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## OPTIMUM PERFORMANCE OF STABILIZED EDE LATERITE AS AN ALTERNATIVE CONSTRUCTION MATERIAL

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### Abstract:

*Laterite samples from Ede area with particle components of 19.7% clay, 32.8% silt and 47.5% sand was stabilized with combined cement, lime and bitumen and test for Compressive strength, Linear Shrinkage, Permeability and Water Absorption. The stabilizers were mixed with laterite soil in different ratios and percentage. The laterite carried 90% which is constant while the three stabilizers shared the remaining 10% in varying form. After 28 days of curing, laterite stabilizer with 90% of laterite, 8% of cement, 1% lime and 1% bitumen (LCLB1) possessed compressive strength of 2.01N/mm<sup>2</sup>. Its Water Absorption Capacity was 3.05%. LCLB4 stabilizer (90% laterite, 6% cement, 2% lime and 2% bitumen) has the same compressive strength with LCLB1 stabilizer but with a high Water Absorption Capacity of 4.2%. The stabilizer of 90% laterite, 3.33% cement, 3.33% lime and 3.33% of bitumen (LCLB8) has the lowest compressive strength of 0.74N/mm<sup>2</sup> and the highest Water Absorption Capacity of 5.39%. The results show that LCLB1 stabilizer is a better stabilizer for strength and blocks made from laterite stabilized with it stand a good alternative to sandcrete blocks in building constructions. The combination of these stabilizers in order to determine a most economical volume combination for optimum performance is highly possible and economical.*

### Keywords:

*Laterite; Compressive Strength; Water Absorption Capacity; Linear Shrinkage; Curing; Cement; Lime; Bitumen; Stabilized.*

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## 1. INTRODUCTION

Building materials constitute the largest single input in housing construction. According to Adedeji (2010) sixty percent of housing expenditure often goes for the purchase of building materials. Cost of building materials also constitute about 65% of the construction cost (Arayela, 2005). To address this issue consideration needs to be given to locally available materials like LATERITE.

Laterite is an old and popular construction material that has served humanity for centuries now. It is a locally and naturally available material in highly weathered tropical areas. It contains

varying proportion of iron and aluminum oxides (UNESCAP, 1989). Laterite is used for construction purposes both in highways and foundation. It depreciates fast in strength under load. One of the best ways of improving its performance is by stabilization, using stabilizers like cement, lime, bitumen etc. These are some of the constituent that has been found to be more effective in soil stabilization since the strength and stability are the required properties. Some earlier works on laterite was stabilized with straw and wood shavings showed an improvement in the compressive strength over the plain laterite.

Laterite possess a major attraction which is it cheapness. If it should be stabilized, it is possible to produce a construction material out of it which can compete with other materials like sand Crete blocks and serve as an alternative.

Cement is a bounding agent that react with water and hardens by carbonation in the presence of carbon dioxide which naturally present in air. Lime is a dry cementations product obtained by calcining a limestone containing silica and alumina to a temperature short of incipient fusion to form sufficient free lime to permit hydration and at the same time leaving un-hydrated sufficient calcium silicates to give the dry powder. While bitumen is a gooey substance mainly of high molecular hydrocarbons that are usually black and used as binding materials. It also serves as a water proofing agents in engineering constructions.

This presentation gives a laboratory test programme designed to determine the major parameters of the optimum performance of construction materials, but for laterite stabilized with combined cement, lime and bitumen at different ratios. The parameters are Compressive Strength, Water Absorption Capacity, Linear Shrinkage and Permeability. British Standard Institute procedures and ASTM Standards were adopted in the tests.

The combined cement, lime and bitumen stabilized laterite is abbreviated as LCLB1 (90%, 8%, 1%, 1%) ; LCLB2 (90%, 7%, 2%, 1%); LCLB3 (90%, 7%, 1%, 2%); LCLB4 (90%, 6%, 2%, 2%); LCLB5 (90%, 5%, 3%, 2%); LCLB6 (90%, 5%, 2%, 3%); LCLB7 (90%, 4%, 3%, 3%); LCLB8 (90%, 3.33%, 3.33%, 3.33%) and zero stabilized laterite as ZSL for ease of reference. Hydrometer test was conducted on the sample to ascertain the credibility of the laterite before applying the stabilizers. The laterite used fell within the recommended limits of particle distribution for soil blocks.

## **2. MATERIALS AND METHODS**

### **2.1.PREPARATION OF MATERIALS**

Cluster of laterite was collected near the premises of the Federal Polytechnic, Ede. After air drying the clusters were broken down into simple particles for ease of mixing and to maximize surface area contacts during mixing. To further ascertain it properties, particle size distribution and compaction tests were conducted on the laterite.

Ordinary Portland cement of freshly bought “Elephant Cement” brand was used which exhibited all the qualities of a good cement by visual means, touch and hydration. A good quality brand of

lime purchased from the market was used. The bitumen used was heated for 35 minutes with kerosene which is a volatile solvent until it was fluid enough to be mixed with the laterite soil. The water used was clean and free from impurities.

## **2.2.MIXING**

Mixing proportion was specified by volume. The dry mix process was used. It involves thorough mixing of any of the cement, lime and bitumen stabilizers with laterite in their dry state before gradually adding water while the mixing process continues to a required consistence. The mixing was done manually and thoroughly so as to avoid segregation.

## **2.3.COMPACTION AND CURING**

The mixed materials were introduced into 150x150x150mm cube moulds in three layers with hand trowel. Each layer receives a thorough compaction using the 2.4kg rammer. Three samples were prepared for each experiment on different ratio from which averages were determined. The specimen were demoulded after 24 hours and cured by plastic sheeting with black polythene bag to ensure air tightness and prevent evaporation of water for the number of days of curing.

## **2.4.TESTING**

The Compressive Strength test was carried out in line with British Standards Specifications with a compression machine. The compressive strength is the ratio of the crushing force and the cross sectional area of the sample. The weighing of the specimen was conducted before crushing for density determination.

Water Absorption Capacity test was conducted by weighing 28 day sample after which they were re-weighed again after soaking in water for 24 hours. The water absorption capacity is the ratio between the difference in weight and the initial weight, expressed in percent.

The Linear Shrinkage test was carried out by first measuring the length of a sample after demoulding and re-measured after 28 days of curing. The Linear Shrinkage is the ratio of the difference in length and the initial length, expressed in percent.

The Falling Head Permeameter was used in the permeability test. The coefficient of permeability was determined from the equation:

$$K_T = 3.84 \frac{al}{At} \log_{10} \left( \frac{h_1}{h_2} \right) 10^{-5} \text{ m/s}$$

Where a = area of stand pipe in mm<sup>2</sup>

A = area of core cutter of the cell in mm<sup>2</sup>

t = time taken in running the test

h<sub>1</sub>/h<sub>2</sub> = height ratio

l = sample length

### 3. RESULTS AND DISCUSSIONS

The result of compressive Strength, Density, Water Absorption Capacities, Linear Shrinkage in table 1 to 3. The results show that increase in percent stabilization improved the performance characteristics in the sample, i.e. higher Compressive Strength, lower Water Absorption Capacities and lower Linear Shrinkage.

**Table 1:** Average Compressive Strengths and Densities of ZSL and LCLB1- LCLB8 for 28 days curing period

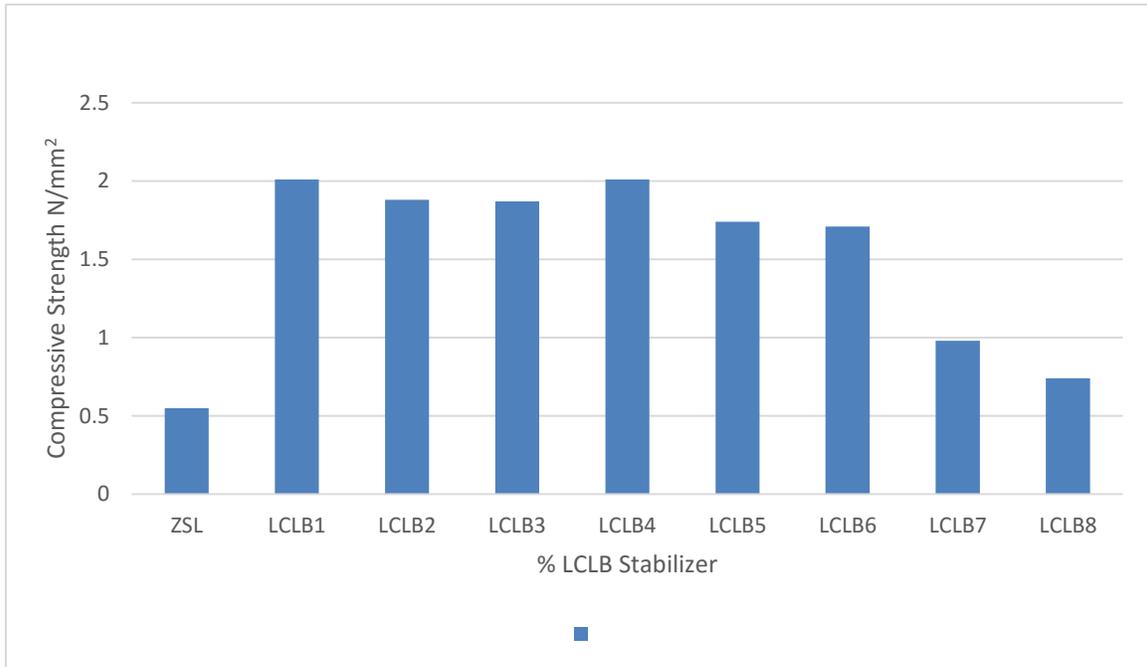
Type of Stabilized Laterite	Curing Periods (day)	Average Cube Density (kg/mm <sup>3</sup> )	Average Crushing Load (KN)	Average Compressive Strength (N/mm <sup>2</sup> )
ZSL	28	1946	12.5	0.55
LCLB1	28	1936	45.3	2.01
LCLB2	28	1896	42.3	1.88
LCLB3	28	1896	42.0	1.87
LCLB4	28	1867	45.3	2.01
LCLB5	28	1817	39.0	1.74
LCLB6	28	1807	38.3	1.71
LCLB7	28	1801	22.0	0.98
LCLB8	28	1673	16.7	0.74

**Table 2:** Average Linear Shrinkage test values for Stabilized Laterite at 28 days curing periods.

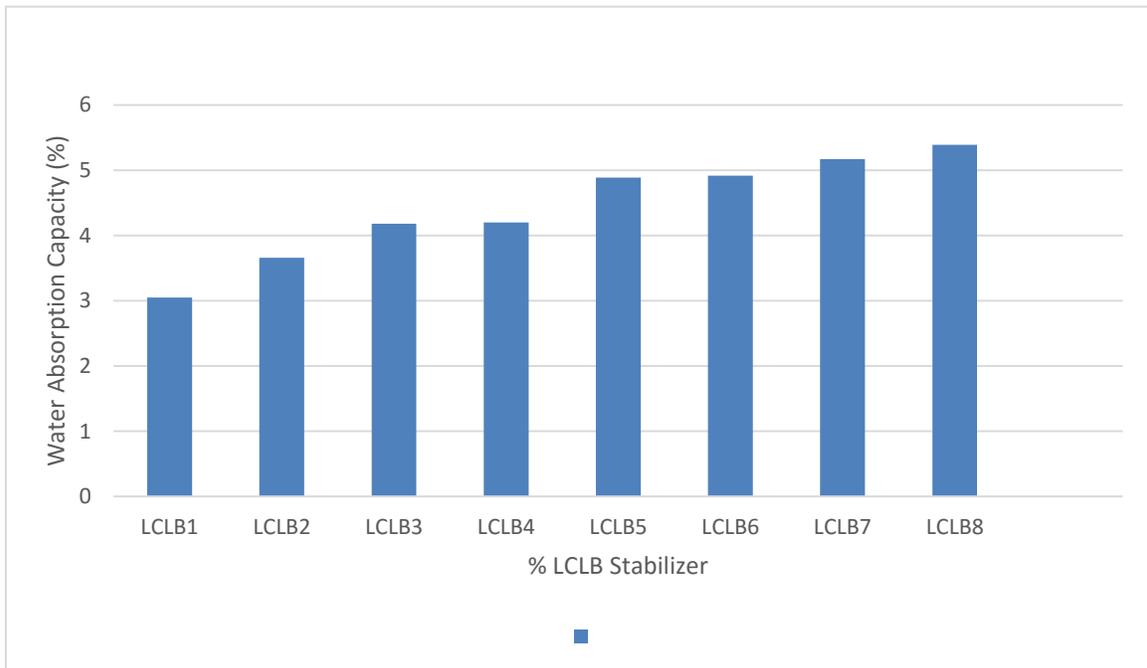
Type of Stabilized Laterite	Linear Shrinkage percent
ZSL	3.22
LCLB1	0.45
LCLB2	0.56
LCLB3	0.78
LCLB4	0.89
LCLB5	1.0
LCLB6	1.0
LCLB7	1.22
LCLB8	1.33

**Table 3:** Average Water Absorption Capacity test value for Stabilized Laterite at 28 days curing periods.

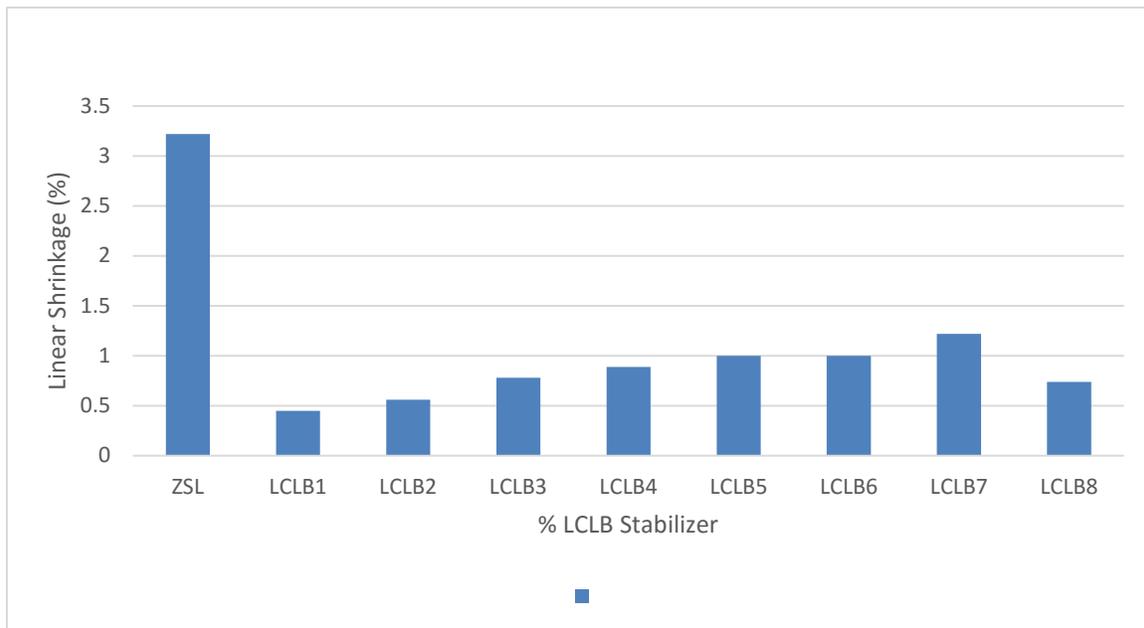
Type of Stabilized Laterite	Water Absorption percent
LCLB1	3.05
LCLB2	3.66
LCLB3	4.18
LCLB4	4.20
LCLB5	4.89
LCLB6	4.92
LCLB7	5.17
LCLB8	5.39



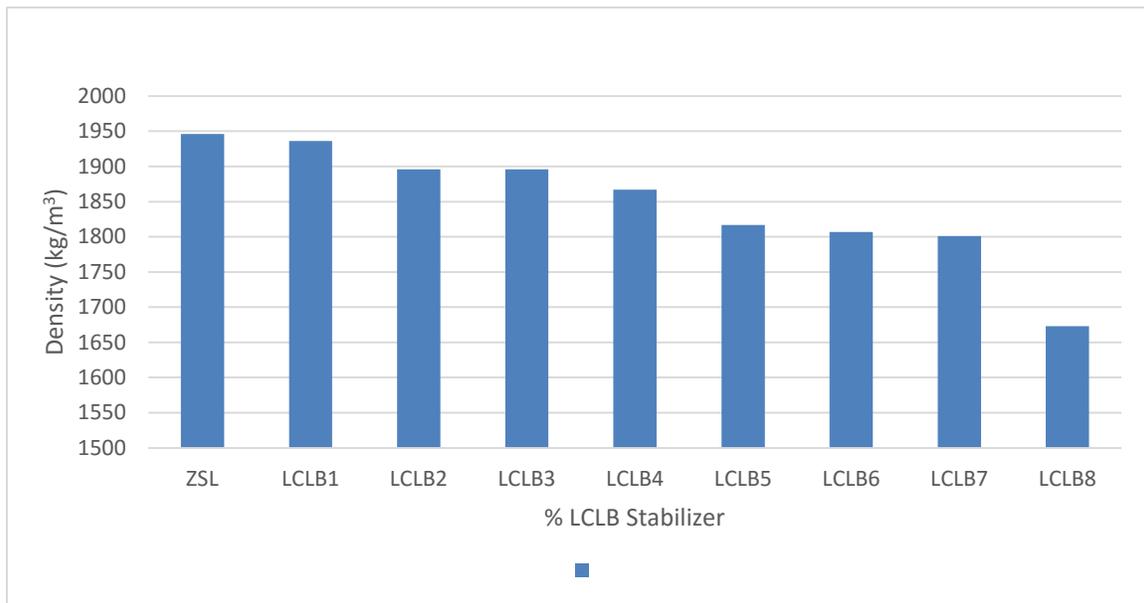
**Figure 1:** Compressive Strength of 28 days stabilized laterite.



**Figure 2:** Water Absorption Capacity of 28 days stabilized laterite.



**Figure 3:** Linear Shrinkage of stabilized laterite



**Figure 4:** Density of stabilized laterite.

### 3.1.DISCUSSION OF RESULTS

The increase of Compressive Strength with age is expected as most building materials show the same trend. The densities however decreased with age indicating that the rate of mass reduction of sample materials as a result of loss of moisture is greater than the rate of volume loss as a result of shrinkage.

Based on the result of compressive strength, the effect of each ratio of the combined stabilizers used quite revealing. The 28 day strength of 2.01N/mm<sup>2</sup> for LCLB1 is almost up to the recommended strength of 2.50N/mm<sup>2</sup> for sand Crete blocks (NS0, 1995). Also, the strength of LCLB1 and LCLB4 are the same in the terms of compressive strength. It is also observed that plain laterite (ZSL) possessed almost as much strength as LCLB8 combined laterite stabilizer. LCLB2, LCLB3, LCLB5 and LCLB6 strength of 1.88N/mm<sup>2</sup>, 1.87N/mm<sup>2</sup>, 1.74N/mm<sup>2</sup> and 1.71N/mm<sup>2</sup> respectively also exceeded the minimum recommended strength of 1.5N/mm<sup>2</sup> for building bricks.

LCLB1 has less water absorption capacity as the water absorption capacity of the sample increase just as the percentage changes in ratio. This shows that LCLB1 may improve compressive strength and may be used as a plastering material due to its low water absorption capacity and less shrinkage to ZSL.

The higher strength by LCLB1 and LCLB2 is connected with the relatively higher sand content in the laterite with which cement binds well. Due to previous test conducted on locally produced sand Crete blocks with an average compressive strength of 1.47N/mm<sup>2</sup> after 28 days of curing, shows that LCLB1 may be at par with the locally produce sand Crete blocks in Ede. Apart from that, it's far more affordable due to its 90% laterite component which is cheaper and much available in abundant.

#### 4. CONCLUSIONS & RECOMMENDATIONS

With the result, combination of the stabilizers could produce a most economical volume for optimum performance. From the result, the higher compressive strength possessed by LCLB is connected to the quicker setting time of cement.

Also average densities for all of the materials are above 1600kg/m<sup>3</sup>, which is recommended for maximum density for light-weight concrete (Department of Environmental, 1973). Therefore, the combination of the stabilized laterite can be used as an alternative construction material especially as light-weight building materials.

In view of the foregoing, combined stabilized materials exhibited higher performance characteristic over plain laterite. This confers merit to the combined stabilized material over plain laterite in low cost engineering constructions.

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