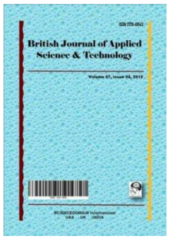

British Journal of Applied Science & Technology
7(6): 642-650, 2015, Article no.BJAST.2015.180
ISSN: 2231-0843

SCIENCEDOMAIN *international*
www.sciencedomain.org

Stabilization of Lateritic Soil with Cassava Peels Ash

Afeez Adefemi Bello[1*], Joseph Adebayo Ige[2] and Hammed Ayodele[1]

[1]Department of Civil Engineering, Faculty of Engineering, Osun State University, Osogbo, P.M.B.4494, Nigeria.
[2]Department of Civil Engineering, Faculty of Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJAST/2015/16120
Editor(s):
(1) Jakub Kostecki, Department of Civil and Environmental Engineering, University of Zielona Góra, Poland.
(2) Harry E. Ruda, Stan Meek Chair Professor in Nanotechnology, University of Toronto, Director, Centre for Advanced Nanotechnology, University of Toronto, Canada.
(3) Humberto Varum, Department of Civil Engineering, Faculty of Engineering of The University of Porto, Portugal.
(4) Rares Halbac-Cotoara-Zamfir, Hydrotechnical Engineering Department, "Politehnica" University of Timisoara, Romania.
Reviewers:
(1) Edward Missanjo, Malawi College of Forestry and Wildlife, Private Bag 6, Dedza, Malawi.
(2) Anonymous, Brazil.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=775&id=5&aid=8518

Original Research Article

Received 8th January 2015
Accepted 20th February 2015
Published 18th March 2015

ABSTRACT

This research is aimed at assessing the impact of Cassava Peels Ash (CPA) on the stabilization of lateritic soil deposit found within Osogbo Local Government Area in Osun State, Nigeria. This project was carried out to study the characteristics of Cassava Peels Ash (CPA) stabilization on lateritic soil. Preliminary tests were performed on three samples, L1, L2, and L3 for identification and classification purposes followed by the consistency limit tests. Geotechnical property tests (compaction, California bearing ratio (CBR), and Unconfined Compression Test) were also performed on the samples, both at the stabilized and unstabilized states by adding 2, 4, 6, 8 and 10% Cassava Peels Ash (CPA) by weight of sample to the soils. The results showed that the addition of CPA improved the strengths of the samples. Optimum moisture contents (OMC) reduced to 14.58, 18.40 and 16.00% at 6, 4 and 6% CPA additions in samples L1, L2 and L3 respectively while maximum dry density (MDD) increased to 1470, 1410 and 1440 kg/m^3 at 10, 4 and 2% CPA additions in samples L1, L2, and L3. The unsoaked CBR values of samples increased from 7.89 to 19.40% at 8% CPA stabilization for sample L1, for sample L2, it increases from 5.80 to 27.02% at 10% CPA stabilization and for sample L3 at the natural state, it increases from 14.50 to

**Corresponding author: E-mail: adefemisola@yahoo.com;*

18.20% at 4%. The shear strengths of samples L1, L2 and L3 also increased from 123.70 to 590.58 kN/m^2 at 2% CPA stabilization, 293.48 to 297.67 kN/m^2 at 10% CPA stabilization and 153.99 to 554.02 kN/m^2 respectively. It was therefore concluded that Cassava Peels Ash has a good potential for stabilizing lateritic soil.

Keywords: Flexible pavement; compaction; California bearing ratio; unconfined compressive strength.

1. INTRODUCTION

Technically, soil improvement could either be by modification or stabilization, or both. Soil modification is the addition of a modifier (cement, lime, etc.) to a soil to change its index properties, while soil stabilization is the treatment of soils to enable their strength and durability to be improved such that they become totally suitable for construction beyond their original classification [1].

Lateritic soils are generally used for road construction in Nigeria. Lateritic soil in its natural state generally have low bearing capacity and low strength due to high content of clay. When lateritic soil contains a large amount of clay materials its strength and stability cannot be guaranteed under load especially in the presence of moisture [1]. It has been stated that laterite is a residual of rock decay that is red, reddish brown and yellowish in color and has a high content of oxides of iron and hydroxides of aluminum and low proportion of silica [2].

When lateritic soil consist of high plastic clay, the plasticity of the soil may cause cracks and damage on pavement, road ways, building foundations or any other civil engineering construction projects. The improvement in the strength and durability of lateritic soil in the recent time become imperative, this has geared up researchers toward using stabilizing materials that can be source locally at a very low cost [3,4,5]. These local materials can be classified as either agricultural or industrial wastes [3]. The ability to blend the naturally occurring lateritic soil with some chemical additives to give it better engineering properties in both strength and water proofing is very essential [3,4,5,6].

Over the years, cement and lime have been the two main materials used for stabilizing soils. These materials have rapidly increased in price due to the sharp increase in the cost of energy and high demand for them. Thus has hitherto prevented third world countries like Nigeria in providing good road for its citizen particularly rural dwellers that are mostly agriculturally dependent. It has been shown by [4,7,8] that Portland cement, by the nature of its chemistry, produces large quantities of CO_2 for every ton of its final product which contributes to the melting of the ozone layer covering the earth surface. Therefore, replacing proportions of the Portland cement in soil stabilization with agricultural waste material like Cassava Peels Ash will reduce the overall environmental impact of the stabilization process.

Cassava Peels (CP) is a by-product of cassava processing, either for domestic consumption or industrial uses. Cassava peel constitutes between 20-35% of the weight of tuber, especially in the case of hand peeling. Based on 20% estimate, about 6.8 million tonnes of cassava peel is generated annually and 12 million tonnes are expected to be produced in the year 2020 [5]. Indiscriminate disposal of cassava peels due to gross underutilization as well as lack of appropriate technology to recycle them is a major challenge, which results in environmental problem. Thus, there is need to search for alternative methods of making use of cassava peels. Therefore, the purpose of this study was to investigate the impact of Cassava Peels Ash on the stabilization of lateritic soils.

2. MATERIALS AND METHODS

2.1 Materials Used

2.1.1 Soil

Collection of three lateritic samples labeled (L1, L2, L3) from the new Oba Adesoji Aderemi Ring road Osogbo, Osun State (behind Ilesha Garage, Ring road, Osogbo, Fountain University, Ring road Osogbo, and behind African Grammar school, Abeere end of the Ring road, Osogbo) disturbed sampling from a borrow pits at a depth of between 1.0 m and 2.0 m at. A study of the soil and geological maps of Nigeria after [9,10], respectively, show that the study area lies within southwestern Nigeria basement complex which forms part of the African crystalline shield. The basement complex is composed predominantly of folded gneisses, migmatite, schist and quartzite of the Precambrian age. The soil samples were collected in large-to-medium-sized bags and thereafter transported to the Soil Mechanics Research Laboratory of the Department of Civil Engineering, Osun State University, Osogbo, Osun State. Each soil sample was spread and allowed to air-dry under laboratory conditions.

2.1.2 Cassava peels ash

Cassava peels were collected from cassava peel site in Oke Baale, Osogbo. The ash was produced by first sun drying till the peel is well dried before burning. The ash was produced by calcination at 700ºC for 90minutes. The cassava peel ash was sieved using 75 µm sieve size to get a fine ash. The chemical composition and physical characteristics are determined at Research Institute of Obafemi Awolowo University using X-ray diffractometry (XRD) and Differential thermal Analysis (DTA).

2.1.3 Water

Potable water was used for the preparation of the specimens at the various moisture contents.

2.2 Methods

2.2.1 Index properties

The index properties of the natural and treated soil were determined in accordance with BS [11,12,13,14].

2.2.2 Chemical composition

The chemical compositions of the soils were determined using X-ray flourescence (XRF) and this was carried out at the Centre for Energy Research Technology (CERT), Obafemi Awolowo University Ile-Ife, Osun Nigeria. The analysis was determined using standard laboratory procedures outlined by [13,14,15] for analyzing the chemical constituents of soils including oxides expressed as percentage.

2.2.3 Sieve analysis

Hydrometer method was used to obtain values of the clay-size (percent < 0.002 mm) fraction of the soil constituents or particles. 250 grammes of each soil samples was first measured and soaked using tap water for at least 2 days to ensure that the dry soil clods were softened. After soaking, the specimen was washed through BS No 200 (i.e., 0.075 mm) sieve. The material retained on the sieve after washing was collected into a small metal bowl, oven dried and sieved based on procedures outlined in [12,13,14]. Sieving was done in three replicates for each specimen. When the lateritic soil was treated with 2 - 12% bamboo leaf ash by dry weight of soil at optimum moisture content (OMC), less than 10% of the material passed through BS No. 200 sieve, and therefore did not meet the minimum requirement for sedimentation analysis to be carried out.

2.2.4 Specific gravity

Specific gravity tests were conducted based on procedures outlined in [11,12,13]. Tests were carried out in three replicates. The specific gravity for each of the specimen was calculated using the expression [13]:

$$G_s = \frac{\rho_L(m_2 - m_1)}{(m_4 - m_1) - (m_3 - m_2)} \quad \text{.............................} \quad (1)$$

Where ρ_L = density of liquid used (ρ_L was assumed to be equal to 1.000 g/ml for this purpose since distilled water was used); m_1 = mass of density bottle (g); m_2 = mass of bottle + dry soil (g); m_3 = mass of bottle + soil + liquid (g); m_4 = mass of bottle + distilled water only (g). Average of three measurements was calculated and recorded in each case. Specific gravity tests were repeated whenever any value differed from the average value by more than 0.03.

2.2.5 Atterberg limits

Atterberg limits tests which are otherwise known as plasticity tests were conducted on air-dried soils that had previously been passed through sieve with 425 µm aperture (Head, 1992). Distilled water was used throughout the tests to determine the plasticity of the soils. The liquid limit was determined with the use of the Casagrande apparatus in agreement with Clause 4.5, Part 2 of [13]. The five-point system was employed in order to obtain the actual liquid limit values of the soils. The plastic limit of each soil was estimated on the basis of procedures outlined in Clause 5.3, Part 2 of [13]. Portions of paste with water contents close to the liquid limit were used for plastic limit determination. The plasticity index of each soil was obtained as the difference between the liquid limit and plastic limit. The percentage linear shrinkage of each soil specimen was determined according to procedures in Clause 6.5, Part 2 of [13]. Moisture content determinations for the liquid and plastic limits tests were carried out by oven-drying in conformity with Clause 3.2, Part 2 of [13].

2.2.6 Compaction of soil

The standard Proctor (SP) compaction procedures were utilized during the tests. The SP compactions utilized 3 layers applying 27 blows each of a 2.5 kg rammer falling from a height of 300 mm using 1000cm^3 mould.

2.2.7 California bearing ratio

The CBR were carried out in conformation with the recommendations of the Nigerian General Specifications for Roads and Bridges [15], which states that specimens be cured for 6 days unsoaked (that is, at a temperature of 25±2ºC and relative humidity of 100%) and immersed in water for 1 day before testing.

2.2.8 Unconfined compressive test

Unconfined compression test was carried out on soil specimens previously mixed with tap water and compacted at moulding water contents in the range of 6.5 - 22.5% using British Standard Light energy. Compacted specimens were sealed in plastic bags and allowed to stand for at least 24 hours before trimming and testing. At least three specimens (38 mm diameter by 76 mm high) per moulding water were used in the unconfined compression tests [16].

3. RESULTS AND DISCUSSION

3.1 Preliminary Test

The results from the preliminary test such as natural moisture content, specific gravity, particle size analysis, atterberg limits and plasticity index before the addition of Cassava peels ash are presented in Table 1, particle size distribution for the samples are shown in Fig. 1, atterberg limits tests after addition of Cassava peels ash of 2, 4, 6, 8 and 10% are presented in Table1 and engineering property tests such as compaction, California bearing ratio (CBR) and unconfined compressive strength test are presented in Tables 2 and 3 respectively.

The results show that L3 has the highest natural moisture contents while L1 has the lowest (Table 1). The moisture content of soil depends largely on void ratio and specific gravity [6,15,16,17,18].

These values ranged within that given in [7] for clay minerals, as Halloysite (2.0 - 2.55). According to [8,19,20] noted that the higher the specific gravity, the higher the degree of laterization. This indicates that soil L2, exhibits higher degree of laterization than samples L1 and L3. However, the specific gravity of Cassava peels ash is 2.05.

Particle size distribution curve is shown in 1 below. The three samples were classified using the [9,20,21] soil classification system. All the samples fell within the silt-clay materials under the general classification as their percentages passing sieve No 200 were all more than 35%. They all fell within A-7 groups. Based on their Liquid Limit (LL) and Plastic Index (PI), samples L1, L2 and L3 were further classified as A-7-6(6), A-7-5(5) and A-7-6(6) respectively. This shows that all the samples fall below the standards recommended for most geotechnical construction works and would therefore require stabilization.

The results of the Atterberg's limits test (Liquid Limits (LL), Plastic Limits (PL) and Plastic Index (PI)) on the samples are shown in Table 1. According to [10], if liquid limit is less than 35%, it indicates low plasticity, if it is between 35% and 50%, it indicates intermediate plasticity, if it is between 50% and 70%, it has high plasticity and if it is between 70% and 90%, it has very high plasticity and if it is greater than 90%, it is extremely high plasticity. This shows that samples L1, L2 and L3, have intermediate plasticity. The addition of Cassava peels ash in 2, 4, 6, 8 and 10% to the samples caused changes in the liquid limits and plastic limits of all the samples, which are shown in Table 1. These reductions in plasticity indices are indicators of soil improvement.

Engineering Tests: The summary of compaction, CBR and UCS are shown in Figs. 2 and 3. The addition of increasing percentages of CPA in 2, 4, 6, 8 and 10% by weight of sample led mostly caused a corresponding reduction in OMC of the samples. The lower the optimum moisture content, the better its workability [11,20,21,22].

Table 3 shows the summary of the unsoaked CBR results on the soil samples. The results show that the CBR values of samples L1, L2 and L3 increased considerably with the addition of Cassava Peels Ash. The California Bearing Ratio (CBR) test is commonly used to obtain an indication of strength of a subgrade soil, sub-base and the base course materials for use in road and airfield pavement design [12,22,23,24]. The results therefore showed that the strength of the samples has been improved with CPA stabilization. These improvements in the CBR values of samples L1, L2 and L3 satisfy the minimum requirements that qualify them as road construction materials for subgrade and showed that the soil samples were effectively stabilized by CPA.

Table 3 shows the summary of the unconfined compression test results. It is a special type of unconsolidated-undrained test that is commonly used for clay specimens where the confining pressure (σ_3) is 0 and the major principal stress (σ_1) is the unconfined compression strength (q_u). The unconfined compression strength of samples L1, L2, and L3 increased considerably with the addition of Cassava Peels Ash. These results further confirmed the stabilizing potentials of CPA on lateritic soil if added at the optimum level.

Table 1. Summary of properties of soil samples

Properties	**Sample**		
	L1	**L2**	**L3**
Colour	Yellowish brown	Yellowish brown	Reddish brown
Natural moisture content (%)	12.1	13.2	14.8
Percentage passing BS No 200 sieve	52	50	52
Liquid limit (%)	45	45	42
Plastic limit (%)	28	30	23
Plasticity index (%)	17	15	19
Specific gravity	2.23	2.41	2.34
AASHTO classification	A-7-6	A-7-5	A-7-6
Group index	6	5	7
USCS classification	CL	SC	CL
Optimum moisture content (%)	17.48	19.76	17.07
Maximum dry density (Mg/m^3)	1.4	1.38	1.43

Table 2. Summary of atterberg limit for CPA

Samples	**Lateritic soil + CPA (%)**	**Liquid limit (%)**	**Plastic limit (%)**	**Plasticity index (%)**
L1	0	45.00	28.00	17.00
	2	37.40	25.00	12.40
	4	42.30	25.00	17.30
	6	42.30	33.00	9.30
	8	43.60	27.70	15.90
	10	45.20	27.70	17.50
L2	0	45.00	30.00	15.00
	2	37.50	25.00	12.50
	4	38.70	30.40	8.72
	6	45.60	27.70	17.90
	8	41.00	35.60	5.40
	10	43.70	33.30	10.40
L3	0	42.00	23.00	19.00
	2	29.00	14.00	15.00
	4	39.70	27.70	12.00
	6	39.12	30.40	8.72
	8	38.80	33.30	5.50
	10	36.00	27.70	8.30

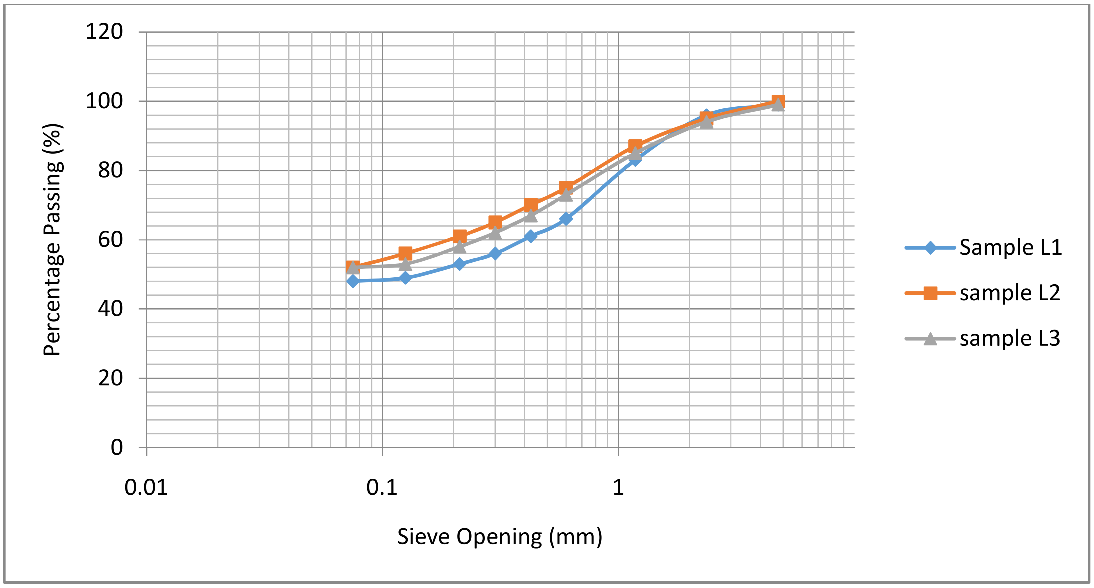

Fig. 1. Particle size distribution of the natural soil

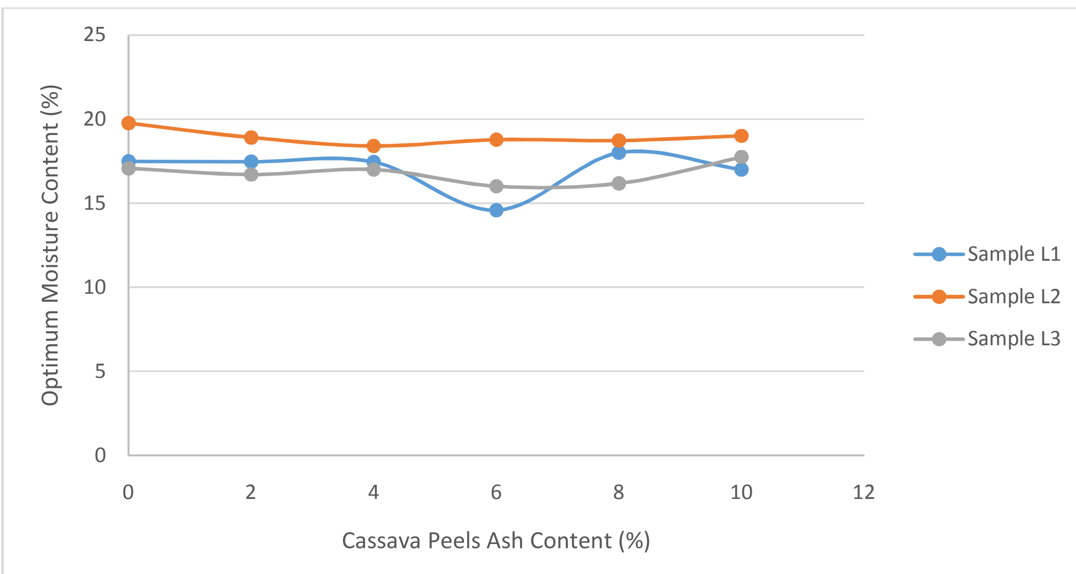

Fig. 2. CPA on the optimum moisture content of the samples

Table 3. Summary of CBR and unconfined compressive test

Samples	Percentage stabilization (%)	California bearing ratio (Unsoaked)(%)	Unconfined compressive strength (kN/m^2)
L1	0	7.8	123.70
	2	11.25	590.58
	4	12.63	511.53
	6	16.40	150.33
	8	19.40	490.82

Samples	Percentage stabilization (%)	California bearing ratio (Unsoaked)(%)	Unconfined compressive strength (kN/m^2)
	10	15.50	398.16
L2	0	5.80	293.48
	2	13.75	131.94
	4	16.46	187.55
	6	23.74	79.30
	8	25.45	110.19
	10	27.02	297.67
L3	0	14.45	153.99
	2	14.97	216.36
	4	18.20	403.03
	6	7.97	581.71
	8	11.02	554.02
	10	14.03	467.98

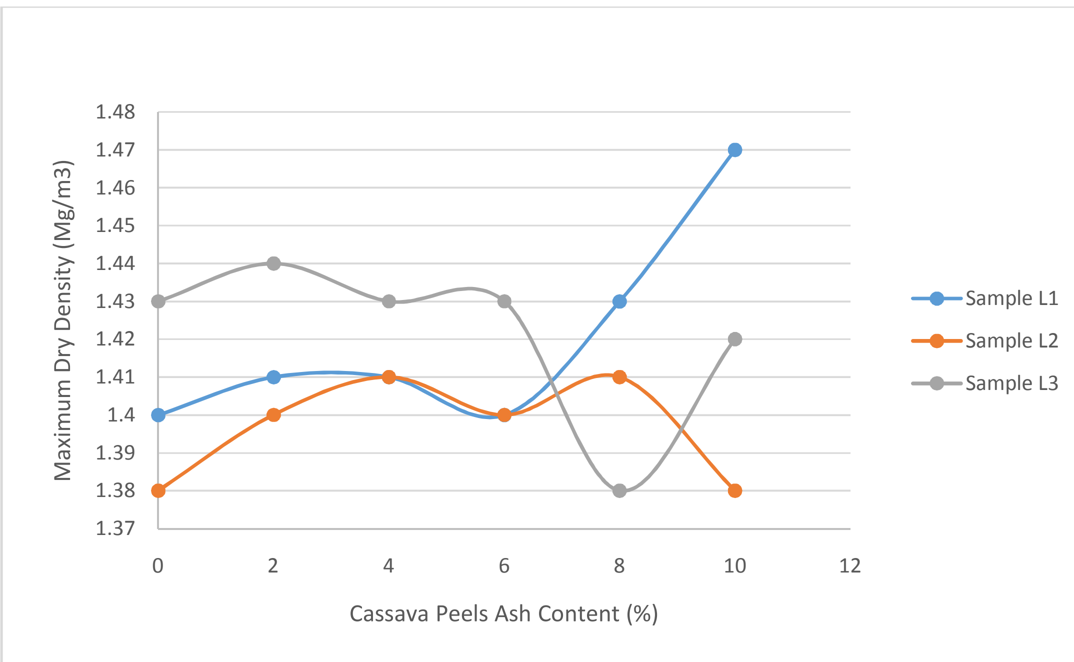

Fig. 3. CPA on the maximum dry density of the samples

4. CONCLUSION

The soils samples were classified to be A-7-6, A-7-5 and A-7-6 [11] soil classification system. These fall within silt-clay materials under general classification. It was shown that Cassava Peels Ash (CPA) improved the qualities of the soil samples by significantly reducing their plastic indices. The plasticity indices of samples L1, L2 and L3 decreased. These reductions in plasticity indices are indicators of soil improvement. The results showed that the addition of CPA improved the strengths of the samples. Optimum moisture contents of all the samples reduced while Maximum dry density increased considerably. The unsoaked CBR values of samples increased at 8, 10 and 4% CPA stabilization for sample L1, L2 and L3 respectively. The shear strengths of the samples also increased. The study therefore concluded that Cassava Peels Ash (CPA) has the potential to effectively stabilize lateritic soils for highway construction. Based on this study, it is therefore necessary to recommend Cassava Peels Ash as a stabilizing agent for improving soils with low California bearing ratio.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Alhassan M. Potential of rice husk ash for soil stabilization. AUJT. 2008;71(4):246-250.
2. Bello AA, Adegoke CW. Geotechnical characterization of abandoned dumpsite soil. ARPN Journal of Earth Sciences, ISSN 2505-403X, Asian Research Publishing Network. 2013;2(3):90-100. Available: http://www.arpnjournals.com
3. Amu OO, Ogunniyi SA, Oladeji OO. Geotechnical properties of lateritic soil stabilized with sugarcane straw ash. American Journal of Scientific and industrial Research. 2011;2(2):323-331.
4. Amu OO, Bamisaye OF, Komolafe IA. The Suitability and Lime Stabilization requirement of Some Lateritic Soil Samples as Pavement. Int. Journal of Pure Applied Science and Technology. 2011;2 (1):29–46.
5. Amu OO, Adetuberu AA. Characteristics of bamboo leaf ash stabilization on lateritic soil in highway construction. International Journal of Engineering and Technology. 2010;2(4):212-219.
6. Bello AA, Awogboro OS, Oriaje AT. ‘Influence of Compactive Efforts on Lateritic soil stabilized with Rice Hush Ash. International Journal of Applied Engineering. 2014;9(21):9639-9653.
7. Bello AA, Ige JA, Ibitoye GI. Geotechnical properties of lateritic soil stabilized with cement-bamboo leaf ash admixtures. International Journal of Applied Engineering Research. 2014;9(21):9639-9653.
8. Sear LKA. Should you be using more PFA. Proc. Int. Conf. Cement Combination for Durable Concrete held at the University of Dundee, Scotland; 2005. UK. Lambe W.T. and Whiteman V. R., Soil Mechanics, SI Version. New York: John Wiley and Sons. Inc; 1979.
9. Akintola FA. Geology and Geomorphology. In: Nigeria in Maps. R.M Barbour, Editor, Hodder and Stoughton, London; 1982.
10. Areola O. “Soils”. In: Nigeria in Maps, R. M, Barbour, Editor Hodder and Stoughton, London, UK; 1982.
11. AASHTO. Standard Specifications for Transportation Materials and Method of Sampling and Testing. Amer. Assoc. State Highway and Transportation Officials, Washington, DC, USA; 1986.
12. BS 1377. Methods of Testing Soil for Civil Engineering Purposes. British Standards Institute, London; 1990.
13. BS 1924. Methods of Test for Stabilized Soils. British Standards Institute, London; 1990.
14. Head KH. Manual of soil laboratory testing. Soil classification and compaction tests. Second Edition, Pentech Press, London. 1992;1.
15. Nigeria General Specification. Bridges and Road Works. Federal Ministry of Works and Housing, Headquarters, Abuja, Nigeria. 1997;11. (Revised)
16. Amu OO, Bamisaye OF, Komolafe IA. The Suitability and Lime Stabilization requirement of Some Lateritic Soil Samples as Pavement. Int. Journal of Pure Applied Science and Technology. 2011;2 (1):29–46.
17. Adesanya OA, Oluyemi KA, Josiah SJ, Adesanya RA, Shittu LAJ, Ofusori DA, Bankole MA, Babalola GB. Ethanol Production by Saccharomyces Cereviasiae from cassa peel hydrolysate. The Internet Journal of Microbiology. 2008;5(1):25-35.
18. Lambe WT, Whiteman VR. Soil Mechanics, SI Version. New York: John Wiley and Sons, Inc; 1979.
19. Ola SA. Stabilization of Nigeria Lateritic Soils with Cement, Bitumen and Lime. Proc. 6^{th} Reg. Conf. Africa on Soil Mechanics and Foundation Engineering. Durban, South Africa; 1978.
20. Liu C, Evett J. Soils and Foundation, 6^{th} ed. USA: Prentice Hall; 2003.
21. De Graft-Johnson, JWS. Engineering properties of lateritic soil proceedings of the special session in laterite soils. 1969;4:1050-1066.

22. Whitlow R. Basic soil mechanics. 3rd edition. Addison Wesley Longman Limited, Edinburgh Gate; 1995.
23. Lambe WT, Whiteman VR. Soil Mechanics, SI Version. New York: John Wiley and Sons, Inc; 1979.
24. Liu C, Evett J. Soils and Foundation, 6th ed. USA: Prentice Hall; 2003.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=775&id=5&aid=8518