VOL. 15, NO. 17, SEPTEMBER 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

STABILIZATION EFFECTS OF LOCUST BEAN ASH ON THE COMPACTION CHARACTERISTICS OF LATERITIC SOIL SAMPLES

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ABSTRACT

This research was carried out to investigate the effects of locust bean ash on the compaction characteristics of some selected lateritic soils with a view to discovering a cheaper and effective replacement for the conventional soil stabilizers. The necessity for improving the compaction characteristics of soil to enhance construction procedures has been recognized for a long time. Preliminary tests were performed on the natural soil samples for identification and classification purposes followed by the consistency limit tests. This was followed by compaction test carried out on the natural soil samples and when stabilized with 2, 4 and 6% locust beans ash (LBA). The results of the research showed that the Optimum Moisture Contents (OMC) of Samples A, B and C at their natural states were 25.0, 26.5 and 28.0% respectively while Maximum Dry Densities (MDD) were also 1396.3, 1523.0 and 1626.5 kg/m^3 respectively. However, only at 6% LBA addition was a consistent pattern observed in all the samples where they all experienced reductions in both OMC and MDD values. It is therefore reasonable to conclude that 6% LBA addition will reduce the water absorption properties of the lateritic soil samples in these areas to provide for improved shear strength, decreased compressibility, reduced swell potential and shrinkage properties. However, reductions in MDD increase the susceptibility of these soils to settlement. Therefore, LBA is not considered an effective stabilizer for these soil samples in terms of construction works.

Keywords: stabilization, locust bean ash, compaction, lateritic soil.

INTRODUCTION

The necessity of improving the engineering properties of soil has been recognized for as long as construction has existed. Many ancient cultures, including the Chinese, Romans, and Incas, utilized various techniques to improve soil stability, some of which were so effective that many of the buildings and roadway they constructed still exist today. Soil is one of nature's most abundant construction materials. Almost all construction is built with or upon soil. Improving an in-site (in situ) soil's engineering properties is referred to as either 'Soil stabilization' or 'Soil modification'. The term 'modification' implies a minor change in the properties of a soil while 'stabilization' means that the engineering properties of the soil have been changed enough to allow field construction to take place.

The needs for adequate provisions of transportation facilities are enormously increasing with increase in population and also the maintenance of the existing one. Highway engineers are faced with the problems of providing very suitable materials for highway construction. Owning to this fact, continuous researches have been carried out and still being carried out by individuals, firms and institutions on ways to improve the engineering properties of soils. The most available soils do not have adequate engineering properties to really bear the expected wheel loads, therefore improvisations have to be made to make these soils better. This has led to the concept called soil stabilization which is any treatment (including technically, compaction) applied to a soil to improve its strength and reduce its vulnerability to water. If the treated soil is able to withstand the stresses imposed on it by traffic under all weather conditions without excessive deformation, then it is generally regarded as stable.

Essentially, soil stabilization allows engineers to distribute a larger load with less material over a longer life cycle. Soil stabilization is used in many sectors of the construction industry. Roads, parking lots, airport runways, building sites, landfills, and soil remediation all use some form of soil stabilization. Other applications include water way management, mining, and agriculture.
This research was therefore conducted to investigate the effects of locust bean ash on the compaction characteristics of some selected lateritic soils with a view to discovering a cheaper and effective replacement for the conventional soil stabilizers.

Lateritic Soil

These soils are formed in-situ by chemical weathering and may be found on level rock surfaces where the action of the elements have produced a soil with little tendency to move. Residual soils can also occur whenever the rate of breakup of the rock exceeds the rate of removal. If the parent rock is igneous or metamorphic the resulting soil sizes range from silt to gravel. Laterites are formed by chemical weathering under warm, humid tropical conditions when the rain water leaches out the soluble rock material leaving behind the insoluble hydroxides of iron and aluminium, giving them their characteristic red-brown colour.

Soil Stabilization

Soil Stabilisation in the broadest sense, refers to the procedures employed with a view to altering one or more properties of a soil so as to improve its engineering performance. Soil stabilisation is only one of several techniques available to the geotechnical engineer and its choice for any situation should be made only after a comparison with other techniques. It is a well-known fact that every structure must rest upon soil or be made of soil. It would be ideal to find a soil at a particular site to be satisfactory for the intended use as it exists in nature, but unfortunately, such a thing is of rare occurrence.

Stabilization is the process of blending and mixing materials with a soil to improve certain properties of the soil. The process may include the blending of soils to achieve a desired gradation or the mixing of commercially available additives that may alter the gradation, texture or plasticity, or act as a binder for cementation of the soil.

The laterite and lateritic soils can be effectively stabilized to improve their properties for particular uses. However, because of the wide range in lateritic soil characteristics, no one stabilizing agent has been found successful for all lateritic materials. Laboratory studies, or preferably field tests, must be performed to determine which stabilizing agent, in what quantity, performs adequately on a particular soil (Mohammed, 2011).

Some successfully used stabilizers are cement, asphalt and lime.

African Locust Bean (Parkia Biglobosa)

Locust bean, a long pod containing small beans and sweetish edible pulp; is a parkia in the genus of flowering plant in the legume family *fabaceae* which belongs to the sub-family *mimosoideae.* About 31 species were known in 1995, four more have been discovered since that time. The type species for the genus is Parkia biglobosa (Locust Bean). A type species is a species to which the name of a genus is permanently linked. Parkias are found throughout the tropics, with 4 species in Africa, about 10 species in Asia, and about 20 species in the Neotropics. The most important use of African locust bean is found in its seed, which is a grain legume, although it has other food and non-food uses. On a moisture-free basis, the fermented locust bean contains about 40% protein, 32% fat and 24% carbohydrate (Campbell-Platt, 1980). Thus, apart from being a food condiment the fermented bean also contributes to the calorie and protein intake. According to Diawara *et al*. (2000), it has essential acids and vitamins and serves as a protein supplement in the diet of poor families. See Plates 1 and 2.

Plate-1. Fermented locust beans

Plate-2. Locust bean pod showing the seeds.

African Locust Bean as a Pozzolan

Locust bean ash (LBA) is the product of combustion of the waste husk of locust bean pod. The locust bean tree is common in the Nigerian environment and it grows to about 15m in height and has dark, evergreen, pinnate leaves. The fruit, which is a brown, leathery pod about 10 - 30cm long contains a gummy pulp of an agreeable sweet taste in which lie a number of seeds. The seeds are edible but the wastes litter our communities with corresponding negative environmental impact. Once the seed is used for local food seasoning, the waste husk from it when burnt produces the locust bean ash (LBA). The LBA - a pozzolana - has been reported to have a good potential for improving some of the geotechnical properties of soils. Being pozzolanic in nature, LBA is capable of reacting with free lime, released during hydration of cement at ordinary temperatures to produce cementitious compounds.

MATERIALS AND METHODS

The following materials were used for the study: Lateritic soils, Locust bean ash and Water. The lateritic soils were obtained from three different locations within the environs of Obafemi Awolowo University. The locations are “New Buka”, adjacent to ETF Hall (Sample A), opposite the University main gate (Sample B) and the burrow pit along OAUTHC link road (Sample C) and the locust bean pod was purchased locally and air-dried for easy burning. Portable water was obtained from the hydraulics laboratory in the Department of Civil Engineering, Obafemi Awolowo University.

Classification test (natural moisture content, specific gravity, particle size analysis and Atterberg’s limits) were performed on the natural soil samples. Compaction test was also carried out on the unstabilized samples A, B and C and when stabilized with locust bean ash in 2, 4, 6% by weight of the samples.

VOL. 15, NO. 17, SEPTEMBER 2020 ISSN 1819-6608
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RESULTS AND DISCUSSIONS

Table-1 gives the summary of the properties of the soils in their natural states. Accordingly, the shear strength property of Sample B will be lower than for Samples A and C due to the higher soil natural water content. According to Craig (1987), by virtue of the values of the Coefficient of Uniformity (Cu) contained in the Table-1, it can be said that soil Sample B has the largest range of particle sizes than the others. With respect to the Atterberg's limit tests and according to Skempton (1944), Sample A has the highest liquid limit with very high compressibility potential. The swell potential which is a function of the plasticity index is high. Therefore, Sample A has a very high potential to undergo volume change with high compressibility. The other properties the soils in their natural states are also shown in Table-1 below.

Table-1. Summary of the properties of the soils in their natural states.

Properties	Sample A	Sample B	Sample C
Physical Description	Laterite is reddish brown, with rock boulders fragments from the parent rocks.	Laterite is reddish and having soft whitish particles interwoven into it. The soft whitish part of the laterite can be said to be mica flakes.	Laterite is dark brown, with parent rock fragments.
Specific Gravity(Gs)	2.78	2.55	2.62
Moisture Content (%)	22.08	27.23	20.47
Gradation Analysis			
▪ Coefficient uniformity (Cu)	17.78	20.77	16.50
▪ Coefficient of curvature (Cc)	0.625	1.633	2.97
▪ AASHTO classification	A-2-7	A-2-7	A-2-7
▪ USCS	GW-GM (GW)	GW-GM (GW)	GW-GM (GW)
Atterberg's limit			
▪ Liquid Limit (%)	75.226	53.812	50.499
▪ Plastic Limit (%)	51.607	29.444	35.619
▪ Plasticity Index (%)	23.619	24.368	14.879
Maximum Dry Density (MDD) (kg/m^3)	1396.3	1523.0	1626.5
Optimum Moisture Content (OMC) (%)	28.30	26.50	28.00

Compaction Characteristics

At the natural states, the OMC of Samples A, B and C are 25.0, 26.5 and 28.0% respectively. This implies that the Sample C has more affinity for water for maximum strength of compaction and that it requires more water to attain to maximum dry density. The Maximum Dry Densities (MDD) of Samples A, B and C in the natural states are 1396.3, 1523.0 and 1626.5 kg/m^3 respectively. Figures 1 and 2 show the plots of Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) at increased percentages of Locust bean ash (LBA) for the samples. From the results, it was observed that as from 2% LBA addition, the affinity for water (OMC) decreased in Samples A and C and MDD decreased in Samples B and C. When the percentage LBA was increased to 4%, the OMC of only Samples A and B

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decreased while the MDD of all the samples reduced. However, only at 6% LBA addition was a consistent pattern observed in all the samples. All the samples experienced both OMC and MDD reductions in value. By virtue of these, it is reasonable to conclude that 6% LBA addition will reduce the water absorption property of the lateritic soils in these areas to provide for improved shear strength, decreased compressibility, reduced swell potential and shrinkage properties. However, reduced MDD increases the susceptibility of these soils to settlement. Therefore, LBA is not considered an effective stabilizer for these soil samples in terms of construction works.

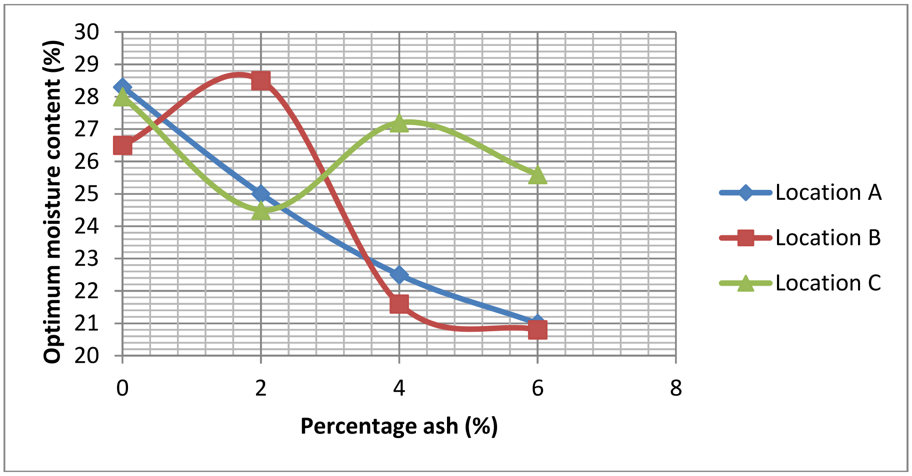

Figure-1. Plot of optimum moisture content against locust beans ash (%).

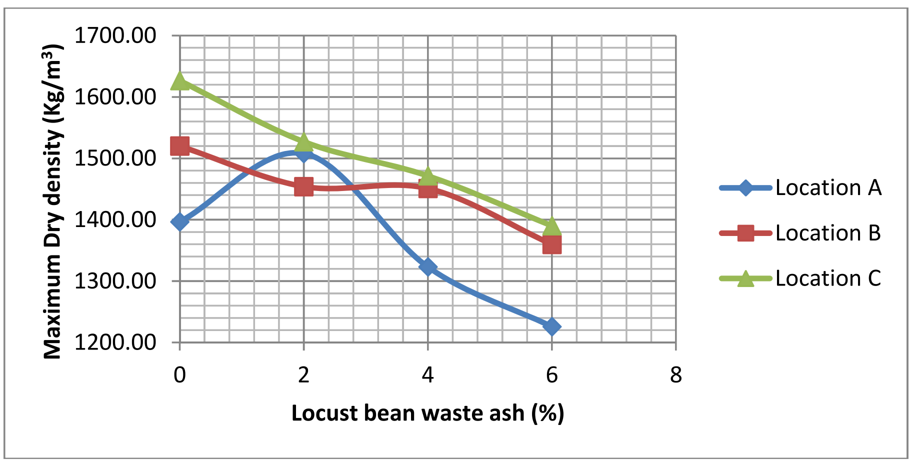

Figure-2. Plot of maximum dry density against locust bean ash (Kg/m^3).

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