



THE PROPERTIES OF LATERITE SOILS AS THEY AFFECTS THE STABILITY OF BITUMEN STABILISED BRICKS

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Abstract:

The purpose of this study is to determine the properties of laterite soil and how they affect the stability of bitumen stabilized bricks. The samples for the study were disturbed samples sourced in seven locations in Adamawa State. Each sample weigh 20kg transported to the laboratory for tests. The tests conducted include: Sieve Analysis, sedimentation Test, Liquid Limit Test, Plastic Limit Test, Activity Ratio, Free Swell Test and Optimum Moisture Content Test. Three research questions guided the study and the findings of the study include; that the samples shows increase percentage smaller or less than 63 microns sizes, which indicate that the samples are more of silt and clay particles. The properties of the laterite soils taken for the study include; liquid limit ranging from 35-49, plasticity index from 11-14 percent, the activity ratio ranges from 1.0-1.4, and free swell test shows less than 100 percent. One of the recommendations made was that, Laterite soil stabilization should precede a study of the particles size distribution to ensure that the categories of the Laterite soil can bland with the bitumen emulsion to envelop the particles for the purpose of preventing moisture movement in the bricks.

Keywords: Properties; Bitumen; Stabilized; Laterite; Brick.

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1. Introduction

Laterite soil is a term used to describe all the reddish residual and non residual tropically weathered soils which generally form a chain of materials ranging from weathered rock through clay to sesquioxide, (Olusola, 2005). According to McHenry (2005) the use of laterite dates back to the Stone sundried Ages when man began to live in brush shelters that were covered with laterite to prevent wind and water penetration. McHenry (2005) went on to say that man's ingenuity created solid walls of laterite that were stronger and lasted longer, it was later that the production of bricks started with hand shaped lumps which evolved into the use of mould of a particular size. The bricks in their primitive form were not fired but were sun dried. John (2004) reported that approximately 30 percent of the world present population still lives in laterite structures.

One of the main advantages of laterite materials is that it does not excessively swell or shrink in moisture variation. Laterite is rich in crusts generally known as carapace which is stabilized to improve the quality of the laterite material and its mechanical properties. Improved laterite cohesion by stabilizers are commonly used in both rural and semi urban housing construction.

Improving the cohesion of laterite soil for brick production and construction purposes using stabilization are very complex because many parameters come into play. Ameli (2001) noted that the knowledge of soil properties help to better consider what change the economic studies as well as production and construction techniques to use. The process includes heat treatment, or mixing laterite soil with ordinary Portland cement, lime, bitumen etc.

The major weakness of laterite bricks as reported by Kenley (2001) is moisture absorption when wet; this weakness is rectified by bitumen stabilization which acts as water proofing material in a solid brick (Enkerta 2008). Bitumen stabilized laterite bricks do withstand water penetration such as during rain or flood as it will absorb less moisture. John (2004) reported that the horizontal surface of top walls erode due to rains at the rate of 51-76mm per annum if the bricks are not stabilized. Stabilized laterite bricks can be made by adding sufficient quantity of water (up to 10-15%) and a stabilizing agent such as bitumen emulsion, lime or Portland cement to the mix during the brick production. Similarly, a stabilized laterite brick absorbs less than 4% moisture during moisture penetration test (Kenley, 2001).

The idea of laterite stabilization according to Kenley (2001) includes; The improvement of the strength requirement of laterite and provide cost effective construction materials. The elimination of certain undesirable properties of laterite, such as excessive swelling and shrinkage. Adequate compaction to reduce moisture movement and increase the load bearing properties in the laterite products.

In trying to describe bitumen Olusola (2005) stated that bitumen is a mixture of hydrocarbon, and the common types of bitumen used in building construction is the one that becomes viscous or soft and flows when heated. Generally, the properties of bitumen include impermeability to water, resistance to acid and alkalis, and it is mostly black in colour. According to Stulz (2004) bitumen are thermoplastic therefore softens on heating and solidifies on cooling. It resists corrosion, oxide alkalis and sodium solution.

Jackson and Dhir (2004) reported that bitumen is generally characterized by its impermeability to water, resistant to acids and alkalis, black or brown in colour unlike coal tar pitch. Bitumen is not brittle when hard, but softens gradually when heated. The properties of bitumen are dependent on the rate of temperature exposed to it. In contrast to many other materials such as steel where properties are for practical purposes which are constant, the behaviour of bitumen under stress would vary from elastic to viscose, according to condition of stressing. Under stress of short duration and at low temperature bitumen behaves purely elastic whereas under conditions when the stress is applied for a long time at high temperature the behaviour is purely viscous.

2. Purpose of the Study

The general purpose of the study is to determine the properties of laterite soil as they affect the stability of bitumen stabilized bricks. The specific purposes include;

- 1) To determine the particle size distribution of the laterite soil sample taken for the study.
- 2) To determine the properties of the Laterite soil sample taken for the study.
- 3) To determine how the properties of Laterite soil affect the stability of bitumen stabilized bricks.

3. Research Questions

The following research questions served as a guide to the study

- 1) What are the particle size distributions of the laterite soil sample taken for the study?
- 2) What are the properties of the laterite soil sample taken for the study?
- 3) How does the properties of Laterite soil samples affect the stability of bitumen stabilized bricks?

4. Experimental Procedure

The experimental procedure will begin with samp colectionle of the required sample to be conveyed to the laboratory for the tests.

4.1. Sample and Sample Collection

The samples collected for the study were in seven locations. Disturbed samples were collected in Madgali, Michika, Hong, Mubi North, Mubi South, Maiha, and Gobi, all in Adamawa State. 20kg each of the samples were conveyed in jute bags for laboratory analysis which includes: Particle size analysis, sedimentation test, free swell test, Optimum Moisture Content, Liquid Limit test and Plasticity test were conducted. The results of the analysis are shown on table 1&2.

The samples were collected using pick axe, shovel, head pan, Jute bags, and weighing scale and were conveyed to the laboratory for analysis.

4.2. Tests Conducted

1) Optimum Moisture Content

The tests conducted were carried out to determine the moisture content of the samples of laterite soil obtained for the study. This was done by weighing the dry sample and the wet samples to determine the difference in percentage moisture content. To achieve the desired result the values of the dry weight was reduced from the wet weight and the result was the water absorption rate of the samples given in percentage.

2) Laboratory Classification Test

The Unified soil classification system was used to classify the various samples of laterite soil samples taken for the study.

(a) Mechanical Sieve Test

Table 1: Particle Size Analysis.

Sample No	Percentage Passing			%Liquid Limit	%Plastic Limit
	2 microns	0.425	63microns		
1	99.8	89	95	41	25
2	98.9	87	91	49	24
3	99.6	90	92	39	22
4	98	93	94	35	23
5	97	93	39	49	20
6	97.5	94	92	42	25
7	98	91	55	45	22

Table 1, expresses the percentage passed BS sieves 63 microns are silt and clay which values ranges from 39-95. The liquid limit values range from 35-49 percent, the plastic limit range between 20- 25. And percentage passing BS sieve 0.425mm ranges from 87-94 percent.

(b) Sedimentation Test

The test was conducted in accordance with British Standard 1377; 1975. This is carried out using hydro-meter analysis for the determination of particle size distribution, applying sodium phosphate as dispersant. This was used to determine the particle size distribution up to micron sizes.

3) Free Swell Test

Free swell test is performed by slowly pouring 10cc of dry soil passing BS .425 microns sieve into 100cc graduated cylinder filled with water and noting the swollen volume of soil after it comes to rest at the bottom. This is computed using the following equation;

$$\text{Free Swell} = \frac{V - V^1}{V^1} \times 100\%$$

V=Soil volume after swelling in cc and

V¹=Soil volume before swelling (10cc)

The free swell value for soil with swell potentials above 100%

Table 2: Properties of Laterite soils samples obtained for the study.

Sample No	Plasticity Index	%Liquid Limit	%Plastic Limit	%Activity Ratio	%Free Swell	%Optimum Moisture Content
1	12	41	25	1.0	85	10
2	13	49	24	1.0	84	11
3	13	39	22	1.2	85	12
4	12	35	23	1.3	80	12
5	11	49	20	1.2	91	13
6	14	42	25	1.4	90	13
7	13	45	22	1.2	80	10

Table2 shows the properties of the laterite soil samples obtained for the study. The percentage liquid limit ranges from 35-49 percent, the plastic limit ranges from 20-25 percent, the plastic

index ranges from 11- 14 percent. The free swell ranges from 80-90 percent, while moisture content ranges from 11-13 percent and the activity ratio ranges from 1-1.4 percent.

5. Findings of the Study

- 1) The particles size distribution of the samples taken shows increase percentage smaller than 63 microns size with percentage smaller than 2 microns which indicate that the samples contain silt and clay particles. Other particle sizes are in less percentage.
- 2) The properties of laterite soil sample taken include percentage liquid limit ranging from 35-49, plasticity index of between 11-14 percentage, activity ratio is between 1.1-1.4, optimum moisture content between 10-13 percent and free swell results is 80-90 percent.
- 3) The properties of the laterite soil samples shows minimal swell potentials as the plasticity index are below 15% for most samples and free swell below 100% and percentage particles smaller than 1 micron. The activity ratio of all the samples is above 1 %. These results indicate that the Laterite soil samples are moderately stable; the mechanism responsible for swelling and shrinkage phenomenon in the laterite samples taken can be stabilized by bitumen stabilization. The instability inherent in Laterite soils affects the stability of bricks by way of moisture penetration that leads to disintegration process and cracks on drying.

Laterite soil is vulnerable to change due to its rapid moisture absorption especially when exposed to persistent moisture variation in wet seasons, so measures adopted reduces the moisture movement by way of stabilization to envelope the Laterite particles as repellent substances to reduce moisture movement in the properties.

6. Discussion of Findings

The laboratory test data on table 1 shows that the laterite soil samples taken for the study shows variation in the particle sizes distribution. The percentage content of silt, clay, liquid, and plastic limits and swell potentials shows that Laterite soil should be studied and categorized according to the level of particle sizes; liquid limits, plastic limit and free swell. Edmond (2006) made similar comments on the importance of making design specification he developed for specific categories of laterite soil. It is therefore very necessary to determine the category of laterite soils in an area to design specification for the category encountered in a particular area.

The properties of Laterite soils sample indicate a moderate level of activeness with activity ratio less than 1.5 percent, moisture content of 10-13 percent and free swell potential less than 100% and liquid and plastic limits range from 20-25 percent according to US Corps of Engineers and modified by Transportation and Road Research Laboratory (TRRL) (2000) the percent swell must be limited so that the rate of swelling must be restricted to as low as practicably possible. The design strength in the field must be maintained irrespective of moisture variations, settlement and strict acceptance criteria for insitu density. Moisture content should be adhered to so as to minimize the activities of the laterite properties such as expansion and shrinkage, surface deformations and settlements in construction elements.

7. Recommendations

- 1) Laterite soil stabilization should be done after a study of the particles size distribution to ensure that the categories of the Laterite soil can blend with the bitumen emulsion to envelop the particles for the purpose of preventing moisture movement. The category of the laterite soil will help in determining the ratio of bitumen to a measure of laterite sample during the stabilization process.
- 2) The Laterite soil stabilization to improve the stability of the properties for brick production should reflect the accurate determination of the properties of the soil to minimize the effects of the soil behavior as indicated by the properties of the soil samples taken for the study.

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