Technical Sciences
Academy of Romania
www.jesi.astr.ro

Journal of Engineering Sciences and Innovation
Volume 4, Issue 4 / 2019, pp. 371-380

B. Chemical Engineering, Materials Science and Engineering

Received 7 ***October 2019*** *Accepted 2* ***December 2019***
Received in revised from ***28 November 2019***

Improving the properties of clay soil by using Literate soil for production of bricks

ANTENEH GEREMEW*

Department of Civil Engineering, Faculty of Civil and Environmental Engineering, Jimma Institute of Technology, Jimma University, Jimma, Ethiopia.

Abstract. Know a day's utilization of local accessible materials is an important stage for sustainable, economic construction material in the world. Among them Brick is one of the widely used construction material around Jimma town due to the availability of clay soil. It is not un-common to use locally produced brick for building houses and fences. But brick produced by small micros un-skill enterprises rather than by traditional method, its quantity was small and its quality was unsatisfactory, because it can easily break and it has high water absorbing behavior. Most of peoples uses this brick for beauty of outside of villa houses, partition wall only. The main objective of the study was be to improving the properties of clay soil properties by using Literate soil for in the manufacturing of bricks for masonry units. In order to achieve this researches include, non-probability sampling techniques was be used to collect samples in Jimma area, then collected of samples prepared for different laboratory test and by partially replacing literate soil by 5%, 10%, 15% and 20% on a clay soil in order to get optimum property by different mix ration for different laboratories such as compressive strength, water absorption, atterberg limts, linear shrinkage, density, efflorescent. Test results indicated that shows that the lightweight bricks could be made from this study without any deterioration in the quality of bricks. Further, the compressive strength of the bricks was optimum at 15% lateritic soil replace in clay soil contents. The optimum firing temperature furnace at a duration burning of brick was at 1000°C. It is shown that bricks made of clay-laterite soil can be also used in load bearing wall rather than for beauty.

Key words: literate soil, brick, clay soil, compressive strength, water absorption, sustainable, density, construction material.

*Correspondence address: antjiren@gmail.com

1. Introduction

Ethiopia one of the fast economic growth in East-Africa [12]. Due to urbanization the number of populations living in town becoming increases day to day ; so that for sustainable living standard in a town constructing a house un-questionable for human being although the cost of a unit black of plain concrete highly increases [13].There was small number of micro enterprises production clay brick with traditional way without controlling the quality only by looking a brick face beauty but there was a large deposit of clay soil and literate soil in Jimma area. Production of brick by lateritic soil alone is not suitable but it can be utilized in the manufacture of good quality bricks, if it can be modified by adding clay. On the other hand, plastic clay alone is not suitable for brick making as excessive shrinkage and warping take place in the process of drying of the brick [10]. Many benefits that are offered by laterite earth construction which is often under-utilized in the developed world where the use of laterite earth as a low embodied material is often the case [1].

Historically laterite earth has been the oldest and most widely known used building material and construction, has been the most important of all building materials [2]. According to Yar' adua Muntari Mudi (2012) recorded cases of the use of laterite bricks and clay dated back to Mesopotamia "around 8000 BC". Laterite earth buildings avoid high energy demand and costs in the initial manufacturing and construction period, for their use in homes, dams, roads constructions and in their recycling process thus, it is not surprising that many people value laterite earth construction for the above reasons and their durability, cheapness and qualities [3]The principal reason for using laterite earth is its excellent sustainable characteristics in constructions and recycling process. These include, the efficient use of finite resources, minimizing pollution, waste and low carbon emissions especially in industrial countries [4]. Laterite earth as a building material is available everywhere in the world and exists in many different compositions. It is most efficiently used in developing countries such as Kano, Kaduna and other cities in Northern Nigeria to house the greatest number of people with the least demand. However, it must be noted that laterite earth buildings are not a phenomenon only of the Third World countries, but also in developed countries [1]. Many types of laterites are suitable for use as construction materials. To make effective use, it has to examine their quality, and identify their characteristics, appropriateness for use in general constructions. Besides the addition and removal of certain constituents, several tests need to be carried out to ascertain its quality. Understanding the quality of laterite and clay we can use it as an ecological on site construction material. Different types of laterite and clay are suitable for use in civil and building constructions. More than two billion people live in buildings constructed of laterite earth and clay products mostly in Asia and Africa [9].

To improve their quality, the selection of building materials should meet the local conditions of the area to be use by improving on existing structures or by building new structures. In the past, improving and developing the natural materials using

new technology has created substitute materials. In addition, for energy requirement to produce adobe block is only 5 (kWh)/cubic meter, while it is about 1000 (kWh)/ cubic meter for fired brick and 400 to 500 (kWh)/ cubic meter for concrete block [5]. Laterite earth structures are completely recyclable, so sun dried bricks return to the earth without polluting the soil [6]. Using earth for such environmental buildings will be a strong component in the future of human Earth structures are completely recyclable, so sun dried bricks return to the earth without polluting the soil [7]. Using earth for such environmental buildings will be a strong component in the future of human kind. Laterite earth as a building material is available everywhere in the world and exists in many different compositions. Therefore, there is need to investigate and examine the properties and quality of laterite and clay to produce sustainable buildings [1].
Brick widely used construction material around Jimma town. Unlike other part of our country it can be observed that today most of villa houses, fences, existing old buildings and fences are intensively constructed using brick wall and columns. Especially old buildings brick columns and walls are very inspiring which exist today without significant failure and serving still today. But the study conducted by [8] shows that, the brick produced around Jimma area where below standard specification. In addition, small micros are producing clay brick for low cost houses these days in small amount and with unsatisfactory quality, which can easily break and high water absorbing behavior. It is also known that many people are not using this day's for load bearing rather for beauty and fence purpose only. This study was improve the physical properties of the brick by mixing clay soil with literate soil. So based on this it encourage the use of locally available material for the production of brick for affordable and low cost construction of housing, this study was good opportunity for Job Creation for the society.

2. Material required and methods

2.1 Materials required

Purposively; Lateritic soil and with High plastic clay soil collected at depth of 0.5m in order to protect other organic material.

2.2 Preparation of brick

The clay soil were used in this study was selected with highly plastic contents. In order to improve the property of the clay soil by different percentage laterite soil were 5%, 10%, 15% and 20% (by weight) was used and finally uniform mixing was carried until the same color was obtained. Atterberg limit tests were performed on different percentage of lateritic soil added on clay soil. Water was added in the mixes prepared until it gives a consistency, workable and suitable for different percentage of brick preparation and proper mixing was done in the preparation of bricks.

The following procedure were used during production of clay-lateritic brick units

I. The collected sample lateritic and clay soil allowed to drying separately.

II. By breaking the samples and grinding in small particles until the required sieve size pass.

III. Preparing mix design (according to the percentage) required and separately by adding the required amount of water for different mix until the favorable for workability, finally mix stored in a cool room for at least for two days until uniform distribution of water attained in the mixture.

IV. Before molding start; mould was dipped in water in order to prevent sticking and poured the mix in the mould by thrown forcedly by hand until it a roughly shaped attain. The excess on the top of mould was removed by thin wire cable. Immediately; the moulded brick was demolded and dried in the sun for a week and finally the bricks were a furnace oven dried at 1000°c.

3. Result and discussion

3.1. Engineering properties of lateritic soil and clay soil

3.1.1. Identification of engineering properties of lateritic soils

In order to determine the quality of the materials, laboratory tests were carried out. The tests involved to identify the properties of the lateritic soil such as its physical and mechanical properties.

Table 3.1. Geotechnical Properties of Lateritic

S/N	*Property*	*Observed Values*
1.	Classification	
	AASHTO (group index)	A-2-7
	USCS group symbol	SC
	USCS group name	poorly graded gravels
2.	Specific gravity	2.41
3.	Particle size analysis	
	Sand content % (4.75 to 0.075mm)	65
	Silt and clay content % (below 0.075mm.)	35
4.	Atterberg's Limits: %	
	Liquid limit	75.8
	Plastic limit	40.48
	Plasticity index	35.32
5.	Proctor test	
	Optimum moisture content (OMC), %	40.8
	Maximum dry density (g/cm3)	1.329
6.	California Bearing Ratio value % (Soaked)	3.92

3.1.2. Engineering properties of untreated clay soil

The tests involved to identify the properties of the clay Soil such as its physical and mechanical properties. The tests carried out on the untreated clay soil include sieve analysis, Atterberg limit test, compaction test, California bearing ratio and specific gravity.

Table 3.2. Geotechnical Properties of Clay Soil

S/N	*Property*	*Observed Values*
1.	Classification	
	AASHTO (group index)	A-2-5
	USCS group symbol	CH
	USCS group name	Highly Plastic Clay
2.	Specific gravity	2.6
3.	Particle size analysis	
	Gravel content% (20 to 4.75mm.)	0.588
	Sand content % (4.75 to 0.075mm)	5.514
	Silt and clay content % (below 0.075mm.)	93.898
4.	Atterberg's Limits: %	
	Liquid limit	88.65
	Plastic limit	32.37
	Plasticity index	56.28
5.	Proctor test	
	Optimum moisture content (OMC), %	35.8
	Maximum dry density (g/cm3)	1.26
6.	California Bearing Ratio value % (Soaked)	1.5

3.2. Casting of bricks

3.2.1. Preparation of mixed clay-lateritic soil

Clay bricks were made with laterite soil separately. They are hand moulded and were burnt a furnace oven. Whereas laterite soil was added in 0, 5, 10, 15 and 20%. The mixtures were prepared with the pre-determined optimum moisture content values. The size of the bricks was selected as 230 x110x70mm non-modular bricks. It was decided as per IS 1077:1992. The prepared mix was forced into the mould and after removing the mould kept it for air-drying. The bricks were allowed to dry till they are left with 5 to 7 percent moisture content. The drying period was a weeks. After air-drying process the bricks were transported to the furnace oven, where it was burned at a temperature of 1000^{o}C. Bricks were taken out from the furnace oven after cooling and the testing started only after 21 days of curing as per IS code.

3.2.2. Test methods

The bricks were tested as per IS code for finding the physical properties. The burned bricks were cured for 21 days and only after that testing were started. Compressive strength, water absorption, efflorescence and thermal conductivity are the tests conducted on the bricks. These tests were conducted as per IS 3495 (PART I-III) and as per IS 3346:1980.

3.3. Discussion of test result

Clay bricks made with laterite soil were tested for analyzing the physical properties of bricks such as Atterberg limit test, compressive strength, water absorption, efflorescence and thermal conductivity.

3.3.1. Atterberg limit test and workable mixing water contents

The results of Atterberg limit tests and workable mixing water contents are shown in Table 3.3 and Figure 3.1. It can be show that both liquid and plastic limits decrease, while increases percentage of laterite contents But also the workable mixing water content also decreases with increase percentage laterite. The summary of the results of Atterberg limits shown on Table 3.3.

$$Plastic\ Index = Liquid\ limit - Plastic\ limit \quad (3.1)$$

Table 3.3. Effect of laterite soil on atterberg limit.

Laterite soil content (%)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)	Mixing Water contents (%)
0	88.65	32.37	56.28	38.98
5	83.54	30.11	53.43	35.49
10	76.25	27.47	48.78	33.47
15	69.05	22.61	46.44	31.19
20	53.77	18.87	34.9	30.09

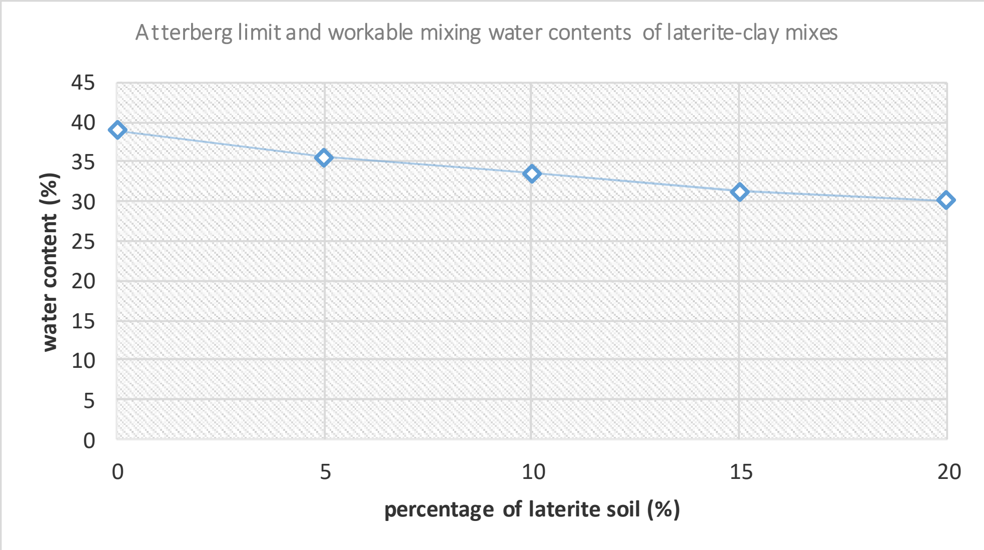

Fig. 3.1. Water contents verses percentage of laterite in clay soil.

3.3.2. Linear shrinkage and density

The summary of the results of linear shrinkage, and dry and firing densities are shown in Table 3.4 the shrinkage decrease with increases the laterite soil contents but decrease in dry density.

Table 3.4. Effect of Laterite soil on linear shrinkage, dry and after furnace densities of clay-laterite.

Laterite soil content (%)	Linear shrinkage (%)	Dry density (kg/m^3)	After furnace oven (kg/m^3)
0	11.63	1820	1753
5	10.16	1756	1654
10	9.25	1611	1488
15	8.85	1523	1376
20	6.11	1402	1224

3.3.3. Compressive strength of clay bricks with Laterite soil

Compressive strength test result of produced clay-laterite bricks made with different percentages of laterite soil with 0%, 5%, 10%, 15% and 20% is shown below on the Table 3.5.

$$Average\ stress(\delta) = \frac{maximum\ load(KN)}{Average\ area\ of\ bed\ face(mm^2)} \quad \text{..........(3.2)}$$

Table 3.5. Compressive strength values of clay-laterite bricks with Laterite soil

Laterite soil content (%)	Compressive strength or stress, σ (MPa)	Specification
0	10.76	Compressive strength not less than 10 N/mm^2 for class designation 100 [11]
5	10.96	
10	11.19	
15	11.37	
20	11.29	

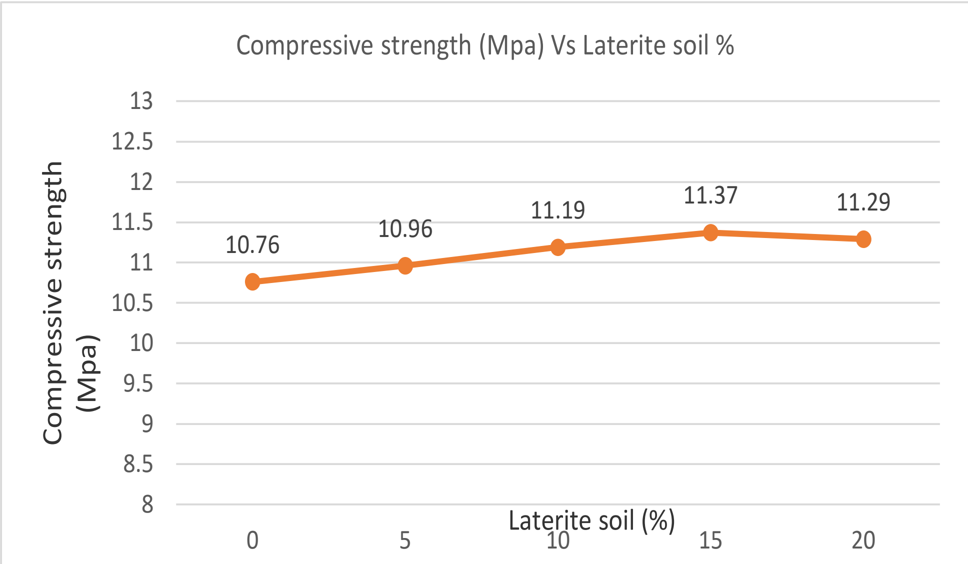

Fig. 3.2. Variation of compressive strength result of clay bricks with Laterite soil.

The compressive strength of the bricks depends mainly on the density and porosity of the bricks. It is observed that the results of clay bricks with laterite soil shows a compressive strength greater than 10 MPa, which belong to class designation 100 as per Indian standard specification. All the modified bricks show higher strength than control bricks.

3.3.4. Water absorption

As the percentage of laterite soil increases water absorption decrease.

Table 3.6. Water absorption test Result of produced with Clay-Laterite bricks

Laterite soil content (%)	Water absorption (%)
0	16.25
5	15.54
10	14.48
15	13.04
20	11.55

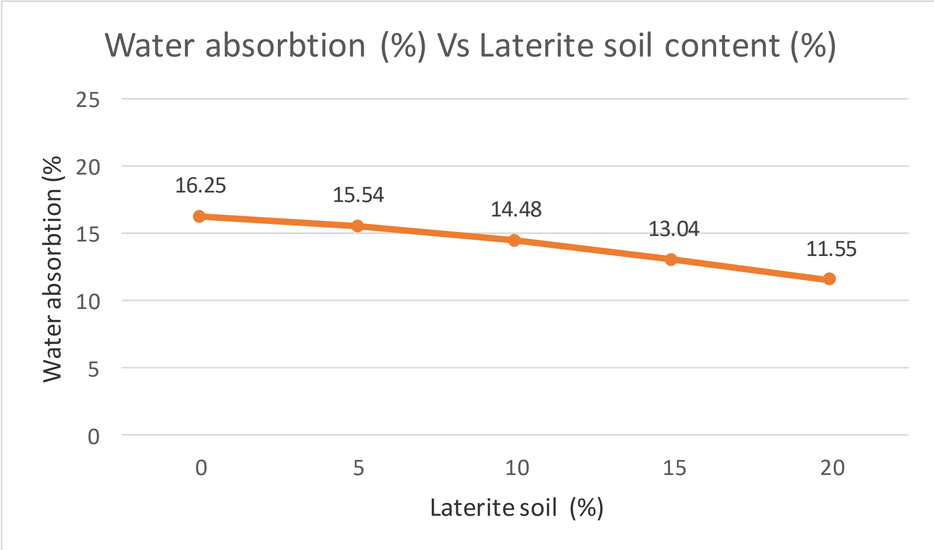

Fig. 3.3. Variation of water absorption of clay bricks with Laterite soil.

Bricks made with laterite soil have similar properties to that of control bricks. Laterite soil- clay brick shows lesser water absorption rate compared to standard specification of the class.

3.3.5. Efflorescence

Efflorescence was determined for find the alkaline salt content in bricks. The test was conducted as per IS 3495 (part III) – 1992. In this experimental work no perceptible deposit is observed on majority of samples but there is a very thin deposit of salts observed on some parts of samples

4. Conclusion

On the basis of test results, the following conclusions can be drawn:

1. The Laterite soils were classified based on ASSHTO classification system as A-2-7 category with poorly graded gravel and based on the USCS classification system as SC soil groups. The compaction test for the laterite soils yielded MDD and OMC which 1.329g/cc and 40.8% & The Clay soils were classified based on ASSHTO classification system as A-2-7 category with high plastic clay and based on the USCS classification system as CH soil groups. The compaction test for the Clay soils yielded MDD and OMC which 1.26g/cc and 35.8% respectively
2. The density of brick decreases with increase in laterite contents. Light weight bricks can thus be produced without any deterioration in the quality of the bricks.

3. Modified clay bricks show increase in compressive strength up to a particular percentage, beyond that point compressive strength decreases. This is due to the less bonding between clay-lateriate and lesser density of the modified bricks. Water absorption decreases with increase percentage addition lateriate soil. This is due to the courser soil particles in bricks; this results in less water absorption. all the bricks have slight efflorescence content. This shows the alkaline salt content in those bricks are less.
4. Bricks made of clay-lateritic mixes can be used for load bearing walls.
Further studies should be carried out in order to identify the long-term effects that clay-laterite soil on the durability of brick and also studies should be made on chemical composition of clay-laterite soil.

References

[1] A.A.A. Yar'adua Muntari Mudi, *An examination of the properties of literate and clay as*, chez University Tun Hussein Onn Johor, Malaysia, Nigeria, July 2012.

[2] M. S., M. M. A.K. Kasthurba, *Investigation of laterite stones for building purpose from*, Construction and Building Materials, p. 73–82, 2007.

[3] C. J. K.K.G.K.D. Kariyawasam, *Cement stabilized rammed earth as a sustainable construction material*, Construction and Building Materials, vol. 105, p. 519–527, 2016.

[4] A.U.K. Muntari Mudi Yar' Adua, *Sustainable environment: laterite as sustainable*, International Journal of Advances in Mechanical and Civil Engineering, vol. 3, n° %12, p. 2394-2827, April 2016.

[5] E.A.C.O.O. Peter O. Akadiri, *Design of a sustainable building: a conceptual framework for implementing sustainability in the building sector*, buildings, n° %12075-5309, p. 126-152, 2012.

[6] *Correlation between total water absorption and wet compressive strength of compressed stabilised peat bricks*, International Journal of the Physical Sciences, vol. 6, n° %11992 - 1950, p. 2432-2438, 18 May, 2011.

[7] B. Bayizitlioğlu, *Conservation and maintenance of earth constructions*, The Historic Environment: Policy & Practice, vol. 8, n° %14, pp. 323-354, 2017.

[8] A. M. Kabtamu Getachew, *Laboratory Investigation of Locally Produced Clay Brick Quality and Suitability for Load Bearing Element in Jimma Area, Ethiopia*, International Journal of Engineering Research & Technology (IJERT), vol. 6, n° %15, p. 809-817, 2017.

[9] SKAT et 1988, *Appropriate building materials: a catalogue of potential solutions*, 1988.

[10] M. A. Rahman, *The Potentials of Lateritic Soil-Clay and Clay-Sand Mixes in the Manufacturing of Bricks for Masonry Units*, Building and Environment, vol. 22, n° %14, p. 325-330, 1987.

[11] B. o. IS 1077, Bu*rea of Indian Standards,Common Burnt Clay Building Bricks –Specification [CED30 Clay and stabilized Products for Construction*, New Delhi ,India., 1992.

[12] B. C. Giles, *Ethiopia is now Africa's fastest growing economy*, CNN, Updated 1031 GMT (1831 HKT) April 24, 2018.

[13] https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=79941&printable=1, Land Use and Urban Planning, 12 Aug 2019, 06:44.