ENHANCING THE PROPERTIES OF GRANITE BASED COMPOSITES BY THE INCLUSION OF WASTE GLASS AND BONE ASH FOR THE PRODUCTION OF SELF-GLAZED CERAMICS

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ABSTRACT

Granite and ball clay in the ratios of 80-20 and 70-30 percent produced clay bodies that are described as self glazed bodies. These are bodies that melt and shine on their own without glaze application. The major drawback of these bodies is their inability to produce free standing forms due to poor tensile strength. This research aims at synergizing bone ash, waste glass and granite based composites with a view of improving the strength of this body for the production of free standing self glazed ceramics. Granite /Clay 70%, Bone Ash 20% and Waste glass 10%, constitutes batch A. While Granite/Clay 70%, Bone Ash 20% and Waste glass 10%constitutes batch B. Granite/Ball clay70%Bone Ash 20% and Waste glass 10% Constitute batch C.Granite/Ball Clay 60%Bone Ash30% Waste Glass 10% represented batch D.These compositions were found suitable for the production of free standing ceramic wares through the casting method of production. The forms produced were fired to 1250 degrees centigrade. Results showed an improvement in the ware hardness at green and fired stages. Products fully vitrified with a corresponding increase in tensile strength which enabled the ware to stand without collapsing. An improved shine on the surface of the wares was also achieved. Based on these results, it was found out that the inclusion of waste glass and bone ash into the granite based composites yielded the desired properties needed for the production of self glazed ceramics.

Introduction

Granite base composites in the ratios of 80% - 20% and 70% - 30% granite and ball clay produced bodies that are described by Dinsdale (1986) as self glazed bodies. These are bodies that melt and shine on their own without any glaze application. These are equally fired once from green to gloss stage.

The major drawback or limitation of this body as discovered in the course of studio experiment is that, it cannot be used to produce standing forms due to poor tensile strength. Standing forms produced and fired to 1200^{0}C collapsed during the process of vitrification and stuck to shelves, while those objects that were fired up 1220^{0}C fused and evaporated completely from the furnace. Ahuwan (2012) once described granite as fugitives. This ephemeral character it manifested confirmed that assertion.

A close study of the mineralogical composition of the materials used for the above mentioned bodies showed a mismatch between fillers and fluxes which resulted in the lowering of body strength and rapid fusion. This research therefore is aimed at synergizing waste glass and bone ash with granite based composites with the view of improving their strength for the production of self glazed ceramics.

Back Ground of the Study

Alkali (2014) citing Conrad (1980) noted that, over the centuries, attempts have been made by various researchers all over the world to develop workable ceramic bodies from earth resources. These efforts have resulted in combining common clays with other minerals to produce functional wares which serve both domestic and engineering purposes. This art of tempering clay is a common practice in ceramic production. Reasons for tempering natural clays are numerous, ranging from

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shrinkage control, drying and attainment of various temperature ranges. Others include improvement in the tensile strength and enhancement of other mechanical properties of clays. The important technological advantage this practice offers is that it presents a constant avenue for research. Granite, quartz and marble stones are known to be the chief materials apart from straw and grog in tempering clays.

Self glazed bodies are special bodies that have gained world-wide recognition. These are also referred to as “Jasper". They vitrify and have smooth surfaces even in an unglazed state and may assume many colours ranging from blue, green and black. According to Dinsdale (1986) these bodies are known for their self decorative ability in the production of ornamental ceramics. Their temperature ranges from 1200°c to 1250°c. Some of these bodies can be derived by using single clays while others are achieved by the art of tempering.

Bray (2000) stated that ceramic materials are classified into three to fulfill functional requirements. These are forming materials which assist in the formation of structures. The second requirement is the flux which assists in the vitrification and sinterabilty of materials while the third functional requirement is the fillers, which occupy the space left by the clays and fluxes. They provide rigid skeleton ability to the body as well as reduce reduction and distortion of forms. The researchers will abide strictly by this formula to obtain bodies that can function as self glazed ceramic.

Bone ash is found to be a cheap source of calcium phosphate and calcium oxide used in stone ware bodies as flux and glass former. A typical analysis of bone ash according to Hamer and Hamer (2004) shows a high percentage of calcium oxide put at 55% and 40% phosphorus oxide. Although calcium is known to promote high fusion, the presence of phosphorus oxide produces a stiff melt. So because of this stiff glassy character, it combines with stones such as Feldspar/Granite and quartz to stabilize ceramic bodies during firing. It is believed by the researcher that this strength imparting quality of bone ash will compliment the granite body in achieving self glazed bodies that produce standing forms.

The presence of quartz obtained from a secondary source in waste glass powder in varying proportions affects form making in several ways. According to Garkida (2006), apart from these waste affecting density changes on a body, mixing glass wastes with other clays help in controlling the overall thermal expansion resulting to extreme fusion and weak tensile strength. It is this quality of extreme fusion due to the presence of strong bases in glass waste that intends to exploit in order to impart strength to the self glazed body and at the same time retain its glossy quality.

It is observed by Askeland *et al;* (2003) that clay mismatch particularly between fillers and fluxes results in cracks and lowering of body strength which appears to be the problem of this study. Therefore this research will endeavour to adopt through studio experimental correct combination of quartz (in waste glass), bone ash and granite bodies to achieve free standing forms that have self glazed character.

Methodology

Waste glass and bone ash in combination with granite based bodies have been identified by the researchers as materials

that when proportionately combined, will solve the problem of the study which is to develop self glazed ceramic bodies for ceramic production. Glass waste was obtained from an accidental truck carrying beer bottles while cow bones were obtained from Zaria abattoir in Kaduna State. The broken bottles were crushed into powder form while the cow bones were calcined to 1000^0c, crushed in a jaw crusher and ball milled to fine grain size and dried to powder form. Samples of these materials were taken to multipurpose science laboratory in the chemistry department of Ahmadu Bello University for analysis.The tables below show the result of the analysis.

Result of Chemical Analysis of Materials
Bone Ash

Element	% composition	% oxide in sample
Calcium	17.04	23.85
Phosphorous	8.15	37.57
Magnesium	0.44	0.75
Zinc	0.41	0.52

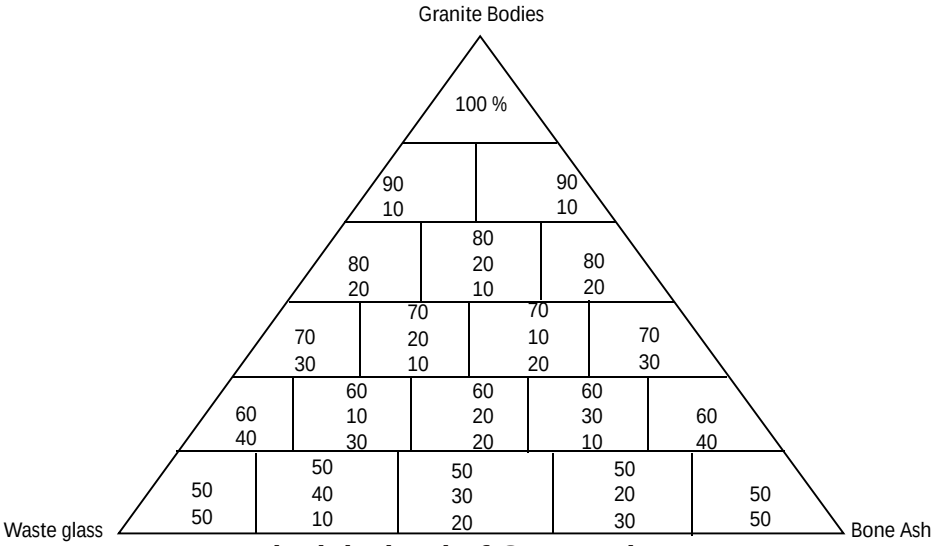
Waste Glass

Element %	% Oxide in samples
Si	19.35845
Mi	0.004110
Fe	0.55856
Mg	0.674146
Al	0.599456
Cu	0.035863
Ti	0.016815
Zr	0.014295
Ca	5.432859
Ce	0.046903
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Na	8.605892
Zn	0.022829

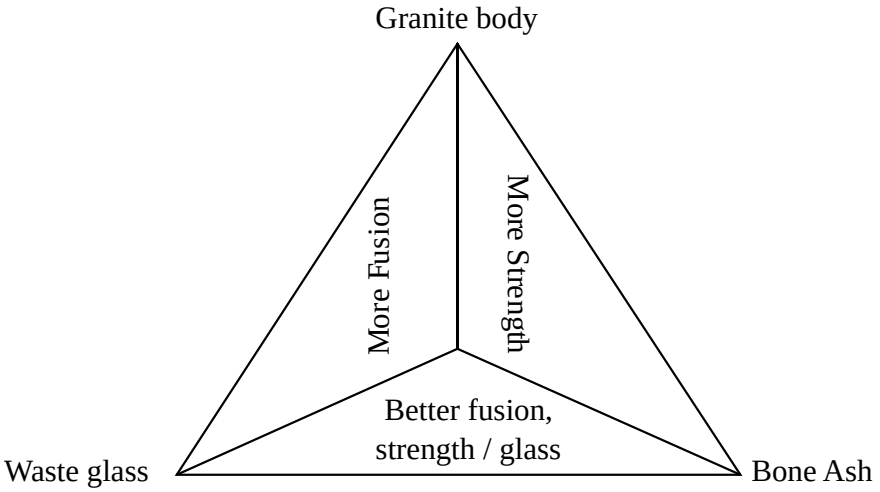
Table 3: Chemical Analysis of Granite/Ball Clay

Granite/Ball clay Batch type	Chemical composition							
	Al_2O_3	SiO_2	Na_2O	K_2O	TiO_2	MgO	Fe_2O_3	CaO
GB1	25.94	48.84	0.46	1.91	1.30	9.14	1.30	9.90
GB2	25.72	49.69	0.67	1.24	1.24	9.15	1.40	9.86

It is observed by Askeland ibid, that once a body has been identified for a particular purpose and the constituents are selected to give the right dry and fired properties, the next major problem lies in synergizing these materials to obtain a homogenous mix. This is achieved by either wet mixing or dry mixing. Dry mixing was chosen by the researchers because of the inherent comparative advantage it has in terms of easy and accurate weighing so long as allowance is made for small moisture content in the materials. The coning and quartering procedure and technique of mixing materials suggested by American Society for Testing Materials (ASTM) was adopted. A scientific weighing scale was utilized afterwards to derive exact measures of materials as predetermined by the researchers. A practical triaxial composition of the bodies and the outcome is given below



Triaxial Blend of Composites



The projected outcome of the blended composites

From the triaxial blend of materials, 4 bodies were identified as possessing the desired properties that are needed to impact strength and maintain the shine of the self glazed bodies under investigation. Bellow is the table showing the batch composition.

Table 4: Batch Composite

Granite/Ball clay %	70	70	60	60
Glass waste %	20	10	30	10
Bone Ash %	10	20	10	30

Production of Wares

There are a wide range of production methods which necessitate the variation in clay body composition and preparation. A ceramic body which is suitable for a particular production method may not be suitable for another. Since the bodies composed lack plasticity which is a major characteristic in stone ware body, casting method seems to be the unavoidable option.

Plaster moulds were obtained and moulds were produced from the clay models of flower vases and snack bowls. Equally compounded and mixed in slip form were the bodies to be used in the production of these standing forms. Following this was the production of these sample wares through the slip casting technique. Several copies of test wares were produced, dried and fired between 900 1260^{0}C. Below are plates showing the objects produced.



Plate I: Finished product of self glazed ceramics



Plate II: Finished product of self glazed ceramics

Results and Findings

In attempting to solve the problem of this study which is the inclusion of waste glass and bone ash into granite based bodies for the production of self glazed ceramics, several steps were taken which involved formulation of granite based bodies, collection of waste glass and bones. These materials were processed, analyzed and incorporated into the base material. Bodies

were developed and objects produced using the slip casting approach. The following results and findings were derived from the experiment.

Result of Chemical Analysis

It was earlier on stated that, mineralogical study of the granite based composites indicated a likely mismatch between fillers and fluxes which could have resulted in the lowering of body strength and rapid fusion of the bodies. In the three material components one considers in making a successful body which are; materials for form making, materials for fluxing, and materials for the opening up of bodies, some could be found more desirable than others. These are maintained or added into the batch, while some are less desirable and so are eliminated from the batches. The chemical analysis of these materials provided a yardstick for the evaluation of the above factors and the eventual adjustment that is aimed at improving the strength of the bodies under investigation.

Result of Body Formulation

Many defects could be associated with ceramic production. Some of the faults are as a result of poor body formulation as in the case of the granite based composites which is weak tensile strength. The four bodies derived from the study showed a significant improvement in the tensile strength of the body which has enabled the wares produced to stand erect during the process of vitrification without collapsing as was the previous experience.

Findings

Granite based composites in combination with waste glass and bone ash produced bodies that overcame the shortcomings of the base materials by impacting strength to the body. The vitrification required for workable body was attained at the temperature of 1250^0C. These bodies which are describe as “self glaze” bodies vitrified completely and shined on their surfaces as if glazed. The only drawback was that the foot rims had to be covered with refractory clay to avoid sticking to the shelves during fusion.

Due to the low plasticity index of these bodies, the handling properties required at green stage and dry stage were very poor. So such bodies could not be recommended for throwing or hand building. However, they are good enough for casting so long as one exercise a good degree of carefulness.

One of the most fascinating discoveries in the research is experiment is the fast casting and drying rate of the wares produced. Because of the large particle size of the material and low water content, they tend to cast faster than the normal casting bodies. They equally dry faster with no incidences of cracks due to rapid exposure. The addition of waste glass and bone ash caused the vitrification temperature to increase from 1200^0C 1250^0C.

CONCLUSION

By this experiment therefore, it can be concluded that the huge granite waste that are generated by quarry industries as well as waste glass and bone when processed and combined together under scientific procedure could give unique body formulations that can be utilized to produce ceramic objects for various applications. The method chosen for its production was appropriate and fewer problems were experienced.

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