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Calcium Carbide Residue-Hydrated Lime Blend as Stabilizing Agent

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ABSTRACT

The suitability of the blend of calcium carbide residue and hydrated lime to serve as a stabilizing agent, in order to overcome the challenge of availability and high cost of hydrated lime in Nigeria was investigated. Calcium carbide residue was replaced with hydrated lime in incremental order of 10 %, from 0 % to 100 %. The blend of calcium carbide residue partially replaced with hydrated lime was used in incremental order of 2 % from 0 % to 8 % to treat laterite soil obtained from Ikpayongo. The sample of laterite soil treated with different percentages of the blend of calcium carbide residue and hydrated lime were subjected to Atterberg's limits test, compaction test, unconfined compression strength test, durability test and California bearing ratio test. Based on result of test calcium carbide residue partially replaced with 70 % hydrated lime is recommended for use as a stabilizing agent. The use of calcium carbide residue as a stabilizing agent will provide an effective way of disposing calcium carbide residue which has negative impact on the environment, in addition to ensuring economy in the use of lime in soil stabilization.

Keywords: *Calcium Carbide Residue, Hydrated Lime, Stabilization Agent*.

1. INTRODUCTION

The treatment of soil to make them suitable for use as road building material is an age long practice, normally carried out with the aid of stabilizing agents. Stabilizing agents are additives used to initiate reactions that help improve the strength properties of soils. Common traditional stabilizing agents according to Ingles and Metcalf (1972) include cement, lime and bitumen. Lime however is the stabilizing agent that is of interested to this study. The word "lime" is a term that has different meaning to different professionals, for a highway engineer the term refers to either quicklime or hydrated lime and not limestone or agricultural lime. Lime according to Little and Nair (2009) is probably the most routinely used traditional stabilizing agent in the treatment of soil for use in pavement construction. It is obtained from the decomposition of limestone at elevated temperatures. Although, quick lime and hydrated lime are both called lime, their mode of production varies slightly. The manufacture of quicklime according to Auststab (2002) involves the heating of excavated limestone in a lime kiln to temperatures above 900 °C, resulting in carbon dioxide being driven off and calcium oxide being produced. The chemical equation is presented as equation (1)

$$CaCO_3 + \text{heat} \longrightarrow CaO + CO_2 \qquad (1)$$

(Calcium carbonate) (Calcium oxide)
(Lime stone) (Quick lime)

(Heat of dissociation is approximately 760 Kcal/Kg of CaO.)

Hydrated lime is produced when calcium oxide component of quicklime at a temperature below 350 °C reacts with water to produce hydrated lime (Calcium hydroxide) as well as liberating heat. The chemical equations is presented as equation (2)

$$CaO + H_2O \longrightarrow Ca(OH)_2 + \text{heat} \qquad (2)$$

(Calcium oxide) (Calcium hydroxide)
(Quick lime) (Hydrated lime)

(Heat of hydration is approximately 272 Kcal/kg CaO)

When hydrated lime or quick lime is used to treat soil, two important reactions normally takes place. the first is cation exchange and flocculation/agglomeration that brings about rapid textural and plasticity changes. The altered clay structure, as a result of flocculation of clay particles due to cation exchange and short-term pozzolanic reactions, results in a large particle agglomerates and more friable and workable soils. The second reaction is a long-term pozzolanic base cementing process among flocculates and agglomerates of particles, results in strength increase which can be considerable depending on the amount of pozzolanic product that develops, and also depends on the reactivity of the soil minerals, with the lime or other additives used in stabilization. The pozzolanic reaction process can continue as long as sufficiently high p^H is maintained to solubilise silicates and aluminates from the clay matrix. These solubilised silicates and aluminates then react with calcium from the free lime and water to form calcium-aluminate-hydrates, which are the same type of compounds that produce strength development in the hydration of Portland cement. Ingles and Metcalf (1972) listed some of the benefit to be derived from the use of lime in soil stabilization to include considerable increase in compressive strength, decrease in plasticity index of clay soils, decrease in linear shrinkage value, and production of more friable clay thereby making it workable.

Different researchers have reported the effective use of lime in soil stabilization. Lime according to Little and Nair (2009) can be used to stabilize fine grained soils with benefits of reduction in the plasticity index and swell potential, increase in soil workability and strength properties. For effective stabilization of soil with lime, NLA (2004) recommended the use of lime in soils with plasticity index value of 10 and above. Nagi et al (2013) reported that lime is an excellent stabling agent, especially in the treatment of highly active soils which undergo frequent swelling and shrinkage. Recognising the importance of lime in the reduction of plasticity index value of soil, and effective and economic stabilization of soil with cement, Yoder and Witzack (1975), Garber and Hoel (2010) recommended the treatment of soil with lime to reduce the plasticity index value to 10 % or less than 12 % before the use of cement in soil stabilization.

Though the benefits to be derived from the use of lime in soil stabilization are enormous, these cannot be achieved in Nigeria, due to the high cost of lime and non availability of hydrated lime. The cost of hydrated lime is approximately twice the cost of cement. However large quantity of calcium carbide residue is generated in large quantities in different urban and semi urban centres. Calcium carbide residue is a lime by-product obtained from acetylene gas (C_2H_2) production process, represented by equation (3).

$$CaC_2 + 2\,H_2O \longrightarrow C_2H_2 + Ca(OH)_2 \qquad (3)$$

Acetylene (C_2H_2) gas is widely used for welding in industry, while the by-product (CCR) is often discarded as waste in landfills and thus pose a threat to the environment. The by-product lime is calcium hydroxide in waste slurry with approximately 40 % solid concentration (Wang and Handy, 1966). Sixty four grams of calcium carbide (CaC_2) according to Isah and Sharmial (2015) provides twenty six grams of acetylene gas (C_2H_2) and seventy four grams of calcium carbide residue in terms of Ca $(OH)_2$. This is an indication that for as long as acetylene gas is used in welding work; large quantity of calcium carbide residue will be generated. Some of the benefits of using calcium carbide residue include a reduction in solid waste disposal costs, reduction in land fill requirements for disposing the waste and the provision of an effective way of disposing the waste.

Reduction in plasticity index and increase in CBR value was reported by Gawu and Gidigasu (2013) when calcium carbide residue was used in the stabilization of laterite. Similar observation was reported by Joel and Edeh (2013), when laterite obtained from Ikpayongo was treated with calcium carbide residue, except that strength indices were lower than values obtained with the use of only hydrated lime. Although singular use of calcium carbide residue was reported not to be too effective and yielding adequate and desire strength properties, some researchers have used a combination of calcium carbide residue and pozzolanic materials to stabilize clay soils. Vichan et al (2013) reported 50 % improvement in UCS values when Bangkok clay soil was stabilized with 15 % calcium carbide residue and Biomass ash in a ratio of (CCR: BA) 60:40. Isah and Sharmila (2015) reported improvement in plasticity index value and increase in CBR value when a CI and CH soil were stabilized with a combination of 4 % calcium carbide residue plus 4 % coconut shell ash, and 6 % calcium carbide residue and 4 % coconut shell ash. Joel and Edeh (2013) attributed differences in the properties of soil treated with hydrated lime and calcium carbide residue to loss of reactivity of calcium carbide residue due to carbonation reaction which takes place when calcium carbide slurry is exposed to air during disposal and the open drying of the slurry to remove moisture from the waste before usage in soil stabilization. Carbonation is the reaction that occurs between free lime and atmospheric carbon dioxide, presented as equation (4).

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O \qquad (4)$$

$CaCO_3$ produced during carbonation reaction according to Jawal et al (2014) is a weak cementing material with weak bonding, it is a soluble salt that may pulverized when exposed to air for a long time. Carbonation process leads to a reduction in calcium ions that is available for pozzolanic reactions.

Laterite is one of the most common borrow material that is stabilized and used in the construction of different layers of flexible pavement in Makurdi, the laterite soil is normally obtained from Ikpayongo in Makurdi, the capital of Benue State, Nigeria, West Africa. Laterite defined by Ola (1983), as the products of tropical weathering with red, reddish brown, and dark brown colour, with or without nodules or concreting and generally (but not exclusively) found below hardened ferruginous crust or hard pan. Although large deposit of laterite is found at Ikpayongo, it is not suitable for use as sub-base and base material without stabilization. To overcome deficiencies associated with the use of calcium carbide residue in soil stabilization and take advantage of its availability at a lower cost compared to hydrated lime in soil stabilization, since little or no work has been done on the combine use of calcium carbide residue and hydrated lime as stabilizing agent. The aim of this study is to investigate the suitability calcium carbide residue partially replaced with hydrated lime to serve as a stabilizing agent. This will be done by subjecting laterite treated with different combination of calcium carbide residue plus hydrated lime to consistency and strength tests. Strength obtained with the use of only hydrated lime will serve as the bench mark.

2. MATERIALS AND METHODS

Disturbed samples of laterite were collected from Ikpayongo, located at a distance of 22 kilometres from Makurdi, the capital of Benue State, Nigeria, along Makurdi-Otukpo road. The borrow pit was located at a distance of 800 meters, at an angle of 180° west from the centre line of the road. The samples were collected from a depth of 0.5 to 2.0 meters after the removal of the top soil which contains organic materials. Calcium carbide residue used was collected from a welder located at the Kanshio Automobile Mechanic site located at the southern part of Makurdi, along Makurdi-Otukpo road. The samples were collected wet in a polythene bags, and transported to the geotechnical laboratory of University of Agriculture Makurdi, were the samples were dried in the open air, and grinded into fine particles, using pestle and mortar (in the absence of a ball mill and made to pass through the 300μm sieve) before the materials passing through the sieve was used while materials retained were discarded. Hydrated lime used in the study was purchased from a chemical shop located in Makurdi. Analysis of chemical components of calcium carbide residue and hydrated lime was carried out using X-ray analyzer together with Atomic Absorption Spectophotometer (AAS). Specimen of soil samples used for different laboratory test were prepared by mixing laterite with 0, 2, 4, 6 and 8 % by dry weight of a mixture of calcium carbide residue partially replaced with hydrated lime. The replacement of calcium carbide residue with hydrated lime was done at an interval of 10 % beginning from 0 % up to 100 %.

Atterberg's limits tests, compaction tests, unconfined compressive (UCS) tests and California bearing ratio tests were performed on the samples of laterite obtained from Ikpayongo in accordance with the provision of BS1377 (1990) for the natural laterite and BS1924 (1990) for laterite mixed with calcium carbide residue partially replaced with hydrated lime. California Bearing Ratio (CBR) tests were conducted in accordance with the Nigerian General Specification (1997), which stipulated that specimens be cured in the dry for six days then soaked for 24 hours before testing. Sieve analysis test was performed on the sample of laterite using the wet sieving method. Specific gravity of the laterite, calcium carbide residue and hydrated lime were determined using pyknometer, and specific gravity bottle respectively. Liquid limit values were determined using the Casagrande method.

Compaction was carried out using the West African standard compactive effort, because it was the conventional energy level commonly used in the region and recommended by the Nigerian General Specification (1997) for road work. The compactive effort was achieved using energy derived from a rammer of 4.5 kg mass falling through a height of 0.45m in a 1.0 x 10^{-3} m^3 mould. The soil was compacted in five layers, each layer receiving 10 blows. The resistance to loss in strength was determined as a ratio of the unconfined compressive strength (UCS) of specimens cured for 7 days under controlled conditions, which were subsequently immersed in water for another 7 days to the UCS of specimens cured for 14 days.

California bearing ratio, unconfined compressive strength and durability tests results obtained with the use of only hydrated lime was compared with results obtained with calcium carbide residue partially replaced with hydrated lime using chi square test. The Chi square formula given as equation (5) was used in the determination of the chi-square value.

$$\chi^2 = \sum_{i=1}^{k} \frac{(O-E)^2}{E} \quad (5)$$

Where χ^2 = chi-Square value, O = Observed result, E = Expected result.

3. RESULTS AND DISCUSSION

The grain size distribution curves of laterite obtained from Ikpayongo used in the study is presented in Figure 1. The chemical analysis of calcium carbide residue and hydrated lime is summarized in Table 1. Summary of the result of test on the natural laterite is presented in Table 2.

Table 1: Chemical Composition of Calcium Carbide Residue and Hydrated lime

Elemental Oxide	Percentage Composition (%)	
	Calcium carbide residue	Hydrated lime.
SiO_2	1.54	2.69
Al_2O_3	0.50	1.78
Fe_2O_3	0.03	0.17
TiO_2	0.32	nd
Mno	0.05	nd
MgO	1.26	0.80
CaO	67.08	61.41
Na_2O	0.02	0.18
K_2O	0.05	0.10
P_2O_5	-	-
LOI	26.85	32.51

LOI= Loss on Ignition. nd= not detectable due to zero or very small concentration

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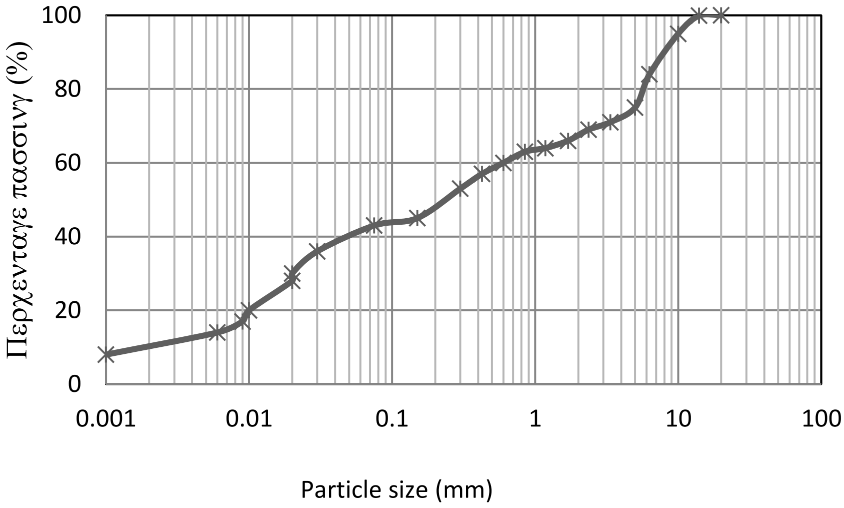

Φιγυρε 1. Παρτιχλε σιζε διστριβυτιον χυρωε οφ Ικπαψονγο Λατεριτε.

Table 2: Some Geotechnical Properties of Ikpayongo Laterite.

Property	Quantity
Percentage Passing BS Sieve No 200 (%)	43
Liquid Limit, (%)	40
Plastic Limit (%)	20
Plasticity Index (%)	20
AASHTO Classification	A-2-6
USCS Classification	GC
Maximum Dry Density (Mg/m^3)	1.86
Optimum Moisture Content (%)	12.0
Unconfined Compressive Strength (KN/m^2)	575
California Bearing Ratio,% (after 24hrs soaking)	25
Specific Gravity	2.69
Colour	Reddish brown
Natural Moisture Content (%)	5.3

Based on the result of tests laterite obtained from Ikpayongo can be classified as an A-2-6 and GC soil by the AASHTOand Unified Soil Classification systems (USCS) respectively. The specific gravities values of Ikpayongo laterite, Calcium carbide residue and hydrated lime were determined as 2.69, 2.20 and 2.25 respectively. The Atterberg's limits values (liquid limit, plastic limit and plasticity index) values and the California bearing ratio value of Ikpayongo laterite in Table 2, are below the requirement specify by the Nigerian General Specification (1997) for materials intended for use in the base or sub base course of flexible pavement, thereby requiring stabilization.

4. VARIATION OF ATTERBERG'S LIMITS VALUES OF LATERITE WITH CALCIUM CARBIDE RESIDUE AND HYDRATED LIME.

The effect of calcium carbide residue, hydrated lime and their combinations on the liquid limit, plastic limit and plasticity index of Ikpayongo laterite, is presented in Table 3. Liquid limit and plasticity index values of laterite decrease with calcium carbide residue, hydrated lime and all the combinations of calcium carbide residue partially replaced with hydrated lime. Plastic limit of laterite increase with calcium carbide residue, hydrated lime, and all combinations of calcium carbide residue partially replaced with hydrated lime. The trend observed with Atterberg's limits values can be attributed to cation exchange and pozzolanic reaction of calcium carbide residue and hydrated lime. The trend observed with atterberg's limits results are similar with the trend reported by Joel and Edeh (2013).

Table 3: Variation of Liquid Limit, Plastic Limit and Plasticity Index with Calcium Carbide residue and hydrated lime

Combination Content (%)		0	2	4	6	8
100% CCR + 0% L	LL	40	40	39	38	37
	PL	20	23	24	25	26
	PI	20	17	15	13	11
90% CCR + 10 % L	LL	40	40	39	37	37
	PL	20	23	25	26	27
	PI	20	17	14	11	10
80 % CCR + 20 % L	LL	40	39	38	38	37
	PL	20	24	25	26	27
	PI	20	15	13	12	10
70% CCR + 30 % L	LL	40	39	37	36	36
	PL	20	24	25	26	26
	PI	20	15	12	10	10
60 % CCR + 40 L %	LL	40	39	37	37	36
	PL	20	25	25	26	26
	PI	20	14	12	11	10
50 % CCR + 50 % L	LL	40	39	37	36	36
	PL	20	24	25	26	26
	PI	20	15	12	10	10
40% CCR + 60% L	LL	40	38	37	36	35
	PL	20	24	25	26	26
	PI	20	14	12	10	09
30% CCR+ 70 % L	LL	40	37	36	35	35
	PL	20	25	26	26	26
	PI	20	12	10	9	9
20 % CCR + 80 % L	LL	40	37	36	35	35
	PL	20	25	26	26	26
	PI	20	12	10	09	9
10% CCR + 90 % L	LL	40	37	36	36	35
	PL	20	24	26	26	27
	PI	20	13	10	10	9
0 % CCR + 100 L %	LL	40	37	36	35	34
	PL	20	24	25	26	26
	PI	20	13	11	9	8

LL= Liquid Limit (%), PL = Plastic Limit, (%), PI = Plasticity Index, (%), CCR= Calcium Carbide Residue. L= hydrated lime.

6. COMPACTION CHARACTERISTICS OF LATERITE TREATED WITH CALCIUM CARBIDE RESIDUE, HYDRATED LIME AND THEIR COMBINATIONS

The effect of calcium carbide residue, hydrated lime and their combination on the maximum dry density and optimum moisture content of Ikpayongo laterite is presented in Table 4. The maximum dry density of laterite decreased with calcium carbide residue, hydrated lime and their combinations. Optimum moisture content increased with calcium carbide residue, hydrated lime and their combinations. Decrease in maximum dry density of laterite with the stabilizing agent can be attributed to more moisture required for cation exchange and pozzolanic reactions. Trend observed with maximum dry density and optimum moisture content of Ikpayongo laterite treated with calcium carbide residue and hydrated lime are similar to the findings of Joel and Edeh (2013), on the compaction characteristics of laterite from the same location using only hydrated lime and calcium carbide residue as stabilizing agents.

Table 4: Variation of Maximum Dry Density and Optimum Moisture Content with Calcium Carbide Residue and Hydrated Lime.

Combination Content (%)		0	2	4	6	8
100% CCR + 0% L	MDD	1.86	1.85	1.84	1.83	1.82
	OMC	12.0	12.5	13	14	15
90% CCR + 10 % L	MDD	1.86	1.85	1.84	1.84	1.82
	OMC	12	13	14	15	16
80 % CCR + 20 % L	MDD	1.86	1.86	1.85	1.84	1.82
	OMC	12	13	14	15	16
70% CCR + 30 % L	MDD	1.86	1.86	1.85	1.84	1.83
	OMC	12	13	14	15	16
60 % CCR + 40 L %	MDD	1.86	1.85	1.84	1.83	1.82
	OMC	12	13	14	15	16
50 % CCR + 50 % L	MDD	1.86	1.85	1.84	1.83	1.82
	OMC	12	12.5	13	14	15
40% CCR + 60% L	MDD	1.86	1.86	1.85	1.84	1.83
	OMC	12	13	14	15.5	16
30% CCR + 70 % L	MDD	1.86	1.85	1.84	1.83	1.82
	OMC	12	13	14	15	16
20 % CCR + 80 % L	MDD	1.86	1.85	1.84	1.83	1.82
	OMC	12	13	14	15	16
10% CCR + 90 % L	MDD	1.86	1.85	1.84	1.83	1.82
	OMC	12	13	14	15	16
0 % CCR + 100 L %	MDD	1.86	1.85	1.84	1.82	1.81
	OMC	12	13	14	15	16

7. STRENGTH INDICES OF LATERITE TREATED WITH CALCIUM CARBIDE RESIDUE, HYDRATED LIME AND THEIR COMBINATIONS

Unconfined compressive strength of laterite used as one of the criteria to determine the suitability of calcium carbide residue partially replaced with hydrated lime to serve as a stabilizing agent is presented in Table 5. Unconfined compressive strength generally increases with calcium carbide residue, hydrated lime and their combinations content. 7,14, and 28 days unconfined compressive strength values obtained with laterite treated with only hydrated lime were higher than values obtained with only calcium carbide residue. However strength obtained with 30 % calcium carbide residue plus 70 % hydrated lime are comparable with values obtained with only hydrated lime.

Table 5: 7, 14 and 28 day UCS and Resistance to loss in Strength values of Ikpayongo Laterite Stabilized with Calcium Carbide Residue, Hydrated Lime and their Combinations

Cement Content (%)		0	2	4	6	8	χ^2
100%CCR+ 0 % L	7dUCS	575	640	714	842	1038	6.382
	14dUCS	575	659	724	945	1132	25.023
	28dUCS	575	683	913	1117	1203	10.341
	R (%)	0	30	40	50	55	27.813
90 % CCR +10 %L	7dUCS	575	646	724	855	1053	3.243
	14dUCS	575	660	754	957	1152	14.891
	28dUCS	575	692	927	1130	1219	6.175
	R (%)	0	35	44	53	58	18.992
80%CCR + 20 % L	7dUCS	575	654	732	861	1059	2.206
	14dUCS	575	666	760	923	1158	19.651
	28dUCS	575	698	933	1136	1225	4.861
	R (%)	0	38	46	55	62	13.739
70%CCR + 30 % L	7dUCS	575	660	738	867	1070	1.365
	14dUCS	575	672	766	969	1164	10.231
	28dUCS	575	705	939	1143	1231	3.812
	R (%)	0	40	46	60	68	8.622
60 %CCR + 40 %L	7dUCS	575	664	744	873	1077	1.064
	14dUCS	575	673	773	975	1170	8.261
	28dUCS	575	711	945	1149	1237	3.119
	R (%)	0	42	50	64	69	4.993
50% CCR + 50%L	7dUCS	575	654	724	852	904	32.910
	14dUCS	575	684	807	982	1170	3.932
	28dUCS	575	698	930	1155	1243	2.415
	R (%)	0	45	60	70	75	0.646
60%CCR + 40 % L	7dUCS	575	628	708	869	1070	2.270
	14dUCS	575	654	810	1019	1170	1.853
	28dUCS	575	673	930	1161	1279	1.385
	R (%)	0	50	65	75	78	1.022
70%CCR + 30 %L	7dUCS	575	634	714	873	1076	1.376
	14dUCS	575	661	820	1025	1176	0.760
	28dUCS	575	678	933	1167	1285	0.795
	R (%)	0	50	65	75	80	0.972
80%CCR +20 %L	7dUCS	575	640	720	900	1085	2.100
	14dUCS	575	667	809	1031	1188	1.001
	28dUCS	575	686	943	1174	1292	0.180
	R (%)	0	48	64	75	80	0.467
90%CCR+10 L	7dUCS	575	646	726	887	1088	0.815
	14dUCS	575	673	832	1037	1188	0.097
	28dUCS	575	692	949	1180	1297	0.079
	R (%)	0	46	63	75	80	0.172
100%CCR+ 0 %L	7dUCS	575	653	732	893	1093	0.000
	14dUCS	575	677	834	1037	1179	0.000
	28dUCS	575	695	949	1178	1288	0.000
	R (%)	0	45	60	75	80	0.000

R = Resistance to loss in Strength, (%). CCR = Calcium Carbide Residue,
CGF= Crushed Granite fine, 7 dUCS= Seven day Unconfined Compressive Strength, kN/m^2
14 dUCS= Fourteen day Unconfined Compressive strength, kN/m^2
28 dUCS = Twenty eight day Unconfined Compressive strength, kN/m^2
χ^2= Chi Square values

Increase in UCS value with calcium carbide residue, hydrated lime and their combinations can be attributed to pozzolanic reactions of the additives and their combinations. Lower strength values associated with the use of calcium carbide residue may be attributed to reactivity loss associated with calcium carbide residue arising from carbonation reactions that takes place when calcium carbide residue is exposed to the atmosphere during disposal and the reduction in pH value of calcium carbide residue with days of exposure as reported by Semikolennylch et al (2012). $\chi^2_{0.05}$ values of 1.376, 0.760

and 0.795 obtained for 7, 14 and 28day UCS values of laterite treated with 30 % CCR plus 70 % hydrated lime, when compared with values obtained with the use of only hydrated lime shows that there is no significant difference in UCS values, since these values were less than the chi square value of 7.815 obtained from statistical table.

The resistance to loss in strength values of laterite treated with calcium carbide residue, hydrated lime and their combinations is presented in Table 5. Values obtained with the use of only hydrated lime were higher than values obtained with the use of calcium carbide residue. Values obtained with the use of 30 % calcium carbide residue plus 70 % hydrated lime were comparable with values obtained with the use of only hydrated lime, as $\chi^2_{0.05}$ value of 0.972, obtained from statistical analysis was less than the value of 7.815 obtained from statistical table. Indicating that increase in resistance to loss in strength values of laterite treated with calcium carbide residue and hydrated lime can be attributed to pozzolanic reactions of calcium carbide residue and hydrated lime.

California bearing ratio values of laterite treated with calcium carbide residue, hydrated lime and their combinations reflected in Table 6, indicate increase in California bearing ratio value with stabilizing agents. Increase in strength can be attributed to pozzolanic reactions of calcium carbide residue and hydrated lime. Values obtained with the use of only hydrated lime were higher than values obtained with calcium carbide residue. Statistical analysis using chi square test show that values obtained with the use of 30 % calcium carbide residue plus 70 % hydrated lime were comparable with values obtained with the use of only hydrated lime as $\chi^2_{0.05}$ value of 1.190 obtained from statistical analysis was less than the value of 7.815 obtained from statistical table. Signifying that there is no significant difference between values obtained with hydrated lime and hydrated lime-calcium carbide residue combinations.

Table 6: Variation of California Bearing Ratio with Calcium Carbide residue and hydrated lime content.

Combination Content (%)	0	2	4	6	8	χ^2
100% CCR + 0% L	25	30	35	40	50	13.006
90% CCR + 10 % L	25	30	40	40	50	12.381
80 % CCR + 20 % L	25	30	40	40	55	9.881
70% CCR + 30 % L	25	30	40	45	60	5.179
60 % CCR + 40 L %	25	30	40	45	60	5.179
50 % CCR + 50 % L	25	30	40	50	60	3.095
40% CCR + 60% L	25	30	40	55	65	0.774
30% CCR + 70 % L	25	35	40	60	75	1.190
20 % CCR + 80 % L	25	35	40	60	75	1.190
10% CCR + 90 % L	25	35	40	60	70	0.802
0 % CCR + 100 L %	25	30	40	60	70	0.000

Based on unconfined compressive strength, California bearing ratio, and resistance to loss in strength values, the use of calcium carbide residue partially replace with 70 % hydrated lime is recommended for use in the treatment of soil as an alternative to the use of only hydrated lime as a stabilizing agent since results of tests and statistical analysis has proved that there is no significant difference between the strength and durability indices values of laterite treated with only hydrated lime and laterite treated with 30 % calcium carbide residue plus 70 % hydrated lime.

Using CBR value criterion of 40 %, 80 % and 100 % (standard proctor) for lime treated soils for use as sub-base; base (lightly trafficked roads) and base (heavily trafficked roads) respectively as by Osinubi (1999). Seven days unconfined compressive strength value of 1034.25kN/m^2 and maximum allowable loss in strength value of 20 % suggested by Ola (1974). Laterite obtained from Ikpayongo treated with 8 % combination of 30 % calcium carbide residue plus 70 % hydrated lime with a CBR value of 75 % , 7 day UCS of 1076 kN/m^2 and resistance to loss in strength value of 80 % which translates to the maximum allowable loss in strength of 20 %, is recommended for use as base material of a lightly trafficked road, since pozzolanic reaction of calcium carbide residue which continues with days is likely to increase to the value of 80 % and results obtained with the use of this combination is comparable to results obtained with the use of only hydrated lime.

7. CONCLUSIONS

I. Liquid limit and plasticity index values of laterite treated with calcium carbide residue, hydrated lime and their combinations decreased with their respective content while their plastic limit values decreased with the stabilizing agents. Results obtained with calcium carbide residue partially replaced with 70 % hydrated lime were comparable with the results obtained with the use of only hydrated lime.

II. Maximum dry density of laterite decreased with calcium carbide residue, hydrated lime and their combinations. While optimum moisture content increased with calcium carbide residue, hydrated lime and their combinations.

III. Unconfined compressive strength values of laterite increased with calcium carbide residue, hydrated lime and their combination content and days, with results obtained with the use of 30 % calcium carbide residue plus 70 % hydrated lime being comparable with results obtained with the use of only hydrated lime.

IV. California bearing ratio value of laterite increased with calcium carbide residue, hydrated lime and their combinations content. Results obtained with the use of 30 % calcium carbide residue plus 70 % hydrated lime are comparable with results obtained with the use of only hydrated lime.

V. Based on result of tests and statistical analysis, the use of 30 % calcium carbide residue partially replaced with 70 % hydrated lime is recommended for use as an alternative stabilizing agent, to the use of only hydrated lime.

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