STABILIZATION OF BLACK COTTON SOIL USING FLY ASH

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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 and stable 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 (BS 1377-1990). 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 fly ash has a good potential to be used as an additive for improving the engineering properties of black cotton soils. The research recommended 30% of fly ash content for improving the engineering properties of BCS and to make it suitable in many civil applications.

Keywords: ***Atterberg's limit, Black Cotton soil (BCS), shrinkage, swelling***

1.0 INTRODUCTION

Black cotton soils (BCS) are soils characterized by high swelling and shrinkage on the absorption of water. They form a key soil group in Nigeria (Adeniji, 1999). These soils alternatively swell and shrinks depending upon the presence of moisture in it. This characteristic causes the volume change of the soil and consequently result in formation of cracks and ultimate failure of structures built on that soil. Its properties differ from place to place. Generally, BCS has very low bearing capacity and high swelling and shrinkage characteristics. Swelling pressure is a key cause of failure in foundations supported by BCS (Erdal, 2001).

Fig. 1.1 Typical Cracks in Black Cotton Soil of selected areas within Ilaro

Structures situated on these soils are prone to uneven settlements owing to its moisture variations (Bala Subramanyam *et.al* 1989), hence, the subgrade and its undesirable characteristics needs to be modified using an appropriate stabilization method. Stabilization encompasses the methods used for modifying the characteristics of a soil to improve its engineering performance. Stabilization as a procedure has been broadly employed for modifying the geotechnical properties of soils, to increase its strength hence, increasing the stability of the soil mass. There are however different kinds of stabilization which comprise but not limited to lime, cement, and bitumen stabilization. In the present investigation, various percentages of Fly ash and cement mixes were added to BCS and the effect of these mixtures was studied in terms of plasticity, compaction, swell and strength characteristics.

2.0 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.

Satyanarayana *et al*. (2013) in a study on strength characteristics of expansive soil-fly ash mixes revealed that fly-ash increases the strength and decreases the swelling characteristics. It was shown that 20-30% fly-ash is needed to stabilize expansive soil. In a similar study carried out by Satyendra S. (2015) on the effect of fly-ash on geotechnical characteristics of BCS it was shown that a rise in optimum moisture content (OMC) from 19% to 23% and decrease in maximum dry density (MDD) from 1.63g/cc to 1.52g/cc can be attained. Test results indicates that fly-ash has a potential to improve the properties BCS. Brooks (2009) studied soil stabilization with fly-ash and rice husk ash and reported that rice husk ash content of 12% and a fly-ash content of 25% are recommended for fortifying the expansive sub grade soil. Ahmed (2014) stabilized clayey soil for the construction of urban roads using fly ash. It was found that the optimum ratio of fly ash with clayey soil is 15% by weight of soil. The liquid limit decreased from 55% to 48% for increase of fly ash from 0% to 15% by weight. Plasticity Index changes from 30% to 13% for addition of 0%to 15% of fly ash. C.B.R value of soil changes from 3% to 56%. Karthik *et al*., (2014) evaluated the effect of fly ash derived from combustion of subbituminous coal at electric power plants, for stabilization of soft fine grained red soil. At 6% of fly ash the bearing capacity of soil changes from 10kg/mm^2 to 35kg/mm^2 and CBR value changes from 3.1% to 4.82%. Due to increase in CBR values the thickness of pavement decreases from 12 inches to 8.5 inches. Ankur *et al*., (2014) stabilize the Black cotton soil using Lime and stone dust. The MDD of lime stabilized B.C. soil increases up to the addition of 20% stone dust and further increase of the stone dust decreases the value. Similarly for CBR and UCS the strength increases up to 20% addition of stone dust in lime stabilized soil. Elias (2015) stabilized the soil using waste paper sludge. The addition of WPS increased the strength at 5% and it was found to be constant and optimum value of strength to soil.

3.0 MATERIALS AND METHODS

3.1 MATERIALS

Black Cotton Soil

Black cotton soil was collected from Idogo town, Yewa South Local Government, Ogun State, Nigeria, dried and pulverized into the required sizes.

Fly ash

The fly ash used in this research 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 pozolan in the construction industry.

3.2 METHODS

About 200kg of the soil samples were sun dried and air dried, it was then pulverized manually and their geotechnical properties were determined in the laboratory. The effectiveness of the stabilizer (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 BS 1377-1990.

3.3 RESULTS AND DISCUSSION

Effect of Fly ash on Engineering Properties of Expansive Soils

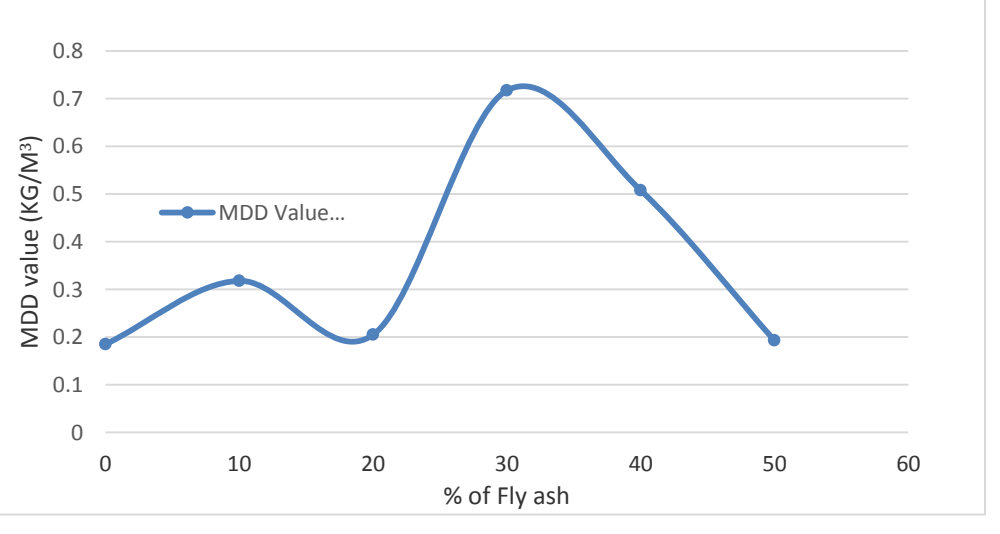

Fig 3.1: Variation of MDD with Varying Percentage of Fly ash in Black Cotton Soil.

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 FA.

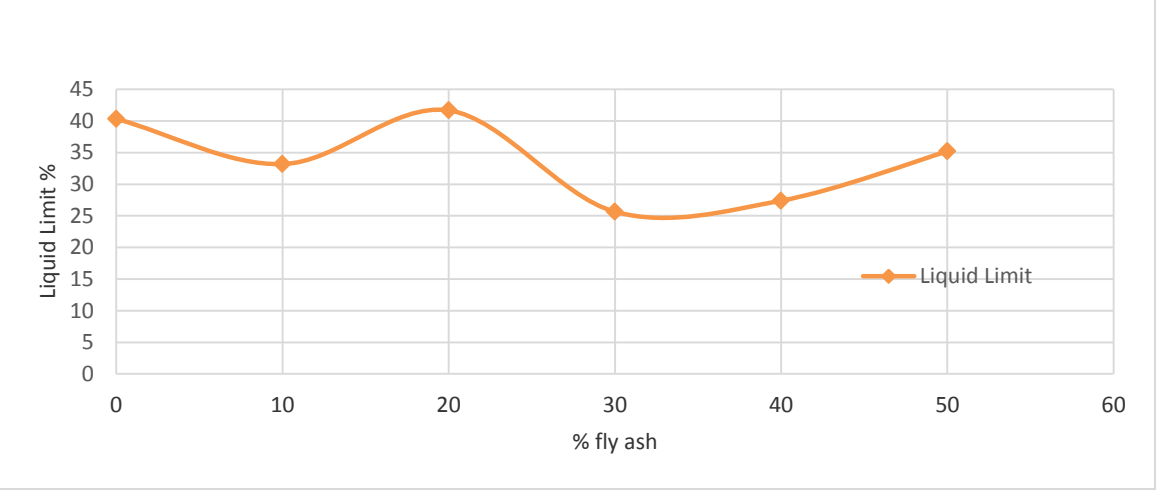

Fig 3.2: Variation of Liquid Limit with Varying Percentages of Fly ash in Black Cotton Soil

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.

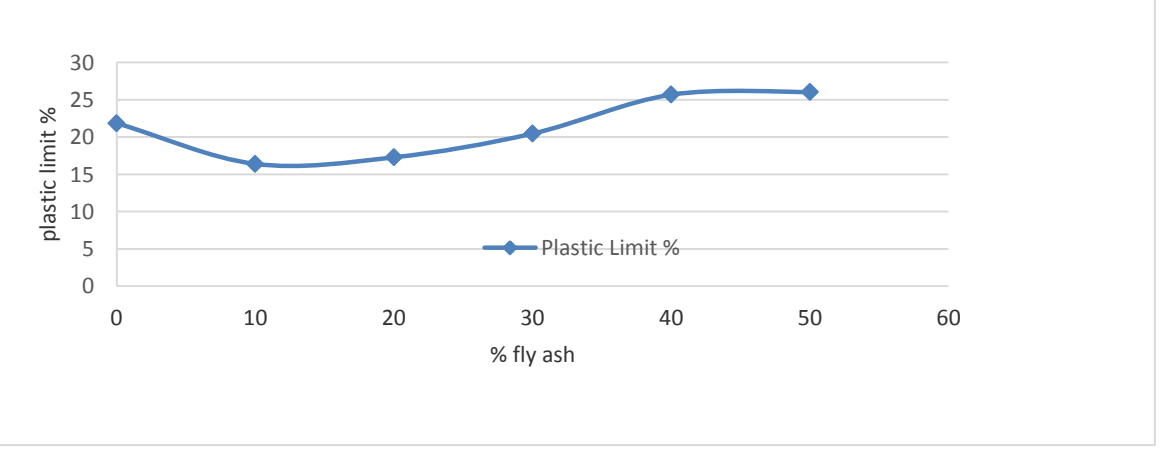

Fig 3.3: Variation of Plastic Limit with Varying Percentages of Fly ash in Black Cotton Soil

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 FA 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.

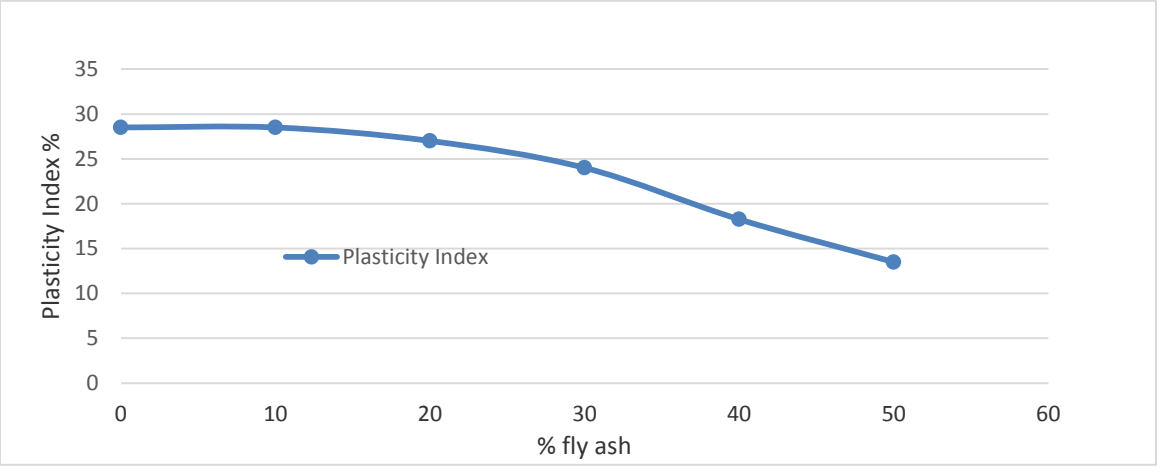

Fig 3.4: Variation of plasticity index with varying percentages of Fly ash in BCS.

Plasticity index shows the range of moisture content within which soils mixture shows the plastic property. The addition of FA decreases the plasticity index of black cotton soil in FA application.

California Bearing Ratio (CBR)

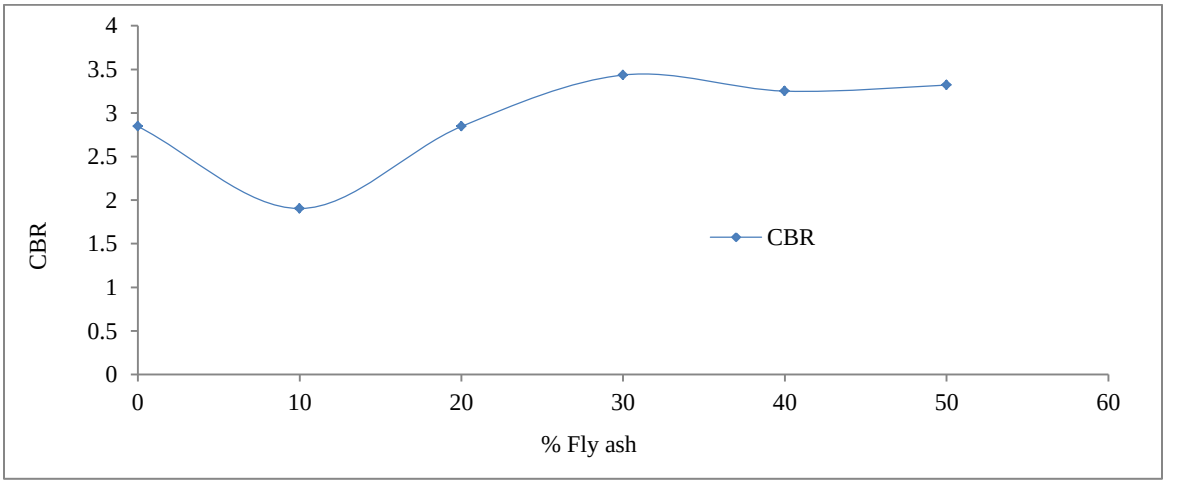

Fig 3.5: Variations of California Bearing Ratios with Varying Percentages of Fly ash in BCS

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.

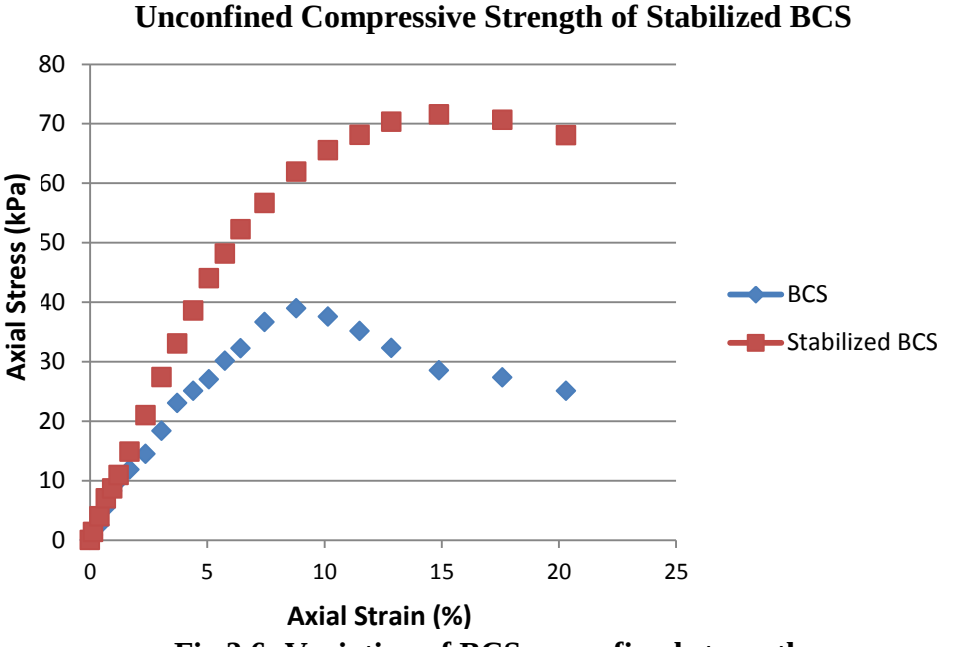

Fig 3.6: Variation of BCS unconfined strength.

From the stress–-strain curve, the unconfined compressive strength of stabilized BCS attains its peak value at 72.0kPa and later steady decrease to 68.1kPa 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.

4.0 SUMMARY OF FINDINGS

i. Black cotton soil is combined with varying percentage of fly ash (from 0% to 50%, intervals in multiples of 10) by dry weight of the soil to observe its effect as an additive on the expansive soil.

ii. Liquid limit of the expansive soil are decreased with increase in fly ash content. It has been found that the liquid limit decreased from 40.343 to 25.625 at 30% increase in the fly ash content.

iii. Maximum Dry Density (MDD) was found to change with varying content of fly ash. The highest value observed being at fly ash content of 30% by weight.

iv. The change in Unconfined Compressive Strength (UCS) of the soil with varying content of fly ash is observed. The graph shows the variation of UCS with changing fly ash content. 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.

v. From the free swell ratio tests on the soil-fly ash mixture, the value of free swell ratio decreased with the increasing fly ash content.

5.0 CONCLUSIONS

Based on the laboratory tests conducted on BCS 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.

6.0 RECOMMENDATIONS

The research recommended 30% of fly ash content for improving the engineering properties of BCS and to make it suitable in many civil applications. However, fly ash along with another additive like lime, cement, and other such materials can be used together, and may be varied in quantity to obtain the best possible stabilizing mixture.

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