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Comparative Studyon the Strength of Bricks Produced With Lime Stabilization of Red And Brown Clay Soils

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ABSTRACT
Clay soils have been used locally in sokoto to make bricks without stabilizing the soil.The bricks usually experience structural failure such as cracking and seasional swelling when used for the construction of wall. Stabilization simply refers to blending and mixing of materials with soil with the view of enhancing certain properties of the soil. However, this can be achieved by using mechanical method, additive method or modification method.The method used in this study was additive method of stabilization in which proper percentage of lime was added to the red and brown clay soils to improve their strength properties and durabilities. This study carried out the result of the physical test on red and brown clay soils samples and the comprehensive strength of the bricks produced. The liquid limit plastics limit and plasticity index of the red and brown clay soils sample were determined to be 240,16.0, 0.8 respectively. A varying percentage of lime stabilization was used in this research, these are 0%, 3%, 6%, 9% and 12%. Batching weight was adopted in this study. The dimension of the mould of the machine is 225mm x 112.75mm x75mm. Atotal of 30 bricks where produced tested. The curing method adopted was moisture and curing period was 28days and 56days. Fifteen of bricks were produced at each curing period. The bricks were allowed for 24hrs before curing commenced. After the stipulated curing period, the brick samples were tested for compressive strength. At 6% stabilization, the highest average compressive strength was recorded in 28 and 56 days. The value derived was 1.07N/mm^2 and 1.19N/mm^2. The highest value obtained is not closer to the stipulated value of 2.8N/mm^2 in B.S 5628 apart (1978).

Keywords: Compressive, Strength, Concrete, Red and brown Clay soils, lime

I. INTRODUCTION

Nikhil, S.K (2014) assessed that, a land-based structure of any type is only as strong as its foundation for that reason, soil is a critical element influencing the success of a construction project. Soil is either part of the foundation or one of the raw materials used in the construction process.

Ramesh et al (2012) postulated that red earth soil is a non-expensive soil having kaolinite as primary clay material and it is a natural soil available in vast area of India and Karnataka. This soil is available in abundance in almost all the local government of Sokoto State, Nigeria. Clay particles contain Silica (SiO_2) and a mixture of other minerals such as quartz, carbonate, aluminium oxides and iron oxides, and ratio of SiO_2 to other clay mineral within clay determines clay types. Meanwhile, highly weathered clay deposits contain mostly aluminium or iron oxides which are mineral in red clay (Blue 2016)

According to Guyer, (2011) 'stabilization is the process of blending and mixing material with a soil to improve certain properties of the soil.' Colwill (2012) also opined that stabilization is the process of the performance of a material by increasing the strength, stiffness and durability. Mustapha (2006) defined soil stabilization as the treatment of soil to enable their strength and durability to be improved such that they become totally suitable for construction beyond their classification if left untreated. Kim,Gopalakrishnan and Ceylan (2012) viewed stabilization as the process of blending and mixing with a soil to improve certain parts of its properties.

Only quick and hydrated limes are used as stabilizers in road construction. They are usually added in solid form but can also be mixed with water and applied as a slurry (BLA 2011). It must be noted that there is a reaction between quicklime and water and consequently operatives exposed to quicklime can experience a severe external and internal burns, as well as blending.

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Hussaini, S (2019), Stressed that to a civil engineer, soil occurs naturally and refers to clay as a very incremented or weakly cemented accumulation of mineral particles formed by the weathering of rocks, the void space between the particles containing water and/or air.

Clay is sticky and plastic like to handle when wet, the individual particles are extremely small and can only be seen with the aid of an electron microscope. The three main soil text classification, are fine textured and silly soils (caterpillar,2006).

Before soil can be stabilized with lime the plasticity index (PI) must be measured when the plasticity index is at least 10, according to the Atterberg limit (Consistency limits), the soil can be stabilized with lime (K. Gandhi and S. Shukla 2019.)

1.To determine the properties of sokoto red and brown clay soils (i.e. physical, mechanical and chemical compositions).
2. To produce brick samples made with stabilized Sokoto red and brown clay soils.
3.To determine the optimum level of lime stabilization required in the case of sokoto red and brown clay soils.
4. To test the compressive strength of the brick sample.
5.To make recommendation on the use of lime-stabilized sokoto red and brown clay bricks.

Justification of the research

It is undisputable fact that clay soils are in abundance at Amanawa, Mana,SabonbirninGobir and parts of Binji areas in Dange/Shuni and Sabonbirnin and Binji local government of Sokoto state respectively. Research has categorically indicated that sokoto state has a very good quality lime stone deposited in more than three (3) local government in the state. Presently cement is being manufactured in the state since early 1980´s in Kalanbaina in Wammako local government due to large quantities off limestone deposited in the area compare to other local governments. However, it was observed due to the quality of the limestone in Sokoto State, the red and brown clay soils in the area possess some quality which can make them suitable for building construction when well treated. Therefore, this brought about the reason for this research work.

Blocks and bricks are two major material used for construction of well. A lot of research has been carried out on the sand Crete block (either hollow or solid) such as partial replacement of cement to make, compressive strength properties of the sandcrete block, an assessment on the quality of sandcrete hollow block production etc. Blocks are more common in use for wall construction than the bricks. Probably, that is the reason why researcher focus more attention than the bricks. More research work has not been documented on how to improve on the strength characteristics of clay bricks. Also, in Sokoto State, blocks are more commonly in use the construction wall compare to bricks. So if at the end this research the strength characteristics (both compressive and tensile strength) of the stabilized red and brown clay bricks moulded with strength characteristics are in conformity stipulated in building regulation standard, therefore, clay bricks will be a better alternative to conventional sandcrete blocks in the area and thereby reduced the cost of sandcrete block,

II. LITERATURE REVIEW

Soil stabilization

Traditionally, soil is being mixed with straws or hays, watered and later mulched thoroughly for proper mixture. Many traditional methods of stabilization where adopted ranging from mixture of two different types of soil (soft and grained soil) in other to have an improved plasticized mixture suitable for plastering/rendering, Bricks moulding and etc. to addition of vegetable materials to be decayed and decomposed into the clay to be stabilized traditional architect are the Masjid of Agadas, first church in Northern Nigeria (Wusasa- Zaria).

The term soil stabilization is the process whereby natural strength and durability of a soil or granular material is increased by the addition of a stabilizing agent (Guyer,2011). He pointed out that the main objective of the stabilization is to improve the performance of a material by increasing its strength, stiffness and durability.

Procedure for Stabilization

Quantity of Stabilizer

It is important that the correct amount of stabilizer is added to the material. If too much of the stabilizer is added, It can cause excessive shrinkage cracks. Too little stabilizer will produce a material with insufficient strength or durability (Guyer,2011)

Mixing

Yusuf, A.M (2015) that, the stabilizer and material must be thoroughly and evenly mixed throughout the full depth of layer. For in-situ stabilization, this is best achieved with a pulvimixer, rotavator or a disc harrow; however, an experienced grader operator can also obtain good result.

Compaction and Limited time

Ziyate, A. and Roshani, M. Z (2012) asserted that, it is essential that the correct degree

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of compaction is achieved if the material is the to reach the required strength. Compaction must be completed within the limited time period set in the specification, which is often only a few hours for cement.

Rapid setting

A number of problems have been reported where a lime stabilizer has reacted very quickly with certain material (typical calcretes and tillites containing amorphous silica, aluminum and/or high clay contents)

Lime

Lime, basically is derived by the Roman around 300 B.C. from the process of burning limestone at temperature above 900^0C (Paige green, 1984). Lime is a chemical additive that has been utilized as a stabilizing agents in soil for centuries. Lime as described by Guyer (2011), react with medium, moderately fine and fine-grained clay soil.

SoilThe Term Soil has different meanings depending on the various Engineering displines. The definition given to soil by a geologist or Agriculturalist is quite different from the one Building or Civil Engineer (Ioanna C. Toumpanou, Ioannis A. Pantazopoulos, Ioannis N. Markou&Dimitrios K. Atmatzidis 2021). To penologist, Soil is the substance existing on the earth's surface, which grows and develops plant life.

Atkinson (2000), the term soil means different things to different professionals. He opined that to a builder and civil engineers, it is a natural material that can be built on (eg. Foundation to building, bridges), built in (like tunnels, basement, culvert),built with roads, dams, runway, etc. Smith (2003) confirmed that there are three types of soil when considering modes of formation; these are transported soil, residual soil and organic soil.

Organic Soil

These soil contain large amount of decomposed animal and vegetable matter that are usually dark in colour and give off a destructive colour. Deposits of organic silts and clay have usually been created from river or lake sediments (Smith and Smith, 2003).

Clay formation

Clay minerals are formed through a completed process from an assortment of parent materials. The parent material includes feldspar, and lime stone. The constituents of the parent material during the early and intermediate stages of the weathering process determine the type of clay formed.

A. **Physical weathering:** It changes the particles size and bulk volume of the parent material with no significant change in composition. The processes include expansion due to unloading, crystal growth, thermal expansion and contraction, organic activity and colloidal plucking.
B. **Chemical weathering:** it causes a complete change in the chemical and physical properties, accompanied by an increase in bulk volume caused both by the lesser density of the new compounds and by additional porosity of the weathered aggregate. It includes hydration, hydrolysis, oxidation, carbonation, and solution. All these processes depend on the presence of water as the means by which they occur.
C. **Biological weathering:** It is similar to the chemical weathering in that it changes both the state of the aggregate and chemical composition. The principal source of clay minerals is the chemical weathering rocks which contain orthoclase feldspar, plagioclase feldspar and mica (muscovite). The three most important groups of clay minerals are montmorillonite, illite, and kaolinite which are crystalline hydrous aluminosilcates. Montmorillonite is the clay that presents most of the expansive soil problems.

Clay Structure

Clay minerals are predominantly silicates of aluminum and/or iron and magnesium. Some of them also contain alkalies and/or alkaline earths as essential components. These minerals are predominantly crystalline in that atoms composing them are arranged in definite geometric pattern.

Physical properties of clay soils

It is well known to soil engineers that montmorillonite clays swell when the moisture content is increased, while swelling is absent or limited in illite and kaolinite. The types of soils, and the conditions under which the most critical situation exists, can be outlined as follows.

Moisture content

Irrespective of high swelling potential, If the moisture content of the clay remains unchanged, there will be no volume change; structures founded on clays with constant moisture content will not be subjected to movementcaused by having.When moisture contents of the clay is changed, volume

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expansion, both in the vertical and horizontal direction will takes place.

Materials and methods

Materials

All the material used for the research were obtained within Sokoto environ. Test on the soil particles size distribution, plastic limit, the liquid limit and compressive strength test were carried out at Road Nigeria PLC central laboratory besides sokoto cement, Kalambaina road, Sokoto. Batching, moulding and curing were done at building workshop of Umaru Ali Shinkafi polytechnic Sokto. All test were carried out based on relevant British Standard Code of Practice (BS)

Red clay soil

The red clay soil samples were obtained from a borrow pit at 'AMANAWA' in DangeShuni local government area of sokoto State, Nigeria, using a method of disturbed sampling.The soil was cruished manually and size graded using a sieve of 4.00mm size to remove leaves and other unwanted materials from it.

Brown clay soil

The brown clay soil was obtained from a borrowed pit in Gwiwa village about 100m behind CABS in wammako local government area of SokotoState,Nigeria using the method of disturbed sampling and it was crushed manually and size graded by sieve 4.0mm to remove leaves and other unwanted materials.

Lime

The Aglo- American plc group manufactured high quality hydrated lime was used for stabilization and the product name was **LIMBuX**manufactured in Great Britain. It was obtained from a market in Sokoto. The product is classified as BS EN 459-1 C190-S building lime and 12518 class type for treating drinking water.

Water

Fresh water tap fit for drinking has been chemically treated from Sokoto State Water Board was used for the research'

Method

The quantities of materials were determined by using absolute weight method (i.e. Batching by weight). The red, brown clay soils and water was batched by weight. All the quantities of red and brown clay soils used to produce 5 bricks samples at 0% stabilization was noted and used as the basis for other stabilized red and brown clay soils materials. Shovel was used for manually mixing of the materials (red and brown clay soils,50:50 and lime) were measured separately before mixing the quantities and measured quantity of water was added.

After water was added, the material was then re-mixed thoroughly to ensure that the materials are properly mixed with water.

When the material is finally transferred into the mould it was compacted by upper hydraulic ram with flat like surface. After the compaction the brick sample is formed and released out from mould. A total of 50 bricks were produced for the research in one day. The samples were allowed for 24 hours after moulding before curing commenced. Moist curing method was adopted as described by Oti et al (2009). All the stabilized bricks were moist cured twice a day for 28 and 56 days at room temperature of about 20^{o}C before testing for compressive strength in accordance with BS 1924-2(1990) and BS EN 771-1(2003)

III. RESULTS AND DISCUSSIONS

Table 1: Compressive strength test after 28 days

S/N	Percentage	Average weight(g)	Average Density (g)	Average Load (KN)	Average compressive Strength
1	0	2886	1.88	6	0.43
2	3	2753	1.79	13	0.95
3	6	2770	1.80	15	1.07
4	9	2560	1.66	7	0.50
5	12	2528	1.64	9	0.66

Source; Laboratory test [2021]

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Table 2: Compressive strength test after 56 days

S/N	Percentage	Average weight(g)	Average Density (g)	Average Load (KN)	Average compressive Strength
1	0	2939	1.91	7	0.50
2	3	2420	1.57	15	1.07
3	6	2484	1.64	17	1.19
4	9	2298	1.33	9	0.66
5	12	2266	1.47	10	0.74

Source; Laboratory test [2021]

Table 3 Particle size distribution

BS Sieve Size		Weight Retained	% Retained	Total passing	Remark
18 inch	3.35 mm			100.0	
No 7	2.36 mm			100.0	
No 14	1.18mm	0.3	0.06	99.94	
No 25	600mm	0.2	0.06	99.83	
No 36	425mm	5.2	1.04	98.84	62%
No 52	300mm	13.3	2.66	96.18	
No 72	212mm				
No 100	150mm	90.0	18.0	78.18	
No 200	75mm	81.0	16.2	62.00	
Passing 200		310.0	62.0		

IV. DISCUSSION OF RESULT.

According to Craig (2005) particle analysis of a soil sample involves determining the percentage by mass (weight) of particles within the different size ranges. Since sieving method of soil was adopted for this research, the soil sample was passed through a series of standard test sieves as described in BS 812-103:1985 and BS 1377-2: 1990.

The weight of soil retained in each sieve was determined and the percentage by weight passing each sieve was noted and presented in the table above. However, at sieve 100, it was observed that the sieve retained highest percentage soil sample followed by 200, Thus, at sieve 100, 78,18% 0f the clay soil sample passing the sieve. Hence, 62% of the soil sample passed the sieve 200. The results presented also indicate that at the lowest compressive strength recorded so far at 28 days from the table at 0% stabilization is 0.43N/mm$^{2.}$ BS 5628 part 1 (1978) specified that minimum compressive strength for masonry (bricks) is 2,8N/mm^2.

CONCLUSION AND RECOMMENDATION

Conclusion

Based on the research conducted, the following conclusions were drawn

That the plasticity index of the two soils used (red and brown soils) in this research were determined to be 8.0. This is slightly lower than 10 as specified by Atterterg´s limits. That the total percentage of soil passing the sieve 200 during particles size analysis is 62%. This percentage of passing is satisfactory. The highest compressive strength test was derived from stabilized bricks produced at 6% stabilization.

Recommendation

Based on the research conducted, the following recommendations were drawn, Brown clay soil should not be used to stabilized re clay soil, as the mixture produced low plasticity. It is recommended that another stabilizer should be used together with lime to stabilized red clay soil before making bricks. It is also recommended that, since only negligible increase in the compressive strength of the bricks in relation to days of curing was noticed, the hydration period of lime stabilized bricks of red and brown clay soils should not extent beyond 28 days

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