REPUBLIC OF RWANDA

ULK POLYTECHNIC INSTITUTE

P.O BOX 2280 Kigali

Website: //www.ulkpolytechnic.ac.rw

ACADEMIC YEAR 2023/2024

DEPARTMENT OF CIVIL ENGINEERING

CONSTRUCTION TECHNOLOGY

FINAL YEAR PROJECT

FINAL YEAR PROJECT REPORT

FEASIBILITY STUDY ON THE USE OF MAISE HUSKS MIXED WITH CLAY IN THE PRODUCTION OF BRICKS

A dissertation submitted in partial fulfilment of the requirements for the Award of advanced diploma in Construction technology.

Presented by:

NDARUHUTSE Benjamin: 202150427

Under the guidance of:

Eng. HISHAMUNDA Ignace

Kigali, October 2024

DECLARATION

I, NDARUHUTSE Benjamin declare that this research entitled

"Feasibility study on the use of maise husks mixed with clay in the production of bricks presented in this dissertation is my contribution to the best of my knowledge. The same work has never been submitted to any other university or institution. I, therefore, declare that this work is my own for the partial fulfilment of the award of an advanced diploma in Civil Engineering at ULK

POLYTECHNIC INSTITUTE

NDARUHUTSE Benjamin (202150427)

Date.....

Signature.....

CERTIFICATION

This is to clarify that this final project report entitled "Feasibility study on the use maize husks mixed with clay in the production of bricks" submitted to the Institution (ULK Polytechnic Institute), is the work of NDARUHUTSE Benjamin. The project was Carried out under my supervision and to the best of my knowledge the project has not in any Part been submitted to any other academic institution.

Eng. HISHAMUNDA Ignace
Supervisor

Head of the Civil Engineering Department
Eng. Bonaventure NKIRANUYE

DEDICATION

- Our god
- Our families
- Our classmates

ACKNOWLEDGEMENT

Writing a project is a process that requires the involvement of several people who play a significant and effective role in the whole process and whose names do not appear on the cover of the book. However, without their help and assistance, a final year project like this would never come to realisation we would therefore like to thank all the staff of the Kigali Independent University (Kigali) in particular, the Department of Civil Engineering that provides theoretical knowledge and practical skills that have become a foundation of this final project. This project would not have been successful without the deep help of our supervisor Eng. Ignace HISHAMUNDA and we humbly thank him for his warm and kind help. We would also like to express our special thanks to all lecturers' boards who gave their best support to bring out incorporated intellectual baggage to students in the field of construction technology. We are grateful to our family members and our relatives for their support in our education from the start up to this level.

ABSTRACT

Clay has been used as the main material in the fabrication of bricks however the use of waste Materials in brick manufacturing has been introduced for the conservation of dwindling clay resources, as well as preventing environmental and ecological damages caused by quarrying and depletion of Raw materials. Bricks that are available in some regions have poor quality, low compressive strength, higher water absorption and uneven surfaces therefore in this study, maize husks have been utilized for the preparation of bricks in partial replacement of clay. The specimens were cast with different replacement levels of clay varying as 0%, 5%, 10%, 15%, and 20% with maize husk, The Specimens were tested for water absorption and compressive strength according to the British standard specifications. Experimental shows that excessive addition of maize husk has higher water absorption and low compressive strength as maize husk percentage increases maize husk characteristics predominate. The bonding between the clay particles and the maize husk particles is weak. I did this process by hand moulding, used to produce our sample which has size (195x95x65) mm with a portion ratio of 1:4, the moulds are rectangular and made of wood which are opened at the top and bottom. The longer the of Moulds are projected out of the box to serve it as handles. As the results of the water absorption test it was found that according to the number of specimens, a 13.4% water absorption test result of 13.4% for a brick indicates that the brick absorbs 13.4% of its dry weight in water within a specified time frame. This level of absorption suggests moderate porosity, which can affect durability and thermal properties. Generally, lower absorption rates are preferred for better performance in construction. On the other hand, the results of the compressive strength test (0.00068 N/mm²) indicate a brick that is unsuitable for construction purposes.

Keywords: Maize husk, brick, clay

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LIST OF ABBREVIATION AND SYMBOLS

GGBFS: ground granulated blast furnaces slag

IS: Indian standard

USC: unified soil classification

MH: maize husk

BSS: British standard specifications

SiO2: silicon dioxide

CHAPTER 1. GENERAL INTRODUCTION

1.1. BACKGROUND OF STUDY

Maize husk mixed with clay in the production of brick is one of the best and most abundantly available Building materials in Rwanda and there are different techniques of manufacturing it.as far as many Structure is elevated, construction material is still needed especially brick to be used for portion walls which can be found by burning quarried materials like clay or curing those which are Made of aggregate mixed with binding material like cement. It is necessary to us e lightweight Material as portion wall especially in large building to reduce loads on support structure like beam, Columns and foundation but it are found that basic material of making brick is very expensive As if those use cement, sand and aggregate (block) and they allow thermal to pass through it Easily because it is solid so that the room become so hot therefore, from that reason we have Proffered to make the study assess a brick which made by using maize waste to produce some Void or space the inside part of brick is preferred to be economically, environment technology Benefit.

1.2. PROBLEM STATEMENT

In Rwanda, there are various types of buildings including industrial, commercial, and office buildings. However, there is the challenge of insufficient construction materials, as a solution, this project come up with the idea of making bricks by mixing maize husks with clay to assess their suitability as a construction material.

1.3. OBJECTIVES OF STUDY

MAIN OBJECTIVE

The main objectives of this project are the feasibility study on the use of maize husk mixed

With clay in the production of bricks.

SPECIFIC OBJECTIVES

- To determine the compressive strength of brick
- To determine the water absorption of brick
- To determine the soundness of brick

1.4. SCOPE AND LIMITATION OF THE STUDY

This project did not talk about the details of all types of building materials for all types of bricks, but it focused on those new types of bricks, which made of clay with

Maize wastes by comparing with normal solid brick and even different laboratory test which show the strength of that new kind of brick resist to different condition like compression, soundness, water absorption test.

1.5 SIGNIFICANCE OF THE STUDY

THIS PROJECT WILL BE IMPORTANT IN DIFFERENT MEMBER OF SOCIETY

- Among the builders, they will find a brick which will be strong, economic and easily Workable.
- People will be in good condition of life because this project will aim to reduce thermal in the building
- government will be able construct and maintain the house of vulnerable people in the country.

1.6. RESEARCH OF STUDY

- What other structure can be made out of clay bricks?
- How do you make clay brick stronger?
- What are the advantages of clay bricks?
- Are bricks made only from clay?

1.7. ORGANIZATION OF STUDY

This research is divided into main five chapter in order to provide clarity and coherence on the discussion of all investigation carried out on the assessment of ‘’feasibly study on the use of maize husk mixed with clay in production of bricks’’

CHAPTER ONE: general introduction which deals with introduction of the study, background of the study, problem statement, objectives, research question, scope and limitation of the study, Significance of the study, and finally organization of the study

CHAPTER TWO: Literature review, to give all the details and theories concerning feasibility Study on the use of maize husk mixed with clay in the production of bricks.

CHAPTER THREE: Material and method, which deals with the method, procedures, the definition of the instruments that were used for rhea investigation and, the method and techniques, used to collect all the data required.

CHAPTER FOUR: Result and discussions, which deals with the presentation, analysis and interpretation of the finding.

CHAPTER FIVE: Conclusion and recommendation, which is the last, present conclusion, recommendation to state the output of the research.

CHAPTER 2. LITERATURE REVIEW

2.1. INTRODUCTION

Bricks are an ancient building material have been made and used by romans for aches, facing, paving, etc. through they were at the period of larger and smaller sizes than those used bricks, the chief material of bricklayer are hard rectangular blocks of an originally clayey substance which has been tempered and melded into the shape required and then burnt in a clamp or kiln until it is quite hard.

Generally, in the present days, they were always made with half brick or double bricks their width in length to allow of bond, as will here in after be explained. they thus varied in length from 71/2 to 22 inches, and were generally very thin (about 11/2 inch) the smaller sizers being used for facing rubble walls, and the larger were also used for arches. (das, saikia,2010).

In more modern times bricks have been used for walling, facing, arches and paving bad generally their dimension are now about 9 inches long by 4 ½ inches (or half their length) in breadth. So that two laid crosswise will cover two laid lengthwise. They are made from 2 ½ to 3 ½ inches in height, according to local custom or requirement of construction.

They are of numerous different qualities, kinds and colour each from its peculiar nature adapted to a particular purpose or use. A concise classification of the various kinds, their peculiarities, qualities and uses will be given hereinafter.

It is also be noted that the quality of a bricks depends on the clay from which it is made, on the different manipulation which the clay will allow off in its manufacture.

2.2. DEFINITION OF BRICK

BRICK: is the building material used to make walls, pavement and other element in masonry construction. Traditionally, the term brick referred to a unit composed of clay, but it is now used to denote any rectangular units laid in mortar. A brick can be composed of clay bearing soil, sand and lime or concrete material.

Bricks are produced in numerous classes, types, materials and sizes, which may vary with region and time and are produce in bulk qualities. (Chalabi, Mona..., 2014)

Two basic categories of brick are fired and non_fired bricks. Fired bricks are none of the longest lasting and strongest building material, sometime referred to as artificial stone and have been used since circa 500BC. Air dried bricks also known as mud bricks, have a history older than fired bricks, and have an additional ingredient of a mechanical binder such as straw. Brick

is laid in courses and numerous patterns is known as bonds, collectively known as brickwork and may be laid in various kinds of mortar to holds the bricks together to make a durable structure.

2.1. COMPARISON OF STONE WITH BRICK

Table 1: Comparison of brick with stone

Stone	Brick
1.It is natural material	It is manufactured from clay
2.It is heavier	It is lighter
3. It costs much to dress it to the required shape and sizes	It can easily be to any shape and sizes
4.It is more costly except in hilly areas	Except in hilly area, it can locally be manufactured and is cheaper
5.It is less porous and as such better suited for construction of water retaining structure	It is more porous and requires costly water proofing treatment when used for constructing water retaining structures
6. Because of more strength it is better suited for construction structures carrying extra heavy loads or subjected to pressure egg.: harbour, dock and forts etc.	Reasonably good for normal loads
7. It is a better conductor of heat	I t is a poorer conductor of heat
8.It withstands attacks of weather better	It is good for normal conditions but needs protection by way of plastering and pointing.
9. Superior qualities of stones are used for constructing monuments and decoration.	Good quality of bricks is sometimes left plaster to achieve some architectural effect

2.4. TYPES OF BRICKS

Bricks are used for building and pavement all throughout the world. In addition, brick was once use as pavements all throughout the world. Also, were once used as pavement material, and now it is more widely used as decorative surface rather than a road material. Bricks are usually laid flat and are usually bonded forming a structure to increase its stability and strength. There are several types of bricks used many of them being about 8 inches long and four inches thick.

There are various types of bricks used in masonry

- Common burnt clay brick
- Sand lime bricks (calcium silicate brick)
- Engineering bricks
- Concrete brick
- Flay ash clay bricks

Bricks are used as siding in the building industry due in parts to its important characteristics and just because it can be a good affordable option. Below we summarised the benefits and applications of the most commonly used types of bricks.

2.4.1. Common burnt clay bricks

Common burnt clay bricks are formed by pressing in melds. Then these bricks are dried and fired in a kiln. Common burnt clay bricks clay bricks are used in general work with no special attractive appearances. When these bricks are used in wall, they require plastering and rendering

Figure 1: Common burnt brick

2.4.2. Sand lime bricks

Sand lime bricks are made by mixing sand, fly ash and lime followed by a chemical process during wet mixing. The mix is then moulded under pressure forming the brick. These bricks can offer advantages over clay bricks such as: Their colour appearance is grey instead of the regular reddish colour: (Urquhart, Leonard church, 2013). Their shape is uniform and presents a smoother finish that does not require plastering. These bricks offer excellent strength as a load-bearing member.

Figure 2: Sand lime brick

2.4.3. Engineering bricks

Engineering bricks are bricks manufactured at extremely high temperatures, forming a dense and strong brick, allowing the brick to limit strength and water absorption. Engineering bricks offer excellent load bearing capacity damp proof characteristics and chemical resisting properties. These bricks are used in specific projects and they can cost more than regular or traditional bricks.

Figure 3: Concrete bricks

Concrete bricks are made from solid concrete and are very common among homebuilders. Concrete bricks are usually place in facades, fence and provide an excellent aesthetic presence. These bricks can be manufactured to provide different colours pigmented production.

Figure 4: concrete bricks

2.4.5. Fly ash clay bricks

Fly ash clay bricks are manufactured with clay and fly ash at about 1,000 degrees C. Some studies have shown that these bricks tend to fail poor produce pop-outs, when bricks meet moisture and water causing the bricks to expand. (Dr N Bhanumathidas and N Kailas, 2002)

Figure 5: Fly ash clay bricks

2.5. Brick work

2.5.1. Advantages of bricks in construction work

These are many advantages when bricks are used as the part of the construction. The following lists present some part of the most common advantages when using bricks instead of other construction materials.

Aesthetic: bricks offer natural and variety of colours including various textures.

Strength: bricks offer high excellent high compressive strength.

Porosity: the ability to release and absorb moisture is one of the most important and useful properties of bricks, regulating temperatures and humidity inside structures.

Fire protection: when prepared properly a brick structure can give a fire protection maximum rating of 6 hours.

Sound attenuation: The brick sound insulation is normally 45 decibels for a 4.5 inches brick thickness and 50 decibels for a nine-inch-thick brick.

Insulation: Bricks can exhibit above normal thermal insulation when compared to other building materials. Bricks can help regulate and maintain constant interior temperature of structure due to their ability to absorb and slowly release heat. This way bricks can produce significant energy savings, more than 30%of energy saving when compared to wood.

Wear resistance: A brick is so strong, that that is molecular composition provides excellent wear resistance.

Efflorescence: Efflorescence forms on concrete structures as structures when soluble salt dissolved in water are deposited and accumulated on surfaces forming a visible scum.

Durability: Brick is extremely durable and perhaps is the most durable fabricated structure building material so far. The other advantages of bricks are economical (raw materialism easily available), compressive strength is good enough for ordinary construction, different orientations and sizes give different surface textures, very low maintenance cost is required, demolishing of brick brick structure is very easy, recyclable, produces less environmental pollution during manufacturing process. (Puma, B.C, Jain, Ashok Kumar, 2003)

2.5.2 Disadvantages of brick in construction work

Time-consuming construction

Cannot be used in high seismic zones

Since bricks absorb water easily, therefore, it causes fluorescence when not exposed

Very less tensile strength

Rough surface bricks may cause mild growth if not properly cleaned

Cleaning brick surface is a hard job

Colour of low-quality brick changes when exposed to sun for a long period of time

2.5.3. Qualities of good brick in construction work

Clay bricks have been used all over the world in very class and kind of building. good quality bricks have the capacity to resist atmospheric effect. In place where plenty of clay is available. Brickwork is cheaper but nowadays natural soil is scared and hence we have to find alternative building material instead of clay bricks like as fly brickbat block, dry walls etc.

2.5.3. Qualities of good brick in construction work

Clay's bricks have been used all over the world in every class and kind of building. Good quality brick has the capacity to resist atmospheric effect. In place where plenty of clay is available, brickwork is cheaper. However, nowadays-natural soil is scared and hence we have to find alternative building material instead of clay brick as if as fly ash brick AAC block, walls etc.

Whether you are building a new home or commercial building or remodelling an existing one, there are many reasons to choose clay brick both in the wall and on the ground.

1. Brick earth

   They should be free from stone, organic matter, saltpetre and harmful chemical etc.
2. Size

   The brick should have a uniform size, plain, rectangular surface with parallel side and sharp straight age. whatever brick are used for construction but the bricks should be regular and uniform in size. Good brick should not exceed 3mm tolerance in length and 1.5 mm tolerance in width and height.

Standard size of brick 190×90×90 mm high with a mass of between 3.0 kg and 3.5 kg.

3. Shape

Good brick should be uniform in shape. Edge of bricks should be sharp, straight and at a right angle.

4. Colour of brick

   Good brick should be well burnt and should have a uniform copper colorwork burnt and under burnt bricks loses uniformity of colour on its surface and its strength. Good quality brick should always be a uniform of colour throughout

5. Soundness

   Well-burnt brick should give a metallic sound when struck with a hammer or another brick.

6. Hardness

   The brick should be hard that when scratched by fingernail no impression is made.

7. Strength

   The compressive strength of brick should be minimum 3.5 N/mm2 as per IS code

8. Texture and compactness

   The surface of brick should not be too smooth to cause slipping of mortar. The brick should have pre compacted and uniform texture. A fractured surface should not show cracks, holes, grits or lumps of lime

9. Water absorption

   Water absorption of good brick should not exceed 20 percent of its dry weight when kept immersed in water for 24 hours.

2.5.4. Characteristic of good brick

Bricks required for use in important building should have the characteristic and essential features of first-class bricks as detailed below:

- These should be sound and well-burnt bricks having uniform red colour.
- These should have even surface free from flaws or crack and should have sharp and well-defined edges.
- These should be also hard that no impression should be left when scratched with fingernails.
- No brick should absorb more than 15 percent of its weight of water when kept immersed in it 24 hours
- On breaking, the surface should show a bright homogenous and compact surface free from voids or grit.

- A brick soaked in water for 24 hours should not show deposits of white salts on drying shade

2.5.5. Classification of brick

Brick Can classified in three ways namely according to their use or its general physical requirement and strength or is in IS classification. The classification of brick on the basic of these criteria is as follow:

A) According to the use: brick is sometime broadly classified according to their uses as:

I. Common bricks

II.engineering bricks

III.Facing bricks

IV.fired bricks

V. Special bricks (special face)

B) According to the physical requirement. In some specification, clay bricks are classified as class I, class II, classier according to their general physical properties indicated in table 2.2. As can be seen, the bricks of different classes differ I their water absorption property. No good bricks should disintegrate when immersed in water even for long period. Such disintegration shows lack of good burning

C) IS classification of bricks, Indian standard I.S 3102-1971 Classification of burnt clay solid bricks classifies bricks according to their strengths?

Note: generally, factory made (wire cut) bricks in India give strength of order of 17N/mm2 when wet. Common handmade bricks, generally, given the strength of the order of only 3 to 5N/mm2 when dry

2.5.6. Categories of bricks

There are thousands of categories of bricks that are named for their use, size, forming method, origin, quality, texture, and or materials.

Categorized by manufacture method:

- ✓ Extruded made by being forced through an opening in a steel die, with a very consistent size and shape.
- ✓ Melded shaped in mild rather than being extruded
- ✓ Machine melded clay is forced into melds using pressure

- ✓ Handmade clay is forced into melds by a person
- ✓ Dry pressed similar to soft mud method but start with a much thicker clay mix and is compressed with great force.

Categorized by:

- ✓ Common or building: a brick not intended to be visible, used for internal structure
- ✓ Face: a brick used on exterior surfaces to present a clean appearance
- ✓ Hollow not solid: the holes are less than 25% of the brick volume
- ✓ Perforated holes greater than 25% of the brick volume
- ✓ Paving brick intended to be in ground contact as a walkway or roadway
- ✓ The brick with normal height and length but thin width to be used as a veneer

2.5.7. Different types of manufacturing bricks

Brick making at the beginning of the 20^{th} century. Three basic types of brick are un-fired, fired and chemically set bricks. Each type is manufactured differently.

1. Unfired bricks, also known as mud bricks, are made from a wet, clay containing soil mixed with straw or similar binders. They are air dried until ready for use.
2. Fired brick

Raw bricks sun drying before being fired, they are burned in a kiln which makes them durable. Modern fired clay bricks are formed in one of three process soft mud, dry press, or extruded. Depending on the country, either the extruded or soft mud method is most common, since they are the most economical.

3. Chemically set bricks

Chemically set bricks are not fired but may have the curing process accelerated by the application of heat and pressure in an autoclave.

Calcium-silicate bricks

Swedish mextegel is sand –lime or lime cement brick.

Calcium silicate bricks are also called sand lime or flint lime bricks, depending on their ingredients. Rather than being made with clay they are made with a lime binding the silicate material. The raw materials for calcium silicate bricks include lime mixed in a proportion of about 1 to 10 with sand, quartz, crushed flint, or crushed siliceous rock together with mineral colorants. The materials are mixed and left until the lime is completed hydrated; the mixture is then pressed into melds and cured in an autoclave for thee to fourteen hours to speed the chemical hardening. The finished bricks are very accurate and uniform,

Although the sharp arises, need careful handling to avoid damage to brick and bricklayer. The bricks can be made in a variety of colours, white, black, buff, and grey blues are common, and pastel shades can be achieved. This type of brick is common in Sweden, especially in houses built or removed in the 1970s. In India, these are known as fly ash bricks, manufactured using fly ash, and lime and gypsum process.

Normally,

The bricks contain following chemical properties:

Silica (sand): 50% to 60% by weight

Alumina (clay): 20%to 30% by weight

Lime: 2 % to 5 % by weight

Iron oxide: ≤ 7% by weight

Magnesia: less than 1% by weight

Face brick (house brick) sizes, standard imperial metric

Australia:	9× 4 1/3× 3 in	230× 110× 76 mm
Denmark:	9 ×4 1/4× 2 ¼ in	228× 108× 54 mm

Germany: 9× 4 ¼ × 2 ¾ in 240 ×115× 71 mm

India: 9× 4 ¾ × 2 ¾ in 240× 115× 69 mm

Romania: 9× 4 ¼ × 2 ½ in 240× 115×
63 mm Russia: 10× 4 ¾ ×2 ½ in 250×
120× 62 mm
South Africa: 8 ¾ × 4× 3 in 222 ×106 ×73 mm

Sweden: 10 ×4 ¾ × 2 ½ in 250× 120× 62 mm

United Kingdom: 8 ½ ×4 ×2 ½ in 215× 102.5× 65 mm

United States: 7 5/8 × 3 ×2 ¼ in 194 ×92 ×57 mm

2.5.8. Selection 0f material

All primary materials of construction or structural materials must perform the following function:

1. Carry out demoded standard load
2. Aesthetically phasing
3. Be economical practical
4. Be environmentally friendly

The most important requirement of materials used in civil engineering project is to be able to carry the design load; the material should have adequate strength in the area applied when using varieties of materials on the same project the effect of combination of two materials on the durability of the structural must be considered when accessing long-term performance.

2.6. Defect of clay brick

2.6.1 Over burning of brick:

Brick should be burned at which incipient, complete and viscous verification occur. However, if the bricks are over burnt, as often molten mass is produced and not more the bricks lose their shape. Such bricks are not used for construction works.

2.6.2 Under burning of bricks:

When bricks are not burnt to cause complete verification, the clay is not softened because of insufficient heat and pores are not closed. This result in higher degree of water absorption and less compressive strength. Such bricks are not recommended for construction work.

2.6.3 Bloating:

This defect observed as spongy swollen mass over the surface of burned bricks is caused due to the presence of excess carbonaceous matter and sulphur in bricks clay.

2.6.4 Black core:

When brick clay contains bituminous matter or carbon and they are not completely removed by oxidation, the brick result in black core mainly because of improper burning.

2.6.5 Chuffs:

The deformation of the shape of bricks caused of lumps by the rainwater falling on hot bricks is known as chuffs.

2.6.6 Crack:

This defect may be because of lump of lime or excess of water, in case of the former, when bricks meet water; he reacts with lime nodules causing expansion and the consequent disintegration of bricks, whereas shrinkage and burning cracks result when excess of water is added during brick manufacturing.

2.6.7 Spots:

Iron sulphide, if present in the brick clay, result in dark surface spots on the brick surface such brick though not harmful are unsuitable for exposed masonry work.

2.6.8 Blisters:

Broken blisters are generally caused on the surface of sewer pipes and drain tiles due to air imprisoned during their melding.

2.6.9 Lamination:

These are caused by the entrapped air in the voids of lamination procedure thin lamina on the brick faces, which weather out on the exposure. (McGraw-Hill dictionary of architecture and construction, 2003)

2.7.2Clay brickwork

2.7.1 Reasons for choose clay brick

Whether you are building a new home or remodelling your current one, there are many reasons to choose clay brick. Both in the wall and on the ground.

1. Genuine clay brick is made from natural materials
2. Many people may confuse clay brick with 'brick' made from other materials

For example, concrete unity relies on a cement paste to bond the materials together. Moreover, concrete units are inherently a greyish colour, which means that users must inject colour pigments before the setting process and use colour sealant afterwards to have a colour affect. On the other hand, clay brick has the thousand colorant shade options that will not fade. Contrary to some people's perception, clay brick is actually significantly stronger than concrete brick as well. Another brick like the one material made from fly ash claims to meet the same performance standards as clay brick. Since fly ash has no ASTM standards of its own, do not make a mistake of assuming that brick resembling products automatically perform as well as genuine clay brick (Research and consultancy directed of the associated cement Cos. LTD, 1992).

3. Brick has been proven for centuries

What began as building essential in the near east and India more than 5,000 years ago, would its way through the ancient Egyptians, the Indus valley civilisation and the Romans and today was amazingly become the all-American building product through our country's history. Just look at the structures and the roadways in your community. Chances are at least some of the are built with bricks.

At the same time, bricks today are subject to much more stringent manufacturing process than used in the past, which result in the more consistently performing product. While it is still possible to purchase handmade brick, it is also possible to buy the type of architectural brick that need extremely strict product specifications.

4. Bricks offer the superior protection over other wall cladding materials

The story of the three little pigs is just as true today as it was when it was first told to children long ago. Research confirms that genuine clay bricks provide superior shelter in three categories

5. Fire protection

Since the primary ingredient in brick is a clay, which is fired to around 2000F, it is a non-combustible material. As such, it is an excellent cladding choice to resist or confine fires. In fact. Both the national institute of standards and technology and BIA conducted separate fire test that conclusively demonstrate that nothing outperforms good old-fashioned brick in one-hour fire test and that today's advanced materials, such as vinyl are engulfed by flames within minutes.

6. High wind protection

A shelter from the storm study conducted in September 2004 shows that homes built with brick offer dramatically more protection from windblown debris than homes built with fibre cement siding. Conducted at the wind science and engineering research centre at Texas Tech University, the study demonstrated that a medium sized windblown, such a 7.5-foot-long 2 x 4, would penetrate home built with vinyl or fibre cement siding at a speed of 25mph. By comparison, the same object would need to travel at a speed exceeding 80 mph in order to penetrate the wall of a brick home. The tests found that homes made with brick exceed the 34-mph impact resistance requirement for high velocity hurricane zones in the Florida building code. Brick also exceeds Florida's impact resistance requirement for essential facilities in hurricane areas. Brick is such strong and durable building material that your insurance companies may offer you a discount on your home insurance costs (Purnima, B.Sc., Jain, Ashok Kumar, 2003).

7. Superior moisture control

According to the nationally renowned, independent building product research laboratory, brick veneer wall assemblies control moisture than wall systems clad with other exterior materials, therefore, brick veneer wall systems help minimize mild growth, wood rot and infestation by insects, and corrosion of fasteners embedded in wood better than other wall assemblies.

8.Bricks look better, for far longer and with less maintenance than other building materials.

9.Brick offers lasting value

It does not need to be painted and it will never tear or be eaten by termites. Its modular units and variety of shapes have resulted in beautiful structures in just about every architectural style, ranging from colonial to Victorian to post-modernist. It is one of the few materials that can actually look better with age. Brick also absorbs noise, giving it an acoustic advantage over other materials especially helpful in densely populated areas.

10. Brick is naturally efficient

Brick is a building material that has exceptional thermal mass properties. Thermal mass is the ability of a heavy, dense material to store heat and slowly release it. For you this, earns that during the summer months your brick stays cool during hottest parts of the day. During the winter, brick walls store your home's heat and radiate it back to you. Vinyl, aluminium, wood or artificial stucco are all thin, light building materials that do not have good thermal mass properties. The superior thermal mass qualities of brick have been known for centuries (N. Banumthidas, Kalidas, 2006).

11. Brick is the most suitable green building material made

Given the significance building have on energy consumption, bricks should be part of a comprehensive green strategy because today's brick includes:

Inherently natural ingredients. Brick is predominantly made from clay and shale, which are among the most abundant materials available on earth.

Countless recycling option, brick can salvage crust brick, for sub; base materials and chipped brick for permanent landscaping mulch.

Mineral waste. Virtually all the mined clay used in the manufacturing process making the recycling and waste containment unequalled by any other building materials. In fact, over 80% of our manufactures use their own-fired waste material or convert it into other product. In addition, if you decide to pitch it, there is no special handling required because brick is simply earth, so it is inert

(N. banumathidas, N. kalidas, 2000)

2.7.2. Clay and its constituents

A good brick earth or clay, such as is used for common red bricks, is generally composed of silica and alumina without a small quantity of flux I in the form of lime or oxide of iron and it acts as preventative to cracking. Shrinking or wrapping. Up to certain proportion, the more silica there is the better shape and more even texture resulting brick. An excess of silica should be in chemical combination with the alumina as opposed to a mere mechanical admixture.

Alumina is the principle and the most important constituent of good clay, as it imparts the plastic qualities though it shrinks, crack and warp very considerably under the influence of heat, which renders it very hard.

Lime may be called as flux, though its presence in the bulk has a double effect, it both diminishes the contraction in the process of drying the raw material and it blend the silica and the alumina together in the burning. This carbonate of lime must be present in very small quantities, comminute and equally distributed throughout the mass for if it exists in lump, it

will be slaked by moisture and cause the disintegration of the brick whether laid or not in the finished work.

Iron is also a flux, when in the form of an oxide and in the presence of nearly equal quantities of silica and alumina. It is the colouring matter of mast kinds of brick, the intensity of the colour (from a light yellow to dark red) being in 8 or 10% of oxide of iron, the colour is dark blue or purple and the addition of a small proportion of manganese gives almost a black colour to the brick and with lime the two impart the cream colour, the one darkening and the other lightening the shade. Magnesia and iron oxide make a yellow brick. The presence of alkalis is generally a source of trouble.

As they act too strongly as a flux when in any quantity, though that may be only a small percentage. They melt the clay, as it were and render the resulting brick unsymmetrical, while giving it a greenish blue tint.

That why suitable clay for the manufacturing of bricks or coarse pottery. Often an impure clay containing iron, calcium, magnesium and other ingredients is referred to as brick clay. The chief chemical composition of brick clay is silica, alumina, iron oxide, magnesia, lime and alkalis either more or less than the required amount of any of these constituents may cause serious damage to products. The presence of some harmful constituents like iron concretions, stone particles, soluble salts and limestone has a detrimental effect on brick.

All properties of bricks are affected by composition of the raw materials and the manufacturing processes. It is for this reason that most manufacturers blend clays to reduce the possibility of impurities from one clay source affecting the overall quality of the finished product. Similarly, the standardization of the manufacturing process permits the manufacturer to limit variations due to processing and to produce uniform products (Mc Graw-Hill Dictionary of architecture and construction, 2003).

2.7.3 Varieties of clay

There are three different kinds of clay as follows:

1. Pure clay also called plastic or strong clay, which contain silica and alumina with such a small proportion of lime, iron oxide or other flux that the brick maker calls it ‘foul clay’ as it is of very little use by itself, a soft uncombed brick being the result of what little burning the clay will stand. The addition of more lime or other flux improves the clay greatly for brick making purposes.
2. Sandy, mild or loamy are so loose that they are useless for the manufacture of bricks unless a flux is added in sufficient quantity to make the fusion perfect.

3. Maris or limy clays are the best of all, as they contain the necessary constituents in the first instance without further addition except to regulate burning.

4. An artificial brick making clay of this quality can be obtained by washing the clay and mixing it with the necessary lime in a mill.

5. Having dealt with the quantities and peculiarities of the different clays and their constituent, a short resume of the process used in the preparation of the clay and manufacture of the bricks may with advantage be given before proceeding to a detailed classification of the different kinds of bricks and their characteristics (McGraw-Hill Dictionary of architecture and construction, 2003)

2.8 Clay

Clay: is a finely grained natural rock or soil material that combines one or more clay minerals with traces of metal oxides and organic matter…clays are plastic due to their waste content and become hard, brittle and non- plastic up on drying or firing.

The essential ingredient in the soil used for brick making and as raw material for manufacturing clay brick is clay. The size of each particle is extremely small, generally less than 0.002 mm across. Various forces act between these fine particles in the moistened clay.

Allowing the latter to be deformed into the desired shape which must be retained on drying. Clay material can be readily identified by simple manipulation of moist sample with a view to checking the plasticity of the latter. Therefore, there are three types of clays that are used in brick manufacturing:

1. Surface clay
2. Shale
3. Fire clay
4. Good clay should be such that it can be easily molded, dried and burnt without cracking and warping (Chalabi, Mona, 2014)

2.8.1 Requirement of good clay

1. It must have proportions of sand, silt and clay
2. It must be homogenous
3. It should have sufficient plastics
4. It must be free from limps, people, grits and earth
5. It must not contain vegetables and organic matter

6. It should not mix with salty water

2.8.2. Manufacture of clay brick

The manufacture of clay bricks involves the following steps

1. Preparation of clay
2. Molding of clay
3. Drying of bricks
4. Burning of bricks

Properties of clay minerals include plasticity, shrinkage under firing and air-drying. Fineness of grain, colour after firing, hardness, cohesion and capacity of the surface to take decoration (punmia, BC, Jain Ashok Kumar, 2003)

2.8.3. Types of kilns for clay bricks

The bricks may be burnt in anyone of the following kilns

1.clamp or open kilns

2.intermittent kilns

3.continuous kilns (punmia, BC, Jain Ashok kumar,2003)

2.8.4 Different types of mortar used for clay bricks

Mortar is mechanical mixture in varying proportion of binding materials like cement or lime and inert materials or fine aggregate like sand etc. binding materials is referred to as matrix and fine aggregate is referred to as adulterant. The proportioning of material can be carried by volume, but this method is inaccurate and it is much better to proportion by weight. The effect of lime is to make the mix more workable but as the lime, content increases the mortar's resistance to damage by frost action decreases.

The plasticizers by having the effect entraining small bubbles of air in the mix breaking down surface tension will also increase the workability of mortar. Mortar should never be reattempted and should be used within 2 hours of mixing or be discarded (Punmia, B.C, Jain, Ashok Kumar, 2003)

2.8.5 Types of mortar

1. Cement mortar

2. Lime mortar

3. Lime cement mortar (composite or gauge)

Mud mortar, cement-clay mortar, light and heavy mortar, decorative mortar mortar, fire resistance mortar, sound absorption mortar.

Mortar is used as a building material in stone or brick masonry or as a covering material to walls in the form of plaster to provide a smooth, hard and decorative surface (N Banumathidas, Kalidas, 1992).

2.8.6 Requirement of mortar used in clay brick work

The mortar used in the brickwork transfers the tensile, compressive and shear stresses uniformly between advancements bricks. To do this it must satisfy certain requirement:

- It must have adequate strength, but not greater than required for the design strength
- It must have good workability
- It must retain plasticity long enough for the bricks to be laid
- It must durable over a long period
- It must bond well to the bricks
- It must be able to be produced at an economic cost

If the mortar is weaker than the bricks, shrinkage cracks will tend to follow the joint of the brickwork and these are reasonably easy to make good. If the mortar is stronger than the bricks, shrinkage cracks will tend to ne vertical through the joints and the bricks, thus weakening the fabric of the structure (McGraw-Hill Dictionary of architecture and construction, 2003).

2.8.7 Function of mortar

1. It binds together stones or bricks properly (as to provide the strength to the structure)
2. In any concrete, it holds coarse aggregate together (as to form solid mass)
3. In brick masonry, it fills up empty joint. A thin liquid mortar used for such purpose is termed as grout.
4. It provides a durable/weather resisting layer between different courses of masonry in the structure
5. It forms homogenous mass of the structure so that it may resist all the loads coming over it and transfer the same uniformly to its foundation.
6. Pointing or plastering to the structure (puma, BC, Jain, ashik kumar,2003)

2.8.8. Some use of mortar

1. It is used to fill up the spaces between bricks for making wall weather tight.
2. It is used to bind together the bricks in bricks masonry
3. It is employed to give a soft even bed between the different layers of bricks masonry for equal distribution of pressure over the bed.
4. It is used pointing and plastering to protect the joints and surface of bricks masonry
5. It is used improve the general appearance of structure
6. It is used to hide open joint of brickwork (N. banumathidas, Kalidas, 2002)

2.8.9. Ingredient of mortar

1. Binding or cement materials such as cement and lime
2. Fine aggregate such as sand ashes, cinder etc.
3. Water

1.Cement

It is used as binding materials for the preparation of mortars required for the engineering application where strength and durability are the primary requirement. For this purpose, ordinary Portland cement is mostly used, however special works rapid hardening cement, low heat cement or any other types of cement may also be used

1.It makes the mortar impermeable by filling up the voids existing in the fine aggregate
2.It affects strength to the mortar on setting and hardening
Lime: it is used, as building materials in preparing the mortar for various purpose but its strength is less than cement (puma, BC..., Jain ashik Kumar, 2003)
3.Fine aggregate usually sand:
- Sea sand should be washed with flesh water
- Function of sand in mortar.

i. It does not increase the strength of mortar but is used as an adulterant for economy
ii. It reduces the shrinkage of the building material and hence cracking of mortar during the setting is void.
iii. It increases the resistance of mortar against crushing.
iv. It helps in setting/hardening of flat lime by making it porous.

1. Water

- Water plays a significant role in mixing, transporting and proper laying of mortar

- The strength of the mortar depends upon the quality and quantity of the water used in the mix

2.8.10. Bonding of clay brickwork

When building with clay brick it is necessary to lay the bricks to some recognized pattern or bond in the order to ensure stability of the structure and produce a pleasing appearance. All the various bonds are designed so that no vertical joint in adjoining course. To simplify this requirement special bricks are produced to BS 4729. The various bonds are also planned to give the greatest practical amount of lap to all the bricks, and this should not be less the quarter of the brick length. Properly bonded brick work distributed the loads through the bonded brick is 60º (Panama, BC, Jain, ashik Kumar 2003)

2.8.11. Common bonds for clay brick

Stretcher bond: consist of all stretcher in very course and is used for half brick walls and brick skins of hollow or cavity walls

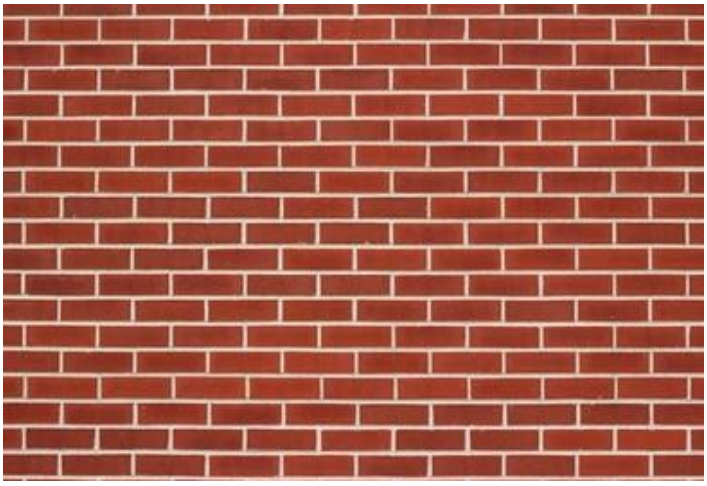

Figure 6: stretcher bond

- header bond

Is created by rows of header only displaced by half a brick on each row. This bond is often used to create curved brickwork

- Flemish bond

Each bond consists of alternate header and stretcher; its appearance is considered to better than English bond but it not quite to strong

This bond required fewer facing brick than English bond, needing only 79 bricks per square meter as opposed to 89 facing brick per square meter for English bond. This bond is sometime referred to as double Flemish bond.

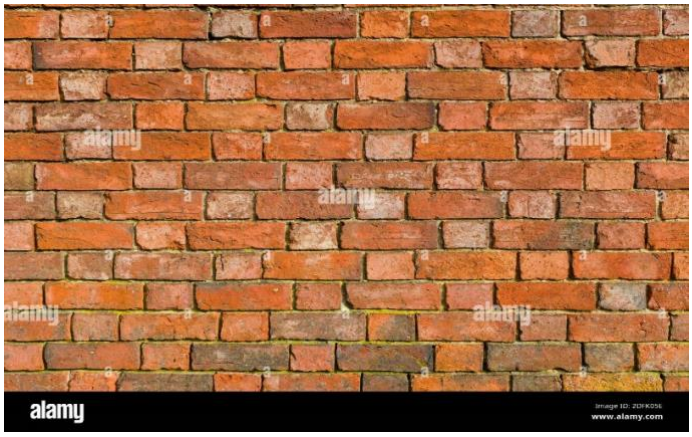

Figure 7: Flemish bond

- Single Flemish bond

A combination of English and Flemish bond, having Flemish bond on the front face with backing of Flemish bond. It considered being slightly stronger than Flemish bond. The thinnest wall that can be built is one-and half brick wall.

Figure 8: single Flemish bond

- English garden wall bond

Consist of three courses if stretcher to one course of header.

- English garden wall bond

Consist of three courses of stretchers to one course of header

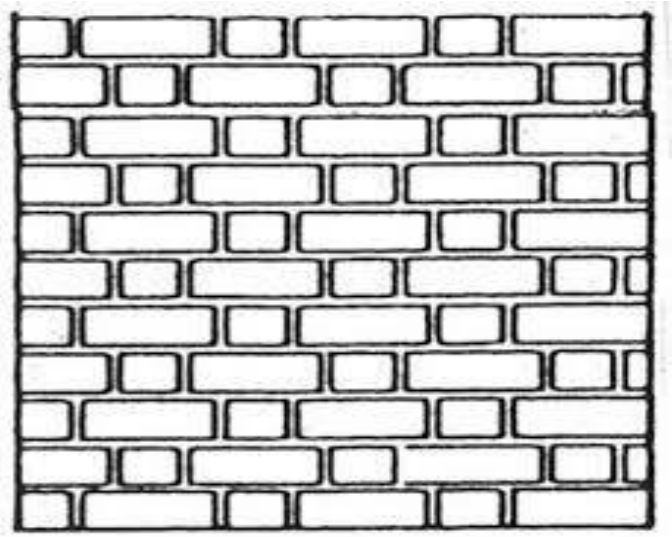

Figure 9: English garden wall bond

- Flemish garden

Bond consists of one header to every three stretchers in every course, this bond is fairly bricks and has pleasing appearance

- Stack bond

  Made up of courses of stretcher where each stretcher is stacked directly above stretcher and the joints align. This is not a structure bond and is generally used on interior for non-load bearing walls.

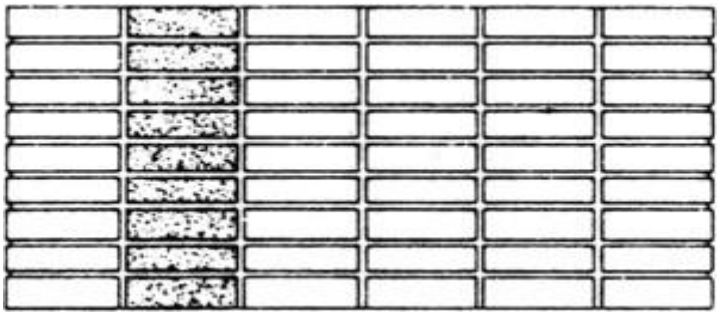

Figure 10: stack bond

2.8.12. Water used in clay brick production

The necessary amount of water (7-10 % of moisture) was added

To obtain adequate plasticity and absence of defects, mainly cracks, during the semi dry compression-melding stage. An alternative to tempering is disintegration or weathering which involves allowing clay to dry in the sun and accept moisture from rain and dew. The repeated drying and moisture of clay will bring clay to plasticity and workability appropriate of brickmaking. Crushing will make the mixture more homogenous (punmia, B.C. Jain, Ashok Kumar, 2003)

2.8.13. Properties of clay brick with maize waste

1. Physical and chemical properties

The shrinkage: the amount of shrinkage for each mixing in brick, which is below 8% then a good quality of bricks, must be manufactured

2. Density: it can be concluded that, the increase for influence the density of brick. As the brick become more porous, it will result to lightweight brick (Dr Bhnanumathidas and N Kalidas, 2002).

3. Compressive strength: it increases percentage of CW will decrease the strength of brick

Table 2: Chemical properties and concentration

Composition	CS	CW
Iron oxide	1.19%	4.58%
Calcium oxide	1.14%	3.75%
Magnesium oxide	0.92%	-
Silicon dioxide	65.77%	3.27%
Aluminium oxide	23.73%	1.84%

Sodium oxide	2.99%	-
Potassium oxide	1.98%	1.71%
Sulphur oxide	-	0.99%
Chlorine	-	0.78%
Phosphorus pent oxide	0.4%	0.25%
Titanium dioxide	0.39%	0.22%
Copper(iii)oxide	-	0.21%

2.8.14. Moulds

Melds are rectangular boxes of wood or steel without top and bottom and the longer sides projecting a few to act as a handle. The edges of the wooden melds should be protected with trip of brass or steel screwed of them. Only best seasoned wood should be used for making melds. Steel keeps their shape and last longer than the wooden moulds and are used on heavy works. These prove to be ultimately cheaper than wooden moulds the inside dimension of the melds are kept a little larger than the size

Of burnt brick, it is done to allow for the shrinkage of melded brick on drying and burning. The exact allowance to be made for shrinkage can be ascertained by field test (McGraw-Hill dictionary of architecture and construction, 2003)

Sand molding

Sand molding utilizes a driver clay mix, formed into a wedge and thrown into mold. A bow cutter will be used to smooth the top of the brick and the form can be released because of a hinged bottom. Since the clay is drier, the brick can be moved with wooden pallets, which can reduce the amount of the surface marks. There are multiple benefits to use sand molding instead of slop molding, such as: less water is used, so there is less cracking and the bricks are stronger.

Fewer molds are needed because they can be removed from the brick right away

The workspace is cleaner because of less splashing of the drier mix.

The worker is standing up instead of squatting down, so they are more comfortable.

The bricks are more regular because they do not deform like slop molded bricks, so a better product is produced.

Therefore, better construction and better-looking buildings will be possible.

Slop molded brick can be imprinted with the brick makers name called a frog o the flat side of the brick.

This helps the brick dry and fire better and is a good form of advertising.

Figure 11: molding of bricks

Drying clay brick

It is process to remove amount of water that was added in clay during clay preparation in order to improve the workability.

2.8.15. Objectives of drying clay bricks

There are several reasons for the drying of brick before firing. These are briefly described below.

In order to obtain the high strength and water-resistant properties of ceramic materials, the bricks must be burnt in a kiln to high temperature. The bricks are piled up one on top another, approximately 20 bricks high. Thus, the bricks at the bottom must be strong enough to carry the weight of those above. When first demoded after shaping, the green brick may not be able to bear the weight of even one more brick without showing some distortion. When a certain amount has dried out and the brick clay is approximately at the critical moisture content, the bricks become leather hard. They are then sufficiently rigid and strong for handling and stacking.

- Once the leather- hard condition is reached, the brick shrinks. It is preferable that this shrinkage takes place before bricks are piled high for burning. Lest the shrinkage causes the whole setting of brick to become unstable or to collapse within the kiln.
- Even after the leather – hard condition has been reached, there is much more water to be dried out of the bricks. If this is not done, water in the bricks nearest to the heat source will evaporate

and condense on cold bricks away from the heat source. These bricks will then absorb the water and are spoilt.

- Another risk is that water remaining in the green bricks will only be driven out by burning expensive fuel. Fuel costs may thus be reduced if the maximum of water is removed through natural drying (McGraw-Hill dictionary of architecture and construction, 2003)

Shrinkage

Shrinkage is inevitable on drying clay ware such as bricks. The most important rule is to dry bricks as slowly as possible in order to minimize stresses and incidence of cracking and distortion. At 7 per cent, linear shrinkage should not cause difficulties in subsequent processing. At 10 per cent, linear shrinkage may also be acceptable with some clays if drying is carried out carefully.

The following point are kept in view to insure successful completion of drying operation:

A) as soon as the molded bricks become dry enough so that they do not get damaged on handling they should be turned on edge and left for day or two more to further harden in initial stage of drying bricks should be protected from severe sun and winds as otherwise rapid drying of bricks must result in their developing cracks.

b) they should then be stacked in such a way that each brick gets full circulation of air all around it, best form of stack is of a breadth equal to two bricks laid longitudinally with interval between them.

c) The drying area should be higher than the surroundings that it does not get flooded due to any occasional rain. It should have a gentle slope to facilitate drainage of rainwater.

c) The drying area should be higher than the surrounding so that it does not get flooded due to any occasional rain. It should have a gentle slope to facilitate drainage of rainwater.

d) A layer of sand should be spread at the drying area to keep it dry in wet weather.

e) to protect the drying bricks from damage caused by occasional rain temporally bamboo frames and Sikri should be provided. The sirks should be provided. The sirks should be weighted down with heavy planks to stop them from being blown away by winds the height of stack may be of eight to ten layers of the bricks

The drying of row bricks is done by naturally process.

- The bricks are laid in stacks. Consist eight to ten stairs the brick in these stacks should be arranged in such way that circulation of air in between the bricks is free.
- The period of drying may be 3 to 10 days. It also depends upon the weather conditions.
- The drying yards are also prepared on higher level than the from the rainwater.

- In some situation artificial drying is adopted under special dryers or hot gases

Figure 12: drying of bricks

2.8.16. Firing brick

These bricks are capable withstanding very high temperature without melting or become a soft. A fire clay must as be free from iron oxide, free lime or any other such substance that causes the early fusion of bricks.

Firebricks are white or yellowish white colour and are used for liming the interior of fire bricks only firely should use as mortar as the ordinary mortar made of lime or cement shall not be able to withstand high temperature and shall thus disintegrate (Chalabi, Mona 2014)

2.8.17. Objectives of firing clay bricks

The green brick changes their physical structure and gives those good mechanical properties and resistance to slaking but water. If carried out properly, the firing process should minimize the occurrence of the following problem:

- The splitting of the bricks due to the incomplete removal of moisture before firing
- Low strength brick due to insufficient hard firing
- Slaking by water due to inadequate control of firing temperature
- Bricks fused together melted on face or distorted by the load imposed by other bricks on top, these problems are caused by too high temperature

- Fine cracking over brick surface resulting from a too-rapid temperature change, either during heating or cooling or from the condensation of water vapour from heated bricks onto cooler bricks
- Local cracking over hard lamps or stone mixed in the clay. This inclusion should have been removed during clay preparation, although rapid changes in temperature may have aggravated the problem
- Scum on the brick surface may be minimized by preventing condensation of the product of a combination of cold green bricks (N. Banumathidas, Kalidas 2002)

CHAPTER 3. MATERIALS AND METHOD

3.1. Making brick specimen

1. Source of materials

- Clay: Obtain from local clay pits or construction sites. Suppliers specializing in ceramics can also provide quality clay.
- Maize husks: You can source these from:
    - Local farms or agricultural co-ops
    - Grain processing facilities
    - Online agricultural suppliers
- Water: Use clean water from your tap or well
- Moulds: It is the process of giving the required shape to the prepared clay bricks is known as moulding bricks. (generally rectangular).

We did this process by hand moulding, if manufacturing of bricks is on a small scale and manpower is also cheap then we can go for hand moulding as we used to produce our sample which has size (195x95x65) mm with portion ratio as 1:4, the moulds are in rectangular made of wood which are opened at the top and bottom. The longer the of Molds are projected out of the box to serve it as handles.

- Burning clay brick

  After the bricks have been dried in the sun, they are burnt in kilns to make them stronger, header, denser, less absorbent and consequently more durable. The bricks are burnt either in (I)clamp or (ii)kiln (a)continuous or (b)intermittent, for our sample, bricks will be burnt in modern kilns which take a few days intruder to be well burned. This temperature is usually used in the fabrication of clay bricks. The bricks were then cooled to room temperature by natural convention inside the furnace after being turned off.

1. **Procedure of making bricks**

- Prepare the clay mixture:
- Gather Material: collect your clay, maize husks
- Mixing ratio: A common ratio is about 70% clay to 30% maize husks, but you can adjust based on your desired properties.
- Chop maize husks: Cut the maize husks into smaller pieces to enhance mixing.
- Mix the ingredients:
- Combine: in a mixing container, combine the clay and chopped maize husk.
- Add water: gradually add water while mixing until you achieve a workable consistency. The mixture should be damp but not too wet.

- Molding the bricks:
- Prepare Molds: Ensure your Molds are clean and slightly lubricated to prevent sticking.
- Fill Molds: Pack the clay-maize husk mixture tightly into the Molds, ensuring no air pockets. Use a flat tool to level the surface.
- Drying:

✓ Air dry: Remove the bricks from the Molds and place them in a shaded area to air dry. This can take several days depending on humidity and temperature. Turn them occasionally to promote even drying.

✓ Initial drying: Let them dry until they are firm enough to handle but still slightly damp.

- Firing:
- Kiln setup: Prepare your kiln according to its specifications
- Fire the bricks: Once the bricks are adequately dried, fire them in the kiln. The temperature should typically range from 900 ℃ to 1,100℃ (1650℉ to 2,000℉) for optimal strength.
- Cooling: After firing, allow the kiln to cool down gradually before removing the bricks.

- Testing and usage

✓ Quality check: Once cooled, inspect the bricks for any cracks or deformities.

✓ Usage: Your bricks are now ready for use in construction or other applications

2.Tools of making bricks

✓ Molds: Used to shape the bricks. Can be made of wood, metal, or plastic.

✓ Brick press or extruder: A machine that compresses the clay to form bricks often used in large scale production

✓ Clay Mixer: A machine or tool for mixing clay, water and any additives to achieve the right consistency.

✓ Shovels and Spades: For moving clay and materials

✓ Trowels: Hand tools for shaping and smoothing the clay.

✓ Water source: Essential for mixing and shaping the clay.

✓ Safety gear: Gloves, masks and goggles for protection during the process

3.2 Testing the compressive strength of a brick

3.2.1. Procedures of testing compressive strength of a brick

- Preparation of specimen

✓ Select bricks: choose a sample of bricks (5 bricks) from the lot a ensure a representative sample.

✓ Conditioning: allow the bricks to dry in a controlled environment for at least 24 hours to ensure uniform moisture content.

- Measurement

- ✓ Dimensions: Measure the dimensions (length, width, height) of each brick accurately using a calliper or ruler.
- ✓ Calculate cross-sectional area: Use the formula area= length x width

- Setup for testing

- ✓ Testing Machine: Use a compression testing machine capable of applying a uniform load. Ensure that the machine is calibrated.
- ✓ Placement: Position the brick in the machine, ensuring it is cantered. Use a cushion or smooth plate to avoid stress concentration.

- Conducting the test

- ✓ Apply load: Gradually the load on the brick until failure occurs.
- ✓ Record load: Record the maximum load applied at the point of failure.

- Calculating compressive strength

- ✓ Formula: Use the formula:
  Compressive strength= Maximum load /Cross sectional area
- ✓ Units: Report the result in megapascals (MPa) or pounds per square inch (psi0

- Analysis and reporting

- ✓ Average strength: If multiple bricks were tested, calculate the average compressive strength.
- ✓ Documentation: Record all data including individual brick strengths, average strength, and any observation during the test.

3.2.2Tools used in water absorption test

- ✓ Balance: a precise scale is essential for weighing the sample before and after immersion to determine the amount of water absorbed
- ✓ Water container: a sturdy container often a graduated cylinder or a basin, is used to hold water for immersing the sample.
- ✓ Vacuum chamble: in test requiring saturation under vacuum, this chamble helps remove air from the sample, allowing for more effective water absorption.
- ✓ Drying oven: used to dry the sample before the test and sometime after immersion, the oven ensures accurate measurement of moisture content.
- ✓ Graduated cylinder: useful for measuring the exact volume of water to be used in the test.
- ✓ Time: a stopwatch or timer helps track the duration of the immersion period to ensure consistency in testing.

3.4. Testing the soundness of the bricks

3.4.1. procedure of testing the soundness of bricks

- ✓ Preparation: select a clean, dry brick for testing. Ensure its free from dirt and moisture.
- ✓ Striking: hold the brick in one hand and gently strike it with a hard object, like another brick or metal tool.
- ✓ Listening: pay attention to the sound produced. A clear, ringing sound indicate good quality, while a dull thud suggests defect or poor quality
- ✓ Assessment: evaluate the sounds' tone and duration. A higher–pitched, **sustained ring indicates better soundness.**

3.4.2. Tools are used to test the soundness of bricks

This test was performed by striking two specimen bricks with each other. The bricks should not break and a clear ringing sound should be produced.

CHAPTER 4: RESULT AND DISCUSSION

4.1 Water absorption rate of brick

Table 3: Water absorption rate of brick

Bricks test number	Dry weight (w1)	Wet weight (w2)	W=(w2-w1/w1) ×100
1.	1.900	2.175	14.47
2.	1.935	2.180	12.66
3.	1.950	2.205	13.07
AVERAGE			**13.4%**

Interpretation of water absorption test of brick

A water absorption test result of 13.4% for brick indicates that the brick absorbs 13.4% of its dry weight in water within a specified time frame. This level of absorption suggests moderate porosity, which can affect durability and thermal properties. Generally, lower absorption rates are preferred for better performance in construction.

4.2 Compressive strength test of the brick

Table 4: Compressive strength test of the brick

S/N	Size of brick (length, width) in mm	Area of brick (mm2	Compressive load (N)	Compressive strength of the brick cube= load/area N/mm2
1	200×96	19,200	25.669	0.0013
2	200×95	19,000	28.35	0.0014
3	200×96	19,200	11.43	0.0005
4	200×97	19,400	20.00	0.0001
5	200×95	19,200	24.34	0.0001
AVERAGE				0.00068

In summary, a compressive strength of 0.00068 N/mm2 indicates a brick that is unsuitable for construction purposes. It is crucial to investigate the causes and consider re-evaluating the source of brick to ensure safety and compliance with building standards.

You have to interpret based on the average

4.3 soundness test of the brick

This test demonstrated the nature of bricks during sudden impact. To perform this test, two bricks were chosen randomly and struck against each other. The bricks tended to crack, and the sound that produced was not a clear, bell-ringing sound.

CHAPTER 5. CONCLUSION AND RECOMMANDATIONS

5.1 Conclusion

The bricks made of clay and maize husk were made using a mould (195x95x65). The specimens were tested for water absorption and compressive strength according to the British standard specifications. The Experimental results show that the excessive addition of maize husk has a gradual increase of water absorption with critically low compressive strength as maize husk percentage increases. Since the bonding between the clay particles and the maize husk particles is weak. The soundness test also demonstrated a bad-quality brick. In general, the results demonstrate that a brick from a mixture of maize husk and clay is inappropriate for construction purposes.

5.2. Recommendation

The following recommendations are proposed for further research:

- Study the effect of maize husks additive on the thermal conductivity of firing clay bricks
- Study the effect of firing time on the properties of fired clay bricks

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APPENDIX