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Effect of Melon Husk and Cocoa Pod Ashes on Compaction and Strength Characteristics of Lateritic soil

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K E Y W O R D S

Melon husk ash (MHA)
Cocoa pod ash (CPA
California bearing ratio (CBR),
Optimum moisture content (OMC)
Maximum dry density (MDD)
Pozzolana

A B S T R A C T

Stabilization of weak lateritic soils using melon husk and cocoa pod ash (MHA and CPA) was studied and reported in this paper. The MHA was considered as a Class C group of the ASTM (American Society for Testing and Materials) pozzolan. The soils used in the study were obtained from depth of exhausted good quality materials of borrow pits at Auchi Polytechnic, Area II, Auchi South-south Nigeria. The materials were analyzed for main geotechnical index properties, compaction and strength (CBR) characteristics. The MHA and CPA pozzolan stabilizer was administered to the soil samples up to 12% and at a rate of 2%. The experimental results comparing the strength of the natural soil samples with the MHA-CPA-stabilized samples revealed that MHA-CPA increases the California Bearing Ratio (CBR). AASHTO (American Association of State Highway and Transportation Officials) classified A-5 and A-5 subgrade soils. An optimum stabilizer content of 8% was determined with about 50% advantages in the CBR (increase in CBR of stabilized soil / CBR of raw soil × 100) for unsoaked conditions. At the established optimum stabilizer content, the weak hitherto unsuitable soils have been improved to meet the requirements for Type 2 subbase road development soils.

1. INTRODUCTION

Soil has been used as a construction material for various types of roads with notable advantages in the tropics. These roads include paved and unpaved roads, even though, it is the most abundant construction material globally, its use has been limited due to its poor mechanical and durability properties when used as base materials in highway construction (Oluniyi *et al.*, 2019). These challenges associated with the use of soil as base materials in highway have over the years been minimized by stabilization. Soil Stabilization entails modifying any property of soil in order to improve its engineering performance. The art of stabilization is not new as Indians have stabilized earth from pre-historic times up to 600 BC although in recent times, the process has been conducted popularly with cement and lime (Kulkarmi, 1973).

Studies conducted on stabilized earth have shown remarkable improvement which includes increase in strength, water repellant and cohesion with reduced permeability, shrinkage and expansion (Oluniyi *et al.*, 2019). With the skyrocketing prices of these stabilizing agents, studies have been tilted to the area of using agricultural wastes and industrial byproducts which possess cementitious properties. Some of the notable byproducts with such properties include the ashes of rice husk, melon husk, groundnut, coconut shells, corn cob and husks, wheat husk among others (Yalley and Asiedu, 2013). Aside, the enormous benefits derived from these agricultural byproducts, the process of utilizing them as stabilizing agents also minimizes the negative effects on the environment due to improper disposal mechanisms. One abundant agricultural byproduct indiscriminately disposed on most Nigerian farms for decades are melon husks and cocoa pod husks.

In addition, the utilisation of stabilising agents in roadwork and in sub-grade with poor soil condition improves other qualities such as cohesion, thereby contributing to the strengthening of the structure or embankment. This can eventually lead to a remarkable reduction in road building costs. Different additives like cement, lime or other minerals such as fly ash have been used for this purpose. For any civil structures, the underneath sub-soils for the foundation are the most vital and should be strong to bear the weight of the entire design (Adetayo *et al*., 2022). They are extensively available across the warm sub-humid areas of the tropical world. Polson *et al*. (2017) indicated that they are shaped in hot, wet tropical areas with an annual precipitation between 750 mm to 3000 mm (as a rule in region with a huge dry season) on a wide range of types of rocks with high iron substance.

Stoops (2018) stated that the soil is discovered essentially, yet not solely, as a residual enduring item on mainly or fully disintegrated basalts and other fundamental to moderate molten rocks. Nigeria is among the nations favoured with tremendous deposits of laterite, which is residua in nature, and one of the least expensive material for civil construction (Adetayo *et al.,* 2019). In any respect, not all deposits of laterite are appropriate for use as subgrade, base and sub-base material in their common state. Some contains a critical extent of clay which may expand when moisture is present. Cracks may develop because of the shrinkage which may prompt a decrease of a portion of the mechanical properties of the laterite. Subsequently, there is a need to improve the geotechnical attributes of lateritic soil in Nigeria, particularly for its utilization as a base course material in civil structures (Adetoro and Dada, 2021).

Conventionally, lime, Portland cement and bitumen have been used to appropriately improve properties of most soils to make them meet requirement of construction work (Patrick, 2022). The need to improve the strength and durability of lateritic soil in recent times has become imperative; this has geared researchers toward using stabilizing materials that can be sourced locally at a very low cost (Adetoro and Dada 2021).

It is also well known that stabilising soil with local natural and industrial resources have a significant effect on the improvement of soil properties. Lime and fly ash in particular have been used as an appropriate additive in soil stabilisation in a variety of geotechnical constructions such as highways, foundation bases and embankments. The importance of utilisation of lime and fly ash in soil treatment has been recognized (Patrick, 2022). Therefore, this study wants to focus on Melon Husk and Cocoa Pod Ash in stabilizing soil. This method will be applied in the wide range of civil engineering projects including road works specifically. In understanding the triggering mechanisms of landslides, the examination of the geotechnical behaviour of soil is essential. Compaction properties, soil's permeability, consolidation and strength characteristics of soil as some of main geotechnical properties will be considered in this study (Patrick, 2022).

In a country like Nigeria where there has been a recent tendency of civil structure collapses, and an increasing issue in the development and maintenance of good-condition pavements, the relevance of subsoil investigations has become highly crucial. However, the rising cost of traditional stabilizing agents, as well as the demand for cost-effective use of industrial and agricultural waste for engineering applications, has driven substantial global study into waste utilization for engineering purposes. The safe disposal of industrial and agricultural waste products necessitates immediate and cost-effective solutions because of the detrimental effect of these materials on the environment and to the health hazards that these wastes comprise (Dauda, 2022). Additionally, the over-dependence on industrially manufactured soil-improving additives (cement, lime, etc.) has rendered the cost of building of stabilized roads financially high (Mandeep and Jaspal, 2018).

Citrullus vulgaris (Melon) husks (MH) are shells that are discarded after milling of melon. Melon is a cucurbit crop belonging to the family *cucurbitaceae*. Melon crops are grown, harvested and processed in large tonnage in Nassarawa, Kogi and Edo states, Nigeria. The seeds are removed from the fruit, washed, sun-dried and sold in large quantities (tonnage) annually for commercial purpose (as a special soup condiment). Large quantities of the MH are discarded and burnt, which causes pollution of the environment (Fagbohun *et al.*,2011*)*. The advantages of Melon Husk Ash Concrete could probably consume less quantity of cement with environmental benefits and lower emission of CO_2 (Ekundayo and Idzi, 2005).

Melon husk when milled and burnt under a controlled temperature of 600°C to produce ash and used to replace cement at different percentage levels (5%, 10%, 15%, 20%) increases the strength of soil (Uneke and Akpan, 2013). It was also reported by John and Banje, (2022) that melon husk ash relative to cement as a partial replacement at 5% and 10% can be adopted since its compressive strength when compared to the controlled results at 0% replacement showed a tremendous increase. Muhammed *et al.,* (2015) reported that the total percentage composition of aluminum oxide (Al2O3 = 18.5 %), Iron oxide (Fe_2O_3 = 2.82 %) and silicon dioxide (SiO_2 = 51.24 %) was found to be 72.56 %. This is more than the minimum requirement for pozzolana (ASTM C 618-94, 1994). The loss on ignition obtained was 5.67 % which is less than the 10.0 % maximum as required for pozzolana (ASTM C 618-94, 1994). This means that it does not contained un-burnt carbon which can reduce its pozzolana activity.

The first phase of the chemical reaction involves immediate changes in soil texture and soil properties caused by cation exchange. The free alumina of the MHA exchanges with the adsorbed cations of the clay mineral, resulting in a reduction in the size of the diffused water layer surrounding the clay particles. This reduction in the diffused water layer allows the clay particles to come into closer contact with one another, causing flocculation/agglomeration of the clay particles, which transforms the clay into a more silt-like or sand-like material. Overall, the flocculation and agglomeration phase of MHA stabilization results in a soil that is more readily mixable, workable, and, ultimately, compactable. The second phase of the chemical reaction involves pozzolanic reactions within the lime soil mixture, resulting in strength gain over time. When MHA is combined with clay soil, the pH of the pore water increases. When the pH reaches 12.5, the silica and alumina from the clay become soluble and are released from the clay mineral (Muhammed *et al.*, 2015). In Nigeria there are many states where cocoa is grown. Cocoa is a seasonal crop, which constitutes the main and only stream of income for most farmers in western Nigeria.

Regarded as the Food of the Gods or *Theobroma cacao*, cocoa has been an indispensable part of our lives through its use for a wide variety of edible products. The fat from cocoa (cocoa butter) is used in the cosmetics and pharmaceutical industries (Fapohunda and Afolayan, 2012).

When cocoa is harvested, the pod husk is thrown away as a waste because many people do not know its economic benefit. Heaps of cocoa pod husk wastes are usually seen in most cocoa-growing communities and the management of this waste is a challenge for many rural communities, as the waste is mostly burnt and the resulting ash blown away by the wind. Notwithstanding this, Onyelowe (2016) indicates that CPHA can be used as a stabilizer for weak lateritic soils in road construction and as such, should be seen as a resource and not waste which will increase Ghana’s environmental burdens.

Aside these benefits, local indigenes have substantial benefits such as the use of the cocoa pod husk in the production of soaps, fertilizer and as poultry feed whiles the juice is used for vinegar and another alcoholic beverage production (Nfor *et al.,* 2012). Others benefits attached to cocoa include the use of the shells of the Cocoa beans, a by-product of chocolate production are commonly sold as mulch for landscaping (Hansen *et al.*, 2003) whiles cocoa pulp can also be used in soft drink, alcohol and pectin (for jelly, marmalade and jam) production. It is stunning to know that the numerous benefits associated with cocoa plant could be attributed to the cocoa beans which constitute only 10% by weight of the cocoa fruit (ADM cocoa, 2009) whiles the remaining 90% predominately the cocoa pulp and cocoa pod husk are regarded as wastes with minimal commercial values in Ghana. Manu *et al.*, (2015) opined that data showed a gradual increase in in the engineering properties of the stabilized earth bricks as the CPHA content increased from 0% to 10% before declining slightly after subsequent additions. Data showed that the optimum amount of ash required for stabilizing the earth is 10% by weight.

Studies on the chemical composition of the Cocoa Pod Husk Ash (CPHA) were conducted using the X-ray Fluorescence technique with focus on its Pozzolanic properties has been presented in Table 2 below. According to ASTM C 618-78 (2012), materials regarded as Pozzolanic in nature should have compounds such silica (SiO_2), Alumina (Al_2O_3) and Iron Oxide (Fe_2O_3) exceeding 50% by composition. Data results showed a combined sum of 13.618% for the SiO_2, Al_2O_3 and Fe_2O_3 which were far below the minimum quantum of 50% indicating the CPHA does not have adequate amount of siliceous or aluminous compounds to exhibit Pozzolanic characteristics. It is also evident that the quantum of K_2O was relatively high which is likely to result in a weaken bonds between the particles in the soil matrix due to alkali reaction in higher variations. This undesirable amount of K_2O present in the CPHA makes it an ideal natural source of alkaline for soap production as seen in most rural communities in Ghana (Manu *et al* 2015).

2. MATERIALS AND METHODS

2.1 Materials

The melon husk ash (MHA), cocoa pod ash (CPA), soil specimen and water were the materials utilized in the research; some of these materials are displayed in Figure 1. Figure 1a and 1b shows both the fresh melon husk (MH) and the cocoa pod (CP); Figure 1c shows the melon husk ash and cocoa pod ash; while Figure 2 represents the soil sample. The MHA AND CPA were obtained in various farms around Auchi and dried in the sun. The dried melon husks were burnt in open furnace at temperature of 630^0C. The cocoa pods were scorched outside and were pulverized before being burnt in a muffle furnace at over 800°C for two hours. Prior to use, the recovered MHA and CPA was sieved through a BS sieve No. 200 (75µm or 0.075 mm). Its properties met the needed prerequisites for cement in BS 12 (Jafer *et al.*, 2018).

Figure 1a: Melon Husk

Figure 1b: Pulverized Cocoa Pod

Figure 1c: Melon Husk Ash and Cocoa Pod Ash

Figure 2: Laterite Soil

2.3 Experimental Procedure

The elemental oxides of the soil sample, melon husk ash and cocoa pod ash were all identified using the gravimetric method. Preliminary studies of the soil sample were performed using the Atterberg limits, specific gravity, and particle size distribution (dry sieving). Also performed on the natural soil sample, were compaction and the California bearing ratio tests. The soil example was then exclusively treated with MHA and CPA at different ratio of 2%, 4%, 6%, 8%, 10%, and 12%. At each stage of the mixes, Atterberg limit, compaction and California bearing ratio were performed on each of these samples. The entire set of tests was completed in accordance with British Standard 1924 for stabilized samples and BS 1377 for natural soil samples. The process flow chart of the testing and analysis are presented in Figure 2.

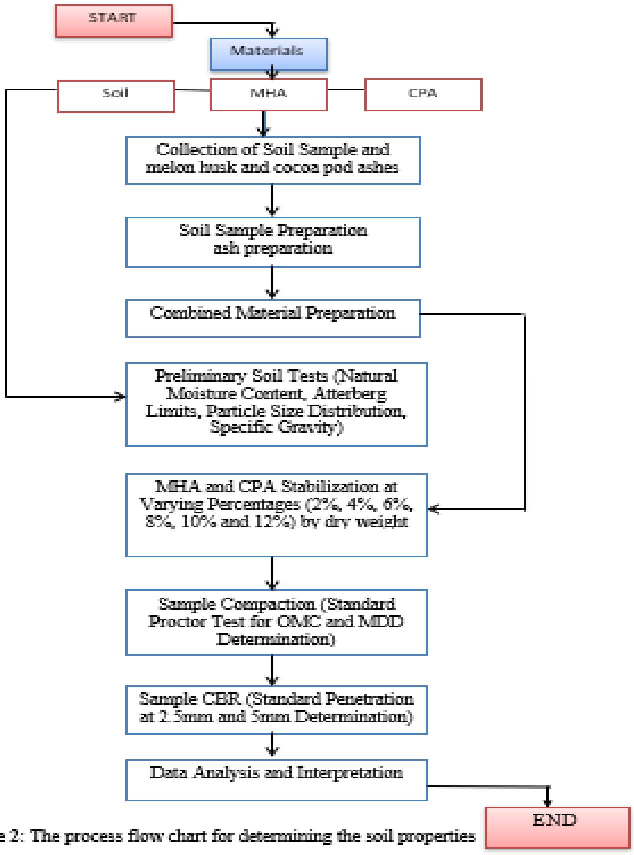

Figure 2: The process flow chart for determining the soil properties

3. RESULTS AND DISCUSSION

The analysis of the chemical characteristics of the lateritic soil, MHA and CPA is displayed in Table 1 as a percentage of weight composition. According to Kaze *et al.*, 2022. lateritic soil has a silica (SiO2) to sesquioxide (Fe2O3 and Al2O3) ratio of 1.33 to 2.0 in a specific soil sample.

Additionally, pozzolanic compounds pass for only MHA and not CPA. MHA is effective pozzolan, according to ASTM C618. A natural soil sample's attributes are shown in Table 2. According to AASHTO characterization, the soil specimen is named for having a place in the A-5 subgroup. Yet, as per the framework for soil characterization, the A-5 soil test is classified as having low clay content, since low clay content soils have liquid limit values of less than 50% (Moreno-Maroto *et al.*, 2021).

Table 1. Chemical Properties of the Samples of Lateritic Soil, MHA and CPA

Elemental Oxide	Soil Sample (%)	MHA (%)	CPA (%)
SiO_2	56.50	51.24	9.727
Fe_2O_3	0.83	2.82	0.447
Al_2O_3	41.00	18.5	3.444
CaO	0.44	15.3	0.000
MgO	0.31	6.8	4.299
SO_3	-	11.43	2.171
P_2O_5	-	-	0.276
Cl	-	-	0.155
K_2O	0.49	11.43	25.61
MnO	0.43	-	0.09
NaO	-	3.4	-
L.O.I	-	5.67	-

Table 2: Result Summary for Untreated Lateritic Soil Material

Soil Properties	Experimental Value
Natural Moisture Content	8.24%
Specific Gravity	2.04
Liquid Limits	29.78%
Plastic Limits	19.50%
Plasticity Index	10.28%
Percentage Passing 200 Micron Sieve	37%
AASHTO Classification	A-5
Maximum Dry Density	1.43g/cm^3
Optimum Moisture Content	9.40%
California Bearing Ratio	28.37%
Colour	Reddish brown

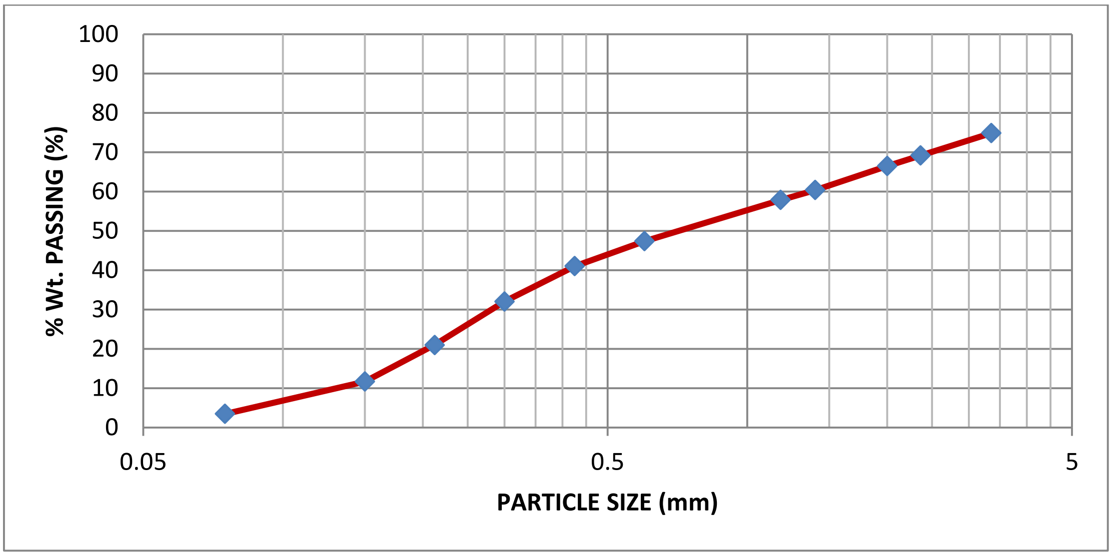

Figure 3: Particle Size Distribution for Untreated Soil Sample

Figure 3 shows the soil particle distribution analysis. As indicated by Table 2, 37% of the soil samples go through BS Seive No. 200. The effects of MHA and CPA on the California bearing ratio of the properties of the A-5 soil test are portrayed in Figures 5. The Atterberg limit tests were recorded in line with work of Arinze and Ibe (2015). The Untreated laterite has LL, PL and PI of 29.78%, 19.50% and 10.28% respectively. This was recorded in line with the work of Arinze and Ibe (2015). Onyeka and Osegbowa (2020) recorded similar atterberg limit value for lateritic soil around Abuja area. the authors recommend that since the implementation of MHA increases the compressive strength, its combination with lateritic soil is highly recommended with the optimal parameters.

3.2 Compaction Tests Results

The compaction tests were conducted over a broad range of moisture contents. From the standard proctor compaction test, the dry density fluctuates between 1.43g/cm^3 to 2.10g/cm^{3}with water content variations from 5.0%to 9.6%. It can be seen from table 3 and figure4 that the dry density increases as the water content decreases until it attains a maximum value of 1.43, 1.54, 1.85, 2.10, 2.06,1.73 and 1.90 g/cm^3, at an optimal water content of 9.40, 7.70, 7.90, 5.00, 4.70, 9.60 and 7.00% for 0%, 2%, 4%, 6%, 8%, 10% and 12% respectively.

Table 3: MDD and OMC for Treated and Untreated Samples

Soil sample with percentages of MH and CP ash (%)	Optimum Moisture Content (%)	Maximum Dry Density (g/cm3)
0	9.40	1.43
2	7.70	1.54
4	7.90	1.85
6	5.00	2.10
8	4.70	2.06
10	9.60	1.73
12	7.00	1.90

The Optimum Moisture Content table 4.7 and figure 4.7 decreases from 7.70% at 2% treatment to 4.70% at 8.0% treatment and then slightly increases to 9.60% at 8% treatment. The initial reduction in Optimum Moisture Content (OMC) indicates that the melon husk and cocoa pod ash improve the soil's ability to achieve maximum compaction with less water.

The maximum dry density increases as the percentage of melon husk and cocoa pod ash was increases, the maximum dry density peaked at 6% and 8% ashes blending. Further incremental the addition of ash results in the reduction of the dry densities. The increase and decrease in maximum dry density might be as a result of binding action and complete reaction of calcium silicates on MH and CP ash respectively. This reveals that the optimum value of the MH and CP ash on lateritic soil at 6-8%.

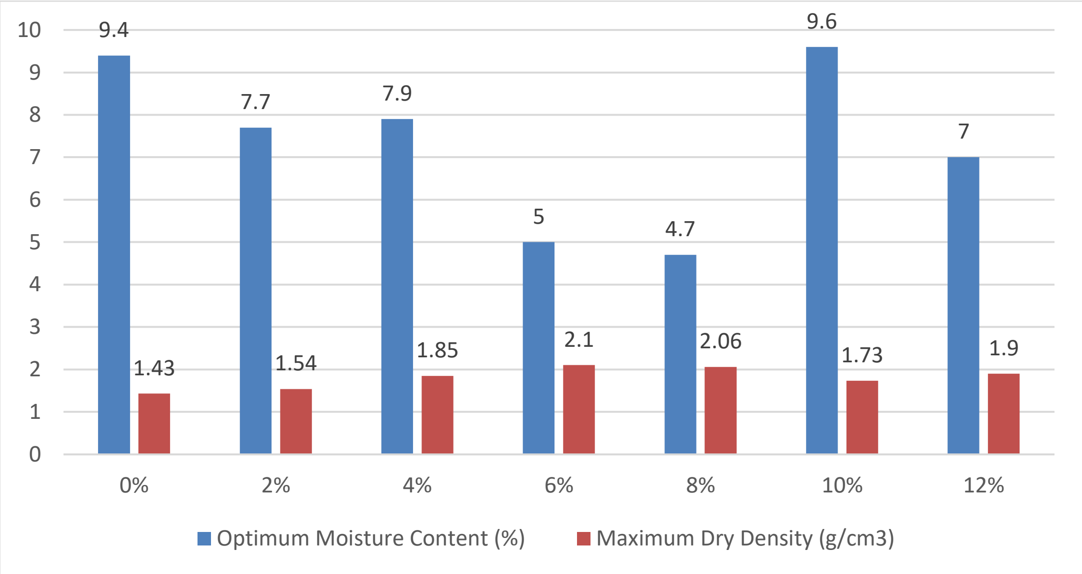

Figure 4: MDD and OMC of MHA and CPA on Lateritic Soil

The Maximum Dry Density (MDD) increases from 1.54 g/cm³ at 2% treatment to 2.10 g/cm³ at 6% treatment, and then slightly drops to 1.90 g/cm³ at 12% treatment. The increase in MDD up to 6% indicates improved particle packing and soil stabilization due to the binding effect of melon husk and cocoa pod ash. The slight reduction at 12% may be attributed to the formation of flocculated particles, leading to a less dense structure or inefficient compaction. The results of the Standard Proctor Compaction Test show that the untreated soil reached a maximum dry density (MDD) of 1.43 g/cm³ at optimum moisture content (OMC) of 9.4%, with dry density decreasing at higher moisture levels, which reflects typical compaction behavior. Overall, the treatment improved the soil's compaction behavior, making it more suitable for engineering applications such as subgrade stabilization.

The values fall within the minimum required MDD (1.48-2.60g/cm^3) and OMC (6.60-16.40%) for subbase materials as per the Federal Ministry of Works and Housing (FMWH, Nigeria) and AASHTO standards.

3.2 California Bearing Ratio

The study investigates the effect of stabilizing lateritic soil with melon and cocoa pod husks ash by evaluating California Bearing Ratio (CBR) values at different depths (top and bottom) and penetration levels (2.5mm and 5mm). The CBR is a critical parameter used to assess the strength and load-bearing capacity of subgrade soil materials for pavement and road construction. For the untreated soil (Figure 4.8), the CBR at 2.5mm penetration was 12.34% (top) and 25.48% (bottom), while at 5mm penetration it was 15.95% (top) and 28.3% (bottom).

Table 4: CBR Values for Treated and Untreated Samples

% MHA and CPA	2.5mm Penetration		5.0mm Penetration	
	Top(%)	Bottom(%)	Top(%)	Bottom(%)
0	12.34	25.48	15.09	28.37
2	13.72	30.30	18.54	30.35
4	20.07	43.65	26.42	41.61
6	26.50	45.26	27.69	44.87
8	28.61	48.83	29.78	46.42
10	19.78	33.50	26.72	42.23
12	17.45	29.69	30.66	33.14

These results reflect relatively low bearing capacity, which is typical of natural lateritic soil without stabilization. The values fall below the minimum required CBR of 30% for subbase materials as per the Federal Ministry of Works and Housing (FMWH, Nigeria) and AASHTO standards, which often recommend a minimum of 30–80% depending on the pavement layer function (subgrade, subbase, base). At 2% MHA and CPA added, a noticeable improvement in CBR values was observed. At 2.5 mm penetration, values increased to 13.72% (top) and 30.30% (bottom), and at 5 mm, to 18.54% (top) and 30.35% (bottom). This increase in strength can be attributed to pozzolanic reactions between the silica in MHA, leading to the formation of additional calcium silicate hydrate (C-S-H) gel, which enhances the soil matrix. The bottom CBR value at 5 mm penetration (30.35%) now meets the minimum requirement for subbase applications.

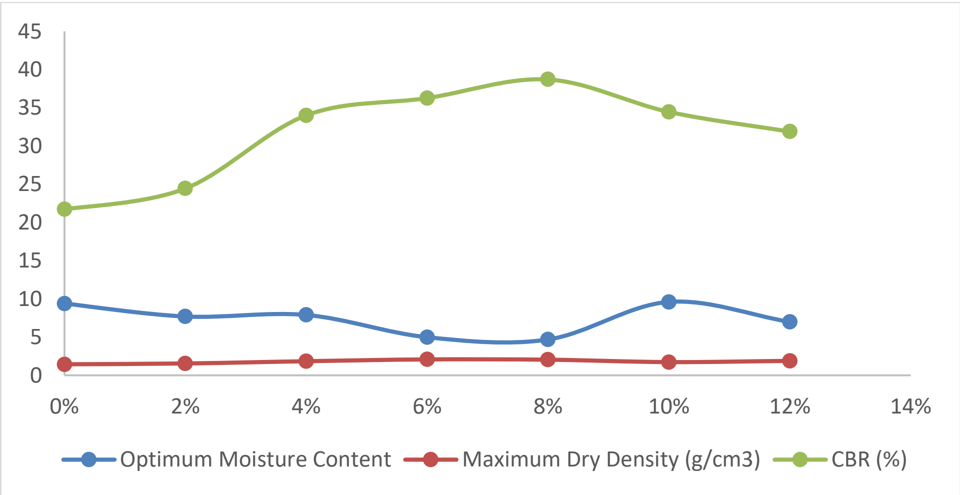

Figure 5: Graph of OMC, CBR, and MDD for Treated and Untreated Soil Samples

This result is consistent with findings by Muhammed *et al* (2014) who reported that partial replacement of cement with melon husk ash and lime in clay soil improved strength characteristics due to the pozzolanic reactivity of the ash. The sample with 4% MHA and CPA, CBR values at 2.5mm penetration increased to 20.07% (top) and 43.65% (bottom), while at 5mm penetration, the values were 29.78% (top) and 46.42% (bottom). With 6% MHA and CPA, CBR values at 2.5mm penetration increased to 26.50% (top) and 45.26% (bottom), while at 5mm penetration, the values were 27.69% (top) and 44.87% (bottom). 8% MHA and CPA, CBR values at 2.5mm penetration rose to 28.61% (top) and 48.83% (bottom), while at 5mm penetration, the values were 29.78% (top) and 46.42% (bottom). The sample with 8% MHA and CPA showed the highest improvement. 10%

Ash mix, CBR values at 2.5mm penetration were 19.78% (top) and 33.50% (bottom) while at 5mm penetration, the CBR values were 26.72% (top) and 34.48% (bottom). At 12% MHA and CPA blending with laterite CBR values at 2.5mm penetration decreased to 17.45% (top) and 29.93% (bottom), while at 5mm penetration, the values were 30.66% (top) and 33.14% (bottom). This enhancement suggests that the optimal percentage of MHA and CPA may lie between 6–8%, beyond which additional MHA and CPA may not necessarily lead to further significant improvements due to potential dilution of cementing content or unreacted ash.

Compared to standards, the bottom 2.5mm penetration CBR value of 48.83% at 8% MHA and CPA is very promising and exceeds the minimum thresholds for both subgrade and subbase material specifications. These findings align with research conducted by Ettu *et al.* (2013), who concluded that agricultural ashes can enhance the mechanical properties of weak soils when added within optimal limits. Moreover, Woode *et al.* (2014) also observed that cocoa pod ash addition in stabilized lateritic soil improved CBR values significantly up to 2–4% replacement levels.

4. CONCLUSION

The study confirms the blending melon and cocoa pod husks ashes with lateritic soil enhance the geotechnical properties of the soil. The stabilization process leads to enhancement in strength, reduced plasticity, and better consolidation characteristics, making the soil more suitable for construction and engineering applications. The results of this study demonstrate that the blending of melon and cocoa pod husks ashes significantly improves the geotechnical properties of the treated soil. The Following conclusion were made;

i. The result of PSD in Figure 4.1 revealed that the Cu of the untreated Laterite was 4 and Cc = 0.6. This showed that the above results partly satisfied ASHTO classification for fine aggregates i.e. Cu>4, and 1>Cc<3forlaterites. Based on the sieve analysis results, the sand sample can be classified as medium-coarse sand, with a medium-coarse sand fraction of 47.38% and a fines content of 3.45%.

ii. From the Standard Proctor Compaction tests, the untreated soil exhibited an Optimum Moisture Content (OMC) of 9.60% and a Maximum Dry Density (MDD) of 1.43g/cm³. After blending, the OMC decreased, reaching 4.70% at 8% additive, while the MDD increased, peaking at 2.10g/cm³ at 6% additive content. This indicates improved densification due to the combined action of melon and cocoa pod husks ash, enhancing particle rearrangement and bond formation within the soil matrix.

iii. The California Bearing Ratio (CBR) results showed that the untreated had CBR 0f 21.73%. The CBR values increased from 21.73% to 38.72% with higher percentages of melon and cocoa pod husks ash at 8% addition, confirming that such treatment enhances soil bearing. This reflects the formation of cementitious bonds due to ash and the soil interaction, contributing to improved load-bearing capacity over time.

iv. The oxide composition of stabilizing agents confirms that MHA meets the ASTM C 618 requirements for pozzolana, as the sum of SiO_2, Al_2O_3, and Fe_2O_3 is72.56% whereas CPA is not pozzolanic (only 13.618% total oxides). High pozzolanic properties of MHA suggest a more prominent contribution from the melon husk ash additive in the cementation and densification of the stabilized soil mass which in turn enhance the structural strength of the stabilized soil. The CPA on the hand exhibits a very high potassium oxide K_2O) content of 25.61%, indicating its primary role is filling of air voids in the soil mass and likely alkaline activation rather than cementitious contribution. Further studies on the microstructural properties of soil stabilized with MHA and CPA will provides further information the individual contribution of MHA and CPA.

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