Original Research Article

A RESEARCH ON GROUNDNUT SHELL ASH'S IMPACT ON LATERITIC SOILS' SOIL STABILIZATION

***ABSTRACT* -** This study aims to provide information on the engineering characteristics of laterite soil, which is frequently used as a building material in civil engineering projects. The significance of subsoil investigations has grown significantly in light of the recent trend of civil construction collapses. In non-industrial nations like Nigeria, minimal residual soil has long been a problem for civil infrastructure, including buildings, culverts, dams, and highways. Also, there has been a lot of global research into using lateritic soil for engineering reasons due to the rising costs of conventional stabilizing agents and the need to utilize industrial and agricultural waste in cost-effective ways for engineering applications. As implied by the research project's topic, this is accomplished through a comprehensive field inquiry and intensive laboratory testing (the effect of groundnut shell ash on lateritic soil properties). The index property test categorized the soil into the A-2-4 subgroup in accordance with the AASHTO standard. As a result, the substance is deemed unfit for use as a foundation or sub-base for paving roads. Tests on the soil's index and geotechnical characteristics after adding groundnut shell ash show significant changes in the parameters. The tests performed for this study adhered to BS 1377:1975 standards. An analysis of the data shows that GSA can be used as a binding agent in the absence of cement, even if it does not have the same binding strength as cement. 4% G.S.A. was also discovered to be the optimal content concentration. All tests and analyses are shown in chapters three and four.

***Keywords* -** Effect, Groundnut, AASHTO, Shell, Ash, Soil, Stabilization.

I. INTRODUCTION

Finding an alternate binder or pozzolanic substance has turned into a problem for national development. Locally, laterite soil has a great deal of potential as a trustworthy and long-lasting building material and has long been a popular choice.

The most prevalent type of soil found in the tropics and subtropics, laterite, is of particular relevance for building and road development. As a result of extensive weathering, laterite soils have a high but highly variable concentration of iron and aluminum oxides, as well as quartz and other minerals. Soils were divided into seven classes by AASHTO. A – 1 to A – 7.

Remaining soils are normally categorized as A- 2 in the AASHTO subgrade classification system (AASHTO Designation: M 145 – 87). The northern states' glacial soil can be categorized as gravel (A-1), sand (A-2), silts (A-5) or silty clays (A-1) (A – 6). Sands and gravel make up the majority of the coaster soils along the eastern coastal and in the Gulf region. However, keep in mind that there are large areas of highly flexible clay in this area (A – 7). Ola (1978), asserts that the A - 2, A - 6 and A - 7 group contains the majority of lateritic soil for road fall and that the A - 3 and A - 5 group has the majority of lateritic soil.

According to Osula, (1984) laterite is defined is a highly worn tropical soil that is rich in secondary oxides of any one or a combination of iron, aluminum, and manganese. Notable laterites found in India and Nigeria include manganese in combination with iron. In the sedimentary basin and all over the basement complex region of the country, laterite soil is found. It is generated from basic igneous, metamorphic, and sedimentary rock (Durotoye, 1983). The usage of laterite soil in different aspects of civil engineering construction projects has been successful. Construction of earth fill dams, motorways, airport runways, low-cost buildings, etc. all use laterite materials.

Laterite soil is the most typical pavement material in the tropics and subtropics, according to Osinubi and Kate (1997). Some laterite soil, such as laterite clays, needed to have their engineering properties improved before they could be used in any kind of construction because they have high swelling potentials that caused issues with construction and made them unsuitable for use as building materials in their natural states.

- **Aim and Objectives of The Study**
  - ***Aim***

In order to choose the appropriate mix design, the purpose of this research is to ascertain how groundnut shell ash affects lateritic soil qualities.

- ***Objectives***

1. To properly analyze the soil samples using a sieve to determine the particle sizes.
2. To use a specific gravity test to identify the samples' specific gravities.
3. To experimentally establish their liquid and plastic limits.
4. To perform a test for compaction on samples with 0%, 4%, and 8% groundnut shell ash.
5. To test the California Bearing Ratio (CBR) using groundnut shell ash at 0%, 4%, and 8%.

Finding the strength and bearing capability of the chosen lateritic soil sample is part of the project's scope. further to assess the soil sample's viability for civil engineering projects like road building and other engineering endeavors. They will assess the index qualities of their chosen soil sample in accordance with the AASHTO soil classification scheme, and the outcomes will establish if the presence of groundnut shell ash had an impact on the samples.

In order to determine whether adding groundnut shell ash as an alternative binder to lateritic soil properties is a good idea and whether it can be used in any civil engineering projects, the effect of groundnut shell ash on lateritic soil properties will be assessed through a variety of laboratory tests.

II. LITERATURE REVIEW

Many studies on lateritic soils have been conducted, but the connection between plasticity (consistency limit) and compressibility properties has received little attention. Many road and structural collapses have been caused by construction engineers' negligence in Sub-Saharan Africa. Lateritic soils are classified as having a lack in sand and silt size particles, according to Ashworth (1996).

Krishna *et al*, (2015).: stated that groundnut shell ash might be employed as a great ground improvement approach, especially for engineering projects on unstable soils where it can be used as a cheap and energy-efficient alternative to deep or raft foundations. Based on unconfined compressive strength tests on soil samples containing groundnut shell ash of 3%, 6%, and 9%, it was determined that the increase in unconfined compression strength was determined to be 24.60%, 44.26%, and 59.01%, respectively.

Ola, (1974).: Laterite stability issues were investigated, and the modified outcome was employed to make blocks. In order to determine whether the materials could be used to make bricks, Balogun (1982) looked into the physical and geotechnical characteristics of laterite soil in Sagamu, South-Western Nigeria. He discovered that there were significant differences in some index properties and the crushing strength of three lateritic clay deposits in this region.

The findings indicated that firing significantly boosts strength. The inability of laterite soil to produce repeatable findings when tested in a laboratory is an issue. It is challenging to assess the soils as a construction material for engineering. Thermal and mechanical instabilities, or the sensitivity to major change on the addition of tiny quantities of thermal or mechanical energy, have been highlighted as the particular difficulties of the soil.

Moses, George (2015).: Black cotton soil stabilization with groundnut shell ash. He had come to the conclusion that the natural soil was categorized as A—7–6 or CL under the AASHTO and USCS, respectively. These groups soils are not very useful for engineering. A maximal 7-day UCS value at SP of 455KN/m^2 at 4% GSA content and 526KN/m^2 at 6% GSA content were obtained for WA compactive effort after treating natural soil with groundnut shell ash. This result was below the 1710 KN/m^2 threshold set by TRRL (1977) for base material stabilization using OPC, and it was also below the 687-1373 KN/m^2 threshold set by Ingles and Metcay for sub-base (1972). At 6%, the peak soaking CBR values at SP and WA were 4% and 4%, respectively (GSA).

III. RESEARCH METHOD

By using the bulk disturbed sampling technique, a lateritic soil sample was obtained from an excavated trench at university road, Uli, Anambra state, for use in this study.

The research tests were carried out in accordance with the protocols outlined in BS 1377 (1975) and BS 1924 (1990) for wild and stabilized soil, respectively. The test that follows was carried out specifically.

Plantain leaf ash is used in this project to create self-compacting concrete. Compressive strength tests, California Bearing Ratio tests, Atterberg limit tests, and other tests were performed as workability tests, whereas sieve analysis and specific gravity tests were performed as preliminary tests since they helped the concrete develop its strength.

Set of Sieves, Compressive Strength Machine, and Automated CBR Test Machine are the key testing tools utilized in the test. Cement, sand, coarse aggregate, water, and groundnut shell ash were additional supplies employed in the trials (GSA).

IV. RESULT AND ANALYSIS OF RESULT

SIEVE ANALYSIS TEST

Sample: Lateritic Soil

Initial Dry Weight of Sample: 288% g

Table 1: Sieve Analysis test

Sieve Size	Mass Retained (g)	Percentage Retained	Cumulative % Passing
10.00mm	21.30	218.10	98.28
5.00mm	83.50	1134.60	91.54
2.00mm	118.30	1016.30	82.00
1.18mm	127.20	889.10	71.74
600 microns	143.70	745.40	60.14
425 microns	147.80	597.60	48.22
300 microns	151.60	446.00	35.99
150 microns	158.00	288.00	23.24

75 microns	161.70	126.30	10.19
Pan	126.30	0	0
Total	1239.40		

SPECIFIC GRAVITY (GS) TEST BS 812)

Table 2: Specific Gravity Test

	M_1	M_2	M_3
Number of trials	1	2	3
Mass of density bottle + plate (M_1)	855.60	2010.30	825.60
Mass of density bottle+ plate + soil (M_2)	1055.60	2210.30	1025.60
Mass of density bottle + plate + soil + water (M_3)	2217.20	2085.80	2208.20
Mass of density + plate + soil + water (M_4)	2050.70	2072.80	2085.70
$(M_4 – M_1) – (M_3 – M_2)$	33.43	187	77.70
$(M_2 – M_1)$	200	200	200
Specific Gravity (GS)	5.98	1.07	2.57

Mass of Sample Use = 200g

$$Gs = \frac{(M_2 - M_1)}{(M_4 - M_1) - (M_3 - M_2)}$$

$$GS = \frac{200}{33.43}$$

GS = 5.98

Average GS = (5.98 + 1.07 + 2.57)/3

GS = 3.21

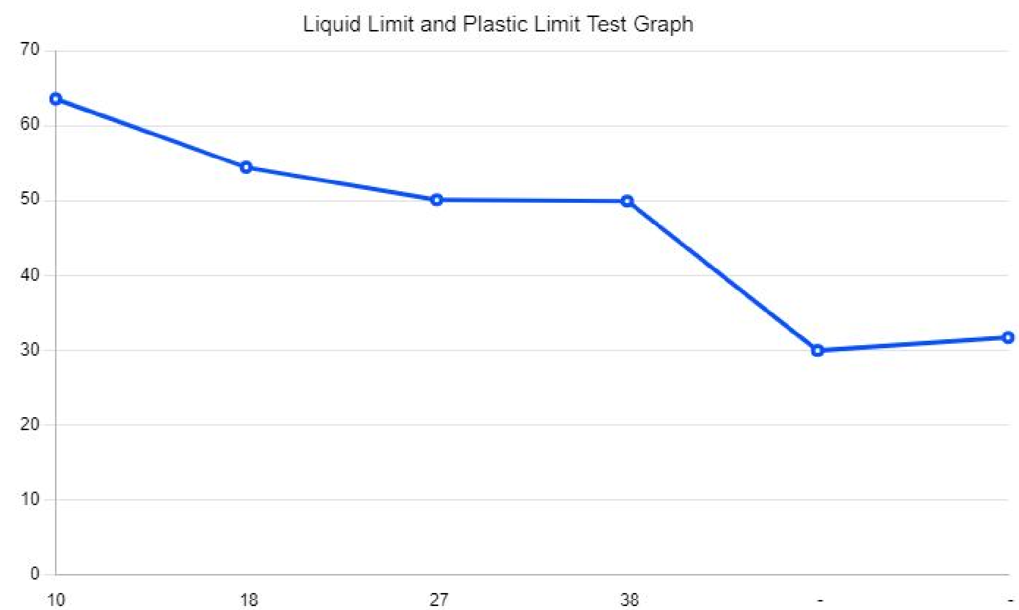
LIQUID LIMIT AND PLASTIC LIMIT TEST

Table 3: Liquid Limit and Plastic Limit Test

Test Number	**1**	**2**	**3**	**4**	**5**	**6**
Type of test +	L.L	L.L	L.L	L.L	P.L	P.L
No of blows (liquid limit test)	10	18	27	38	-	-
Container No	25	28	4	44	39	35
Mass of Wet soil + container (g)	28.5	26.3	27.8	31.5	22.0	27.4
Mass of Dry soil + container (g)	23.9	22.8	24.1	26.7	20.7	24.8
Mass of Container (g)	16.66	16.37	16.71	17.08	16.36	16.59
Mass of Moisture (g)	4.6	3.5	3.7	4.8	1.3	2.6
Mass of Dry Soil (g)	7.24	6.43	7.39	9.62	4.34	8.21
Moisture Content (%)	63.54	54.43	50.07	49.9	29.95	31.67
						30.81

Type of Test Natural Moistures Content + (N)

Liquid Limit (L.L) Plastic Limit (P.L.)



Results, Liquid Limit (L.L.) = 50.8

Plastic Limit (P.L.) = 30.81

Plasticity Index (P.I) = 19.99

Fig. 1. **LIQUID LIMIT AND PLASTIC LIMIT TEST RESULTS CURVE**

COMPACTION TEST

5000grm laterites

Sample: Laterite Soil at 0% Stabilization

chart 1: Compaction Test

Sample No	**N / M**		**2%**		**4%**		**6%**		**8%**	
Pan	50	25	35	22	20	47	38	9	5	51
Weight pan + moist soil (g)	65.7	49.4	73.2	53.1	67.5	71.2	59.7	67.2	73.2	67.2
Weight pan + dry soil (g)	61.1	46.3	66.0	53.1	61.0	64.9	53.8	60.2	64.5	60.0
Weight water (g)	4.6	3.1	5.3	47.5	6.5	6.3	5.9	7	8.7	7.2
Weight pan (g)	16.51	16.66	16.5	16.7	16.52	17.15	17.01	16.21	15.69	16.91
Weight dry soil (g)	44.5	29.64	49.41	137.03	44.48	47.75	36.79	43.99	48.81	43.08
Moisture Content (%)	10.32	10.46	12.9	12.82	14.61	13.19	16.04	15.91	17.82	16.71
Average moisture content (%)	10.39		12.41		13.9		15.98		17.27	
Mass of mould + base + compacted specimen (m_2)	8123		8414		8698		8925		8900	
Mass of mould + base (m_1)	4488		4488		4488		4488		4488	
Mass of compacted specimen ($m_2 - m_1$)	3635		3926		4210		4437		4412	
Bulk density $S = \frac{M_2 - M_1}{2085.71cm^3}$	1.80		1.94		2.08		2.19		2.18	
Moisture content container No	50125		35122		20147		3819		5151	
Moisture Content (w) (%)	10.39		12.4		13.9		15.98		17.27	
Dry density $Sd = \frac{100p}{100 + w}$ mg/m^3	1.63		1.73		1.83		1.89		1.86	

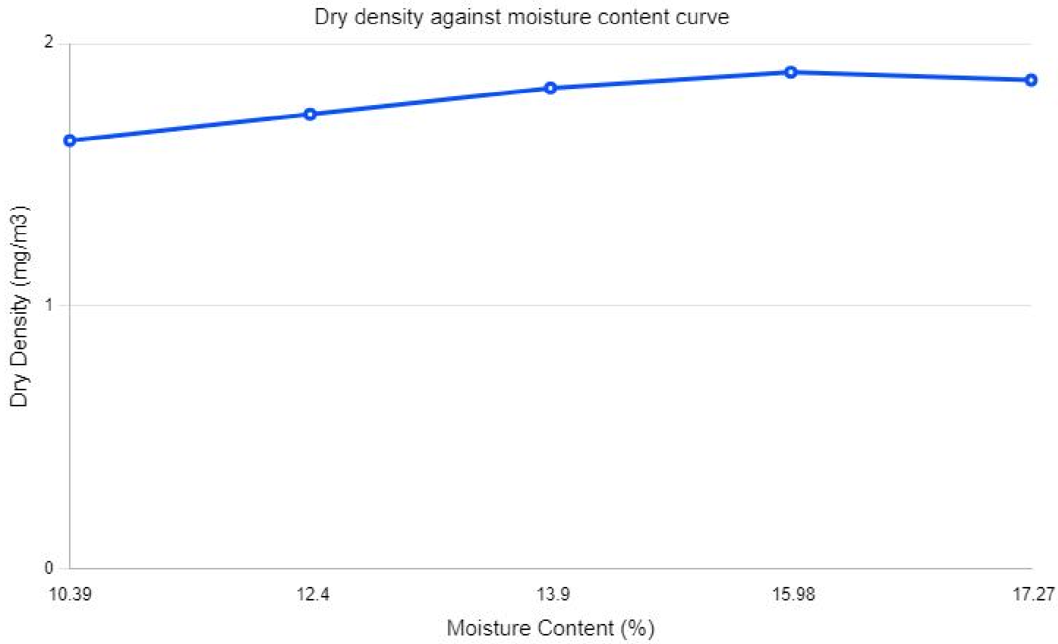


Fig. 2. COMPACTION TEST RESULTS CURVE

COMPACTION TEST

4% of G.S.A. 240 / 5760grm laterite

Sample: Laterite Soil at 4% Groundnut Ash Replacement

Table 3a: Compaction Test

Sample No	**N / M**		**4%**		**6%**		**8%**		**10%**	
Pan	40	32	8	45	35	34	12	43	33	39
Weight pan + moist soil (g)	59.58	65.69	73.64	64.88	70.46	60.31	70.05	63.8	75.16	61.77
Weight pan + dry soil (g)	56.42	62.06	67.86	59.70	63.62	54.93	62.20	56.22	66.03	54.44
Weight water (g)	3.16	3.63	5.78	5.19	6.84	5.36	7.85	6.61	9.13	7.30
Weight pan (g)	15.97	16.91	16.67	16.55	16.59	16.43	16.52	16.29	16.54	16.36
Weight dry soil (g)	40.45	45.15	51.19	43.15	47.03	38.50	45.68	39.93	49.49	38.08
Moisture Content (%)	7.81	8.04	11.29	12.03	14.54	13.92	17.18	16.55	18.45	19.17
Average moisture content (%)	7.93		11.66		14.23		16.87		18.81	
Mass of mould + base + compacted specimen (m_2)	8760		8189		8504		8813		8827	
Mass of mould + base (m_1) (g)	4644		4565		4565		4565		4565	
Mass of compacted specimen (m_2 - m_1)(g)	4116		3624		3939		4248		4262	
Bulk density S = $\underline{M_2 – M_1}$	1.99		1.74		1.89		2.04		2.04	

2085.71cm^3					
Moisture content No	46155	8145	35134	12143	33139
Moisture Content (w) (%)	7.93	11.66	14.23	16.87	18.81
Dry density Sd = $\frac{100p}{100 + w}$ mg/m^3	1.46	1.56	1.65	1.75	1.72

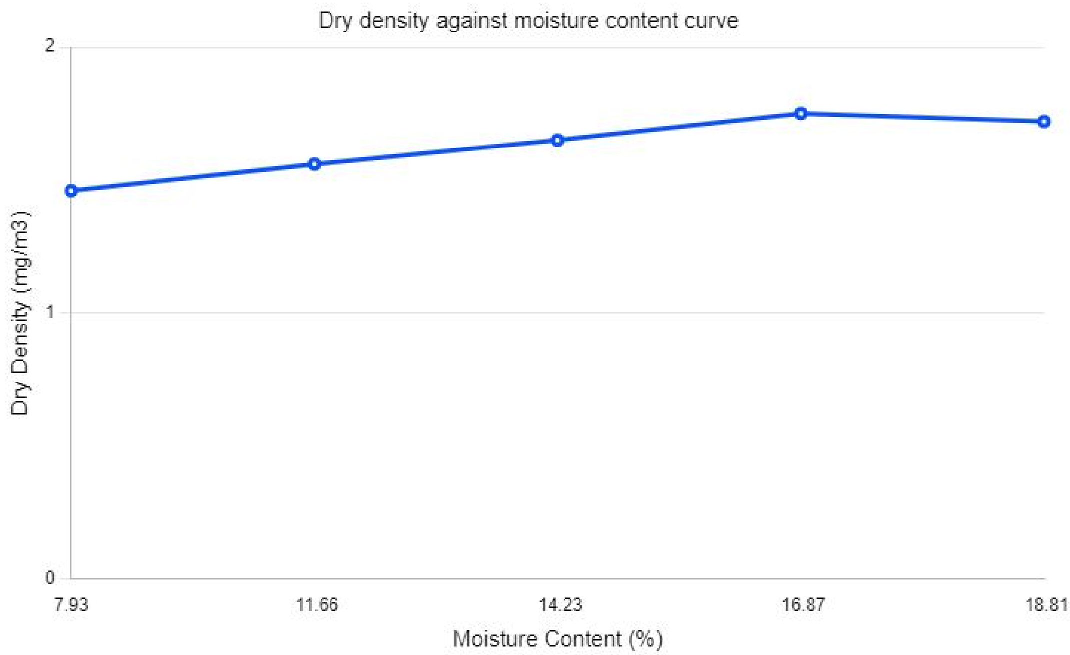


Fig. 3. Dry density against moisture content curve 1

COMPACTION TEST

8% of G.S.A. 480 / 5520grm laterite

Sample: Laterite Soil at 8% Groundnut Ash Replacement

Table 3b: Compaction Test

Sample No	N / M		4%		6%		8%		10%	
Pan	6	47	27	14	46	55	17	52	26	54
Weight pan + moist soil (g)	81.82	89.98	58.42	72.39	43.60	41.12	53.66	55.70	61.68	53.74
Weight pan + dry soil (g)	80.64	88.63	56.05	69.10	41.72	39.22	50.51	52.32	56.70	50.10
Weight water (g)	1.18	1.35	2.37	8.29	1.88	1.9	3.10	3.30	4.9	3.64
Weight pan (g)	16.90	17.15	16.47	6.92	16.85	1645	16.99	16.75	16.69	17.10
Weight dry soil (g)	63.74	71.48	39.58	47.18	24.83	22.77	33.54	35.57	40.01	33.03
Moisture Content (%)	1.85	1.45	5.0	7.0	7.6	8.3	9.4	9.5	12.4	11.0

Average moisture content (%)	1.65	6.0	8.0	9.5	11.7
Mass of mould + base + compacted specimen (m_2)	8333	8492	8760	8915	9191
Mass of mould + base (m_1) (g)	4544	4530	4644	4644	4644
Mass of compacted specimen (m_2 - m_1)(g)	3789	3962	4116	4271	4547
Bulk density S = $\frac{M_2 - M_1}{2085.71cm^3}$	1.82	1.90	1.99	2.06	2.20
Moisture content No	35131	27114	46155	17152	26154
Moisture Content (w) (%)	1.65	6.0	8.0	9.5	11.7
Dry density Sd = $\frac{100p}{100 + w}$ mg/m^3	1.34	1.79	1.84	1.88	1.97

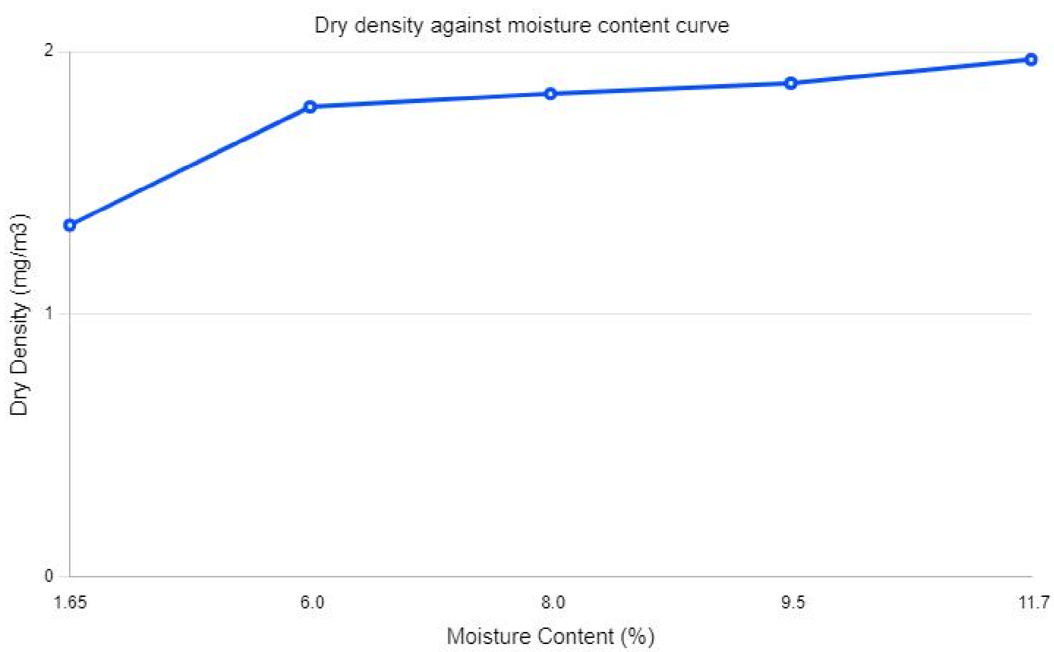


Fig. 4. **Dry density against moisture content curve 2**

California Bearing Ratio (C.B.R.) Test

O% Stabilization

Load-Ring: 0.0275. Bearing Value (%) 33%

Dry Density - - - - - - - - Top - - - - -   29.70% 39.95%

Moisture Content - - - - Bottom - - - -   27.87% 35.27%

Table 4: California Bearing Ratio Test

Penetration (mm)	**Reading (div)**		**Force on Plunger (KN)**		**Penetration (mm)**	**Reading (div)**		**Force on Plunger (KN)**	
	Top	Bottom	Top	Bottom		Top	Bottom	Top	Bottom
0.25	13	13			3.00	170	160		
0.50	24	36			3.50	200	184		
0.75	34	48			4.00	230	208		
1.00	47	60			4.50	260	232		
1.25	65	73			5.00	290	256	7.98	7.04
1.50	80	84			5.50				
1.75	98	95			6.00				
2.00	112	108			6.50				
2.25	130	121			7.00				
2.50	143	134	3.9	3.69	7.50				

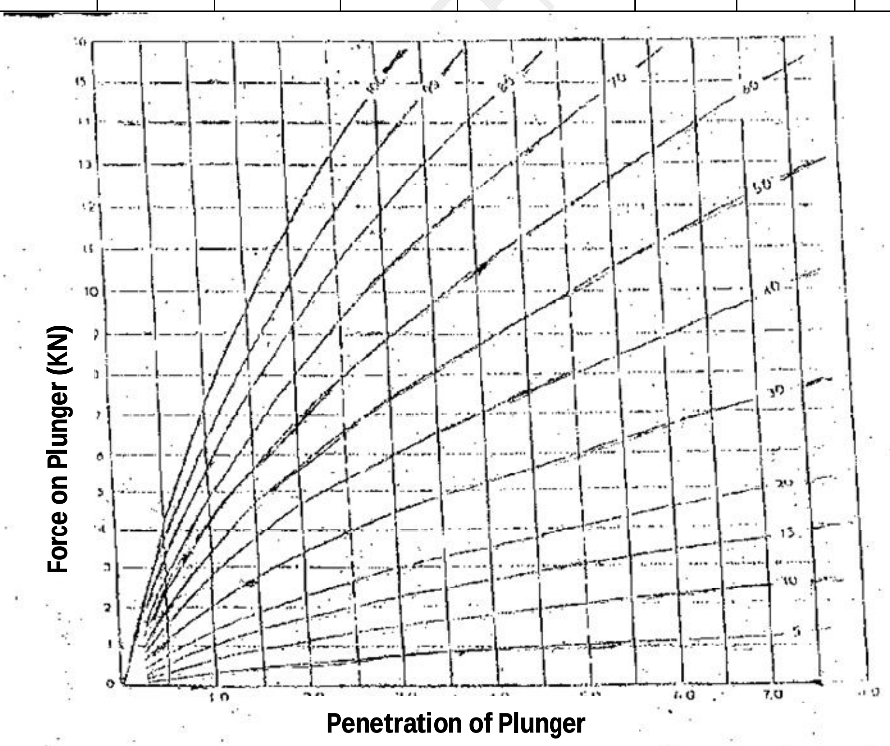


Fig. 5. Graphical presentation of plunger and force ratio 1

California Bearing Ratio (C.B.R.) Test

Description: Laterite soil at 4% groundnut ash replacement

Load-Ring: 0.0275. Bearing Value (%) 52

Dry Density - - - - Top - - - - - 45.69 44.78

Moisture Content - - - - Bottom - - - 52.55 61.45

Table 4a: California Bearing Ratio Test

Penetration (mm)	**Reading (div)**		**Force on Plunger (KN)**		**Penetration (mm)**	**Reading (div)**		**Force on Plunger (KN)**	
	Top	Bottom	Top	Bottom		Top	Bottom	Top	Bottom
0.25	15	12			3.00	245	298		
0.50	30	23			3.50	265	335		
0.75	63	40			4.00	285	372		
1.00	93	60			4.50	305	409		
1.25	122	85			5.00	325	446	8.94	12.29
1.50	150	111			5.50				
1.75	175	143			6.00				
2.00	192	185			6.50				
2.25	209	225			7.00				
2.50	220	253	6.05	6.96	7.50				

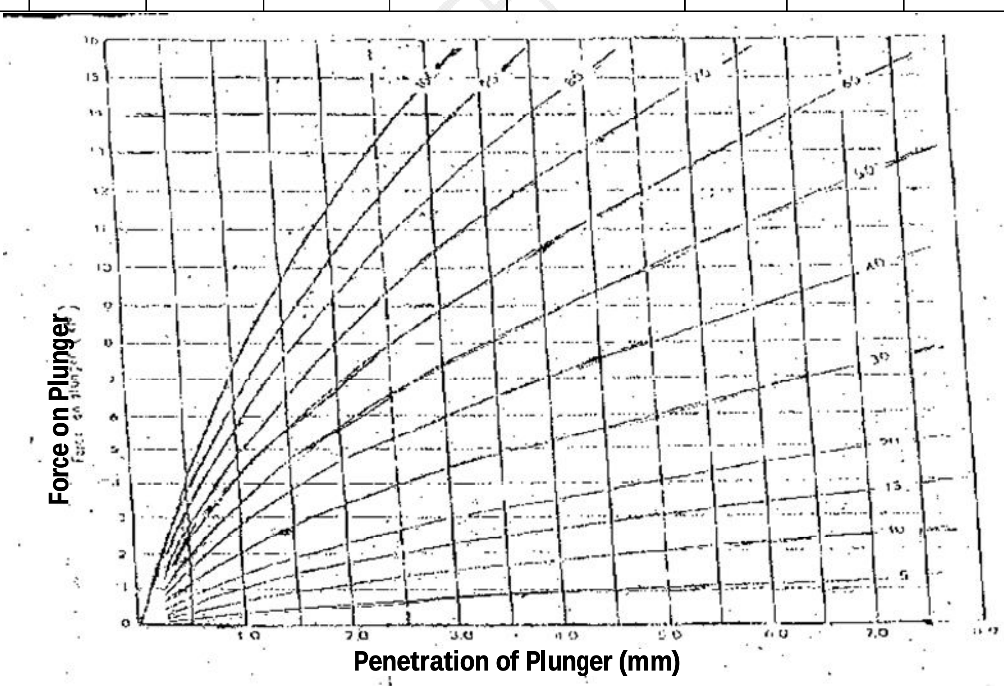


Fig. 6. Graphical presentation of plunger and force ratio 2

California Bearing Ratio (C.B.R.) Test

Description: Laterite soil at 8% groundnut ash replacement

Load-Ring: 0.0275. Bearing Value (%) 14

Dry Density - - - - Top - - - - - 10.39 14.19

Moisture Content - - - Bottom 13.50 16.67

Table 4b: California Bearing Ratio Test

Penetration (mm)	Reading (div)		Force on Plunger (KN)		Penetration (mm)	Reading (div)		Force on Plunger (KN)	
	Top	Bottom	Top	Bottom		Top	Bottom	Top	Bottom
0.25	10	09			3.00	59	77		
0.50	13	14			3.50	70	88		
0.75	18	21			4.00	81	99		
1.00	23	28			4.50	92	110		
1.25	27	36			5.00	103	121	2.83	3.33
1.50	30	42			5.50				
1.75	36	48			6.00				
2.00	41	54			6.50				
2.25	45	60			7.00				
2.50	50	65	1.38	1.79	7.50				

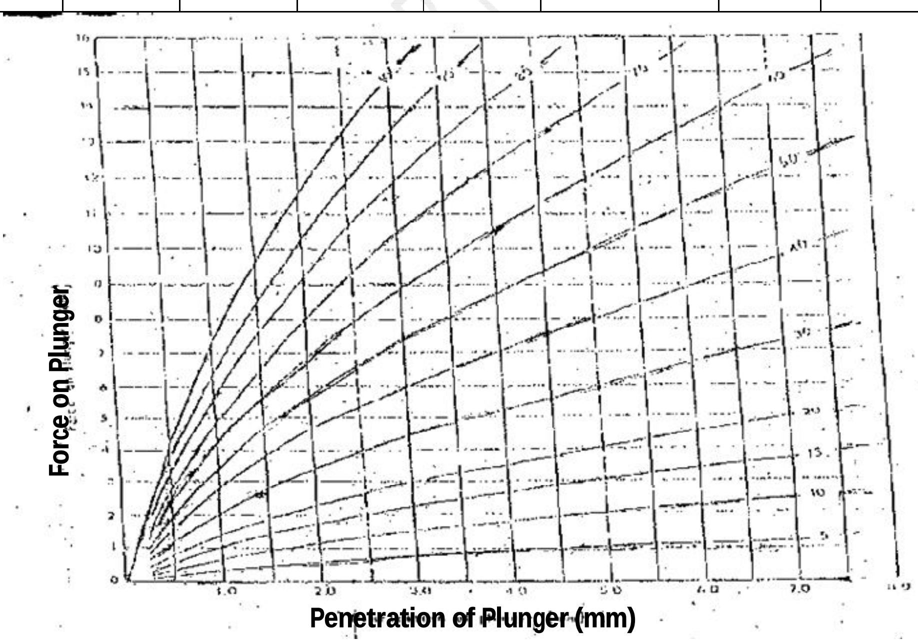


Fig. 7. Graphical presentation of plunger and force ratio 3

V. CONCLUSION AND RECOMMENDATION

Conclusion

based on the findings of numerous experiments performed on a borrow pit sample. From the study, the following findings can be made.

- **i.** The soil sample was assigned to the (A-2-4) subgroup in accordance with the AASHTO soil classification system.
- **ii.** The volume stability of the soil is improved by the addition of G.S.A.
- **iii.** The increase in groundnut shell ash (GSA) lowers the soil's plasticity index while increasing the OMC and decreasing the MDD of the soil. This demonstrates that adding groundnut shell ash caused the mixture's activity to decrease.
- **iv.** The lateritic soil was found to have an optimal moisture content of 4% of groundnut shell ash.
- **v.** According to the research shown above, G.S.A. works well as a low-cost stabilizing agent for lateritic soil used in sub-grade applications.

Recommendation

Based on a laboratory analysis of a soil sample from a borrow hole in Uli, Nigeria's Anambra state. It is crucial to advise against modifying the soil sample with a binder that replaces groundnut shell ash by more than 4%.

Consequently, based on the findings of the laboratory test. Groundnut Shell Ash is not having enough binding power as pozzolanic materials for the better lateritic soil sample.

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