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Investigation of the Physical Properties of Uruan Clay Soil Used for Manufacturing of Burnt Bricks

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Abstract
This work evaluates the physical properties of clay used for manufacturing of burnt bricks inIfiayong,Uruan Local Government Area of AkwaIbom State, South Eastern Nigeria. The clay was sampled for physical tests which includenatural moisture content, sieving analysis, consistency limit (Atterberg limit), specific gravity, water absorption, compaction, compressive strength and porosity. The bricks produced under standard compaction methods gave cold water absorption of 1.75%;compressive strength between 1.30N/mm^2 and 1.43N/mm^2; plastic limit of 51%; porosity of 0.99% and Atterberg liquid limit of 80.5%.The bricks on examination exhibited change in colour due to thermal stress (high temperature). If properly harnessed, these widely available raw materials and their cheap products will readily substitute cement blocks for most housing, and other structural workas well as ceramic production.
Keywords: Clay, burnt bricks, compressive strength, engineering properties, Aterberg limits, ceramic production.

1. Introduction

It is universally acknowledged that shelter is the basic need for both psychological and physical comfort of mankind (Saridharan and Venkatappa, 1973). The struggle by man to have shelter dates back to the Stone Age and transcends through all civilizations. Severe housing shortages have been experienced by most developing countries in the past decades. Irrespective of the technological advancements of the present generation, shelter still remains inadequate for the world growing population, especially in developing countries like Nigeria.Before the invention of cement, all forms of houses were constructed using locally available material such as clay bricks, thatched raffia palm and bamboo for roofing. Nigeria has many large deposit of clay scattered all over the country which have not yet been exploited much on a technical scale (Saridharan and Venkatappa, 1973).

According to Ou*et al*. (1998a and 2000b), evaluation of soil is a method used to check the consistency of the soil parameters such as stiffness of the soil, compressive index, swelling index, shear strength, etc.Bricks especially burnt bricks are among the man made building materials with superior characteristics such as; weather resistance, durability, fire resistance, compressive strength, sound and thermal insulation etc. Thephysical properties of clayinclude natural moisture content, sieving analysis, consistency limit (Aterberg limit), specific gravity, water absorption, compaction and porosity whileengineering properties include (tensile strength /compressive strength), shear stress, etc.

The utilization of lateritic clay for burnt bricks and other earthen wares in Obudo, Cross River State, South East Nigeria was investigated by Ushie and Anike, (2010). It was observed that Ikwete lateritic clay produces high quality bricks with a compressive strength between 6300Kn/m^2 and 6900Kn/m^2.Emmanuel (2008), in his work on the engineering properties of locally manufactured burnt brick pavers for agrarian and rural earth road in Ado Ekiti western Nigeria, revealed that the density of the material (soil) normally influenced other properties such as compressive strength, durability, thermal conductivity, porosity, etc, and depends on the mineral composition. He also revealed that the density of burnt bricks pavers made from soil sample range between 1826 and 1985Kg/m^3. Mesida (1978), studied the utilization of some lateritic clay of burnt brick at Ala River, Akure and Okeigbo near Ondo, South Western Nigeria and observed that the crushing strength value of bricks ranging from 38 to 111N/mm^2 are suitable for building and in ceramic industries because of their good qualities. Durotoye et al. (1988) and Ogunsawo (1989) also obtained similar result for clay deposited in part of south Western Nigeria.

Tse (2012), worked on the suitability of flood plain deposited for the production of burnt bricks in part of Benue State, central Nigeria. His results showed that the plasticity index of the soil ranges between 10-27% with an average of 90%. He also obtained that the bricks from Makurdi have the average crushing strength of 98.63N/mm^2 and can be used for all designation except load bearing bricks of high class while those from KatsinaAla, Naka, Nyaro-Tsambe with average crushing strength value of 46.55N/mm^2, 42.03N/mm^2 and 41.30N/mm^2 respectively are designated as load bearing brick of low class. This article presents the physical/ engineering properties of clay used for the manufacturing of burnt bricks.

2. Materials and Methods

The clay sample was collected from Ifiayong riverbank, Uruan,AkwaIbomState. Afterwards the clay was dried and washed to get rid of some associated impurities (sieving). This was achieved by first drying the wet excavated sample for about 7 days; the dried clay was crushed, sieved, soaked with distilled water and allowed for one hour and a uniform mixture was obtained by stirring the sample. Some quantity of the clay sample was dried in an oven at a regulated temperature of 110^0C for 24 hours (for moisture content determination). The filtrate obtain was mixed with water and molded into bricks each measuring 100m x 100m x 100m using a good mold cavity.

The molded bricks were carefully removed from the mold. The bricks were left to dry under room temperature for 14 days. After careful drying, the bricks were fired in an electric muffle furnace to a temperature of 700^0C, 1000^0C and the compressive strength for three bricks was taken respectively.The samples were tested for liquid limit, plastic limit, plasticity index, compaction, porosity, water absorption. As earlier stated moisture content andsievingwere carried out in civil engineering laboratory, University of Uyo, Uyo, Nigeria.

2.1 Determinations of Moisture /Water Content of the Soil Sample.

Water is present in most naturally occurring soils. Moisture content is required as a guide to classification of natural soil and as a control criterion in compaction of soil and is measured on sample used for most field and laboratory tests. The oven-drying method was employed in carrying out the test.

The moisture content was determined using the expression:

$$\text{Moisture content M} = \frac{\text{weight of moisture soil}}{\text{weigh of dry soil}} \times \frac{100}{1} \quad (1)$$

$$M = \frac{(W1-W2)}{(W2-W4)} \times \frac{100}{1} \quad (2)$$

2.2 AtterbergLiquidLimit

Liquid limit (LL) is the minimum moisture content at which the soil will flow under its own weight and determined as the water content at which 25 blows close the groove made in the soil sample (Albracht and Benson, 2001).

2.3 PlasticLimit

Plastic limit (PL) is the minimum moisture content at which the soil can be rolled into thread of 3mm diameter without breaking up. 20g of sieved soil was mixed thoroughly with water.The plastic limit was calculated using the following expression:

$$Plastic\ limit = 100 \times \frac{\text{weight of water}(g)}{[\text{weight of dry soil}(g) - \text{weight of container}(g)]} \quad (3)$$

The weight of water being the difference between the mass of wet soil and the mass of dry soil.

2.4Plasticity Index

Plasticity index (IP) is the difference between liquid and plastic limits.

$$Plasticity\ index\ (IP) = Liquid\ limit - Plastic\ limit, (LL - PL) \quad (4)$$

2.5 Grain Size Analysis/ Sieve Analysis

Grain size analysis expresses quantitatively, the proportion by weight of the various sizes of particles present in the soil.

$$Percentage\ retained\ on\ any\ sieve = \frac{\text{weight of soil retained}}{\text{total soil weight}} \times \frac{100}{1} \quad (5)$$

2.6Compaction Test

This test is specifically carried out to determine the range of moisture content at which maximum compaction can be achieved provided the moisture content obtained during test is not exceeded.The stability of the compacted layer can always be achieved. It ensures that no further deformation occurs provided the imposed load does not exceed that obtained during laboratory test. Some calculations related to compaction test are given thus:

$$Wet\ density = \frac{Weightofwetsoil}{Mouldvolume} \quad (6)$$

$$Weight\ of\ dry\ soil = (weight\ of\ dry\ soil + tin) - weight\ of\ tin \quad (7)$$

$$Weight\ of\ water = (weight\ of\ wet\ soil + tin) - (weight\ of\ soil + tin) \quad (8)$$

$$Moisture\ content\ (\%) = \frac{Weightofwater}{Weightofdrysoil} \times 100 \quad (9)$$

$$Dry\ density = \frac{Wetdensity}{(100+moisture\,content)} \times 100 \quad (10)$$

2.6 Compressive Strength

Compressive strength (σ) is the maximum compressive stress that a material is capable of withstanding without fracture. Compressive load tends to squeeze the specimen. The compressive strength is given as:

$$\sigma = \frac{\text{Maximun load (F)}}{\text{original cross-sectional area(A)}} \quad (11)$$

3.Results and Discussions

The summary of results is presented in table 1.The particle size analysis of the sample shows that they are well graded because it cut across the three classifications (coarse, gravel and fine) grains. Table 2 and figure 1 show the grain size analysis.The clay has a high plastic limit of 51% which agrees with Sowers (1979) which stipulate that clay of 30% and above has a high plastic limit and the liquid limits were determined to be 80.5% from the summary table. The liquid limit, plastic limit, and plasticity index of soils are used extensively, either individually or together, with other soil properties to correlate with engineering behaviour such as compressibility, hydraulic conductivity (permeability), compatibility, shrink swell, and shear strength (Albracht and Benson, 2001).

The porosity was determined to be 0.99. However, this value is slightly above the specification of the Institute of Science and Technology for ceramics/bricks which is between 0.51 and 0.58. It is interested to note that porosity decreases as the particle size increases. Also, high porosity leads to low compressive strength.The compressive strength of the raw brick, fired bricks at 700^{o}C and 1000^{o}C obtained were 1.30 N/mm^2 and 1.43 N/mm^{2}respectively, which is in line with the British Standard (BS, 1976) specification of 2.75N/mm^2 and 1.38N/mm^2 respectively for bricks used in two storey buildings and non-loading bearing walls. Compressive strength increases with increased in firing temperature. Clays may be thermally transformed into other phases when subjected to high temperature.

Table 1.Summary of physical properties of clay

Property		Value
Average moisture content %		76.04
Plastic limit %		51
Atterberg liquid limit %		80.5
Plasticity index %		29.5
Porosity		0.99
Specify gravity		1.96
Average compressive strength (N/mm^2)		1.30
Compaction	Maximum dry density MDD (KG/cu.m)	1260
	Optimum moisture content OMC %	33.5
Water absorption %		1.75

Table 2: Table showing grain size analysis (initial weight of sample, 1000g)

Sieve Diameter	Mass Retained	% Retained	% Passing
5.00mm	-	-	100
3.35mm	-	-	100
2.36mm	74.85	7.485	92.515
1.18mm	75.45	7.545	84.970
400µm(0.4mm)	85.00	8.500	76.470
250µm(0.25mm)	86.55	8.655	67.815
150µm(0.15mm)	87.55	8.755	59.060
75µm(0.075)	76.90	7.690	51.370
Pan	74.80	7.480	43.890

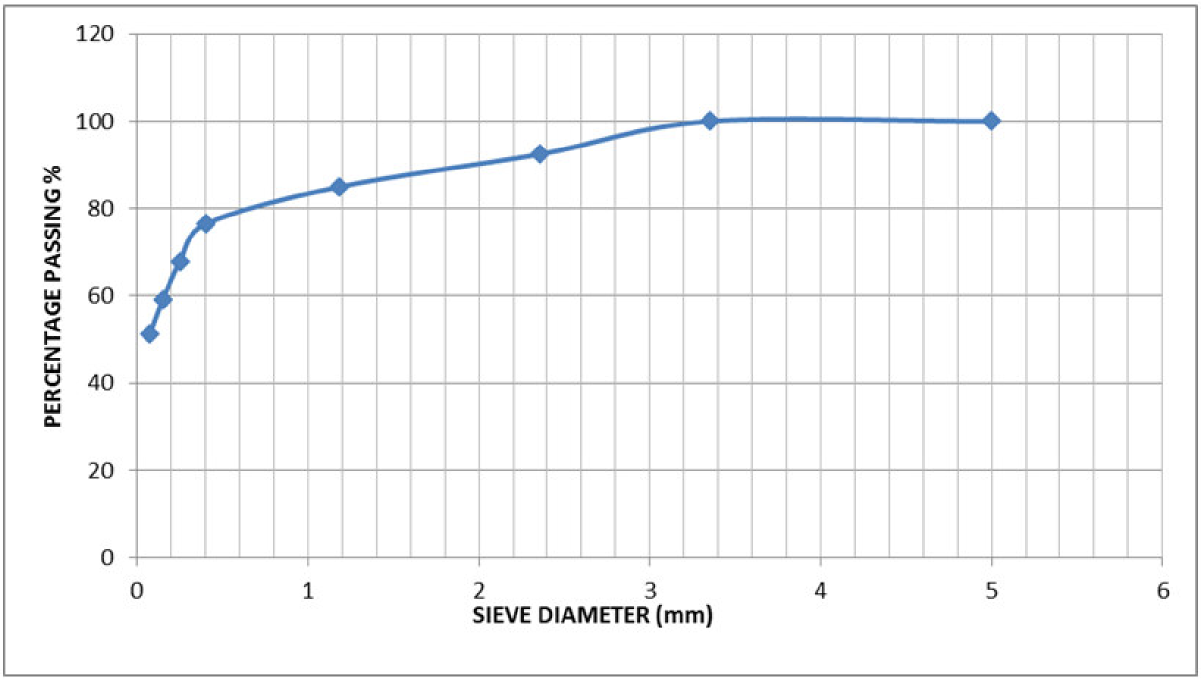

Figure 2: Graph of particle size distribution

The plasticity index value of 29.5% obtained from this research did not falls within the range of value for plasticity index as indicated by Tse, (2012) which ranges from 10 – 27%. Soils with a high PI tend to be clay, those with a lower PI tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay (Albracht and Benson, 2001).The main factor that affect the clay plasticity, according to Barba*et al.* (1997) and Handle (2007), are related to physical characteristics of the soil, particularly the particle size distribution and its specific surface area, the water characteristics (viscosity, surface tension, etc), the solid mineralogical composition (clay mineral type, proportion of non-plastic minerals, etc), the dispersion state of the particles that depends on the ionic change capacity and nature and proportion of additives, as well as on the ceramic body temperature.

The specific gravity was determined to be 1.96. This value however is slightly lower thanthat of Bowles (1979) which concluded that specific gravity normally ranges from 2.55 to 2.80.During compaction test, the sample had a maximum dry density (MDD) of 1260 KG/cu.m, optimum moisture content (OMC) of 33.5% and water absorption of 1.75%. Maximum dry density (MDD) is a dependent of the optimum moisture content (OMC).

4. Conclusion

From the studies carried out so far, it is evident that brick's building can be produced using local clay from Ifiayong and the sand from its shores will be a perfect source of quartz. The production of burnt bricks usingIfiayong clay requires fewer additives because, the properties examined met most of the requirements.More researches should be carried out on ways of producing high strength bricks that would have impact on the structural /technological advancements of the present society. Also, more researches should be carried out on the thermal and chemical properties of Ifiayongclay samples for better utilization.

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