Engineering Properties of Dangote Fly Ash Stabilized Black Cotton Soil (BCS)

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ABSTRACT

The rapid growth of Ilaro and its environs have led to an increase in construction activities in the area. These projects require quality earth for its implementation. However, large areas are covered with highly plastic and expansive soil, which is not suitable for such purpose. Consequently this research was undertaken to investigate and improve the engineering properties of the black cotton soils of Ilaro and its environs. In Experimental investigation, the soil-Fly ash mixtures were prepared by mixing 0%,10%,20%,30%, 40% and 50% of fly ash (by weight). All these mixtures were tested in the laboratory for their index properties, compaction characteristics and California Bearing Ratios in accordance with British standard. From the test results it was identified that addition of fly ash decreases plasticity and improves strength characteristics. Addition of 30-40% attains higher CBR values and improved swell characteristics. The study concludes that Dangote fly ash has a good potential to be used as an additive for improving the engineering properties of black cotton soils.

Keywords: Atterbergs limit, Black Cotton soil, Compaction test, Specific gravity

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1. INTRODUCTION

Expansive soils, popularly known as black cotton soils in India are, amongst the most problematic soils from Civil Engineering construction point of view. Of the various factors that affect the swelling behaviour of these soils, the basic mineralogical composition is very important. Most expansive soils are rich in mineral montmorillonite and a few in illite. The degree of expansion being more in the case of the former. Soil suction is another quality that can be used to characterise a soil's affinity for water on its volume change behavior. It is a well-known fact that water is the worst enemy of all structures, particularly in expansive soil areas. The structures on Black cotton soil (BC soil) bases develop undulations at the road surface due to loss of strength of the sub-grade through softening. Water penetrates into the foundation from three sides viz. top surface, and from bottom layers due to capillary action. Therefore, specifications in expansive soil areas must take these factors into consideration. The surfacing must be impervious, sides paved and soil beneath well treated to check capillary rise of water.

Fig. 1.1 Typical Cracks in Black Cotton Soil

Structures located on these soils subjected to differential settlements due to moisture variations (Bala Subramanyam et.al 1989). Hence the subgrade and its undesirable characteristics to be modified using a suitable stabilization technique. Stabilization involves the methods used for modifying the properties of a soil to improve its engineering performance. Stabilization as a process has been widely employed for modifying the geotechnical properties of a soil to improve its engineering properties to increase the strength of the soil hence increasing or maintaining the stability of soil mass. However, there are different types of stabilization which include but not limited to lime stabilization, cement stabilization, bitumen stabilization. In present investigation various percentages of Dangote Fly ash and cement mixes are added to expansive soils and effect of these mixes was studied in terms of plasticity, compaction, swell and strength characteristics.

2. LITERATURE REVIEW

To enhance the engineering properties of black cotton soil, several researchers carried out works on black cotton soil with different stabilizing materials. In the past many researchers have carried out their research work on the use of industrial waste for soil stabilization. A study on strength characteristics of expansive soil-fly ash mixes carried out by Satyanarayana et al. (2013) revealed that fly-ash increases the strength and decreases the swelling characteristics and 20-30% fly-ash needed to stabilize expansive soil. Shreyas.K (2017) studied the stabilization of Black Cotton Soil By Admixtures and concluded that there is a gradual increase in the CBR values with the increase in percentage of stabilizers. Jaya Prakash Babu et. al (2016) studied Engineering Properties of Black cotton soil Modified with Fly ash and Cement, and conluded that that addition of Fly ash and cement decreases plasticity and improves strength characteristics.

Addition 32-40% Fly ash and 6-8% cement attains higher CBR values and improved swell characteristics. Study carried out by Satyendra S. (2016) studied on the effect of Fly-Ash on Geotechnical Characteristics of Black Cotton Soil revealed that showed an increase in optimum moisture content (OMC) from 19% to 23% and decrease in maximum dry density (MDD) from 1.63g/cc to 1.52g/cc. Test result indicates that fly-ash has a potential to improve the properties of black cotton soil. BROOKS (2009) studied “soil stabilization with fly-ash and rice husk ash” and reported that the rice husk ash (RHA) content of 12% and a fly-ash content of 25% are recommended for strengthening the expansive sub grade soil while a fly-ash content of 15% is recommended for blending into RHA to form a swell reduction layer.

Sivapullaiah et.al. (1996) reported that the addition of fly ash decreased the liquid limit of black cotton soils and studied the effect of fly ash on the index properties of these soils from Karnataka, India. Bhoominadhan and Hari (1999) proposed the use of fly ash in construction works like brick making and soil stabilization. Pandian et.al. (2002) in their study on the effect of fly ash on the CBR characteristics of the black cotton soil inferred that there is an increase of strength with the increase in the fly ash content.

3. MATERIALS & METHODOLOGY

3.1 Black cotton soil

Black cotton soil was collected Idogo town Yewa South Local Government Ogun State, Nigeria, dried and pulverized into the required sizes and tested for properties like gradation , compaction, strength as per IS2720.

Table 1: Characteristics of Black cotton soil

Property	Value
Dry density (γd)	1300- 1800 kg/m³
Liquid Limit (L.L.)	40 - 120%
Plastic Limit (P.L.)	20 - 60%
Specific Gravity(G)	2.60 - 2.75
Proctor Density	1350- 1600 kg/m³
OMC (Max dry density)	20- 35%
Swelling pressure	50- 800 kN/m²
Free Swell Index	40- 180%
C.B.R. (soaked)	1.2- 4.0
Compression Index	0.2- 0.5
Fines(<75μ)	70- 100%
Soil Classification	CH or MH

3.2 Fly ash

The fly ash used in this work was procured from Dangote Cement factory, Ibese, Ilaro, Ogun State. The fly ash is extremely fine powder consisting of spherical particles less than 50 microns in size and it is commonly used as pozzolan in the construction industry.

3.3 Methodology

About 200kg of the soil samples are sun dried and air dried, it was then pulverized manually and their geotechnical properties were determined in the laboratory, the average of the result obtained from the laboratory test are presented in the result section The effectiveness of the stabilizer (Dangote Fly Ash) for soil strength improvement was studied by replacing the collected soil samples in percentages of 10, 20, 30, 40 and 50 (by weight) with the fly ash and performance tested in the laboratory. The laboratory tests carried out include compaction test, atterberg's limit (i.e. plastic limit, liquid limit and shrinkage limit), California bearing ratio (CBR) test and Unconfined Compression test in accordance with BS1377-1990.

4. RESULTS AND DISCUSSION

4.1 Effect of Fly ash on Engineering Properties of Expansive Soils

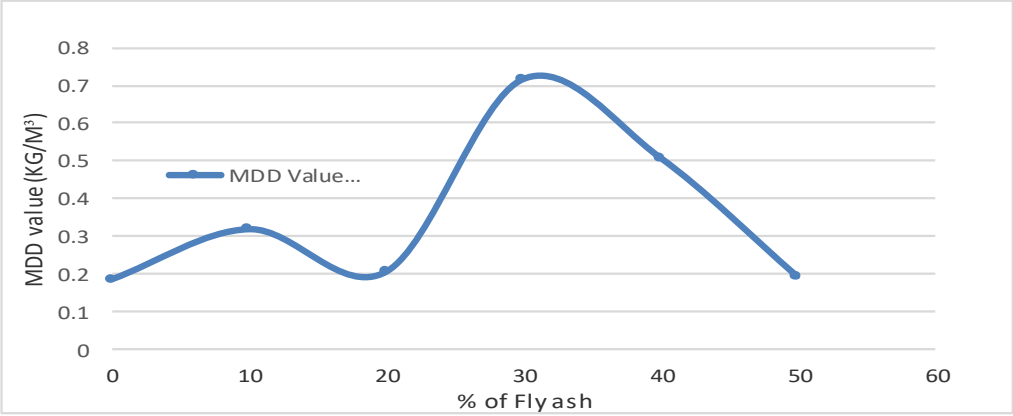

Fig 1: Variation of MDD with Varying Percentage of DFA in Black Cotton Soil.

From the graph above, the value of maximum dry density increased continuously after addition of DFA content. Maximum increased by 0.71% at 30% addition of DFA.

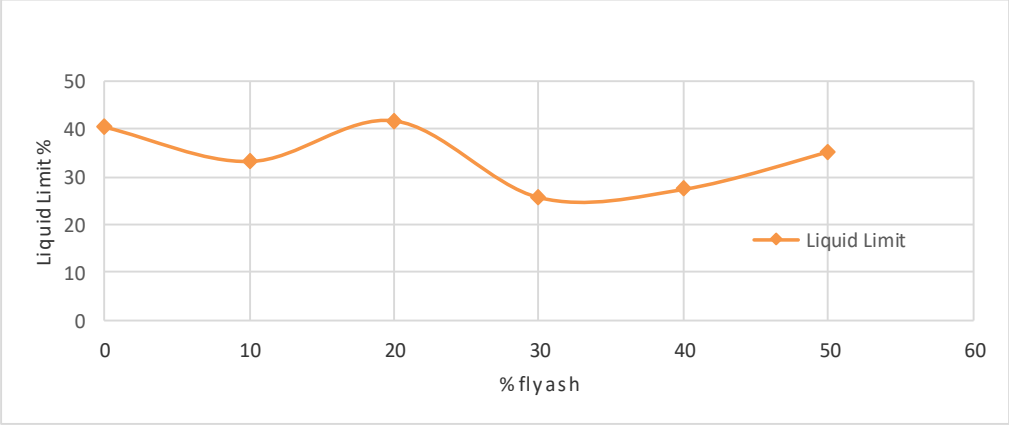

Fig 2: Variation of Liquid Limit with Varying Percentages of DFA in Black Cotton Soil

The result shows a considerable decrease in the liquid limit from 40.343 to 25.625 at 30% increase in the fly ash percentage. The liquid limit of BCS is essentially controlled by the thickness of the diffused double layer and the sharing resistance at particle level.

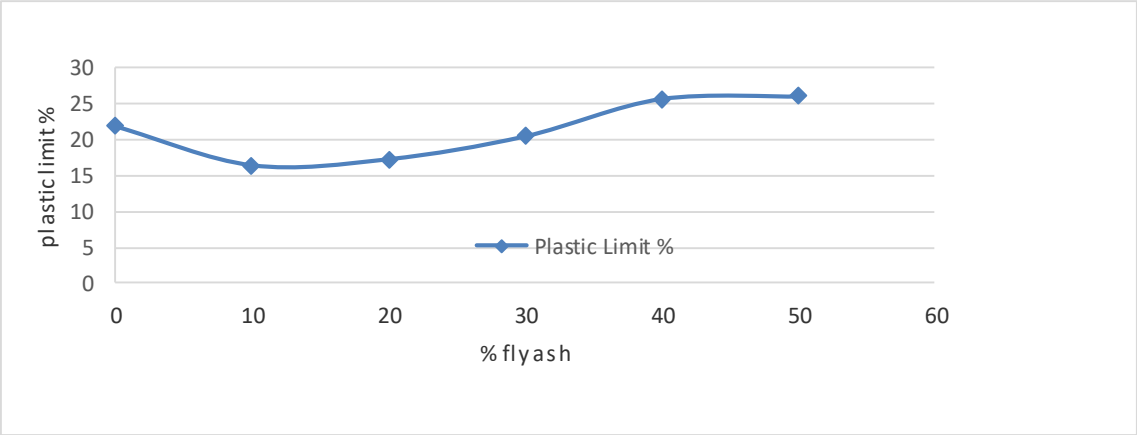

Fig 3: Variation of Plastic Limit with Varying Percentages of DFA in Black Cotton Soil

The addition of fly ash result in steady decrease from 21.85 to 17.28 at 20%, but at 30% it increases at any further addition of DFA content. This is because of the fact that as the quantity of fly ash mix increases above 20%, the amount of soil to be flocculated increases.

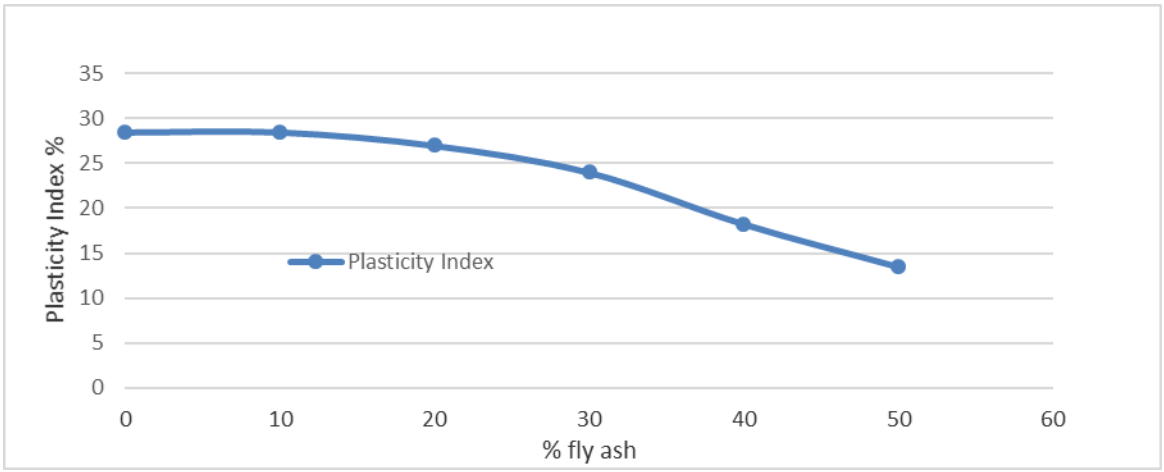

Fig 4: Variation of plasticity index with varying percentages of DFA in BCS.

The addition of DFA decreases the plasticity index of black cotton soil in DFA application.

California Bearing Ratio (CBR)

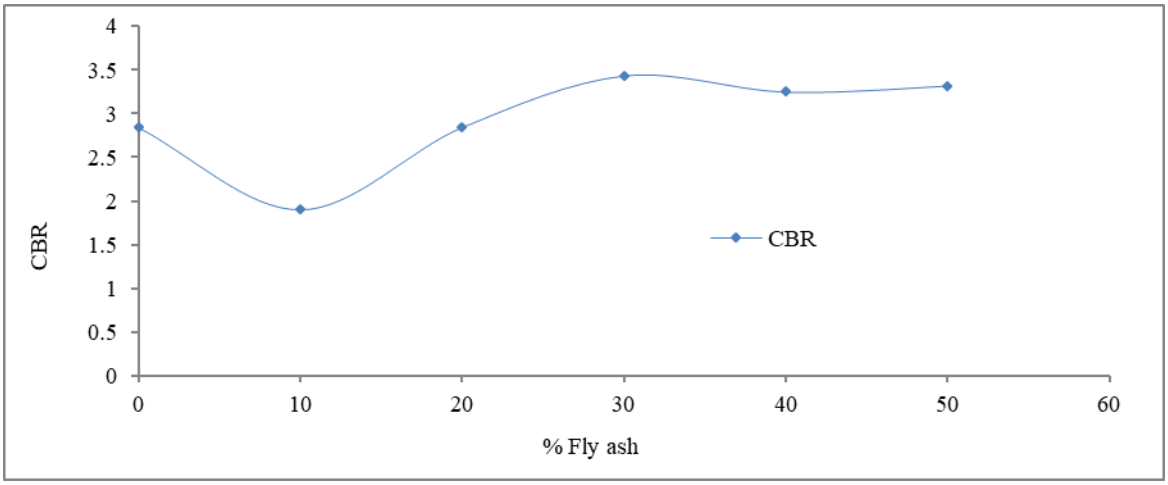

Fig 5: Variations of California Bearing Ratios with Varying Percentages of DFA in BCS

The CBR value of BCS increased after addition of all percentage of fly ash except for 10% and attained maximum increase of 3.435 at 30% of Fly Ash content. Good CBR value increases the stability of soil.

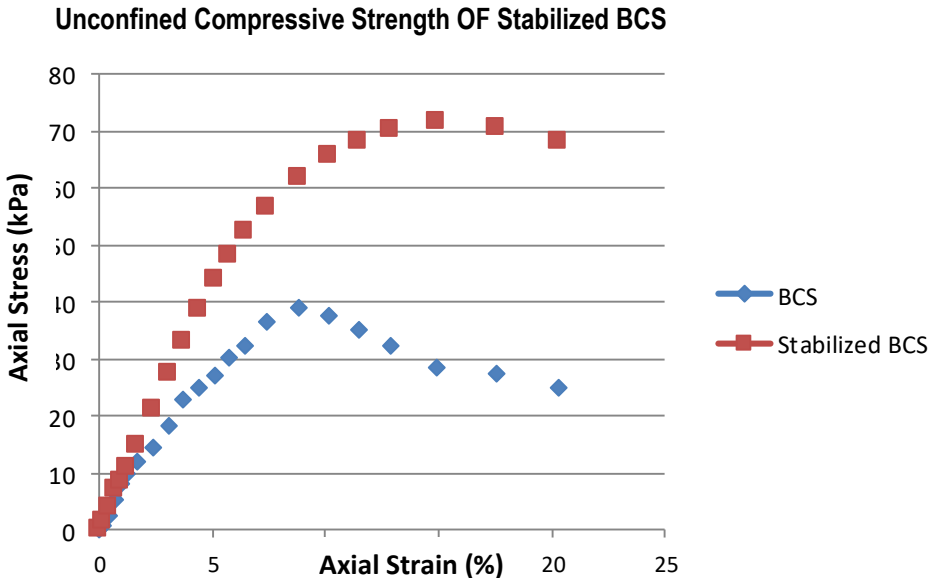

Fig 6: Variation of BCS unconfined strength.

From the stress--strain curve, the unconfined compressive strength of stabilized BCS attains it peak value at 72.0kpa and later steady decrease to 68.1kPa was observed while that of the un-stabilized BCS attains its peak value at 38.9kpa. This shows that the stabilized BCS has more strength compared to the ordinary BCS.

5. CONCLUSIONS

Based on the laboratory tests conducted on black cotton soil mixed with the fly-ash from 0% to 50% by dry weight of the soil. Following conclusions can be drawn:

i. Liquid limit of samples are decreasing with the increasing of fly-ash into the Black soil. It has been found that the liquid limit decreased from 40.343 to 25.625 at 30% increase in the fly ash percentage.
ii. Maximum dry density increases from 185 up to 714 at 30% fly ash mix.
iii. CBR value increases with higher rate from 2.845 to 3.435 at 30% of fly ash content.
iv. Unconfined compressive strength attains peak value at 72.0kpa and then decreases. The addition of fly ash to expansive soil reduces the free swell and swelling pressure.

From this research it can be concluded that fly-ash has a good potential to be used as an additive for improving the engineering properties of black cotton soils and to make it suitable in many civil applications.

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