ENGINEERING PROPERTIES OF SOME CERAMIC LOCAL RAW MATERIALS IN ETSAKO WEST LOCAL GOVERNMENT AREA OF EDO STATE

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Abstract

Clay is one of the major raw materials used by Ceramic industries. Etsako West Local Government of Edo State has huge Deposits of clay scattered all over the area un-used because of lack of the basic scientific knowledge. This study is basically exploring the ceramic properties of two clay deposits, Auchi/Igarra Road Darkish clay and the Afowa Whitish clay both in Etsako West Local Government Area. The samples investigated have been subjected to physical test, shrinkage test, loss -on - ignition Test, water absorption test and possible colour test to determine their chemical composition impurity contamination and its suitability in the production of ceramics.

The most widely used raw material in Ceramics is clay and the use of Clay dates back to the early 10th Century. Clay is defined as a hydrated aluminum silicate ($AI_2$03 2S.C»2, 2$H_2$0). Clay has generally been defined in the past as the product of geologic weathering of rocks on the earth surface (Rhodes, 1957). This has not actually given us the knowledge about Clay. This definition of clay applies to other earthly minerals like lime stone (Ca Co_3), loamy soil and sandy soil. Past literatures reveal that various tests carried out on each sample has made it possible for us to detect clay wherever it abounds. Clay also possesses some physical properties, which distinguishes it from other earthly minerals e.g.

1. It forms a coherent, stickly mass when mixed with water and this enables shaping and forming of articles from it easy. It is also capable of retaining that shape and remains brittle when dried. When heated to red heat to temperature of above 700°C in the kiln, it becomes hard and could no longerbeslaked in water. This behaviour of clay has made it possible for use in different industrial processes and for different purposes.
2. Clay is used in Ceramic industries as the basic raw material in paper and paint industries, cement industries for refractory bricks as well as the pharmaceutical industries to mention but a few of the industries requiring the use of clay.

Types of Clay

Based on geological history, clays have been divided into two main groups viz-primary clays, which are those that have been formed on the site of the parent rock. These types of clays are relatively pure and free from contamination with

non-clay minerals since they were not transported by any agent of weathering. The secondary clays are the clays that have been transported by glacier, running water or wind from the site of the parent rock to a new site; this in fact enables the ceramist to understand the physical properties of his raw materials, (Rado, 1969). For the purpose of the clays under investigation, this study will endeavour to treat them differently starting with the primary clay from Afowa in Etsako West Local government Area of Edo State.

Geologic Origin of Clay

Clay is a natural material found in the earth's crust or rock and it is characterized by plasticity when appropriate amount of water is added. Another characteristic is its temporary hardness when dry and permanent hardness when fired. It is a fine - grain hydrous aluminous silicate and it consists of one or more minerals together with some free silica and other materials, which can determine the properties and uses of particular clay. Clay minerals have been formed by alteration and breakdown of parent igneous rocks. The alteration of parent rocks to form clay minerals is the result of the action of hot gases and water, which usually takes place deep within the crust. Despites the clays formed by this hydrothermal process, they are frequently found, mixed with fragments of unaltered parent rock. The common clay mineral is kaolinite and the less common are montmorillonite, hallaysite, nacrite and dickite. They all have chemical and mineralogical similarities. The properties of clay depend on the type and amount of clay mineral, particle size, the distribution of the particles and other minerals present, in the manufacturing of ceramic wares, clays play an important role in supplying the plasticity or workability in the ware. It also increases the dry strength of the green ware; hence it assists in the reduction of breakages during handling. The common clays are kaolin, plastic clays and fireclay.

Whitish Clay Called Kaolin

The kaolin under study is a residual type of clay still at the site of formation. The site is about some kilometers away from a river in Afowa and is exposed by erosion. The seam is deep, it is pure white in raw state, this is attributed to lack of transportation preventing the contamination of the clays.

Winning of the Clay

The method of winning and beneficiation vary according to the depth and the extent of the deposit, as well as the depth of the over burden. The clay in Afowa is mined manually with the aid of shovels and hoes, and women usually do it. The mined clay is purified by soaking in water for some days usually a week and then mixed to form slip which is sieved through a hundred mesh sieve and dried before being used. Darkish Clay (Ball Clay)

The ball clay under this study is a sedimentary type of clay, which has a dark colour and has been traced to the presence of carbonaceous materials. It is deposited

along Igarra-Auchi road in Etsako West Local Government Area of Edo State; it is exposed due to road construction, occurs in layers and is darkish in colour.

Winning of the Clay

The method of winning this clay deposit at Igarra/Auchi road in Etsako West Local Government Area of Edo State is manual, using shovels, diggers, iron bars and head pans to dig and convey the clay to the major road. The mined clay is soaked in water for some days and passed through hundred-mesh sieve then dried to the plastic stage before use.

Experiments (1)
Plasticity and Shrinkage Test
Apparatus
Slab sticks, flat wood, ruler, knife, and plastic container.

Method

Some samples of the clay were soaked over night to make sure that water penetrates into the pores of the clay. The plastic mass, which is obtained from the mixture of clay and water is then used to form slab between the slab sticks, which acts as a guide. With the aid of the ruler, smaller slabs were cut out with the knife and a line is drawn on the center of the slab and the measurement taken. This center line helps to measure the shrinkage after drying and firing.

Observation

During the making of the slabs, the darkish clay was easier to work with than the whitish clay. The whitish clay was collected from Afowa, while darkish clay was collected along Igarra\Auchi road. The whitish clay looked fragile and always cracking, during drying, it is observed that the slabs from the whitish clay looks deformed, (bending) resulting into reduction of weight and length.

Results
Darkish Clay (Igarra Road Clay)
The wet length of the slabs (inside line) 8cm.

After drying (bone dry state) slab shrinked to 7.3cm. The Dry shrinkage was Calculated thus:

$$\text{Dry shrinkage} = \frac{\text{Wet length - dry length}}{\text{Dry Length}} \times \frac{100}{1}$$

$$= \frac{8\text{cm} - 7.3\text{cm}}{8\text{cm}} \times \frac{100}{1}$$

Therefore, Dry shrinkage = 8.75%. The sample bricks were fired to 1200^{0c}, and these were further reduction in length from 7.3cm to 5.8cm resulting to additional loss of 1.4cm length.

Fired shrinkage = $\frac{\text{Dry length - fired length}}{\text{Dry Length}} \times \frac{100}{1}$

$= \frac{7.3\text{cm} - 5.8\text{cm}}{7.3\text{cm}} \times \frac{100}{1}$ -20.6%

To obtain the total percent shrinkage, the formula below was used.

$\frac{\text{Wet length - fired length}}{\text{Wet length}.} \times \frac{100}{1}$

$= \frac{8\text{cm} - 5.8\text{cm}}{8\text{cm}} \times \frac{100}{1}$

Total percentage contraction = 27.5%

Whitish Clay (Afowa Clay)

The wet length of the slabs is 8cm (inside - line). After drying (bone dry stage) the slabs shrinked to 7.4cm resulting in loss of 0.6cm length. Percentage Dry shrinkage was calculated thus:

Dry shrinkage = $\frac{\text{wet length - dry length}}{\text{Wet length}} \times \frac{100}{1}$

$= \frac{8\text{cm}-7.4\text{cm}}{8\text{cm}} \times \frac{100}{1} = 7.5\%$

When fired to 1200^{0c}, there is a further reduction in length from 7.4cm to 6.6cm resulting in additional loss of 0.8cm length.

Fired shrinkage $= \frac{\text{Dry length - fired length}}{\text{Dry Length}} \times \frac{100}{1}$

$= \frac{7.4\text{cm}-6.6\text{cm}}{7.4\text{cm}} \times \frac{100}{1}$

$= 10\%$

To obtain the total percent contraction, the formular below is used:

$\frac{\text{Wet length - fired length}}{\text{Wet length}} \times \frac{100}{1}$

$= \frac{8\text{cm}-6.6\text{cm}}{8\text{cm}} \times \frac{100}{1}$

Total percentage contraction = 17.5%

Experiment 2

Loss on Ignition Test

The loss - on - Ignition is a measure or comparism for purity of the raw material in general, it can be said that the purer the quart sand, the lower the loss on ignition.

Apparatus

For the loss on ignition test, the following apparatus were used.
1 oven (kiln) 1200^{OC} with temperature indicator.
1 scale (balance).
1 desicator.

Method

The weight of the test slabs were taken at bone-dry stage and recorded. The slabs were loaded into the kiln and fired to 1200^{OC}. When the slabs were cold enough, their weights were again taken. The difference in weights between the raw slabs and the fired slabs now determine the loss on ignition.

Observation

It was observed that the weights of the slabs before firing were higher than after firing.
The colour also change after firing.

Results

Darkish Clay (Igarra Road Clay)

At bone-dry stage, the slab was weighed: A - 43.1 grams
B - 44.8 grams
Average weight = 43.95 grams

After firing, the slabs were weighed again and their weights are as follows:
A- 35.2 grams
B - 34.8 grams
Average weight = 35 grams

To calculate the loss on ignition:

$$\text{Loss - on - ignition (\%)} = \frac{\text{weight raw - weight fired}}{\text{Weight raw}} \times \frac{100}{1}$$

Therefore, loss on ignition $= \frac{43.95 - 35}{43.95} \times \frac{100}{1} = 20.4\%$

Whitish Clay (Afowa Clay)

At bone-dry stage, the slabs weighed
A = 40.9 gram
B = 41.4 grams
Average weight = 41.15 grams.
After firing, the slabs are weighed again and their weight are as follows:
A = 38.3 grams
B = 39.9 grams
Average weight = 39.1 grams
Loss - on -ignition = 41.5 - 38.1 = 2.05 grams per cent loss on

ignition = $\frac{\text{weight raw - weight fired}}{\text{Weight raw}} \times 100$

$$= \frac{41.15-39.1}{41.15} \times \frac{100}{1} = 4.98\%$$

Conclusion

The above result shows a higher loss in weight from the Darkish Clay than the whitish clay, which could be due to the presence of too much carbonaceous materials in the clay structure and moisture in.the Darkish clay.

Experiment 3 Water Absorption

Water absorption test was carried out to determine the porosity of ceramic materials. It is important because porous materials have low resistance to erosion and abrasion. Though porosity quickens the rate of drying of ware. Test on water absorption of a ceramic bisque gives information on:

1. The degree of sintering
2. It also enables a control of the production
3. Its possibility of use during glazing.

Apparatus

Dry oven (110OC)

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Scale (Balance) Clock

Beaker containing distilled water Desicator

Method

The samples (bisque slabs) made from both Darkish and the whitish clays are dried at 110^{OC} in an oven till the weight remains constant. The samples are: weighed twice at 2 hours interval and the weight difference is not more that 0.1% of the weight of the samples. The samples are submerged in the distilled water inside the beaker and left for 24 hours after which the samples are removed from the water and the adhering water on the samples are removed with moist sponge and weighed again. The dry weight and soaked weight recorded, the percent water absorption is calculated using the formula:

% W.A. = $\frac{\text{soaked weight - dry weight}}{\text{Dry weight}} \times \frac{100}{1}$

Observation

When the slabs are submerged in water, there are bubbles escaping which shows that the pores initially occupied by air is now being filled with water. It is also observed that there is an increase in the weight of the slabs after the expiration of 24 hours.

Results

Darkish Clay
Dry Weight
A- 35.2 grams
B - 34.8 grams
Average weight = 35 grams
Soaked weight:
A- 35.8 grams
B - 36 grams
Average soaked weight = 35.9 grams

$$\% \text{ W.A} = \frac{\text{soaked weight - dry weight}}{\text{Dry Weight}} \times \frac{100}{1}$$

$$\% \text{ W A.} = \frac{35.9 - 35}{35} \times 100$$

Therefore, W.A. = 2.6%

Whitish Clay

Dry weight =
A- 38.3 grams
B-39.9 grams
Average weight = 39.41 grams
Soaked weight =
A - 40 grams
B-41.3 grams
Average soaked weight - 40.7 grams

$$\% \text{ W.A.} = \frac{\text{soaked weight - dry weight}}{\text{Dry weight}} \times \frac{100}{1}$$

$$= \frac{40.7-39.1}{39.1} \times \frac{100}{1}$$

% W.A. = 4.09%

Conclusion

During water absorption test, water penetrated into all open pores resulting in an increase in weight of the slabs. From the result above, one can then say that the whitish clay has higher rate of water absorption due to its loose parking of particles (greater voids).

Possible Firing Colour Apparatus: Kiln

Method

That the colours of the clays are in the green state are noted and then the slabs are packed into the kiln and fired to 1200^{OC} after which they are physically examined.

Observation

During firing, at a particular temperature 600-700^{OC} choking smell emits from the kiln, which is an indication of the escape or burning of the organic matters contained in the clays.

Results

Darkish Clay

In the green state, the colour of the Darkish clay is black, after firing to 1200^{OC}, the colour changes to yellowish.

Whitish Clay

In the green state, the colour is white and after firing to 1200^{OC}, the resulting colour is cream.

Summary

The change in the darkish clay is as a result of the burning off of the carbon present while that of the whitish clay is as a result of the attack of the carbon so released from the darkish clay.

Conclusion

From the shrinkage test carried out on the two clays (Darkish and Whitish clays) it is discovered that the Darkish clay has a higher shrinkage rate than the whitish clay. This is due to the fact that the whitish clay has a larger particle size and has smaller surface area due to the particle sizes. The Darkish clay has a smaller particle size with a larger surface area and contracts more than the whitish clay. Total concentration for both clays are as shown:
Darkish clay - 27.5% - total contraction
Whitish clay - 17.5% - total concentration
Loss - on – ignition

The result of loss on ignition test on the Darkish and Whitish clay shows a higher loss on ignition on the Darkish clay than the whitish clay, which could be due to the presence of too much carbonaceous materials in the clay structure and moisture in the Darkish clay. This appears to be a good clay for ceramic forming processes, weight at bone dry = 43.95 gram, weight after, firing = 35 grams, the loss on ignition of the black clay is 8.95 %. From the result of the water absorption test,

one can then say that the whitish clay has higher water absorption due to its loose parking of particles (greater voids).

Recommendation

The Afowa and Igarra Road clays have been discovered to be of good quality for the production of high quality refractories and sanitary wares. As a result it is therefore recommended that the clays should be mined in commercial quantity for both local use and export..

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