IMPROVING THE PROPERTIES OF CLAY SOIL BY USING LATERITE SOIL FOR PRODUCTION OF BRICKS

Anteneh GEREMEW^{1,*} and Yibas MAMUYE¹

¹ Department of Civil Engineering, Jimma University, Jimma, Ethiopia.
^{*} corresponding author: antjiren@gmail.com.

Abstract

Nowadays, the utilization of locally accessible materials is a crucial stage for sustainable, economical building material on the earth's surface. Within them, brick is one of the commonly used construction materials around Jimma town due to the availability of clayed soil. Nevertheless, brick produced by small micro-uns skilled enterprises rather than by traditional methods, its quantity was small, and its quality was unsatisfactory because it can easily break, and it has high water-absorbing conduct. The purpose of the investigation was to improve the properties of clayed soil properties by using laterite soil for the manufacturing of bricks for masonry units. In order to achieve this, research used non-probability sampling techniques to collect samples in Jimma area. Then, the collected samples prepared for different laboratory tests and by partially replacing laterite soil by 5 %, 10 %, 15 % and 20 % on a clayed soil in order to get optimum property by different mix ratio for different laboratory tests results indicated showed that the lightweight bricks could be made from the approach of this study without any deterioration in the quality of bricks.

Additionally, the compressive strength of the blocks optimum at 15 % lateritic soil replaces in clayed soil contents. The optimum firing temperature furnace at a duration burning of brick was at 1000 °C for 5hrs. It has shown that bricks prepared of clay-laterite earth capable of high resisting capacity rather than for beauty.

Keywords:

Laterite soil;
 Brick;
 Clayed soil;
 Compressive strength;
 Water absorption.

1 Introduction

Ethiopia, one of the fast economic growth in East-Africa [1]. Due to urbanization, the number of populations living in towns becoming increases day to day; so that for sustainable living standards in a town constructing a house un-questionable for human beings, although the cost of a unit block of plain concrete highly increases [2]. There was a small number of micro-enterprises production clay brick with a traditional way without controlling the quality; only by looking at a brick face beauty, but there was a large deposit of clayed soil and laterite soil in the Jimma area [3]. Laterite earth material was considered to be one of the oldest and commonly used building materials. It was considered to be one of the essential construction materials on the earth's surface was widespread [4]. Unfortunately, laterite earth construction in developed countries is diminishing with the abrupt changes in construction materials and methods [5]. Good quality bricks can be manufactured using lateritic soil provided that accepted clay material has added. The use of plastic clayed alone in the production of brick may not be suitable due to shrinkage and warping effect during the drying process [6]. Partially substituting clay earth with disburshed unwanted shea has upgraded the scientific enactment of block of the earth in decrease the mass, improved in performance satisfies specification [7].

Appropriateness of the application of natural flavors in brick earth to be established was upgraded competence and continuing. Therefore it decreases ecological effect [8]. Burring of a unit of earth brick exhaustive a tremendous amount of power utilized approximately 24 million tons per annual; this is one of the major causes of the environmental defect [9]. A Block earth material has

numerous practices on construction industry resources [10].

According to [6], the application of lateritic brick added clay started around 8000 B.C. in Mesopotamia, the construction of houses, dams, and roads. Most of the builders and construction peoples value most of the soil. Due to its durability and cost-effectiveness, it can also be considered as an excellent sustainable material in the construction and recycling process, for it can minimize pollution and has low carbon emission during the application [11]. The application of laterite earth in building construction almost exists anywhere in the world, especially in third world countries. In a country like Kano, Kaduna, and other cities in Northern Nigeria, the use of this material is beneficial. However, it has noted that laterite earth is also applied in developing countries [6, 12]. In many countries, in Asia and Africa, more than two billion peoples are using in building or house construction using lateritic earth and clay products. The application of these materials has earned many advantages by determining its quality, identifying its characteristics, and its application in construction

Additionally, it improves the quality of lateritic earth, additives, and removes one of its contents is also an option [13]. The reduction of energy requirement in the production of a brick using lateritic soil is an advantage. It will be produced using 5 kWh/m^3 compared to fired brick and concrete blocks, which consume 1000 kWh/m^3 and 450 kWh/m^3 , respectively. Additionally, lateritic soil structure is easily recyclable without polluting the environment [14]. Due to its availability or existence in any part of the world, the application of its uses in environment building construction is very crucial. It is available in many different compositions, which needs further investigation when added to other materials such as clay to produced sustainable structure [6, 15, 16].

Brick extensively adopted building material around Jimma town. Unlike other cities outside of Jimma, they used most implemented for modern households, pale, and ancient houses have intensively built by block partition and pillars. Particularly ancient structures brick pillars and partitions were precise exciting, which occur today without major failure and attending still current time. Nevertheless, the research conducted shown by [17] shows that the brick produced nearby the Jimma area where below standard specifications. Besides, small micro enterprises are producing clay brick for low-cost houses these days in small amounts and with unsatisfactory quality, which can easily break and with high water absorbing behavior. It has also known that many people are not using these days for load-bearing purposes but instead for aesthetic and fence purposes only. This study has improved the physical properties of the brick by mixing clayed soil with laterite soil. So based on this, it encourages the use of locally available material for the production of brick for affordable and low-cost construction of houses. This study was an excellent opportunity for job creation for the society living around Jimma town.

2 Materials required and methods

2.1 Materials required

In order to succeed the objective, purposive sampling techniques have implemented; Lateritic soil sampled around Jimma town and a clayed soil having high plasticity collected at a depth of 0.5 m in order to protect other organic material and also clay samples were collected by using engineering judgment, by observing color texture, and by its index property.

2.2 Preparation of brick

The clayed soil has utilized for this particular research was selected with high plastic contents. In order to improve the property of the clayed soil, different percentages of laterite soil 5 %, 10 %, 15 %, and 20 % (through mass) been used, and finally, uniform mixing carried until the same color obtained. Atterberg limit tests performed on different percentages of lateritic soil added to the clayed soil. Water added in the mixes, prepared until it gives consistency, workable, and suitable for different percentage of brick preparation; and proper mixing done in the preparation of bricks.

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

1. The collected samples, lateritic and clayed soil, allowed for drying separately.
2. By breaking the samples and grinding in small particles until the required sieve size pass.
3. Preparing mix design (according to the percentage) required and separately by adding the necessary quantity of water for different mix until the favorable for workability, finally mix stored in a cold room for at least two days until the uniform distribution of water attained in the mixture.

4. Before molding starts, the mold dipped in water in order to prevent sticking and poured the mix in the mold by thrown forcedly by hand until it attains a roughly shaped. The thin wire cable removed the excess on the top of the mold. Immediately, the molded brick then removed from the mold and dried in the sun for a week, and finally, the bricks were furnace oven-dried at 1000 °C for 5 hours.

2.3 Methods and standard testing procedure

Table 1: Summary of test method.

Type of test	Test method/ Designations
MOISTURE CONTENT	AASHTO T - 265
SIEVE ANALYSIS	ASTM -D422-63
ATTERBERG LIMITS	ASTM -D4318-98
SOIL GROUPING	ASTM -D2487-98
SPECIFIC GRAVITY	ASTM -D854-83
PROCTOR TEST	ASTM -D698-98
COMPRESSIVE TEST	IS 3495 (PART I-III) and IS 3346:1980
PREPARATION OF SAMPLES	IS 1077:1992
EFFLORESCENCE	IS 3495 (part III) – 1992

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 control the quality of the materials, laboratory tests were carried out based on the standard specification. The experiments elaborate to classify the belongings lateritic earth, such as its physical and mechanical possessions.

Table 2: Geotechnical properties of lateritic soil.

S/N	Attribute	Empirical Standards
1	Catalog	
	AASHTO	A-2-7
	USCS cluster	SC
	USCS cluster	poorly -graded sands
2	Specific gravity	2.37
3	Sieve analysis	
	Sand content % (4.75 to 0.075mm)	62.4
	Silt and clay content % (under 0.075mm.)	37.6
4	Atterberg's limits: %	
	Liquid limit	78.54
	Plastic limit	41.19
	Plasticity index	37.35
5	Proctor test	
	Optimum moisture content (OMC), %	41.56
	Maximum dry density (g/cm ³)	1.31
6	Red literate soil	By visual inspection

3.1.2 Engineering belongings of clayed soil

The experiments elaborate to classify the possessions of the clayed earth, such as their physical and mechanical possessions. Therefore investigations carried out on the unprocessed clay earth contain sieve analysis, Atterberg limit test, compaction test, California bearing ratio, and specific gravity.

Table 3: Geotechnical properties of clayed earth.

S/N	Attribute	Empirical standards
1	Catalog	
	AASHTO	A-2-5
	USCS cluster	CH
	USCS cluster	Soft Soil
2	Specific gravity	2.485
3	Sieve analysis	
	Gravel content % (20 to 4.75mm.)	0.533
	Sand content % (4.75 to 0.075mm)	4.952
	Silt and clay content % (below 0.075mm.)	94.515
4	Atterberg's limits: %	
	Liquid limit	87.42
	Plastic limit	31.85
	Plasticity index	55.57
5	Proctor test	
	Optimum moisture content (OMC), %	34.54
	Maximum dry density (g/cm ³)	1.235
6.	Greyish clayed soil	By visual inspection

3.2 Casting of bricks

3.2.1 Preparation of mixed clay-lateritic soil

As control of the test, a clay brick alone was prepared accordingly and shaped based on the size of the box and burn in a furnace oven. Additionally to this, unlike proportion of laterite earth added 5 %, 10 %, 15 %, and 20 %. The blends were set with the pre-determined optimum moisture content values. The size of the box of bricks to be cast dimension of 230 x 110 x 70 mm non-modular bricks. It is evident as per IS 1077:1992. The arranged combination forced into the mold, and subsequently removing the mold, retained for sun drying. The prepared sample of bricks was allowed to dry until it reduces the moisture content. Exposing to ventilation to sun drying period approximately a week and finally transferring the samples to the furnace oven and burn at a temperature of 1000 °C for 5 hours. Sample of bricks taken out from the furnace oven and allow to cool; and then the laboratory testing followed 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 cured for 21 days, and only after that, testing can be started. Compressive strength, water absorption, efflorescence, and thermal conductivity are the tests conducted on the bricks. The experiments continuously 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 tested for analyzing the physical properties of bricks such as the 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 shown in Table 4 and Fig.1 based on standard specification [19, 20]. Both liquid and plastic limits have decreased, with increasing of the percentage of laterite content. However, also the workable mixing water content decreases with increase percentage laterite. Shows in Table 4, a summary of the results of Atterberg's limits.

$$\text{Plastic Index} = \text{Liquid limit} - \text{Plastic limit} . \quad (1)$$

Table 4: Effect of laterite soil on Atterberg limits.

Laterite soil content (%)	Liquid limit (%)	Plastic limit (%)	Plastic index (%)	Mixing water contents (%)
0	87.42	31.85	55.57	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.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 5, the shrinkage decreases with an increase of the laterite soil contents but decreases in dry density.

Table 5: 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

The compressive strength test results of produced clay-laterite bricks made with different percentages of laterite soil with 0 %, 5 %, 10 %, 15 %, and 20 % are shown below in Table 6, Fig. 2.

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

Table 6: 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 [18]
5	10.96	
10	11.19	
15	11.37	
20	11.29

Fig. 2: Variation of compressive strength results of clayed bricks with laterite soil.

On the porosity and density of the bricks, the compressive strength is depending mainly on it. The results of clay bricks with laterite soil show a compressive strength greater than 10 MPa, which belongs to class designation 100 as per Indian standard specification. All the modified bricks showed higher strength than control bricks.

3.3.4 Water absorption

As the percentage of laterite soil increases, water absorption decrease, Table 7 and Fig. 3.

Table 7: Water absorption test result of produced bricks with clay-laterite.

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

Fig. 3: Variation of water absorption of clay bricks with laterite soil.

Based on the experiment achieved in the laboratory for the manufactured bricks made with laterite soil have similar properties obtained as the control bricks. Laterite soil - clay brick shows a lesser water absorption rate as compared to the standard specification of the class.

3.3.5 Efflorescence

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

4 Conclusion

The laterite earth soils were classified based on the ASSHTO classification system as the A-2-7 category with poorly graded gravel and based on the USCS as SC soil groups. The compaction test for the laterite soils yielded MDD and OMC with 1.31 g/cc and 41.56 % respectively. The clay soils were classified based on the ASSHTO classification system as the A-2-5 category with high plastic clay and based on the USCS as CH soil groups. The compaction test for the clay soils yielded MDD and OMC which 1.235 g/cc and 34.54 % respectively.

The density of brick decreases with an increase in laterite contents. Lightweight bricks can thus produced without any deterioration in the quality of the bricks. Modified clay bricks showed an increase in compressive strength up to a particular percentage; beyond that point, compressive strength decreases. This is due to the less bonding between clay-laterite and lesser density of the modified bricks. Water absorption decreases with an increasing percentage of addition laterite soil. This is due to the coarser soil particles in bricks; this results in less water absorption. Samples of bricks have minor efflorescence content observed on the face of brick. It shows less amount of the alkaline salt content in those bricks.

Bricks prepared of clay-lateritic combinations also utilized for high resisting capacity for simple structure except for underground structures. In order to recognize the long term effects of the clay-laterite block on the toughness of bricks and to examine the chemical composition of clay-laterite soil materials, more research needed.

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