International Journal of Research in Advanced Engineering and Technology
www.allengineeringjournal.in
ISSN: 2455-0876
Received: 21-05-2024, Accepted: 11-06-2024, Published: 02-07-2024
Volume 10, Issue 2, 2024, Page No. 1-4

Improving the properties of adobe earth brick using groundnut shell ash and potassium hydroxide

Alka Umar Alka, Abdullahi Garba Musa, Aminu Shehu Yakubu, Abdullahi Musa
Department of Civil Engineering, Nigerian Army University Biu, Nigeria

Abstract

Earth as a building material is available everywhere. Building materials are always regarded as essential components for constructing living spaces which would help in good habitation of human beings. In developing countries, earth construction is economically the most efficient means to house the greatest number of people with the least demand of resources. Traditional earth construction techniques such as adobe bricks suffer from water attack and cracks, thus they need to be continuously maintained to keep them in good condition.

This project studies the relationship between Gudum Sayawa laterite (Bauchi state), groundnut shell ash, and potassium hydroxide; and their compressive strength. The concentration (pH 10) of potassium hydroxide (KOH) was mixed with lateritic soil and groundnut shell ash of 2%,4%,6%,8% and 10% by weight. 12 bricks were molded for each mix ratio and were crush at intervals of 7, 14 and 28 days to determine the compressive strength. Water absorption test was carried out after 28 days after all the bricks increased and lost some particles in the water. The compressive strength and water absorption ratio of each mix ratio was determined. The lowest and highest result for compressive strengths at 0% and 6% were 1.03N/mm^2 and 1.85N/mm^2 for 7 days, 0% and 6% were 1.06N/mm^2 and 1.68N/mm^2 for 14 days, 0% and 6% were 1.11N/mm^2 and 1.70N/mm^2 for 28 days curing age respectively. This shows an increase in strength with stabilization. Compressive strength test carried out on the stabilized bricks showed an increase in strength than the un-stabilized or those gotten from the locality (0.28N/mm^2). This signifies an increase in strength with stabilization. The study concluded that the use of Groundnut Shell Ash as filler in the production of bricks with (pH 10) Potassium Hydroxide KOH solution is suitable for use in the construction industry.

Keywords: Adobe bricks, groundnut shell ash, laterite, compressive strength, water absorption

Introduction

Earth as a building material is typically associated with low embodied energy due to the minimal processing required. Along with the environmental benefits from using earth, the aesthetic and tactility of the material have led to resurgence in the use of earth as a building material that largely died out in the 19th century (Morton, 2009) [13]. Lateritic soils give very good results for brick molding especially when stabilized (Aguwa, 2009) [7]. Laterite walls tend to be the least preferred materials by builders in recent times due to some challenges associated with their use. They are known to be lacking compressive strength, having low resistance to abrasion and are highly susceptible to water ingression. (Riza, 2011 and Adogla *et al*., 2016) [4]. The ultimate goal for using locally available walling materials is to erect structures which one would describe as sustainable (UN Habitat, 2006) [15].The specific factors ensuring sustainability include low initial and running costs of the buildings, comfort and convenience experienced by users, freedom from environmental hazards, the ease at which modern functions, features and services can be inculcated into the buildings using these local walls (Rumana, 2007; Humberto *et al*., 2012 and Adzraku *et al*., 2016) [14, 5]. Buildings made from earth materials can be a way towards sustainable management of the earth's resources. Various binders in recent times have been added to laterite to successfully attain technical qualities and these include the combination of Cow dung and ash from agricultural wastes to serve as an effective binder (Yalley and Manu, 2013) [16, 17]. In a separate experiment Yalley and Asiedu (2013) [16] combined cement, lime and bitumen to form a formidable binder. Adesanya and Raheem (2009) [3] also combined Industrial by-products and agricultural wastes to serve as stabilizer of laterite. The need for alternative materials for brick production became imperative hence, lateritic soil, a reddish-brown soil type rich in iron and aluminum formed in hot and wet tropical areas, from parents' rocks (sedimentary rock, igneous rock and metamorphic rock) by a process called "leaching" was used extensively by researchers for the production of lateritic bricks (Morin and Peter, 2010). For this study, groundnut shell ash (GSA) and Potassium Hydroxide (KOH) have been chosen to produce a stabilizer for the improvement of strength and durability properties of lateritic bricks for low-cost housing schemes.

Materials and Methods

The materials used for the production of bricks in this research were groundnut shell ash, potassium hydroxide solution and laterite.

Groundnut Shell Ash

The groundnut shell for this study was obtained from local farmers within Sabon Kaura and Yelwan Tudu areas of Bauchi, Bauchi state and then taken to the Industrial Design Department of Abubakar Tafawa Balewa University ATBU Bauchi, where it was open-air dried for 7 days and then calcined in a furnace at a very high temperature after which it turned gray in color.

Potassium Hydroxide Solution

The Potassium hydroxide was prepared by dissolving "caustic potash" in 40Liters of distilled water to make KOH solution. For this study, the solution was prepared for a pH of 10 which was used to mixed the lateritic soil with the varying proportions of GSA at 2%, 4%, 6%, 8%, and 10% respectively. (BS 3148, 1980)

Laterite

The lateritic clay used for this study was gotten from Gudun Sayawa Area in Bauchi metropolis. The material was obtained from a borrow pit which is being used by the residents of the area for making earth bricks. The sample was collected using the disturbed sampling approach (Agbede and Manasseh, 2008) [6]. The geotechnical properties of the soil sample as determined in this study for the purpose of its classification are presented in Table 4. Testing was carried out at the Soil Laboratory of the Civil Engineering Department of ATBU in accordance with the BS 1377 (BSI, 1990).

Plate 1: Laterite Soil borrow pit

Preliminary Test on Laterite Aggregates

The results of particle size distribution for the laterite aggregates are shown in figure 1 below. The coefficients of conformity of the laterite are 2.06, while those of curvature are 0.94, with specific gravity of 2.61. The laterite aggregates are classified as well graded and suitable for bricks production.

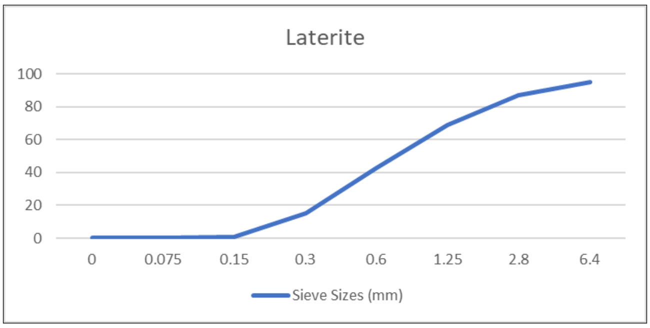


Fig. 1: Particle size distribution curves for laterite

Production of Laterite Bricks

Mixing and Molding of Samples

The bricks were formed with varying mix proportions of 0, 2, 4, 6, 8 and 10% 0f GSA with a solution of KOH (pH 10) and lateritic clay. The mix proportions were weighed accordingly using a digital weighing balance, and water was added slowly. While mixing, it was ensured that the mold was placed on a flat surface, and the mud was not too wet to avoid a gradual slump while it dries outside the mold.

Plate 2: GSA and Laterite soil before mixing.

Plate 3: Molded bricks before curing

Curing of Cube Samples

Curing is essential for stabilized earth blocks. Curing aids the hydration process of bricks during the different aging periods of up to 28 days for earth stabilized blocks and thus gives strength to the blocks. It also enables the effective movement of stabilizers within the block. However, in this study, the bricks were placed in an open shed for 28days and open-air dried.

Plate 4: Bricks during curing

Testing of Laterite Bricks

Compressive Strength Test

The compressive strength was determined after 28 days and 56 days curing ages. Compressive strength test was conducted in accordance with BS 1881 (1983) [9] Part 116 using a Seidner compression machine to determine the load bearing capacity of the soil bricks. Five bricks from each batch were weighed individually and the weight of each brick was recorded before placing on the compression testing machine for testing. The corresponding loads and compressive strength were recorded.

Plate 5: Compressive strength testing of bricks

Water Absorption Test

The principle of water absorption testing is to immerse a face of a masonry unit in water for a particular period and determine the increase in mass. The bricks were immersed in 5 mm depth of water for 10 min. The gross area of the test face and the increase in brick weight were measured. The initial rate of absorption was calculated as the ratio of increase in mass and gross area in 10 min as outlined by Olutoge *et al* (2017). The water absorption is the ratio of increase in mass and dry mass expressed as a percentage (Malisa *et al*., 2014).

Results

Physical and chemical properties of GSA

Table 1: Chemical composition of Groundnut Shell Ash

Constituent	Percent
SiO_2	26.46
Al_2O_3	28.39
Fe_2O_3	0.86
CaO	21.55
Na_2O	47.18
MgO	61.35
K_2O	65.05

Table 2: Physical properties of GSA

Specific gravity	2.05-2.3
Colour	Grey
Odour	Odourless
Particle size 25 microns –	Mean
Appearance	Very fine
Physical state	Solid-non-Hazardous one.

Table 3: Geotechnical properties of the Lateritic clay used

Property	Value
Natural moisture content: %	14·27
Gravel: %	7·08
Sand: %	65·18
Clay: %	27·20
Coefficient of curvature	1·2
Coefficient of uniformity	6·7
USCS classification	SP
Liquid limit	48
Plastic limit	36·33
Plastic index	11·67
Specific gravity	2·63
sample	Air-dried
Colour	Reddish brown

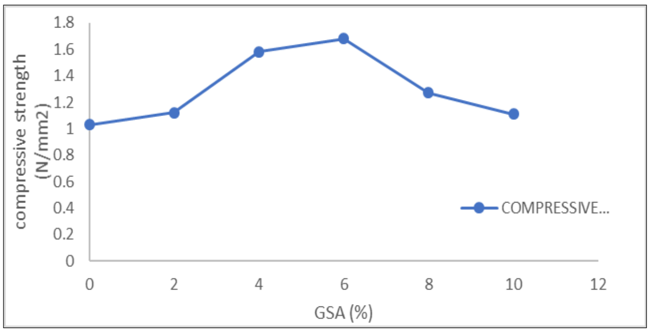
Table 4: Chemical composition of the laterite soil

Property	Value
Organic Carbon (%)	0.15- 0.329
Calcium carbonate (ppm)	0 - 2.35
Phosphate (mg/100g of soil)	6.64 – 15.6
Sodium (ppm)	0.68 – 175.53
Calcium (ppm)	0 – 0.50
Potassium (ppm)	1.87- 26.61

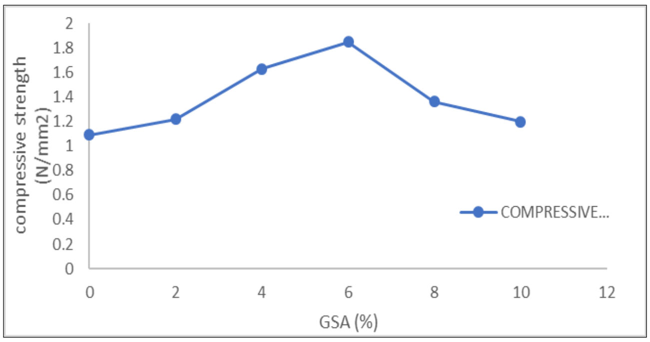
Compressive strength

Table 5: The results of compressive strength

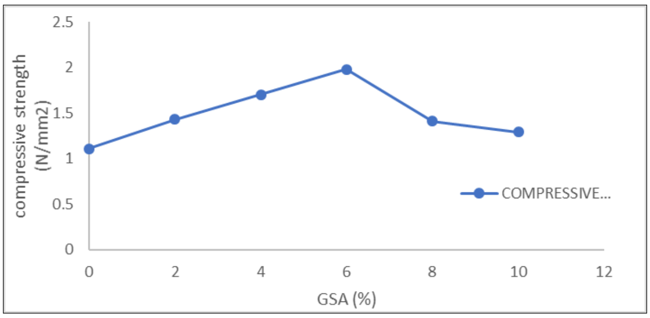
Curing age	kOH (pH)	GSA (%)	Weight (Kg)	Density (kg/m^3)	Compressive strength (N/mm^2)
7	0	0	9.03	2021	1.03
	10	2	8.86	1984	0.72
	10	4	9.48	2122	1.58
	10	6	9.09	2035	1.85
	10	8	8.39	1879	0,95
	10	10	8.39	1879	1.23
14	0	0	8.86	1984	1.06
	10	2	8.81	1973	0.96
	10	4	9.18	2055	1.62
	10	6	9.03	2022	1.68
	10	8	8.22	1841	1.11
	10	10	8.38	1876	1.36
28	0	0	8.74	1957	1.11
	10	2	8.75	1959	1.43
	10	4	8.88	1988	1.34
	10	6	8.96	2006	1.70
	10	8	8.04	1800	1.41
	10	10	8.37	1874	1.60



Graph 1: Compressive strength against GSA after 7days of curing.



Graph 2: Compressive strength against GSA after 14days of curing.



Graph 3: Compressive strength against GSA after 28days of curing

Water Absorption

Table 6: The results of water absorption

GSA + KOH	Dry weight	Wet weight	Water absorption	Rise of water from 25mm
0%	8.74	8.08	-8.29	6.5
2%	8.75	8.40	-4.05	5.4
4%	8.88	8.37	-6.09	5.0
6%	8.96	8.22	-3.04	5.2
8%	8.04	7.75	-3.61	5.5
10%	8.37	8.07	-3.59	4.9

Summary

Adobe earth brick stabilized with GSA and KOH was mould at five levels of stabilization of 0%,2%,4%,6%,8% and 10% GSA with a constant pH concentration 10 of caustic potash (KOH). The lowest and highest result for compressive strength at 0% and 6% were 1.03N/mm^2 and 1.85N/mm2, 0% and 6% were 1.06N/mm2 and 1.68N/mm2, 0% and 6% were 1.11N/mm2 and 1.70N/mm2 for 7-, 14- and 28-days curing ages respectively. This shows increase in strength with stabilization. Compressive strength test carried out on the stabilized bricks showed an increase in strength than those unstabilized and that gotten from the locality (0.28N/mm^2).

Efflorescence

The presence of whitish particles was observed on the bricks containing 2%,4%,6%,8% and 10% GSA with pH concentration of KOH. This is as a result of loss of water of crystallization from the brick with the presence of KOH, leaving a coating of the salt. It is also as a result of the pozzolanic composition of the GSA.

Conclusion and Recommendation

Conclusion

This study has revealed the effects of GSA, KOH (caustic potash) on lateritic clay bricks. The water absorption pattern in the stabilized bricks was irregular; though with a low absorption rate. There was lost of the material immersed in water. Compressive strength tests revealed that the stabilized bricks had higher compressive strength that bricks without stabilizers.

The increase in compressive strength with an increase in percentage of stabilizer could be due to increased bonding within the aggregates of the lateritic soil as reported by Metcalfe (2007).

Therefore, considering the findings of this study and the availability of laterite soil deposits (especially in Nigeria), the use of laterite can be well harnessed for the production of low-cost laterite–cement and laterite–lime blocks and bricks. It is there concluded that lateritic blocks stabilized with GSA and KOH be used as alternatives to sandcrete blocks in the construction of non-high-rise buildings.

Recommendations

1. The need to stabilize adobe earth bricks before been used in construction is important.
2. The ratio with the highest compressive strength should be adopted.
3. Further research should be carried out on the stabilization of bricks using other forms of stabilization material like; groundnut shell ash, bagash ash etc. with potassium hydroxide or other forms of base activators.
4. Adobe Earth bricks should not be used below ground floor level as they have low water resistivity and tend to dissolve in water.
5. Further research should be conducted to consider the molar concentration of the Alkali.

References

1. Alabadan BA, Njoku CF, Yusuf MO. The potential of GSA as concrete admixture. Agricultural engineering international: the CIGR Ejournal. Manuscript BC 05012, 2006, 8.
2. Ali AA, Ali AK, Yero SA. Compaction Behaviour of Lateritic Soils Stabilized with Blends of Groundnut Shell Ash and Metakaolin, 2017.
3. Adesanya D A, Raheem AA. Development of corn cob ash blended cement Construction and Building Materials. Reed Business Information, Inc. (US), HighBeamResearch. Retrieved from, 2009. http://www.highbeam.com/doc/1g1-19024210.html
4. Adogla F, Yalley PPK, Arkoh M. Improving Compressed Laterite Bricks using Powdered Eggshells.The International Journal of Engineering and Sciences,2016:5(4):65-70.
5. Adzraku DW, Yalley PPK, Akubah TJ Bonney SO. Prospects for Sustainable Housing in Northern Ghana with the use of Local Walling Materials, Journal of Economics and Sustainable Development, 2016, 7(20).
6. Agbede IO, Manasseh J. Use of cement–sand admixture in laterite bricks production for low-cost housing. Leonardo Electronic Journal of Practices and Technologies,2008:7(12):163–174.
7. Aguwa JI. Study of compressive strengths of laterite–cement mixes as a building material. AU Journal of Technology,2009:13(2):114–120.
8. BS 1377. Methods for tests for soils for civil engineering purposes, 1975.
9. BS 1881: part 116. Methods for determination of compressive strength of concrete cubes, 1983.
10. BS 3921. Specification for clay brick European Standard (EN), 680 (1993). Determination of drying shrinkage of concrete, 1981.
11. BS 812: part 2. Methods for determination of physical properties of aggregates, 1975.
12. Keeling PS. The Geology and Mineralogy of brick clays, Brick Development Association Monograph, 2009.
13. Morton P. Rice Husk Ash-a unique cementing material; Advances in concretetechnology, MSL92-6R, Canada, 2009, 407-431.
14. Rumana R. Traditional house of Bangladesh: Typology of house according to materials and location, 2007.

15. UN-HABITAT. Ghana country report: West Africa High-level peer exchange on government enablement of private sector lending for affordable housing. Accra: UN-HABITAT, 2006.
16. Yalley PPK, Asiedu E. Enhancing the properties of soil bricks by stabilizing with corn husk ash. Civil and Environmental ResearchISSN 2224-5790 (Paper) 2225-0514 No11(2013)>yalley retrieved from, 2013. www.iiste.org>Home>vol.
17. Yalley PPK, Manu D. Strength and Durability Properties of Cow Dung Stabilised Earth Brick. Civil and Environmental Research,2013:3(13):117-125.