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Effect of Temperature Changes on the Unconfined Compressive Strength of OPC Stabilized Engineering Soil with Palm Bunch Ash, PBA as Admixture

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Abstract
Nowadays, waste product such as Palm Bunch Ash (PBA) is produced in large quantities from the agriculture industry on a daily basis. Improper disposal of the agricultural wastes at landfills contribute to environmental pollution. The cost of construction material increases when the demand is high. Therefore, reutilization of these waste products not only reduces the cost of construction material but also minimizes waste disposal problem. In this research, "The Effect of Temperature on Ordinary Portland Cement Stabilization of Engineering Soil using Palm Bunch Ash as Admixture", The compressive strength of the (Laterite + cement + palm bunch ash) specimen cured for 14 days was studied and found to have more strength than that of the 7 days curing period. The addition of palm bunch ash from 0% to 10 % was found to have increase in strength from 23ºC to 60ºC and records its maximum strength at 60ºC which later reduces slightly from 80ºC to 100ºC, hence its maximum strength was acquired at 60ºC. It was observed that the specimen placed at room temperature has a higher strength than that of 100ºC. The specimen subjected to 100ºC was observed to have the lowest strength for both 7 and 14 days cured specimen. From the compaction test, the optimum moisture content increased from 11.7% to 17.6% considering 0% to 10% addition of Palm Bunch Ash while the Maximum Dry Density decreases from 1860kg/m^{3}to 1730kg/m^{3}for 0% to 10% addition of PBA admixture and the CBR increased from 82% to 93% with the increase in Palm Bunch Ash addition.
Keywords: Temperature changes, unconfined compressive strength, palm bunch ash, ordinary Portland cement, admixture.

INTRODUCTION

Land based structure of any type is only as strong as its foundation. For that reason soil is a critical element influencing the success of a construction project. Soil is either part of the foundation or one of the raw materials used in the construction process. Therefore understanding the engineering properties of soil is crucial to obtain strength and economic performance (US Army Corps of Engineers, 2005). One of the major reasons for structural failure particularly in pavement design is the non-availability of generalised relevant data of the particular soil involved in the area of construction and how these soils respond to atmospheric and moisture temperature. Cases of under design of pavement strength have been recorded largely due to assumption of sub-grade properties involved which resulted into early failure. To be cost effective, pavement should be constructed over good sub-grade materials therefore remove early failure such as pot holes, ravelling, shoving, rutting and so on. The cost of construction material is often exorbitant, particularly when most of the materials have to be imported. It is preferable to construct with locally available material that may have limited durability but cost considerable. In tropical climate that possess an important consideration that must be factored into the design of low cost road, research has shown that it is possible to provide construction material and method that are appropriate for that environment and are also affordable (Mbumbia *et al.,* 2002). The pursuit for improvement of soil structure, its cost-effectiveness in road and other construction works and effect of temperature and palm bunch ash on soil stabilization forms the basis of this research. As the conventional road construction material become scarce or more expensive there is need to choose alternatives. The common soil stabilization technique are becoming costly day by day due to the rise of cost of the stabilizing agent like cement, lime e.t.c (Salahudeen and Akiije, 2014).Thus the use of agricultural waste like rice husk ash, bamboo leaf ash, palm bunch ash and so on will considerably reduce the cost of construction and as well reducing the environmental hazards they cause (Oyetola and Abdullahi, 2006; Sadeeq et al, 2015). Nowadays, waste products such as Palm Bunch Ash (PBA) are produced in large quantities from the agriculture industry on a daily basis. Improper disposal of the agriculture wastes at landfills contributes to environmental pollution. The cost of construction material increases when the demand is high. Therefore, reutilization of these waste products not only reduces the cost of construction material but also minimizes waste disposal problem. The primary objectives of this research work are; (i) To determine "The Effect of Temperature on Ordinary Portland Cement Stabilization of Engineering Soil using Palm Bunch Ash as Admixture, (ii) To investigate the effect of PBA on soil stability (iii) To reduce cost of construction of pavements by reutilization of these waste product (palm bunch) and (iv) To investigate the strength of stabilized soil at high temperature. Soil stabilization improves the engineering properties of a soil and thus making it more stable (Arora, 2009). Stabilization can be defined as the alteration of soils to enhance their physical properties. Stabilization includes compaction, pre-consolidation, drainage and many other such processes. Stabilization can increase the shear strength of soil and control the shrink swell properties of a soil, thus improving the load bearing capacity of foundation soil (Breneman, 2010). Soil stabilization refers to the procedure in which a special soil, a cementing material or other chemical or non chemical materials are added to a natural soil or a technique used on a natural soil to improve one or more of its properties. One may achieve stabilization by physically mixing the natural soil and material together so as to achieve a homogenous mixture or by adding stabilizing material to an undisturbed soil deposit and obtaining interaction by letting it permeate through soil voids (Abood et al, 2007). Soil stabilization additives are used to improve the properties of less desirable soils. When used, these stabilizing agents can improve and maintain soil moisture content, increase soil particle cohesion and serve as cementing and water proofing agent (Salahudeen and Akiije, 2014). Cement is composed of calcium silicate and calcium-aluminate that when combined with water hydrate to form the cementing compounds of calcium-silicate, hydrate and calcium-aluminate-hydrate, as well as excess calcium hydroxide (lime) formed cement may be successful in stabilizing both granular and fine-grained soils as well as aggregate and miscellaneous materials (Little *et al.,* 2010; Okafor and Egbe, 2013).

Non-Cementitious Additive Stabilization

There are lots of additives that have been experimented on with effect to improve the geophysical properties of soil at lower cost by replacing certain percentage of cementitious stabilizers with non-cementitious additives which include: (i) Quarry dust obtained as waste in a quarry silt, (ii) Bagasse ash obtained as waste from sugar cane processing factory, (iii) Egg shell ash, (iv) Palm kernel shell ash, (v) Saw dust ash etc (Onyelowe, 2011; Sadeeq et al, 2015).

Temperature

Pozzolanic and cementing reaction is sensitive to changes in temperature. In the field, temperature varies continuously throughout the day. Pozzolanic reaction between binders and soil particles will slow down at low temperature and result into lower strength of the stabilized mass. In cold regions, it may be advisable to stabilize the soil during the warm season (Sherwood, 1993, Maher *et al.,* 2004).

Palm Bunch Ash (PBA)

Palm Bunch Ash (PBA) is one of the products of palm trees. Palm tree are economic trees dominantly grown in the south-east and south-south of Nigeria where production averages approximately 95% of the total production in Nigeria (Onyelowe and Ubachukwu, 2015). The two major economical produce from palm trees processing are palm wine and palm oil. Palm fruits are used for the production palm oil-and are harvested from the palm bunch. The empty palm bunches are the waste from the processing of the palm fruits. These wastes presently are used as organic fertilizers, bio fuel in the rural areas, soap making (black soap) etc. The waste produce considerable amount of solid waste by-products in the form of fibres, shells and empty bunches which are discharged from the mills. Presently, shell and fibre are used extensively as bio fuel for the production of steam in the palm-oil mills as a means of waste disposal and energy recovery. Tables 1 and 2 below show the physical and chemical properties and components of PBA.

Table 1: Physical Properties of Palm Bunch Ash (Ettu *et al*., 2013; Onyelowe and Ubachukwu, 2015)

Property	Palm bunch ash
Moisture content %	0.35
Specific gravity	2.33

Table 2: Chemical Properties of Palm Bunch Ash (Ettu *et al*., 2013; Onyelowe and Ubachukwu, 2015)

Constituent	Percentage weight in PBA (%)
MgO	0.89
Fe_2O_2	0.45
CaO_2	14.59
Al_2O_3	15.49
SiO_2	60.96
TiO_2	Trace
Na_2O	0.81
ZnO	0.99
CuO	Trace
CdO	Trace
MnO	0.89
MgO	0.40
PbO	0.24
LiO	5.8

Climate Change

There is a growing concern about global warming and the impact it will have on people and the ecosystem on which they depend. Temperature changes vary over the globe and since 1979 land temperature increased about twice as fast as ocean temperature (Trienberth *et al*., 2007). Nine of the ten warmest years in the instrument record occurred since 2000, with 2014 being the warmest year, on the record (NASA, 2015). This has prompted calls for action at every level of government and across many sectors of economy and society. It is therefore pertinent to establish sort of coordinated activities that will examine the serious and sweeping issues associated with global climate change including the science and technological challenges involved and provide advice on actions and strategies nations can take to response to it (The National Academics, 2008). Global warming refers to an average increase in the earth's temperature which in turn causes change in climate (EPA, 2009). The term climate change is often used interchangeably with "global warming" however, giving the wide range of impact beyond temperature variation. The former is generally the preferred in the scientific community because it helps convey that there other changes in addition to rising temperature (Trienberth *et al*., 2007). Climate change refers to the variation in the earth's global climate or in regional climates over time. It describes changes in the variability or average state of the atmosphere over time scales ranging from decades to millions of years. These changes can be caused by processes internal to the earth, external forces (e.g. variation in sunlight intensity) or more recently, human activities (Wikipedia, 2009). In recent usage especially in the context of environmental policy, the term "climate change" often refers only to changes in modern climate, including the rise in average surface temperature known as global warming. In some cases the term is also used with a presumption of human causation (Trienberth *et al*., 2007).

Monthly maximum temperature and minimum temperature data for the selected cities (Owerri, Calabar and Port-Harcourt) were obtained from the Nigeria Meteorological Agency (NIMETA), Oshodi Lagos, Nigeria. The nature of the data collected as maximum and minimum temperature (°C) recorded for every month of the year. (Olofintoye and Sule, 2010).

Table 3: Statistical Summary of the Temperature Data Spanned between 1983 and 2008 (26 years) for all Stations (Olofintoye and Sule, 2010).

	(°C)	Mean °	Variance	Standard deviation
Owerri	Min. temperature	23.42	0.30	0.55
	Max. temperature	32.19	0.20	0.45
Calabar	Min. temperature	23.09	0.31	0.55
	Max. temperature	30.79	0.17	0.42
Port-Harcourt	Min. temperature	22.66	0.12	0.35
	Max. temperature	31.38	0.11	0.33

MATERIALS AND METHODS

Materials

Materials used for the research work include Azaraegbelu in Owerri-North L.G.A Of Imo State, Nigeria lateritic soil, Dangote OPC and Palm Bunch Ash (PBA) as admixture. Laterite samples were gotten from a borrow pit site situated along latitude 05° 26′ 44.288″ N and longitude 07° 32′ 33.229″ E (www.google.com, 2015, Imo State Ministry of Environment, 2014) used as a source of laterite for civil engineering works within Owerri municipal and Owerri North, South Eastern Nigeria was investigated under normal laboratory condition. The laterite was obtained having little content of moisture in it i.e. semi-solid state and it was reddish brown in colour. Palm Bunch was collected from dump site at and oil mills. The PB was then sun dried for 3 weeks and then burnt without gasoline or fuel on a clear dried surface. The pulverization was carried out immediately on that same clear and dried surface. The ash was sieved using the 0.75µm BS TEST sieve to achieve a smooth, uniform and fine particle. The ash was found to be hygroscopic hence the ash was stored in an air-tight container. Ordinary Portland cement was gotten from Dangote Cement shop at Nekede, Imo State. The cement was preserved to prevent contact with water in a dry place.

Methods

The physical characteristics of Azaraegbelu laterite was determined which includes; particle size distribution, Atterberg limit, compaction/moisture content, specific gravity, CBR, and unconfined compressive strength (ASTM D-1632; ASTM D-1633; ASTM D-5102-09; ASTM D-2166-06; IS: 2720-Part XVI, 1990).

Particle Size Distribution

Orderly arranged British Standard Sieves to BS1377 (1990)**;** 4.36mm, 2.36mm, 1.18mm, 600µm, 425µm, 300µm, 212µm, 150µm, 75µm; Lid and receiver; balance readable and accurate to 0.1g, drying oven, sieve brush and the mechanical shaker were the apparatuses used for the PSD test.

Atterberg Limit (Plastic Limit, Liquid Limit & Plasticity Index)

A flat glass plate (10mm thick and 500mm square); two palette knives (200mm long and 30mm wide); Cassagrande liquid limit apparatus; a grooving tool and gauge; an evaporating dish or a damp cloth; a beaker containing distilled water; and a non-corrodible air tight container large enough to take about 250g of wet soil and the material soil sample were the apparatuses use for the above examination.

Soil Compaction/Moisture Content Test

A cylindrical metal mould having an internal diameter of 105mm, internal effective height of 115.5mm and a volume of 1000cm^3 (the mould shall be fitted with a detachable base plate and a removable extension 50mm high); a metal rammer having a 50mm diameter circular face and weighing 2.5Kg (the hammer was equipped with a suitable arrangement for controlling the height of drop to 300mm); a balance readable and accurate to 1g; a palette knife (100mm long and 20mm wide); a straight edge steel strip 300mm long, 25mm wide and 3mm thick with one bevelled edge; 20mm BS test sieve and a receiver; large metal tray (600mmx500mm with sides 80mm deep) were apparatuses used for moisture content and MDD examination.

Specific Gravity Test

The apparatuses used for this examination are; two density bottles (pycnometers) of approximately 50ml capacity with stoppers; water bath maintained at constant temperature of 20^{o}C within +0.2^{o}C; vacuum desiccators; thermostatically controlled drying oven (105-110^{o}C); balance readable and accurate 0.001g; a vacuum pump, spatula (150mm long, 3mm wide); plastic wash bottle containing air-free distilled water; sample divider of the multiple slot type (riffle box) with 7mm width of opening; and a length of rubber tubing to fit the vacuum pump and the desiccators.

California Bearing Ratio (CBR)

The apparatuses used for this examination are; Compressive machine, proving ring, dial gauge, stopwatch, sampling tube, split mould, vernier caliper, and balance.

Effect of Temperature on the UCS of Stabilized Azaraegbelu Laterite

The following apparatuses were used in this investigation; electric oven, cured specimen, and unconfined compressive strength test apparatus and the following procedure were adopted; (i) The 0% Palm Bunch Ash + 12% cement stabilized specimen was cured for 7days and 14days after that one each was left at room temperature for control and twelve others were subjected to oven temperatures of 50^{o}c, 60^{o}c, 70^{o}c, 80^{o}c, 90^{o}c and 100^{o}c for 24hours (ii) the process in (i) above was repeated for stabilized specimen with 2%, 4%, 6%, 8% and 10% Palm Bunch Ash at constant cement content of 12% and (iii) the stabilized specimen was crushed to determine the strength of the specimen at varying temperatures and PBA.

RESULTS AND DISCUSSION

Table 5: Properties of the Natural Soil Sample

Properties	**Quantities**
Natural Moisture Content (%)	36.8
Percentage Passing B.S. sieve No.200	38
Liquid Limit (%)	34
Plastic Limit (%)	20
Plasticity Index (%)	14
AASHTO Classification	A-2(6)
Maximum Dry Density (Kg/m^3)	1800
Optimum Moisture Content (%)	14.78
California Bearing Ratio (%)	8.0
Specific Gravity	2.69
Unconfined Compressive Strength (KN/m^2)	186

Table 6: Grain size analysis of Lateritic soil

Sieve size	Weight retained (g)	Weight passing (g)	% passing
9.5mm	9	491	98
6.7mm	36	455	91
4.75mm	66	389	78
2.36mm	104	285	57
1.18mm	30	255	51
600µm	8	247	49
425 µm	5	242	48
300 µm	5	237	47
212µm	7	230	46
150µm	11	219	44
75µm	30	189	38

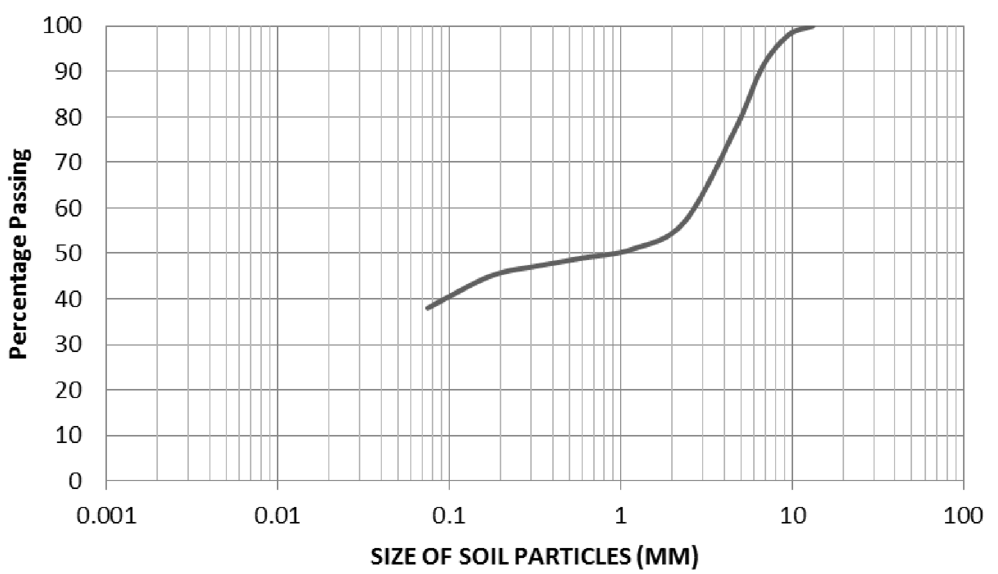

Fig. 4: Particle size distribution for Laterite

As shown in Table 8 and in Figure 8, for 7 days curing period that the unconfined compressive strength of the specimen increased as the palm bunch ash increases from 0% to 10% at room temperature. But as the temperature increased there was also a general increase in strength to an extent and dropped at higher temperature of 80°c to 100°c. The maximum strength of the specimen was around 60°c to 70°c and its lowest strength was at 100°c.

From Table 9 and Figure 9, for 14days curing period the UCS of the specimen generally increased as palm bunch ash increases at room temperature and as the temperature increased there was early increase in strength which later dropped at higher temperature of 80°c to 100°c. We also observed just like in 7days curing period that the specimen's maximum strength was at 60°c to 70°c and its lowest strength was at 100°c.

The specimen cure for 14days generally has a higher strength than that of 7days curing duration. As a known fact, concrete's strength increases by age (Punmia *et al*, 2005), this may also be applied in the increase in strength of the palm bunch ash + cement + soil mix as curing period elongate

Table 8: Effect of Temperature changes and PBA variations on the Compressive Strength of Stabilized Sample for 7 Days Curing Period.

Palm Bunch Ash (%)	Compressive strength (KN/m$^{2)}$ (7 days curing) (Subjected Temperatures)						
	Room temp.	50^{o}c	60^{o}c	70^{o}c	80^{o}c	90^{o}c	100^{o}c
0	267	286	297	291	276	258	230
2	281	304	318	322	308	282	265
4	293	321	334	329	295	278	262
6	312	336	345	347	316	302	284
8	320	341	333	326	317	290	275
10	332	358	364	370	357	328	314

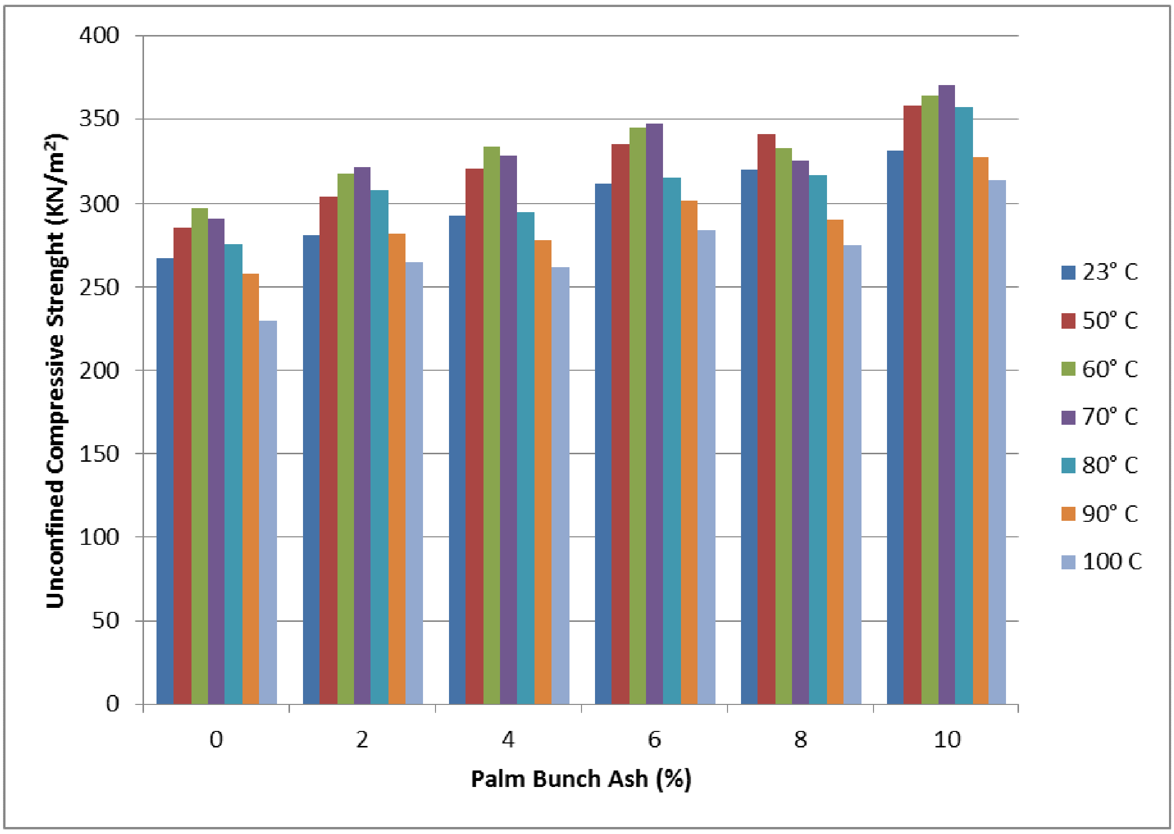

Figure 8: A graph showing the effect of temperature on palm bunch ash stabilized lateritic soil (for 7 days)

Table 9: Compressive Strength in KN/m^2 of Different Percentage Composition of Palm Bunch Ash as Well as Their Strengths in Temperature Changes for 14 Days Curing Period.

Palm Bunch Ash (%)	Compressive strength (KN/m$^{2)}$ (14 days) (Subjected Temperatures)						
	Room temp.	50^{o}c	60^{o}c	70^{o}c	80^{o}c	90^{o}c	100^{o}c
0	370	398	396	387	369	360	345
2	462	480	485	464	459	447	432
4	507	523	537	540	531	518	495
6	533	551	563	578	569	553	547
8	605	634	642	655	644	630	619
10	614	640	662	654	635	619	598

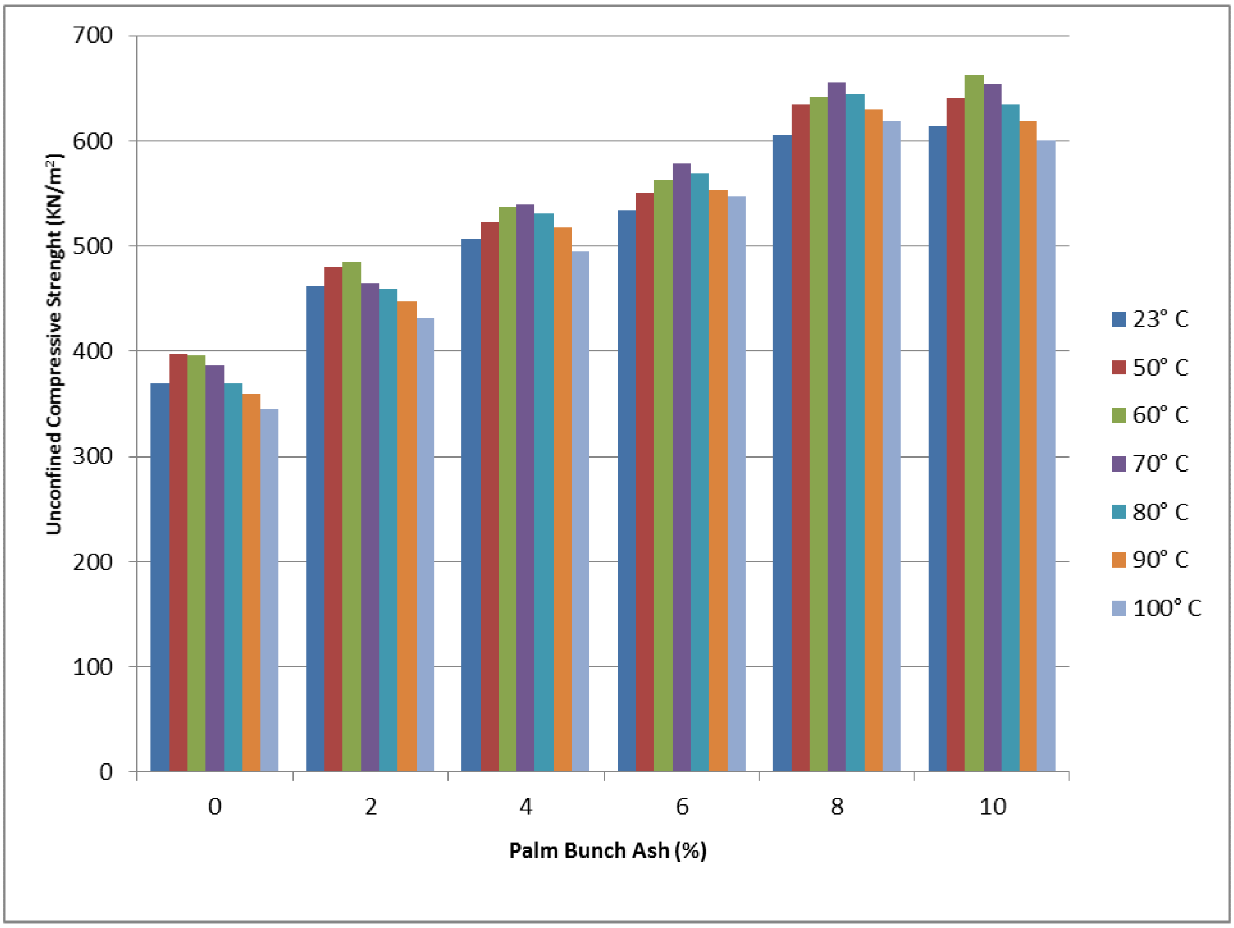

Figure 9: A graph showing the effect of temperature on palm bunch ash stabilized lateritic soil (for 14 days)

CONCLUSION

From the foregoing, the following conclusions were made;

1. The lateritic soil was identified as A-2(6) soil based on AASHTO classification system.
2. The value of UCS of the stabilized soil generally increased as the palm bunch ash increase and the value increased to an extent and dropped at higher temperature. The higher the duration of the higher the strength of the stabilized soil. The result obtained revealed that it's not advisable to use palm bunch ash as admixture in area with a very high temperature since the strength of the stabilized soil decreases at a higher temperature. The unconfined compressive strength test carried out also exposed that maximum and preferable strength was attained at temperature of 60°c to 70°c.
3. The compressive strength of the (Lateritic soil + cement + palm bunch ash) specimen cured for 14 days was also found to have more strength than that of the 7 days curing period.

REFERENCES

AASHTO (1988), Manual on Subsurface Investigations American Association of State Highways and Transportation Officials, Washington D. C.

Abood, T.T., Kasa, A.B., and Chik, Z.B. (2007), Stabilization of Silty Clay Soil Using Chloride Compounds, JEST, Malaysia, Vol.2, pg 102-103.

Arora, K. R. (2009), Soil Mechanics and foundation Engineering, published by Standard publishers Distribution, 7th Ed.

ASTM D 1632, "Standard Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory".

ASTM D 1633, "Standard Test Method for Compressive Strength of Moulded Soil-Cement Cylinders".

ASTM D 5102-09, "Standard Test Method for Unconfined Compressive Strength of Compacted Soil-Lime Mixtures".

ASTM D-2166-06, "Standard Test Method for Unconfined Compressive Strength of Cohesive Soil".

B.S, 1377 (1990), Methods of Testing of Soils for Civil Engineering Purposes, British Standards Institute, London, United Kingdom.

EPA (2009), Climate change, United States Environmental Agency. www.epa.gov.
Ettu, L. O., Osadebe, N. N., and Mbajiorgu, M. S. W. (2013), "Suitability of Nigeria agricultural by-products as cement replacement for concrete making," International Journal of Modern Engineering Research, 3 (2): 1180-1185.
Imo State State Ministry of Environment (2014), Geological Data of Umuahia, Abia State, Nigeria.
IS:2720-Part XVI, Laboratory CBR Apparatus, (1999), Atterberg, A. Uber Die PhysikalischeBodenunteiSuchung and Uber Die Plastizitat Der Tone Int. Mitt Far Bodenkunde, Berlin, Vol. 1, 1911.Exas Department of Transportation. Determining Moisture Content in Soil Materials.
Little, D.N., Males, E.H., Prusinski, J.R., and Stewart, B. (2010), Cementitious Stabilization; Transportation in the New Millennium, Louisiana, USA, pg 1-7.
Maher, A., Bennert, T., Jaferi, F., Douglas, W.S. and Gucunski, N. (2004), Geotechnical properties of stabilized dredged material from New York-New Jersey harbour, Journal of the Transportation Research Board, Pp. 86-96.
Mbumbia I. and Tiirloeqj (2002), Performance characteristics of lateritic soil bricks fired at low temperatures: a case study of Cameroon. Construction and building material, n0 14; pp121-131
Okafor, F.O. and Egbe, E.A. (2013), Potentials of cement kiln dust (CKD) in subgrade improvement, NIJOTECH, Vol. 32, No. 1, Pp. 109-116.
Olofintoye, O.O and Sule, B.F. (2010), USEP, Jornal of Research Information in Civil Engineering Vol.7.
Onyelowe, K. C. and Ubachukwu, O. A. (2015). In review: Palm Bunch Ash Stabilization Of Olokoro-Umuahia Lateritic Soil.
Onyelowe, K. C. (2011): Geosynthetics and Geotechnical Properties of Soil in a Developing World; A Lesson for Nigeria, EJGE. USA, Vo1.16, pg 1481-1487.
Punmia, B.C; Jain, A.K. and Jain, A.K. (2005). Soil Mechanics and Foundation. Lanani Publication.
Sadeeq, J.A., Ochepo, J. and Salahudeen, A.B. (2015), Assessment of bagasse ash effect on the California bearing ratio of used oil contaminated lateritic soils, NIJOTECH, Vol. 34, No. 2, Pp. 223-231.
Salahudeen, A.B. and Akiije, I. (2014), Stabilization of highway expansive soils with high loss of ignition content kiln dust, NIJOTECH, Vol. 33, No. 2, Pp. 141-148.
Sherwood, P. (1993). Soil Stabilization with Cement and Lime, State of The Art Review, London Transport Research Laboratory, HM50
The National Academics (2008), Americas climate choice, natural academy of science. 500 fifth st.nw,. Washington dc 2001.
Trenberth, K.E., Jones, P.D., Ambenje, P., Bojanu, R., Easterling, D., Klen Tank, A., Panker, D., Rahim Zadeh, F., Renwick, J.A., Risticucci, M., Sodden, B., and Zhai, P., (2007). Observation and Atmospheric Climate Change, Climate Change Workshop.
Wikipedia (2010), Environmental Issues in the Niger Delta, from Wikipedia the Free Encyclopedia Http://Enwikipedia.Org
www.google.com (2015), the location of Amaoba, Umuahia accessed on November 08. 2015.