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TOWARDS SUSTAINABLE BURNT BRICKS PRODUCTION IN AKURE, ONDO STATE - NIGERIA

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Abstract

This paper is an experimental pilot test conducted at the Ceramics section of the Department of Industrial Design, Federal University of Technology, Akure to explore the possibility and sustainability of producing refractory burnt bricks in Akure, Ondo State – Nigeria. Physical characteristic tests were conducted on clay types sourced at different locations within Akure. Samples were taken and processed at various stages of production from mining, processing, storage, forming to firing. Result of the tests includes colour change, shrinkage, size variation, compressive strength and rate of water absorption.

Keywords: Refractory, Shrinkage, Lining, Formulation, Insulating and Binder.

INTRODUCTION

Refractories and structural clay products are used for widely different purposes and under different physical conditions. The raw materials are however very similar in that both use various forms of clay, and the production processes are also similar. Refractory bricks are used to line high temperature furnaces and kilns and must therefore be able to resist high temperatures, while the structural clay products are used in construction, where strength and porosity are of importance.

Kaolin and fire clay are the raw materials needed for the production of burnt brick, which forms well over 70% of the refractory needed by Nigerian Industry, (RMRDC, 2003). Most clay refractory products are manufactured in the form of bricks, but refractory clay may also be formed into special shapes, such as the T-sections of refractory pipes or the small stands (props) that support ceramic products during firing in a kiln, (Campbell & Pryce, 2003).

Kaolin occurs in commercial quantity in most Nigerian states, with the possible exception of those states that lie on the coast. User industries are all heat using industries, such as iron and steel, cement, glass, galvanizing, ceramics, petroleum refining etc, (Abdullahi, 2001).

Bricks made of clay are categorized into two basic types; *fired* and *non-fired* brick. Fired brick are one of the longest lasting and strongest building materials sometimes referred to as artificial stone and have been used since circa 5000 BC. Air dried bricks have a history older than any fired brick. The synonyms, mud brick and adobe as popularly known, have an additional ingredient of a mechanical *binder* such as straw. These bricks have maintained their reputation as superior building products longer than perhaps any other product in the modern world.

After the Stone Age, when man began to settle outside the cave, different materials have been adapted as means of providing shelter before brick was discovered. Early bricks though made of a mixture of mud and straw have been used to construct crude huts to protect human from their enemies and the harsh weather. Adobe bricks or Sun dried mud bricks were perhaps the first handmade solid building materials used by man, allowed to dry under the sun and eventually shaped into crude housing units. Evidence of the first sun-baked brick made in the ancient city of Ur, Mesopotamia according to James (2013) was found in Iraq dated 4000BC. Sharon (2008) also acknowledged that since trees were scarce in the old Southwest, the pioneer settlers of the American Indians chose adobe brick as the logical material for buildings. This type of bricks is still used today in many parts of world including Nigeria. The fired or burnt brick was discovered out of curiosity, having noticed over time the effect of rain water dissolving and cause building made of adobe to crumble or fall apart. The early brick makers eventually learned that bricks become very hard and durable when they are burnt.

In the late 19th century, most brick works had similar components. Clay was mixed with water and soaked overnight for softening. By doing that the clay became more pliable so that it could be shaped into bricks using

wooden forms. Once technology began to take over, moulding the bricks into the proper shapes became easier by using a soft-mud brick machine. The machine automatically shaped the pieces of clay into the form of bricks. A talented brick maker could produce about 4,000 bricks per day by hand. By the 1890's, some brick machines could even produce up to 5,000 bricks per hour. These Bricks have been used for years and are still a highly desired choice today in the European and British building industry Refractory brick is a type of burnt ceramic brick used for lining furnaces, kilns, and fireplaces to withstand high temperature, but have low thermal conductivity for greater energy efficiency. They are basically of two types; dense and insulating. In the beginning fired bricks were baked in open air. But as technology advances with the economy of heat and the quest to attain high temperatures, the technique of insulating bricks was discovered and kiln building with chamber became popular.

Ceramics is an ancient tradition among the Nigeria people and has undergone changes over time in the use of materials, styles of production, process and forms but the use of red burnt bricks has never been part of Nigerian Architecture until during the advent of the colonial. D. Roberts at Ibadan in 1904 and Michael Cardew in the 1950s, in their pioneering efforts, introduced kiln building and firing ceramic wares inside the refractory brick lined kilns (Tanya 2012). This development gave birth to the contemporary ceramic practice in Nigeria. At the time of plenty contemporary potters could purchase or imported sophisticated kilns from abroad to enhance their crafts. And there was no need for enquiries on how the kilns were made. Having undergone different management and economic recession created by government policy misappropriation or misplaced priority; Ceramic practice in Nigeria has suffered a lot of technological setbacks as a result, (Saidu Na"Allah, 2001).

According to Ali (2012) before the development of indigenous kilns with local materials, not much was known about the kiln because the experience necessary for kiln design and construction was kept secret by the expatriates. In desperation for survival in ceramic profession, ceramicists have advanced their quest for knowledge and looked inward for locally fabricating kilns at different parts of Nigeria. These locally made kiln have witnessed different challenges over a period of time ranging from structural, strength, ability to retain and withstand high temperature without slagging. The aim of this paper is to approach brick making from an experimental point of view as prototype for sustainable refractory brick production for local kiln building in Ondo state, Nigeria.

NATURE OF MATERIALS

Refractory materials are capable to retain the heat directed to them, accumulate and withstand the high temperature of the kiln without melting or evaporation, (Anderson, 1990). Rhode (1977) highlighted the seven main types of chemical substances with high, resistance to heat; this includes oxides, carbides, nitrides, silicates, sulphides, borides and single elements. The most refractory of all the substances is Tantalum Carbide which belongs to Carbide group. This melts between $3880^{o}C$ and $4000^{o}C$. But the most important to ceramic is the oxide group which consist of Al_2O_3, MgO, BeO, ZrO_2 and ThO_2. Unfortunately they are expensive, scarce and have short life span. The most available is the Alumina (Al_2O_3) found in Clay or Kaolin ($Al_2O_3.2SiO_2.2H_2O$). A pure alumina melts between $1780^{o}C$ and $1810^{o}C$. Kaolin according to Norsker (1987) is the best refractory clay type which will not melt below $1750^{o}C$ and has been created by the decomposition of feldspar. Once heated to a high temperature where it becomes mature and irreversible, it becomes stable and may be reheated again and again with little or no change occurring in it. Pure kaolin is usually found at the site of its parent rock and has not been seen to have much impurity which would reduce its refractoriness or change its colour. This clay is also referred to as primary clay. It is usually of very minute plasticity due to its particle size.

Refractory bricks are construction bricks for potter's kiln and are also used in many other industries for instance glass factory, foundries and boilers. Norsker (1987) recognized dense bricks, hollow firebricks, ash bricks and Insulating bricks as the basic refractory bricks used. Dense bricks are used for the fireboxes, chimney, bag-wall, floor and flue system, while the kiln inner wall linings are made of insulating bricks in most cases. Ash bricks and Hollow bricks can also be used as support bricks during kiln construction; but when it comes to bricks for heat retention, Insulating bricks appear to be the most focused in this experiment.

MATERIAL SOURCING

Geographical reports according to Adewunmi (2002) and Fayose (2002) identified kaolin as one of the solid natural raw materials Ondo state is endowed with. It is also evident that this state is well located in thick vegetation where a lot of agricultural activities take place throughout the year. Akinbogun (2004) also acknowledged the fact that raw materials are not in the list of problems confronting ceramic production in Nigeria. Rhode (1977) and Norsker (1987) identified clay and combustible as the main ingredient for the production of Insulating bricks. Combustibles such as sawdust and rice husk are dumped in heaps at different sites in Ondo state constituting environmental menace. These basic raw materials are in abundance but yet to be optimized for the benefit of ceramics.

In accordance with Ali (2012), Rhodes (1977) and Norsker (1987), Insulating bricks made of a mixture of fireclay and sawdust. Other combustible materials such as coals, lignite, peat, rice husk etc. can also be used as

Figure 1: Irese Deposit of Kaolin in Akure South LGA, Ondo State

Figure 2: Ilesha Road Deposit of Kaolin in Akure South LGA, Ondo State

fillers and should be prepared like sawdust. The sawdust will burn away in the kiln and leave plenty holes in the bricks. These holes make the bricks better heat insulators when they become part of a kiln. Therefore, bags of sawdust were collected from the nearby sawmill "Road block" in Akure, Ondo State and was used as combustible materials. There was no emphasis on any particular tree species for the saw dust collected.

Also samples of kaolin often called Primary or China clay were collected from four mining sites in Akure, namely Irese, Ipinsa along Ilesha Expressway, Fiwasaye along Ijapo road and Igoba along Ado Ekiti road Figure 1-3. Unfortunately the miners of the raw materials were using this material for land fill. The samples excavated were brought to the Department of Industrial Design, Federal University of Technology, Akure and were processed separately. Ball clay was also collected at a stream bank behind Solab Suites along FUTA road, in Akure. This primary clay was used to enhance the binding since Kaolin has low plasticity.

FORMULATION AND TESTS

Simple site and Studio sample tests were conducted to confirm the authenticity of the materials. A wooden slop-mould frame was constructed. The Kaolin samples were dried, crushed to powder and kept separately in the store. Small linear slabs were made for shrinkage test. A ten centimetre line was drawn on each sample slab. After a

Figure 3: Fiwasaye Deposit of Kaolin in Akure North, Ondo State

Table 1: Preliminary Test Results

Clay Location	Observation at site	Dry Linear Shrinkage after 200^{o}C	Fired Linear Shrinkage at 1000^{o}C	Colour Change	Strength
Ipinsa	Off white with little dots of brown	7.62%	9.40%	Light Cream	Fused
Fiwasaye	White but has more silica	7.40%	9.08%	Creamy White	Fused
Irese	Off white	7.91%	9. 59%	Light Cream	Fused
Igoba	Brownish white	9.50%	13.71%	Deep Cream	Hardened

week air drying the same samples subjected to heat treatment of about 200^{o}C. The measures of the dry shrinkages were taken and colour changes were also observed. After the first green drying the bone dried-slab samples were carefully placed in a test kiln which was also heated to 1000^{o}C. The result of the test is presented in Table 1.

After the First preliminary test, Igoba sample was discarded because it was considered unsuitable for the desired purpose. It has the highest plasticity which makes it suitable for ceramic production and dense brick, but not for insulating brick. Each of the remaining samples was mixed with saw dust and ball clay in accordance with the Kashim (1999) recommendation; 40% Saw dust, 50% kaolin and 10% ball clay. Norska (1987) noted that the combustible will burn off leaving the bricks with plenty of holes, after firing at high temperature. These holes make the bricks better heat insulators when they become part of a kiln. This happens because heat cannot pass through motionless air which is trapped in the holes.

During the process of mixing of kaolin, sawdust and ball clay, the mixture was moisturized with water enough to make it malleable. A wooden mould of 9”x 4.5”x 3” (inches) was used to form the bricks from each sample by ramming. The manual method of stuffing the mixture into moulds to form bricks was adopted. The formed bricks were put on planks under a shed separately to dry gradually. When the blocks were freshly made, the bricks had gray like colours but as they were getting dried the colour began to change towards white.

After a month of drying, the bricks were loaded into an intermittent kiln to be fired using a gas kiln. The weight of an average brick at green was 3kg. The brick firing spent four (4) hours of pre-heating in order to totally remove the moisture content of the bricks, while the normal firing took two hours, to attain 1000^{o}C. The kiln was left till the next day to cool down naturally. When the bricks where removed from the kiln the following was observed.

The results from table 2 suggest that kaolin found at the three sites is of good quality. Irese and ipinsa bricks seem to be more plastic than Fiwasaye; although the percentage shrinkage for Fiwasaye brick is alright for an Insulating brick which would fire regularly at 1250^{o}C. In order to control plasticity during brick production other formula can be adopted, for instance, 60% Kaolin and 40% sawdust formula of Ali (2012). The three bricks have the capacity of attaining higher temperatures without melting or deforming, but Fiwasaye is more refractory than Irese and Ipinsa. In order to establish this assertion another firing test was conducted. The brick samples were labelled and used to construct a mock kiln chamber, supported with other available bricks within the surrounding. Six different Staffordshire cone were arranged inside the kiln to measure firing temperature. This time the temperature of the kiln was

Table 2: Report of Insulating Bricks after Firing at 1000^{o}C

Description		Ipinsa	Fiwasaye	Irese
Fired colour		Creamy White	Creamy White	Creamy White
Surface Appearance		No cracks	No Cracks	No cracks
Strength		Firm	Firm	Firm
Average wet weight at point of moulding (Initial weight)*W*		3000g	3000g	3000g
Average weight at bone dry		2510g	2540g	2500g
Average weight of fired brick (Final weight) *w*		2342g	2380g	2300g
Total water in brick		658ml	620ml	700ml
Water Absorption $WA = \frac{W-w}{W} \times 100$		29.93%	20.66%	23.33
Dimension of Green Brick (inches)	Length *L*	22.8cm	22.8cm	22.8cm
	Width *W*	11.4cm	11.4cm	11.4cm
	Height *H*	7.6cm	7.6cm	7.6cm
	Volume $V = L \times W \times H$	1975cm^3	1975cm^3	1975cm^3
Dimension of Fired Brick (inches)	Length *l*	22.1cm	22.3	21.9
	Width *w*	10.8cm	11.0	10.4
	Height *h*	7.0cm	7.1	6.9
	Volume $v = l \times w \times h$	1670.8cm^3	1741.6cm^3	1571.5cm^3
Shrinkage Volume $SV = \frac{V-v}{V} \times 100$		15%	11.84%	20%

raised to 1300^{o}C. After dismantling the kiln the bricks still maintain their white colour. The only difference in term of colour was that the parts exposed to oxidation were whiter than the other parts.

CONCLUSION

The volume of quality Kaolin and sawdust found within Akure is still a fragment when compared with what is available within Ondo state, Nigeria. This Volume of raw material is enough to stimulate a wide range of ceramic production, if adequate production facilities for processing them are made available. In doing this potters will be encouraged to practice ceramics with assurance of an ideal condition better than the difficult situation they find themselves.

Considering the back breaking cost of imported kilns and other accessories including insulating bricks for kiln construction from abroad, couple with the escalating threat of scam tagged on Nigerians outside the country; it has become absolutely necessary for ceramicists to seek alternative ways of addressing local ceramic related hitch. In alliance with Ali (2012) it is possible for every ceramicist to build one kiln without alternative or depending on specialist in kiln design and construction since insulating bricks raw materials are abundant, cheap and easy to handle. This will pave way for employment opportunities for ceramic graduates willing to invest in kiln construction, pottery and raw material processing.

Finally, on a national scale, facts of availability of Kaolin in abundance have been known for very many years, it is difficult to see how we can be serious about the production of iron and steel without a home grown refractory brick plant. Nigeria's inability to actualize this dream must be as a result of lack of political will in the leadership towards a sustainable local production.

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