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MECHANICAL PROPERTIES OF FLY ASH STABILIZED CLAYEY LATERITE

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Abstract- ***Most of the Niger Delta area in Nigeria are undergoing rapid industrialization. Transportation demands are on the increase, requiring long lasting pavements. Laterites are generally being used for most embankments and road fills. However, in areas of the clayey laterites, not meeting specification, it will be cheaper to stabilize insitu instead of importing laterite. This paper presents the use of fly ash to stabilize the laterite to produce cement treated road base and roller compacted concrete (RCC) without cement.***

Result show improvement in shear strength from 960kPa to 1210kPa. The CBR also increased from 3.0% to 68%. Generally, an optimum ash content of 60% increased shear strength and CBR and lowered the swelling potential.

Keywords: Laterites, pavement, fly ash, shear strength, CBR.

Introduction

Laterites distribution, classification, depth extent, general nature and formation have been presented by Faniran 1970, 1972, 1974 and 1978, Adekoya et al 1978; while the geotechnical study of laterites are presented by Ola 1978, 1980a, 1980b and Alao 1983. Little or no attention has been paid to the strength characteristics of compacted laterites (Omire and Yasufuku 2005, Oota and Iba 2009).

Otoko (1985, 1987, 1988a, 1988b, 1997, 2014a) has shown that in soil design, engineers require the strength of the field compacted soil for analysis in the design of an embankment or road fill. This is necessary to avoid damage to road founded on unsaturated subgrade resulting from collapse of the soil structure upon wetting – drying process. Such unsaturated laterites can cause damage to roads as the change in the degree of saturation cause corresponding change in the shear strength (Maaitah et al 2004). It is clear that during rainy season, the rain infiltration to the subgrade increase soil saturation and decreases shear strength, which in turn causes the pavement layers to be unstable and fail (Reinson 2001).

Soil stabilization is a technique of improving the soil to meet the requirements of the specific engineering projects (Kolias et al 2005) several additives have been used to stabilize soils (Otoko 2014b), but it is the use of fly ash instability laterites that is the subject of this paper. Fly ash has been used beneficially in soil stabilization (Li et al 2008; Ferguson 1993 and Parsons et al 2005 Ferguson and Levorson 1999)

The aim of this work is to stabilize unsaturated laterite with fly ash. Although Nigeria has about 1296 million metric tonnes reserve of Coal at Enugu and substantial deposits at Kaba in Kwara State, only Oji River is used it for the generation of electricity and therefore the only source of fly ash in the country (Ngwu, 1984). This waste material can be used beneficially.

Experimental Procedure

The laterite was obtained from Port Harcourt. The grain size distribution (fig. 1) was carried out in accordance with ASTM D-422 and the physical and mechanical properties obtained are presented in table1. Different percentages of ash (10%, 20%, 30% and 50%) were added to the laterite soil sample before carrying out atterberg and compaction tests. Test result show that the plasticity index of the soil is inversely proportional to the ash content. (Fig. 2).

Table 1: Physical and mechanical properties of laterite

Parameter	Laterite
Liquid limit (LL)	48
Plastic Limit (PL)	23
Shrinkage Limit (SL)	16
Plasticity Index	25
Passing 200%	93
Clay Fraction %	55
Specific Gravity	2.69
Unconfined Compressive Strength	580kPa
Maximum Dry Unit Weight	16.4Kn/m^3
California Bearing Ratio	8

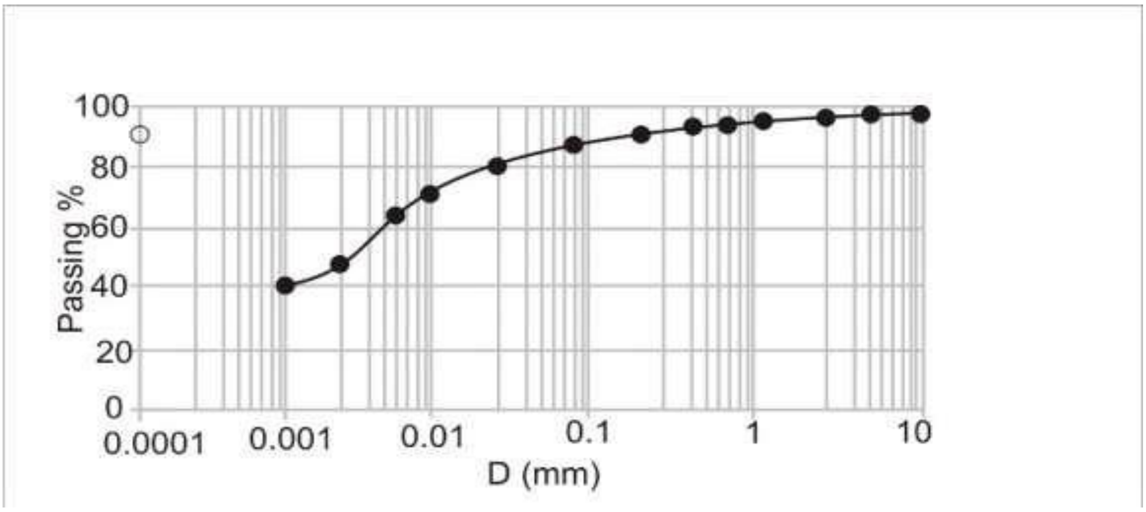

Fig. 1: Particle Size Distribution Curve

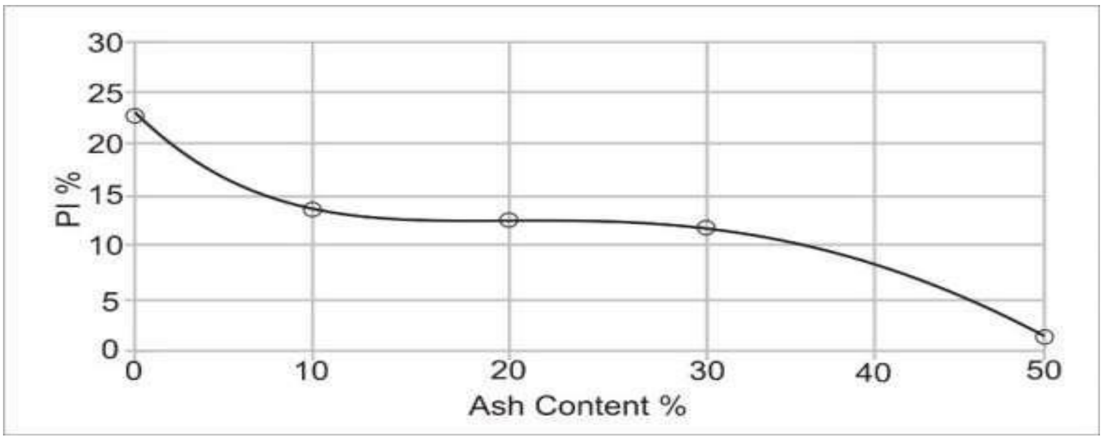

Fig. 2: Variation of P.I with ash content

Fig. 3: Drying of moisture content cans using electric oven

Fig. 4: Sieve analysis test

Compaction

Compaction tests were carried out in accordance with ASTM D 698. Test results shown in Fig. 5, that the Maximum Dry Unit Weight is inversely proportional to the ash content (Fig. 5). The salinity to water however decreases due to the increase in the ash content.

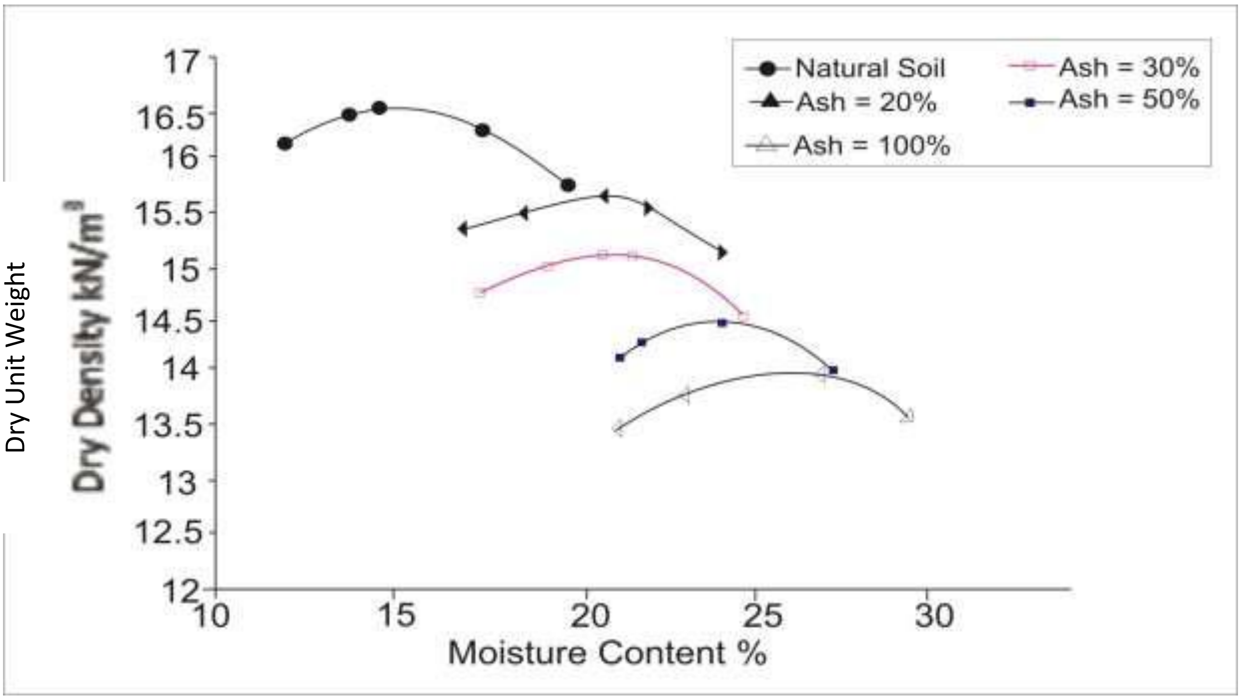

Fig.5: Compaction behaviour of ash - laterite mixtures

Shear strength of Stabilized Laterite

Fig. 6 shows the effect of degree of saturation on the unsaturated shear strength of the natural laterite. It is clear from the figure, that there is drop in strength as the degree of saturation increases due to change in water content.

Fig. 7,8,9,10 and 11 show gradual increase in strength of the soil with increase in time and ash content; probably due to exchange of calcium cations supplied from lime (CaO). Hydrated lime reacts with clay minerals to create cementitous products in high pH environment (Qubain 2000). The shear strength is directly proportional to the curing time and ash content (Fig. 7) and also directly proportional to the Normal Stress (fig. 8).

Fig. 9 shows the effect of ash content and degree of saturation on shear strength of a stabilized laterite, which eliminates the drop in strength as the saturation increases beyond 35%. Similar behaviour is also seen in Fig. 8 showing that the ash content plays an important role in the shear strength increase. These improved properties of the soil are maintained for over 20 to 40 years (Little 1999 and Qubain 2000).

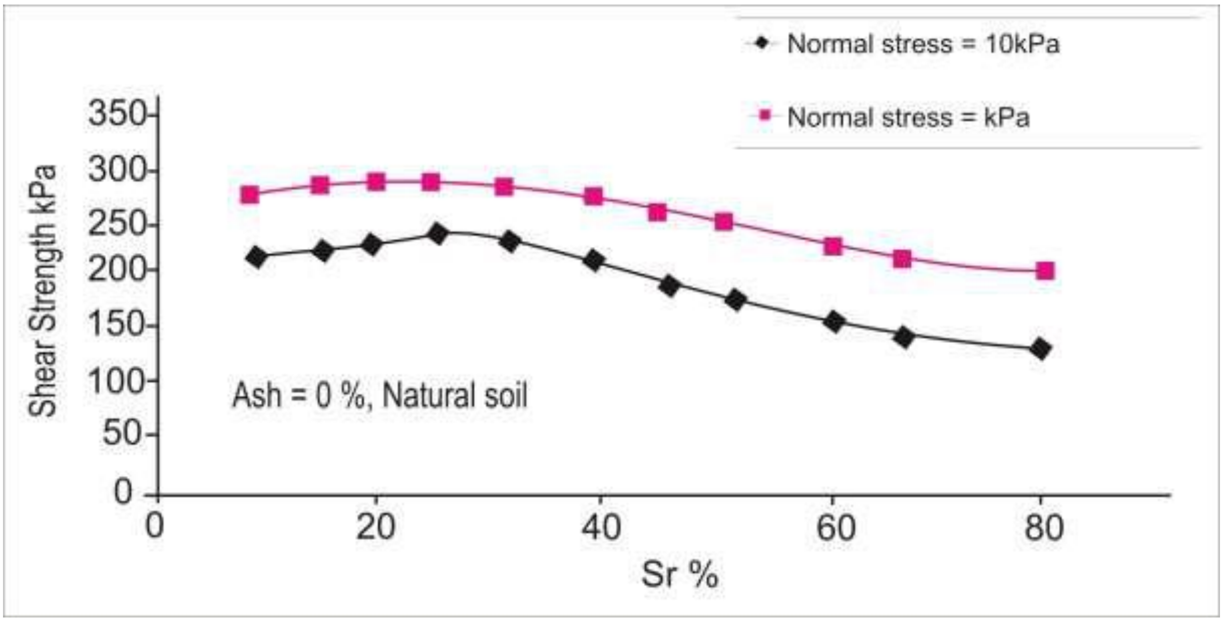

Fig. 6: Effect of degree of saturation on the unsaturated shear strength for natural soil

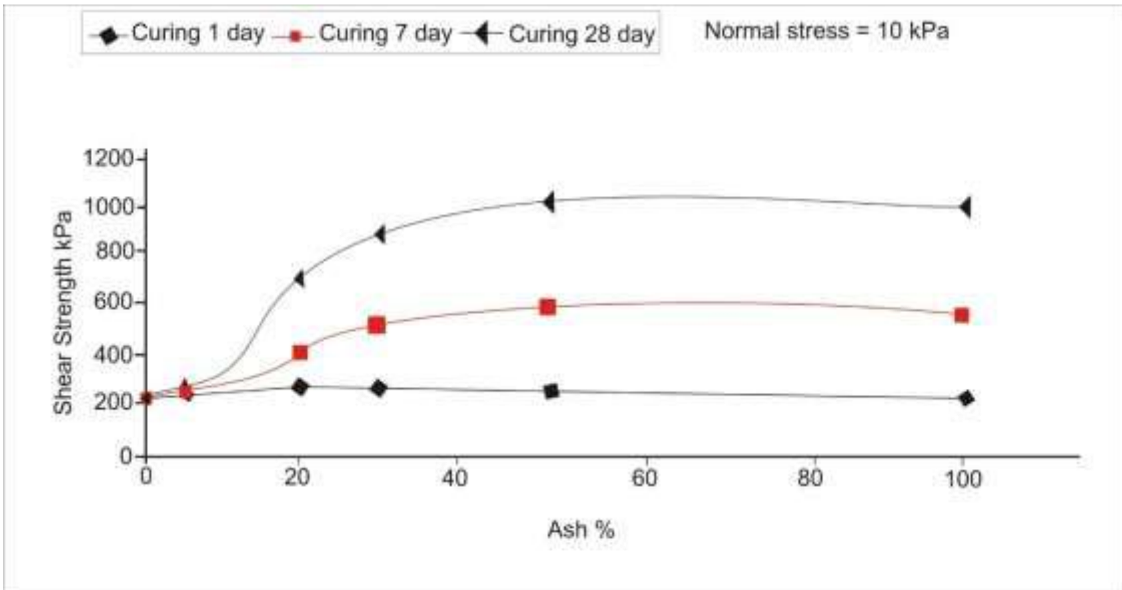

Fig. 7: Effect of curing time on the shear strength of ash - laterite mixture

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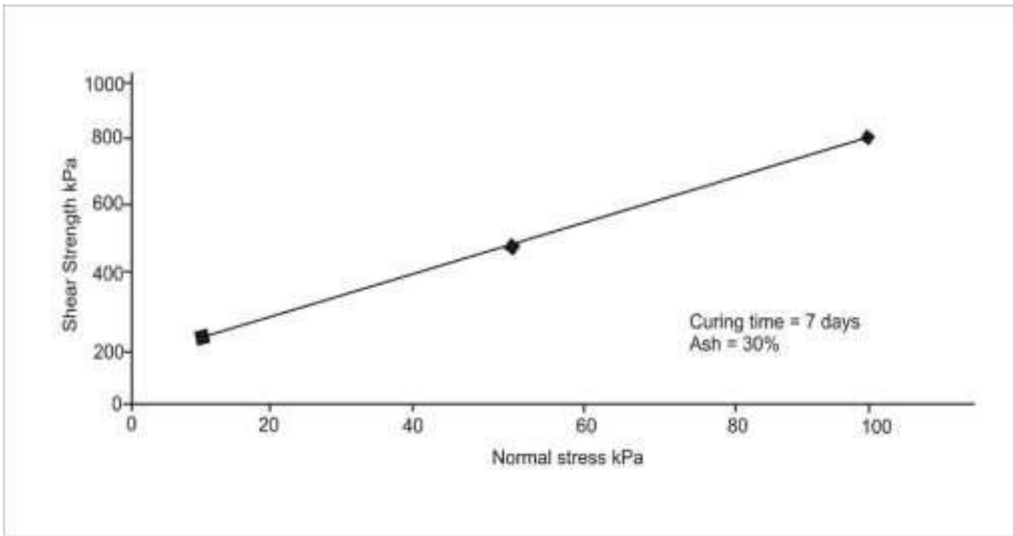

Fig. 8: Effect of confining stress on shear strength of stabilized soil

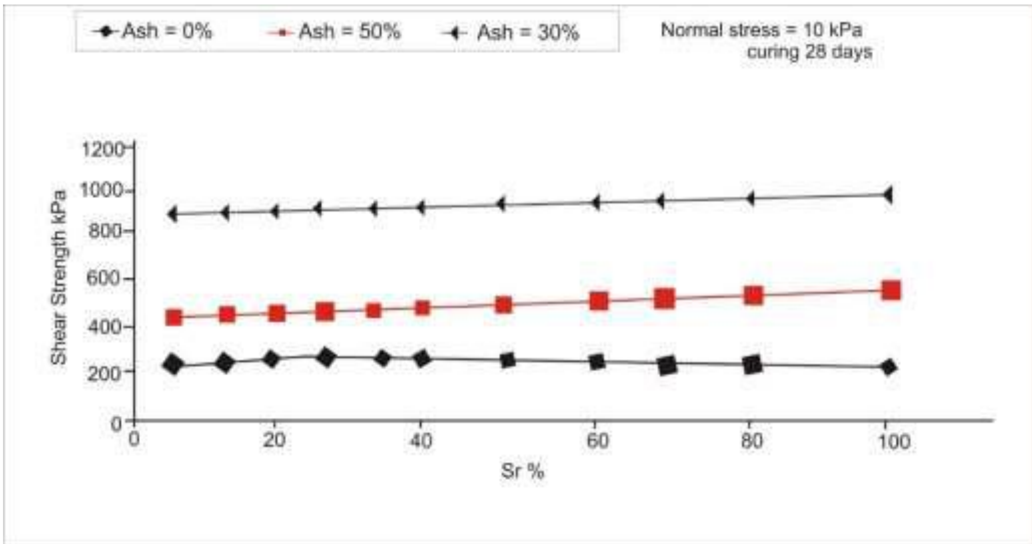

Fig. 9: Effect of ash content and degree of saturation on shear strength of stabilized soil

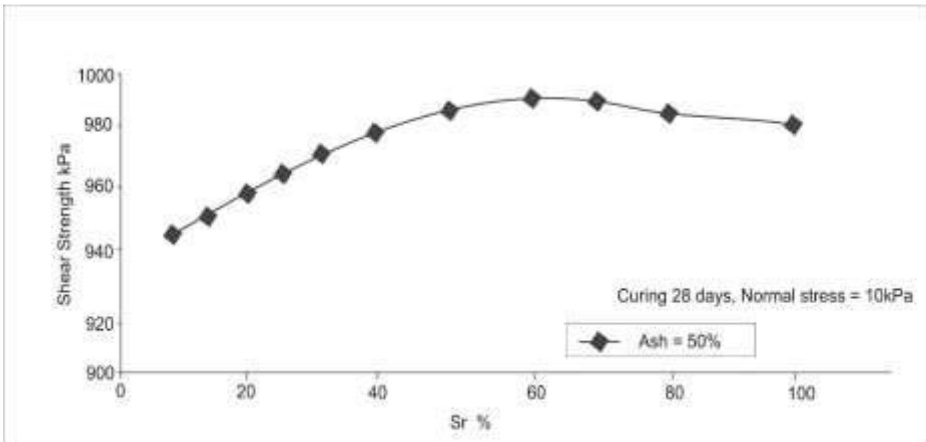

Fig. 10: Effect of degree of saturation on stabilized soil

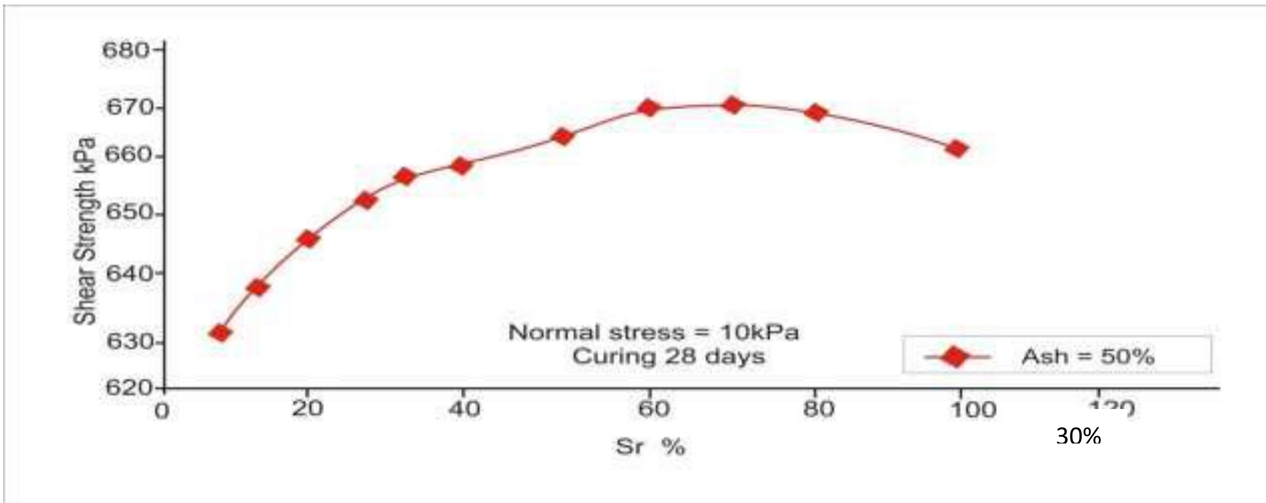

Fig. 11: Effect of degree of saturation on stabilized soil

California Bearing Ratio

The ash-laterite samples were compacted and cured at ambient temperatures for 28 days in light polythene bags to maintain the optimum moisture content. The samples are then soaked for 4 days before testing. Test results shows that the CBR values obtained were directly proportional to the ash content (Fig. 12).

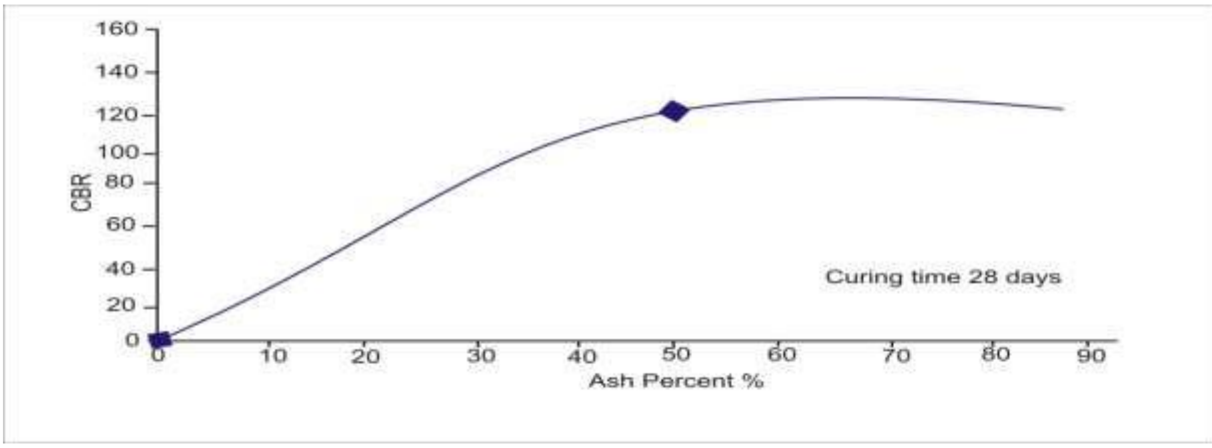

Fig. 12: Effect of ash on CBR

Fig. 13: CBR test

Fig. 14: specific gravity test

Swelling Potential

Fig. 15 shows the effect of fly ash on the free swelling potential of laterite. Ash reduces volume of swelling road base and instead stiffens the base. The optimum quality of ash from Fig. 15 is about 95% for the laterite tested.

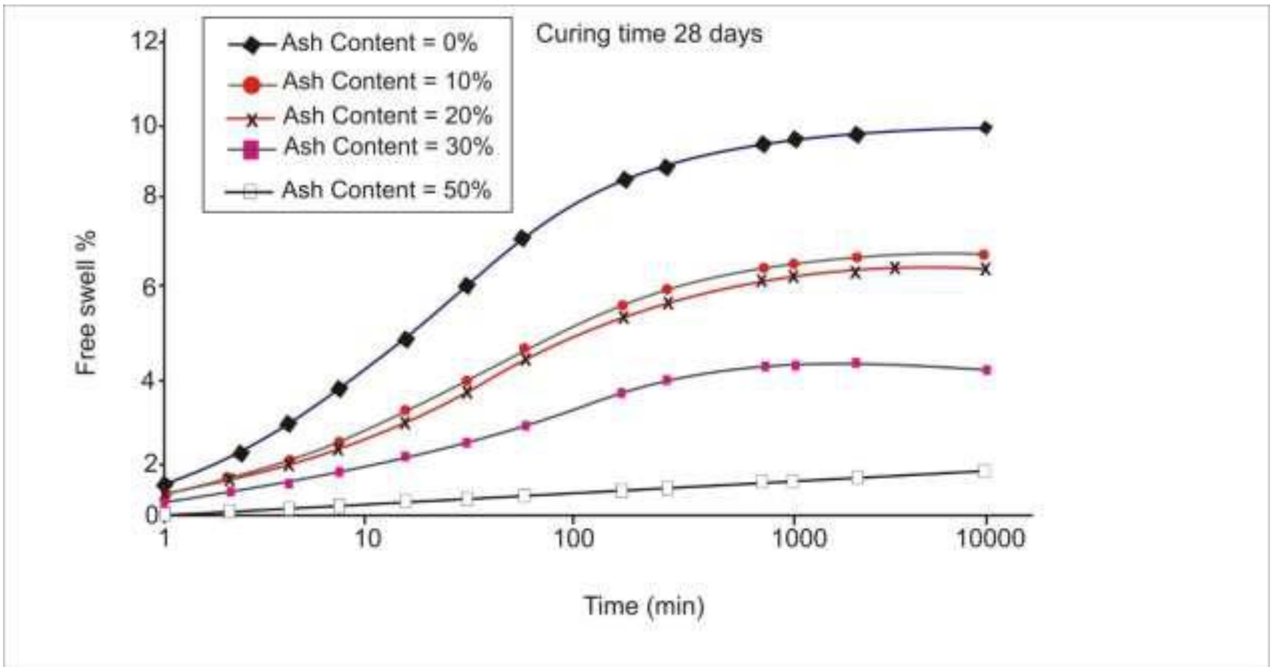

Fig. 15: Effect of ash on swelling

Discussions and Conclusions

Test results shows that curing period of 28 days and more has considerably influenced the strength results. Samples are intact, without investigation under fully saturated conditions, thus giving high strength. The ash-laterite soil mixtures are compacted to maximum dry unit weight and optimum moisture content. The CBR values increased from 3% for 0% ash content to about 68% for the stabilized soil.

It is concluded that fly ash obtained from Oji River Power Station, Nigeria is a reliable stabilizer in embankments and road subgrades; and that deltaic laterite under highways can easily be tested and modified by the fly ash to fit the construction properties. The optimum requirement for the laterite is 95% to give high CBR value and strength, and minimize the swelling potential. The shear strength and CBR of the stabilized soil is directly proportional to the curing time, ash content and normal stress and also depends on the ash content and curing period.

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