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California Bearing Ratio of Palm Oil Contaminated Subgrade under Soaked Condition

Adeyinka, S.M., Adeyinka, C.O. and Adeyinka, A.I.

Abstract:. The effects of palm oil contaminant on the soaked California Bearing Ratio (CBR) of subgrade was investigated. The following objectives were set out in accordance with BS 1377: 1-8 (1990) and BS 1924 (1990); Particle Size Distribution, Atterberg Limits, Compaction and California Bearing Ratio for oil-palm contaminated and uncontaminated subgrade. Palm oil and four soil samples are used in this research work. The air-dried samples were contaminated with oil-palm at 0, 2,4, 6, 8 & 10% of the dry weight of the samples for 7 days thereafter air-dried for another 7 days. Laboratory experiments on the control (0%) and palm oil-contaminated subgrade samples were conducted after 24 hours of soaking the samples in accordance with BS 1924 (1990). It was found that the soaked CBR for the contaminated soil showed a lower values (17.45%, 24.80%, 49.50% and 21.50%) than the control CBR values (48.20%, 138.40%, 160.00 and 132.10%) for sample A, B, C and D respectively. It is therefore concluded that palm oil has a negative effect on the geotechnical properties and the mechanical strength of the soil hence it is not suitable in any Civil Engineering work.

Keywords: Palm Oil, Subgrade, California Bearing Ratio, Compaction, Contaminant

I. Introduction

Soil improvement and soil stabilization is the addition of binders to soil in a bid to improving the performance of soil as an alternative to dig and dump.[1] stated that the results of rapid economy growth are causing increasing technical challenges than before for Civil Engineers in performing their professional duties. He further stated that challenges coming uncertainties in the ground conditions, which are sometimes the product of mother of nature or man-made, and the ability to adopt timely effective measures to reduce the inherent geotechnical risks.

Adeyinka, S. M (Department of Civil Engineering, Ogun State Institute of Technology Igbesa, Nigeria)
Adeyinka, C. O (Department of Building Technology, Bell's University of Technology Otta, Nigeria)
Adeyinka, A. I. (Department of Architectural Technology, Olabisi Onabanjo University, Ago Iwoye, Nigeria,)
Correspondence author: adeyinka.stephen@ogitech.edu.ng
Phone No: +234-803-303-3420

In pavements construction, subgrade soil serves as the foundation and as a result adequate CBR values is required for the subgrade soil to ensure adequate strength to support the imposed loads. [2] opined that pavement are exposed to repeated high and focused loads which causes precipate aging and failure of the road construction. [3] defined laterite soil as a weathered tropical or sub-tropical remaining soil, generally covered with sesquioxide rich solidification.

Palm fruit is one of the most commercial agricultural produce after cocoa, cashew, and vegetable fruits. As important agriculture is to the existence of man, it is also posing a great concern as is responsible for many of the environmental ills facing the world today [4]. [5] opined that the use of agrochemicals such as chemical fertilizers and synthetic pesticides has not only helped in the increase in production of agricultural products but has also causes negative effects; these include eutrophication of fresh and marine waters,

excessive nitrate leaching into ground water and the persistence of pesticides residues in food, soil and water. Hence, this study aim to investigate the effect of Palm oil contaminants on the California Bearing Ratio of subgrade soil under soaked conditions.

II. Materials

The materials used in this research work are the soil samples and Palm Oil.

A. Soil

Four different soil samples are collected for use in this study. The soil samples are collected at different locations in Ilaro, Ogun State, Nigeria. During the sample collection process at each location, the top soil was stripped off to about 1.5m below ground level and the required quantity of undisturbed soil was collected into clean bags. A total of 6 bags amounting to 300kg each were collected from each location in other to perform the laboratory test.

B. Palm Oil

The palm oil (PO) used for this study was purchased from a local market in Ilaro (New Market). It was obtained in a clean yellow gallon and covered tightly to prevent being contaminated.

III. Methodology

Representative samples were immediately taken (2 per sample) with a labelled known weight moisture content Can and oven-dried to determine the Natural Moisture Content (NMC) of each soil sample.

A. Preparation of Sample

Each collected samples (of about 300kg) were spread on the clean floor as shown in PLATE 1 to air-dried the soil samples for 7 days, thereafter the samples were divided into 6 equal portions (about 50kg) and labelled. A

portion of the divided soil samples were set apart for the control test and analysis, while the remaining portion of each samples were contaminated with the Palm Oil once per day for 5 days at a different percentage of 2%, 4%, 6%, 8% and 10% respectively and thereafter air-dried for 7 days before laboratory tests were conducted on the contaminated soil samples as shown in PLATE 2.

B. CBR Test Procedure

The CBR is a penetration test for mechanical strength evaluation of road subgrades and base courses materials with standard circular piston at the rate of 1.5mm/min. The test is made according to [6]. The samples were placed in three layers at the standard mould and compacted by 56 rammer dropped blows.



Plate 1: Air drying of soil samples



Plate 2: Soil Contaminated with Palm Oil

IV. Results and Discussion

A. Preliminary Test Result

Table 1 showed the summary of the results of the preliminary tests (grain size analysis, specific gravity and Atterberg limit tests).

The results show that the liquid limit of the uncontaminated (0% PO) soil samples ranges from 14.85% for SAMPLE A to 45% for SAMPLE D. The Plasticity Index (PI) of the uncontaminated samples ranges from 18.43% for SAMPLE C to 25.98% for SAMPLE B while a SAMPLE A is Non- Plastic (NP). However, [7] specified that soil with liquid limit less than 35% indicates low plasticity between 35% and 50% indicates intermediate plasticity, and between 51% and 70% indicates high plasticity and liquid limit greater than 70% indicate a very high plasticity.

Also according to [8] soil is suitable as subgrade or fill material if the liquid limit is less than 50% and Plasticity Index equal or less than 30% while as sub-base if the liquid limit is equal or less than 30% and the plasticity index equal or less than 12%. Therefore soil sample A, B, C & D are suitable as subgrade (fill) materials in their natural state, while sample B is suitable as sub-base materials, this is in accordance with the work of [9].

The addition of varying percentage of PO content to the soil samples gives a general trend in all the samples as shown in Table 2, such that the liquid limit decreases with an increase in the PO content. However, PO content above 2% in soil SAMPLE A gives no positive result as it becomes less workable. The results of the contamination on the plasticity index (PI) give slight differences in their trend. SAMPLE A retains its Non-Plastic nature with the increase in PO percentage, while the addition of PO causes an initial increase above the control

value in soil SAMPLE B and D up to 4% PO content and 2% PO content in SAMPLE C.

The addition of PO above these percentages causes a micro-structural transformation of the soil, which leads to interlayer expansion within the clay minerals. The results also show that the palm oil might have exposed both the clay minerals of the soil and the

Table1: Summary of Preliminary Test Results

Parameters	A	В	С	D
USCS	SP	SP	SP	SP
AASHTO	A- 3(0)	A-2- 4(0)	A-2- 6(6)	A-2- 7(0)
LIQUID LIMIT (%)	14.85	30	35	45
PLASTIC LIMIT (%)	NP	25.98	18.43	24.04
PLASTICITY INDEX (%)	-	4.02	16.57	20.96
SPECIFIC GRAVITY (%)	2.72	2.58	2.57	2.37

Table 2: Palm oil-contaminated soil Atterberg Limits Results

SAM	LIMITS	0%	2%	4%	6%	8%	10%
PLE							
A	LL	14.85	12.18	0	0	0	0
:	PL	0	0	0	0	0	0
	PI	NP	12.18	NP	NP	NP	NP
В	LL	30	28.6	26.5	26	17	12.15
	PL	25.98	19.5	11.7	10.2	7.5	0
	PI	4.02	9.1	14.8	15.8	9.5	NP
С	LL	35	34.1	30.1	24	17.6	10.03
	PL	18.43	17.4	15	12.4	9.3	0
	PI	16.57	16.7	15.1	11.6	8.3	NP
D	LL	45	36.8	34.3	26	25	23
	PL	24.04	17	11	9.08	8.2	7.3
	PI	20.96	19.8	23.3	16.92	16.8	15.7

Table 3: Compaction test result for Control samples

Parameters	A	В	С	D
OMC (%)	14	16.5	14.5	17
M.D.D. (kg/m^3)	1.82	1.56	1.98	1.52

Table 4: CBR Result for Control and Soaked Samples Test

Soil	CONTROL CBR	SOAKED CBR
Samples	VALUE (%)	VALUE (%)
A	48.20	17.45
В	138.40	24.80
С	160.00	49.50
D	132.10	21.50

adsorbed water bonded to the soil surface thus leading to a decrease in the liquid limit. This is in agreement with the works of [10 and 11] on the effects of crude oil contamination on the index properties, strength and permeability of lateritic clay and [12] on the effects of compactive efforts on geotechnical properties of spent engine oil contaminated laterites soil.

As the clay particles carry a net negative charge, it attracts cations from the environment. Palm Oil being an organic compound contains a large amount of hydrogen ions. The decrease in liquid limit values may be due to the presence of water around the charged clay particles getting replaced by non-polarized liquid oil. PO would thus make earlier contact with clay particles causing removal of interaction between water and the clay particles.

For the Natural soil samples (0% PO), the specific gravity ranges from 2.37 for sample D to 2.73 for sample A, the result obtained for sample D fall below the standard of 2.60-2.80 as specified for laterites used as subgrade soil by [13]. However, [9] opined that soils with specific gravity value within the range of 1.9 – 2.6 are classified as Halloysites soil

B. Compaction Test Result

The MDD result at the natural state of the subgrade soil was 1.82kg/m³, 1.56kg/m³, 1.98kg/m³ and 1.52kg/m³ respectively for sample A, B, C and D respectively as shown in Table 3.

The addition of palm oil-contaminant shows an initail decrease in the MDD of the soil samples at 2% PO and a further increase to 8% palm oil-contaminant as shown in Figure 1. This decrease in MDD maybe as a result of flocculation-agglomeration process resulting in floc flomation. The enlarge particle size causes the void ratio to increase, this increase

in void ratio reflects the decrease in MDD, this is in similarity to the work of [14].

Figure 2 and 3 shows the OMC for the control soil sample and the palm oil contaminated soil sample. The decrease in the OMC with increase in PO may be attributed

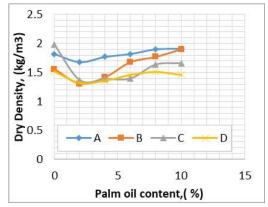


Figure 1: Maximum Dry Density for contaminated soil samples

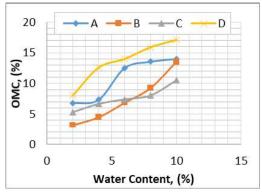


Figure 2: Optimum Moisture Content for control soil samples

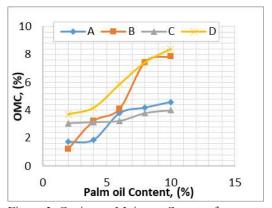


Figure 3: Optimum Moisture Content for contaminated soil samples

to the to the increase in the quantity of free silt and clay fraction.

C. California Bearing Ratio Test

Table 4 shows the result of the CBR result for the control and soaked soil samples. The results of the CBR values at MDD for the samples are 48.20%, 138.40%, 160.00% and 132.10% respectively for sample A, B C and D.

Addition of palm oil-contaminant under soaked condition for 24 hours gives a decrease in CBR values to 17.45%, 24.80%, 49.50% and 21.50 % for sample A, B, C and D respectively. This decrease could be due to the inadequate amount of calcium required for the formation of calcium silicate hydrate and calcium aluminate hydrate which are the major compound responsible for strength gain. This result is in contrary to the work of [15].

V. Conclusion

Based on the preliminary investigations and various geotechnical index tests conducted on the natural soil samples, the soil samples are classified as SP according to USCS and A-3(0), A-2-6(0), A-2-4(0) and A-2-7(0) according to AASHTO soil classification respectively and the following conclusions were drawn;

- (1) The natural soil samples have LL, PL, and PI ranging from 14.855-45%, 18.43%-25.98% and 4.02%-20.96% respectively. However, SAMPLE A can be concluded to be NP. Increase in PO causes a decrease in the LL and PI values.
- (2) The MDD values decrease with an increase in PO contents. However, a general trend was observed for the OMC such that with higher PO contaminant the OMC decreases.

(3) For soaked CBR at MDD, the CBR value decreases for the palm oil-contaminated soil samples.

Based on the results of this present study, it is evident that the contamination of soil with PO causes a reduction in the bearing capacity of soil thus unsuitable for highway pavement design.

Further study can be conducted under different compactive energy on PO contaminated soil so as to check CBR and MDD variation.

Similarly, the addition of naturally available stabilizers such as jute fibres, etc. can be added at different percentages to check its suitability on the geotechnical properties of soil.

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