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EFFECT OF MAIZE POD ASH AS STABILISATION OF SUBGRADE SOIL

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Abstract: This study focused on effect of Maize Pod Ash (MPA) as stabilisation of subgrade soil and MPA have been found to be promising stabiliser due to its pozzolanic properties. The soil sample was obtained from a borrow pit located at Orita Ara, Ede–Iwo road in Osun State, South Western Nigeria. Maize pod was obtained from maize vendors in Ifon, a rural community in South Western Nigeria. It was dried in the sun to eliminate moisture and was later ground and took to furnace at 650°C temperature to obtain the MPA. Laboratory tests carried out on the soil sample and MPA include X–Ray Fluorescence (XRF), particle size analysis, and the soil stabilisation with 0%, 4%, 8%, 12% and 16% MPA using Atterberg limit, compaction, and California Bearing Ratio (CBR) tests. Chemical analysis using XRF test revealed that MPA is class F pozzolan while the soil was classified as A–2–7(4) according to American Association of State Highway Transportation Official. The compaction test showed that as the percentage of MPA increases, the Maximum Dry Density (MDD) decreases and the Optimum Moisture Content (OMC) increases with the highest MDD (23.2 kN/m^3) and lowest OMC (11 %) observed at 8% MPA. It was also observed that 8% MPA have the highest CBR value of 12.94 % compared with the soil sample with 1.40 %. This observation showed that the MPA can upgrade the geotechnical properties of subgrade soil.
Keywords: Maize Pod Ash, X–Ray Fluorescence, pozzolan, California Bearing Ratio

INTRODUCTION

The importance of road in the development of any nation can hardly be over–emphasized, as it plays a strategically important role in the transportation of good and services and this is commonly achieved through the vast network of roads that connect the rural and urban centers (Joel and Edeh, 2015). Lateritic soil, being a sedimentary rock deposit and a product from the weathering of rocks, is one of the most common, ubiquitous and readily available road building materials that can be sourced locally in Nigeria (Ola, 1980).

Lateritic soils have been generally found to be good construction materials and are therefore commonly used in construction. In the tropical part of the world as Nigeria, lateritic soils are used as a road making material and they constitute the subgrade of most tropical roads (Amu et al., 2011) and they are used as sub base and bases for low cost roads and these carry low to medium traffic. Lateritic soils have wider applications in the Nigerian construction industry, especially in road–construction projects where they are utilized as fill materials and flexible pavement foundations as subgrade (Layade and Ogunkoya, 2018).

Generally, soil stabilization is the process of improving the load bearing capacity and engineering properties of subgrade soil to support pavements and structures (Ogundare et al., 2018). It is a method of improving soil properties by blending and mixing other materials (Firoozi et al., 2017). Improvements include increasing the dry unit weight, bearing capabilities, volume changes, the performance of in–situ subsoils, sands and other waste materials in order to strengthen road surfaces and other geotechnical applications (Firoozi et al., 2017). It is also any treatment (including technically and compaction) applied to a soil to improve its strength and reduce is vulnerability to water and if the treated soil is able to withstand the stresses imposed on it by traffic under all weather conditions without excessive deformation, then it is generally regarded as stable (Amu et al., 2011).

In order to reduce the cost of stabilization of materials for road construction, one reasonable alternative is the use of wastes. Researchers have shown that utilization of wastes has resulted in considerable savings in construction costs as well as improvement in soil properties (Ogundare et al., 2024; Okafor and Okonkwo, 2009).

Maize pod is an agricultural waste product obtained from maize or corn which is reputed to be most important cereal is Sub–Sahara Africa (Olafusi and Olutoge, 2012). 589 million tons of maize were produced worldwide in the year 2000, the United States was the largest maize producer having 43% of world production while Africa produced 7% of the maize (Olafusi and Olutoge, 2012). Nigeria was the second largest producer of maize in Africa in the year 2001 with 4.62 million tons while South Africa had the highest production of 8.04 million tons (Olafusi and Olutoge, 2012). Maize pod is a by–product of corn production with about 160–180 kg maize pod generated for every 1 ton of corn produced (Zhang et al., 2013). However, most of the maize pod generated worldwide is discarded as waste hence, the need to harness ways of managing this waste for use as road construction.

METHODS

Materials

The soil sample used was obtained from a borrow pit located at Orita Ara, Ede–Iwo road Osun State, Nigeria. The soil sample was collected in the polythene bag and was air–dried in the laboratory prior to being used. Maize pod was obtained from the maize vendor in Ifon Osun State, Nigeria. It was dried in the sun to eliminate moisture and was later ground with mortal and pestle and took to furnace at 650°C temperature to obtain the Maize Pod Ash (MPA).

Methods

MPA at varying percentages (0, 4, 8, 12, and 16%) by dry mass of soil were used to stabilise the soil to evaluate the effects of the additive on the geotechnical properties of the soil. Physical tests carried out on the soil sample and maize pod ash are X–Ray Fluorescence, particle size analysis, specific gravity and Atterberg limits while the tests conducted on the stabilised soil with MPA are compaction and California Bearing Ratio tests. They were carried out in accordance with procedures described by British Standards Institution (BS 1990).

RESULTS AND DISCUSSION

Chemical Composition Test

Table 1 shows the chemical composition of the soil sample and MPA used in form of their oxides composition. It was observed that the sum of Silicon dioxide (SiO_2), Aluminum oxide (Al_2O_3), and Iron oxide (Fe_2O_3) for the soil sample and MPA gives 86.31% (class N pozzolan) and 71.86% (class F pozzolan) which are more than 70% as recommended by ASTM C618–12 for classification of pozzolans indicating MPA as a good pozzolana material. However, the MPA is rich in Calcium Oxide (CaO), a trend also noted by Akinwumi and Aidomojie, (2015).

Table 1: Chemical composition of Soil Sample and MPA

Oxide	Percentage Composition (%)	
	Soil sample	MPA
SiO_2	52.85	62.80
Al_2O_3	29.23	6.40
Fe_2O_3	4.23	2.66
TiO_2	1.45	0.48
CaO	1.57	5.50
P_2O_5	0.05	2.47
K_2O	0.83	7.38
MnO	0.08	0.66
MgO	4.45	2.20
Na_2O	0.72	1.99
SO_3	3.20	1.75
LOI	0.03	5.50

Sieve Analysis Test

The result of the sieve analysis on the soil sample shows that the soil was classified as A–2–7(4) according to American Association of State Highway and Transportation Officials (AASHTO M145–91, 2004) classification indicating it as a good material for road works.

Specific Gravity

The specific gravity of the soil sample and maize pod ash was determined to be 3.54 and 2.92 respectively. The value of the specific gravity is greater than what was reported (1.90) by Akinwumi and Aidomojie, (2015).

Atterberg Limits Test

Variation of the liquid limit, plastic limit and plasticity index of the soil with addition of various percentages of MPA is shown in Figure 1.

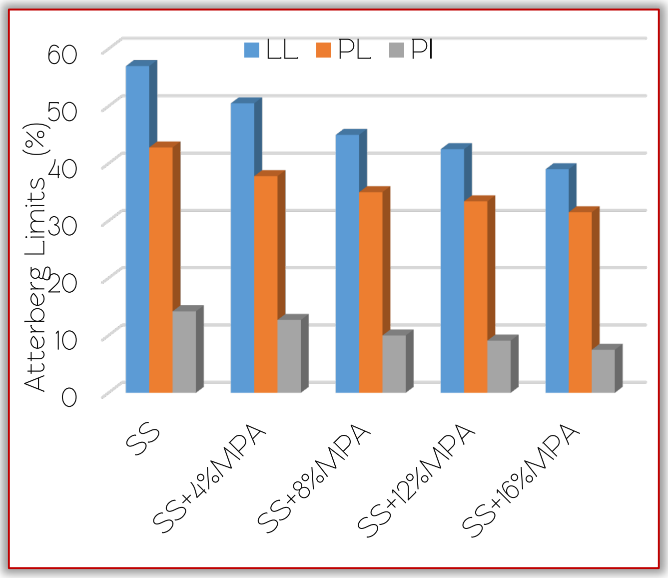

Figure 1: Atterberg Limits of Soil Sample Stabilised with MPA

It was observed that liquid limit and plasticity index of the soil decreases as the percentage of MPA increases adjudging that MPA is fit for improving soil with high liquid limit. The percentage reduction of the liquid limit and plasticity index are 32 % and 47 % respectively. This is due to the absorption of Ca^{2+} by some of the clay particles of the soil and the clay–size particles of the maize pod ash, thereby minimizing the interaction between the water and clay–size particles (Kampala and Horpibulusuk, 2013). This consequently reduced the moisture–holding capacity of the soil making the soil more workable as also noted by Akinwumi and Aidomojie, (2015).

Compaction Characteristics

The variation of Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of soil sample stabilised with maize pod ash is shown in Figure 2. The MDD of the soil decreases for 0% and 4% (22.2 kN/m³ and 21.6 kN/m³), 12% and 16% (22.8 kN/m³ and 20.5 kN/m³) MPA contents respectively while it increases for 8% MPA content (23.2 kN/m³). Also, the OMC increases as the amount of MPA in the mixture increases for 0% and 4% (12 % and 13 %), 12% and 16% (13.5 % and 15 %) before it decreases at 8% MPA content (11 %).

The increase in maximum dry density for 8% MPA content could be attributed to the specific gravity of maize pod ash used for stabilisation of the soil a trend noted by Oluremi et al., (2018) and improved binding capacity. Also, the decrease in optimum moisture content for 8% MPA could be attributed to the proper rearrangement of soil particles of modified mix which may be reducing the voids as noted by Thombre and Koranne, (2018) which shows that 8% MPA increases the compaction and strength of the soil while reducing the moisture content.

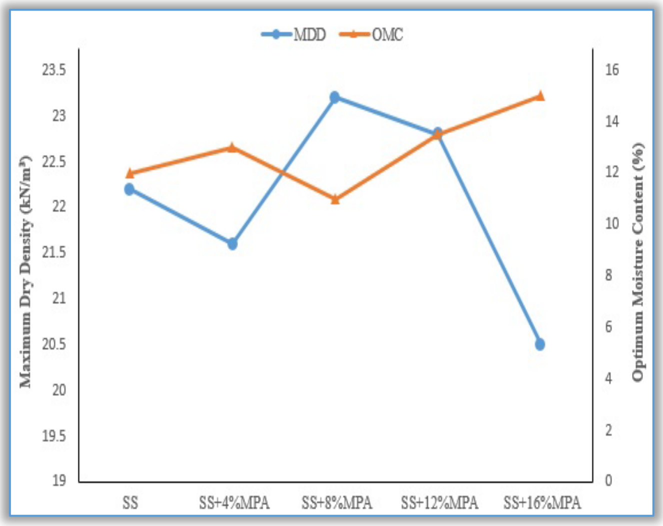

Figure 2: Compaction Characteristics of the Soil Stabilized with MPA

California Bearing Ratio Test

Figure 3 displayed the CBR of the subgrade soil stabilised with MPA. There was increase in the CBR values as the percentages of MPA increases up to 8% MPA exhibiting the highest CBR value of 12.94 % while it declined at 12% (9.60 %) and 16% (8.70 %) respectively. This is in tandem with the findings of Jimoh and Apampa, (2014). This upper limit of 12.94 % at 8% MPA is in consonance with the recommended standard of Asphalt Institute (2008) and the Federal Ministry of Works and Housing in Nigeria (Nigerian General Specification, 1997) with recommended CBR of ≥ 9 %, and ≥ 10 %, respectively, as usage for pavement subgrade.

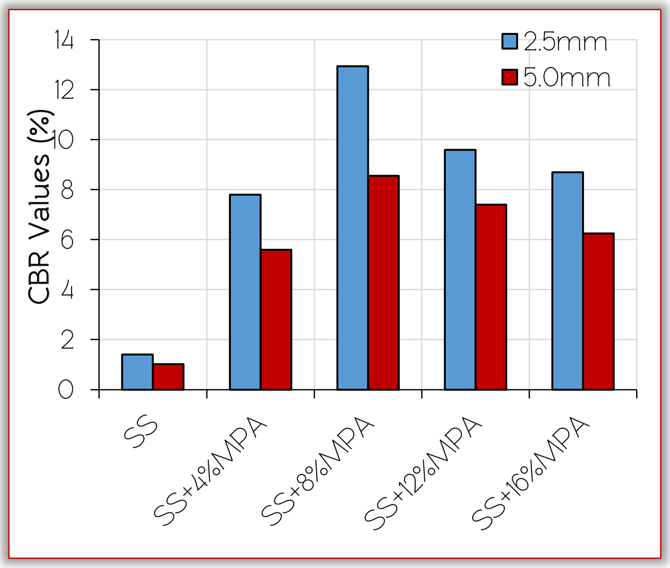

Figure 3: CBR values of the Soil Stabilised with MPA

CONCLUSIONS AND RECOMMENDATIONS

From the research work carried out, the following conclusions were drawn:

- The chemical components of MPA showed that the material is a good pozzolan as evidenced by the presence of SiO_2 (62.80%), Al_2O_3 (6.40%) and Fe_2O_3 (2.66%).
- The material, MPA improved the qualities of the soil sample thereby increased the liquid limit, plastic limit and decreased the plasticity index. These reductions in plasticity index from 14.2 % at 0% MPA to 7.5 % at 16% MPA are indicators of soil improvement.
- Addition of MPA enhanced the strength of the soil sample as the highest maximum dry density (23.2 kN/m³) and lowest optimum moisture content (11.0 %) occurred at 8% MPA.
- The MPA used as stabilising agent increased the CBR values of the soil sample from 1.40 % at 0% MPA to 12.94 % at 8% MPA signifying improved strength and stability of the soil sample.

The following were recommended;

- Soil stabilisation should be well promoted among the professionals in local road construction industry as a solution for the problem of soil without good quality.

— Maize pod ash can serves as alternative to modify and stabilise problematic soil such as lateritic soil and bring about improvement for geotechnical properties of the soil.

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