An Experimental Study on Stabilization of Lateritic Soil Using Bitumen Emulsion

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***Abstract*: Soils are used as a road making material and they form the sub-grade of most tropical roads. They are used as sub-base and bases for low cost roads and carry low to medium traffic. Stabilization is a technique to be considered in improving the properties of soils and making them suitable for use in specific engineering project soil.**

This research studied the effect of bitumen on the geotechnical properties of lateritic soil. Two soil samples were taken at 1km interval, at 1.2m depth from RCC borrow pit along Lagos Ibadan express way and a small container of bitumen was also collected at RCC, Toll-gate Ibadan for the study. Classification and CBR test were carried out on the untreated samples and treated sample with different percentages of bitumen [0%, 25%, 50% and 75%] under unsoaked condition.CBR values of sample A for different percentages are 17.68N/m^2, 32.10N/m^2, 36.80N/m^2, 45.90N/m^2 while for sample B, CBR value are 15.68N/m^2, 36.85N/m^2 , 46.45N/m^2 , 58.80N/m^2. This result indicates that the addition of bitumen increased the CBR values of both soil samples. The experimental work shows bitumen is a promising soil stabilization agent and that there is need to find out the influence of bitumen on the properties of the soil under a longer duration of about a year.

***Keywords:* Lateritic soil, CBR (California Bearing Ratio), Bitumen, Stabilisation**

I. INTRODUCTION

Stabilization is a process of improving subsoil engineering properties prior to construction. This can be accomplished in several ways such as preloading of the grounds, application of high energy impacts, use of sand drains and sand filters, prefabricated wick drains, and chemical additives (Aziz, 2013).

The word laterite describes no material with reasonable constant properties. To those in the temperate countries, it could be described as a red friable clay surface. To those in the hilly tropical countries, it could be described as a very hard homogenous vesicular massive clinker – like materials with a framework of red hydrated ferric oxides of vesicular infill of soft aluminium oxides of yellowish colour and in less hilly country, it could exist as a very hard, or soft coarse angular red. Lateritic soils as a group rather than well-defined materials are most commonly found in a leached soils of humid tropics. Laterite is a surface formation in hot and wet tropical areas which is enriched in iron and aluminium and develops by intensive and long lasting weathering of the underlying parent rock (Amu et al, 2011).

Developments in the country have awakened the sense of economical resource management in the populace. People are being inspired to go back and take a closer look at the resources which they have earlier condemned, so as to find ways through which they could put such materials into use again. This is mainly because there is an increased competition for available materials as multiple uses of such resources are being discovered, and the cost of acquiring these suitable materials increases alongside. Major steps have thus being taken to make research into putting abandoned materials into full use again. Moreover, various studies are being carried out to discover better ways of achieving this goal, ways that will cost less and would be more economical when compared to using materials that naturally meet requirement standards, (Olugbenga et al, 2011).

In the road construction industry, there is much need for soil material in the construction of pavements. When a section of the road is to be filled with soil, the material is either obtained from other cut sections along the road or from a borrow site where the suitable material is present, if the material from the road does not meet the required standards. A major cost that would be incurred by “borrowing” soil material is that involved in hauling the material from the borrow site to the construction site. This cost, in terms of finance, resources, and time, could however be avoided by simply improving the characteristics of the road material that was earlier rejected, (Olugbenga et al, 2011).

Bitumen is a viscoelastic material, a black or dark-colored (solid, semi-solid, viscous), amorphous, cementitious material that can be found in different forms (Jenkins et al, 2003). Bitumen Emulsion is liquid asphalt cement emulsified in water. The emulsifying agent is sometimes called the surfactant, which is composed of large molecules. All bitumen emulsions are designed to eventually break, or revert to bitumen and water. Bitumen emulsion is a mixture of water & bitumen. We know that bitumen is a oil product and it cannot be mixed with water. That is why we add an emulsifier (a surface active agent) with water before adding bitumen. Addition of emulsifier with water facilitates breaking of bitumen into minute particles and keeps it dispersed in suspension.

Therefore we can say that a bitumen emulsion is a liquid product consisting of three things, (i.e. water + Emulsion + Bitumen) where droplets of bitumen are suspended in water.

When bitumen emulsions are applied on aggregates, water starts to evaporate causing separation of bitumen from water. And then bitumen spreads on the surface of the aggregate and acts as a binding material and slowly attains its strength.

Depending upon the speed at which water evaporates and bitumen particles separate from water, it is classified into following 3 types.

1. Rapid Setting Emulsion (RS)
2. Medium Setting Emulsion (MS)
3. Slow Setting Emulsion (SS)

Note: Here the word "setting" should not mean attainment of strength; rather it means the time taken by the bitumen to separate from water.

In case of rapid setting emulsion, bitumen is intended to break rapidly. Therefore this type of emulsion sets and cures rapidly.

Medium setting emulsions do not break spontaneously when applied on aggregates. But the process of breaking starts when fine dusts of minerals are mixed with aggregate-emulsion mix.

Slow setting emulsions are manufactured by using special type of emulsifier, which makes the setting process very slow. These types of emulsion are relatively stable.

Aim and Objective of the Study:

This research aimed at assessing suitability of bitumen as lateritic stabilized agent while objectives of the research were to determine the CBR values of the soil samples with and without the inclusion of bitumen emulsion under unsoaked condition and to investigate the effect of bitumen emulsion in stabilizing laterite soil.

II. MATERIAL AND METHODS

Since the aim of the project work was to establish the effects of bitumen used as stabilizing agents in laterite soil for engineering purposes, samples were obtained from two borrow pits in RCC, Lagos Ibadan express way. The samples were taken to the laboratory, air-dried for 24 hours and various tests such as particle size distribution, compaction and Atterberg limits were carried out. Varying bitumen percentages for both the samples A and B were applied, for each borrow pit sample0%, 25%, 50% and 75% of bitumen were batched. Samples were prepared for California Bearing Ratio (CBR) tests in order to establish the effect of those varying proportions on the strength of the lateritic material. The two borrow pits were located at RCC, Lagos Ibadan express way Nigeria, with a distance of 1km apart. The top soil of the borrow pit was removed before excavating to depth of about 1.2m. At the depth of 1.2m, enough samples were taken from the two borrow pit in bags, labeled for proper identification purpose and transported to the soil laboratory in University of Osun. At the structures laboratory, the samples were air-dried for 24 hours stock pilled separately and covered with polythene material to prevent moisture ingression.

Grain size analysis was performed to determine the percentage of different grain sizes contained within a soil sample. The sieve analysis was performed to determine the distribution of the coarser, larger-sized particles, and the hydrometer method was used to determine the distribution of the finer particles while Atterberg's test was performed to determine the plastic and liquid limits of a fine grained soil. The tests was carried out in accordance with BS 1377:Part 2:1990

The liquid limit is the moisture content that defines where the soil changes from a plastic to a viscous fluid state. The compaction test was carried out to find the optimum moisture content at which the maximum dry unit weight is attained for all the 2 samples A and B. The compaction method employed was that of Modified AASHTO.

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strengthof natural ground, sub-gradesand base courses beneath new carriageway construction.

The test was carried out on both samples A and B. For each of the sample, (Bitumen Emulsion) proportions was varied as follow 0, 25, 50 and 75.

Fig. 1 Soil Sample Collection

Fig. 2. Collected Soil Samples being air dried

III. RESULTS AND DISCUSSION

3.1. Result

3.1.1. Moisture Contents

Another parameter that changed in the course of the experiment was the moisture contents. Table 3.1 below showed the summary of water contents versus Bitumen contents for sample A soil. From the table, water contents increased with increase in the bitumen content. The highest values of water content were observed at 75% bitumen. The same trend was the case with sample B soil. Bitumen emulsion already contained water and emulsifier which added up to the OMC which at some level, could not hydrate before water content sample was taken.

Table 3.1.Summary of Moisture Content Versus Bitumen contents for Samples A and B

Bitumen Contents (%)	Moisture Contents Sample A	Moisture Contents Sample B
0	8.50	19.0
25	10.50	11.2
50	12.20	12.9
75	14.10	15.2

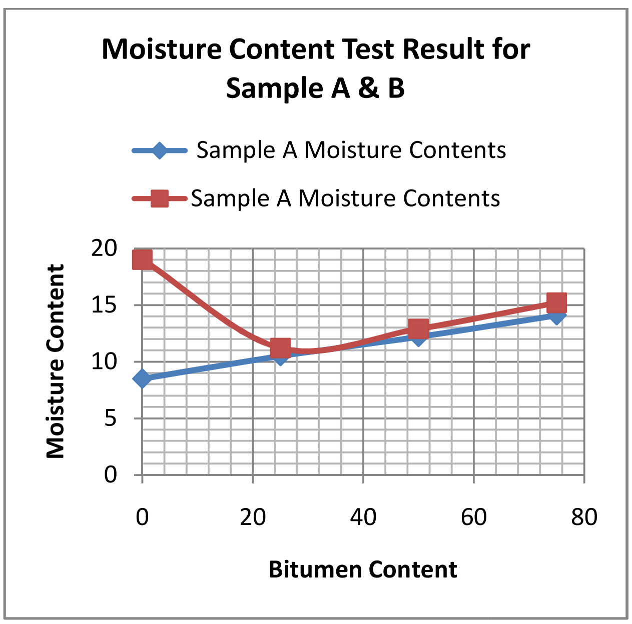

Fig 3.1 Moisture Contents Vs Bitumen Content for Sample A & B

3.1.2. Grain Size Analysis

The grain size analyses of the two soil samples A and B were carried out after each was thoroughly mixed together to produce homogeneous soil. Considering the figures 3.2 below, the results showed that the two soil samples were well-graded soils.

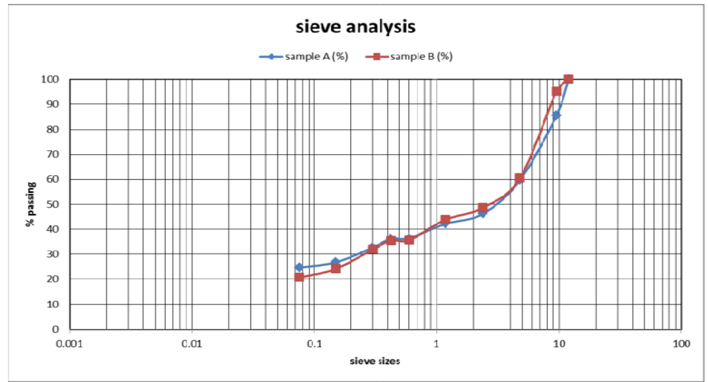

Fig. 3.2. Grading Curve for Sample A & B

3.1.3. Liquid Limit and Plastic Limit

The LL results for samples A is 34.40% and for B is 32.00%y. Also the PL results for samples A and B was 26.2 and 23.0 respectively. Why the Plastic Index for samples A and B were 8 and 9.

3.1.4. California Bearing Ration (CBR) Test

The California Bearing Ration Test was carried out on all the specimens from both samples A and B in order to ascertain the effect of the additive on the soils' bearing capacity.

Table 3.2.Summary of CBR Test result for Samples A and B

Bitumen content	CBR Value Sample A	CBR Value Sample B
Control (%)	17.68	15.68
25	32.10	36.85
50	36.80	46.45
75	45.90	58.8

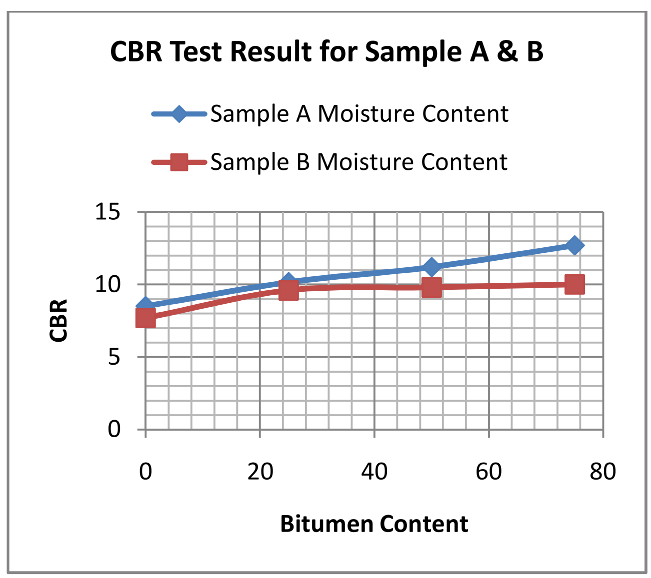

Fig. 3.3. CBR vs Bitumen Content for Samples A& B

3.2 Discussion

California Bearing Ratio (CBR)

From the results of unsoaked CBR for samples A and B respectively, it was observed that, CBR values increased with increase in bitumen proportion. The CBR value for the control specimen was 17.68% for sample A soil. Addition of 25% bitumen emulsion to the sample by weight, increased value to 32.86 percent CBR. Also, the CBR value increased as the percentage of bitumen increased at a specific mix proportion.

The Federal Ministry of Works' General Specification (Roads and Bridges) gave strength requirements in terms of CBR for road pavement structures on Nigerian roads. The minimum CBR value for subgrade was given as 20%, for sub-base, 30% and base material with 80% CBR values. Based on the results for samples A and B, the materials are suitable to be used as base course for road works after stabilized with 50% bitumen emulsion.

IV. CONCLUSION AND RECOMMENDATION

Conclusions

Laboratory tests were conducted on laterite soil using bitumen as stabilizing agents at varying proportions to determine strength parameters of the two sample of laterite sourced from two different locations in RCCC, Lagos Ibadan expressway. The CBR values were determined after 24hrs. After the collation and analysis of the results from the experiment, the following conclusions were made:

i. The soil samples experienced increase in strength as the proportion of bitumen content increased
ii. It was observed that as the proportion of bitumen content increased, moisture content of the samples increased which suggest that inclusion of bitumen should bring about reduction in content of water used during compaction.

Recommendations

The following recommendations were proposed.

1. *Bitumen is recommended as a promising soil stabilization agent*
2. Although the strength of the stabilized laterite is not in doubt, but chemical analysis of the reaction of bitumen emulsion needs to be investigated.
3. There is a need of investigating the durability of the stabilized soil to ascertain its suitability for rural road surfacing.
4. The result of moisture contents showed that water should be reduced from OMC when bitumen emulsion is used as stabilizer.

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