KWAME NKRUMAH UNIVERSITY OF SCIENCE AND

TECHNOLOGY, KUMASI, GHANA

EXPLORING THE POTENTIALS OF MFENSI CLAY FOR THE PRODUCTION OF GARDEN STOOLS

.

By

JOHN KOJO TORSU

(B.A INDUSTRIAL ART)

A Thesis submitted to the Department of Integrated Rural Art and Industry in the

Faculty of Art

College of Art and Built Environment,

in partial fulfilment of the requirements for the degree of

MASTER OF PHILOSOPHY

MARCH, 2019

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DECLARATION

I hereby declare that this thesis as embarked on in the Department of Integrated Rural Art and Industry for the award of MPhil. Integrated Art (Clay Technology) is entirely mine and that no part of this thesis has been published or submitted elsewhere for the award of degree. All sources used have been duly acknowledged.

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ABSTRACT

Furniture and stool production have been in various shapes and forms usually with materials which are resistant to the harsh weather conditions such as wood, metal, plastic, bamboo and cement. Nevertheless, beauty and strength have become an integral part of outdoor furniture due to their numerous technological innovations and marketing. Today, cement has become the basic material for garden stool production with wood being the most dominating raw material. Critical observations and analysis into the mineralogical composition of Mfensi clay, compelled the researcher to aim at exploring the potentials of Mfensi clay for clay garden stool production. As a result, this research seeks to test for the potential properties of Mfensi clay, feldspar and silica for suitable clay body composition for the production of clay garden stools. To achieve these set objectives, the researcher used the qualitative research method, coupled with the experimental and the descriptive research designs to analyse and draw meaningful conclusions. The following three clay body compositions were subjected to shrinkage test, water absorption test and atterberg limits respectively. Clay body 'A' constituted 70% Mfensi clay, 10% feldspar and 20% silica. Clay body 'B' constituted 80% Mfensi clay, 10% feldspar and 10% silica whiles, clay body 'C', constituted 60% Mfensi clay, 20% feldspar and 20% silica. Conclusions drawn from these tests revealed that, clay body 'A' which constituted 70% Mfensi clay, 10% feldspar and 20% silica exhibited creditable physical and chemical properties that renders it more potent for clay garden stool production. It is recommended that, the Department of Integrated Rural Art and Industry, takes advantage of the properties in Mfensi for clay garden stools production.

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DEDICATION

I dedicate this research to the Lord God Almighty for his guidance and protection throughout my MPhil study. Also, to my parents and siblings for their prayers and to all individuals who contributed to the success of this thesis.

CHAPTER ONE

INTRODUCTION

1.1 **Overview**

This research aims at exploring the potentials of Mfensi clay in the production of garden stools. This chapter contains information on the background to the study, statement of the problem, purpose of the study, research questions, delimitation, definition of terms, the significance of the study and arrangement of the rest of text.

1.2 Background to the Study

This study examines the need and use of garden stools (patio furniture). Apart from the need and functions of outdoor furniture, its aesthetic values and resistance to the harsh weather conditions cannot be over emphasized. This makes beauty and strength an integral part of every outdoor furniture. Tanya (2015), in his contribution to the use of outdoor furniture in the environment explained that, apart from designers being consumed with function in mind, creating drab but durable pieces that could withstand the effects of heat, precipitation, rust and excessive use of the outdoor furniture, consideration should be given to innovative skills, attractive forms and good finishes used by their counterparts in the field of interior furniture designing to uplift the face of the outdoor.

In addition, key design trends today, is the breaking down of boundaries between the indoor and outdoor spaces which will gradually merge into one another. Nevertheless, the outdoor, which is an extension of the living room serves as an outdoor living room for individuals, families and the general public as a whole, where people dine or rest. It is therefore significant that, safety precaution in designing and constructing outdoor furniture must be paramount.

On the other hand, the Mfensi clay deposit in the Atwima Nwabiagya District in the Ashanti Region is among the various clay deposits found in commercial quantities in

Ghana. The clay which is in abundant is basically used for the designing and production of crockeries, pots, flower vases, and wall vases. Various clay tests conducted on the Mfensi clay, informed the researcher that, the Mfensi clay, when well composed with feldspar and silica, glazed and fired, achieves a desirable result.

According to Nsiah (2008), when the following test, X-ray fluorescent analysis (XRF), X-ray diffraction (XRD), firing test, plasticity index (Atterberg's method), particle size analysis, thermos gravitational analysis (TGA), exothermic and differential thermal analysis (DTA), and endothermic analysis (EDA), were conducted on Mfensi clay, it revealed that, the Mfensi clay has important potential characteristics such as low percentage drying, volumetric shrinkages and good compressive strength, most substantial characteristics of garden stools the researcher is interested in. The Mfensi clay which is stiff, sticky fine-grained earthen material that can be molded when wet, dried and baked to produce ceramics wares, has good potentials for garden stools production.

1.3 Statement of the Problem

The knowledge and skill for producing ceramics wares among the people of Mfensi is limited to crockeries, pots, flower vases, and wall vases. For many years, the people have devoted their time trying to develop innovative skills in the production of these articles without paying attention to other areas such as garden stools production. The great values of clay are that, it develops plasticity when mixed with water and so can be manipulated into diverse shapes and forms and put into diverse uses Anquandah. (2006.). Clay presents a continual challenge to the ceramist because of the numerous ways it can be shaped into. Its unpredictability and the fact that when well composed yields a desirable result is its key property. Besides, several materials have been used in the designing and production of garden stools over decades. These include metal, wood (causing deforestation), plastic and stone. Material such as the local clay has not been given attention in the area of furniture construction especially the Mfensi clay. This study seeks to use Mfensi clay as a base material in clay body composition for garden stools production. Tite, (2008), refers to the manufacturing of decorative or useful wares made of clay as valuable works of art whish's surface treatment serves as decoration and reduces absorbency to liquids. Again, garden stools by nature are mostly left at the mercy of the weather anytime they were in used. The need and functions of these garden stools make it necessary to use materials which will make it possible to withstand harsh weather. Based on blend of creativity, customization, innovation, and modern production, materials such as wood, concrete, metals or bamboo, which are often used for outdoor furniture usually rot, rust or form spirogyra which often stain dresses. This may be due to their physical or chemical reaction to the weather. Hence the need for the researcher to explore the potentials of Mfensi clay for the production of garden stools.

1.4 Objectives

To explore the potentials of Mfensi clay for the production of garden stools, the researcher set the following objectives:

1. To test for the potentials of clay bodies composed of Mfensi clay, feldspar and silica for the production of garden stools.
2. To compose clay body with Mfensi clay, feldspar and silica suitable for designing and production of garden stools.
3. To design and produce garden stools with a well composed clay body with the Mfensi clay as a based material.

1.5 Research Questions

1. What are the potential characteristics of clay bodies composed of Mfensi clay, feldspar and silica for the production of garden stools?
2. How can Mfensi clay be composed with feldspar and silica for the production of garden stools?
3. How can Mfensi clay be used as an alternative material for designing and production of clay garden stool?

1.6 Delimitation

The research is focused on identifying the potential properties of Mfensi clay in clay body composition with feldspar and silica for the production of garden stools for the people of Mfensi in the Atwima Nwabiagya District of the Ashanti Region of Ghana. This will be based on gathering data from the Ashanti region, specifically in the Industrial Art Ceramic Section of KNUST, Kumasi, Integrated Rural Art and Industry Clay Section KNUST, Kumasi and Mfensi clay workers and sellers of clay wares in the region.

1.7 Definition of Terms

To facilitate the understanding of this research, technical terms used in the text are explained as follows:

Bisque*:* Refers to the first firing that clay bodies undergo at a relatively low temperature to maintain its porosity.

Clay – Clay is a fine-grained materials consisting of hydrated aluminium silicates that occurs naturally in soil and sedimentary rock. It is soft when wet and hardens when dried and heated.

Clay body - A mixture of different types of clays and minerals for a specific ceramics purpose. For example, Porcelain is a translucent white clay body.

Earthenware*:* Earthenware is a low-fired clay that is porous and not waterproof

Greenware - Clay or clay body which is completely dried but yet to be fired. It is usually in the wet to bone - dried state.

Kiln - A furnace of refractory clay bricks for firing pottery and for fusing glass.

Kiln Furniture - Refractory posts and shelves used for stacking pottery in the kiln for firing.

Leather-Hard **–** A state of clay where clay is partly dried but holds enough moisture that permit it to be curved.

Plasticity - The property of clay that permits it to be manipulated or stretched into various shapes but still hold its shape with no cracks or breakages.

Wedging - A method of kneading clay to make it homogenous by cutting and rolling.

Vitrification: The firing of pottery to the point of glassification.

1.8 Importance of the Study

- This study will provide an alternative material for designing and production of garden stools.
- To open avenues for further studies into Mfensi clay for the production of garden stools.
- To help generate income for small-scale ceramics industries who have mentality for creativity and innovation.

1.9 Arrangement of the Rest of the Text

In accordance with the research objectives, the thesis comprises five chapters. Chapter Two present the theoretical background information for the study. This is followed by Chapter Three which elucidates on the entire process of the research. Subsequently, Chapter present findings; that is, the outcome of the works produced in Chapter Three. Chapter Five contains the summary, conclusions and recommendations made by the researcher during the research. These were concluded by the list of references and appendices.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Overview

This chapter outlines related literature reviewed that has direct linkage to the study which aims at building in-depth understanding towards establishing facts from the information gathered for the progress of the study. These topics are classified under the theoretical and the empirical basis for further understanding of the research work.

2.2 Clay and Clay Formation

Peterson (2017), refers to clay body as the actual clay mixture that is used in forming objects. It might only have one specific type of clay or may consist of a mixture of different types of clay. Other additives may also be introduced into the mixture. Each specific ingredient used is included to give the clay body a particular attribute. For example, feldspar and silica may be added to aid plasticity, to lower or raise the clay body's firing temperature, or change its fired coloration. As defined by Schulze (2005). Clay is a finely-grained natural rock or soil material combined with one or more clay minerals with possible traces of quartz (SiO_2), metal oxides (Al_2O_3 , MgO etc.) and organic matter. These minerals are formed within a long period of time due to the gradual chemical weathering of rocks especially silicate by low carbonic acid. The formation and alteration of clay minerals and their accumulation as clay materials can occur by a very wide range of processes. In one way or the other, most of these processes and the environments in which they occur involve chemical and physical movement of water, Altaner and Ylagan (1997).

Kerr (2007), brought to light that, clay is formed through a range which involves at one extreme the action of compressed water vapour at a temperature of several hundred degrees centigrade, and at the other extreme, the action of atmospheric agencies at an ordinary temperature. Kaplan (2015) explains that, typical clay bodies are built with three main ingredients: clay, feldspar, and silica. Depending on the firing temperature, the ratios between plastic materials (clays) and the non-plastic materials (feldspar and silica) change to produce bodies of excellent workability, proper vitrification, and glaze fit. Clay bodies can generally be divided into three groups, temperature ranges: low fire (terra cotta, white talc bodies) firing to maturity temperature between cones 06–04, mid-range (white ware, stoneware, porcelain) firing to maturity temperature between cones 4–6, and high fire (stoneware, porcelain) firing to maturity temperature between cones 8–11.

2.3 Classification of Clay Types

Ivana *al el.*, (2014), attest to the fact that, clays often contain different minerals such as iron as Hydroxides, organic substance and some small amounts of manganese depending on how they were formed. Based on the mineralogical composition, clay can be grouped into four, namely: kaolinite (Al4(OH)8Si4O10), montmorillonite (complex hydrated silicates of Al, Mg and Na), illite (complex hydrated silicates of Al, Mg, Fe i Na) and haloizit (Al4(OH)8Si4O10×4H2O). In addition, thirty different types of pure clays can further be grouped within these categories. Such groups of montmorillonite important of these clays have high capillarity, unique rheological properties, thixotropy, high degree of swelling, hardening and good plasticity.

There are several family types of clays used by artists, sculptor and ceramist of which the following types of clay interest the researcher: oil-based clays, water-based clays, polymer clays, paper clays, fire clays and ceramic clays (earthenware clays, stoneware clays, ball clays, kaolin clays) (https://www.artmolds.com/clay-types), which are elaborated as follow:

2.3.1 Oil-Based Clays

This type of clay is made of various combinations of oils, waxes and clay minerals. This is based on the fact that oil does not evaporate as water and remains malleable for a long duration in dry environment. Anon (2017), stated that, articles made from oil-based clays cannot be fired due to the fact that the viscosity of oils decreases as temperature rises, the malleability is influenced by heating or cooling the clay. It can be re-used and so is a popular material for animation artists who need to bend and move their models.

2.3.2 Water-Based Clays

This is a type of modelling clay based on the polymer polyvinyl chloride (PVC) which can hardens based on the atmospheric temperature. Water-based clay is generally used for making arts and craft items and is also used in commercial applications to make decorative parts. Art made from water-based clay can now be found in major museums. Polymer clay remains workable until cured generally from between 265 F (129 C) to 275 F (135 C) for 15-minutes per ¼-inch (6.4 mm) of thickness.

Mirtys *al el.*, (2012), describe bentonite clays as a typical clay type of water-based clay found as part of fluids in drilling wells for the extraction of oil and water. The physicochemical and rheological properties of water-based clay enhance their good performance. As a result, the bentonite clays are mostly used after previous organic treatment to make it hydrophobic, since they are naturally hydrophilic.

2.3.3 Polymer clays

Polymers are composed of large molecules called macromolecules, which have its atoms associated with covalent bonds. The common polymers are formed of flexible chains which are generally made of carbon atoms, Anadão (2012).

Polymer-clay nanocomposites minerals are formed of polymer matrix and nanometer-size clay particles. Polymer matrix and nanometer-size clay particles composed with layered silicates have gained great improved characteristics of very low volume fractions of filler in its composition. The importance of using low amount of filler helps to retain the optical clarity in polymer-clay and low density of the formed composite minerals for its enhancement Dulebová *al el* (2016). In addition, polymer matrix and inorganic phases in the polymer-clay composition improves mechanical, thermal and gas barrier properties. Again, better load transfer, better heat transfer to the inorganic part that acts as insulator and mass transport barrier minerals in the composition creates path for the gas molecules. These improvements allowed the polymer-clay compositions to be used as engineering materials.

Sudip *al el.,* (2006), also discussed the properties of nanocomposites of polymer-clay as mineral with several improved properties such as mechanical strength, thermal properties, flammability and barrier.

2.3.4 Paper clays

Paper clays are combined with cellulose fibre in its composition to make them strong, decreases warping, improve joining capabilities in building pottery and ceramics wares in the wet-to-wet and dry-to-dry state, but with the interest of avoiding heaviness which is linked with regular clay bodies. Paper clay can be earthenware clay, stoneware clay, raku or porcelain for the production of ceramics wares but with the main aim of making them lighter. Apart from clay body composition, they are also used for slip and is good for joining small cracks on bisque wares, Merida-Paytes (2010). This referred to a clay body to which processed cellulose fibre (paper being the most common) has been added. Earthenware, terra cotta, stoneware, porcelain and bone china clay bodies can be made into paper clay. The fibre increases the tensile strength of the dry clay and enables dry-to-dry and wet-to-dry joins.

2.3.5 Fire clays

Anon. (2015), explains that, fireclay is the type of refractory clays that can withstand temperatures above pyrometric cone equivalent (PCE) - 19. The two main characteristics of fireclay are refractory and plastic materials in the pottery and ceramics industry. Fireclay enhances suitability in the manufacture of refractory fibres and bricks and also have high fusibility point and good plasticity. It is composed of high alumina and low iron oxide, lime, magnesia and alkalies which is appropriate for refractory manufacturers. Aluminous (kaolinitic) variation of fireclay is more refractory because of its hardness, density and absence of iron, which gives it a white-burning colour. Absence of the mineral alkalies gives it a very high fusion temperature.

Martirena, (2015), further explained fireclays as the most popular building materials of all times. Ancient civilizations identified quality materials for building temples, houses and cities as materials made of fireclay. Fireclay over the years has improved in technology to allow higher productivity mainly through the improvement of fireclay material for building kilns. The use of fireclay materials in kiln construction and the automation of the process with further energy improvements enable fireclay to withstand the maturity temperature of various bodies required for kiln construction.

2.3.6 Ceramics Clays

According to Marta (2015), ceramics clays are earthly raw solid material formed of non-metallic plastic minerals such as illite or smectites, kaolinites, smectites, micas etc, which are usually associated with other earthly minerals used for designing and production of functional and aesthetics wares in the ceramics industry. Ceramics clays after modelling are subjected to high heat temperature to harden and make them either vitrified or semi-vitrified. Ceramics clay types include earthenware clay, stoneware clay ball clay, fireclay and kaolin clay:

2.3.6.1 Earthenware clay

Earthenware clay bodies are the most common type of clay bodies which are plastic and easy to work with. They exhibit higher plastic properties than most clay bodies and possess non-vitreous pottery characteristic when fired. Generally, earthenware products are fired at the lowest temperatures ranging from 900º C to 1050º C. Another important characteristic of earthenware pottery products are colour and texture. After firing, earthenware products generally range from buff to yellow, pink, red and somewhat gray colour. The texture of earthenware pottery products is usually divided into two; coarse earthenware and refined earthenware, Park, (2014).

Atkin, (n.d.) explains white-burning earthenware bodies as clay bodies with a low green strength because, they are composed of other materials which are usually china clay, ball clay and about 50 percent non-plastic earthly minerals such as feldspar. In addition, because of the iron and other mineral impurities in earthenware clay, their maturity temperature ranges between 1745°F and 2012°F (950°C and 1100°C) and looks like terracotta red through white to buff. Glaze application on earthenware products enhances aesthetics and functional properties in the ceramics industry.

2.3.6.2 Stoneware

Taskiran, *et al.,* (2004) explained ceramics stoneware materials as extremely hard, highly dense, impermeable and usually an unglazed vitrified ceramics ware which are obtained by firing temperature range of 1200 ºC–1230ºC and with water absorption of 0.5% or less from a green pressed ceramics body. The term stoneware was as a result of the production of pottery and ceramics wares with dense, opaque, non-porous characteristics similar to natural stones such as granite, marble, sandstone, travertine etc. The material commencement of pottery and ceramics stoneware product was universally dated back in the 1980s and especially over the last decade its mechanical properties and aesthetic appearance have improved in the pottery and ceramics industries. This progress has attracted the attention of many potters and ceramists to maximize their effort in the production of stoneware artifacts. Basically, a well composed stoneware body may consist of SiO2 and Al2O3 as major oxides and CaO, MgO, Na2O, K2O, and ZrO2 as minor compounds.

Plate 2.1: stonware clay
(source: https://dickblick.com)

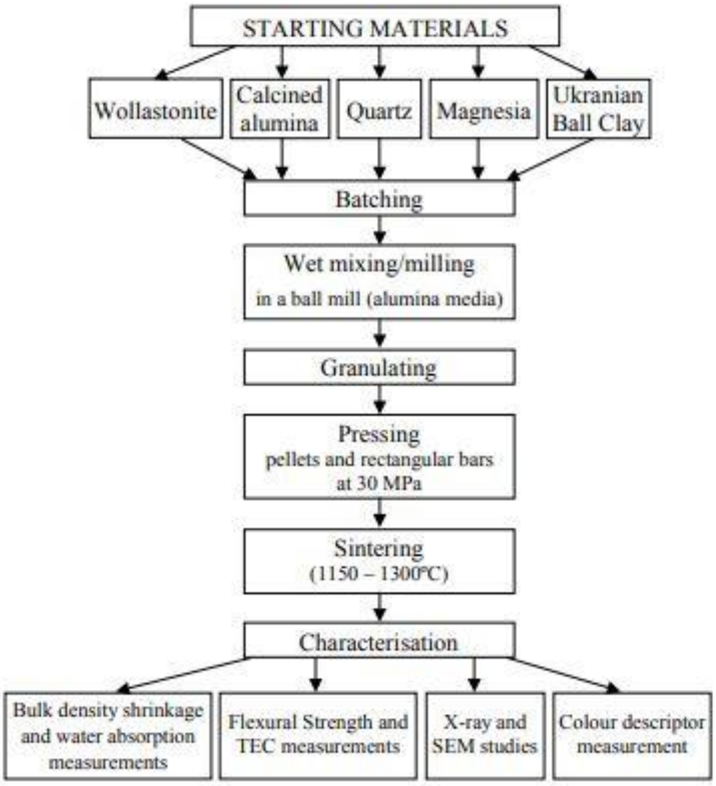

Plate 2.2: Flow chart for the processing and characterization of anorthite based porcelainized stoneware
(Source: https://pdfs.semanticscholar.org)

Zanelli, *et al.*, (2004), also revealed that, ceramics stoneware products are glass-bonded wares with excellent technical performances in the pottery and ceramics industries. In the last decade, the progressive growth of the global production of stoneware products has increased more than other ceramics products. The technical characteristics of stoneware, coupled with more improved aesthetic appearance, has given stoneware products a prominent role in marketing ceramics products. Stoneware bodies are usually composed of ball clays (30-40%), alkaline feldspars (40-50%), and quartz sands (10-15%) depending on the result one desires to achieve. The chemical composition may depend on the kind of fluxes (sodium or potassium feldspars) and their ratio,

Color Temperature Chart

Color	Cone	Degrees F
Lowest visible red to dark red	022 to 019	885 to 1200
Dark red to cherry red	018 to 016	1200 to 1380
Cherry red to bright cherry red	015 to 014	1380 to 1500
Bright cherry red to orange	013 to 010	1500 to 1650
Orange to yellow	09 to 03	1650 to 2000
Yellow to light yellow	02 to 10	2000 to 2400

Plate 2.3: A colour temperature chart for firing clay bodies
Source: http://www.paragonweb.com/files/manuals

Ana *et al.*, (2014), argued that, ceramic products undergo various stages of changes in their manufacturing before they becomes functional or used for aesthetics purpose. These stages are: the raw materials preparation, the forming method, drying, decorating, glazing and firing. At the firing stage, the green ware can be fired once together with glaze, this is termed as single firing. On the other hand, the green ware can be fired first before glaze application is carried out for the second thermal cycle to fire the glaze. This process is also known as double firing. Each process yields a desirable result in the ceramics manufacturing industry.

2.4 Clay body

A perfect clay body seldom occurs in the natural state. Clay body also refers to the preparation of non-metallic plastic and non-plastic earthly material composed with other earthly minerals to meet specific purpose in the ceramics industry, Moses *et al* (2014). Clay body might have one specific type of clay or may consist of a mixture of different types of clays in its composition to achieve a particular result. For example, some earthly bodies may be composed to aid plasticity, workability, lower or raise the clay body's firing temperature, or change its firing coloration. Kalilu, *et al.*, (2006) perceived that, the two major types of ceramics clay (primary and secondary clays) are the basis upon which the three basic types of clay bodies are formed. Namely, earthenware, stoneware and porcelain whose maturing temperature ranges between 750ºC and 1150ºC, 1150oC and 1350ºC as well as 1400ºC and 1700ºC respectively, and form the rudiments for other clay bodies. Kaplan, (2015) further explains that, the division can be generalised into the following temperature ranges, low fired (terra cotta, white talc bodies) firing to maturity temperature between cones 06–04), mid-range (white ware, stoneware, porcelain) firing to maturity temperature between cones 4–6, and high fired (stoneware, porcelain) firing to maturity temperature between cones 8–11. Again, typical clay bodies are composed with three main ingredients: clay, feldspar, and silica.

Depending on the firing temperature, the ratios between plastic materials (clays) and the non - plastic materials (feldspar and silica) change to produce clay bodies of excellent workability, proper vitrification, and glaze fit. Composing a successful clay body is the result of understanding how the many materials are combined in specific proportions to produce a desirable result. The types of clay and other constituents that forms the clay body, the atmosphere, the forming method and the firing temperature are all important factors to be considered in clay body composition. In addition, shrinkage, fired absorption, what burns off during the firing (the loss on ignition or LOI), and the thermal expansion of the clay body relative to glaze fit, are all significant to the researcher.

2.4.1 Ball clays

They are extremely useful; however, they are added to other clays to increase plasticity and workability. They cannot be used by themselves due to their excessive shrinkage during drying and firing. According to Finkelnburg, (2017), Ball clay has four characteristics; particle size, shrinkage, variable quartz, and organic content which influence the performance of a particular clay body. Its wide range of particle sizes makes it more plastic which increases green strength, influence drying and makes clay body easy to work with. Again, because the particle sizes are fine, it requires more water which means that, more water will evaporate on drying to increases shrinkage. Again, ball clays are used in clay body, blended with kaolins and other non-plastic minerals like quartz sand for a specific purpose.

Plate 2.4: ball clay composition
(Source: https://.amazonaws.com)

2.4.2 Kaolin clays

Kaolin is a fine soft white clay which is composed as a result of the natural decomposition of other minerals in the soil such as clay or feldspar. Due to their mineral purity, kaolin clays are used for porcelain. Although kaolin clays do have some range in colour, they are all very light in colour. Kaolin is used to make porcelain in china, filler in paper and textiles, and as absorbents in medicine. Jorge *al el.*, (2003) revealed that, the remarkable property of kaolin is that, it is one of the most abundant earthly minerals in the soil. Kaolin interacts with other soil minerals and combines with the soil column.

The advance weathering process of the minerals in the soil forms Kaolinite. Metal adsorption by kaolinite may affect the mechanical characteristics of the soil. The mineral Kaolinite belong to the group of minerals known as alumina-silicates which is commonly termed as "China Clay" because it was first found at Kao-Lin, in China. Kaolin is a term used to describe a group of relatively common clay minerals associated with kaolinite and found primarily from the alteration of alkali feldspar and micas.

2.4.3 Feldspar

Joseph and Ralph (2007) attest to the fact that, feldspar is the main component of igneous rocks making up the earth's surface. The chief commercial source of feldspar is found in pegmatite dikes formed with other pegmatite minerals such as quartz and micas as well as minor amounts of tourmaline, beryl, garnet, spodumene, pyrite and magnesite.

Osama *et al.*, (2015) stateed that, feldspar is the greatest single group of composed rock silicate minerals. The silicate minerals (feldspar) is derived from the German words field + spar. The word (field) is field in German and (spar) is a term for light colored minerals that break to form a smooth surface. Feldspar minerals therefore are earthly bodies used as flux to lower the vitrifying temperature of a ceramic body by melting gradually over a range of temperatures during firing. This greatly influence the melting of quartz and clays to form glassy appearance on ceramics wares. Potter, (2000) discussed feldspar as the most abundant group of all minerals found in the earth's crust, it forms about 60% of terrestrial rocks. The most important source of feldspar is in Europe where potassium feldspar and sodium feldspar deposits are found in most countries like Sweden and Norway. The mineral is sometimes offered as mixed feldspar because, feldspar can occur naturally as a result of flotation of mined and crushed rock.

The mineralogical composition of feldspar can be expressed into four chemically distinct groups; Potassium feldspar ($KAlSi_3O_8$), Sodium feldspar ($NaAlSi_3O_8$), calcium feldspar ($CaAlSi_3O_8$) and Barium feldspar ($BaAl_2Si_3O_8$).

Joseph and Ralph (2007) again explained that, the glossy property of feldspar improves the strength, toughness, and durability of ceramics clay bodies which cement the crystalline surface of other ingredients by softening, melting and wetting other batch constituents useful in the manufacture of ceramics products. Feldspar which is used as flux reduces the melting temperature of ceramics bodies which reduces the amount of energy to be used and soda ash needed for the production of ceramics wares. Feldspars can also be used as fillers and extenders in the applications of paints, plastics and rubber. Beneficial properties of feldspars include good dispersability, high chemical inertness, high resistance to abrasion and low viscosity at high filler loading,

2.4.4 Silica

Silica is the name given to the group of earthly minerals composed of silicon and oxygen, the two most abundant elements in the earth's crust. Silica is formed commonly in the crystalline state and rarely in an amorphous state. Its composition is made up of one atom of silicon and two atoms of oxygen which result in the chemical formula SiO_2. Hansen, (2012) revealed that, the genesis of silica formation began with a parent material such as bedrock, volcanic ash, sediments and windblown materials.

Climatic forces of water, temperature and other elements break down the parent material to form the earth's upper layer, or life-supporting outer crust. Quartz is the best example of a natural mineral that is almost pure silicon dioxide which is the most abundant mineral on the planet earth. Other ceramics minerals like feldspar and clay contain some 'free silica' known as the accessory quartz. They usually contain 'silicates', which is, SiO2 chemically combined with other oxides to form crystalline minerals. Ariffin, (2004) states that, silica consists of small grains or particles of varying sizes of mineral and rock fragments.

These grains may be of different mineral composition, but the dominant constituent of sand is quartz, which consists of small grains or particles of mineral and rock fragments. Other components may include aluminium, feldspar and iron-bearing minerals. The type of sand naturally occurring in the environment depends upon natural phenomenon such as bedrock, climate and forces of glacial movement, flooding and the direction of wind. Sand is a crystal form of silica or silicon dioxide.

Silica is a very basic sand formed as a result of decomposition of rock and hard minerals of varying particle sizes. Brenda *et al.*, (2016) discussed silica as the second most abundant element in the earth's crust, almost exclusively found in the form of silicon dioxide in association with a wide array of Si-bearing minerals in crystalline. Silica is found as part of rocks and clays, it is so common that it makes up 60% of all earthly materials of the earth crust. As a free mineral, combined in clay and other materials, it occurs as silica sand, quartz, sandstone, and flint pebbles. The common source of silica is sand. All sands contain some amount of silica in the form of small quartz crystals, but a specific sand may contain some small crystals of other minerals e.g. mica which will not cause problems in clay body composition.

2.5 Uses of Clay

Rytwo, (2007), indicates that, the use of clay since the very beginnings of civilisation was for making cooking pots, bricks, porcelain and also drainage pipes. Both brick clays and other clays bodies are used for different purposes such as the manufacture of clay pipes, floor and wall tiles. Fireclays are used for more refractory purposes such as heat-resistant tiles, fibres or bricks. China clay, predominantly kaolinite is used in ceramics as a filer and for manufacturing drugs. Expanded clays are used as a lightweight aggregate in the manufacturing of expanded clay blocks used for insulation. However, the major use of clay after brick manufacturing, is the manufacturing of cement. Ball clays are noted for the production of pottery and ceramics wares.

2.6 Some Products Made with Clay

Plate 2.5: flower pot.
(Source: pecenppot.com)

Plate 2.6: ceramic bowl
(Source: barterdesign.ca)

Plate2.7: Innovative ceramic pot
(Source: Pinterest.com)

Plate 2.8: Ceramic jar
(Source: Pinterest.com)

Plate 2.9: ceramic tea pot
(Source: amazon.ca)

Plate 2.10: ceramic mug
(Source: pinterest.com)

2.7 Glazes

Glaze is raw materials of silica, metal oxides, sodium, alumina, potassium and calcium used for ceramic masonry building material which provides an impermeable layer or coating on ceramic wares as a result of firing. It is also a vitreous substance fused on ceramics wares to colour, decorate or waterproof them and also serve as a seal on their inherent porosity.

Casasola *et al.*, (2011) discuss glaze as composition of some specific raw materials obtained by cooling oxides melted on the surfaces of ceramics earthenware by firing to provide glassy coatings. Apart from sealing the porous surfaces of biscuit wares to prevent evaporation of liquids, glazed wares are important innovation for earthenware because, they provide a great variety of artistic features by adding colour, beauty and also providing waterproof characteristics to wares. Development of the first glaze was around 3500 BC in the Eastern Mediterranean countries by potters who tried to imitate the precious blue stone lapis lazuli. Malachite powders, natural ores of copper with blue and green colours were composed for glazing. Rinco *et al.,* (2011) further explians that, when glaze was fired on a clay ware, it generated a thin layer of coloured glass coating on the surface of the ware. Afterwards, potters started experimenting with combination of different materials to coat the surfaces of pots.

Blanchart *et al.*, (2015) in their conclusion to the Simulation Methods for Ceramic Glaze Formulation propounded that, efficient methods of analysing the properties of glaze composition reduce the time of forming new glaze for commercial purposes. Satisfactorily, degree of accuracy in calculating the composition and temperature ranges of glaze have so far been investigated. Today, significant result of glaze formation is achieved by the calculation of the viscosity and thermal expansion coefficient (TEC) of glazes based on experimental data and analysis which improve its composition. The result of glaze on ceramics ware depends on the algorithms used in its composition. Studies have therefore proved that, glazes are composed of silica as a glass former, flux for lowering the melting point, alumina for adhesion and consistency and colorant as a pigment.

2.7.1 Classification of Glaze

Glaze classification possesses a difficult change based on the fact that, it is not easy to determine the technical and operational classification criteria. Each criterion explains a different type of classification which may or may not be useful in glaze classification. Glaze classification depends on its intended purpose and certain expected results in the production process, Maximina *et al.*, (2012). Usually, glazes are classified according to their fusibility, the Presence of some important components, application methods, and effect on finished glazed wares. Glaze can be classified according to their chemical composition, the technological properties and superficial glassy appearance on ceramics wares. Plates 2.11 and plates 2.12 represent classifications of glaze compositions by criteria and chemical respectively.

Criterion	Classification	
Fusibility	- Fusible - Hard or less fusible	
Presence of an important component	- Lead-containing - Non lead-containing	
Further application and firing process	- Single-firing covering - Single-firing pavement - Double conventional-firing covering - Double fast-firing covering	
Production application	- Bases - Airbrushing (pulverised) - Pips - Serigraphy	
Effect on the finished product	- Shining - Matte - Semi-matte - Satin	- Transparent - Opaque - Coloured

Plate 2.11: Glaze classification according different criteria.
(Source: glaze and ceramics for tiles pg. 11)

	Criterion	Classification
Raw glazes	Lead-containing	- With alumina - Without alumina
	Non lead-containing (with alumina)	- With alkaline-earth - With alkaline and alkaline-earth - With alkaline, alkaline-earth and ZnO - With boron - Salt glazes
Fritted glazes	Lead-containing	- With alumina - Without alumina and boron
	Non lead-containing	- With boron - Without boron - With high BaO content

Plate 2.12: Ceramic glaze classification according to chemical composition, proposed by Parmelee
(Source: glaze and ceramics for tiles pg. 12)

2.7.2 Glaze Application Methods

According to Turner, (2015), method of glaze application depends widely on what effect one wants to achieve as the surface appearance of a clay ware. Preparing the surface of the ware to be glazed is very significant because, that determines how fusible or less fusible glazes will fit on wares. The ceramic piece, when bisque fired, burns off organic materials which may complicate glaze firing and makes the ware slightly less porous. Ceramics wares ready for firing should also be cleaned with a damp sponge to make sure it's free of oil and dust for a good fusibility. Wax resistant should be applied to surfaces areas where glaze is not needed.

Moulson & Herbert (2003), opine that, glaze is applied on smooth or easily cleaned surfaces of a biscuit fired clay wares because, glaze is higher in coefficient of thermal expansion than clay bodies. Glaze can be applied by dipping, sponging, pouring, spraying or painting of which dipping and pouring are the most common methods used.

They are usually applied once or twice depending on the glaze coat thickness and effect one expect to achieve.

2.7.2.1 Dipping

Pitelka (2015) pointed out that, it is important to compose and mix glaze to the rightful consistency before dipping in any ware. The correct dipping consistency also depends largely on colour, glaze coat thickness and effect one requires to achieve. A good glaze mixture should be about the consistent of heavy cream to ensure even glaze coat. The mixture should be stirred evenly with wooden paddle and devoid of air packet before wares are immersed into it. It is essential to determine the time frame for the ware to be immersed in glaze. Usually a quick dip and an adequate quick firm shake will give even glaze coating with minimal runs and drips on glazed wares. This is achieved by practice and conscious intent. The effect of glaze on ceramics wares depends on the composition of the glaze and how faster it can coat an immersed piece.

Hopper, (2004) states that, glaze application by dipping is better achieved by applying a slightly thicker coating. Wares which are dipped into glaze should be held firmly for some few second enough and shake off in the glaze. To glaze the inside of ceramics wares, it is advicesable to pour glaze mixture into the inside of the ware, leave it for about three seconds then quickly pour it back into the glaze bucket. Excess glaze can be flipped or left depending on the decorative effect one seeks to achieve. To apply a thin layer of glaze over the top of a base, the glaze can also be poured over the outside of the pot which end up giving more interesting effect.

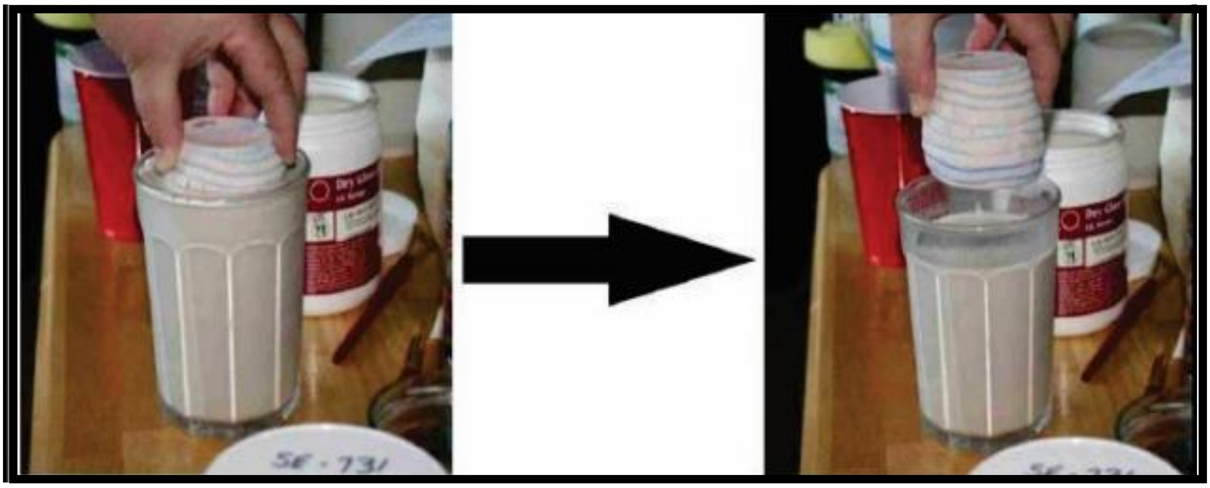

Plate 2.13: glaze application method
(Source: hwww.academia.edu)

2.7.2.2 Sponging

A study by D'souza, (2017), showed that, sponge glaze application was dated back in the 19th century and is much simpler and requires less patience to create some interesting but simple and far more complex designs on ceramics wares. Wares to be glazed must first be completely cleaned and wiped down with damp sponge. Areas to be unglazed should be covered with wax resist to create the kind of effect the artist seeks to achieve. Glaze of different kinds to be applied are then poured into a palette in readiness for the glazing or dipping the sponge into the bucket of glaze. The sponge is dipped into the coloured glaze and used to create interesting designs on the wares. The wares are then fired to complete the process.

A report by Peterson, (2017), also reveals that, the synthetic sponges and natural sponges are the two main type of sponge used for glaze application in the ceramics industry today. Again, because sponge has greater liquid-holding capacity, abrasive, shred and tear resistant, they serve as good medium for glaze application on the exterior and interior part of ceramics wares. The texture of the sponge can be translated into very interesting patterns when carefully applied. This gives unique effect depending on the expected results the artist seeks to achieve.

Plate 2.14: sponging technique of glaze application
(source: www.pinterest.com)

2.7.2.3 Pouring

Pitelka, (2015), explained that, glaze pouring application method gives the same result as glaze dipping method and requires similar glaze consistency in order to yeild such a desirable result. In this methood, it is advisible to glaze the intside of the ware first before the outside. Due to the trouble and stress of cleaning the entire outer surface of any glaze spilled over the unglazed outside with sponge and start all over after lifting. Care must be taken in the pouring process to avoid living with the effect of an undesirable result one might not be interested in. To glaze the inside of a ware, glaze is poured half way inside the ware, winded around and poured out while unwinding to glaze the entire inside and inner rim of the ware. Care must be taken to ensure that, every part of the inside and inner rims of the wares are well covered with glaze.

Again, according to Peterson, (2017), glazes can also be applied on the outside of ceramics wares by pouring the glaze over the outside surfaces of the ware. This is done by placing the ware upside down on sticks over a container. For specific effect, glaze is applied over the top of a ware, having waxed parts of the ware to be unglazed. This result gives very interesting effect after firing.

Plate 2.15: pouring technique of glaze application
(Source: www.pinterest.com)

2.7.2.4 Brush Glazing

Glaze for brush application should be well stirred and passed through a 40 mesh sieve, then to an 80 mesh sieve before appling on ceramics ware. The glaze to be applied should be fairly thick and the consistency of the wetted glaze should be equal to the thickness of honey. The piece to be glazed is raised on a pedestal that sits in a basin to allow the crystalline glazes that run off the pot to be collected in the basin. The glaze is then applied by the brush three to four time on the piece by brushing each layer in a different direction (horizontal, vertical and diagonal) to ensure that, the brush strokes are not visible and have an even coating before firing, Schran, (2010).

According to Ranlett (2015), hake or fan brushes are recommended for wide coverage to a soft liner wares which requires detailed glazing. Glaze which overlap could be mixed during firing to pruduce unexpected but interesting results. In addition, brush glazing is one of the earliest way of combining wax with commercial glazes for dramatic results. This technique allows the potter to manuplate glazing on his piece.

Cunningham (2010) also explains that, the brush is also recommended for the application of wax on ceramics wares for glaze resistance. Before bisque firing, the unglazed areas and the foot of the piece are painted with a thin layer of red terra sigillata melted or waxed to resist glaze. This result in creating very nice, rich and shiny clay exposure with water-tight surface on the wares. Brush glazing yields very interesting result when well applied.

Plate 2.16: brush application mode of glaze

(Source: pinterest.com)

2.7.2.5 Spraying

Spraygun that uses electric motor and a compressor pump is the most common machine used for glaze application in the ceramics industries. Glaze to be applied on ceramics wares should be carefully measured and tipped into the gravity-feed cup. It is important to note that, for the purpose of clarity and choice of colour, the gravity cup should be well washed before colour is changed for the next glaze application. Graham, (2000). He further reveals that, the best way to yeild good result is to adjust the air control and gently spray off finely divided droplets carried by just enough air all over the ware to give a smooth and even coating.

Hill, (2002), in his final taught in glaze spraying technique explained that, glaze spraying technique is the most flexible method that permit the potter to blend multiples glaze or isolate and change colours on the rims, handles and feet of the ware to give glossy effect. The method of glaze application result in giving the potential surface variation occuring naturally on ceramics wares fired in atmostpheric kiln.

Plate 2.17: glaze application by spraying
(Source: www.pinterest.com)

2.8 Tensile Strength

The most natural test of ceramics materials is to test for the mechanical properties to determine the tension stress limit of the clay body composition when subjected to axial load. The test is carried out by gradually increasing load on a special fired cubed clay body specimen till it reaches the limit where it may break into pieces or may suddenly develop fracture. The tensile stress test machine is used for this test for reading and recording the weight load of a particular clay body specimen when subjected to the test. The tensile strength test, tested for the materials composition and how their relationships are influenced by the microstructure in a particular clay body as recalled by Roylance, (2008).

Plate: 2.18: samples of tensile stress test machines
(Source https://www.pinterest.com)

Nyongesa and Aduda, (2000) dicussed the tensile strength test as subjecting an optimized clay body composition to the tensile stress test machine to determine their axial weight load. According to them, the test is best carried out by first preparing the test sample of the clay body by passing the powdered form of the composites through a sieve aperture to discard coarse particles. The composites of the composition in the powdered form are then mixed and made into a soft mass with water. The clay body composition is then formed into cubes and are left to be completely dried under room temperature and then fired to 1100^{o} C. The modulus of rupture (tensile strength test) is determined according to the standard procedure and measurements recorded on the test machine.

2.9 Kiln

A Kiln is a thermally insulated chamber which's source of heat is usually gas, electricity, or fire wood used for firing pottery and ceramics wares. The temperature in the chambers of the kiln are regulated and controlled by an instrument known as the pyrometer. The kiln is used to harden, burn or dry pottery and ceramics wares completely (en.wikipedia.org/wiki/kiln). The concept of kiln design and construction emerged in the history of the pottery and ceramics industry when man realised that, there was no means to control the heat lost that occurred in open firing or in shallow firing pits. Goyer, (2006) states that kiln relies on its volume of wares to determine the amount of heat that can be retain in it.

The larger the kiln size, the less heat is lost in relation to the volume since the surface area increases only on the square of the size and the volume increases on the cube of its size. For instant, a kiln that can fire only 150,000 bricks when used for firing 1,000,000 bricks at once will yield a bad result. This is because the wares which demand high firing temperature will not attain their maturity temperature. The stages involved in firing clay bodies to make them permanently hard had been a greater concern to the potter and ceramist right from the pre-historical era. Mohajeri and . Ghafghazi (2012) explained that, strength and strains are very important in every clay test. Various tests on pottery raw material are as much as 30,000 years old. History also have it that, types of Kilns varies in its purpose, construction and the choice of fuel. Besides, the design principles are common to almost all kilns. For instance, a stoneware body to be fired at 1150º C–1200º C requires a kiln which is constructed with a refractory material that will exceed 1150º C–1200º C.

2.10 Firing and Firing Temperature

Bloomfield (2017), disscussed firing as, the process of subjecting clay works to heat so that they undergo several physical changes to make them hardened and vitrified. In addition, these physical changes are what explain firing. Firstly, wares to be fired must be completely dried to avoid cracks and explosion during steam escape. It is better done by pre-heating the wares in the kiln to 176°F (80°C) - 212°F (100°C), known as water smoking. At this stage, the water in the pores between the clay crystals evaporate to ensures complete drying.

The next stage is called dehydroxylation, the chemically combined water with the clay is driven off around 1022°F (550°C), a state which the wares cannot be returned to plastic state. Organic matter in the clay body then burns and oxidizes to carbon dioxide whiles Sulphur dioxide are driven off at 1292–1652°F (700–900°C) which completes biscuit firing for handling and glazing. Above 1652°F (900°C), the clay body shrinks and becomes vitrified. Silica starts to melt and fuses the particles together.

Igor *et al.*, (2013) in their introduction to the effect of firing temperature on hardness of alumina porcelain discussed firing temperature as, the mechanical properties of ceramics wares achieved by composed clay body in the green state which go through different significant mechanical changes at each temperature level to the maturity state. The changes affect the modulus, mechanical strength, and hardness within the mechanical parameters of the clay body. The composed clay body determines the hardness of the ceramics wares produced. A body composed of porcelain will be hard enough to be used as floor tiles when subjected to a specific heat temperature.

Rasmussen *et al.*, (2012), dicussed firing and firing temperature as ssubjecting raw material such as clay minerals mixed with other earthly mineral to heat to undergo certain chemical changes such as dihydroxylation, decomposition, and transformation in the kiln. During firing, stable and metastable neoformation phases are produced, depending upon the mineralogy of the clay body composition. The hardness of the fired ceramics ware depends on the grain-size distribution, maximum firing temperature, duration for firing, and the redox conditions in the atmosphere of the kiln. The magnetic characteristics of a ceramics product change upon firing due to a combination of the original minerals and growth of neoformation mineral phases. Mineralogical assemblage is introduced upon firing which cause changes in the magnetic susceptibility of the ceramics wares. During the firing process, ceramic wares transforms completely from fragile substance (clay) to stone like substance (ceramic). This makes it resistant to water, does not soak water (Bone dry). Firstly, carbon and Sulphur are burnt because, clay bodies contain carbon, organic materials, and sulphur which burn off between 570°F and 1470°F (or 300°C and 800°C). Air dry the clay ware as clay bodies contain about 15% of water which are chemically bonded and are loosened when heated during the same time. Carbon and Sulphur burn off. The chemically bonded water escapes from the clay body between 660° F and 1470°F (350° C and 800° C). This process makes the clay substantially lighter with no physical shrinkage.

Bisque firing after driving chemically combined water out starts at about 1650°F (900°C) a stage at which the clay particles begin to fuse. This process when completed renders the clay body a pottery material at a temperature range of 1800°F (cone 06) to 1950°F (cone 04) which is also known as bisque ware. At this stage, the ware is called earthenware or bisque ware. The bisque ware allows wet raw glazes to adhere to the pottery before firing.

Heatwork Chart: Transformation of Ceramic Materials by Heat

Kiln Color	Cone	°F	°C	Description
white	14	2552°	1400°	Porcelain: cone 10-13
yellow	10	2380°	1300°	**High-fire**/Stoneware: cone 8-10, average=cone10
	6	2192°	1200°	Mid-range glaze: cone 2-7
	04	1950°	1100°	**Low-fire**/Earthenware: cone 015-1, average=cone 04
yellow-orange			1000°	
	010	1650°	900°	Clay particles beginning to vitrify; the lowest **BISQUE** temperature (cone 010-04)
		1450°	800°	Vitrification begins, carbonaceous material is burned off.
red	018	1292°	700°	RED HEAT
dull red			600°	
		1060°	500°	573° C, quartz inversion in both heating and cooling stages.
			400°	From 480-700° C, chemical water (water smoking) occurs.
			300°	From 300-800° C, carbonaceous material burns off.
		439°	200°	220° C, cristobalite expansion (heating), squeeze (cooling)
dark		212°	100°	Water converts to steam (expands).

Plate 2.19: Chart representation of firing temperatures and their transformations.
(Source: www.lakesidepottery.com)

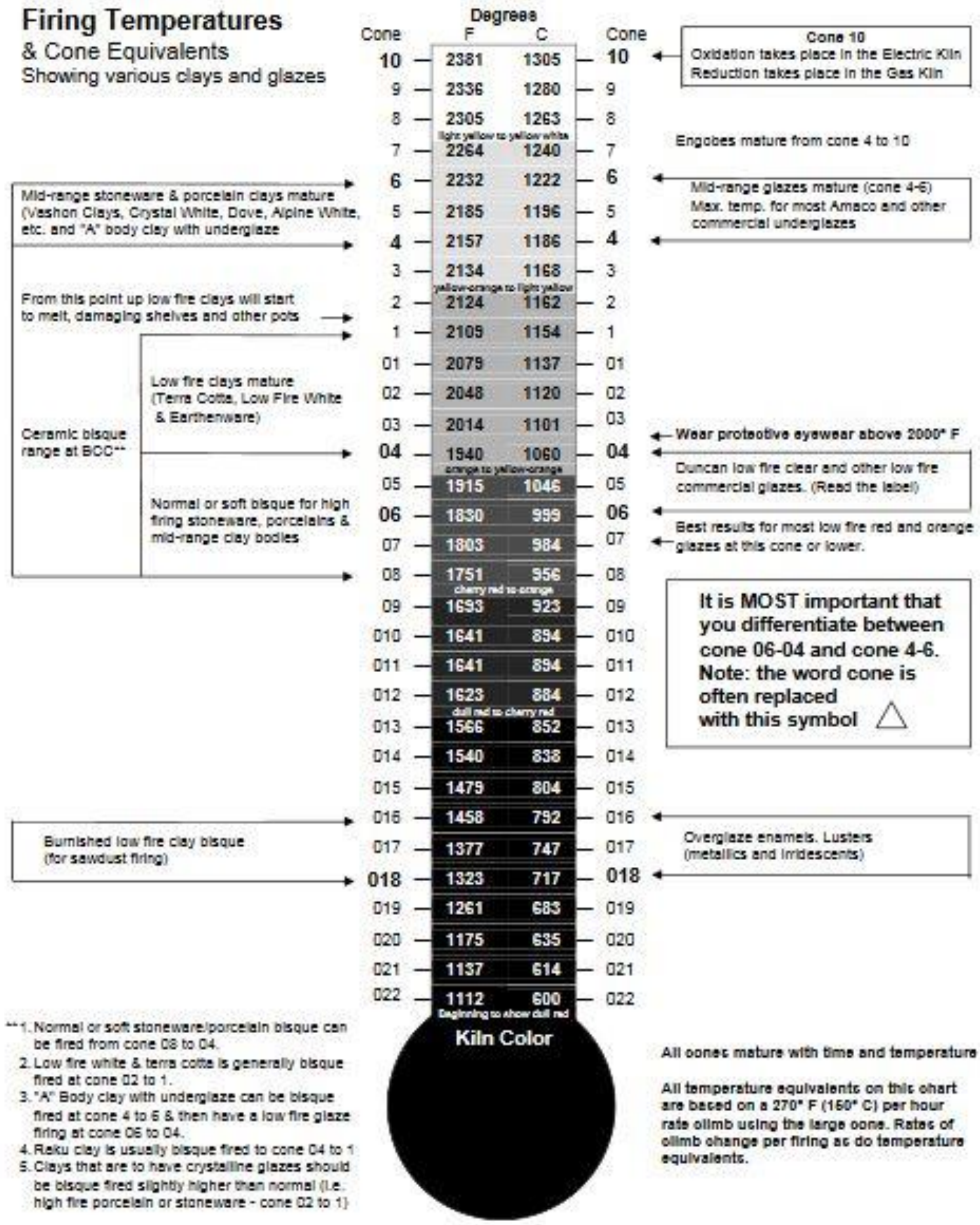

Plate 2.20: Firing temperature and cone equivalence
(Source: www.bellevuecollege.edu)

2.10.1 Firing Methods and Types

According to Jackson (2013), four different types of firing methods are basically used for firing ceramics wares, these are, salt glaze firing, wood firing, raku firing, gas firing, and pit firings.

2.10.1.1 Salt Glaze Firing

Stengel (2010) points out that, salt glaze firng is the process by which solid salt (NaCl) is introduced into a fuel burning kiln in order for the salt to evaporate and spread the vapour within the kiln with flame. The silica and alumina in the clay react with the sodium in the vapour to create glaze on the ware. Due to the high thermal expansion and excessive fluidity in the kiln, the sodium and glaze should be just enough for the process.

Soldner (2010) also articulates that, desirable results can be achieved with the use of hard-bricks or soft-brick even in fiber kilns, but the spot for the burner must enter horizontally. A salting pot should be positioned right above each burner to allow salt to drop directly into the frame for evaporation.

Plate 2.21 : Salt glazed fired ceeramics
Source: Nan Rothwell Pottery

2.10.1.2 Wood Firing

According to Ryan, (2016), clay wares need a source of fuel for firing to be able to serve their intended purpose. Hotory atests to the fact that, wood is one of the easiest accessible source of fuel for heat production. In pottery production. Wood is used as a source of heat in firing. Apart from the heat energy they provide for firing, it also provides resulting wood ash that creates an admirable surfaces on clay wares. The wood ash can be classified into two division, fly ash and bottom ash. Fly ash have light and small particle size which can be deposited on ceramics surfaces during firing. The ash particles which are too large to be carried up by the flame are retained as bottom ash.

Baker (2016), augues that, wood gasifies at about 500°F. Wood burns in two different stages, one is the burning of gasses produced when wood is heated and the burning of charcoal which burns after the materials that form the gasses have completely burnt out. The coal provides heat to the kiln as radiant heat energy. Wood produces long flame during burning in the kiln but shortens with changing oxygen-fuel ratio which produces more heat. In the process, smaller flame tips appear in the middle of the flame which is the place where the flame is hotter. Heat is then provided in the kiln for firing.

Plate 2.22: A kiln using wood as fuel for firing
(Source: crownstudio.co.uk)

2.10.1.3 Open Firing or Pit Firing

Pit firing is an atmospheric process of firing ceramics wares that is done typically in a hole in the ground, or a pit. This process basically deals with pots placed in the pit and burned irregularly where different colours and patterns are derived. The basic colours normally achieved are black gray or white dependent on the hotness of the ceramics piece which causes the pores to open leaving coloured vapour permanently on the surface, Anon, (2014).

Plate 2.23: Pit firing technique being exhibited
(Source: Art Elements Gallery)

2.11 Garden stools

The Collins English dictionary defines garden stool as a seat, usually kept permanently outdoors in a garden. As part of functional and decorative items, it is basically an item made based on the combination of functional and aesthetic values to serve a particular purpose. Hoffiman, (2012) revealed that, ceramics stool traditionally originated from Chinese homes because of the function, versatility and variety of decorative uses of stool for about 1,000 years ago. It is believed that, the idea came from natural elements like stumps and smooth rocks which were used as seat in gardens. He added that, traditionally, the Chinese homes were built with much emphasis on landscape and garden, so garden stool or furniture were very essential in the life of the Chinese man. The author further explained that, the historic stools of the Chinese is believed to have been emanated from the features of the late Ming Dynasty in the early 17th century. The Ming Dynasty has a range of decoration including fretwork, relief decoration and pierced motifs of a nailed head from ancient Chinese drums which had wood bodies with skins stretched over each end and affixed with nails. Stotempted, (2014) asserts that, garden stools have became a regular addition to both interior and exterior of homes for the purpose of both functional and style. To him, the invetion of garden stool in china is about 3,000 to 4,000 years ago when the Chinese began to move away from the use of floor mat to a raised stool in their environment. The first pieces were made of wood, lower than today's garden stool with a mat on top. They also served the purpose of both functional and style. He identified that, the oldest known furniture was from the Warring States period of the latter Zhou Period (1122 BC to 256BC).

Today, a vast majority of Garden stools available in Chinese market are ceramics wares. These are either porcelain, high fired stoneware, or pottery. The porcelain stools have blue and white style with Chinese traditional designs. The high-fired stoneware and pottery stools generally have varieties of modern designs. Garden stools as understood have several materials for its execution and these are: wood, metal, plastic, stone and glass.

2.11.1 Uses of garden stools

The use of outdoor or garden furniture is quite common in the modern homes, these stools are actually quite functional and versatile and can serve a variety of decorative uses in the home. Movable garden stools can also serve as a seat in the bathroom. Stools can function as decorative side tables to hold books, drinks and other accessories.

Pictorial representations of some garden stools made in various materials

Plate2.24: Garden stool in ceramics
Source: pinterest.com

Plate 2.25: Garden stool in plastic
Source: pinterest.com

Plate 2.26: Garden stool in metal
Source: pinterest.com

Plate 2.27: garden stool in wood
Source: pinterest.com

Plate 2.28: Garden stool in Cane
Source: pinterest.com

plate 2.29: Garden stool in glass
Source: Pinterestcom

2.12 Mfensi clay

Mfensi clay is found along the river banks of the river Offin in the Atwima Nwabiagya District in the Ashanti Region of Ghana. During the raining season, the clay site becomes flooded with water due to the over flow of the Offin river. The flow of the water washes clay from all angles of the river bank and gather them at the river bank at Mfesi. After the rains, the river settles and a lot of clay is deposited at the river bank. The clay which is known for its plasticity is basically used for the production of earthenware, for both functional and aesthetics purposes.

Today, the clay is the main source of clay material used by many institutions including the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. Amoanyi *et al.,* (2012), reveals that, to improve the strength properties of Mfensi clay by chemical stabilization, it is important to improve the engineering properties by binding the particles together so that they become rigid. The stability of Mfensi clay largely depends on the additional minerals added to improve its physical properties. Nevertheless, cocoa pod, feldspar, silica, sawdust, etc. are minerals added to the Mfensi clay to improve its strength property by chemical stability.

Sample	Colour	Drying Shrinkage (%)	Volumetric Shrinkage (%)	Atterberg Limits Test (%)			Particle size distribution (%)		
				Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI) LL-PL= PI	Clay <2μm	Silt 2μm60μm	Sand 60μm2000μm
Mfensi Clay	Greenish grey	7.4	21.89	43.34	20.80	22.54	37	43	20

Plate 2.30: Table representation of physical properties of Mfensi clay
(Source: www.scientific.net)

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter outlines the general plan of the study and strategies adopted by the researcher to resolve the problems of the study. This includes the research design, research methods, data collection, population and sampling, research experiments, data collection and data analyses plan.

Research design refers to the overall strategy that one chooses to integrate the different components of the study in a coherent and logical way thereby ensuring that, one will effectively address the research problem. It constitutes the blueprint for collection, measurement, and analysis of data, William, (2006). As a result, the researcher adopted the qualitative and the experimental methods for this research.

3.2 Qualitative Research Method

This is the systematic and subjective approach used to describe life experiences and give them meaning to gain insight, explore the depth, richness, and complexity inherent in phenomenon, Berg, (2012). The researcher employed the qualitative approach to derive meaning from situations and issues from the surroundings. This method was employed because, the researcher seeks to analyse the views of various individuals, the evironment and observe critically their reaction to problems solving.

3.2.1 Experimental research design

Experimental Research method makes use of random assignment to place participants in two groups: an experimental group which receives intervention and the control group without intervention. The researcher, used a positive control approach where he influence his variables and observed the result based on comparison. This method is adapted to know the various options that provide the opportunity for the selection of best result for a particular purpose. Experimental Research Method is a systematic approach to research in which the researcher manipulates one or more variables, controls and measures any change that may occur, Blakstad, (2008).

The Experimental Method makes it possible to determine whether changes in the independent variable cause subsequent changes in the dependent variable Zen (n.d). The main weakness of the experimental research method is its dependence on what many see as an "artificial" environment. People may behave differently in the experimental setting than they would under more ordinary conditions. The independent variables will be the tools and materials and the dependent variables will be the designs and the actual model. Before the actual model will be brought to the public, it would have been tested to help the researcher produce the highest level of evidence for the study and provides solutions for any future effects and unforeseen occurrences.

3.2.2 Descriptive research design

The objective of the Descriptive Research is to depict an exact profile of persons and events of a situation. Shuttleworth, (2008) stated that, Descriptive research design is a method which involves observing and describing the behaviour of a subject without influencing it in any manner or way. It is useful where it is not possible to test and measure large number of samples needed for the type of experiment. The idea of selecting Descriptive research is that, the steps employed for carrying out the experiment needed to be described chronologically gives a clear and detailed account of all occurrences in connection to the project.

3.3 Population for the Study

Hawking, (2018) writes that, research population is a scientific analysis of a large collection of the entire set of persons or object of similar features or traits that possess interest for a study. Hence, the research population was based on the two types of research population, the target population and assessible population.

3.3.1 Purposive sampling technique

The purposive sampling represents a group of different non-probability sampling techniques, Laerd (2012). The goal of purposive sampling is not to randomly select units from a population to create a sample with the intention of making generalisations from that sample to the population of interest. This sampling technique was applied by the researcher to achieve or gather credible data from the targeted population because the group is homogeneous. They shared common characteristic or set of characteristics and have the needed information to aid the researcher.

3.4 Target Population

Target population refers to the total section of individuals or objects of which the researcher intends to generalize his conclusion, Françoise *et al.,* (2010). The researcher in this regard considered a target population of 58 individuals puposefuly selected due to the fact that they have racquired knowledge to help in answering and addressing issues concerning ceramics and other related issues. The population consisted of 5 lectures from the Department of Industral Art Ceramics Section of the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, 3 lectures form the department of Integrated Rural Art and Indutry Clay Section of the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, 20 ceramics workers at Mfensi and 30 sellers of ceramics wares in the Kumasi metropilis.

Table 3.1: Target population for the study

TARGET POPULATION	DESCRIPTION	NUMBER
Industrial Art Ceramic section	Lectures	3
	Technicians	2
IRAI ceramic section	Lectures	3
Mfensi clay workers	Producers	20
Sellers of ceramic wares	sellers at Kumasi metropolis	30
TOTAL		**58**

3.4.1 Accessible Population

Nestor *et al.*, (2017), in summury explained accessible population as the subset of the target population which forms the population from which primary data was gathered. The accessible population for the study constituted 3 lecturers from the Industrial Art ceramics section of the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana (two lecturers and one technician), 2 lectures from the Department of Integrated Rural Art and Industry of the Kwame Nkrumah University of Science Technology, Kumasi, Ghana, 15 Mfensi clay workers and 15 sellers of ceramic wares in the Kumasi metropolis.

Table 3.2: Accessible population for the study

ACCESSIBLE POPULATION	DESCRIPTION	NUMBER
Industrial art ceramic section	Lectures	2
	Technicians	1
IRAI ceramic section	Lectures	2
Mfensi clay workers	Producers	15
Sellers of ceramic wares	sellers at Kumasi metropolis	15
TOTAL		**35**

3.5. Sampling Technique

Alvi, (2016) explains sampling technique as a target group of relatively smaller number of people carefully chosen from a population to participants in the reviews of a particular purpose to draw conclusions to become the foundation for estimating and predicting the result of the population. In research, it is difficult to assess every single element of a population to achieve a desirable result so the sampling technique is adopted by selecting a group of people smaller in number than the population for assessment. On the basis of data obtained from sampling, interpretations are drawn for an entire population, that is, the result obtained from sampling is used as a representative for a population.

The higher the sampling elements, the more the results becomes authentic for generalization for the entire target population. A report by Micah *et al.,* (2014) also reveals that, sampling techniques are basically used for research investigations to better estimate a general conclusion for an entire population. The sampling technique is associated with collection of a subset of individual elements from within a population to estimate the common characteristics for the whole population. The technique is carried out to investigate a small group as a representative of an entire population. The collection of sampling methods and determination of sample size are extremely important in every research problem to draw valid conclusions.

3.6 Data Collection Instruments

Data collection instruments suitable for a qualitative research study are, personal accounts, written documents, in-depth interviews and observation. These methods help in gaining in-depth understanding to the subjects under study by generating rich detailed data. Abawi, (2013) concludes that, a valid data and accurate information largely depends on the loyalty of the respondent. This researcher employed two of the methods which are in-depth interview and observation

3.6.1 Interview

This refers to one-on-one directed conversation with an individual using a series of set of questions designed to elicit extended responses. Interviews allow participants to express their thoughts using their own words and organization. They are particularly valuable for gaining insight understanding. Interview is one of the ultimate ways for collection data and information in qualitative research, Jamshed, (2014). This procedure also allows or creates room for questions that are unstructured to play part.

3.6.2 Observation

Observation refers to the systematic examination of real-time processes and operations with the goal of identifying needs or challenges or improving processes and practices of all that can be seen. Observations typically incorporate a prescribed protocol containing specific measures of observable behaviour and the narrative recording of the program activities and their context. The most significant aspect of observation is that, it widely covers ethnography and the research work in the field of study, Jamshed, (2014). From the aforementioned, the researcher participated directly in the survey carried out in relation to stool types employed by Ghanaian ceramics craftsmen to determine classification and general suitability and usage of the stools. This gave the researcher the opportunity to make direct observation and objectively record information from respondents for the benefit of this research.

3.7 Data Collection for Objective One

To test for the potentials of clay bodies composed of Mfensi clay, feldspar and silica for the production of ceramics garden stools.

The purpose of this objective is to test for the potentials of Mfensi clay that makes it a viable material for clay garden stools production. In achieving this objective, certain properties of Mfensi clay were considered to be suitable for the production of garden stools coupled with identifying chemical components of the clay body. Properties such as chemical properties and physical properties formed the main spine for this study, these were outlined towards identifying the potential of the Mfensi clay as follow.

3.7.1 Test for plasticity

Plasticity is the outstanding property of clay water systems. It is the property substances have that allow them to be manipulated continuously under a finite force. When the force is removed or reduced, the shape is maintained, Andrade *et al.*, (2011).

The clay body composition suitable for designing and production of the clay garden stools was composed as, Mfensi clay 70%, feldspar 10% and silica 20%. Experiments were carried out to identify the physical properties of the clay body such as colour, drying shrinkage, volumetric shrinkage, liquid limit, plastic limit, plasticity index, silt and sand of the clay body. To test for the plasticity of this clay body, small amount of the clay body composition was rolled into coils and looped into a circular form for the test. It was realised that, no cracks were formed on the coiled clay. A clear characteristic of clay that determines its plasticity. The experiment also informed the researcher about the functional importance of these properties in relation to materials suitability for designing and production of the clay garden stools.

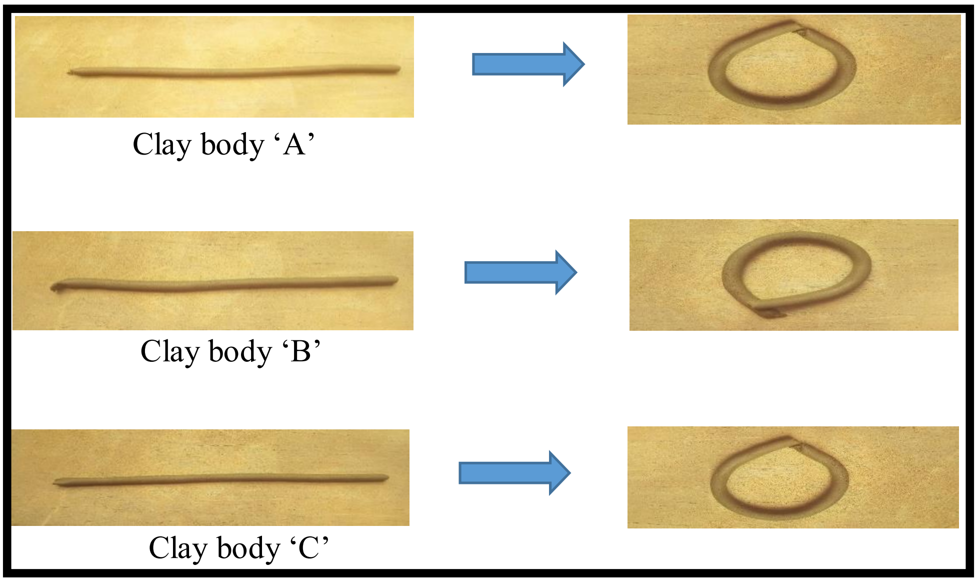

Plate 3.1: simple physical test of the three clay bodies

The experiment also revealed that, the clay body's plasticity development is good for modelling and retention of strength when used for garden stools and allowed to be air-dried before glazing and firing. The Silt and sand particles were considered as fine-grained non-plastic minerals that resulted in providing the clay body good stability and slight shrinkage. The clay body composition also have good liquid limit which influence optimum workability during mixing. The physical properties of the composed clay bodies are represented in table 3.4.

Sample	Colour	Drying Shrinkage (%)	Volumetric Shrinkage (%)	Atterberg Limits Test (%)			Particle size distribution (%) D,		
				Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI) LL-PL= PI	Clay <2µm	Silt 2µm60µm	Sand 60µm 2000µm
Mfensi Clay	Greenish grey	5.2	19.72	44.51	21.65	23.54	36	45	22

Table3.3: Physical properties of the composed clay body suitable for the garden stool (Source: www.scientific.net)

3.7.2 Porosity experiment

This test requires the identification of how compact the particles sizes of Mfensi clay is. Porosity is the open spaces between grains or trapped in grains in a microstructure, that is the presence of tinny spaces or opening in a clay material.

3.7.2.1 Porosity before Glazing (Biscuit)

Three separate clay bodies were subjected to the porosity test. The first clay body 'A 'of Mfensi clay 70%, silica 20% and feldspar 10% was formed into cubes and fired to 1180°C, the fired piece was then weighed on the measuring scale and recorded 60.54g.

The piece was then immersed in water for 48 hours to note the amount of water the piece can hold. It was then weighed again after the 48 hours and recorded 68.45g with an immersed weight of 56.32g. The porosity rate for the body was then recorded as 24.85%.

The second clay body 'B' of Mfensi clay 80%, silica 10% and feldspar 10%, was also formed into cubes and fired to 1180°C, the fired piece was then weighed on the measuring scale and recorded 59.33g. The piece was then immersed in water for 48 hours to find out the amount of water it can hold. When weighed again after 48 hours, it recorded 67.52g with an immersed weight of 36.35g. Its porosity rate was then recorded as 26.28%.

The third clay body ;C' of Mfensi clay 60%, silica 20% and feldspar 20%, was again formed into cubes and fired to 1180°C, the fired piece was then weighed on the measuring scale and was recorded as 57.11g. The piece was then immersed in water for 48 hours. It was then weighed and recorded 64.61g with an immersed weight of 65.09g. The apparent porosity rate for the body was then recorded as 25.41%.

3.7.2.2 Porosity after Glazing

After glazing, the three clay bodies test samples were again subjected to the final porosity experimental test for justification and selection for the project work as follow;

The first clay body 'A 'of apparent porosity rate of 24.85% after the first firing was glazed and fired to 1180ºC the piece was then weighed on the measuring scale and it recorded 62.11g. The piece was immersed in water for 48 hours. It recorded 64.19g with an immersed weight of 31.37g. The apparent porosity rate for this sample recorded 6.34%.

The second clay body 'B' of apparent porosity rate of 26.28% after the first firing was also glazed and fired to 1180ºC the piece was then weighed on the measuring scale and it recorded 61.27g. This piece was also immersed in water for 48 hours. It recorded 63.42g with an immersed weight of 30.13g. The apparent porosity rate was recorded as 6.46%.

The third clay body 'C' of apparent porosity rate of 25.41% after the first firing was glazed and fired at 1180ºC the piece was then weighed on the measuring scale with

59.62g as its result. This piece was once more immersed in water for 48 hours and recorded 69.92g with an immersed weight of 29.28g. It then recorded 6.46% as its apparent porosity rate.

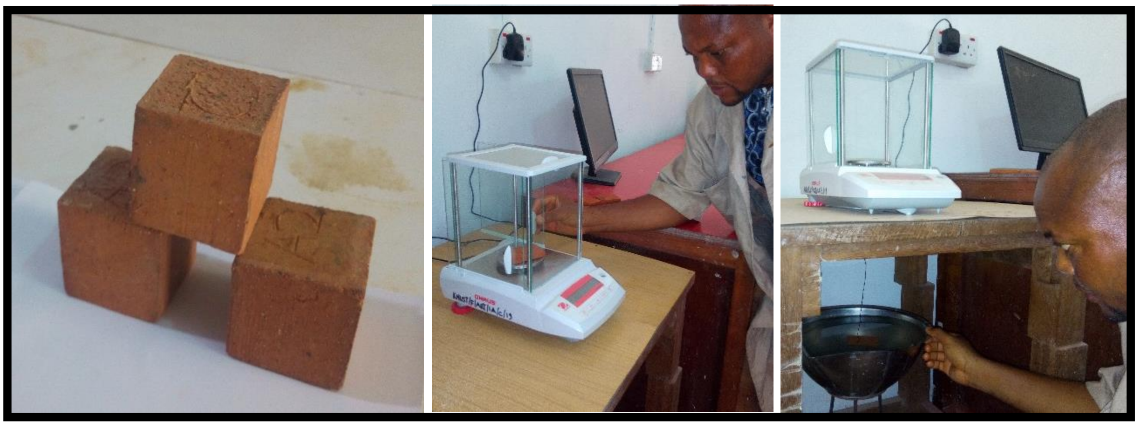

Plate 3.2: simple test for porosity.

3.7.3 Compressive Strength/ Stress Test

This process was undertaken in three stages in order to give a clear description of the compressive strength or stress test. The following tools and materials were used for this process; Powdered clay body composition for each sample, water, foam, kiln, cube metal mould., ram metal stick, oil and mallet. The first stage requires mixing of clay body samples, Water was first mixed with the powdered form of each of the composed clay body samples to a constituent that was just enough to be rammed in the metal mould and was labelled as ‘A’.

The second stage of the process was the application of oil on the metal cube mold. This was done by the use of foam which ensure effective application of oil on all sides necessary. This process simply enhance easy compression and removal of the test pieces. The mixture of the clay body samples were then filled in the metal mould and rammed batched into cubes with the help of the metal stick and mallet for each of the clay body specimens. After ramming the clay into cube, it was removed by placing a metal bar precisely the size of the cube from beneath the metal cube mold and carefully exerting pressure on the cube containing the clay specimen to gently remove it.

Plate 3.3: Application of oil and filling of cube with mixed clay body

Plate 3.4: Compressing and removal process of the clay body

The third stage is the drying and firing of the molded specimens where the specimens were allowed to dry at room temperature and then dried in the oven for 10 hours, this process was to expel chemically combined H_2O in the clay body cubes completely. After the drying, the cubes were then fired in the kiln at a temperature of 1180^{o}c prior to its test conduction.

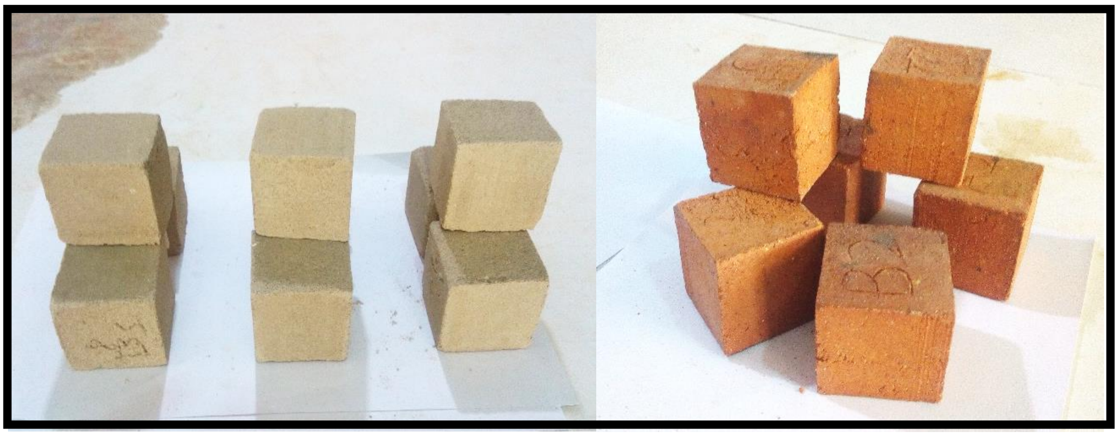

Plate 3.5: Dried and fired cubes after molding

The fourth stage of the process has to do with the testing and recording of figures. Each test was done using the same procedure to ensure the result achieved are accurate and recognised as such. Tools and materials needed for this process are compression machine, fired cube, paper and pen. During the testing, the fired clay body was placed in between two plates known as the pressure plates, then direct load was exerted on the test cube by the use of the electronic compression machine. The values of the break load of the test cubes were recorded and documented accordingly.

Plate 3.6: cube placed under compression machine for pressure exertion

3.7.3.1 Results after pressure exertion on the cubes

When each of the fired clay body samples were subjected to the compressive tress/strong test, it revealed that, the clay body sample labelled A, crushed at weight load 4,078.86 kg whiles clay body B and C crushed at weight load 2651.26 kg. The test informed the researcher that, the amount of weight load required to crush each of the clay body samples was just enough to withstand the weight of an average human being. Walpole *et al.*, (2012) explained that, the Average body mass globally in 2005, was 62 kg of which the North Americans who have the highest average body mass, have an average body mass of 80.7 kg. The three clay body samples were represented in table 3.6 for emphasis and clarity.

Table 3.4: Break load results for specimens A, B and C

Clay body	Mfensi	Feldspar	Silica	Crushed Weight load in kg
Specimen A1	60%	20%	20%	2651.26
Specimen B1	70%	20%	10%	2651.26
Specimen C1	80%	10%	10%	4078.86

3.7.4 Shrinkage experiment

Shrinkage is defined as the rate at which clay body contrasts during drying and subsequent firing. This is associated with Mfensi clay to help analyse and conclude convincingly on the level of shrinkage percentage needed for designing and production of the clay garden stools.

3.7.4.1 Wet Length to Dry Length

In this experiment, three clay specimens labelled A, B and C were rolled into slabs for the study. The clay body samples were composed as follow:

Specimen ‘A’ Mfensi clay 70%, silica 20% and feldspar 10%.

Specimen ‘B’ Mfensi clay 80%, silica 10% and feldspar 10%.

Specimen ‘C’ Mfensi clay 60%, silica 20% and feldspar 20%.

The clay bodies were rolled into small squares of clay slabs and straight lines were drawn at the centre of each of the clay slabs, known as the wet length. Marks, measuring 5cm in between each straight line were created on each of the wetted samples of clay slabs and were recorded. The clay slabs were then allowed to dry at room temperature.

After drying, the length of the marks on the dried piece, known as the dry length were again measured and recorded as follows:

Specimen ‘A’ Mfensi clay 70%, silica 20% and feldspar 10% = 5cm wet state to 4.98cm dry state representing 0.4%.

Specimen B’’ Mfensi clay 80%, silica 10% and feldspar 10% = 5cm wet state to 4.80cm dry state representing 4%.

Specimen ‘C’ Mfensi clay 60%, silica 20% and feldspar 20% = 5cm wet state to 4.83cm dry state representing 3.4%.

Table 3.4 represents the dry length to wet length shrinkage of the bodies.

Table 3.5: Percentage shrinkage of specimens.

Clay body	**Wet length**	**Dry length**	**Percentage**
Specimen (A)	5cm	4.98cm	0.4%
Specimen (B)	5cm	4.80cm	4%
Specimen (C)	5cm	4.83cm	3.4%

3.7.4.2 Dry Length to Fired Length

After the drying shrinkage, the clay body specimens were subjected heat test for the firing shrinkage test. The measurements on the three clay bodies were again recorded and documented. The dried clay body samples after firing recorded the following results:

Specimen ‘A’ recorded 4.98cm dry state to 4.85cm fired sate representing 2.60% of the total percentage shrinkage.

Specimen ‘B’ recorded 4.80cm dry state to 4.70cm fired sate representing 2-08% of the total percentage shrinkage.

Specimen ‘C’ recorded 4.83cm dry state to 4.65cm fired sate representing 3.73% of the total percentage shrinkage.

Table 3.6: Represents the dry length to fired length shrinkage of the specimens

Clay body	**Dry length**	**Fired length**	**Percentage shrinkage**
Specimen (A)	4.98	4.85cm	2.60%
Specimen (B)	4.80	4.70.cm	2.08%
Specimen (C)	4.83	4.65cm	3.73%

3.8 Data Collection for Objective two

To compose clay body with Mfensi clay, feldspar and silica suitable for designing and production of garden stool.

The main purpose of this objective is to compose clay body made of Mfensi clay, Feldspar and Silica for clay garden stools production. Series of experiments were conducted on the sample clay body specimens to test, assess and select the best results required for building the garden stools. The clay body compositions were based on the three components that is: Silica, Feldspar and Mfensi clay where three samples were composed with different ratios of Clay, Feldspar, and Silica respectively. Activities in this regard are underlined in table 3.3 to emphasize or throw light on details of the process.

Clay body ‘A’

Clay body ‘B’

Clay body ‘C’

Plate3.7: measuring composites using a balance measuring steal

Table 3.7: activities undertaken in stages

ACTIVITY	**DESCRIPTION**
ACTIVTY 1	Measuring of Composites
ACTIVITY 2	Mixing and Composing of Clay Body samples
ACTIVITY3	Assessment and Selection of Best Composition

3.8.1 Activity 1: Measuring of composites

This stage outlines basically a vivid description of the processes which were taken in a chronologically order to achieve this objective. The first composition or clay body test ‘A’ consisted of 70% Mfensi clay, 10% Feldspar and 20% Silica in the ratio (70:10:20) is measured and obtained with the use of the balance measuring steel since an absolute

100% was required to complete the composition. The second clay body test ‘B’ consisted of 60% Mfensi clay, 20% Feldspar and 20% Silica in the ratio (60:20:20). The final clay body test ‘C’ consisted of 80% Mfensi clay, 10%Feldspar and 10% Silica in the ratio (80:10:10) Out of these three compositions, the clay body composition ‘A’ with 70% Mfensi clay, 10% Feldspar and 20% Silica in the ratio (70:10:20) was selected for the project. Plate 3.1 represents the measuring process using the balance measuring scale.

Plate3.8: measuring composites using a balance measuring steal

3.8.2 Activity 2: Composition of clay body samples

This activity was carried out to build the actual clay body per the suitable properties for the production of the garden stool. The sample materials required for its progress were: Mfensi clay 70%, feldspar 10%, and silica 20%. The clay body composites were then mixed in a bowl with gradual introduction of water to the constituency which was just enough to be used for the project. The clay body was composed to satisfy all the forming techniques in the ceramics industry such as throwing, coiling, slabbing and pinching. The tools needed for the execution of the project work consisted: measuring scale, balance measuring steel, knife, mallet, working table, bowl, modelling tools and shaping tools.

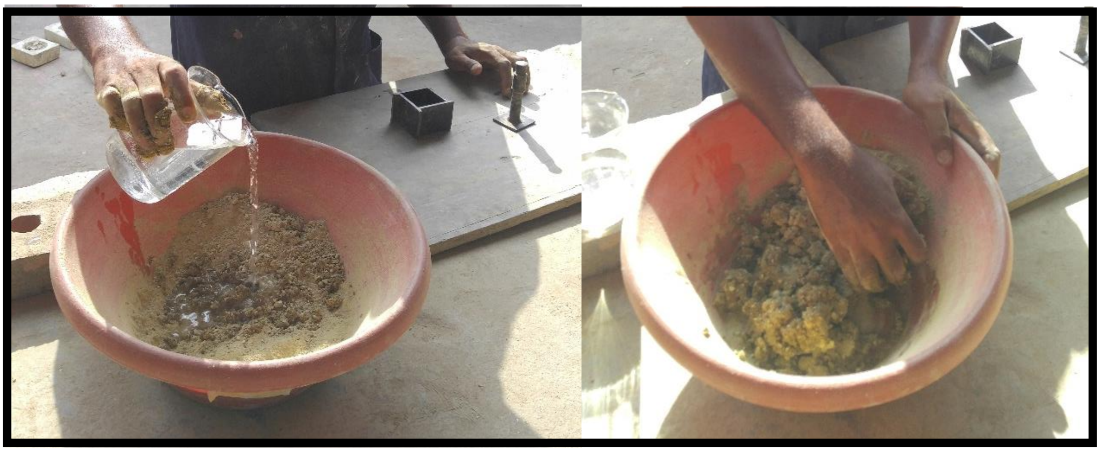

Plate 3.9: Adding of water and mixing of body

3.9 Data Collection for Objective three

To design and produce garden stools with a well composed clay body with Mfensi clay

The purpose of this objective was to design and produce garden stools with the composed clay body.

3.9.1 Tools and materials requisite for the production of the clay garden stools.

The following tools and materials were used in the producing of the ceramic garden stool as represented in table 3.5 respectively.

Table 3.8: Tools and materials

MATERIALS	TOOLS
Mfensi Clay	Measuring cylinder
Feldspar	Ram Metal mould
Water	Compressive strength test machine
Silica	Ram metal stick
Glaze	Bowl
	Rolling pin
	Sack board
	Guide stick
	Potter’s wheel
	Modelling tools
	Ruler
	Knife
	Kiln
	Analytical balance
	Mallet
	Spraying gun
	Brush
	Cutting wire
	Scrapper
	Cutting pin/pricker
	Metal/wooden kidney

3.8.2 Activity one: Technical illustrations in 2-dimensional rendition

The initial stages of the production process begins with idea development where preconceived concepts are drawn to portray the idea at hand. In this stage, eight (8) sketches were made with different shapes, forms, and sizes to give room for selection of appropriate design.

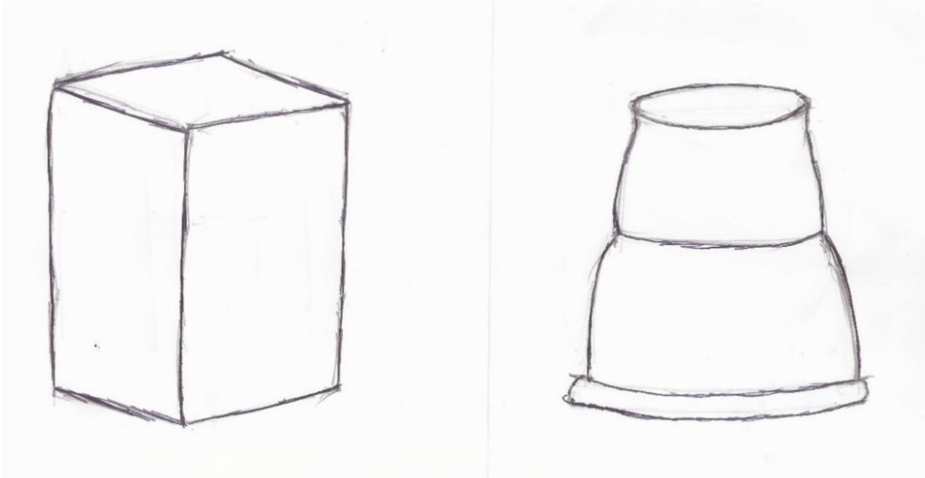

Plate 3.7: Pencil illustrations of sample A and B garden stool

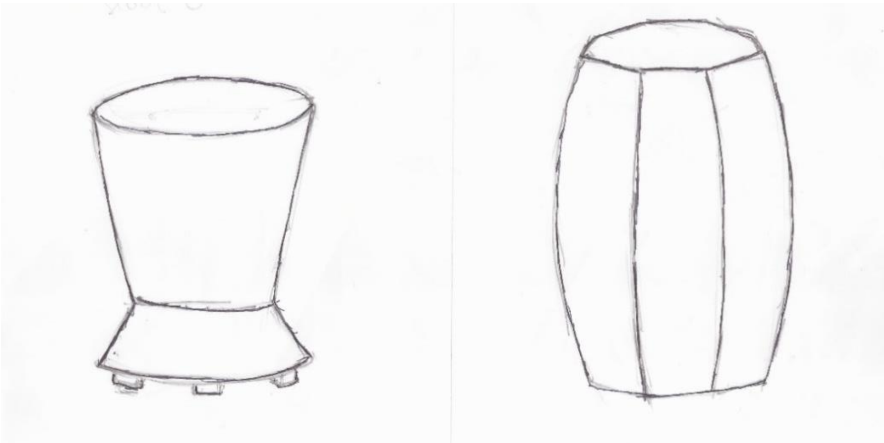

Plate 3.8: Pencil illustration of sample C and D garden stool

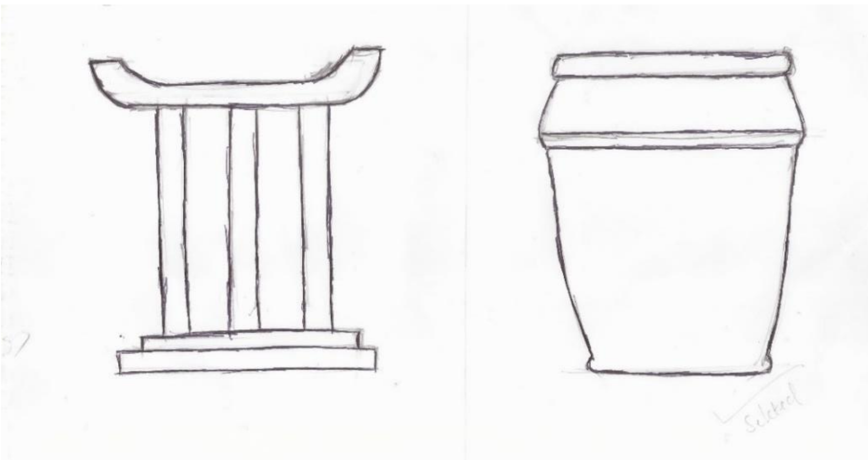

Plate 3.9: pencil illustration of sample E and F garden stool

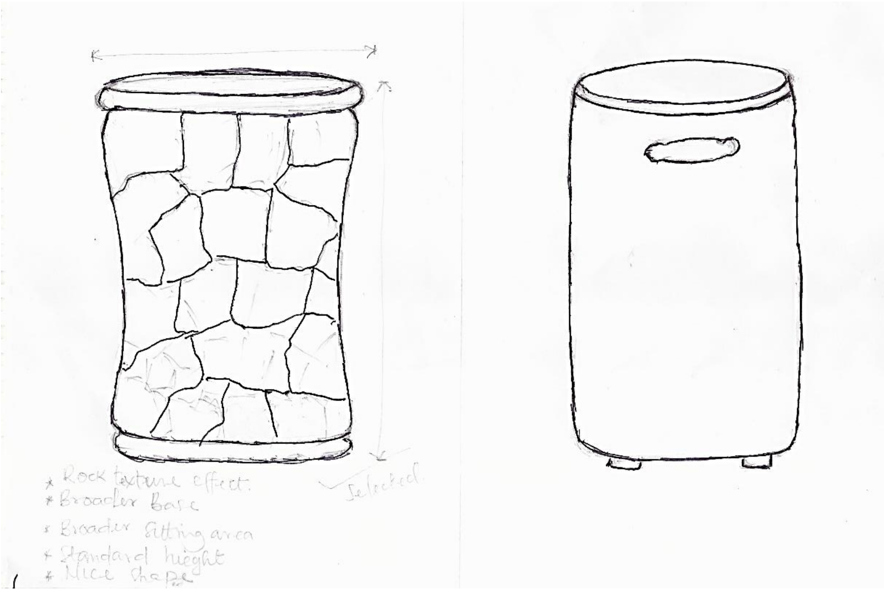

Plate 3.10: pencil illustration of samples G and H garden stool

3.9.2.1 2-D illustrations

The second stage of the production process was to design two-dimensional (2-D) view of the stool types selected for the project in order to vividly and realistically allocate the measurements required for the execution of this project.

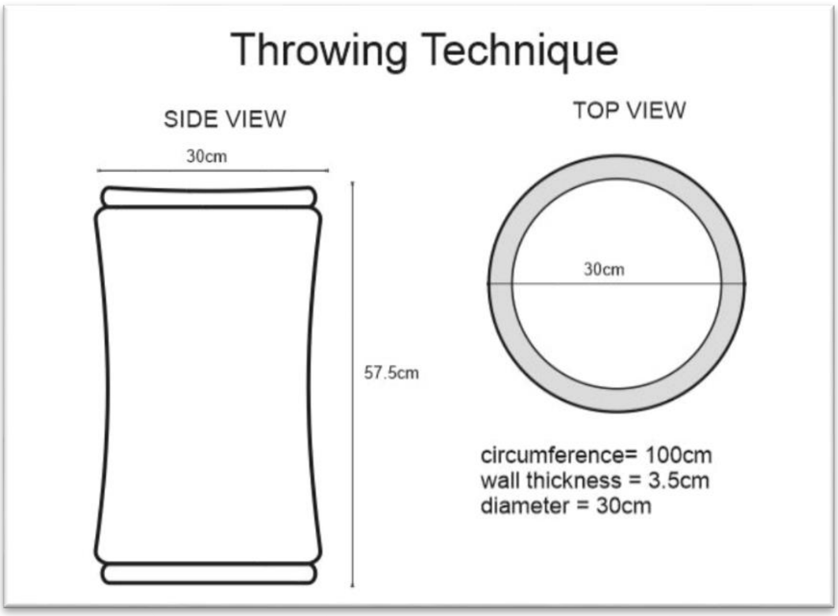

Figure 3.1: side and top view of designed garden stool with throwing technique

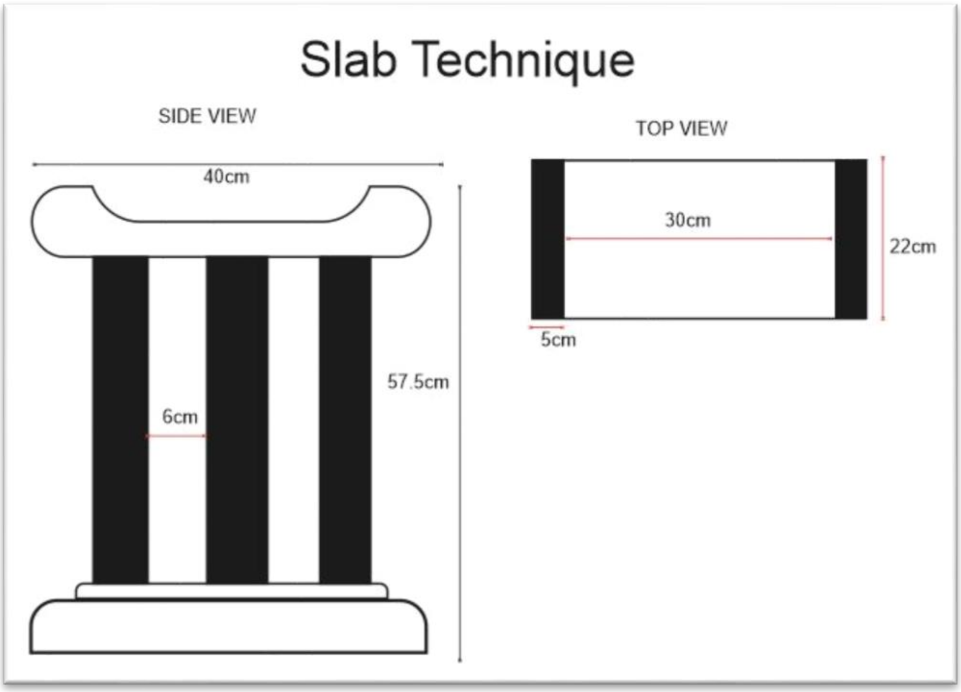

Figure 3.2: side and top view of designed garden stool with the slabbing technique

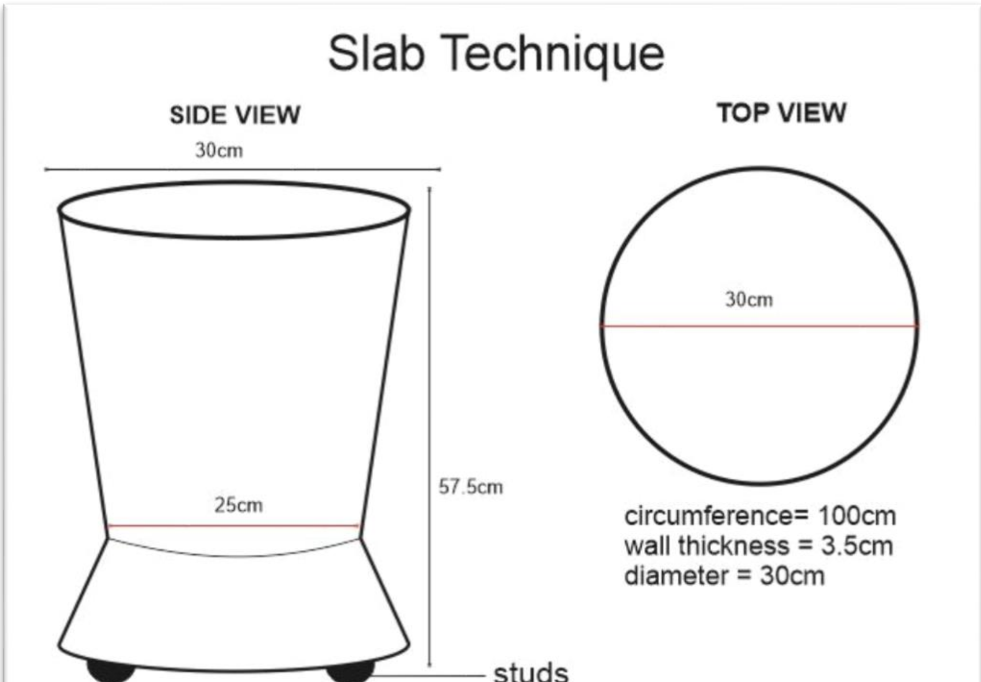

Figure 3.3: Side and top view of garden stool with slabbing technique

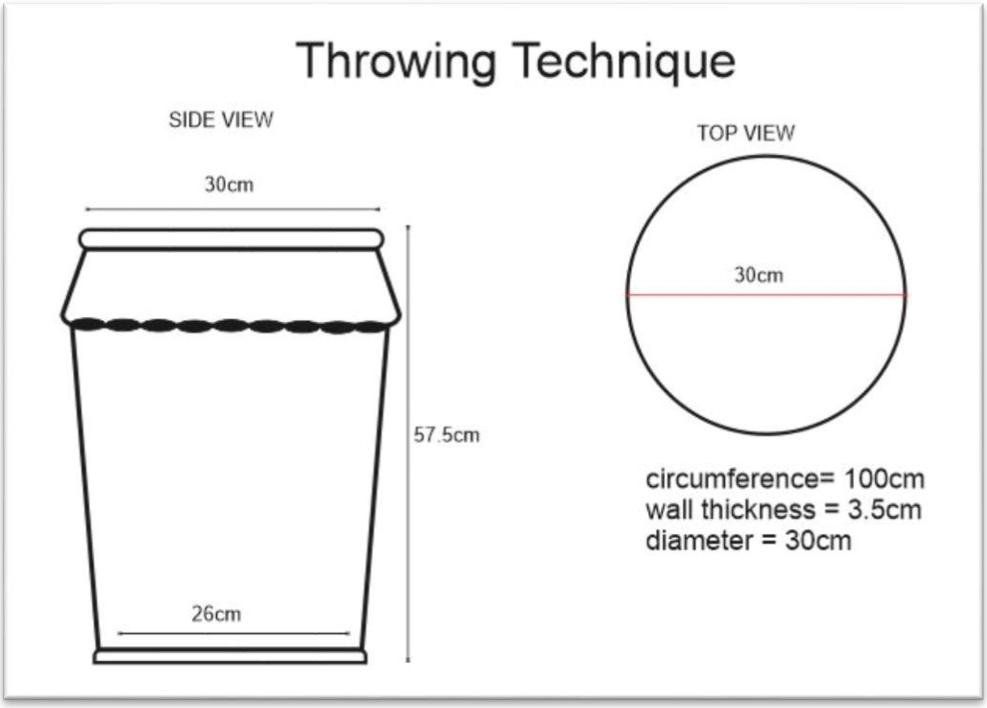

Figure 3.4: Side and top view of garden stool design with throwing technique

3.10 Activity two: Production of actual garden stools

The designing and production stage required the following tools and materials. Pencil, pen, ruler, knife, cutting wire, weighing balance, bowl drawing sheet, trimming tools, modelling tools, the potter’s wheel, water and the clay body. The concept for the production of the design was based on natural objects, that is: tree back, tree stump and rock. Preliminary sketches of the idea were developed into a simple drum. The idea was then manipulated in coral draw to give shapes and dimensions to the final piece. To build up this project, the throwing technique was adapted. In all, three garden stools were produced. An amount of 50kg of the composed clay body was required for building up each garden stool. The researcher grouped the execution of the project work into five stages, kneading, throwing, joining, decoration and firing.

3.10.1 Stage one: Kneading

The clay body composites were first weighed on the analytical balance for mixing. Mfensi clay, 70% of 50kg, feldspar 10% of 50kg and silica 20% of 50kg. Water was then added to the composites and mixed to ensure an even consistency throughout the clay body's mass to make it soft enough to work with ease. This included physically working the clay into lumps of similar sizes for wedging/kneading. A clean surface board, covered with a thick sack to prevent the clay body from sticking was the surface on which the clay body was kneaded on a table. The table which had a height that allowed the human upper body strength and strong hands to work on the clay body comfortably was used for the process. In this regard, though the pugmill was used for pugging this particular clay body, the researcher preferred to wedge and knead the clay body after pugging to ensure that, no air was trapped in the ball clay and also, the clay particles were evenly aligned,

Plate3.10: kneading of the clay prior to throwing

The clay body was drawn and pulled back with pressure contentiously with the heel of the hand. This was to ensure that, air bubbles trapped in the clay body are forced out and the clay particles aligned to form a good working texture that was suitable for throwing the piece on the potter's wheel. To find out whether the clay body had been well kneaded, the cutting wire, was used to slice the lump of the clay body into two halves to check whether the clay body was smooth, devoid of air pockets, display the same texture and colour throughout the ball clay.

Plate 3.11: proper opening to remove air pokects and impurities

3.10.2 Stage two: Throwing

After kneading, the next stage was to throw the piece in two halves on the potter's wheel. A bowl of water, sponge, foam, knife, pin, modelling tools and shaping tools were gathered for this process. The throwing process was carried out in four stages, centring, opening, pulling shaping and lifting. Three clay stools were produced in all. Each clay stool was thrown in two halves and joined by scoring and slip application.

3.10.2.1 Centring

This process was started with a ball of clay centred on the potter's wheel head and legs planted firmly on it. This process was carried out to ensure that, the outer edges of the ball clay on the potter's wheel head, spins perfectly and smoothly with no bumps nor wobbling. Both hands and the ball clay were kept wet before the ball clay was carried onto the potter's wheel head. In order for the ball clay to be stacked at the centre of the potter's wheel head, the palm of both hands were used to smoothen and compress the ball clay onto the potter's wheel. With the wheel in motion at a speed that can be controlled, the ball clay was firmly held with both hands and with pressure, it was pressed downward and inward towards the centre of the potter's wheel head and kept stable with the hand to make sure it was well centred. Using both hands firmly against the spinning clay, the ball clay was pulled to form a conical shape. The ball clay was allowed to rotate evenly like the wheel of a car when viewed from the side.

The conical shaped clay was drown with one hand and kept in stable motion with the other hand. This is done three or four times to help centre the clay and to keep the clay aligned correctly.

Plate 3.12: Centering of clay body for shaping

3.10.2.2 Opening

To start with the opening process, the ball of clay was well aligned and spans without any bumps or wobbles. A hole was created in the ball clay by carefully moving the thumb across the top of the clay in a straight line in order to locate the exact centre of the ball clay on top of the potter's wheel head. At this stage, because of poor uniformity of the ball clay as a result of the opening process, the ball clay began to wobble and had to be re-centred. The fore finger which is the thumb is slowly pressed down into the centre of the spinning ball clay to about 5cm from the bottom, whiles using the other hand to cup the clay and acting as a stabilizer to support the work. Once an enough hole was created, the fingers were put into the hole to open it by pulling the ball clay upwards the body at the sitting position on the potter's wheel with the other hand being used to brace the wall in order to make it stable, firm and even. The cylinder, with the help of the hand, was controlled so that it spans symmetrically perfect by periodically releasing the hand and finger slowly to check alignment. Due to the pressure involved in the opening, the bottom of the piece was compressed.

Plate 3.13: Opening process of the clay on the potter's wheel.

3.10.2.3 Pulling

After opening, the next step was to pull the walls of the piece up to about 30cm high, that is, about half the hight of the stool. At this stage, excess water was mopped up with a foamy sponge. With the left hand braced against the inside wall toward the bottom and the right hand outside the wall was exactly oposite the fingers inside the piece. The lower wall was pressed between the fingers and pulled slowly upward with both hands rising along side each other repeatedly to thin the wall until an appreciable height was achieved.

At this stage the potter's wheel was allowed to spin at a managerble speed which allowed the piece to be pulled gradually. The weakness and strength of the ball clay were controlled by the fingers, water, sponge and foam. The foam is then used to clean the excess water and also the potter's wheel head.

Plate 3.14: pulling to raise the walls of the stool

3.10.2.4 Shaping

The walls of the ware were shaped straight with the use of the right hand whiles the left hand serves as a support for the wall. The square measure, was used to help form a perfect straight wall. This piece was a stool which had the shape of a cylinder. Just the top part of the piece was carefully burnt towards the inside. The other piece was left to take up the shape of a cylinder. The top was given an even thickness and by measuring 30cm as the height of the piece, the excess parts were cut off. With the left hand inside, a pin was pressed into the spinning ball clay near the top until it gets to the other fingers inside. When it had completely cut all along the whole piece, it was simply lifted up from the piece. The inside and the outside were trimmed to reduce weight and also to give the piece aesthetics views. At the leather hard state, the ware was further trimmed to give it the finishing needed for joining


Plate 3.15: shaping of stool with the help of a shaping tool

3.10.2.5 Stage two: Joining

The wares were thrown in two halves and joined by scoring and slip application. This was done by raising one of the halves of the thrown pieces upright on the binder’s wheel with the part to be joined facing upright. The other half of the thrown piece was also allowed to rest on the working table with the part to be joined facing upright. With the same dampness, the area that needed to be touching each other were scored in a cross-hatched pattern with an old metal fork. Slip was then applied to all the scored areas of each of the two halves.

plate 3.16: application of slip prior to joing

The piece on the working table was lifted and with care, joined with the other half on the binder's wheel. Care was taken not to trap any air in the joint. A sizeable piece of board was laid on top of the joint stool .and with the hand, firm pressure was exacted on the board on top of the stool to push both pieces against each other. The joint areas were cleaned and wrapped in a polythene to equalize the moisture of the whole stool. This process was carried out to join all the three stools at the leather-hard state because, clay is best attached when it is in the leather-hard stage.

Plate 3.17: Joinig the two halves together

3.10.2.6 Stage three: Decoration

After joining the next stage was to decorate the clay stool since the ceramics surface is one of the most versatile outlets for creativity. The idea of the motifs for decorating this garden stools were developed from natural objects such as tree bark and rocks. The incision technique for decorating ceramics which involves curving clay by cutting into the surface to create linear designs, a style of decoration in china in the 18th to 13th century as described by Mill, (2008) was adopted. The surface areas of the garden stools were divided into equal segments. Firstly, the rocklike sketches were made directly onto the surfaces of the stools with a sharp pencil to lightly lay out the designs. With the help of the modelling tools, angles and shallow angle for clean, deep and clarifying lines were curved on the leather hard garden stools. For continuity in the day to day decoration, the stools were wrapped in a polythene rubber to keep track of the moisture content till the entire designs were well modelled. The clay crumbs were left to dry a little bit before dried brush was used to clean them away to prevent clog on the carved lines. On the other hand, the effect on a tree bark was pressed unto the surface area of the other stool for its decoration.

Plate 3.18: creating effects on the stools using natural texture from stone and tree back

3.11 Stage four: firing and glazing

The clay garden stools after being allowed to completely dry under room temperature were ready to be subjected to heat in a kiln. The kiln was to transform the greenware into a ceramics stoneware product suitabe to be used outdoor. The clay garden stools in the kiln were first subjected to heat temperature of about 350ºC to drive away the chemical bonded water in the greenware known as water smoking. At a temperature of about 500ºC in the kiln, the ware became completely dehydrated and the clay properties were changed completely into ceramics. The clay garden stools were then fired to 1000ºC as biscuit ware. After biscuit firing, the wares needed to be given a vitreous surface coating which will be fused to the clay garden stool as a result of high temperature in the kiln. This was to give the ware a glassy surface appearance to avoid water absorption. As a result, glaze was then applied by the brush glaze application method on the biscuit ware. The wares, were again subjected to heat and fired to 1180ºC to complete the process.

Plate 3.19. Biscuit fired clay garden st

Plate 3.20. Glazed fired clay garden stools

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF FINDINGS

4.1 Overview

This chapter is the presentation of analysis of data gathered from primary and secondary sources. To facilitate the analysis, and also establish superior implications of the data in relation to the research problem and set objectives. Charts and tables have been used to synthesise the data into a logical organisational structure.

4.2 Presentation and Discussion of Results for Research Question One

What are the potential characteristics of Mfensi clay when tested?

The objective of this research question seeks to identify the potential characteristics of Mfensi clay. Clays are important to the designer and constructor based on the fact that, their structures frequently depend upon their formation which are associated their physical and chemical properties respectively.

In attempt to answer the set research question, it revealed that, the Mfensi clay in its general state has several chemically and physically characteristics that promote or demote its usage depending on the kind of ware to be produced. Table 4.1 and 4.2 represent the chemical and physical properties associated with Mfensi clay and also with their roles or description(s).

NO.	Chemical Property	Description
1	Iron Content	Mfensi clay has high iron content hence its reddish orange appearance when fired.
2.	Alumina Content	Mfensi clay possesses low alumina content.

Table 4.1: Chemical Properties of Mfensi clay and their roles
(Source: www.scientific.net)

NO.	Physical Properties	Description
1	Colour	Greenish grey in nature
2	Particle Size (Texture)	Has fine particle sizes
3	Colour when fired	It fires orange or reddish orange
4	Maturity temperature	It can only stand a temperature up to 1100 degree Celsius
5	Shrinkage	Mfensi clay has high level in shrinkage
6	Plasticity	Mfensi clay has high level of plasticity

Table 4.2: physical properties of Mfensi clay and their Description
(Source: www.scientific.net)

4.3 Presentation and Discussion of Results for Research Question Two

How can Mfensi clay be composed with feldspar and silica for the construction of garden stool?

This objective seeks to compose Mfensi clay with feldspar and silica for designing and the production of clay garden stools. In addressing this objective of the study, the researcher carried out an experiment to explore the potential characteristics of Mfensi clay bodies based on the composition of the right formula or ratio as identified in this research. All the properties: shrinkage, apparent porosity, water absorption and compressive stress/strength are important considerations so far as this project work is concerned. However, the water absorption and compressive strength are quite critical.

Experiment 1 of clay body ‘A’ had water rate as 3.35%, Experiment 2 of clay body ‘B’ had 3.51% and Experiment 3 of clay body ‘C’ recorded 3.86%, hence the researcher concluded that, clay body ‘B’ had the lowest water absorption rate of 3.35% over the other two clay bodies but took 3.35% KN (approximately 4,078.86kg or 4.07886 metric tons) of hard to break clay body ‘A’. It therefore proved that, clay body ‘A’ as composed by the researcher consisting a formula of Mfensi clay 70%, feldspar 10% and Silica 20% was the strongest among the tested bodies hence its usage for the production of the stools. Table 4.3, 4.4 and 4.5 represent respective results for the formula.

Table 4.3: calculation for physical and chemical property test of clay

<table>
<tr><th>POROSITY BEFORE GLAZING (BISQUE)</th><th>POROSITY (AFTER GLAZING)</th></tr>
<tr><td>
% Apparent porosity
DW= Dry Weight
SW= Soaked weight
IM = Immersed weight

Formula = $\frac{SW - DW}{SW - im} \times 100$
Body 1 SW = 68.45
DW = 60.54
IM = 36.62

$\text{Body 1} = \frac{68.45 - 60.54}{68.45 - 36.62} \times 100$
$\frac{7.91}{31.83} \times 100$
=24.85%
Body 2 SW = 67.52
DW = 59.33
IM = 36.35
$\text{Body 2} = \frac{67.52 - 59.33}{67.52 - 36.35} \times 100$
$\frac{8.19}{31.17} \times 100$
=26.28%
Body 3 SW = 64.61
DW = 57.11
IM = 35.09
$\text{Body 3} = \frac{64.61 - 57.11}{64.61 - 35.09} \times 100$
$\frac{7.50}{29.52} \times 100$
=25.41%
The porosity of open pores volume to total volume – apparent pores.
Porosity is widely expressed in apparent porosity and water absorption.
</td><td>
% Apparent porosity

$\textbf{Body 1} = \frac{64.19 - 62.11}{64.19 - 31.37} \times 100$
$\frac{2.08}{32.82} \times 100$
=6.34%

$\textbf{Body 2} = \frac{63.42 - 61.27}{63.42 - 30.13} \times 100$
$= \frac{2.15}{33.29} \times 100$
= 6.46%

$\textbf{Body 3} = \frac{61.92 - 59.62}{61.92 - 29.82} \times 100$

$= \frac{2.30}{32.10} \times 100$
=7.17%
</td></tr>
<tr><td>
WATER ABSORPTION BEFORE GLAZING (BISCUIT)

DW= Dry Weight
SW= Soaked weight
</td><td>
WATER ABSORPTION

$\textbf{Body 1} = \frac{64.19 - 62.11}{62.11} \times 100$
</td></tr>
</table>

$water\ absorption = \frac{\text{SW} - \text{DW}}{DW} \times 100$ **Body 1** SW = 68.45 DW = 60.54 $\text{Body 1} = \frac{68.45 - 60.54}{60.45} \times 100$ $\frac{7.91}{60.54} \times 100$ = 13.07% **Body 2** SW = 67.52 DW = 59.33 $\text{Body 2} = \frac{67.52 - 59.33}{59.33} \times 100$ $\frac{8.19}{59.33} \times 100$ = 13.80% **Body 3** SW = 64.61 DW = 57.11 $\text{Body 2} = \frac{64.61 - 57.11}{57.11} \times 100$ $\frac{7.50}{57.11} \times 100$ = 13.13%	$\frac{2.08}{62.11} \times 100$ = 3.35% **Body 2** $= \frac{63.42 - 61.27}{61.27} \times 100$ $\frac{2.05}{61.27} \times 100$ = 3.51% **Body 3** $= \frac{61.92 - 59.62}{59.62} \times 100$ $\frac{2.03}{59.62} \times 100$ = 3.86%
WET TO – DRY SHRINKAGE **WL** = wet length **Dl** = dry length Formula $DL = \frac{\text{WL} - \text{DL}}{WL} \times 100$ **Body 1** Wet length=5cm Dry length=4.98cm $DL = \frac{5 - 4.98}{5} \times 100$ = 0.4% **Body 2** = Wet length=5cm Dry length=4.80cm $DL = \frac{5 - 4.80}{5} \times 100$ = 4% **Body 3** = Wet length=5cm Dry length=4.83cm	**DRY - TO – FIRED SHRINKAGE (LINEAR)** **Dl** = Dry length **Fl** = Fired length Body 1 = Dry length = 4.98cm Fired length = 4.85cm $FL = \frac{4.98 - 4.85}{4.98} \times 100$ =2.61% **Body 2** = Dry length = 4.80cm Fired length = 4.65cm $FL = \frac{4.80 - 4.70}{4.80} \times 100$ =2.08% **Body 3 =** Dry length = 4.83cm Fired length = 4.65

$DL = \frac{5 - 4.83}{5} \times 100$ = 3.4%	$FL = \frac{4.83 - 4.65}{4.83} \times 100$ =3.73%

Table 4.4: Dry Weight (Fired at 1180ºC)

BODY	**UNGLAZE**	**GLAZED**
Body 1	60.54	62.11
Body 2	59.33	61.27
Body 3	57.11	59.62

Table 4.5: Water absorption for unglazed

BODY	**% APPARENT POROSITY**	**% WATER ABSORPTION**
Body A	24.85	13.07
Body B	26.28	13.80
Body C	25.41	13.13

A. WET – TO – DRY SHRINKAGE (LINEAR)

Body A – 0.4%

Body B – 4%

Body C – 3.4%

B. DRY – TO FIRED SHRINKAGE (LINEAR)

Body A – 2.61%

Body B – 2.08%

Body C – 3.73%

4.4 Presentation and Discussion of Results for Research Question Three

How can Mfensi clay be used as an alternative material for designing and production of ceramics garden stool?

The objective of this research question is to find out how Mfensi clay can be used as an alternative material for designing and production of garden stool. In answering or addressing the underlined question, it was identified that, certain factors contributed to the effective achievement of using Mfensi clay for stools production, these factors are;

4.4.1 Right Composition Ratio

Having the right composition for any ceramics wares places a great advantage on clay wares. The right composition ratio of Mfensi clay for its use depends on size or quantity of the product to be used for. It was identified during the experimental stages of the composites that, clay bodies composed of a ratio of Mfensi clay 70%, feldspar 10% and silica 20% is the ideal formula or ratio for producing stonewares or relatively hard ceramics artefacts such as garden stools in the ratio of 7:1:2 was applied.

4.4.2 Building technique

Mfensi Clay or ceramics ware production has varied methods of production especially when it comes to building or achieving a set of design. These methods or hand forming techniques such as slabbing which involves the method of making pottery in which a thick, flat plate are cut into shapes which are joined to form an object, Throwing is the ability or activity of shaping the clay on the potter’s wheel, Pinching also which is the method of making a pottery by pulling, pressing and pinching ball clay by the use of the hand. Finally, coiling is defined as the art of building a ceramics product by using clay coils. Mfensi clay plays a vital role in building a desirable ceramics wares. It has high level of plasticity that allow it to be manipulated in any shape or forms.

4.4.3 Stool design

Design as enlightened by the Cambridge dictionary of American English is the creation of a plan or convention for the construction of an object, system or measurable human interaction such as sewing patterns, architectural constructions and some simple handmade product. Ideally, garden stools made of clay must or should have a design based on the strength of the material, since area or place of usage plays a major role including the ergonomics of the stools to the user. Designs that engage concepts such as broad sitting area exposes the surface to easy breakage in the sense that, clay as a fragile mineral needs a relatively small surface area for sitting to prevent it from breaking. Secondly, the stool design should possess a quality of comfort. This is defined as the pleasant and satisfying feeling of being physically or mentally free from pain or free from uncomfortable feelings. In view of the definition, sitting posture of the user is critically considered since it also has to do with the health of the user. In a case of having a relatively short garden stool or a relatively tall garden stool design, the user may not have the needed comfort needed. Garden stools are basically meant for relaxation. Thirdly, wall thickness of the garden stool is to be considered in the designing process. A thick wall gives a strong and well-balanced stools that easily prevent breakage during firing under required temperature.

4.4.4 Firing method employed

Bloomfield (2017), defines firing as the process of subjecting clay works to heat so that they undergo several physical changes to make them hardened and vitrified. Firing method is also considered as another factor to be regarded in selecting alternative materials for garden stool production. Mfensi clay having the ability to be fired up to a temperature of 1100°C or 1950°F gives a tangible reason to its usage. This level of firing renders the product hard or stone-like. The kind of firing method suitable for clay garden stool with respect to Mfensi clay is the electric kiln which gives room for firing to the maturity temperature of 1100°C. Also, the size of the kiln plays a role since a spacious kiln gives good and evenly distributed heat flow, the size and height of the works parked into kilns must have even and equal or relatively big space to be able to contain certain number of wares to be fired.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

This chapter outlines the summary, conclusions and recommendations of the study.

5.2 Summary

The research was targeted at exploring the potentials of Mfensi clay in the production of clay garden stools. The objectives of the research study were;

1. To test for the potentials of Mfensi clay for the production of ceramics garden stools.
2. To compose clay body with Mfensi clay, feldspar and silica suitable for designing and production of garden stool.
3. To design and produce garden stools with specially composed clay body using Mfensi clay.

The researcher in his quest to find solution to the outlined problem resorted to the use of qualitative research method coupled with the descriptive and experimental design. It was identified during the study that, several materials have been used in the production of garden stools. Materials such as wood, metal and plastics have been the most resilient materials due to their physical and chemical properties that allow them to withstand the harsh weather or environmental conditions. There were also some observations and analysis based on the outlined objectives that constituted the major findings. These are as follows:

5.3 Major Findings

1. With regards to objective one which aimed at testing for the potentials of Mfensi clay for the production of ceramics garden stools, the researcher adopted critically the observational method in accounting for the outcomes. Out of the three clay bodies composed during the experimental stages, it was noticed that, Mfensi clay in its raw state cannot be used for building certain stone ware artefacts since it does not stand the chance of withstanding the pressures to be exerted on such artefacts. In addition, the Selection of the best composition, clay body 'A' was due to the fact that, the rest could not meet required specifications as a result of the ratios administered to each composition.
2. As objective two seeks to compose and produce clay-body with Mfensi clay, feldspar and silica for designing and production of the clay garden stools, it was noticed that, the researcher's composition which has 70% of Mfensi clay, 10% of feldspar and 20% of silica proved to be the strongest of all the three composed clay bodies. Again, the researcher identified that, introducing the same quantity of water into the three clay body compositions resulted in having varied softness in the three clay bodies since the formula for these composition do not follow the same pattern.
3. The third objective which was to design and produce garden stools with a well composed clay body with the Mfensi clay. As a result, some observations were made to the benefit of the study undergone. The researcher identified that, ceramic garden stools with Mfensi clay cannot be suitable or feasible when produced in a bench form or cannot be executed with broad sitting area due to the fact that the material is fragile and hence will not gain the needed strength to carry required load that it's meant for.
4. Another observation in this regard was the types of forming techniques suitable for the garden stool. In this regard; the throwing and slabbing methods among all the forming techniques were employed, since the throwing method ensured smooth and

easy achievement of shape desired by the researcher. The slabbing technique required joining two or more slabs in attaining the height and shape of the stools whiles a technique like the coiling technique required joining several coiled chains to form clay wares. This basically does not assure that, the garden stools have the needed strength, compatibility, desired shape and form needed.

5. It was also identified during the firing stages of the clay garden stool that, Mfensi clay cannot be fired above 1300ºC which subjects the ware to glassification which will may collapse the ware. The rock effect designed on the surface of the stools affected the thickness of the walls since cutting and scooping was involved in achieving the design.

5.4 Conclusions

The researcher's findings obtained in the study were concluded as follow:

1. Mfensi clay is an original earth material containing minerals attributed to its colour and characteristics which if well composed with other minerals could be used for clay garden stools production.
2. Mfensi clay bodies when fired to 1180 ºC becomes vitrified and strong. This makes clay in general a material that can stand the test of time especially when in appropriate areas.
3. This research aims at successfully contributing innovative ideas to the growth and development of the local clay craftsmen in Mfesi and beyond by reviling certain properties and potentials of Mfensi clay that makes it a potent material for garden stool production.

5.5 Recommendations

The researcher recommends the following to address the outlined issues associated with the study:

1. Local ceramic craftsmen and researchers should take interest in exploring more into Mfensi clay towards the production of more innovative artefacts such as the clay garden stools.
2. Workshops and seminars should be organized to help introduce and teach local ceramics craftsmen or potters innovation ideas on clay body compositions that make the Mfensi clay strong enough for stools production. This research also aims at capacity building towards the awareness of reviving the face of the clay or ceramic industry in Ghana.
3. Further research should be conducted into Mfensi clay in the construction of garden stools to increase the economic value of producers and the industry at large.

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APPENDIX ‘A’

Interview guide For Students

(1) What are the physical characteristics of Mfensi clay?

(2) Mfesi clay fires red. Yes or No

(3) Clay bodies are composed to enhance their physical and chemical properties. True or False

(4) Feldspar and silica are earthly minerals which are good composites for clay bodies. Yes or No

(5) By nature, Mfensi clay appears yellow in colour. True or false.

Interview guide For Lectures

(1) What are the chemical characteristics of Mfesi clay?

(2) Outline other earthly bodies suitable for clay body composition apart from clay?

(3) Discuss the colour appearance of Mfensi clay when fired?

(4) What are the steps involved in throwing?

(5) Discuss the temperature ranges associated with fired clay?

Interview guide Clay Workers and Sellers

(1) What products are Mfensi clay used for?

(2) Other earthly minerals can be mixed with Mfensi clay to enhance its physical and chemical properties. true or False

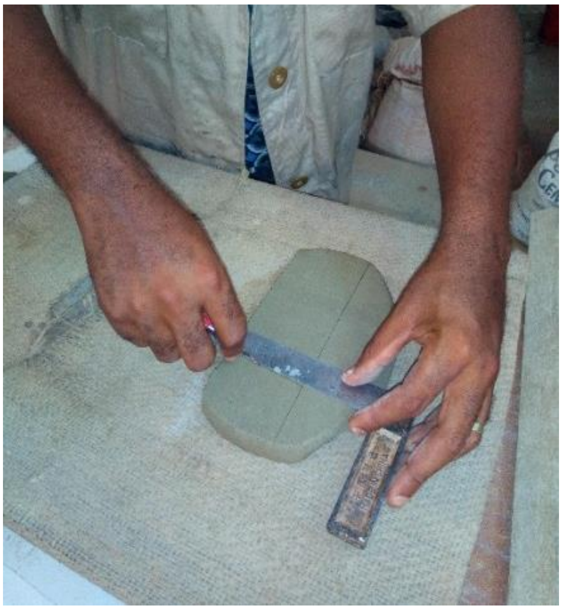
(3) Plasticity is one of the chemical properties of Mfensi clay. Yes or No

(4) Porosity is one of the physical properties of Mfensi clay. True or False

(5) Where can the Mfensi clay be found?

APPENDIX 'B'

Pictures of Various Stages for Progress of Work



Pictures of Various Stages for Progress of Work

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