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Mechanical Study of Stabilised Earth Bricks with Eucalyptus Ash

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ABSTRACT

Background: Given the growing concern and awareness regarding sustainable building material and environmental issue, Stabilized Earth Brick (SEB) gives the view of energy efficiency and the cost reduction of materials. And due to the limited supply of sand for cement blocks/bricks and the price of cement to be used for construction as well as the weak bricks and expensive nature of importing fire bricks in our locality. Materials: This research was aimed at stabilizing earth from a pit at BANGSHIE with eucalyptus ash to be used for construction which was achieve by sitting apart the soil at a depth of (50-100) cm from the earth surface and some Geotechnical studies carried out. Results: The studies show that the laterite was a clay material composed of 0.6% gravel, and 14.7% sand, and the optimal dry density of 1.608 g/cm^3 and water content 21.2% from the proctor test. The Atterberg limits test has also reveal that the soil had liquid limit of 60.0, plastic limit of 50.0 and the Plasticity index of 10.0 from which our soil was classify as A-5 using

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the universal soil classification system. Fifty-six (56) samples with 0 %. 5%, 10 %, 15 %, and 20 % of eucalyptus ash were moulded and the compressive strength, and total water absorption test carried out which revealed that the more the percentage of eucalyptus wood ash (EWA) the more the strengths and water absorption. With the maximum compressive strength of 1.56 MPa, and water absorption of 10.04% after 28 days. Conclusion: From these results, it was seen that for works in non-humid environment the percentage of EWA should be 20% and are economical as per using other construction materials such as the sand, cement and sundry brick.

Keywords: Eucalyptus Wood Ash, Stabilized Earth Bricks, Compressive Strength, Water Absorption.

INTRODUCTION

Construction with earth (soil) is a form of sustainable architecture. It can be said that one [1]. Primitive man did little more than stick mud on poles woven closely together. But even with this, he found shelter that would be wherever he wanted, having an advantage to move around. Today, there are earth dwellings in many parts of the world that have endured centuries. Climate is an important factor when deciding where to build an earth dwelling. They have a better performance in arid regions, where there is no more than 64-76 cm (25-30 in.) of rainfall a year [1]. The civil construction sector is of great importance for humanity because there is an economic investment linked to it in society. Along with this growth, the need to produce sustainable materials arises, which meet technical requirements, as well as conventional materials, and contribute to the reduction of both solid waste and extraction of natural materials. To do so, it is necessary to better use the waste, whether generated by civil construction itself or waste from other segments, such as industrial waste. The demand for cement in the construction industry promotes production and is a determinant of the cement subsector's energy consumption and CO_2 emissions. Adopting material efficiency strategies to optimize cement use would help reduce demand across the entire construction value chain, helping to reduce CO_2 emissions from cement production. The reduction in cement demand can be achieved through actions such as optimizing the use of cement in mixtures [2]. It is known that many industries adopt the generation of energy in the form of heat by burning wood, thus producing a large amount of waste, including wood ash; [3]. Researchers have been improving their studies, demonstrating the possibility of using wood ashes in construction materials, presented as an opportunity for reuse from the study of its physical-chemical and mineralogical composition; [4,5]. Researchers analysed 11 types of wood ash and recorded that, 10 types of ash showed a predominance of calcium oxide (CaO: 31.5%-79.8%) and one type of silicon dioxide (57.8%). [6-10].

The principal objective of the paper is to produce stabilize earth brick from laterites with eucalyptus wood ash to be used for construction.

MATERIALS AND METHODS

Materials

The materials used for this research were soil (clayed soil) and wood ash from eucalyptus ash. The soil sample was collected from Bangshie, Bamendankwe in Bamenda North West region of Cameroon. The soil used was taken from a pit containing stone dug for construction and was excavated at a depth of 50-100 cm after we had cleared the vegetable soil since it has high

amount of Iron and Aluminum after which a small amount was collected for the natural water content and the other air dry for the other test such as the grain size analysis and so on. The wood ash was gotten from waste from eucalyptus such as saw dust and eucalyptus wood which was then burnt in other to obtained wood ash. Also, some of the ash was gotten from charcoal production. Given the fact that it's difficult getting much ash from eucalyptus, we had to grind charcoal to add to the ash since all are waste from eucalyptus which was then used. All this was done in mendankwe forest.

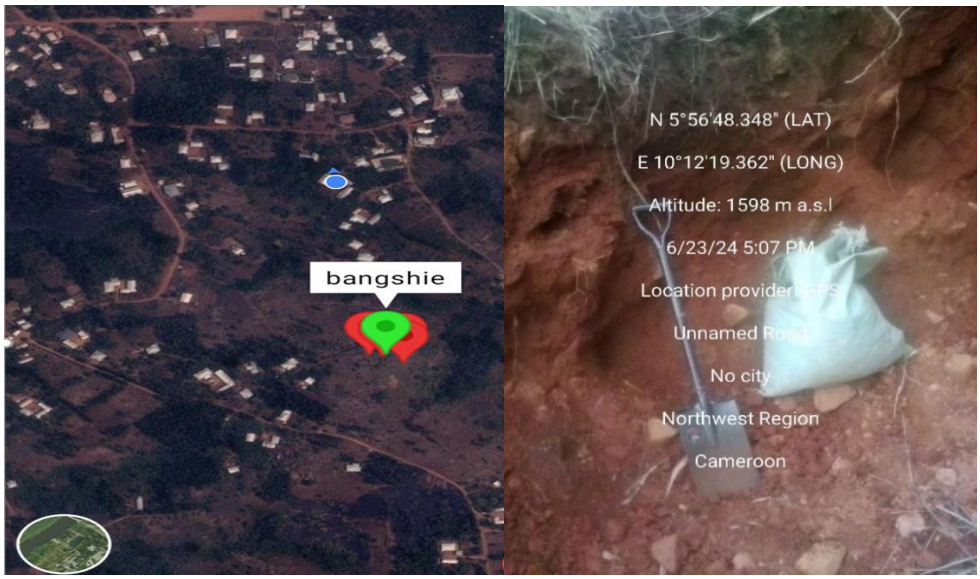


Figure 2.1: location of the site (Google earth)

Methods

Geotechnical Properties:

The ASTM D 2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures was used to obtain the engineering properties of soils (water content) [11]. The grain size analysis was determined by dry sieving method according to EN 933-2 norm [12]. The coefficient of uniformity (Cu) and coefficient of curvature (Cc) was also determined which help us to classify the laterite as poorly graded or well graded based on the Unified Soils Classification Systems. The Casagrande method was used to determine the liquid limit and the roller method to determine the plastic limit. The difference between the liquid limit and plastic limit gave us the plasticity index (PI= WL-PL). These measurements were obtained according to ASTM D 4318 – Standard [13]. The modified Proctor test was carried out in accordance with NF P94-093 (1999) standards [14]. The curve of modified Proctor permit to determine the optimum moisture content (OMC) and obtain the maximum dry density (MDD). The MDD is a good indicator of the compactness and bearing capacity of the soil after sufficient compaction.

Preparation of Sample:

The earth collected from BANGSHIE and was brought to the laboratory (BEST) for preparation work

- The soil was air dry and a small quantity was taken for the natural water content.

- Some small quantity was suck in water for the grain size and ATTERBERG Limit test.
- The soil was sieved to obtain a grain with maximum diameter 20 mm.
- The sieved ground was put inside the oven for at least 24 hrs.
- After that 24 hrs. It was removed and weighed to determine the water content.
- The required quantity of the material was measure plus the various quantity of eucalyptus ash (0%, 5%, 10%, 15%, and 20% using a scale balance.
- 5200 g (5.2 kg) of soil for each mixture was taken and each percentage is calculated and mixed with the laterite for moulding.
- The weigh sample plus the quantity of ash were put in the mixing tray.
- The sample was dry mix for at least 2 minutes with a spatula
- Water was added and remix for another 2 minutes till the mixture was saturated
- The various mould was prepared and oiled, the sample was then casted inside in three different layers with each layer given 15 blows per layer. This blow was given with a locally made rammer weighing approximately 1000 g (1 kg).

Mechanical Properties:

After the classification of the soil, 56 sample were moulded with 28 samples of size (7*7*7) cm^3 for compressive strength using the compressive strength test machine and 28 samples of size (4*4*16) cm^3 for water absorption test as shown on the table 2.2 below. The water absorption test was done with some of these samples using a sensitive scale balance and also the compressive test machine was used to determine the compressive strength of the brick after 7, 14 and 28 days.

Table 2.1: Sample preparation (field data)

Sample proportion	Numbers of bricks	Dimensions for compression test (cm)	Dimensions for tensile test (cm)
0%	16	7*7*7	16*4*4
5%	16	7*7*7	16*4*4
10%	8	7*7*7	16*4*4
15%	8	7*7*7	16*4*4
20%	8	7*7*7	16*4*4

NB: the quantity of water for the compressive strength test was determined with the used of the PROCTOR test as well as the degree of compaction that is the number of blows. After moulding the sample, the following tests were done: Compressive test, water absorption test

RESULTS AND DISCUSSION

Results

Natural Water Content:

Table 3.1: Natural water content result (field data)

WATER CONTENT		
Can number	U	07
Total weight wt.	200	200
Total dry weight wt.	174.0	173.62
Weight of can	28.4	25.69
Weight of water **humid weight – dry weight**	26.0	26.38

Weight of dry soil **Dry Weight – Weight of Can**	145.6	147.93
Water content % $w = \frac{M_w}{M_s}\ x\ 100$	17.85	17.83
Average	**17.84**	

Grain Size Analysis:

Below is the result of the grain size analyses test carried out at BEST lab in Ayaba Street, Old town Nkwen Bamenda. The graph of figure 3.1 show the various sieve sizes used for this test as well as the percentage of passing. This test will help us to classify the soil and know the different grain sizes present in the soil.

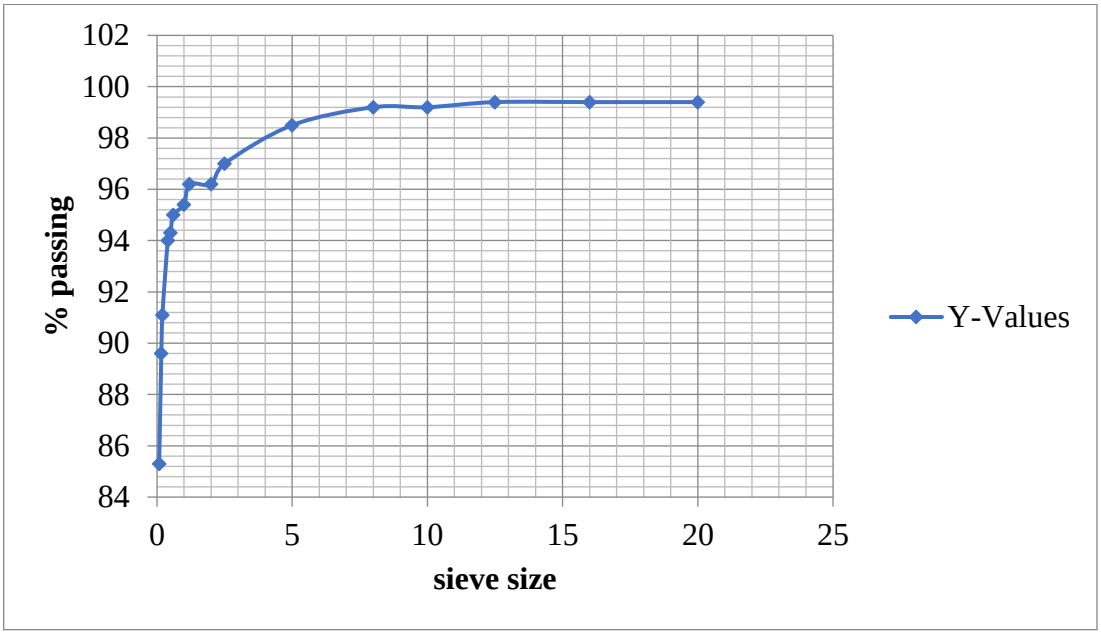


Figure 3.1 Grain size analysis curve results plotted with the percentage of passage against sieve size

Determination of Specific Gravity:

Table 3.2: Determination of Specific Gravity

SOIL		
Test number	SGT01	SGT02
Weight of PICNO (M1)	392.88	399.92
Weight of soil (Ms)	200	200
Weight of PICNO +soil+water (M3)	871.04	979.11
Weight of PICNO + water (M4)	775.38	877.39
Specific weight **Gs=**$\frac{ms}{(m4-m3)+ms}$	1.917	2.035
Average	1.976	

Atterberg Limits Result:

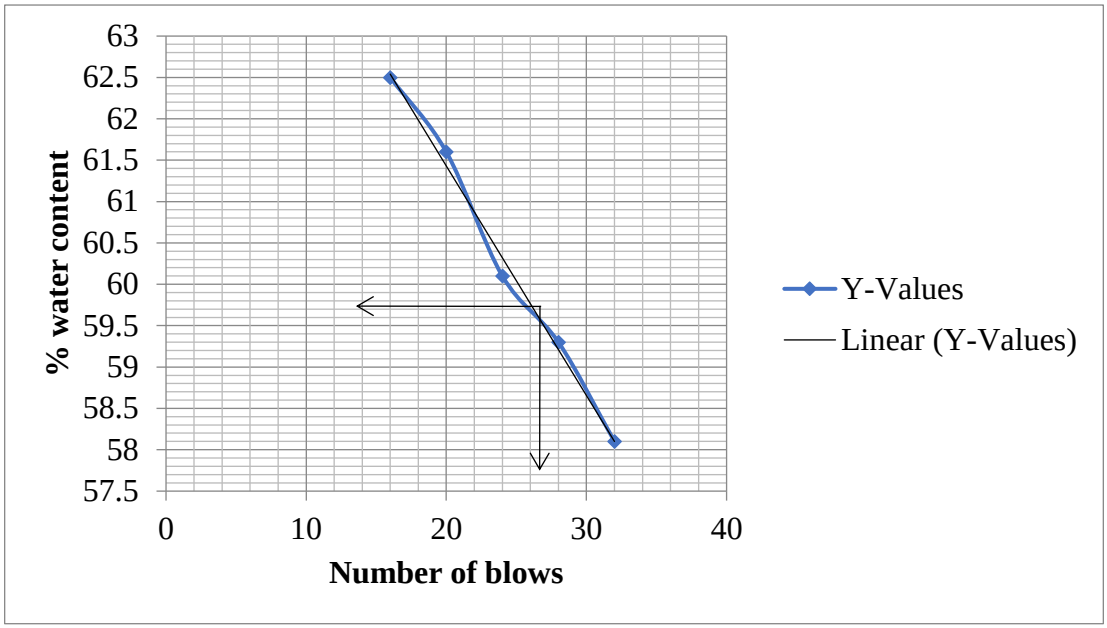


Figure 3.2: Number of drops vs. water content to look for liquid limit

Modify Proctor Test:

The results are those carried out in the lab for the modify proctor test

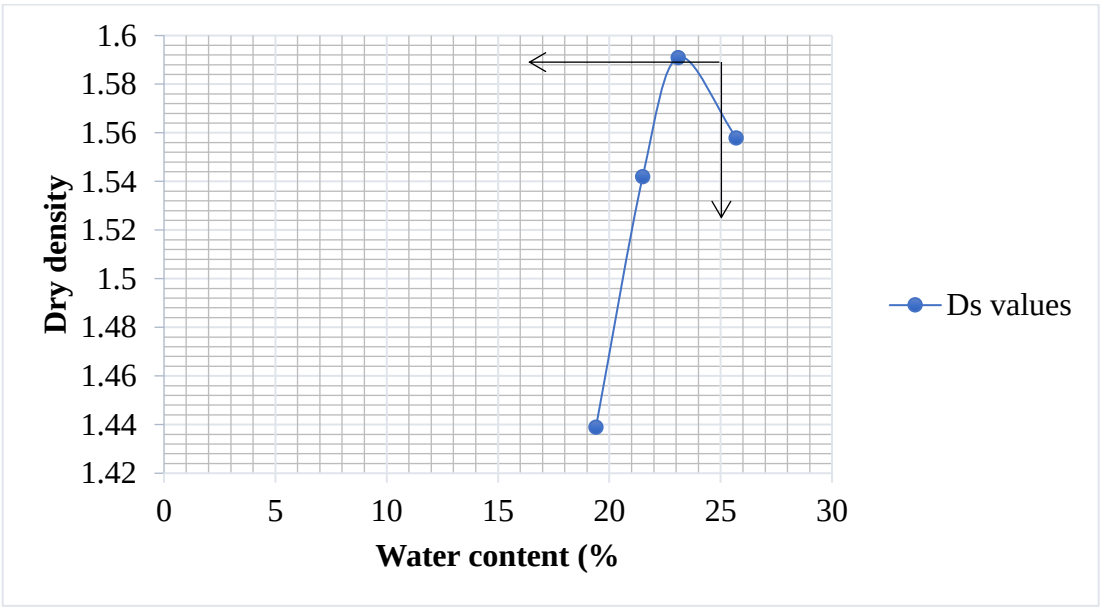


Figure 3.3: Dry density vs. water content to look for optimum dry density and optimum water content (first proctor test)

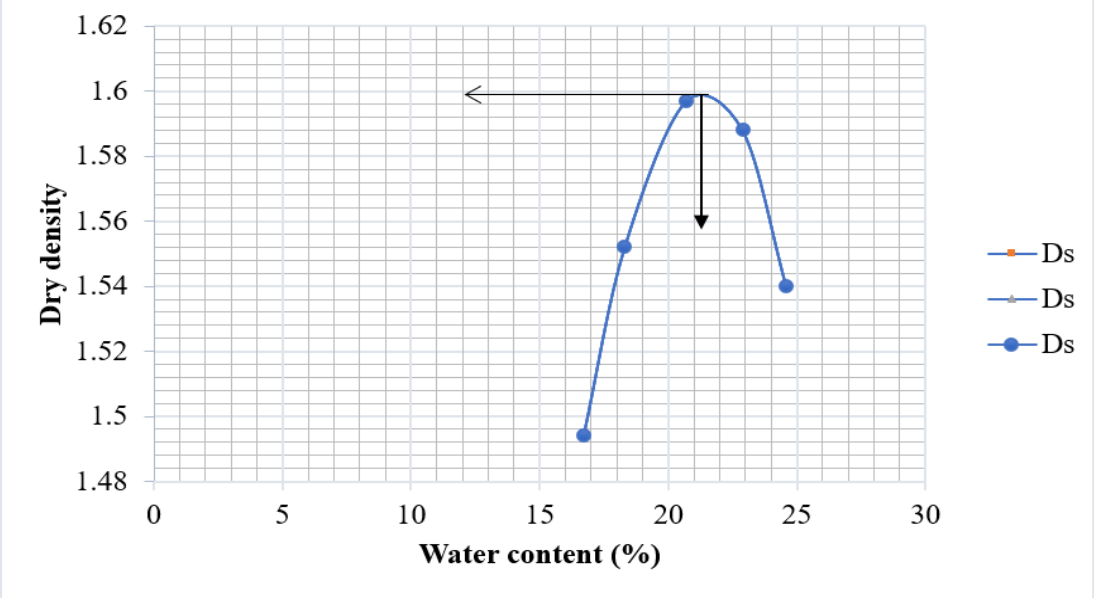


Figure 3.4: Dry density vs. water content to look for optimum dry density and optimum water content (second proctor test)

Two of the proctor tests was done and the results were just the same.

Water Absorption Test:

After 7 day the samples were weighted and then put in water. It was observed that after 24 hours the particles have fall off. This also happen for 14 days so after noticing that the particles fall off after 24 hours. On the 28 day we decided to carry the water absorption test just for 3 hours instead of the normal 24 hours. This was done in order just to ascertain the rate at which the different samples will behave when immerse in water.

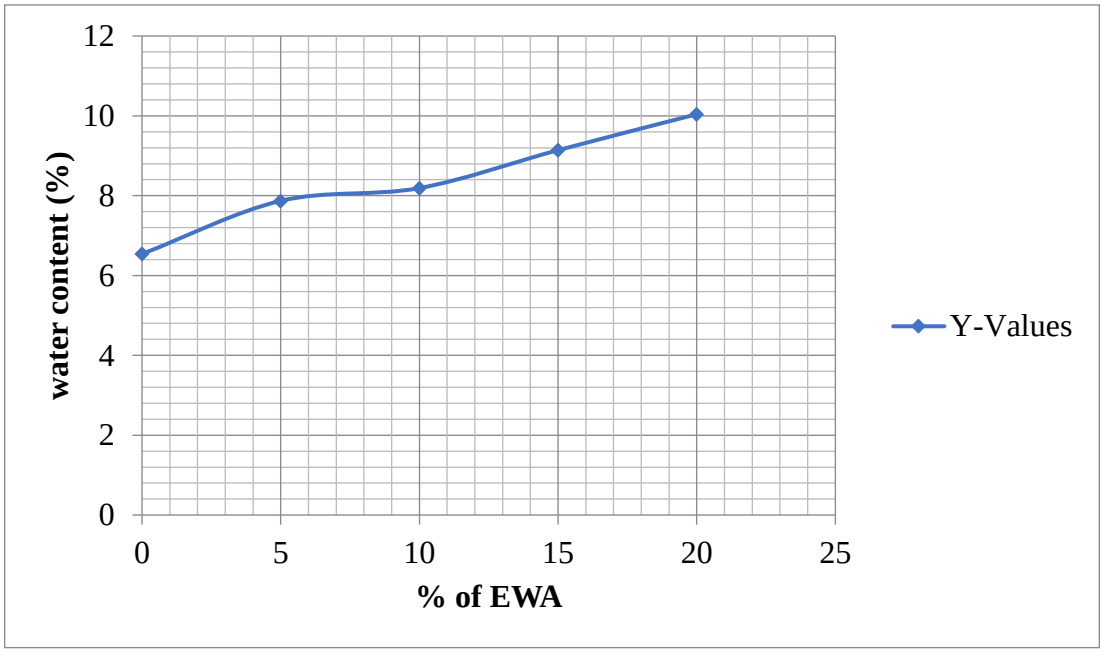
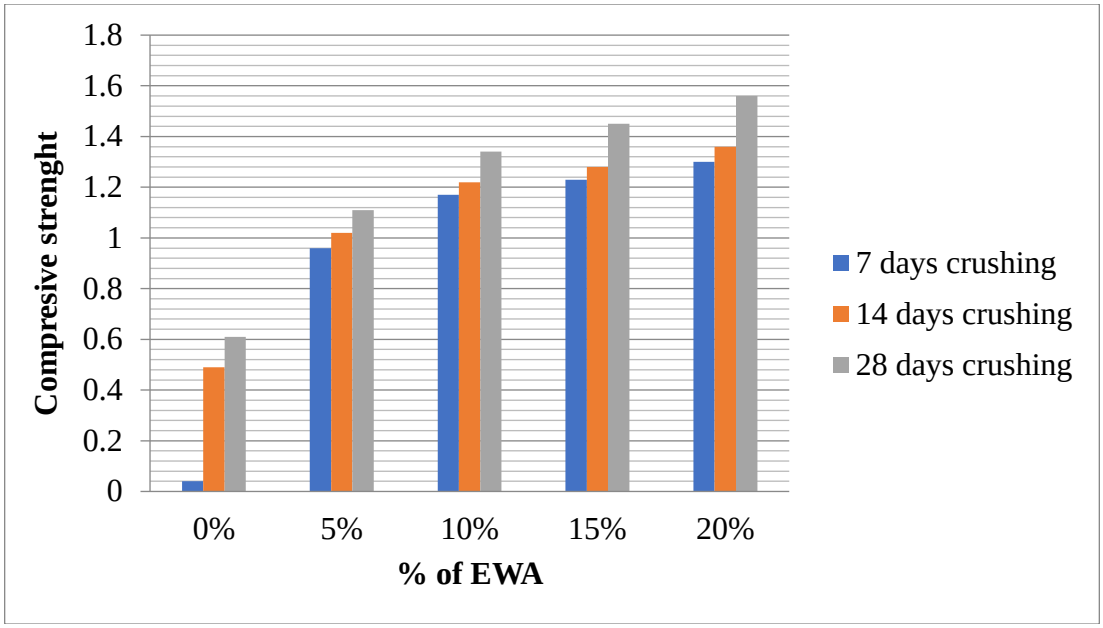


Figure 3.5: results of water absorption test

Compressive Test (ASTM C39 Standard Test Method):



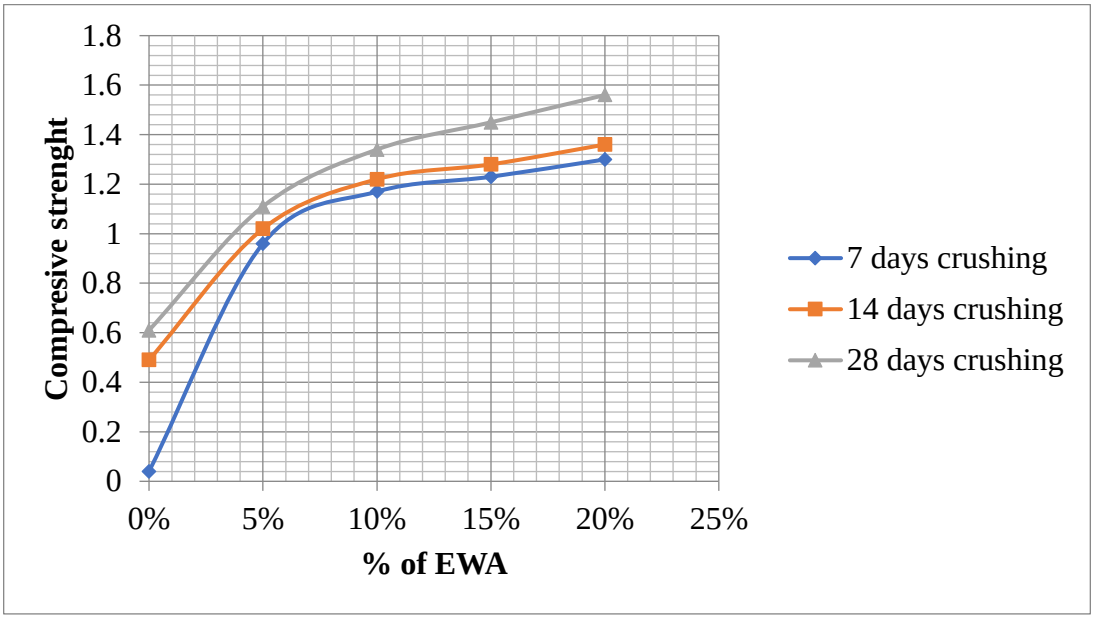


Figure 3.6 Results of compressive strength test

Table 3.2: Summary of compressive strength

% Of EWA	0%	5%	10%	15%	20%
7 days	0.04	0.96	1.17	1.23	1.3
14 days	0.49	1.02	1.22	1.28	1.36
28 days	0.61	1.11	1.34	1.45	1.56

Discussion

Table 3.1 above gives us the natural water content of the soil which was done using 2 cans carried out at BAMBUIY ENGINEERING SERVICES AND TECHNIQUES (BEST) A Geotechnical lab at Ayaba Street, Old town Nkwen Bamenda in the North west region of Cameroon and the average is gotten from them. This means that in every quantity of laterite you take, 17.84% of its weight is water.

Grain Size Analyses:

The curve of grain size vs. percent finer (passing) in fig 3.1 was plotted and from the curve the laterite was composed of 0.6 % gravel; 14.7 % sand and from the curve it shows the material is completely a clay material since its just hanging up and it had just little gravel and sand.

$$\text{Coefficient of uniformity Cu} = \frac{D60}{D10} \quad \ldots\ldots 5.1$$

$$\text{Coefficient of curvature Cc} = \frac{D30^2}{D10 * D60} \quad \ldots\ldots 5.2$$

From figure 3.1, D10=0, D30=, D60=0, Cu=0, Cc=0

D60 is the diameter of the soil particles for which 60% of the particles are finer, D10 is the diameter of the soil particles for which 10% of the particles are finer. D30 is the diameter of the soil particles for which 30% of the particles is finer. In addition, If the coefficient of curvature is between 1 and 3 the soil is well-graded soils. Since Cc is 0 which in not in the set of range, it shows that our soil is poorly graded soil and using the universal soil classification system our soil is of class SM silty sand soil mixture.

Atterberg Limits Result:

Atterberg limit test by the Casagrande method was performed in accordance with ASTM D 4318 - Standard Test Method [13] to ascertain plasticity index (PI) of the soil samples. The results are presented in figure 3.2. The PI of 10% does not exceed the maximum value of 35% stipulated by IJSCET [15]. Thus, indicating a good laterite soil that is cohesive and hence able to receive proper compaction to enhance the strength and durability characteristics of the laterite. with plastic limit of 30. The samples are suitable for stabilization as their PI values does not significantly exceed 15% as stipulated by Fetra, and al [16]. Also, the soil is highly plastic given that the liquid limit is more than 50.

Modified Proctor Test:

The result of modified proctor test is summarised and illustrated in Figure 3.3/3.4 The value of 1.608 g/cm3 represent the maximum dry density (MDD) which shows that, the maximum dry density (MDD) corresponds to the lower optimum water content 21.2%. The variation of the data recorded in the same area is due to the different size of grain size content. For example, when you look at clay and sand content, it can be seen that, the low amount of clay increases the maximum dry density with low amount of optimum moisture content. The average maximum dry density value (1.608 g/cm^3) of the analysed samples corresponds to the lower limit recommended for the use of sub-base materials by DESIGN [17]. With the research reference of O'Flaherty [18] on modified proctor test: the clay materials shall have the

maximum dry density and optimum water content 71 which range from 1.4 and 1.7 g/cm3; 20 and 30%; silty clay (MDD: 1.6 to 1.8 g/cm3; OMC: 15 to 25% and sandy clay (MDD: 1.8 to 2.2 g/cm^3 ; OMC: 8 and 15%). By considering the obtained result, the soil samples belong to silty clay soils.

Water Absorption Test:

From the water absorption test, we can observe that the water absorption increases when the percentage of EWA increases, it was observed that when the samples were put in water after 7 day it absorbed water and scattered with 20% scattering more this is because of the high wood ash percentage that makes it to absorbed much water and disintegrate. So, we had to do the water absorption test for 3hours noticing a high-water absorption of 10.04 at a percentage of 20% EWA. Given that the particles had to fall off when immerse in water shows that EWA has fewer binding properties with a PH of 8 gotten from the PH meter compared to cement which has higher binding strength and a PH greater than the EWA and also the reason could be from the compaction and size of the brick. So, if we could mix the wood ash with little of cement it results will be convincing. And also, to reduce the rate of water absorption we could use cicelies

Compressive Strength Test:

The compressive strength is the most universally accepted value for determining the quality of bricks [19]. Nevertheless, it is intensely related with the soil type and the content of stabilizer. The crushing strengths of the blocks were tested using the compressive testing machine. A total of 56 specimens were prepared and crushed at different curing ages of 7, 14 and 28 days. Compressive tests were conducted on the bricks at different ages to indicate the rate of strength gain and the strength at a point in time. From figure 3.6 and table 3.2, we observed that when we add the percentage of eucalyptus wood ash; to the mix, the compressive strength will increase and the maximum compressive strength of 1.3Mpa, 1.36MPa, and 1.56MPa when dry after 7 days, 14 days, and 28 days respectively the maximum compressive strength of 1.56 with an area of (7*7) cm with wood ash percentage of 20%. Though the increase in the strength for the various percentage is minimal it still shows that at a percentage more than 20% it can still give a good compressive strength. Further research could still be done with cow dunk and laterite and the different test carried out to see the strength and behaviour when put in water

CONCLUSION

To conclude, the main objective of this work was to produce stabilize earth brick from laterites with eucalyptus wood ash to be use for construction thereby solving the problem of using bricks that are less resistant to pressure and cheaper as compared to sand cement blocks. To achieve this objective a reviewed of related stabilized soil brick were done by defining soil stabilization, name different stabilizing agent for soil brick and works which has been undertaken by other researchers on this domain. A soil from a depth of 50cm -100cm was set from the earth surface from Bangshie dry and sieve it for sample and sampling techniques, the various equipment, test procedure and analysis method to do grain size analysis, Atterberg limits (plastic limit, liquid limit and plasticity index), standard proctor test of the given soil. Fifty-six samples of stabilized brick were fabricated with different proportion of eucalyptus ash. On these samples, the compressive strength test was done to determine the maximum compressive strength, and water absorption test was also carried out. From those result, it was observed that when we

increase the proportion of eucalyptus ash, the compressive strength, and water absorption increases.

Acknowledgements

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Conflict of Interest

The authors of this article declare that there are no known conflicts of interest that could have appeared to influence the work reported in this paper. All the standards and ethics of scientific writing have been respected.

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