3: Cross-Section of the Road (N 04^{0}36'35.52'', E 006^{0}20'46.74'')

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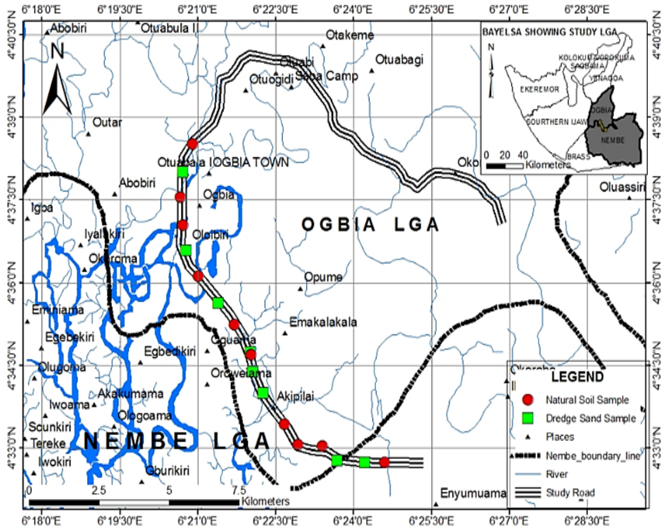

Figure 4: Map showing the Ogbia-Nembe road project with Locations of Dredged sand and Natural superficial soil points2

4. Results and Discussion

The moisture content ranges from 41.3% - 58.2%. These are high value because of the fine texture of the soils. They are also higher than the average range (5-15%) specified by Underwood for engineering specifications (Underwood, 1967). The study area is within the coastal zone which comprises of beach ridges and mangrove swamps underlain by an alternating sequence of sand and clay with high frequency of occurrence of clay within 10m below the ground surface (Nwankwoala and Oborie, 2014). The study was carried out during the raining season resulting in the high value of moisture content. Atterberg limits are used directly in specifications for controlling and evaluating earthwork construction (involving pavement, embankment, fill) and semi-empirical methods of design (Akpokodje, 2001). The liquid limits and plasticity index, PI, ranges 45.5% to 50.5% and 16.8% to 20.6% respectively. Plasticity, PI, indicates that, the soil is of medium swelling potential and liquid limit according to BS 5930 [10] code of practice for site investigation, indicating intermediate plasticity (British Standards Institution, 1990).

When plotted on the casangrade's plasticity as OH and MH using the Unified Soil Classification System (USC), it is classified as Inorganic Silts of High Plasticity (MH) because the Atterberg limits are below the A-line and PI is greater than 7. Soil that possesses high values of liquid limit and plasticity are said to be highly plastic. The larger the plasticity index, the greater the engineering problems the soil will have on foundation or pavement. The Federal Ministry of Works specified that, for the design of sub-base and base coarse material, the liquid limit and plasticity index should be greater than 30% and 12% respectively, therefore the natural superficial soil is not suitable for sub-base material. Soils with high plasticity will exhibit poor engineering qualities because they show great tendencies to loss moisture when they get exposed to dryness (Ekeocha and Akpokodje, 2012). The particle size distribution test results reveal that the soils are clay, clayey silt and sandy silt.

The colour of the clayey silt is grey to dark brown while that of the silty sand is grey. The average values of soils and fines (Silt and clay) content are 45.6% and 54.4% while D_{60} ranges from 0.17 to 0.99mm. When classified using AASHO classification system, the dominant percentage of fines in A – 7 materials is between 51-90%. The texture of the dredged soil is mainly medium sand. The dredged sand is yellowish in colour. From the Particle Size Distribution (PSD) curves, the percentages of fine, medium and coarse sands ranges from 32.6 to 48.7%, 30 to 56.6% and 5.7 to 19.3 respectively while the coefficient of uniformity. Cu ranges from 2.15 to 3.55. According to AASHO classification system, the dredged sands are classified as A-3. A soil is classified as poorly graded if the Cu is less than five (5) or if it contains an excess of one particles or a deficiency of others (Akpokodje, 2001).

Therefore, the dredged sands are considered poorly graded since the Cu is above 2 but less than 5. The optimum moisture content (OMC) and maximum dry density (MDD) ranges from 9.2 to 9.4% and 1600 to 1620kg/m^3 respectively. This result shows that, the OMC is fair while the dry density did not meet the required condition as a backfill material and therefore needs improvement. The Federal Ministry of Works (FMW) specification for a soil to be used as a good backfill material, the dry density should fall between 1700 to 1900kg/m^3 and OMC of 7 to 15%. The main reason for compaction is to improve the engineering properties of the sand/soil mass. The values of the dry densities and optimum moisture content depend on the grading of cohesionlesss soils (Akpokodje, 2001). The effectiveness of stabilization is based mainly on the type of bonding agent (cement), degree of bonding (% of cement), percentage and type of dominant active mineral (number of positions of exchangeable ions – mineralogical composition which is related to liquid limit) and particle size distribution of soil mass (Stavridakis, 2005).

The laboratory result for the compaction test when added cement increases the MDD and OMC. The MDD and OMC range from 1.83 to 1.88kg/m^3 and 10.2 to 12.6% respectively. They also fall within the Federal Ministry of Work specification for a soil to be used as a backfill material. The result shows that, the addition of cement to the soil has increased the strength of the soil making it suitable to be used as backfill material. California Bearing Ratio (CBR) gives an indication of the strength and bearing ability of the soil, which will assist in recommending or rejecting the soil as suitable for base or sub-base for a flexible pavement (Moses et al., 2012). The CBR has an average range of 177 to 313%. A soaked CBR of 180% required for the use as base-course materials can only be achieved at a higher cement, starting from 6% (Omotosho and Eze-Uzomaka, 2008). The higher the CBR value, the better the material provided other necessary parameters are in conformity with the relevant regulatory specifications (Ekeocha and Egesi, 2014). The UCS is used to access the mechanical properties of rocks and fine-grained soils. The primary purpose is to quickly determine a measure of the unconfined strength of rocks or fine-grained soils that posse's sufficient cohesion to permit testing in the unconfined state. The UCS has an average range of 1148 to 2941kN/m^2 for both soaked and unsoaked samples. 1720kN/m^2 is the criterion that is adequate for cement stabilization hence 6% to 10% cement stabilization is in accordance with standard (Habeeb et al., 2013).

Table 4: Summary of Moisture Content

Location	Depth	Mass of can (g)	Can + wet soil (g)	Can + dry soil (g)	Mass of wet soil (g)	Mass of dry soil (g)	Mass of moisture (g)	Moisture content (%)
7km+400	0.5	31	66.3	54.2	35.3	23.2	12.1	52.2
7km+500	0.5	31	61.8	52.8	30.8	21.8	9.0	41.3
10km+100	0.69	31	61.7	50.4	30.7	19.4	11.3	58.2
10km+200	0.79	31	44.2	40.2	13.2	9.2	4.0	43.5
13km+300	0.60	31	48.6	43.2	17.6	12.2	5.4	44.3
13km+400	0.66	31	53.5	46.1	22.5	15.1	7.4	49.0
17km+100	0.55	31	59.0	49.4	28.0	18.4	9.6	52.2
17km+200	0.50	31	48.8	43.6	17.8	12.6	5.2	41.3
19km+200	0.40	31	51.2	44.4	20.2	13.4	6.8	50.7
19km+400	0.35	31	45.7	41.1	14.7	10.1	4.6	45.5

Table 5: Summary of Atterberg Limit Results

Location	Depth (m)	Limit liquid %	Plastic limit %	Plastic Index (PI)	Classification (USC)
N04⁰37’33.36’’ E006⁰20’45.72’’	0.5	48.8	29.9	18.9	OH or MH
N04⁰37’29.88’’ E006⁰20’46.98’’	0.5	49.4	29.2	20.2	OH or MH
N04⁰36’08.64’’ E006⁰21’01.56’’	0.69	50.4	30.3	20.1	OH or MH
N04⁰36’06.84’’ E006⁰21’02.94’’	0.76	47.9	29.1	18.8	OH or MH
N04⁰34’44.82’’ E006⁰22’00.84’’	0.6	48.6	29.3	19.3	OH or MH
N04⁰34’42.00’’ E006⁰22’01.68’’	0.66	50.5	33.7	16.8	OH or MH
N04⁰33’02.10’’ E006⁰22’57.90’’	0.55	45.5	26.2	19.3	CL
N04⁰33’00.66’’ E006⁰23’00.96’’	0.5	46.6	27.1	19.5	OH or MH

Table 6: Summary of Particle Size Distribution Result for the Natural Superficial Soil

Location	Depth (M)	% Passing						Sand	Fines
		Sieving Diameter				D60 (mm)	D10 (mm)		
		5cm	2cm	0.425mm	(#200) 0.075mm				
N04⁰37’33.36’’ E006⁰20’45.72’’	0.5	100	98.0	86.9	53.6	0.098	-	46.4	53.6
N04⁰37’29.88’’ E006⁰20’46.98’’	0.5	100	98.3	78.6	48.4	0.17	-	51.6	48.4
N04⁰36’08.64’’ E006⁰21’01.56’’	0.69	100	99.4	90.1	60.4	0.074	-	39.6	60.4
N04⁰36’06.84’’ E006⁰21’02.94’’	0.76	100	99.3	97.4	57.0	0.085	-	43.0	57
N04⁰34’44.82’’ E006⁰22’00.84’’	0.6	100	99.2	97.8	54.2	0.092	-	45.8	54.2
N04⁰34’42.00’’ E006⁰22’01.68’’	0.66	100	98.7	88.6	56.7	0.098	-	43.3	56.7
N04⁰33’02.10’’ E006⁰22’57.90’’	0.55	-	100	96.2	48.6	0.098	-	51.4	48.6
N04⁰33’00.66’’ E006⁰23’00.96’’	0.5	-	100	96.4	48.4	0.099	-	51.6	48.4
N04⁰32’46.92’’ E006⁰23’41.22’’	0.4	-	100	94.1	56.5	0.092	-	43.5	56.5
N04⁰32’49.38’’ E006⁰23’43.26’’	0.35	-	100	97.3	60.2	0.075	-	39.8	60.2

Table 7: Summary of Particle Size Distribution Result for the Dredged Sand

Location	Soil identification	Percentage Passing				D_{10} (mm)	D_{60} (mm)	Cu
		Sieve Size (mm)						
		5	2	0.425	0.075			
N04⁰37’29.88’’ E006⁰20’45.72’’	Dredged sand	100	99.7	80.7	2.0	0.098	0.31	3.16
N04⁰36’35.52’’ E006⁰20’46.74’’	Dredged sand	100	99.3	80.0	2.0	0.12	0.33	2.75
N04⁰35’38.28’’ E006⁰21’24.54’’	Dredged sand	100	99.7	81.0	1.7	0.11	0.31	2.82
N04⁰34’44.82’’ E006⁰22’00.84’’	Dredged sand	100	99.3	81.7	1.3	0.096	0.27	2.81
N04⁰33’42.66’’ E006⁰22’19.38’’	Dredged sand	100	99.7	80.0	2.0	0.13	0.28	2.15
N04⁰33’00.66’’ E006⁰23’00.96’’	Dredged sand	100	99.3	80.7	1.3	0.099	0.28	2.83
N04⁰32’46.92’’ E006⁰23’41.22’’	Dredged sand	100	99.7	80.0	1.3	0.11	0.39	3.55
N04⁰32’43.50’’ E006⁰24’02.64’’	Dredged sand	100	99.7	80.3	2.0	0.099	0.28	2.83

Table 8: Summary of Compaction Test Results for the Dredged Sand

Location	Soil identification	Densities g/cm³	OMC %
N04⁰37’29.88’’ E006⁰20’45.72’’	Dredged sand	1.60	9.2
N04⁰36’35.52’’ E006⁰20’46.74’’	Dredged sand	1.60	9.4
N04⁰35’38.28’’ E006⁰21’24.54’’	Dredged sand	1.60	9.4
N04⁰34’44.82’’ E006⁰22’00.84’’	Dredged sand	1.60	9.2
N04⁰33’42.66’’ E006⁰22’19.38’’	Dredged sand	1.62	9.2
N04⁰33’00.66’’ E006⁰23’00.96’’	Dredged sand	1.60	9.3
N04⁰32’46.92’’ E006⁰23’41.22’’	Dredged sand	1.61	9.3
N04⁰32’43.50’’ E006⁰24’02.64’’	Dredged sand	1.60	9.2

Table 9: Summary of Sand Cement

Location	Soil identification %	Densities g/cm³	OMC %	CBR % Wax for 6 days and soaked for 24h			UCS kg/cm²	
		B.S		1	2	Average	Sok. Avg.	Un Sok Avg.
1 (7km +)	4	1.85	12.2	174	181	178	11.69	12.37
	6	1.83	12.5	228	232	230	16.99	18.37
	8	1.85	11.6	278	285	282	23.34	24.36
	10	1.87	10.3	315	307	311	29.41	30.31
2 (9km +)	4	1.85	12.2	184	174	179	11.59	12.28
	6	1.85	12.6	227	234	231	17.27	18.36
	8	1.84	11.2	278	282	280	23.17	24.98
	10	1.87	10.6	309	315	312	28.98	30.42
3 (11km +)	4	1.84	12.2	180	173	177	11.48	12.40
	6	1.85	12.5	228	234	231	16.99	18.55
	8	1.85	11.2	287	276	282	23.25	24.08
	10	1.88	10.3	308	317	313	29.14	30.67
4 (13km +)	4	1.84	12.1	180	175	178	11.52	12.02
	6	1.84	12.2	235	226	231	17.47	18.26
	8	1.86	11.3	275	285	280	23.29	24.32
	10	1.88	10.4	317	306	312	29.39	30.63
5 (15km +)	4	1.84	12.3	183	173	178	11.59	13.11
	6	1.83	12.4	225	219	222	17.17	18.56
	8	1.85	11.4	282	276	279	23.28	24.24
	10	1.87	10.3	306	314	310	29.18	30.85
6 (17km +)	4	1.84	12.4	176	182	179	11.50	12.87
	6	1.84	12.3	230	224	227	17.37	18.17
	8	1.85	11.2	288	280	284	23.33	23.93
	10	1.87	10.4	316	310	313	29.05	30.64
7 (19km +)	4	1.86	12.2	180	176	178	11.69	12.01
	6	1.83	12.5	227	233	230	17.47	18.46
	8	1.85	11.4	276	284	280	23.33	24.16
	10	1.87	10.5	310	317	314	29.35	30.53
8 (21km +)	4	1.85	12.4	182	173	178	11.69	12.37
	6	1.84	12.5	224	231	228	16.99	18.57
	8	1.86	11.1	276	287	282	23.22	23.98
	10	1.86	10.2	315	308	312	29.46	29.83

Table 10: Average CBR value for sand cement

Cement content (%)	Soaked CBR
4	178.00
6	229.00
8	281.00
10	312.00

Table 11: Summary of various property ranges of sand cement mix

Sand cement mix (%)	OMC (%)	MDD (kN/m³)	CBR (%)	UCS (kN/m²) soaked	UCS (kN/m²) unsoaked
4	12.1-12.4	1840-1850	177-179	1148-1169	1200-1311
6	12.2-12.6	1830-1850	222-231	1699-1749	1826-1856
8	11.2-11.6	1840-1860	279-284	2317-2334	2408-2498
10	10.5-10.4	1870-1880	310-313	2898-2941	3031-3085

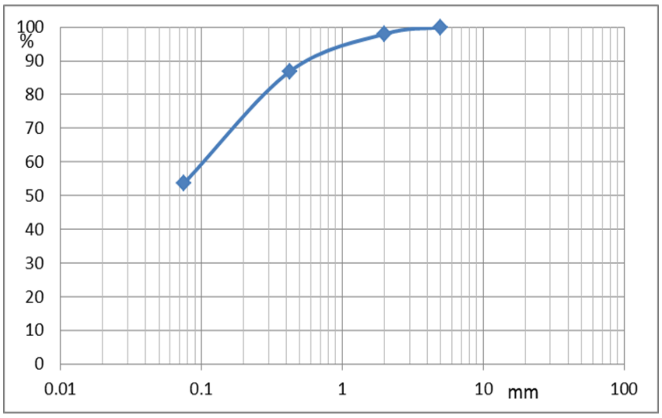

Figure 6: Particle Size Distribution (PSD) Curve for Natural Superficial Soil at 0.5m (7km + 400)

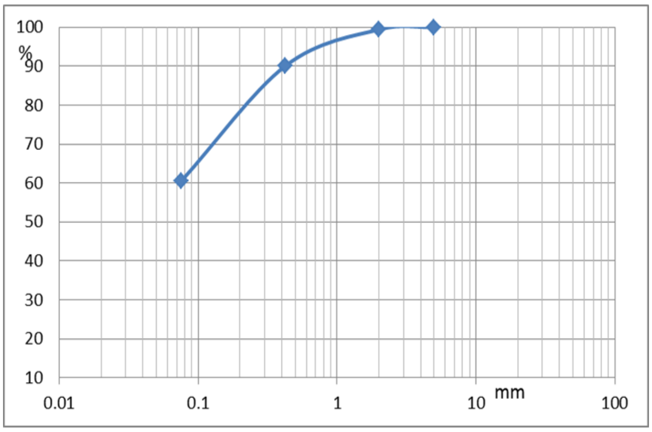

Figure 7: Particle Size Distribution (PSD) Curve for Natural Superficial Soil at 0.69m (10km + 100)

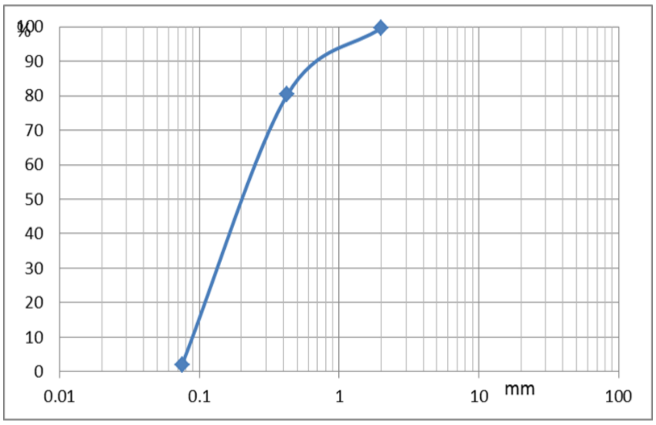

Figure 8: Particle Size Distribution (PSD) Curve for Dredged Sand at N 04°32'43.50'' E 006°24'02.64''

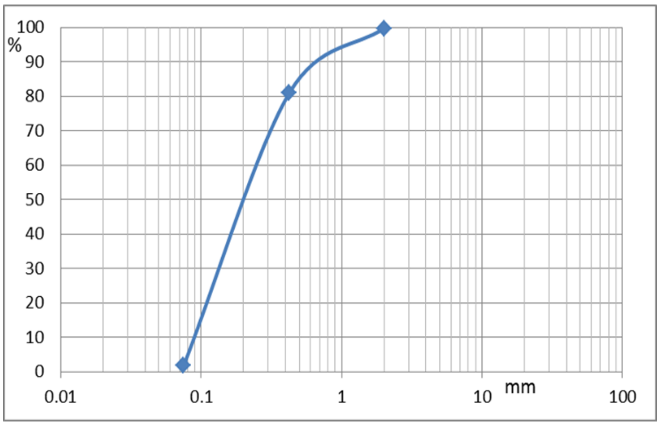

Figure 9: Particle Size Distribution (PSD) Curve for Dredged Sand at N 04°35'38.28'' E 006°21'24.54''

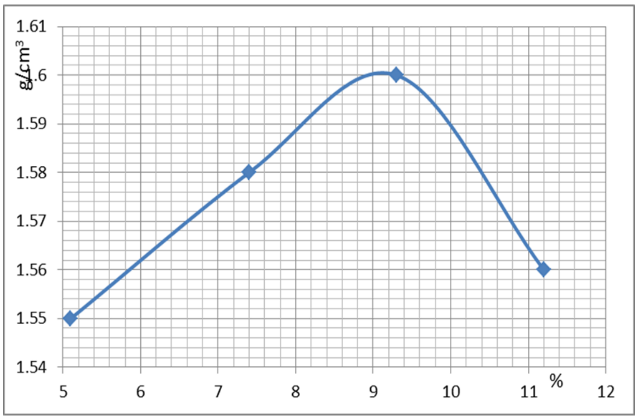

Figure 10: Compaction Curve for Dredged Sand at N 04°32'43.50'' E 006°24'02.64''

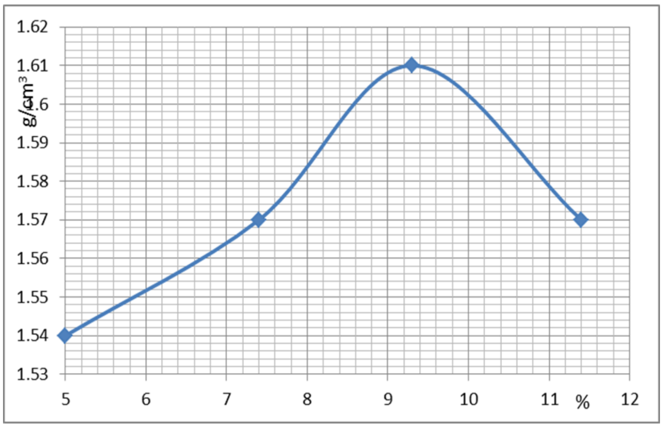

Figure 11: Compaction Curve for Dredged Sand at N 04°32'46.92'' E 006°23'41.22''

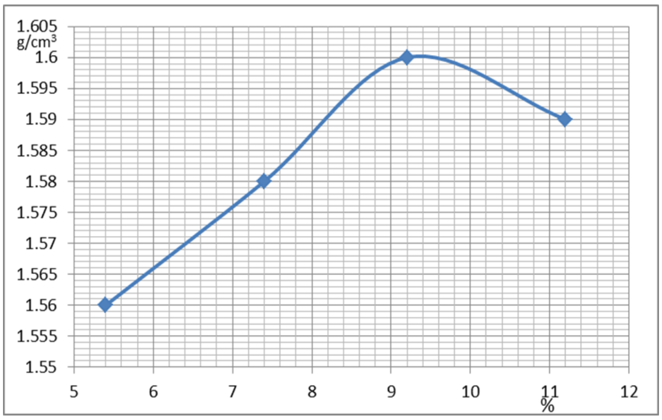

Figure 12: Compaction Curve for N 04°37'29.88'' E 006°202'45.72''

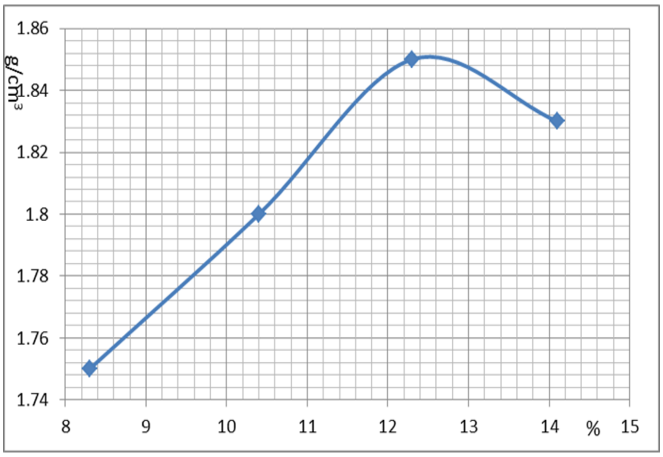

Figure 13: Compaction curve for 4% sand-cement

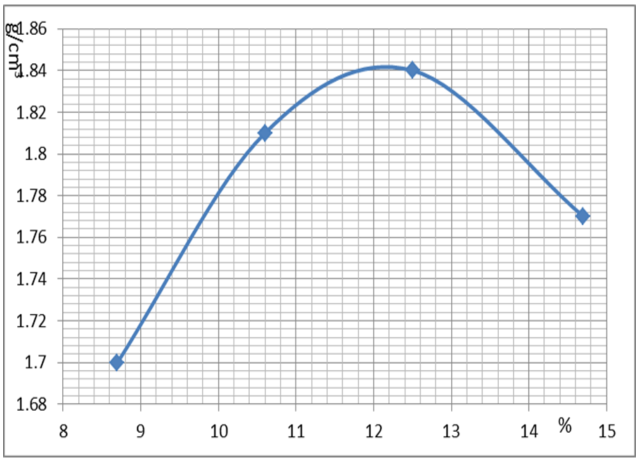

Figure 14: Compaction curve for 6% sand-cement

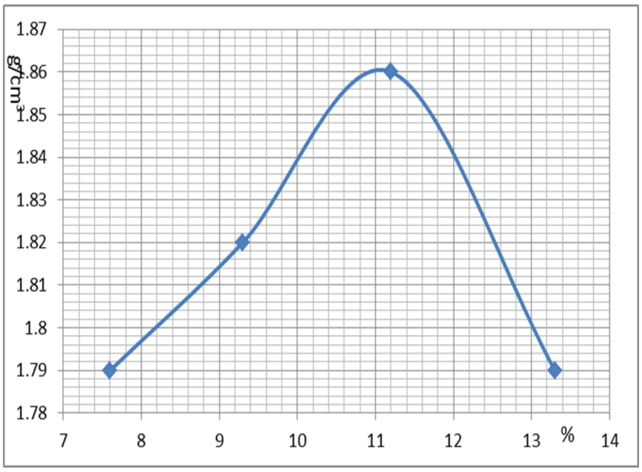

Figure 15: Compaction curve for 8% sand-cement

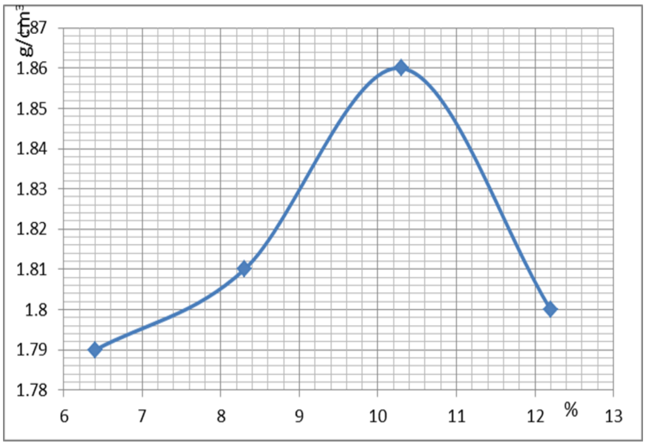

Figure 16: Compaction curve for 10% sand-cement

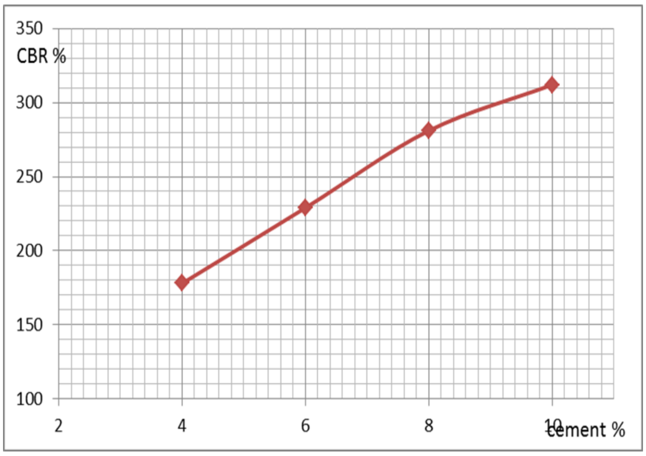

Figure 17: Average California Bearing Ratio (CBR)

5. Conclusion

The natural superficial soil of the study area, indicate that, the soil is inorganic clay of high plasticity. The texture of the dredged sand falls mainly between fine to medium sand. The Particle Size Distribution (PSD) of the dredged sand revealed that, the sand is poorly graded, and does not meet the required standard for road construction as sub-base material, although it is classified as A-3 according to the AASHO Classification System. Also, Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) from the compaction test did not meet the required specification of Federal Ministry of Works (FMW) and therefore, there is need for improvement. The addition of cement to the dredged sand increased the MDD, to the 1700kN/m^3-1900kN/m^3 which falls within the specification of FMW. The CBR has an average range of 177-313% and the UCS an average of 1148-2941kN/cm^2 for both soaked and unsoaked. These ranges of both CBR and UCS met the required specification for the stabilization of the road. However, the study has shown that, particle size of cohesionless soil affect the density and sand-cement stabilization is more economical than paying for additional maintenance cost if the pavement fails and also, shows the increasing the percentage of cement of a sample does make the soil brittle but also, increases the strength of the material/soil.

References

AASHTO Standard M-145. Standard Specification for Classification of Soils and Soil-Aggregate Mixture for Highway Construction Purposes.

Akpokodje, E.G., 1987. The engineering-geological characteristics and classification of the major superficial soils of the Niger Delta. Engineering Geology, 23, Pp. 193-211.

Akpokodje, E.G., 2001. Introduction to Engineering Geology, Paragraphics Port Harcourt, 59, Pp. 180-182.

British Standards Institution – BS 1377. 1990. Methods of Testing for Soils for Civil Engineering Purposes. Determination of Moisture Content, Part 2, Section 3, BIS London.

Ekeocha, N.E. and Akpokodje, E.G., 2012. Assessment of Subgrade Soils of Parts of the Lower Benue Trough using California Bearing Ratio (CBR). The Pacific Journal of Science and Technology, 8, Pp. 572-579.

Ekeocha, N.E. and Egesi, N., 2014. Evaluation of Subgrade Soils using California Bearing Ratio (CBR) in Parts of Rivers State. Journal of Appl. Sci. Environ. Management, 14, Pp. 185-187.

Habeeb, A.Q., Olabambo, A.A., and Bunshiya, G.B., 2013. Impact of Compaction Delay on the Engineering Properties of Cement Treated Soil. IOSR Journal of Mechanical and Civil Engineering, 9, Pp. 09-15.

Marandi, S.M., and Safapan, P., 2009. Base Course Modification through stabilization using cement and Bitumen. American Journal of Applied Sciences, 6, Pp. 30-41.

Moses, G., Saminu A., and Oriola, F.O.P., 2012. Influence of Comp active Effort on Compacted Foundry Sand Treated with Cement Kiln Dust. Civil and Environmental Research, 6, Pp. 11-20.

Nwankwoala, H.O., and Mzaga, T.M., 2017. Geo-Environmental Assessment of Hydrocarbon Contaminated Sites in Parts of Central Swamp Depobelt, Eastern Niger Delta. MOJ Eco Environ Sci., 2 (3), Pp. 00023. DOI: 10.15406/mojes.2017.02.00023

Nwankwoala, H.O., and Oborie, E., 2014. Geo-Technical Investigation and Characteristics of Sub-Soils in Yenagoa, Bayelsa State, Central Niger Delta, Nigeria. Civil and Environmental Research, 8, Pp. 75-82.

Omotosho, O., and Eze-Uzomaka, O.J., 2008. Optimal Stabilization of Deltaic Laterite. Journal of the South African Institution of Civil Engineering, 5, Pp. 10-17.

Onyelowe, K.C., and Okafor, F.O., 2013. Portland Cement/Quarry Dust Improvement of Olokoro Laterite for Road Base. World Journal of Engineering Science, 21, Pp. 133-143.

Otoko, G.R., 2014. A Review of a Stabilization Method for the Nigerian Deltaic Peaty Clay (Chikoko). International Journal of Engineering Sciences and Research, 3 (6), Pp. 298 – 305.

Stavridakis, I.E., 2005. A Critical Bound Meeting the Physical and Engineering Requirments for Best Cement Stabilization Effect on Clay-Sand Mixtures. Electronic Journal of Geotechnical Engineering, 9, Pp. 1-16.

Underwood, L.B., 1967. Classification and Identification of Shales. J. Soil Mech Found Div., ASCE, 93 (111), Pp. 97-116.

Watson, J., 1994. Highway Construction and Maintenance. 2nd Edition. Published by Longman Group, Harlow, Essex.

Youdeowei, P.O., and Nwankwoala, H.O., 2012. Environmental Geological Baseline Study of Obite Gas Plant Site, Eastern Niger Delta, Nigeria. Nature Environment and Pollution Technology, 11 (1), Pp. 41-46.

Youdeowei, P.O., Nwankwoala, H.O., Ayibanimiworio, G.T., 2020. Soil Stabilization and Improvement of Marine Clays Using Cement and Lime in a Marshland. Engineering Heritage Journal, 4 (1), Pp. 08 – 14.