Stabilization of Lateritic Soil for Road Application Using Cement and Cow Dung Ash

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Abstract: The investigation of the strength and durability of earth soil stabilized by cow dung is covered in this study. The main goal of this research was to develop a cost-effective yet effective strategy to enhance soil characteristics, or, to put it another way, to get stabilized soil that was more effective and cost-effective than other techniques already available on the market. An ordinary earth soil was taken, and varied amounts of crushed dry cow dung and dry grass were mixed along with it. Thus, many tests were carried out on various samples, including the Procter test, the unconfined compression test, the CBR test, etc. The maximal strength or abrasion resistance of the soil with an increase in the cow dung content at different percentages was determined after the compilation of tests or on the basis of test results. Even though it was assumed that these materials did not have the potential to be an effective soil stabilizer in field applications, the strength of soft soil or sandy soil was significantly/almost the same when these materials were used. However, if the research is carried out, the beneficial reuse of wet cow dung in soil stabilization can be proven as a step towards a green economy in the future.

Keywords: *Cow Dung; Soil Stabilization; Bearing Capacity; Compaction Test; California Bearing Ratio (CBR), Unconfined compressive strength.*

I. INTRODUCTION

The alteration of soils to improve their physical characteristics is known as soil stabilization (Bergado et al., 1996, Bell 1994). Stabilization can boost a soil's shear strength and/or manage its shrink-swell characteristics, which increases a subgrade's ability to support foundations and pavements by increasing the subgrade's load bearing capacity (Bell, 1996, Chen & Lin 2009).

Soil stabilization are reported by (Boschuk 1991, Cristelo et al., 2012 and Hortz& Kovacs 1981) it can be utilized on roadways, parking areas, site development projects, airports and many other situations where sub- soils are not suitable for construction. Stabilization can be used to treat a wide range of sub-grade materials, varying from expansive clays to granular materials. This process is accomplished using a wide variety of additives; include lime, fly ash and Portland cement. Other materials/by-products used in stabilization include lime-kiln dust (LKD) and cement-kiln dust (CKD) (Elias 2015).

However, in contrast to other additions, we aimed to stabilize the soil more affordably in this research. This strategy of including cow dung was adopted from earlier historical periods when construction was completed using a mixture of cow dung (as a binder), mud or dirt, and dry grass(Ganal and Singh, 1988). For instance, many buildings in rural communities are still built with combinations of cow dung and cement. And even after so many centuries, the world's history has recorded these buildings that are still standing today despite having seen several natural disasters and their effects over time (Zaliha et al, 2013). So, to achieve this goal, the normal soil and the cow dung mixed soil of varied compositions were compared with proportion or content of cow dung ash (Yalley et al. 2013). For this, various soil samples were prepared, and tests were run on them.

II. MATERIALS AND METHOD

Materials used for the research workwere lateritic soil, cow dung ash and cement. Lateritic soil sample used were collected in disturbed state from pit located along New Ado Iyin, Nigeria. The soil sample collected from these pit which are located along Ado Ikare road. Cow dung ash was obtained from an animal farm located within the Federal polytechnic, Ado-Ekiti. The study area has a coordinate 703624.0006N and 502002.598E of Ekiti state with Coordinates $7^0$3624.0006N and $5^0$2002.598E

Cow dung ash obtained was sun dried, broken down and the ash was obtained through closed incineration at the temperature of 750^0c and sieved with mesh of 150μm aperture size before used.

A. *Lab study of lateritic soil sample*

To obtain the characteristic properties of lateritic soil sample used which was collectedalong Ado-Ikare road. The characteristic properties of the soil used were obtained through laboratory tests and investigations in accordance with BS 1377: part 1 - 8; (1990), cow dung used was from the nearby animal farm in Ado Ekiti, cement was bought from an open store in Ado Ekiti, Tap water was used for all mixes.

B. *Test Methods*

A lateritic soil sample was initially collected to determine the fundamental characteristics of the soil, including the natural moisture content of the soil sample in its natural state (air dried), dry density, OMC (optimum moisture content), and other preliminary tests with 0, 2, 4, 6, 8, and 10% cement by weight of the dry soil and subjected to grain size analysis and Atterberg limits test in other to obtain the cement content in percentage that will give the lest plasticity index (optimum cement content). Cement and cow dung ash were examined with 6% optimum cement concentration and additions of 0, 2, 4, 6, 8 and 10% cow dung ash. The blended additives were used to stabilize the soil sample and were subjected to laboratory tests such as Atterberg limits, Compaction, California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS).

The study was conducted using lateritic soil samples, cement, cow dung ash and water. Lateritic soil sample was collected from test pit materials along Ado-Ikare road in Ekiti State Nigeria. The soil sample was collected in large bags and some was also sealed airtight in polythene bags for moisture content determination. To prepare the soil sample for testing, the sample was first air-dried and then pulverized. The pulverized soil was then sieved through several standard sieves for different types of classification tests, such as specific gravity and consistency limits.Cement was added to the soil sample at percentages of 2, 4, 6, 8, and 10%, and the resulting mixture was tested to obtain the compaction characteristics, such as maximum dry density (MDD) and optimum moisture content (OMC), California bearing ratio and unconfined compressive strength test of the soil sample.

The procedures for conducting these various tests were carried out in accordance with the specifications outlined in the BS1377-1990:1-8. Overall, this study aimed to investigate the potential for stabilizing lateritic soils with cement and cow dung ash to improve their geotechnical properties and ultimately contribute to the development of better road infrastructure.

III. RESULTS AND DISCUSSION

A. Results of preliminary tests

Results of natural moisture content shows that the value is in agreement with the recommended range of 5 - 15% (FMWH, 1997). The density of soil sample at natural state are 2.36. The value is lesser than 2.60 shows an indication of organic materials in the soil (Wright, 1986). Density of the soil particle increased appreciably when cement and Cow dung ash was added to the sample.

Particle distribution in percentage weight of soil sample is as shown in Fig. 1. The percentage of soil (65.43%) passing 0.075µm sieve shows that the sample is silt-clay materials (AASTHO, 1986). Given that they contain a very high proportion of fines passing 0.075 mm, or more than 35%, in accordance with AASHTO, this demonstrates the existence of large percentages of clay and silt components. The engineering implication of this is that, they are poor for construction purposes and may require stabilization.

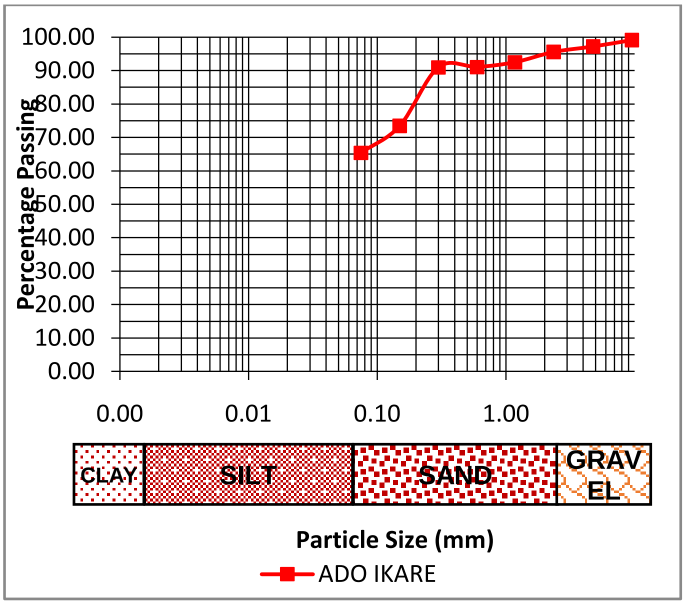

Fig. 1: Particle Size Distribution Curve

B. Results of Chemical Composition of Soil and Cow Dung ash

Table 1, presents the results of chemical composition of Soil and Cow Dung ash. The results shows that the main constituents of the soil and cow dungash are Silicon Oxide (SiO_2) 56.90% and 65.80%, Aluminium Oxide (Al_2O_3) 26.10% and 3.92%, Iron Oxide (Fe_2O_3) 15.20% and 3.81%, Calcium Oxide (CaO) 0.26% and 14.00%. The sum of Silica, Alumina and Ferric oxides (SiO_2+Al_2O_3+ Fe_2O_3) were 98.20% and 73.53% which is greater than the maximum of 70% as stipulated by ASTM C618-12 (1994) as pozzolanic material for soil sample and the ratio silica to sesquioxides shows that the soil is lateritic soil. Value of loss on ignition (LOI) is 2.98% and 10.62% respectively which are amount of unburnt carbon is less than maximum of 10% as stipulated by ASTM C618 - 12(1994).

Table 1: Results of Chemical Composition of Soil and Cow dung ash.

Oxides	SiO_2	Al_2O_3	Fe_2O_3	CaO	P_2O_5	K_2O	TiO_2	CuO	MgO	LOI
Soil	56.90	26.10	15.20	0.26	0.12	1.40	1.50	0.14	0.42	2.98
CDA	65.80	3.92	3.81	14.00	1.50	3.10	0.37	0.02	0.60	10.62

Atterberg Limits

The effect of cement on the Atterberg limits behavior of soil sample is presented in Fig. 2. The liquid and plastic limits of soil sample increase with increase in cement to 2% and reduced was recorded up to 10% cement content. The plasticity index of the sample reduced as the cement contents increases until it reaches 10%.

The natural soil sample having plasticity index value greater than 11% show the sample as clayey materials. Soil samplewas further classified according to AASHTO (1986) as A-6.

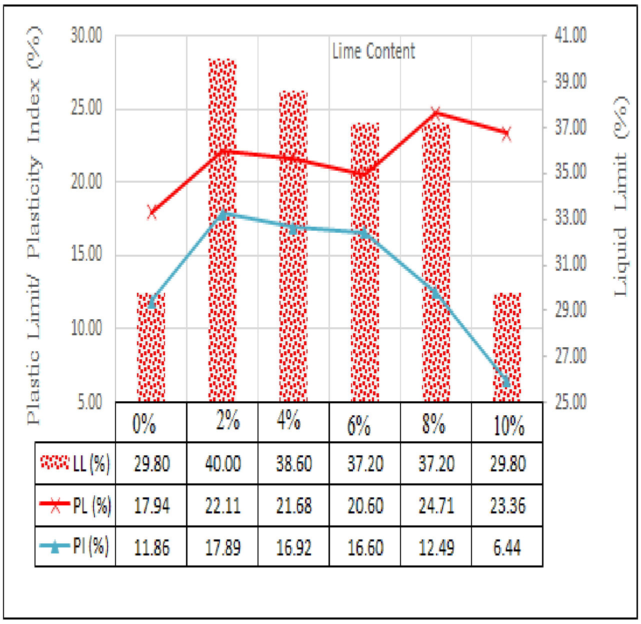

Fig. 2: Atterberg limits behavior of soil sample stabilized with cement and cow dung ash.

Compaction

Compaction characteristics of soil sample compacted with the energy of standard Proctor are presented with Fig. 3. Maximum Dry Densities (MDD) of soil sampleat natural state was observed to be 1612Kg/m^{3}and Optimum Moisture Contents (OMC) of 14.80%. Values of MDDs of soil sample greater than 1760Kg/m^3 make the soil sample suitable for use as subgrade or fill materials (FMWH, 1997).

As shown in Fig. 3, MDDs and OMCs of soil sample increases beyond the natural statewith the addition of cement-cow dung ash irrespective of the additives proportions. Optimumaddition was achieved at 4% (1819Kg/m^3). The increase in OMC of the soil sample could be as a result of the affinity of the mixture (Soil, cement and Cow dung ash) to water.

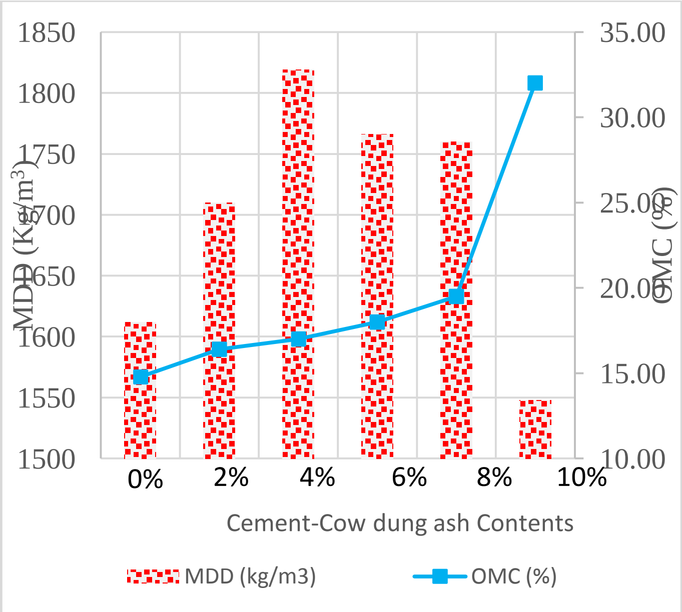

Fig. 3: Compaction Characteristics against Cement - Cow dung ash.

California Bearing Ratio

Figure 4 shown the results of soaked California Bearing Ratio (CBR) of soil sample at natural and stabilized states. CBR values of soil sample at natural state was 12.45%. Addition of cement-cow dung ash at varying percentages increases the CBR values of soil sample (though less than 30% recommended) with the optimum valueachieved at 6% (28.06%) addition of cement-cow dung ash (FMWH, 1997).

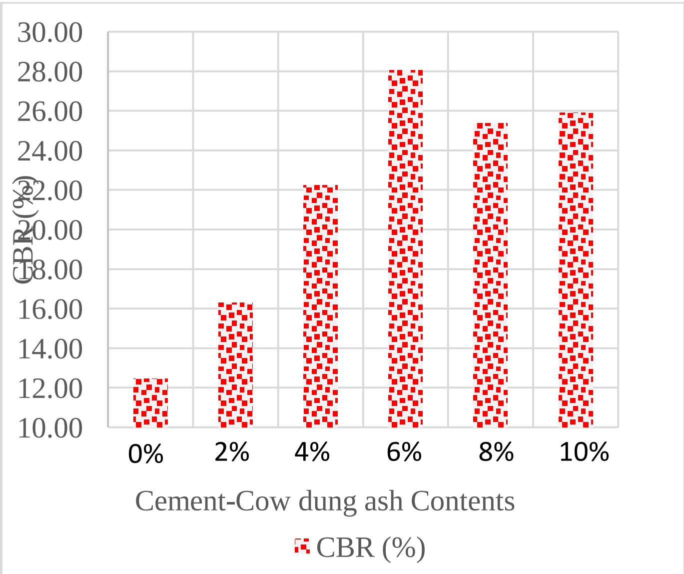

Fig. 4: California Bearing Ratio against Lime- Cow dung powder

Unconfined Compressive Strength

Unconfined Compressive Strength (UCS) of soil sample stabilized with cement-cow dung ash was examined at 7, 14 and 28 days curing. The UCS values as shown in Fig. 5 improved with the addition of cement-cow dung ash and curing age. Cohesion of the soil sample increases with the addition of cement-cow dung ash as its clay consistency which were initially moderately stiff improved to very stiff consistency (engineeringcivil.com, 2020).

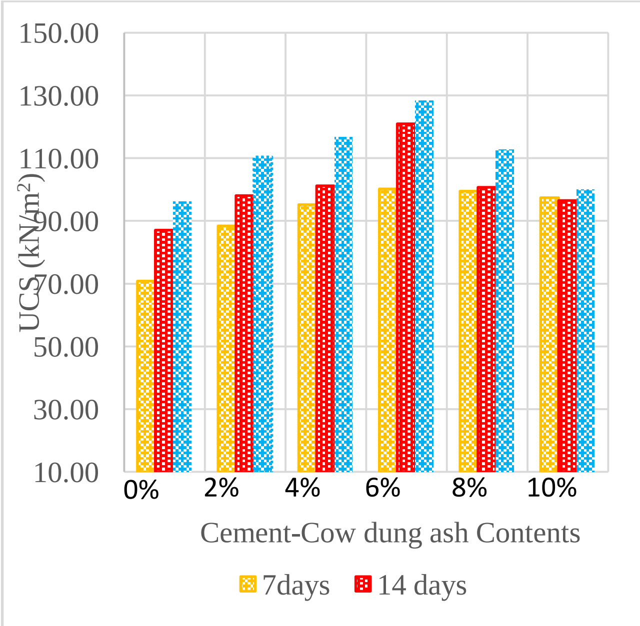

Fig. 5: Unconfined Compressive Strength values against Cement - Cow dung ash

CONCLUSION

Based on the above test reports/results and analysis performed in the laboratory, the soil sample was tested in natural and stabilized states in accordance with British standards BS 1377 and BS 1924 (1990) respectively. Results obtained revealed the effectiveness of the combination of cement and Cow dung ash on some geotechnical properties of A-6 soil. The soil was stabilized with cement and Cow dung ash at different mix proportions, sum of which is equivalent to the optimum cement contents that gave the lowest plasticity index for the soil samples.The optimum cement contents by weight of soil, for soil sample in terms of plasticity were observed tobe 6%. Combination of cement and Cow dung ash improves the examined geotechnical properties of soil considered. The additives mixed in proportions (cement: cow dung ash) was found to be at their optimum when mixed in percentages of 6% for soil sample.

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