CASE FOR

ECO-FRIENDLY BRICK PRODUCTION USING AVAILABLE LOCAL MATERIALS

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MRITYUNJAYA GONNADE

21P058015

Under the Supervision of

DR. ANTHONY A.A.A VIEGAS

School of Earth Ocean and Atmospheric Sciences

ENVIRONMENTAL SCIENCES

Goa University

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Examined by:

Seal of the school:

DECLARATION BY STUDENT

I hereby declare that the data presented in this Dissertation report entitled, **"Case for eco-friendly brick production using local available materials"** is based on the results of investigations carried out by me in the **M.Sc. Environmental Science** at the School of Earth Ocean and atmospheric Sciences, Goa University under the Supervision of **Prof. Dr. Anthony A.A.A. Viegas** and the same has not been submitted elsewhere for the award of a degree or diploma by me. Further, I understand that Goa University or its authorities will be not be responsible for the correctness of observations / experimental or other findings given the dissertation.

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Mrityunjaya Gonnade
21P058015
M.Sc. (Part 2)
School of Earth Ocean and atmospheric Sciences

Date: 02/05/2024

Place: Goa University

COMPLETION CERTIFICATE

This is to certify that the dissertation report **"Case for Eco-friendly Brick Production Using Available Local Materials"** is a bonafide work carried out by **Mr. Mrityunjaya Gonnade** under my supervision in partial fulfilment of the requirements for the award of the degree of **Master of Science** in the Discipline **Environmental Science** at the **School of Earth Ocean and Atmospheric Sciences**, Goa University.

DR. ANTHONY A.A.A. VIEGAS
Guide

Date: 2/5/24

31/7/24
Prof. Dr. Sanjeev Ghadi
Senior Professor and Dean
School of Earth, Ocean and Atmospheric Sciences

SEOAS, GOA UNIVERSITY TALEIGAO PLATEAU GOA

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CONTENTS

PROLOGUE

The study conducted that using laterite soil, rice husk and coconut shell ash in brick production is a sustainable solution as it contributes to judicious use of waste and promotes the holistic use of resources while making it more cost effective and sustainable.

Using laterite soil, rice husk and coconut shell ash for production of brick. Coconut shell and rice husk were collected from the industries, landfills which causes waste management issues such as littering, blockage of water ways and accumulation of landfills. This can result in habitat destruction, aesthetic degradation and potential harm to wildlife. When coconut shell and rice husk are burnt openly or in poorly controlled combustion processes they can release particulate matter, carbon monoxide and other harmful pollutants into the air contributing to air pollution. So, by using coconut shell and rice husk brick production with addition of laterite soil can reduce the harmful effects caused by these waste.

The experimental analysis of the brick was done in various forms like compressive strength, weight measurement, water absorption test, XRD analysis and determination of iron present in the soil to check its durability parameters. The results of the experiment showed durability similar to the other bricks which are being used in the construction.

CHAPTER 1

INTRODUCTION

1.1. GENERAL

Throughout the world there is depletion of natural resources, judicious use of natural by-products and lesser tapped lower grade resources go a long way in optimum use of available resources. The construction industry stands at the crossroads of development and sustainability. As global population growth drives an unprecedented demand for housing and infrastructure, the environmental impact of construction materials comes into sharp focus. Traditional brick production, a staple in the construction sector, has long relied on materials and processes with substantial carbon footprints. However, the imperative for sustainable alternatives has led to innovative research into eco-friendly materials that reduce environmental impact without compromising quality or affordability (Nikhil Bapure et.al). This thesis explores the sustainable use of rice husk and coconut shell ash, combined with laterite soil, in brick production—a novel approach that not only promises to mitigate environmental concerns but also enhances the physical properties of bricks.

1.2. BACKGROUND

The quest for sustainable building materials has unearthed a variety of alternatives to traditional clay and concrete bricks. Among these, agricultural waste products such as rice husk and coconut shell ash emerge as promising candidates due to their abundance and the environmental benefits of their utilization. Rice husks and coconut shells are by-products of the agricultural and food industries, respectively, which would otherwise contribute to waste and pollution. By repurposing these materials in brick production, the industry can address waste management issues while reducing the reliance on depleting natural resources.

Laterite soil, widely available in tropical and subtropical regions, has been historically used in construction due to its rich iron and aluminium content, which contributes to its durability. However, the incorporation of laterite soil in modern brick production has been limited, partly due to its variability in composition and properties. This research posits that blending laterite soil with rice husk and coconut shell ash can result in bricks with improved structural and environmental performance.

1.3. OBJECTIVES

The primary objective of this study is to investigate the feasibility and effectiveness of using rice husk and coconut shell ash with laterite soil in the production of sustainable bricks. This involves:

Characterizing the physical and chemical properties of rice husk ash, coconut shell ash, and laterite soil to understand their suitability and potential interactions in brick formulation.

Evaluating the mechanical properties of bricks produced with varying proportions of rice husk ash, coconut shell ash, and laterite soil, including their strength, durability, and resistance to environmental factors.

Assessing the environmental impact of the proposed brick production method, focusing on energy consumption, carbon emissions, and the life cycle analysis of the bricks.

Comparing the cost-effectiveness of the sustainable bricks with traditional brick production methods, considering both manufacturing costs and long-term performance.

1.4. SIGNIFICANCE

The significance of this research lies in its potential to contribute to the sustainable transformation of the construction industry. By introducing a method to reuse agricultural waste and harness the properties of laterite soil, this study aligns with global sustainability goals, including waste reduction, carbon footprint minimization, and the conservation of natural resources. Furthermore, the development of more sustainable bricks could have wide-ranging implications for the construction industry, particularly in regions where rice husks, coconut shells, and laterite soil are abundant. Enhancing the affordability and accessibility of building materials could also have socio-economic benefits, particularly in developing countries where housing and infrastructure needs are acute.

1.5. STRUCTURE

This study is organized into several chapters, starting with a comprehensive literature review that sets the context for the research and outlines previous studies in the field. The methodology section describes the experimental procedures for material characterization, brick formulation, and testing. Subsequent chapters present the results and discussion, analysing the data in the context of the research objectives. The final chapter offers conclusions drawn from the study, along with recommendations for further research and potential applications of the findings in the construction industry.

By delving into the sustainable use of rice husk and coconut shell ash with laterite soil in brick production, this thesis contributes to the evolving narrative of sustainable construction, offering insights and solutions that could shape future practices in the industry.

CHAPTER 2

LITERATURE REVIEW

2.1. LATERITE SOIL IN BRICK MANUFACTURING

2.1.1. Properties and Suitability

Laterite soil is a highly weathered material rich in iron and aluminium, known for its wide availability and minimal processing needs (Schellmann, W., 1986). Traditionally used in road construction and building due to its hardness and ability to form compact structures, laterite has been identified as a suitable raw material for brick production due to its ease of use and strength when dried (Anand and Ramamurthy, 2005).

Laterite soil is notably varied in its composition, which depends heavily on the local environmental and geological conditions. As defined by Schellmann (1986), laterite soil is primarily formed under high rainfall and temperature conditions, which lead to intense leaching of soluble minerals, leaving behind oxides of iron, aluminium, manganese, and titanium. These soils are typically poor in organic constituents but rich in minerals, making them inherently sturdy and resistant to weathering once hardened.

Gidigasu (1976) in their seminal work, "Laterite Soil Engineering," details the engineering properties of laterite and categorizes it based on its geotechnical properties, including plasticity, compactness, and strength, which are critical in determining its suitability for brick manufacturing.

2.1.2. Use of Laterite in Brick Manufacturing

The use of laterite as a primary material in brick production has been historically prevalent in regions such as West Africa, India, and parts of South America. According to Anand and Ramamurthy (2005), the compressive strength of laterite-based bricks can adequately meet building standards when the soil is sourced correctly and processed using appropriate methods. These authors emphasize the importance of proper selection and treatment of the soil to ensure the bricks possess sufficient strength and durability.

2.1.3. Enhancements in Laterite Brick Properties

The traditional problems with laterite bricks include variability in quality and relatively lower strength compared to fired clay bricks. Recent studies have focused on the stabilization of laterite soil to overcome these issues. Joseph and Mathew (2012) investigated the stabilization of laterite using industrial by-products such as fly ash and rice husk ash. Their findings suggest that the addition of these materials not only increases the compressive strength but also enhances the water resistance of the bricks.

Olubajo (2004) explored the chemical stabilization of laterite bricks using cement and lime, demonstrating significant improvements in their structural integrity. This approach is particularly beneficial in making laterite bricks more uniform in quality and suitable for load-bearing constructions.

2.2. RICE HUSK

2.2.1. Properties of Rice Husk

Rice husk is primarily composed of cellulose, lignin, and silica, making it a valuable resource in brick manufacturing due to its high silica content and fibrous nature (Siddique, 2008). When burnt, it transforms into rice husk ash (RHA), which is highly pozzolanic due to its amorphous silica content, beneficial for enhancing the mechanical properties of bricks.

2.2.2 Utilization of Rice Husk in Brick Manufacturing

Studies have explored the use of rice husk and RHA as an admixture in brick production. The inclusion of rice husk directly into brick clay mixtures has been investigated for its impact on physical properties and firing behaviour. Chowdhury et al. (2015) found that adding rice husk to clay bricks before firing could increase porosity and decrease density, resulting in lightweight bricks with improved thermal insulation properties.

2.2.3. Impact on Mechanical Properties

Adding rice husk or RHA to bricks can alter their compressive strength. According to Dhanapandian and Gomathi (2009), the use of RHA up to 20% by weight can significantly enhance the compressive strength of bricks. This improvement is attributed to the pozzolanic reaction of silica in RHA with calcium hydroxide in cementitious mixtures, forming additional cementitious bonds within the brick.

2.2.4. Durability and Environmental Impact

The use of rice husk in bricks also impacts their durability. Research indicates that bricks with rice husk content exhibit improved resistance to water absorption and efflorescence, contributing to longer-lasting construction materials (Kumar et al., 2010). From an environmental standpoint, utilizing rice husk in brick production contributes to waste reduction and provides a use for this agricultural by-product, thereby reducing environmental pollution associated with its disposal.

2.3. COCONUT SHELL ASH

2.3.1. Physical and Chemical Properties of Coconut Shell Ash

Coconut shell ash (CSA) is derived from the combustion of coconut shells, commonly regarded as agricultural waste. Research by Srinivasan and Sathiya (2010) explored the chemical composition of CSA, highlighting its high silica content, which can contribute to the pozzolanic activity when used in brick manufacturing. According to their analysis, CSA contains silica, along with minor quantities of alumina and iron oxide, which are also crucial for the pozzolanic reactions in brick matrices (Srinivasan and Sathiya, 2010).

2.3.2. Impact of CSA on the Mechanical Properties of Bricks

A number of studies have investigated the mechanical properties of bricks incorporated with varying percentages of CSA. For instance, Gunasekaran et al. (2012) conducted experiments to assess the compressive strength and water absorption of clay bricks with CSA additives. Their findings suggested that the inclusion of up to 20% CSA by weight could improve the compressive strength while slightly increasing water absorption rates. This implies that CSA not only acts as a filler but also contributes to the binding strength in the brick structure (Gunasekaran et al., 2012).

2.3.3. Thermal Properties of CSA Bricks

The thermal properties of bricks are crucial for energy-efficient building design. Raut et al. (2013) studied the thermal behaviour of bricks containing CSA and found that CSA could enhance the thermal insulation properties of bricks due to its inherent porous nature. This aspect is particularly beneficial in hot climates, where improved insulation can significantly reduce cooling costs and energy consumption (Raut et al., 2013).

2.3.4. Environmental and Economic Benefits

One of the key advantages of using CSA in brick production is its potential to mitigate the environmental impact associated with the manufacturing process. CSA, being a waste product, provides a way to recycle coconut shells that might otherwise contribute to waste. Furthermore, Krishnaraj and Sreenivasan (2014) discussed the economic benefits stemming from the reduced need for conventional raw materials and the lower energy requirements for firing bricks when CSA is incorporated, thus making the production process more sustainable and cost-effective (Krishnaraj and Sreenivasan, 2014).

CHAPTER 3

MATERIALS REQUIRED AND METHODOLOGY

3.1. MATERIALS REQUIRED

3.1.1. LATERITE SOIL:

laterite soil is available in abundance. Soil was collected from Goa University campus. Laterite soil is a type of soil rich in iron and aluminium that is commonly found in tropical regions. It can be sourced from a local supplier or collected from the natural environment.

Figure 1: Collection of lateritic soil sample from Goa University Campus

Physical properties	Description
Colour	Typically ranges from red to brown, depending on the oxide content.
Texture	Coarse-grained and gritty, though the texture can vary significantly.
Structure	Well-drained, with a clumpy structure that can harden significantly when exposed to air.
Bulk density	Generally higher than many other soil types, which can affect water infiltration and root penetration.
Porosity	Moderate to high porosity, which can lead to rapid drainage and sometimes poor water retention

Permeability	Generally, high although this can vary with the degree of cementation of iron and aluminium oxides.
Water retention	Varies; tends to retain less water due to coarse texture and high drainage.

Table. No. 1. Properties Of Laterite Soil (Santhy, V., and Sumathy, K. 2006):

3.1.2. RICE HUSK ASH

Rice husk was collected from local rice mill located in Raipur, Chhattisgarh. Rice husk ash is a by product of rice milling and can be obtained by burning rice husks at a high temperature until they turn into ash.

Figure 2: Rice husk

Physical properties	Description
Bulk density	Typically rages from 96 to 160 kg/m^2, making it a lightweight material.
Particle size	Variable, typically 2 to 3 mm in leagth, although this can differ based on the making process and the husk's hadling.
Color	Generally pale yellow to greyish white, depending on the rice variety and proceeding method.
Texture	Coarse and abrasive due to the high silica content.
Porosity	Highly porous with a high surgface area, which contributes to its excellent insulation properties.

Moisture content	Moisture content can range from 8-14%, which influences its combustion and decomposition.
Thermal conductivity	Low thermal conductivity, which ensures its utility as an insulating material

Table. No. 2. Physical properties of rice husk {Rajput, R., Kansal, S., and Kothari, R. 2017}

3.1.3. COCONUT SHELL ASH

Remains of coconut shell after removal of kernel was collected from a local vendor located in Raipur, Chhattisgarh. Coconut shell ash is obtained by burning coconut shells at a high temperature until they turn into ash. Coconut shell ash is considered as a hard substance. This is because coconut shell ash contains high amounts of silica and alumina.

Research has shown that the use of coconut shell ash in brick production can improve the compressive strength, water absorption, and density of the resulting bricks. This is because coconut shell ash is a pozzolanic material, which means that it reacts with calcium hydroxide to form additional cementitious compounds, such as calcium silicate hydrate and calcium aluminate hydrate. These compounds help to improve the strength and durability of the bricks.

Figure 3: Coconut shell

Physical properties	Description
Colour	Generally grey, dependent on the combustion temperature and conditions.

Particle size	Highly variable, can be ground to a fine powder. Particle size significantly affects its reactivity as a pozzolan.
Bulk density	Relatively low, typically ranging from 400 to 600 kg/m^3. This low density is beneficial for applications requiring lightweight materials.
Specific gravity	Typically ranges from between 2.1 to 2.5.
Surface area	High surface area due to the porous nature of the ash, enhancing its pozzolanic activity when used in concrete.
Chemical stability	Generally stable; however, its chemical composition can influence its reactivity and interaction with other materials in a mixture.
Thermal stability	Coconut shell ash exhibits good thermal stability up to about 800^{0}C, beyond which it may begin to lose structural integrity.

Table. No. 3. Properties of coconut shell (Nath, P., Sarker, P. K., and Ranganathan, K. 2015)

3.1.4. WATER

Water is an essential component in brick manufacturing for several reasons:

1. Mixing: Water is needed to mix the various materials used in brick production, such as clay and sand. The water acts as a binding agent that helps to hold the materials together, allowing them to be moulded into the desired shape.

2. Plasticity: Water is also essential in the process of plasticity, which is the ability of the clay to be moulded and shaped. The addition of water to the clay creates a plasticity that allows it to be shaped and Moulded without cracking or breaking.

3. Hardening: After the bricks are moulded, they are dried and fired in a kiln to harden them. During the firing process, the water in the bricks is evaporated, which causes the clay particles to bind together and harden into a solid structure.

4. Dust suppression: Water is also used in brick manufacturing to suppress dust. Brick production generates a lot of dust, which can be harmful to workers and the environment. By spraying water over the area where the bricks are being made, the dust can be controlled and minimized.

Overall, water plays a critical role in the manufacturing process of bricks, as it is necessary for mixing, plasticity, hardening, and dust suppression. Without water, it would be impossible to produce high-quality bricks that are durable and long-lasting.

3.1.5. MOULD

Mould was used from a working brick kiln. Brick moulds, also known as brick forms or brick presses, are used to shape clay or concrete into bricks of a specific size and shape. The mould is made of a durable material, such as metal or plastic, and is designed to withstand the pressure and heat of the brick-making process. The mould was wood which helped the soil to stick properly. The size and shape of the brick mould can vary depending on the desired size and shape of the bricks being produced. Some common sizes of brick moulds include 4x8 inches, 6x8 inches, and 8x8 inches, although other sizes are also available. The brick mould used in this study was 9×4 inches. The shape of the mould can range from a simple rectangular shape to more complex shapes with bevelled edges or curved corners. To use a brick mould, the clay or concrete mixture is placed inside the mould and compressed to form the shape of the brick. Once the desired shape is achieved, the mould is removed, and the brick is left to dry and cure.

Figure 4: A single brick mould of 9″x 4″

3.1.6. PRESS

A press is used to compact the brick mixture into a solid brick. The use of a press is important in brick formation for several reasons:

1. Improved quality: Using a press allows for greater precision and control in the formation of bricks. The press can apply a consistent amount of pressure to the material, resulting in more uniform and consistent bricks with good symmetry and fewer defects.

2. Higher production rate: Presses can produce bricks at a faster rate than traditional hand-moulding methods. This is because the press can form multiple bricks at the same time, allowing for higher production rates.

3. Better material utilization: The use of a press can help to minimize waste by using the exact amount of material needed to create each brick. This can help to reduce material costs and improve the overall efficiency of the production process.

4. Improved working conditions: Using a press can also improve working conditions for brick makers. Traditional hand-moulding methods require a significant amount of physical labour and can be tiring and strenuous. The use of a press can help to reduce the physical demands of the job and make it easier and safer for workers. Overall, the use of a press is important in brick formation because it allows for greater precision and control, higher production rates, better material utilization, and improved working conditions. By using a press, brick manufacturers can produce high-quality bricks more efficiently and sustainably.

3.2. METHODOLOGY

3.2.1. STEP 1: COLLECTION OF RAW MATERIALS

Collect the laterite soil, rice husk ash, and coconut shell ash in separate containers. Measure the appropriate proportions of raw materials based on the desired brick composition. In this study the raw materials are made up of laterite soil : rice husk : coconut shell ash in the ratio of 70:10:20.

3.2.2. STEP 2: MIXING OF THE RAW MATERIALS

Remove any impurities or large particles from the laterite soil, rice husk ash, and coconut shell ash prior to mixing. Mix the laterite soil, rice husk, and coconut shell ash thoroughly in the dry form and take laterite soil : rice husk : coconut shell ash in the ratio of 70:10:20 in a large container. Add water gradually to the dry mixture and mix thoroughly until it reaches a homogeneous consistency. The amount of water needed may vary depending on the moisture content of the laterite soil and other factors, so adjust accordingly to achieve a workable mixture.

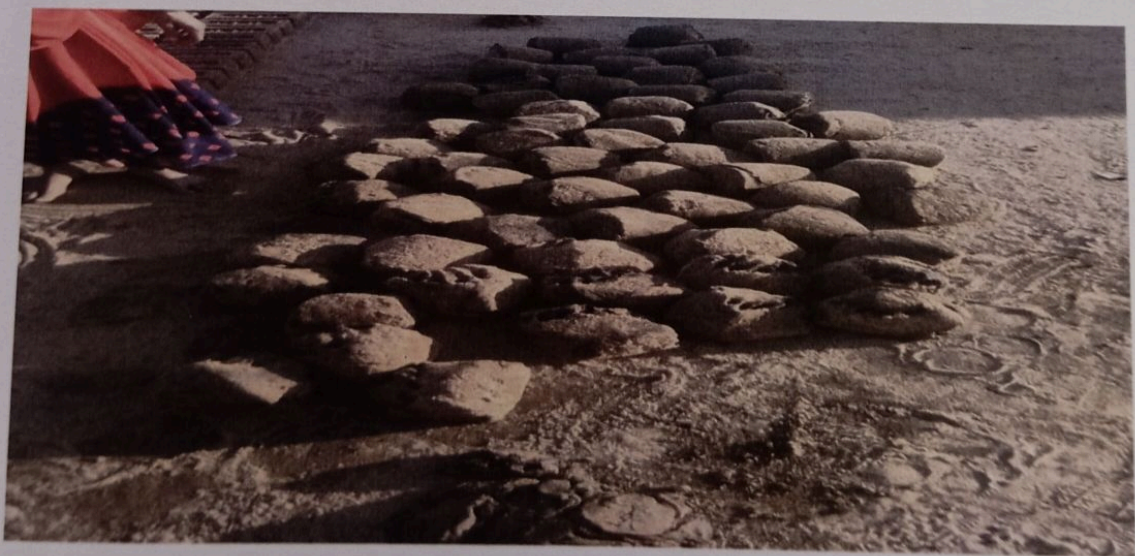

Figure 5: Unmoulded composite of bricks

3.2.3. STEP 3: MOULDING OF THE BRICKS

Transfer the brick composite into the mould, ensuring it is filled evenly and compacted tightly to remove any air pockets. Use a press to apply pressure to the composite, further compacting it into a solid brick shape. Remove the excess mixture from them mould, leaving behind the formed brick. The processed raw materials are then placed into a brick mould or press, which is designed to shape the material into the desired brick size and shape. The mould is designed usually as per the need of the client and industry, made of metal or plastic and can have different configurations to create various brick types, such as solid bricks, hollow bricks, or interlocking bricks.

Figure 6: Moulded bricks including bricks of this study at Mana village, Raipur district, Chhattisgarh

3.2.4. STEP 4: CURING

Place the moulded bricks in a shaded area or cover them with a plastic sheet to protect them from direct sunlight and rain. The bricks are allowed to cure for at least 7-14 days to achieve adequate strength and durability. During this period, the bricks will gradually harden and attain strength through a process called curing. Curing is an essential process in brick formation for several reasons:

Strength: Curing helps to improve the strength and durability of the bricks by allowing them to fully harden and mature. Without proper curing, the bricks may be weaker and more susceptible to get damaged early.

Minimizing cracking: During the curing process, the bricks are exposed to moisture, which helps to prevent cracking and shrinkage. This is especially important in hot and less humid climates, where the bricks may dry out too quickly without proper curing.

Uniformity: Proper curing helps to ensure uniformity in the bricks, both in terms of their physical appearance and their strength. This is important for ensuring that the bricks are suitable for use in construction.

Water absorption: Curing can also help to reduce the water absorption rate of the bricks. This is important because bricks with a high water absorption rate may be more susceptible to damage from freezing and thawing cycles or from exposure to water.

Chemical reactions: During the curing process, chemical reactions take place within the bricks that help to improve their strength and durability. Curing of the bricks, particularly when dealing with concrete or cement bricks, involves several chemical reactions, most notably hydration. Calcium silicate hydrate is primarily responsible for the hardening and strength development of the brick, while calcium hydroxide can react further with carbon dioxide in the air to form calcium carbonate, which also contributes to the hardening process. This series of reactions is essential for the development of durability and structural integrity in the cured bricks. During the curing process, chemical reactions take place within the bricks that help to improve their strength and durability. These reactions can take several weeks to complete, so proper curing is necessary to ensure that the bricks have reached their full strength. Overall, proper curing is essential in brick formation to ensure that the bricks are strong, durable, and suitable for use in construction. Without proper curing, the bricks may be weaker, more susceptible to damage, and less uniform in appearance and strength.

3.2.5. STEP 5: DRYING

Allow the bricks to air dry for several days until they reach the desired moisture content. Avoid rapid drying or exposure to direct sunlight, as it may cause cracks or warping in the bricks.

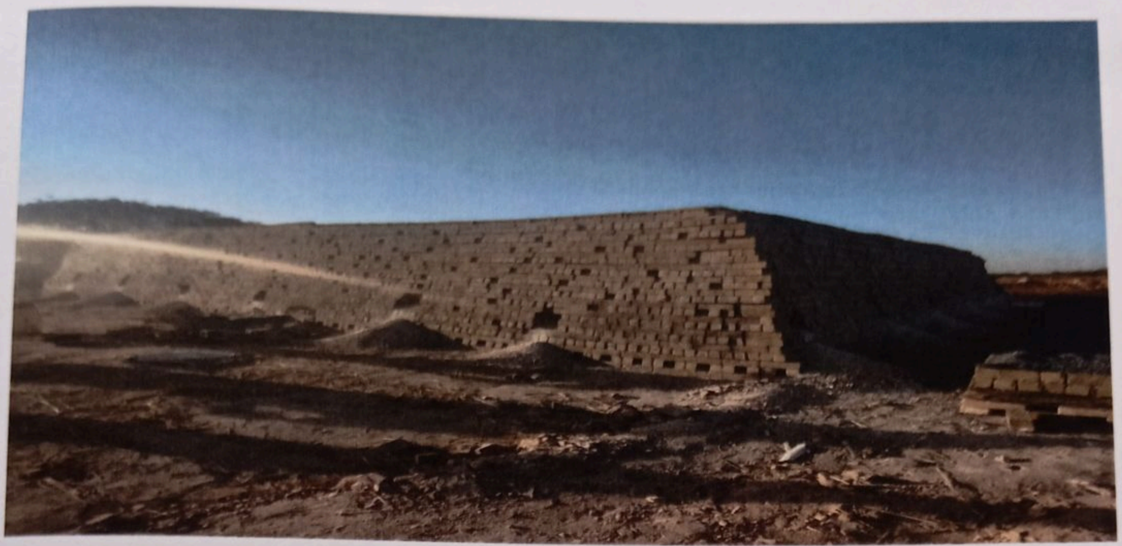

Figure 7: Bricks subjected to the drying process at the Mana village, Raipur district, Chhattisgarh.

3.2.6. STEP 6: FINAL PRODUCT

Once the bricks are completely dry, they are ready for use as a construction material. They can be used for various applications such as building walls, pavements, or other construction projects. It's important to test the final bricks for strength and durability before using them for structural purposes. Testing can be done through compression tests, water absorption tests, and other standard tests to ensure that the bricks meet the desired quality standards.

Figure 8: Finished product of brick of this study at Mana village, Raipur district, Chhattisgarh

3.3. TEST CONDUCTED

3.3.1. WEIGHT MEASUREMENT OF BRICKS

This is a useful tool for ensuring the quality of bricks being produced or used in construction. A brick weight measurement machine is a device used to accurately determine the weight of individual bricks. There are different types of brick weight measurement machines available, but most work by using a scale or balance system to weigh the brick. Some machines may be manual, requiring the operator to place the brick on the scale and manually record the weight. Others may be automated, using sensors or other technology to weigh the brick and record the data automatically. Accuracy is an important consideration when choosing a brick weight measurement machine, as even small deviations in weight can have an impact on the density strength and durability of a brick wall. Additionally, the machine should be easy to use and maintain, with a robust design that can withstand the demands of industrial environments.

Overall, a brick weight measurement machine can be a valuable tool for brick manufacturers and construction professionals, helping to ensure the quality and safety of their work.

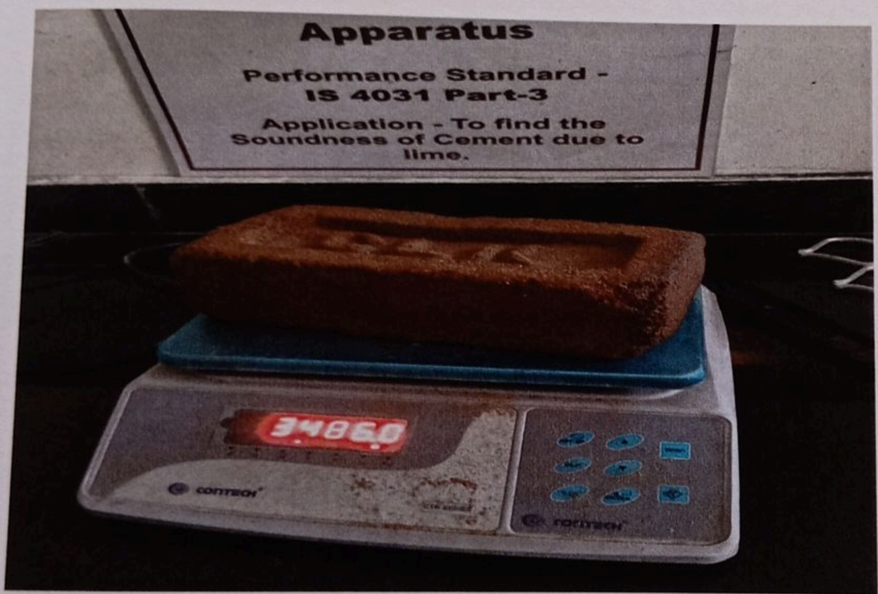

Figure 9: Weight measurement of bricks

Importance of brick weight measurement

Quality control: The weight of a brick is a good indicator of its quality. Bricks that are too light may be weak and prone to cracking or breaking, while bricks that are too heavy may be overly dense and difficult to work with. By measuring the weight of each brick, manufacturers can ensure that their products meet quality standards and are suitable for use in construction.

Estimating material requirements: Knowing the weight of a brick can help contractors and builders estimate the amount of materials needed for a construction project. This is important for ensuring that the right amount of bricks are ordered and that there is enough material on hand to complete the project.

Safety: The weight of a brick can impact the structural integrity of a building. If bricks of varying weights are used, it can result in an uneven load distribution, which may compromise the strength and safety of the structure. By measuring the weight of each brick, builders can ensure that they are using bricks that are uniform in weight and suitable for the project at hand. Overall, measuring the weight of a brick is an important step in ensuring the quality and safety of construction projects.

3.3.2. COMPRESSIVE STRENGTH

A compressive strength testing machine of brick is a device used to determine the compressive strength of bricks. Compressive strength is a measure of a material's ability to withstand compression or crushing, and it is an important property of bricks used in construction. The compressive strength testing machine works by applying a compressive load to a sample brick until it fails. The machine measures the load applied and the corresponding deformation of the brick, which is used to calculate the compressive strength. There are different types of compressive strength testing machines available, but most work by using hydraulic or mechanical systems to apply a load to the brick. Some machines may be manual, requiring the operator to load the brick and apply the force manually. Others may be automated, using computer-controlled systems to apply and monitor the load. To use a compressive strength testing machine of brick, a sample brick is first selected and prepared according to standardized procedures. The brick is then placed between the two plates of the testing machine and a compressive load is applied gradually until the brick fails. The maximum load the brick can withstand is recorded, and this is used to calculate the compressive strength of the brick. Overall, a compressive strength testing machine of brick is a valuable tool for ensuring the quality and safety of bricks used in construction. By testing the compressive strength of bricks, builders and engineers can ensure that they are using materials that meet quality standards and are suitable for the intended application.

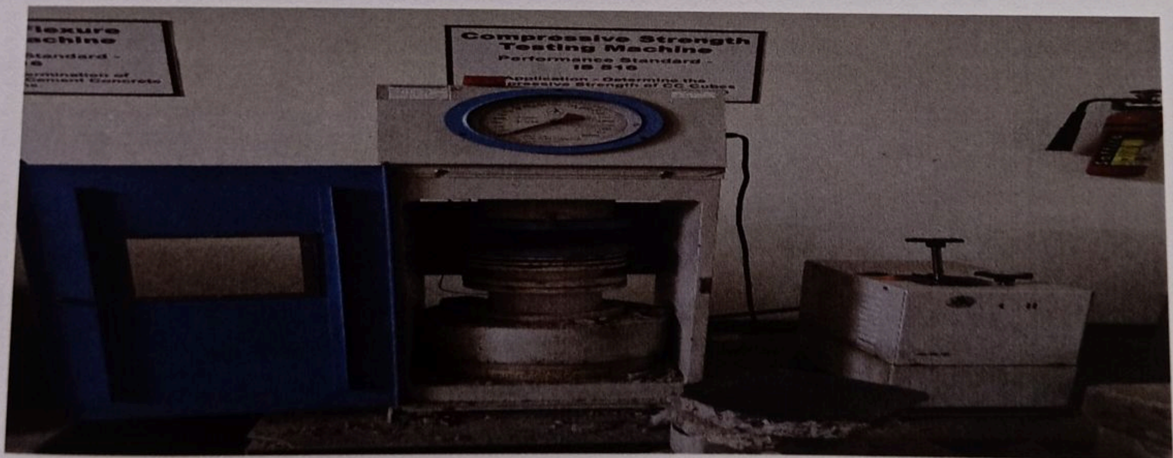

Figure 10: Compressive strength machine at Public Works Department, Tatibandh, Raipur district, Chhattisgarh

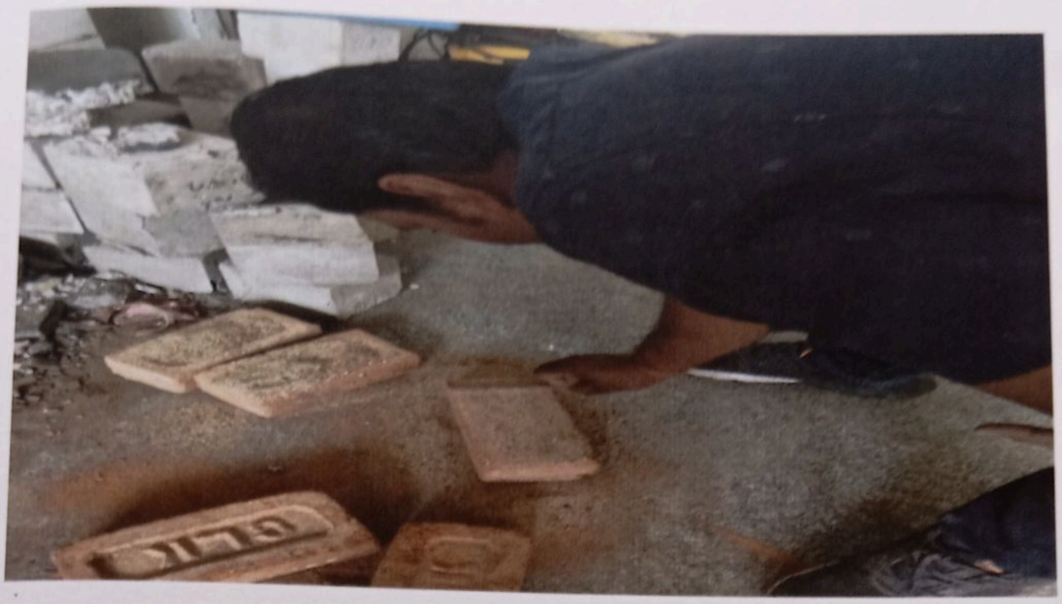

Figure 11: Levelling of bricks prior to being subjected to compressive strength test

Figure 12: Compressive strength measurement at Public Works Department, Tatibandh, Raipur district, Chhattisgarh

Compressive strength calculation:

Compressive strength, C= (W/A)

Where,

W = Caliberated maximum load

A = Average of the gross areas of the upper and lower bearing surfaces of the specimen.

3.3.3. WATER ABSORPTION TEST

Water absorption test is a commonly used test for determining the quality and durability of bricks. The water absorption test of brick involves measuring the amount of water absorbed by a brick when it is immersed in water for a specified period of time.

Process

The water absorption test of bricks is a simple and commonly used method to determine the amount of water absorbed by a brick. The test involves the following steps:

Preparation: Take a dry and clean brick, and weigh it accurately to the nearest gram. Record this weight as the dry weight of the brick.

Immersion: Immerse the brick completely in clean water at room temperature, and keep it submerged for a specified period of time. The most common duration for immersion is 24 hours, but the test may also be conducted for shorter or longer periods depending on the specific requirements.

Removal and wiping: After the immersion period is over, remove the brick from the water and wipe off any excess water from its surface using a damp cloth. The wiping should be gentle, so as not to remove any water that may have been absorbed by the brick.

(a) **Weighing:** Weigh the brick again after wiping, and record this weight as the wet weight of the brick.
(b) **Calculation:** Calculate the water absorption capacity of the brick using the following formula:

Water absorption = ((wet weight - dry weight)/dry weight) x 100

where, **wet weight =** weight of the brick after immersion and wiping

dry weight = weight of the dry brick before immersion

The result is usually expressed as a percentage of the dry weight of the brick.

The water absorption capacity of a brick is an important indicator of its quality and suitability for use in construction. Bricks with high water absorption rates are prone to damage from freeze-thaw cycles, and can also suffer from efflorescence, a white powdery substance that forms on the surface of the brick due to the movement of water through the brick's pores.

Here are some reasons why the water absorption test of brick is important:

Quality control: The water absorption test of brick is an important quality control measure for brick manufacturers. It helps to ensure that bricks produced meet industry standards and specifications. By testing the water absorption capacity of a sample of bricks from a production batch, manufacturers can verify that their bricks have the required water absorption characteristics and are suitable for use in construction.

Material selection: The water absorption test of brick is a crucial factor in selecting the appropriate type of brick for a particular construction project. Bricks with low water absorption rates are preferred for exterior use, as they are less likely to suffer from damage due to freeze-thaw cycles or efflorescence. Bricks with higher water absorption rates may be suitable for interior use or for non-load-bearing walls.

Durability: The water absorption test of brick helps to assess the durability of bricks in different environmental conditions. Bricks with low water absorption rates are less likely to deteriorate over time due to water damage, and are more likely to maintain their strength and appearance for longer periods of time.

Safety: Bricks with high water absorption rates are prone to damage from freeze-thaw cycles, which can lead to the formation of cracks and the eventual collapse of the structure. The water absorption test of brick helps to identify bricks that may pose a safety risk, and ensures that only bricks with adequate water absorption rates are used in construction.

Overall, the water absorption test of brick is an important test for ensuring the quality and durability of bricks used in construction. It helps to identify weak bricks and ensures that only high-quality, durable bricks are used in construction projects.

Figure 13: Water absorption test wherein the bricks are immersed in water for 24 hours

The water absorption test of bricks should be conducted on a representative sample of bricks, and the average water absorption capacity of the sample should be reported. The test should be conducted in a controlled environment, with standard temperature and humidity conditions. The water absorption test of bricks is an important quality control measure for brick manufacturers and is also used by engineers, architects, and builders to select bricks for construction projects based on their suitability and durability.

3.3.4. X-RAY DIFFRACTION (XRD) ANALYSIS

In order to find out the mineral components of lateritic soil they were subjected to XRD analysis. X-ray Diffraction (XRD) is a powerful analytical technique used to determine the crystallographic structure of materials by measuring the diffraction pattern produced when X-rays interact with the sample. This non-destructive method provides valuable information about the crystalline phases, crystal structure, lattice parameters, and orientation of crystallites within a sample. XRD is widely employed in various fields, including materials science, geology, chemistry, and pharmaceuticals, for characterizing solids, powders, thin films, and crystalline surfaces.

Figure 14 : Smart lab Rigaku XRD Machine at Goa University

Principles of XRD:

Bragg's Law:

XRD relies on Bragg's law, which describes the relationship between the angles of incidence and diffraction of X-rays interacting with a crystal lattice. According to Bragg's law, constructive interference occurs when the path difference between X-rays scattered by adjacent crystal planes is an integer multiple of the wavelength of the X-rays.

Diffraction Pattern:

When monochromatic X-rays are directed onto a sample, they interact with the crystal lattice, causing diffraction. The resulting diffraction pattern consists of peaks corresponding to the angles at which constructive interference occurs, providing information about the crystal structure and spacing of atomic planes within the material.

Sample Preparation:

The first step is to prepare the sample for analysis. Depending on the nature of the material, it may need to be ground into a fine powder, homogenized, and mounted onto a sample holder. For solid samples, thin films, or crystalline powders, the surface should be flat and free from irregularities.

Instrument Setup:

Once the sample is prepared, it is mounted onto the sample holder of the XRD instrument. The instrument is calibrated and set up according to the specific parameters of the analysis, including the type of X-ray source (e.g., Cu-Kα radiation), the scanning range (2θ), and the scanning speed.

Data Collection:

The XRD instrument directs a beam of X-rays onto the sample at a specific angle of incidence. The X-rays interact with the crystal lattice of the sample, causing them to diffract in various directions. As the sample holder rotates, the detector records the intensity of diffracted X-rays at different angles (2θ). This process generates a diffraction pattern, typically represented as a plot of intensity versus 2θ.

Data Analysis:

Once the diffraction pattern is obtained, the next step is to analyze the data. This involves identifying the peaks in the pattern, which correspond to specific crystallographic planes within the sample. The peaks are compared to known reference patterns or databases to determine the phases present in the sample. Software programs are often used to assist in peak identification and quantitative analysis. Additionally, the positions and intensities of the peaks provide information about the crystal structure, lattice parameters, and preferred orientation (texture) of the sample.

Interpretation and Reporting:

The final step is to interpret the results of the XRD analysis and report the findings. This may involve discussing the identified phases, their relative abundance, crystallographic parameters, and any notable features or trends observed in the diffraction pattern. The results of the XRD analysis are typically presented in the form of a report, which may include diffraction patterns, peak tables, and interpretations, along with relevant discussion and conclusions.

Overall, X-ray Diffraction (XRD) analysis is a powerful technique for characterizing the structural properties of materials, providing valuable insights into their composition, crystalline phases, and crystallographic parameters.

3.3.5. DETERMINATION OF IRON IN LATERITE SOIL (AAS METHOD)

Laterite soil, renowned for its high iron oxide content, plays a significant role in various applications, including construction, agriculture, and environmental remediation. Determining the iron concentration in laterite soil is crucial for understanding its properties and suitability for specific uses. Atomic Absorption Spectroscopy (AAS) is a widely employed analytical technique for quantifying iron and other trace metals in soil samples. This document provides a detailed overview of the AAS method for testing iron presence in laterite soil.

Principle of Atomic Absorption Spectroscopy (AAS)

Atomization and Absorption:

AAS relies on the principle of atomic absorption, where atoms in the ground state absorb characteristic wavelengths of light when exposed to a light source of the same wavelength. In AAS, a hollow cathode lamp emits monochromatic light at the resonance wavelength of the target element (e.g., iron). This light passes through a flame or graphite furnace, where the sample is atomized into gaseous atoms. The atoms absorb energy from the light source, causing them to transition to higher energy states. The absorption of light at specific wavelengths is measured, and the intensity of absorption is proportional to the concentration of the target element in the sample.

Figure 15 : AAS machine at the chemistry lab of Chemistry department of Pt. Ravishankar Shukla University, Amanaka, Raipur, Chhattisgarh

Quantification:

A calibration curve is established using standard solutions of known iron concentrations. The absorbance of these standards is measured, and a linear relationship between absorbance and concentration is determined. The absorbance of the sample solution is then compared to the calibration curve to quantify the iron concentration in the laterite soil sample. Procedure for AAS Analysis of Iron in Laterite Soil

Sample Preparation:

Laterite soil samples are collected from representative locations and air-dried to remove moisture. The samples are ground to a fine powder to ensure homogeneity and facilitate accurate measurement. A portion of the powdered sample is digested using a suitable acid mixture (e.g., aqua regia) to extract the iron content into solution. The digested sample is then filtered to remove any insoluble residues

Instrument Calibration:

The AAS instrument is calibrated using standard iron solutions of known concentrations covering the expected range of iron concentrations in the laterite soil samples. Calibration standards are prepared by diluting a stock iron solution with a suitable solvent (e.g., deionized water). The absorbance of each standard solution is measured using the AAS instrument.

Analysis of Sample Solution:

The digested sample solution is aspirated into the AAS instrument, where it passes through a nebulizer and spray chamber before entering the flame or graphite furnace. The hollow cathode lamp emits light at the resonance wavelength of iron, and the absorbance of the sample solution is measured. The iron concentration in the sample solution is determined by comparing its absorbance to the calibration curve obtained from the standard solutions.

Data Analysis and Reporting

Calculation of Iron Concentration:

The iron concentration in the laterite soil sample is calculated based on the absorbance measured by the AAS instrument and the calibration curve established from the standard solutions. Results are typically reported in units of weight/volume (e.g., mg/L) or weight/weight (e.g., mg/kg) depending on the dilution factor and sample preparation method.

Quality Control and Assurance:

Quality control measures, such as running blank and standard reference materials, are implemented to ensure the accuracy and precision of the AAS analysis. Instrument performance is monitored through regular calibration checks and maintenance to maintain data integrity and reliability.

Atomic Absorption Spectroscopy (AAS) is a robust and widely utilized method for quantifying iron and other trace metals in laterite soil samples. By accurately determining the iron concentration, AAS analysis provides valuable information for assessing soil fertility, environmental impact, and suitability for various applications. The detailed procedure outlined in this document ensures the reliable and precise measurement of iron presence in laterite soil, contributing to informed decision-making in research, agriculture, and environmental management.

CHAPTER 4

RESULT AND DISCUSSION

4.1. WEIGHT MEASUREMENT (KG)

Result

S.NO.	WEIGHTS OF BRICKS MEASURED (kg)
Brick1	2.65
Brick2	2.6
Brick3	2.4
Brick4	2.55
Brick5	2.7

Table. No. 4. Weight measurement of bricks

Discussion

The weight of bricks is a crucial consideration in construction as it impacts the structural integrity, load-bearing capacity, durability, thermal performance, and acoustic properties of buildings and structures. The bricks were tested in the Public Work Department (PWD), Raipur, Chhattisgarh. The weight of the bricks after testing was found to be around 2.4-2.7 kg which is suitable for construction purpose and was approved by the employee of the PWD. Five representative bricks were prepared whose weights were

4.2. COMPRESSIVE STRENGTH (KG/CM2)

Result

S.NO.	COMPRESSIVE STRENGTH OF BRICKS MEASURED (kg/cm^2)
Brick1	59.37
Brick2	48.58

Table. No. 5. Compressive strength of bricks

Discussion

The compressive strength of the bricks were tested at the Public Work Department located in Raipur, Chhattisgarh .The compressive strength of bricks is essential for ensuring the structural stability, safety, load-bearing capacity, longevity, and quality of construction projects. It is a fundamental parameter that engineers and builders consider when selecting and specifying building materials for various applications. Compressive strength of bricks was found to be 40-70 kg/cm2 which is suitable for construction and was approved by the employee of PWD. Curing of the bricks was done in 14 days, if the bricks were cured in 28 days then the compressive strength would be much better.

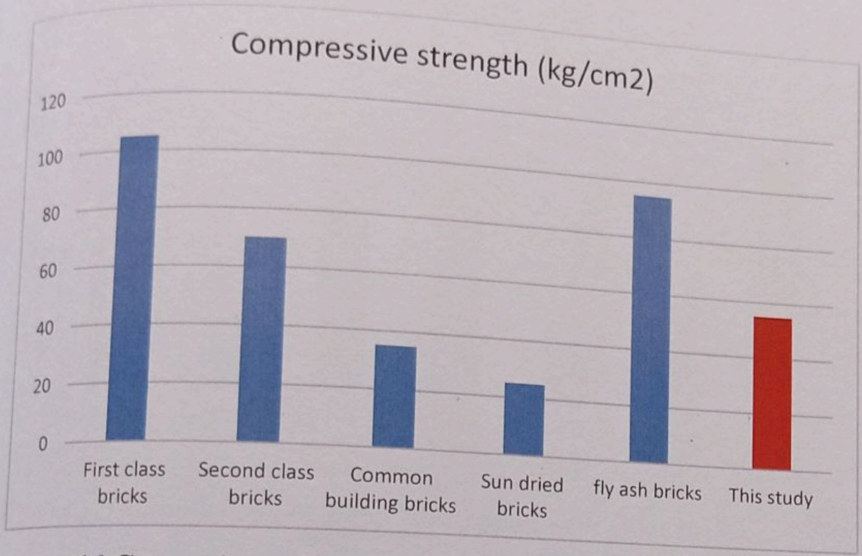

Figure 16:Comparison of compressive strength with other brick

4.3. WATER ABSORPTION OF BRICKS

Result

S.NO.	WATER ABSORPTION OF BRICKS MEASURED IN PERCENTAGE (%)
Brick1	22
Brick2	21
Brick3	22
Brick4	20
Brick5	23

Table. No. 6. Water absorption test of bricks

Discussion

The water absorption of the bricks was tested at the Public Works Department, located in Raipur, Chhattisgarh. The compressive strength of bricks is essential for ensuring the structural stability, safety, load-bearing capacity, longevity, and quality of construction projects. It is a fundamental parameter that engineers and builders consider when selecting building materials for various applications. The water absorption percentage of the bricks was found to be around 20- 23%, which is the optimum percentage for the bricks.

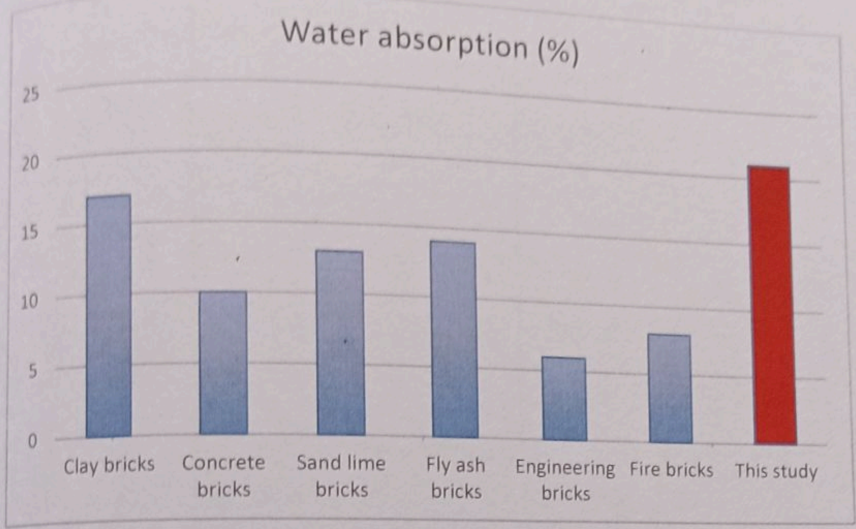

Figure 17: Comparison of water absorption with other bricks.

4.4. XRD ANALYSIS OF LATERITE SAMPLE

Result

PEAK ANGLE	MINERALS
26.6^0	Quartz
12.3^0, 24.8^0	Kaolinite
57.3^0, 62.5^0	Maghemite
36.5^0	Goethite
40.9^0	Hematite
36.0^0, 39.4^0	Calcite
17.7^0, 8.8^0, 26.6^0	Muscovite
20.7^0	Gypsum

Table. No. 7. Minerals found in the laterite soil sample after XRD analysis

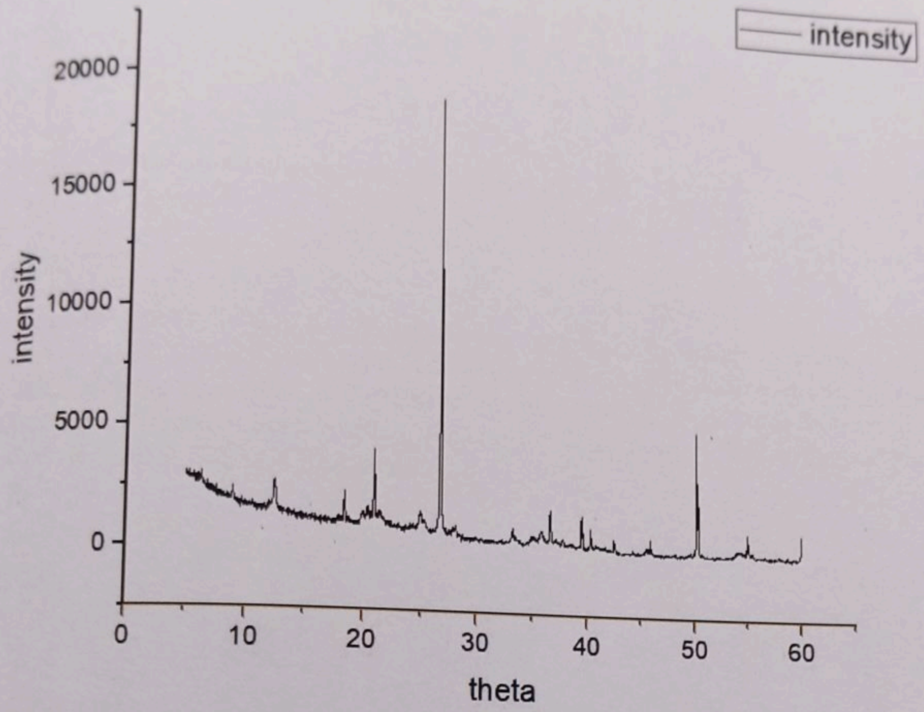

Figure 18: XRD graph

Discussion

The XRD analysis of the laterite soil was performed at the lab of school chemical science of Goa University. XRD analysis of soil plays a crucial role in the making of bricks by providing valuable insights into mineral composition, clay content, particle size distribution, mineral transformations during firing, and quality control. This information guides the selection of raw materials, formulation of brick mixes, optimization of firing processes, and ultimately, the production of high-quality bricks with desired properties.

4.5. DETERMINATION OF IRON IN LATERITE SOIL (AAS METHOD)

Result

S.NO.	SAMPLE ID	Mg/L
1.	Laterite soil	26.54

Table. No. 8. Determination of iron in laterite soil sample

Discussion

Determination of percentage of iron in laterite soil is essential for assessing its suitability for brick-making, establishing its stabilization properties, enhancing brick strength and durability, understanding firing behaviour, and ensuring quality control in brick production processes. This test was performed at the laboratory of chemistry department of Pt. Ravishankar Shukla University, located in Raipur, Chhattisgarh.

CHAPTER 5

CONCLUSIONS

Applying the understanding and inference from the literature review to a practical scenario resulted in the creation of eco-friendly bricks using locally available raw material as well as organic by-products, consisting of laterite soil, rice husk and coconut shell ash. This significantly reduced costs in comparison with conventional bricks. Moreover, this became a sustainable environment technique, as biodegradable waste was reused and utilized in place of conventional materials. If used on a larger scale, use of these bricks might have significant positive impact on the environment.

Through a series of experiments and analyses, these are the key findings:

Firstly, the substitution of laterite soil, rice husk, and coconut shell ash, in making bricks, has shown promising results in enhancing various properties of the bricks. These include improved compressive strength and water absorption. These improvements suggest that these alternative materials can be effectively used to produce durable and high-quality bricks for construction purposes.

Secondly, the utilization of agricultural and industrial by-products such as rice husk and coconut shell ash presents significant environmental benefits. By repurposing these waste materials, we can reduce their environmental impact and alleviate waste management issues. Furthermore, the use of alternative materials in brick manufacturing can help mitigate carbon emissions associated with traditional brick production processes, thus promoting sustainable development in the construction sector.

Thirdly, in terms of economic aspect and comfort,

The individual weight of the brick being 30gms lesser than the conventional brick it will result in cost reduction of any proposed structure either in the case of load bearing structure or frame structure in the case framed structure, the load per running meter of bricks would be 1.5kg lesser per layer of running meter for 2.5 height of the wall.

Another very important property is because of its inherent relatively extra porosity it would behave as a good insulator for cooling of the walls, thereby making the room relatively more comfortable.

Due to the porosity of the brick the load imposed on the beam decreases by 1.5kgs/r m the proportionate decrease by 1.5kgs×2.5(height)=3.75kgs/r m

The load decrease will have no implication (i.e increase or decrease) to the slab.

Since the dead load of the masonary has decreased by 3.75kgs /r m the Moment of resistance will also decrease nominally for small beam spans and appreciably for longer spans since it's calculated using the formula MR= W×l×l/2.

Also the load will transfer from the beams to the columns and thereafter to the footings/spread foundation and since there is a decrease in load to the beams this will proportionately decrease the overall load on the footings/foundation thereby also decreasing the MR (moment of resistance) in every structural member (beam, column and footing) thereby decreasing the steel and overall decreasing the cost. If we compare the cost of the conventional brick and brick of this study then the cost of the conventional brick is around six rupees/brick and the price of the brick of this study is around four rupees/brick, which is cheaper.

Our experiments were conducted under controlled laboratory conditions, and further research is needed to assess the long-term durability and performance of laterite soil, rice husk, and coconut shell ash bricks in real-world applications.

In conclusion, the integration of laterite soil, rice husk, and coconut shell ash in brick manufacturing, could represent a significant step towards achieving environment sustainability.

CHAPTER 6

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