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[1.]Anteneh GEREMEW, [2.]Yibas MAMUYE

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

[1, 2] Department of Civil Engineering, Jimma University, Jimma, ETHIOPIA

Abstract: Now a day's utilization of local accessible materials is an important stage for sustainable, economic building material on the earth surface. Within them Brick is one of the commonly used construction material around Jimma town due to the availability of clayed soil. 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 conduct. The purpose of investigation was to improving the properties of clayed soil properties by using Literate soil for the manufacturing of bricks for masonry units. In order to achieve this researches include, non-probability sampling techniques was used to collect samples in Jimma area. Then the collected samples were prepared for different laboratory tests and by partially replacing literate soil by 5%, 10%, 15% and 20% on a clayed soil in order to get optimum property by different mix ration 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 replace in clayed soil contents. The optimum firing temperature furnace at a duration burning of brick was at 1000°C for 5hrs. It's shown that bricks prepared of clay-laterite earth capable for high resisting capacity rather than for beauty.
Keywords: Literate soil, Brick, Clayed soil, Compressive strength, Water absorption, sustainable, Density, Construction material

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 being although the cost of a unit black of plain concrete highly increases [2]. 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 clayed soil and literate soil in Jimma area [3]. Laterite earth material was considered to be one of the oldest and commonly used building material. It was considered to be one of the most important construction material on the earth surface was widespread [4].

Unfortunately, laterite earth construction in developed country 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 will be 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 disbursed unwanted Shea has upgraded scientific enactment of black of earth in decrease the mass, improved in performance satisfies specification [7].Appropriateness of the application of biological flavours in brick earth to be established was upgraded competence and continuing. Therefore it decreases ecological effect [8] Burring of a units of earth brick exhaustive huge amount of power utilized approximately 24 million tons per annual, this is one of major causes of environmental defect [9]. A Block earth material has a numerous practices on construction industry resources [10]. According to [6], the application of lateritic brick added clay started around 8000 BC in Mesopotamia the construction of houses, dams, and roads.

Mostly of builders and construction peoples value most of the soil. Due to it durability and cost effectiveness. It can be considered also as an excellent sustainable materials in construction and recycling process for it can minimized pollution and has low carbon emission during the application [11].The application of laterite earth in building construction almost exist anywhere in the world especially in third world country.in country like Kano, Kaduna and other cities in Northern Nigeria, used of this material is very effective. But it can be 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/house construction using lateritic earth and clay products. The application of these material has earned lot of advantages by determining it quality, identifying its characteristics and its application in construction. Additionally, it improve the quality of lateritic earth, additives and remove of one of its contents is also an option [13]. The reduction of energy requirement in the production of brick using lateritic soil is an advantage. It will be produce using 5KWH/m^3 compared to fired brick and concrete block which consume 1000KWH/m^3 and 450KWH/m^3 respectively. Additionally, lateritic soil structure are easily recyclable without polluting the environment [14]. Due to it availability /existence ant where in the world, the application of its uses in environment building construction is very crucial. It available in many different composition which need further investigation when added to other material such as clay to produced sustainable structure [6, 15 and 16].

Brick extensively adopted building material round Jimma town. Unlike other than city outside of Jimma used most implemented for modern households, pale, ancient houses are intensively built by block partition and pillars. Particularly ancient structures brick pillars and partitions was precise exciting which occur today without major failure and attending still current time. But the research conducted shown by [17] shows that, the brick produced nearby Jimma area where below standard specifications. In addition, small micros 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 behaviour. It is also known that many people are not using these day's for load bearing rather for beauty and fence purpose only. This study has improved the physical properties of the brick by mixing clayed soil with literate 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 a good opportunity for Job Creation for the society living around Jimma town.

2. MATERIALS REQUIRED AND METHODS

— Materials required

Inorder to succeed the objective Purposively sampling techniques was implemented ; Lateritic soil sampled around jimma town and a clayed soil having high plasticity collected at depth of 0.5m in order to protect other organic material and also clay samples was collected by using engineering judgement by observing colour texture by its index property.

— Preparation of Brick

The clayed soil were was 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) were used and finally uniform mixing was carried until the same color was obtained. Atterberg limit tests was performed on different percentages of lateritic soil added to the clayed soil. Water was added in the mixes prepared until it give a consistency, workable and suitable for different percentage of brick preparation and proper mixing was done in the preparation of bricks.

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

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

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

Before mold 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 for 5hrs.

3. RESULT AND DISCUSSION

— **Engineering Properties of lateritic soil and Clay soil**

≡ **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 to the belongings lateritic earth such as its physical and mechanical possessions.

Table 2: Geotechnical Properties of Lateritic soil.

S/N	Attribute	Empirical Standards
1	Catalogue	
	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/cm3)	1.31
6	Red Literate soil	By visual inspection

≡ **Engineering belongings of Clayed soil.**

The experiments elaborate to classify the possessions of the clayed earth such as its physical and mechanical possessions. Therefore investigations carried out on the unprocessed clay earth contains 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	Catalogue	
	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/cm3)	1.235
6.	Greyish clayed soil	By visual inspection

— **Casting of Bricks**

≡ **Preparation of mixed clay-lateritic soil**

As a control of test a clay brick alone was prepared accordingly and shaped based on size of box and allowed to burnet to 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 box of bricks to be casted dimension of 230 x110x70mm non-modular bricks. It's obvious as per IS 1077:1992. The arranged combination was forced into the mould and subsequently removing the mould retained it for sun drying. The prepared sample of bricks was allowed to dry until it reduces moisture content from it. Exposing to ventilation to sun drying period approximately a weeks and finally transferring the samples to the furnace oven, where they were burnt at a temperature of 1000°C for 5hrs. Sample of bricks was taken out from the furnace oven after that allowed to cool then starting the laboratory testing started after 21 days of curing as per IS code.

≡ 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. The experiments continuously conducted as per IS 3495 (PART I-III) and as per IS 3346:1980.

— Discussion of Test Result

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

≡ Atterberg limit test and workable mixing water contents

The results of Atterberg limit tests and workable mixing water contents are shown in Table 4 and Figure1 based on standard specification [19, 20].It can be seen that both liquid and plastic limits have decreased, with increasing of percentage of laterite content. But also the workable mixing water content also decreases with increase percentage laterite. The summary of the results of Atterberg limits is shown in Table 4

$$\text{Plastic Index} = \text{Liquid limit} - \text{Plasti limit} \tag{1}$$

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

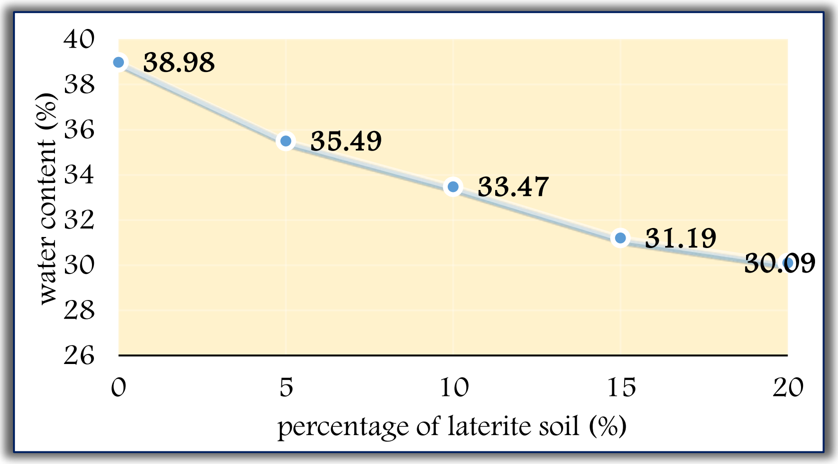

Figure1: water contents versus percentage of laterite in clay soil

≡ 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 decreases with 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/m3)	After furnace oven (kg/m3)
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

≡ **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% are shown below in Table 3.5

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

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/mm² for class designation 100 [18]
5	10.96	
10	11.19	
15	11.37	
20	11.29	

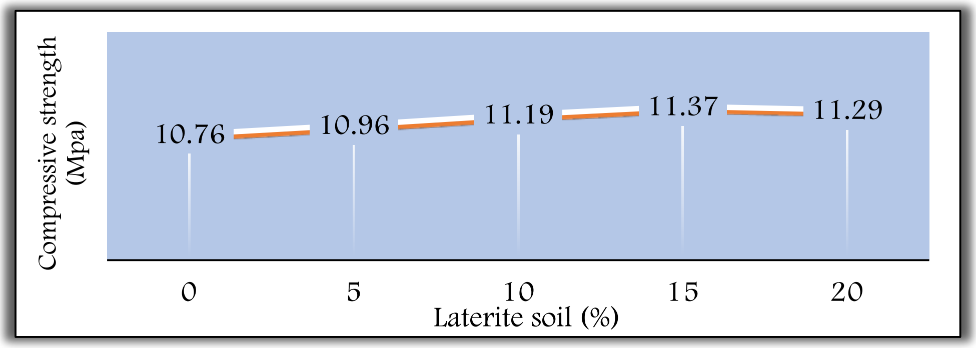

Figure 2: Variation of compressive strength results of clayed bricks with Laterite soil

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 show a compressive strength greater than 10 MPa, which belong to class designation 100 as per Indian standard specification. All the modified bricks showed higher strength than control bricks.

≡ **Water absorption**

As the percentage of laterite soil increases water absorption decrease.

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

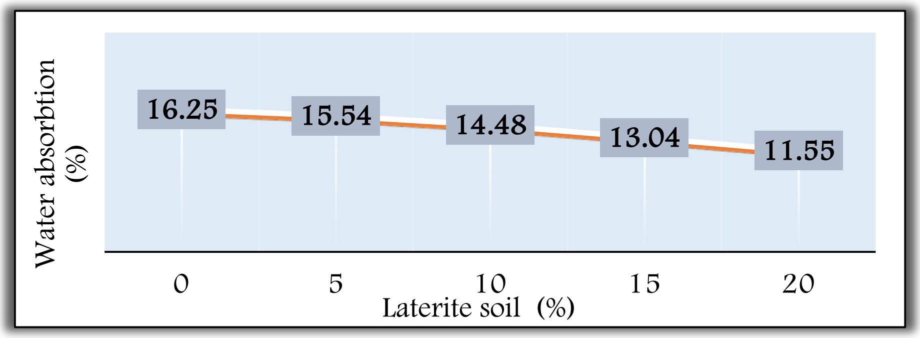

Figure 3: Variation of water absorption of clay bricks with Laterite soil

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

≡ **Efflorescence**

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

4. CONCLUSIONS

On the basis of experiment outcomes, the resulting was summarizes as follows:

— The Laterite earth soils were classified based on ASSHTO classification system as 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 1.31g/cc and 41.56% respectively. The Clay soils were classified based on ASSHTO classification system as 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 1.235g/cc and 34.54% respectively.

— 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. Modified clay bricks showed 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 increase percentage 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. This shows the alkaline salt content in those bricks are less.

— Bricks prepared of clay-lateritic combinations also utilized for high resisting capacity for simple structure except for underground structures. More research must be conducted in order to recognise the long-term effects of clay-laterite block on the toughness of bricks and also examine its chemical composition of clay-laterite soil materials.

Reference

[1] UNDP, ETHIOPIA: Country Economic Brief, UNDP Ethiop. Policy Advis. Unit, no. 1, pp. 1–15, 2014.
[2] Asian Development Bank, Urbanization and Sustainability in Asia: Case Studies of Good Practice, Adb, p. 516, 2006.
[3] Unido, OCCASION This publication has been made available to the public on the occasion of the 50. 2007.
[4] A.K. Kasthurba, M. Santhanam, M.S. Mathews, Investigation of laterite stones for building purpose from Malabar region, Kerala state, SW India – Part 1 : Field studies and profile characterization, vol. 21, pp. 73–82, 2007.
[5] M.A. Rahman, The potentials of lateritic soil-Clay and clay-sand mixes in the manufacturing of bricks for masonry units, Build. Environ., vol. 22, no. 4, pp. 325–330, 1987.
[6] M. Mudi, A. A. Aliyu, An examination of the properties of literate and clay as construction materials for sustainable buildings in Kano and Kaduna Metropolis, Nigeria, no. July, pp. 1–7, 2012.
[7] A.N. Adazabra, G. Viruthagiri, N. Shanmugam, An assessment on the sustainable production of construction clay bricks with spent shea waste as renewable ecological material, vol. 1, no. 2, 2018.
[8] J.A. Lozano-Miralles, M.J. Hermoso-Orzáez, C. Martínez-García, J.I. Rojas-Sola, Comparative study on the environmental impact of traditional clay bricks mixed with organic waste using life cycle analysis, Sustain., vol. 10, no. 8, 2018.
[9] M.L. Mary, C. Peter, K. Mohan, S. Greens, S. George, Energy efficient production of clay bricks using industrial waste, Heliyon, vol. 4, no. 10, p. e00891, 2018.
[10] Zultiniar, A. Fadli, S.R. Yenti, Drastinawati, M.R.A. Thariq, Fabricaton of brick without burning process, IOP Conf. Ser. Mater. Sci. Eng., vol. 345, no. 1, 2018.
[11] K.D. Kariyawasam, C. Jayasinghe, Cement stabilized rammed earth as a sustainable construction material, Constr. Build. Mater., vol. 105, pp. 519–527, 2016.
[12] A.U. Kakale, Sustainable Environment : Laterite as Sustainable, no. 2, pp. 70–73, 2016.
[13] S. Gallen, SKAT Swiss Centre for Development Cooperation in Technology and Management, 1993.
[14] P.O. Akadiri, E.A. Chinyio, P. O. Olomolaiye, Design of a sustainable building: A conceptual framework for implementing sustainability in the building sector, pp. 126–152, 2012.
[15] B. Bayizitlioğlu, The Historic Environment : Policy & practice conservation and maintenance of earth constructions : Yesterday and today conservation and maintenance of earth constructions: Yesterday and Today, Hist. Environ. Policy Pract., vol. 7505, no. December, pp. 1–32, 2017.
[16] S. Deboucha, R. Hashim, Correlation between total water absorption and wet compressive strength of compressed stabilised peat bricks, vol. 6, no. 10, pp. 2432–2438, 2011.
[17] K. Getachew, A. Mosisa, Laboratory Investigation of Locally Produced Clay Brick Quality and Suitability for Load Bearing Element in Jimma Area, Ethiopia Alemu Mosisa, Int. J. Eng. Res. Technol., vol. 6, no. 5, pp. 809–817, 2017.
[18] IS-1077, Common Burnt Clay Building Bricks -Specification, Bur. Indian Stand., 2007.
[19] ASTM C67-90. (1996). Standard test method for the properties of fired clay bricks, Annual Book of American Society for Testing and Materials.
[20] Ethiopian Standards Agency (ESA). (2011). Solid clay bricks, ES 86:2001, Ethiopian Standard, Second edition 2001-06-27.