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RESEARCH PAPER

IMPACT OF LIME AND CEMENT ON VARIOUS LATERITIC SOIL SAMPLINGS AS CONSTRUCTION MATERIAL

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ABSTRACT

This study was performed so as to evaluate the engineering properties and strength of lateritic soils stabilized with hydrated lime and Portland cement as construction materials. Soil sample P1, P2, P3, P4, and P5 were collected from Dualization of Sheda - Abaji, Abuja, F.C.T, Nigeria and stabilized with 0, 3, 6, 9, and 12% of hydrated lime and Portland cement. Many laboratory tests were performed on the soil sample such as Consistency (Atterberg limit), California Bearing Ratio (C.B.R), water absorption, compaction test and particle size distribution. The research revealed that beneficial impacts were obtained through the addition of hydrated lime and Portland cement in order to increase the strength of poor or weak soils. C.B.R values are 9.98, 9.88%, 8.36%, 7.89% and 7.27% for sample P1, P2, P3, P4 and P5 respectively at 0% additive content. At 12% cement additives, the sample gave C.B.R values of 59%, 55%, 53%, 51.0% and 50.00%. All the five samples have the highest C.B.R values of 48.0% with hydrated lime as additives. The introduction of additives improved the soil samples from a very poor subbase and base materials to an excellent base material with C.B.R values of over 40%. Thus, improvement of laterite soil samples from the studied locality performed successfully by using Lime judging from the outcome of the different tests on the various soil admixtures.

Keywords: Hydrated lime, Portland cement, strength, lateritic soils.

INTRODUCTION

As the world's inhabitants continue to increase, the need for housing also does. The rise in the trend of accommodation shortage for the built-up and peri-urban regions in developing nations has inspired research into numerous technological solutions, which include improved varieties in the enhancement and usage of local soil materials (Akinje 2015; Akinwumi 2014). Soil stabilization is the method of mixing additives with soil so as to improve its strength, volume stability, permeability as well as durability (Ali 2012; Amu et al. 2011). The necessities of soil stabilization as cost-effective building materials cannot be overstressed. Lateritic soil with good attributes will have low surface cracks for insects to stay, lessen maintenance as well as renovation costs and, at large, prolong the life-span of construction works (Amu et al. 2011; Rigassi 1995). Knowledge about the stabilizers constituent requirement for lateritic soil material is significant in order to discover the durability as well as strength of construction materials. The properties of hydrated lime, Portland cement and stabilized lateritic soils were summarized by (Wright and Dixon 2013; Bell 1993). Likewise, the basic rules for cement stabilization with a recommendation of five (5) to ten (10) percent cement stabilization as a guide, so as to attain saturated as well as satisfactory compressive strength within the range of 1-3 N/mm^2, was advocated by Akinwumi (2014). It was revealed by Solanke (1998) that lateritic soil can be improved by paying attention during mixing composition and its process, as well as stabilizing. With this, the properties of the soil material concerning any application that is being designed for become vital. It was perceived that compacting soils via mechanical press increases their strength (Rigassi 1995).

Hydrated lime is used for soil improvement to create long-term permanent strength in fine-grained soils that are high in clay and silt content. They utilized pozzolans which are naturally available in clay soils to create cementitious bonds that lastly boost a soil. Pozzolans for instance alumina as well as silica react with calcium, supplied by the lime and water to form calcium-silicate-hydrates (C-S-H) as well as calcium-aluminate-hydrates (C-A-H). Both C-A-H and C-S-H are the equivalent products that are responsible for the strength of materials like concrete. Hydrated lime or calcium hydroxide ($Ca(OH)_2$) is a further treated quicklime via carefully hydrated with an adequate quantity of agitation and water to create a very fine, high-purity product. This is preferable for construction sites that involve wet soils such as pavement, highways, shoulders, parking lots etcetera, since it has already been hydrated and it does minimize much of its drying capacity (Akinje 2015; Akinwumi 2014). On the other hand, soil cement enhancement is a construction technique utilized for improving the strength of subgrade soil via a mixture of cement, water and lateritic soil. The water hydrates the cement causing reactions that yields matrix among the soil particles as well as provide strength to the soils. Soil cement enhancement is preferable in coarse-grained soils. Soil enhancement saves energy, time, materials as well as money. Besides it improves the material that is already in place without the hazards and frustrating logistics connected with hauling material to and from the site. Thus it is the best and most economical option compared with remove and replace operations (Agashua and Ogbiye 2018; Agashua et al. 2018).

Soil enhancement can be in situ or natural state so as to eliminate the need for costly cut-to-spoil and replace operations. Often roads, parking lots, building pads, and other structures need to be erected are naturally weak and wet soils. These soils can be enhanced through chemical treatment for strength improvement and improve engineering features such as plasticity and moisture content. But pre-project scrutiny which prompts this current study is vital for ascertaining the right locally available material to utilize for each project (Agashua and Ogbiye 2018; Agashua et al. 2018). Also, it has been observed that the greater the density obtained, the better the strength attained. The aim of this paper was to assess the engineering properties of lateritic soils stabilized with hydrated lime and Portland cement as construction material.

MATERIALS AND METHODS

Materials and Preparation

The lateritic soil sample utilized for this research work was obtained from a borrow pit within the Dualization of Sheda-Abaji road project in Abuja, Nigeria. Hydrated lime and Portland cement were obtained from Deidei market in Abuja. Potable water was used during mixture of materials to produce soil stabilizer.

Methods

Geotechnical Scrutiny

Preliminary tests like particle size distribution and consistency or Atterberg limit (Plasticity Index) tests were carried out on the lateritic soil sample so as to categorize the soil. The technique utilized for these tests are in agreement with (BS1377, 1990) which endorse terminologies as well as the Unified Soil Classification System (USCS) to define and categorize lateritic soils for engineering reasons.

Compaction

Compaction test were performed on the natural soil sample obtained from Sheda-Abaji Highway after which 3, 6, 9 and 12 percent of hydrated lime and Portland cement, were introduced as soil admixtures. The soil sample were split into, 500 grams each. About 4% water was added to the 500 grams sample, mixed thoroughly was divided into three equal portions and compacted in three layers inside B.S mould with 25 uniform blows via 5.5Kg rammer at height of 12 inches. The compacted sample as well as mould was weighed, and representative sample for dry density and moisture content determination was taken. The same approach was used for the entire admixture at a different percentage. Dry density versus water content was plotted to form a curve, while the maximum dry density is referred to as Zero air voids. Likewise, the optimum moisture content (OMC) determined is utilized during construction work for regulating the quantity of water to be added to earthworks.

California bearing ratio (C.B.R)

For C.B.R test, roughly six kilograms of soil samplings that passed through the number four sieve were mixed with the OMC gotten from the compaction test. This entails compaction of soil thrice with fifteen (15) blows and 2.5 kilograms rammer. Both compacted soil and the mould were positioned under C.B.R machine with an application of penetrations at 25, 50, 15, 100, 125 and 750 inches, which was done for the top and bottom layers. The C.B.R test is principally a penetration test with the function of assessing the soil resistance to penetration erstwhile of reading so as to evaluate shearing value.

$$C.B.R\,\% = \left(\frac{Test\ load}{Standard\ load}\right) x\ 100 \qquad \text{(i)}$$

RESULTS AND DISCUSSION

Laboratory tests were carried out on the three samples obtained for the purpose of sorting, categorization and determination of the engineering physiognomies of the material used as exhibited in Table 1. The sample were treated with 3%, 6%, 9% and 12% of hydrated lime and Portland cement in the research laboratory for properties assessment.

Table 1: Basic and Engineering Properties of the selected laterite soil

Properties	Unit	Soil Samples				
		P1	**P2**	**P3**	**P4**	**P5**
Grain Size Distribution	*%*					
Coarse **Fine** **Bulk density**	% % KN/m³	90.85 09.15 14.64–29.76	91.45 08.55 14.53–29.26	91.55 08.45 14.44–28.78	91.65 08.35 14.42–27.76	91.68 08.32 14.39–27.74
Consistency Limit	*%*					
Liquid Limit **Plastic Limit** **Plasticity Index (PI)**		43.80 19.09 24.41	43.50 25.65 17.85	42.50 26.33 16.17	42.00 22.09 19.91	41.97 22.59 19.38
MDD	KN/m³	18.85	18.62	18.54	18.68	18.64
OMC	%	9.95	9.90	9.85	9.82	9.88
C.B.R	%	9.88	9.78	9.72	9.72	9.78
Soil Classification		A-2-7	A-2-7	A-2-7	A-2-7	A-2-7
Soil Type	***Silty or clayed gravel sand***					

Particle Size Distribution

The results of the particle size scrutiny are graphically displayed in Fig. 1 for the three samples obtained from Sheda-Abaji highway, Abuja. The result indicates that sample P1 is greater in fine and bulk density than other samples, whereas sample P5 is higher in coarse aggregate than other samples.

Atterberg Limits

The results of Atterberg limits scrutiny are presented in Table 2, also graphically displayed in Fig. 2 for the three samples obtained from Sheda-Abaji highway, Abuja. The outcome discloses that the average hydrated lime additive at 3% had Liquid limit and plastic limit values are above Portland cement additive. Similarly Lime additive at 12% Liquid limit and plastic limit values beyond Portland cement additive.

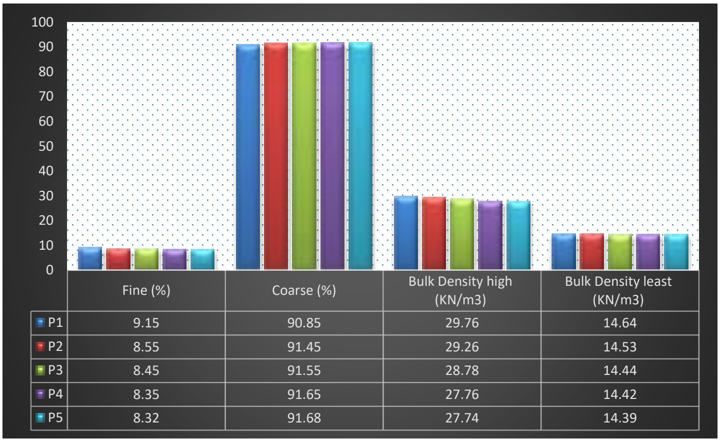

Fig. 1: Chart of sieve analysis

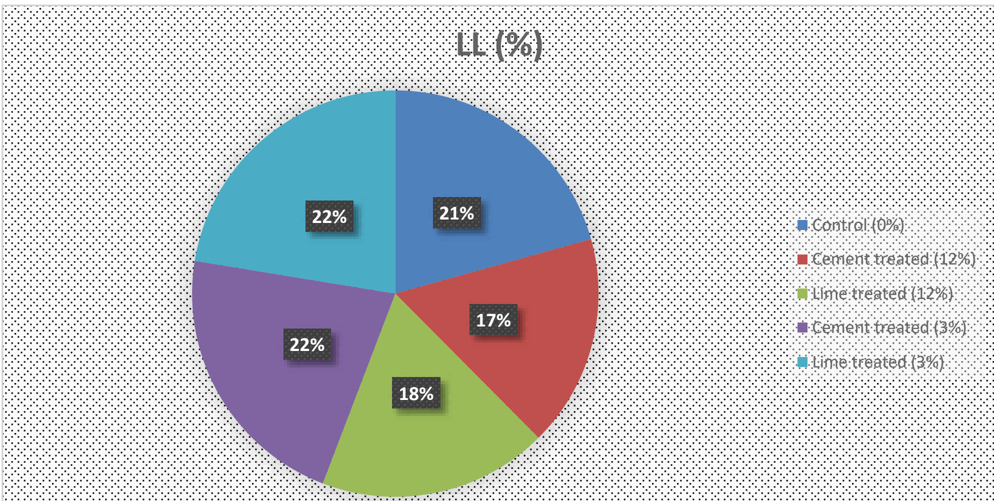

Fig. 2: Chart of Atterberg limit test.

Table 2 Atterberg Limit test control, hydrated lime and Portland cement treated, sample at 3 and 12%.

Samples		Liquid Limit (LL)%	Plastic Limit (PL)%	Plasticity index (PI) %
Control (0%)	P1	43.80	19.09	24.41
	P2	43.50	25.65	17.85
	P3	42.50	26.33	16.17
	P4	42.00	22.09	19.91
	P5	41.97	22.59	19.38
	Average	**42.75**	**23.15**	**19.54**
Cement treated (3%)	P1	45.29	28.81	16.48
	P2	45.19	27.10	18.09
	P3	44.56	26.50	18.06
	P4	44.89	27.69	17.20
	P5	45.09	28.10	16.99
	Average	**45.00**	**27.64**	**17.36**
Lime treated (3%)	P1	46.80	26.49	20.31
	P2	45.80	26.50	19.30
	P3	46.45	26.75	19.70
	P4	46.78	26.76	20.02
	P5	45.90	26.80	19.10
	Average	**46.35**	**26.66**	**19.69**
Cement treated (12%)	P1	35.80	31.00	4.80
	P2	34.60	30.05	4.55
	P3	34.55	28.50	6.05
	P4	34.68	29.50	5.18
	P5	34.75	30.09	4.75
	Average	**34.88**	**29.83**	**5.07**
Lime treated (12%)	P1	38.62	32.85	5.77
	P2	37.94	31.19	6.75
	P3	36.90	30.50	6.40
	P4	37.46	31.29	6.17
	P5	37.84	31.34	6.50
	Average	**37.75**	**31.43**	**6.32**

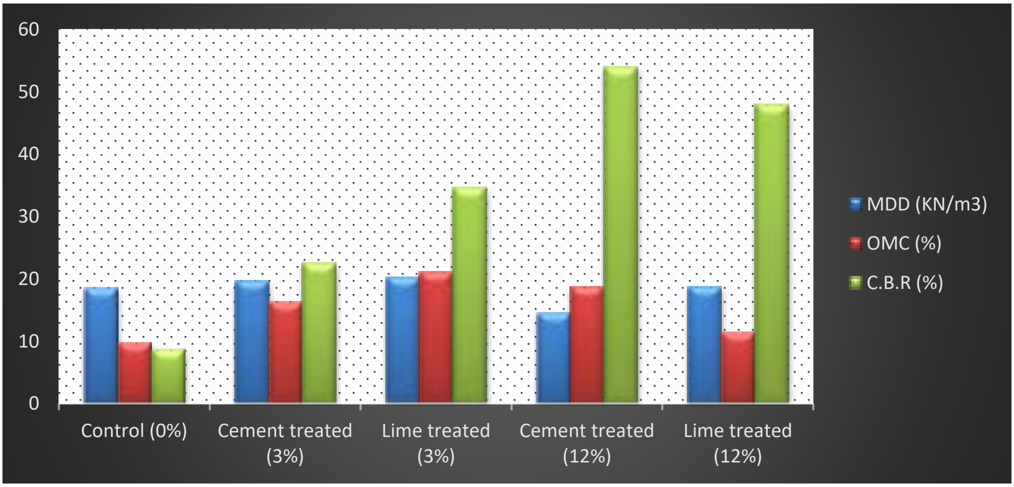

Fig. 3: Chart of C.B.R test.

Compaction and California bearing ratio (C.B.R) Test

The results of the compaction test are demonstrated in Table 3, also graphically displayed in Fig. 3 for the three samples obtained from Sheda-Abaji highway, Abuja. The three sample indicate low dry densities which will cause low strength of the samples if used as construction materials in their raw state. The average hydraulic lime additive at 3% M.D.D value is above Portland cement additive. Also, hydraulic lime additive at 12% Maximum Dry density value is beyond Portland cement additive, whereas cement additive at 12% average Optimum dry density values are larger than lime additive.

For C.B.R, the three samples classified as poor sub-base materials with low dry density and strength based on AASHTO 2007. The average hydrated lime additive at 3% CBR is above cement additive whereas, at 12% average Portland cement is beyond hydrated lime additive.

Table 3. Compaction and C.B.R test control, hydrated lime and Portland cement treated, at 3 and 12%.

Samples		Maximum dry density (MDD) KN/m3	Optimum moisture content (OMC) %	C.B.R (%)
Control (3%)	P1 P2 P3 P4 P5	18.65 18.62 18.50 18.52 18.42	09.90 09.85 09.45 09.65 09.55	9.98 9.88 8.36 7.89 7.27
	Average	**18.54**	**9.68**	**8.68**

Cement treated (3%)	P1 P2 P3 P4 P5	19.80 19.65 19.60 19.68 19.69	16.50 16.45 15.80 16.45 16.45	23.05 21.90 22.95 23.00 21.90
	Average	**19.68**	**16.33**	**22.56**
Lime treated (3%)	P1 P2 P3 P4 P5	20.40 19.80 20.20 20.35 20.24	21.60 20.40 20.80 21.30 21.40	35.00 34.05 34.50 34.80 34.95
	Average	**20.20**	**21.10**	**34.66**
Cement treated (12%)	P1 P2 P3 P4 P5	14.75 14.70 14.15 14.45 14.65	20.00 19.90 18.90 17.50 17.95	59.00 55.00 53.00 51.00 52.00
	Average	**14.54**	**18.70**	**54.00**
Lime treated (12%)	P1 P2 P3 P4 P5	19.00 18.30 19.00 18.50 18.80	12.25 12.24 12.20 12.22 12.23	48.00 48.00 48.00 48.00 48.00
	Average	**18.72**	**12.23**	**48.00**

CONCLUSION

The study on lateritic soil samples from a construction site situated at Sheda - Abaji, Abuja, revealed that constructive impacts are achieved by the addition of hydrated lime and Portland cement. All the lateritic soil samples P1 to P5 belong to A-2-7 which is clayey or silty gravel sand. Atterberg Limits results range from 34.55 to 46.78% for Liquid Limit whereas, the plasticity index is between 4.75 and 24.41%. For Compaction, MDD and OMC at 3% hydrated lime additive is above Portland cement additive, whereas at 12%, hydrated lime MDD values are higher but Portland cement additive higher in OMC. As a percentage of hydrated lime additive increases, both LL and Pl also decrease. This shows that a slight percentage of both hydrated lime and Portland cement will augment the soil strength. A lower percentage of hydrated lime and cement additive gave maximum values of MDD and OMC respectively. With slight quantities of hydrated lime additive and Portland cement, soil enhancement will be great and this is in agreement with (Amu et al. 2011). Thus enhancement of lateritic soil samples from the studied site can be performed successfully by using hydrated lime or Portland cement additives.

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