POSSIBILITY OF USING OKA CLAY IN EDO STATE TO PRODUCE HIGH QUALITY CERAMIC ROOFING TILES

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ABSTRACT

Edo state is gifted with ceramic raw materials ranging from clay, feldspar, quartz etc, spreading from the northern part through eastern, western and southern parts of the state. Before now, there have been high exploration and utility of ceramic raw materials from the northern part of the state, such areas are Auchi, Afowa, Okpilla etc, but no substantial effort has been made to discover same in other parts of the state. This study has been able to establish the availability and suitability of Oka clay in Ikpoba Okha local government area of Edo state for the production of high quality ceramic roofing tiles. The production procedures put into practice in this study beginning with the conceptualization, Draft of the plan/design, Model making, Mould making, casting and test on Oka clay samples before drying of the green tiles and firing of the green tiles. After the procedure adopted for production proved successful, the tiles were found durable, rust free, fire storm proof, low water absorption rate, not too heavy for building and builder to carry and above all it is highly affordable.

Introduction

In recent times, Federal and State Governments have stressed the need to embark on the building of low cost houses for the citizens. Also, the efforts of the private developers in Nigeria today are geared towards a general need for everyone to own a house. But the ever-increasing rates of building materials as cement, roofing sheets/tiles and others, which in most cases are imported, do impede the realization of such desire by the citizenry. Shelter which comes after food is a very vital necessity that man cannot overlook, he will be said to be homeless and for shelter to be complete there must be a roof over a building or structure to prevent rain, sunshine, wind, cold and other harmful weather conditions. It is widely believed that a person with no roof over his or her head lacks shelter and as such homeless.

Government's policies on shelter provision are good, but the implementation may be defective. Since the contemporary potters are living in an era of innovation and high technology, locally produced ceramic-roofing tiles are therefore important and necessary for the realization of the housing policy of government.

Oka Community

The Oka Community where the kaolin is exploited is one of the small clans in Ikpoba-Okha Local Government Area of Edo State. It extends for about five kilometers along the Upper Sakponba, Benin-Abraka Road with nine villages including Oka-evbogo, Okabele, Oghire, Okaniho, Okanawovia, Useni, Iduwungbon, Evboghizenwe and Umogumohen, each spaced out about one kilometer apart. The largest of the villages is

Okanawovia a community of about five hundred to eight hundred people. According Madam Mercy (Oral Interview, 2009), the people who presently occupy the Oka Community are said to have migrated from the Ogbe Quarters in the ancient city of Benin (around the site of the present Samuel Ogbemudia's Stadium outside the city walls) This migration traced back to about four hundred years ago, took along with it the ancient art of pottery still in practice in this part of the city. Their dialect, which is not different from that of the surrounding villages, is the same as that spoken in Ogbe. They have often had a continuous link with the ancient Benin, which they believed was their home. Some very important ceremonies, which are done in Benin like the Igue festival, are also carried out there.

Origin of Roofing Tiles

The industrial tile, according to Fournier (1976:78) usually 4 x 4 inches (100 x 100mm) or 6 x 6 inches (150 x 150mm) pressed from barely damp powder body in a die or metal mould, this Grimmer and Williams, (1992), says can be traced independently to two different parts of the world: To China, during the Neolithic Age, beginning around 10,000 B. C.; and the Middle East, a short time later. From these regions, the use of clay tiles spread throughout Asia and Europe.

Not only the ancient Egyptians and Babylonians, but also the Greeks and Romans roofed their building with clay tiles, and adaptations of their practice continued in Europe to the present. According to Archaeologists, European settlers brought this roofing tradition to America where it was established in many places by the 17th century. Grimmer and Williams, (1992) opines that Clay tile was also used in the early English settlements in Jamestown, Virginia, and nearby St. Mary's in Maryland. Several tile manufacturing operations were in business around the time of the American Revolution, offering both coloured glaze and unglazed natural terracotta tile in the New York City area, and in neighbouring New Jersey. Berendsen, (1967), postulates that the History of tiles dates back to as far as the fourth millennium, B.C. where in Egypt tiles were used to decorate various houses. In those days, clay bricks were dried in the sun or baked. The first glazes were blue and as early as 4,000 B.C such tiles were also found in Mesopotamia. These tiles bore decorations, which possessed various patterns and colours that were hand-made, each tile was hand-formed and hand-painted thus each was a work of art in its own right, Lane (1960), however, submits that accurate dating of early roofing tiles was difficult and often impossible.

Explaining the development of ceramic roofing tiles, Grimmer and Williams (1993), says that the most significant factor in popularizing clay-roofing tiles during the colonial period in America was the divesting fire in London 1666 and Boston in 1679 which prompts the establishment of building and fire codes in New York and Boston. These fire codes; Grimmer and Williams (1993) clarifies further, remained in effect for almost two centuries and encouraged the use of tiles for roofs especially in urban areas, because of its fire proof qualities".

By about 1855, sheet metal roofs designed to replicate the patterns of clay tile were being produced. These sheet metal roofs became popular because they were cheaper and lighter, and easier to installs than clay tile roofs. The popularity of clay tile roofing continued in the 20th century, especially in areas of the South and West most notably Florida and California where Mediterranean and Spanish influenced styles of architecture still predominate.

Clay is known for its sticky plastic nature when in its wet state; it shrinks and hardens upon drying or firing. In order to arrive intelligently suitable mixtures for given use, one must understand these physical properties of clay and the response to firing and also the physical and thermal properties of other materials used in clay bodies.

Clay Prospecting, Equipment and Materials for the Production of the Roof Tiles

Prospecting the Oka clay was done through the manual excavation carried out by digging into the earth just like the Oka potters have been doing for years and similar to the North Ibie whom according to Ibude and Otimeyin (2011) Dunged from the pit with hoes and cutlasses in a near leather hard. The concept of clay prospecting in this text simply means going out in search of clay (Saibu 2005) and (Otimeyin 2008). The collected clay was made into paste mixed with suitable additives like grog, rice husk including Sodium silicate. The equipments used are Slip Storage tank, Kiln and Blunger while the materials used are Oka Clay, Grog, Wood Ash or Rice Husk and Plaster of Paris (P.O.P)

The following Clay Samples were tested for suitability of roof tile production:

SAMPLE A

Oka clay	70%
Wood ash	10%
Grog	20%

SAMPLE B

Oka Clay	80%
Grog	20%

SAMPLE C

Oka Clay	75%
Rice Husk	5%
Grog	20%

Tests

The three samples were also tested physically to determine their suitability. The following were tests carried out:

1. **Shrinkage Test:** This test was carried out on the clay body composition A-C in order to determine the shrinkage before they were put into use. These tests were made by measuring three clay body samples A, B, C, at three different levels of plastic, dry and fired. Generally, good clay shrinkage ranges from 5 – 12% in drying stage, with 8 – 12% shrinkage after firing (Source: Rhodes 1996).

Method: The specimens were pressed into rectangular slabs. The freshly made specimens were identified and marked for shrinkage by impressing reference lines with a thin bladed spatula. They were dried. The specimens' measurements were carried out. The values were noted and the slabs were put into the kiln and were fired to about 1000^{o}C and also measurements were noted after cooling.

2. **Water Absorption or Porosity Test:** The porosity test enables one to determine the amount of water that the body can absorb after firing. The total porosity of a material is the total proportion of the voids, which occur in the bodies' samples: (Source: Rhodes 1996)

Method: The clay body samples pieces A, B, C were obtained and fired in gas test kiln to 1000^{o}C. Later the kiln were put off and was allowed to cool down, the initial weight of the fired pieces were noted and dropped in the boiling water for about two hours. After two hours the record were noted as shown below.

3. **Bending Strength Test:** The tensile strength of clay bodies are widely used to measure the dry bending power of clays body used in ceramics and refractory. The clays body samples required for this test were subjected to bending strength (modulus of rupture). Samples A, B, C, were used to determine modulus of rupture. It should be noted that when a body is held fixed at a point or more along in its length and subjected to stress at a point on the opposite surface, the tendency is for the body to bend until such a time that the magnitude of the applied stress is sufficient to cause fracture. (Source: Rado, 1988:198 – 199)

Method: After the preparation of suitable bodies A, B, C, of rectangular bars, which were air-dried, they were placed in a gas test kiln and were fired to temperature of 1000^{o}C. The bars were allowed to cool down in the kiln. After cooling, the bars were tested for modulus of rupture. (MOR) The various breaking load weights were applied on the bars. The modulus of rupture or bending strength was calculated from available data as follows:

Bending Strength Test Results

Sample	A	-	7kg F/cm3
Sample	B	-	11kg F/cm3
Sample	C	-	9.5kg F/cm3

4. **Plasticity Test:** Plasticity is directly related to the hardness and verification of a clay body. It is a unique property of clay which combines with strength of a solid along with the fluidity of a liquid. Plasticity is of a particular importance in pottery if the new shape to remain is desirable. (Source Rhodes: 1996: 310)

Method: Certain quantities of dry clay were weighed from clay body samples, A, B, and C respectively and were noted as dry weight (DW2). The different clays samples were put into different plastic containers, water was allowed to drip on the clay samples until a plastic paste was obtained. The weight were noted WW2. Note that all the clay body samples A, B, C each first weight was 8.5 grams respectively before water was allowed to drip on them.

After testing the above samples A – C body compositions, they gave excellent ceramic roofing tiles that were able to withstand the firing temperature of $900^{o}C$ – $1000^{o}C$ without warping, crack and excessive shrinkage for except Sample C which proved lighter as result of the Rice Husk in it.

Casting Process

Sample B proved to be best suitable for this study because of its easy castability and all the tests conducted shown that it is proper for production of ceramic roofing tiles. After the proper batching of the suitable materials of good casting slip of high quality, these materials were blended together properly with the addition of water and the required electrolyte in the blunger.

The slip cast method was adopted using solid cast in plaster mould, this was done by filling the mould with slip and left until it casts into a solid piece, this lasted for one hour. The solid cast pieces were carefully removed from the mould before they were fettled.

Drying and Firing of the Roofing Tiles

The solid cast pieces were then allowed to dry slowly under a room temperature. The solid cast roofing tiles were fettled and dressed properly with sponge, spatulas and water. Some of the roofing tiles were dried in the open air turning the tiles over frequently to prevent warping while some were dried between absorbent bats such as asbestos sheets.

The roof tile was once fired in a Kerosene Kiln beginning with one burner, preheating for 3 hours intermittent at 15 minutes interval. After the water-smoking period is the point at which the water of plasticity is expelled completely from the roofing tiles, the second burner was introduced and also increased the pressure of the Kerosene burners. This lasted for about 6 hours with cone 8 firing continued to attain the fusion point of $1000^{o}C$, the Kiln was put off and the ceramic roofing tiles were allowed to gradually cool down for about 8 – 9 hours before the tiles were off loaded from the Kiln.

Findings and Conclusion

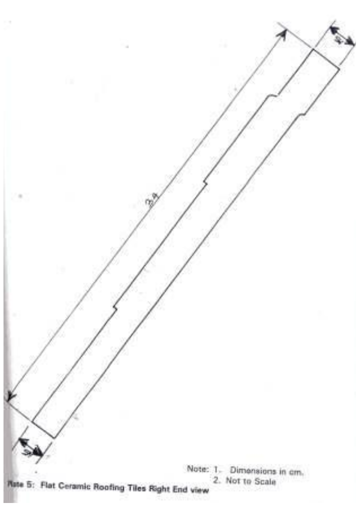
Effort has been made to produce ceramic roofing tiles using available local raw materials in our immediate environment. The ceramic roofing tiles which were not too heavy, exhibits very low water absorption due to the suitable body that vitrified well. The study revealed that locally sourced raw materials can act as substitute to imported raw materials. The execution which was done manually would have been much easier if there were enough fund, time, equipment and division of labour. It was such an interesting experience that government can maximally annex especially the usability of Oka clay in the production of ceramic roofing tiles and other clay related products and should encourage or establish at least two ceramic roofing industries in the location.

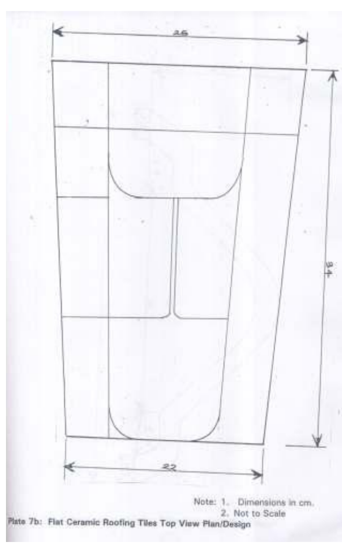
Figure 1 Demoulding of solid cast piece

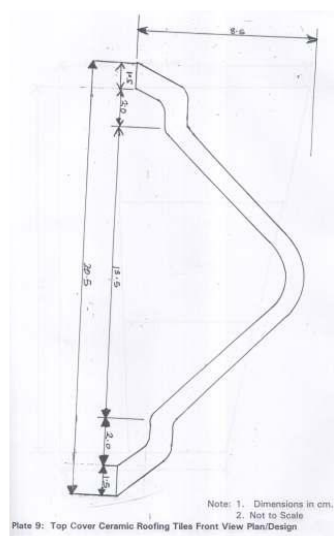
Figure 2 Dried pieces

Figure3 Staking of tiles in the Kiln

Figure 4 Fired Roof Tiles







Shrinkage Test Results	**A**	**B**	**C**
Measurement of fresh slabs	4.8cm	4.7cm	4.6cm
Measurement of fired slabs	4.4cm	4.5cm	4.3cm
Total % Shrinkage	**12%**	**10%**	**14%**

Water Absorption or Porosity Test Results

Samples	**Weight before boiling in water**	**Weight after boiling for 2 hours**	**Total % of water absorption**
A	7.7grams	8.2grams	7.5%
B	7.6grams	7.8grams	3.6%
C	7.8grams	8.4 grams	8%

Plasticity Test Results

The resultant plasticity of the clay body samples are tabulated below:

Clay body Samples	**DW1**	**WW2**	**% Plasticity**
A	8.5grams	9.6grams	13%
B	8.5grams	9.9grams	17%
C	8.5grams	9.4grams	11%

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