EVALUATION OF RICE HUSK ASH PRODUCTION TEMPERATURE ON PERFORMANCE IN FIRE-BURNT CLAY BRICKS

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A FINAL YEAR RESEARCH AND DESIGN PROJECT REPORT SUBMITTED TO THE FACULTY OF ENGINEERING, DESIGN AND TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A DEGREE OF BACHELOR OF SCIENCE IN CIVIL AND ENVIRONMENTAL ENGINEERING OF UGANDA CHRISTIAN UNIVERSITY

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ABSTRACT

This research examined Rice Husk Ash (RHA) as a stabilizer for fired clay bricks, promoting sustainable construction. It involved determining the physical properties of the soil to be used for making the clay bricks, determining the properties of the rice husk ash formed at varying temperatures and heating durations and assessing the performance of the stabilized fire burnt clay bricks. XRF analysis revealed changes in RHA's chemistry with production temperature (600-800°C). Sieve analysis and Atterberg limit tests determined particle size and workability. Bricks with 10%, 20%, and 30% RHA were fired and tested to understand how RHA firing temperature affects strength and water absorption after pozzolanic activity with clay minerals. The study identified the optimal combination for durable, and water-resistant bricks to be a mix ratio of 1:9 (RHA: Soil) with the RHA produced at 700^0C after 6 hours heating. With this mix, an increase in compressive strength of up to 143.5% was deduced after stabilisation with RHA.

DECLARATION

I, MBUGA SOLOMON MUNYWEEZA (S20B32/044) hereby declare that this is my original work, is not plagiarised and has not been submitted any other institution for any award.

MBUGA SOLOMON MUNYWEEZA

Signature: ….…………………………………. Date: ………………………………………….

APPROVAL

This research project report has been submitted for examination with my approval as the University supervisor.

KASUMBA ANDREW

Signature: ….……………………………………….   Date: ……………………………………………

DEDICATION

I dedicate this report to my mother, Ms. Nansubuga Jane for her never ending and unconditional support throughout my education journey.

ACKNOWLEDGEMENT

The successful completion of this research project would not have been possible without the invaluable support and guidance of several individuals and institutions. This project wouldn't have been the same without my project partner, Lakara Eliud Lotyang's dedication and collaboration. Thank you for your insightful ideas, unwavering support, and willingness to tackle challenges.

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LIST OF ACRONYMS

ACRONYM	DEFINITION
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
BS	British Standard
CSH	Calcium Silicate Hydrates
IS	Indian Standard
ISO	International Organization for Standardization
KN	Kilo Newton
Kg/m^3	Kilogram per cubic metre
N/mm^2	Newtons per square millimetre
NMC	Natural Moisture Content
PI	Plasticity Index
RHA	Rice Husk Ash
UCU	Uganda Christian University
USCS	Unified Soil Classification System
XRF	X-Ray Fluorescence

CHAPTER ONE: GENERAL INTRODUCTION

1.1. BACKGROUND OF THE STUDY

Fired clay bricks have been a fundamental building material for centuries due to their affordability, fire resistance, and wide availability (Smith, 2020). However, conventional bricks produced are prone to failure when exposed to adverse weather conditions. (Belkhir et al., 2020). The main drawback on the use of earthen materials in building and construction is about its durability and strength in the face of the ever-changing climate and environmental factors. (Owoeye et al, 2021)

Conventional brick production relies on extracting and processing natural clay deposits. This can lead to the depletion of these resources in certain regions. (Khan et al., 2014; Asola & Fagbenle, 2016). This research project explores a promising alternative stabilizer for fired clay bricks: rice husk ash (RHA), a readily available, low-cost byproduct of rice processing.

In Uganda, for example, a country with a growing construction sector, the reliance on traditional brick production methods poses a potential threat to the sustainability of clay resources. Additionally, with significant rice production, Uganda generates an abundance of rice husks, a byproduct estimated at 70,000 tonnes annually (Uma et al., 2022).

Pozzolans such as RHA react with calcium hydroxide (lime) in the presence of moisture to form cementitious materials (Mehta & Monteiro, 2014). This characteristic offers the potential to improve two crucial performance aspects of fired clay bricks: compressive strength and water absorption. This research project sought to explore the utilization of rice husk ash to enhance the durability of fired clay bricks in harsh weather conditions. By focusing on improving brick performance and resilience.

1.2. PROBLEM STATEMENT

Fired clay bricks exhibit susceptibility to deterioration in harsh weather conditions (Alam et al., 2015). This deterioration can lead to a decline in a brick's structural integrity and overall performance, potentially compromising the safety and longevity of structures built with them. Therefore, there is a critical need for innovative construction materials that can address the limitations of conventional fired clay bricks, particularly their susceptibility to weather-induced deterioration.

Rice husks are the main by-product from rice milling processes. 350,000 tonnes of rice are milled in Uganda every year and of this, 20-30% is rice husks by weight (Ummah, 2015). 70,000 tonnes of rice husks are produced annually in Uganda, therefore, accounting for them being readily available for alternative use as a pozzolanic material (Apollo Uma et al, 2022).

This research project focused on the impact of thermo-processing temperature on RHA's chemical composition and pozzolanic activity. By understanding this relationship, the results would help to identify the optimal combination of RHA content and firing temperature to produce fired clay bricks with superior strength and minimal water absorption. This would ultimately add to the promotion of sustainable construction practices within Uganda.

1.3. OBJECTIVES OF THE RESEARCH

1.3.1. MAIN OBJECTIVE

To optimise of thermo-processing of rice husk ash as a stabilizer in fire burnt clay bricks.

1.3.2. SPECIFIC OBJECTIVES

1. To determine the physical properties of the soil to be used for making the clay bricks.
2. To determine the properties of the rice husk ash formed at varying temperatures and heating durations.
3. To assess the performance of the stabilized fire burnt clay bricks.

1.4. RESEARCH QUESTIONS

1. What are the physical properties of the selected soil that make it suitable to be used in the making of fired clay bricks?
2. What are the chemical properties of the rice husk ash to be used in the stabilisation of fire burnt clay bricks?
3. What is the optimum temperature that can be used to heat rice husks to form an ash that significantly improves the properties of the fire burnt clay bricks?

1.5. SCOPE OF THE STUDY

1.5.1. Geographical Scope

The rice husk used in this study was obtained from Doho Rice Scheme situated in Butaleja District, Eastern Uganda. The soil used in this study was obtained from Ntawo in Mukono district.

1.5.2. Content Scope

1. The use of thermally processed rice husk ash silica at varying temperatures of 600, 700 and 800 degrees Celsius as a stabilizer in production of fire burnt clay bricks for construction purpose to obtain the optimum temperature at which rice husk ash can be formed to improve the strength properties of the bricks.
2. Carrying out a comparative study between locally produced fire burnt clay bricks and locally produced fire burnt clay bricks with the rice husk ash in terms of physical and mechanical properties.

1.6. JUSTIFICATION

The rice husk ash used was obtained from heating of K98 rice husks locally known as 'Kaiso' at varying temperatures to obtain the optimal temperature at which to heat the rice husks to form the rice husk ash. K98 rice husk ash has about 98% silica content (Ogwang et al, 2021) and 99% silica content (Hossain et al, 2015). This serves as a potent source of amorphous silica (SiO_2) when produced at ranges from 600^0C to 800^0C.

Silica acts as a strengthening agent, enhancing the compressive strength and durability of construction materials. The incorporation of high-silica content RHA can contribute to the overall compressive strength and stability of the bricks. The compressive strength of the burnt clay brick significantly impacts other properties, particularly its resilience and resistance to abrasion (Femi timothy Owoeye, 2021).

Hydration of clay minerals releases calcium hydroxide. (Tuan A. et al, 2019) The silica reacts with this Calcium hydroxide in the presence of moisture to form calcium silicate hydrates (CSH), contributing to the densification of the material and improving its mechanical properties. (Ahsan & Hossain, 2018) The addition of rice husk ash to the mix can positively influence the compressive strength of fired clay bricks. The pozzolanic reaction and the resulting formation of cementitious compounds contribute to the overall strength enhancement.

1.7. SIGNIFICANCE

Fire burnt clay bricks are sustainable, and cost effective as a construction material. The application of rice husk ash silica as a stabilizer in the fire burnt clay bricks is an efficient way of improving the strength and durability of the bricks.

1.8. CONCEPTUAL FRAMEWORK

This research project investigated the potential of thermo-processed Rice Husk Ash (RHA) as a stabilizer in fired clay bricks. The conceptual framework centred on understanding how the thermo-processing temperature of RHA influences its pozzolanic activity and ultimately the performance of the resulting fired clay bricks, considering the interaction between RHA and the soil used in the brick production.

1.8.1. Variables:

Independent Variable: Thermo-processing Temperature of RHA (600°C, 700°C, 800°C). It aimed to explore how varying temperatures during RHA production affect its properties.

Dependent Variables:

1. **RHA Properties**

Chemical Composition using XRF Analysis, which was used to determine the elemental composition of RHA, focusing on silica (SiO_2) content, the crucial component for pozzolanic activity.

2. **Soil Properties**

Particle Size Distribution measured the distribution of soil particles across different size ranges. A well-graded soil mix with a variety of particle sizes can promote better packing density and interaction with RHA.

Atterberg Limits including liquid limit, plastic limit determined the plasticity characteristics of the soil, influencing its workability and ability to bind with RHA during brick formation.

3. **Fired Clay Brick Properties**

RHA Content (10%, 20%, 30%) explored how the amount of RHA incorporated into the clay mix affects the final brick properties.

The firing Temperature, while not the main focus, the kiln firing temperature of the clay bricks was kept constant to isolate the effect of RHA thermo-processing.

The Compressive Strength test measured the maximum force a brick can withstand before failure, indicating its overall strength and stability.

The Water Absorption test measured the amount of water a brick can absorb, influencing its durability against moisture exposure.

1.8.2. Theories Applied:

The Pozzolanic Reaction Theory explains how RHA, rich in silica, reacts with calcium hydroxide present in the clay mixture in the presence of moisture. This reaction forms calcium silicate hydrate (C-S-H) gels, which contribute to the strength and density of the fired brick matrix.

The Sintering Theory describes the process of densification and strengthening of a material (like clay) at high temperatures. The firing temperature plays a role in promoting sintering within the fired brick structure

1.8.3. How Theories Guided the Research

The pozzolanic reaction theory provided the foundation for investigating RHA as a stabilizer. By analysing the impact of thermo-processing temperature on RHA's chemical composition and particle size distribution, the research aimed to understand how these factors influence its pozzolanic activity and potential contribution to the strength of fired clay bricks.

Sintering theory complemented the investigation by highlighting the importance of the firing temperature in densifying the overall brick structure. While firing temperature was kept constant, it indirectly influenced the effectiveness of the pozzolanic reaction by affecting the formation and distribution of C-S-H gels within the fired brick matrix.

By analysing the relationships between these variables and applying the relevant theories, the research project aimed to assess the effectiveness of thermo-processed RHA as a stabilizer in fired clay bricks and identify the optimal combination of RHA content and thermo-processing temperature for achieving strong and durable construction materials.

CHAPTER TWO: LITERATURE REVIEW

This chapter highlights the theories upon which this research is to be based as well as the empirical review of existing which highlights studies carried out by different researchers with regards to fire burnt clay bricks, rice husk ash and other related literature to the research.

2.1. THEORATICAL REVIEW

2.1.1. Fired Clay Bricks

These are bricks produced by moulding raw clay, drying it thoroughly, and then subjecting it to high temperatures (typically exceeding 900°C) in a kiln (Belkhir et al., 2020). This firing process induces important chemical reactions within the clay particles, leading to the formation of new phases that significantly enhance the strength and durability of the final brick product (Mehta & Monteiro, 2014).

When moulded and fired at high temperatures (typically exceeding 900°C), a series of complex chemical reactions occur within the clay particles. These reactions lead to the formation of new phases, including mullite and calcium silicates, which contribute to the strength and durability of the final brick product (Mehta & Monteiro, 2014).

Mehta and Monteiro (2014) describe the complex chemical reactions that occur within clay particles during the firing of clay bricks. Below is a breakdown of these key reactions:

1. **Dehydration**

As the temperature rises during firing, the initial stage involves the removal of chemically bound water molecules from the clay minerals. This process, known as dehydration, typically occurs between 100°C and 500°C (Belkhir et al., 2020).

2. **Decomposition of Carbonates**

Many clays contain carbonate minerals like calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$). During firing, these carbonates decompose, releasing carbon dioxide (CO_2) gas. This decomposition typically occurs between 400°C and 700°C (Belkhir et al., 2020).

3. **Formation of New Phases**

The most crucial reactions involve the formation of new crystalline phases within the clay matrix. These new phases, primarily consisting of mullite ($3Al_2O_3 \cdot 2SiO_2$) and calcium silicates, contribute significantly to the strength and durability of the fired brick. The formation of mullite typically starts around 900°C and continues at higher temperatures (Belkhir et al., 2020).

4. **Sintering**

As the firing temperature increases further, the newly formed phases begin to interact and partially melt, leading to a phenomenon called **sintering.** Sintering promotes grain growth and densification of the brick structure, further enhancing its strength and reducing its porosity (Belkhir et al., 2020).

2.1.1.1. The Brick Manufacturing Process

The brick production involves several key stages which are as follows:

1. **Clay Extraction:** Clay deposits are mined or quarried to obtain clay for brick making. (Khan et al., 2014; Asola & Fagbenle, 2016).

2. **Processing and Preparation:** The extracted clay undergoes crushing, grinding, and sieving to achieve a homogenous composition and desired particle size distribution.

3. **Moulding:** Bricks are formed by shaping the prepared clay mixture using moulds. Traditional methods may involve manual hand-moulding, while automated processes utilize mechanical presses.
4. **Drying:** The moulded bricks undergo a drying stage to remove excess moisture and ensure proper shaping before firing.
5. **Firing:** Bricks are stacked in kilns and fired at high temperatures to induce the chemical reactions that enhance their strength and durability. This stage can be energy-intensive and contribute to air pollution from brick kiln emissions (Belkhir et al., 2020).
6. **Cooling:** After firing, the bricks are gradually cooled to prevent cracking and ensure dimensional stability.

2.1.1.2. Performance Indicators in Bricks

Compressive Strength, which is the ability of a brick to withstand loads without failure is crucial for load-bearing walls and structures (ASTM C618-20, 2020). Water Absorption is also important because excessive water absorption can contribute to reduced durability due to freeze-thaw damage and efflorescence (Wang et al., 2020; Jones & Garcia, 2019). Fire Resistance is also important, but clay bricks exhibit excellent fire resistance, making them ideal for firewalls and fire barriers (Smith, 2020).

2.1.2. Rice husk ash (RHA)

Rice husk ash (RHA) is a byproduct of rice milling, predominantly composed of amorphous silica if produced at temperatures ranging from 600^0C to 800^0C. It has been proven that pozzolanic characteristics make it an attractive option for enhancing construction materials, meaning it reacts with calcium hydroxide (lime) in the presence of moisture to form cementitious materials (Shafigh et al., 2019). By incorporating RHA into the clay mixture, this research aimed to improve the overall performance characteristics of fired clay bricks. Existing studies indicate that RHA can enhance the strength and durability of various construction materials when used as an additional cementitious material (Sata, 2006).

2.1.3. Soils and Clay minerals

2.1.3.1. Atterberg Limits and Their Significance in Brick Making

Atterberg limits remain a crucial set of tests used in soil mechanics to classify fine-grained soils based on their water content and plasticity characteristics. These tests, including the liquid limit, plastic limit, and plasticity index, continue to play a significant role in evaluating the suitability of a soil for brick production (Feng et al., 2018).

The literature highlights the continued importance of Atterberg limits in brick making through several aspects:

Workability and Moulding: Studies emphasize that appropriate Atterberg limits are crucial for optimal brick workability (Akpinar, 2018) Soils with a PI within a suitable range are generally more workable and easier to mould into desired brick shapes during the forming process.

Drying and Firing Behaviour: Literature underscores the importance of Atterberg limits in preventing cracking during drying and firing (Adewuyi et al., 2016). Soils with excessively high PI can experience significant shrinkage and cracking due to excessive water loss during these stages.

Strength and Durability: Studies discuss how Atterberg limits can indirectly influence the final strength and durability of fired bricks (Alderete et al., 2018).

Soils with excessively high or low PI might require adjustments in forming techniques or additives to achieve optimal brick performance.

Optimum Atterberg Limits for Brick Making

The specific optimal range can vary depending on the desired brick properties and clay mineralogy. However, the literature suggests a general range for Atterberg limits suitable for brick making:

Liquid Limit (LL): 30% - 50% (Akpinar et al., 2018; Kumar et al., 2015)

Plastic Limit (PL): 12% - 22% (Akpinar et al., 2018; Kumar et al., 2015)

Plasticity Index (PI): 7% - 18% (Akpinar et al., 2018; Kumar et al., 2015)

2.2. EMPIRICAL REVIEW

2.2.1. Pozzolanic Reaction

The pozzolanic reaction is a chemical process where a siliceous material with low hydraulic activity (meaning it doesn't harden by itself with water) reacts with calcium hydroxide (Ca (OH)2), a hydration product of Portland cement or free lime (CaO), in the presence of moisture to form calcium silicate hydrates (C-S-H) gels. These C-S-H gels possess cementitious properties, contributing to strength development and improved pore structure within the fired clay brick matrix (Fernandez-Jimenez et al., 2006).

2.2.2. RHA as a Pozzolanic Material

Rice husk ash is a byproduct generated during rice milling, primarily composed of silica (SiO_2) with varying amounts of alumina (Al_2O_3), iron oxide (Fe_2O_3), and other oxides (Shafigh ethanol., 2019). The amorphous nature of silica in RHA allows it to readily react with Ca $(OH)_2$, promoting the pozzolanic reaction (Boucherie et al., 2011).

Table 1: The percentage of silica in rice husk ash compared to other stabilizers (Source: Chindaprasirt P,2008)

MATERIAL	SiO_2%	Al_2O_3%	Fe_2O_3%	CaO%	MgO%	Na_2O%	K_2O%
Rice Husk Ash	93.2	0.4	0.1	1.1	0.1	0.1	1.3
Bamboo Leaf	75.9	4.13	1.22	7.47	1.85	0.21	5.62
Wheat straw	73	3.9	1.75	8.12	2.8	-	-
Sugarcane Bagasse	72.74	5.26	3.92	7.99	2.78	0.84	3.47
Sawdust	67.20	4.09	2.26	9.98	5.8	0.08	0.11
Corn Cob	66.38	7.48	4.44	11.57	2.06	0.41	4.92
Oil Palm Shell	63.6	1.6	1.4	7.6	3.9	0.1	6.9
Sugarcane straw	59.06	4.75	3.18	19.59	2.25	0.73	4.75
Vetiver grass	57.48	3.73	1.71	5.45	1.24	0.12	15.49
Sewage sludge	50.6	12.8	7.21	1.93	1.48	0.32	1.70
Paper mill sludge	25.7	18.86	0.87	43.51	5.15	1.56	1.31

2.2.3. Impact of RHA on Fired Clay Brick Properties:

Several studies have investigated the influence of RHA incorporation on fired clay brick performance:

Compressive Strength: The compressive strength of the burnt clay brick significantly impacts other properties, particularly its resilience and resistance to abrasion. (Femi timothy Owoeye, 2021) Studies by Bouzid et al. (2014) and Wardhana et al. (2012) demonstrate that incorporating RHA in fired clay bricks can lead to increased compressive strength compared to control bricks without RHA. This is attributed to the formation of additional C-S-H gels that contribute to a denser and stronger brick matrix.

Water Absorption: Water absorption refers to the amount of water a brick can take in. Excessive water absorption can lead to reduced durability from freeze-thaw damage (Wang et al., 2020), increased efflorescence (surface deposits) (Jones & Garcia, 2019), and decreased thermal insulation (Li et al., 2018). Therefore, optimizing for both strength and water absorption is crucial for producing high-quality, long-lasting clay bricks.

Research by Demir et al. (2011) and Uysal et al. (2010) suggests that RHA can contribute to a reduction in water absorption by fired clay bricks. The pozzolanic reaction fills pores within the brick structure, resulting in a less permeable material.

Durability: Studies by Hamad et al. (2014) and Rao et al. (2016) indicate that RHA incorporation can improve the freeze-thaw resistance and sulphate resistance of fired clay bricks. The denser microstructure due to the pozzolanic reaction enhances the brick's ability to withstand harsh environmental conditions.

2.2.3.1. Considerations in RHA use as a pozzolan

While RHA offers promising benefits for fired clay brick performance, some challenges need to be addressed:

Determining the optimal amount of RHA for incorporation is crucial. Excessive RHA content can lead to delayed strength development or even strength reduction (Boucherie et al., 2011).

The pozzolanic reaction rate and the properties of the formed C-S-H gels are influenced by firing temperature. Optimizing firing profiles for RHA-containing bricks may be necessary (Demir et al., 2011).

In summary, the empirical evidence suggests that incorporating RHA in fired clay brick production can be a viable approach to improve durability through the pozzolanic reaction. However, careful consideration of RHA dosage and firing temperature is essential to achieve optimal results. Further research needs to be done on the optimum temperature and dosage of rice husk ash to be incorporated in brick making.

2.2.4. Silica Properties

The effectiveness of rice husk ash in enhancing compressive strength is often attributed to its high silica content. Silica reacts with lime to form calcium silicate hydrate (C-S-H) gel, which is responsible for the binding and strengthening of the material. (Hossain, K. M., 2011)

The specific conditions of the pozzolanic reaction, including the proportion of rice husk ash used, curing conditions, and the quality of materials, play a crucial role in determining the extent of strength improvement. (Mehta, P. K., 2014)

Mehta and Monteiro's book on concrete properties and materials discusses the importance of the proportion of supplementary cementitious materials, including pozzolans like RHA. It highlights the need for careful consideration to avoid issues such as excessive retardation of setting.

2.3. RESEARCH GAP

In the previous research, the rice husks have been heated to varying temperatures ranging from 600 to 800^{o}C to form amorphous silica depending on the publication and used in various research project work like stabilization of expansive soils among others. However, no specific temperature has been researched on to provide the highest levels of improvement in stabilised material.

This research study sought to identify the optimum temperature at which rice husk ash should be thermally processed to provide the highest improvement in fire burnt clay brick production.

CHAPTER THREE: METHODOLOGY

This chapter describes the experiments and techniques that were employed to gather the necessary information for this study to achieve the specific objectives.

3.1. METHODS

3.1.1. Determining the physical properties of the soil to be used for making the clay bricks

A sieve analysis test was done to determine the particle size distribution within the soil sample from the Ntawo brick making site in Mukono district according to BS 1377: Part 2 1990. Atterberg limit tests were then done to determine the liquid limit, plastic limit as well as the Plasticity index according to BS 1377: Part 2 1990.

3.1.1.1. Sieve Analysis

A disturbed soil sample was collected from Ntawo brick making site located in Mukono district. The natural moisture content of the soil was determined to be 53.6% using a moisture meter. It was then packed in well closed polyethene bags and transported to the laboratory for testing.


Figure 1: Using a moisture meter to obtain NMC


Figure 2: Sealing of soil samples in polyethene bags

Preparation of the sample using this test involved soaking the soil sample for 24 hours, then wet sieving with the 0.075mm and 0.425mm sieves. After oven-drying, the dry weight of the sample was measured. Dry sieving was then done with sieves ranging from 0.075mm to 75mm. The sieving results were tabulated along with the percentage retained and the percentage passing through each sieve size. The summary of results obtained from the sieve analysis were as follows:

Table 2: Sieve analysis results

Sieve size	75 mm	50 mm	37.5 mm	20.0 mm	10.0 mm	6.3 mm	5 mm	2 mm	1.18 mm	600 µm	425 µm	300 µm	212 µm	150 µm	75 µm
Percentage passing (%)	100	100	100	100	100	100	100	99	97	91	87	82	77	71	63

The particle size distribution chart was plotted to demonstrate the soil fractions of Gravel, sand and Clay/silt. The results are attached in appendix B.


Figure 3: Dry sieving


Figure 4: Washing the soil sample (wet sieving)

3.1.1.2. Atterberg Limit Tests

The Atterberg limit test was carried out on 19/01/2024 at Teclab laboratory according to BS 1377: Part 2 1990. The cone penetrometer method was used. The essence of the test was to determine the state of the soil at different moisture content. It included finding the liquid limit, plastic limit and plastic index. The state in which the soil exists (solid, semi-solid, plastic and liquid) is dependent on the amount of moisture in the clay soil.

The liquid limit is the moisture content at which soil behaviour changes from plastic to liquid. The plastic limit is the moisture content at which a soil changes from dry to plastic. These can then be used to find the plasticity index which describes the range in which a soil and in this context clay soil exists as plastic.

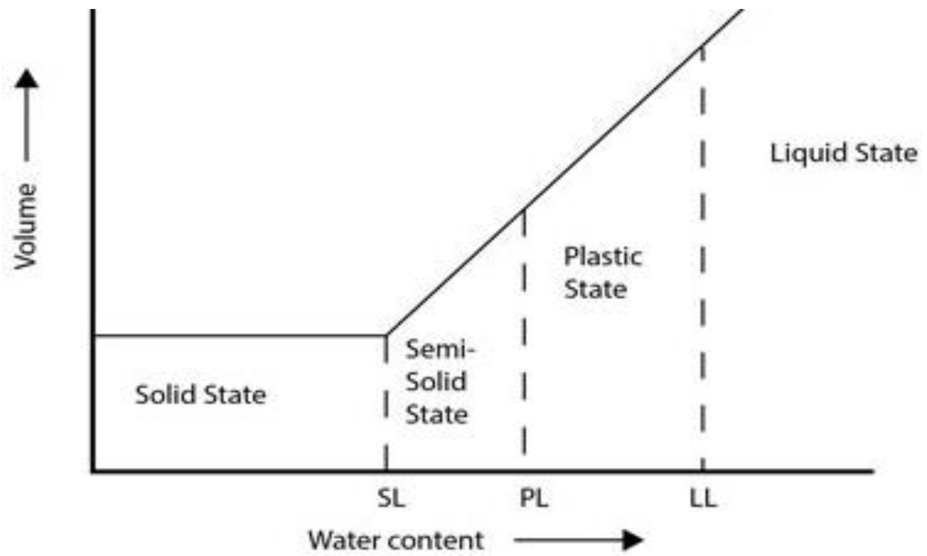

Figure 5: Atterberg limits (Source: Properties and behaviour of soil- Online Lab Manual by MD Sahadat Hossain, Ph.D, 2021)

During sample preparation, the soil was air dried for 7 days. The sample was then crushed using a motor and crucible to form fine particles passing sieve of 0.425mm. A smooth paste was made with the soil and then stored for in an airtight bag for 24 hours. The cone penetrometer method was then used to determine the liquid limit, and plastic limit.

Figure 6: Crushing the soil to form fine particles

Figure 7: Making a soil paste for cone penetration

The test for the Liquid limit was used to determine the soil that passes from the liquid state to the plastic state. It also identified and classified fine grained cohesive soils using the cone penetrometer method. The results obtained are attached in appendix B.

The test for the plastic limit established the moisture content at which a soil becomes too dry to be plastic. The liquid limit and plastic limit provided a means of determining the plastic index of the soil. The greater the plastic index the finer the soil. The summary of results obtained were as follows:

Table 3: Atterberg limits results

ATTERBERG LIMITS			
LL (%)	PL (%)	PI (%)	LS (%)
35.8	13.54	22.2	7.429

The shrinkage limit establishes the point at which the soil stops to decrease in volume with decrease in moisture content. It is at this point that the soil transforms from semi-solid to solid state. The shrinkage limit was obtained by putting saturated soil samples in metallic columns in duplicates.

The sample was air dried for 24 hours and then oven dried for 24 hours. The linear shrinkage was obtained as a percentage from the difference between initial length and oven dried length expressed as a percentage of the initial length of the sample. The summary of results obtained for shrinkage limit were as follows:

Table 4: Shrinkage limit results

Mould No.	L04	L05
Initial length, *Li* (mm)	140.0	140.0
Oven dried length, *Lf* (mm)	129.7	129.5
Linear shrinkage (%)	7.36	7.50
Average (%)	7.43	

3.1.2. Determining the properties of the rice husk ash formed at varying temperatures and durations

X-ray fluorescence (XRF) spectroscopy was carried out at the Government Analytical laboratory on 02/02/2024 according to ASTM D5381-93 (2021) to determine the chemical composition of samples of the K98 rice husks obtained from Doho Rice Scheme. The samples had been heated at 1 hour and 6 hours which showed the effect of heating time with regards to the silica content in the ash. The following steps were followed:

1. Preparing the RHA Sample: The analysis was initiated by conditioning the RHA. This involved ensuring the ash was free from any moisture by adequately drying it. Subsequently, the ash was pulverized to achieve a consistent powder form. This homogenization was crucial for reliable analysis.

2. XRF Instrument Calibration: Prior to analysing of RHA samples, it was essential to calibrate the XRF spectrometer. Standard samples with a known elemental makeup were used to adjust the instrument. This step was vital to guarantee the precision of the spectrometer's readings for subsequent analyses of unknown samples.

3. Conducting the Measurement: The prepared RHA sample was placed into the spectrometer. The device bombarded the sample with X-rays, prompting the emission of secondary X-rays from the elements within the sample. These secondary X-rays are unique to each element, providing a means to identify and quantify the elements present in the RHA.

4. Analysis of Data: The spectrometer captured the emitted X-rays and quantified them. Software associated with the spectrometer interpreted these measurements, identifying each element based on the energy of the emitted X-rays and calculating their concentrations within the sample. This sophisticated analysis allowed for a comprehensive breakdown of the sample's elemental composition.

5. Results Interpretation and Compilation: The final phase involved deciphering the analysis outcomes. The XRF technique furnished a detailed elemental

composition of the RHA, elucidating the concentrations of primary, secondary, and trace elements. This compositional insight is instrumental for evaluating the material's properties and its viability for various applications. The results obtained are attached in appendix B.

Figure 8: RHA produced at 600 degrees Celsius

Figure 9: RHA produced at 700 degrees Celsius

Figure 10: RHA produced at 800 degrees Celsius

3.1.3. Assessing the performance of the stabilized fire burnt clay bricks

Percentages ranging from 0% to 30% of RHA in the soil were used to make fired clay bricks. The RHA had been produced at varying temperatures (600, 700 and 800^{0}C). The tests for **water absorption** according to IS 3495- PART 2 1992 & BS EN 771-1:2003, and **compressive strength tests** were then done in triplicates according to IS 3495- PART 1 1992 & BS EN 771-1:2003. The fired clay bricks were cured for 28 days under a shade and then fired in a kiln with a temperature of 1100^{0}C.

3.1.3.1. Compressive Strength Test

This test was carried out on 25/01/2024 at Teclab laboratories with reference to BS EN 12390:2019 and IS 3495-Part 1: 1992. This test was used to determine the maximum amount of pressure each brick was able to withstand before failure. The nominal dimensions of the bricks were measured and then the mass of the bricks was measured using a balance so as to calculate the density of each block. In this test, the compression testing machine was used to apply pressure on each brick axially at a uniform rate of 14N/mm2 (140kg/cm2) per minute till failure occurred.

Figure 11: Compressive strength test

The procedure for the test was as follows:

1. The test started by measuring the brick's size and finding its weight with an electric scale to calculate its density.
2. The brick was then placed between the plates of a compression testing machine with its flat sides horizontal and the mortar-covered sides facing up.
3. Weight was gradually added to the brick until it failed. The maximum weight it can bear before failing gives us the compressive strength of the brick.

The tests for compressive strength of neat earth bricks were carried out and the results obtained were as shown below:

Table 5: Compressive strength test results summary for neat bricks

Sample ID	Weight of sample (kg)	Density of sample (Kg/m^3)	Failure load (KN)	Corrected failure load (KN)	Compressive strength (N/mm^2)
1	3.78	1890	42.1	41.9	2.1
2	3.96	1980	45.2	45.0	2.3
3	4.01	2000	49.0	48.8	2.4
	Average compressive strength				**2.3**

The compressive strength test was then carried out for stabilised fired clay bricks, with the bricks produced with percentages of RHA in the soil ranging from 10% to 30% for each heating temperature from 600^{0}C to 800^{0}C. The results obtained are as shown in appendix B.

3.1.3.2. Water Absorption Tests

This test was carried out on 25/01/2024 at Teclab laboratories in reference to BS EN 771-1:2003 and IS 3495-Part 2: 1992. It is used to determine the ability of the block to resist water absorption when immersed in water for at least 24 hours.

The procedure used for this test was as follows:

1. The individual sample bricks were weighed and then dried in an oven at 105°C for 24 hours to remove all moisture that was measured at the start of the process using a moisture meter.
2. After removing the samples from the oven and letting them cool, they were weighed again to find their dry weight.
3. They were then fully immersed in water for 24 hours.

4. After 24 hours, their surfaces were dried with an absorbent cloth until there was no visible water left, and weighed again.
5. The difference in weight between the dry and wet samples showed how much water each brick had absorbed.

$$\text{Water Absorption} = \left(\frac{W_w - W_d}{V}\right) \times 100 \quad (1)$$

where: W_w = weight of wet block; W_d= weight of dry block; V= volume of block

The water absorption test was carried out for the neat bricks and the following results were obtained:

Table 6: Water absorption test results

Sample ID	Weight of sample before soaking (kg)	Weight of sample after soaking (Kg)	Mass difference (Kg)	Water absorption (%)
1	4.49	5.05	0.6	12.5
2	3.99	4.51	0.5	13.0
3	3.98	4.59	0.6	15.3
	Average water absorption			**13.6**

The test was then carried out for stabilised fired clay bricks, with the bricks produced with percentages of RHA in the soil ranging from 10% to 30% for each heating temperature from 600^0C to 800^0C. The results obtained were as shown in appendix A01.

3.1.4. Mix Design

The manufacturing of the fired clay bricks adhered to the ASTM 1633-00 Stabilization standard and the BS EN 771-1 standard for clay masonry units. The mix design methodology primarily emphasizes the brick's strength over a specific duration.

The design mix featured thermally processed rice husk ash, subjected to different temperature ranges from 600 to 800˚C. The batching process was based on volume.

Percentages of RHA ranging from 10%, 20% to 30% were used with the soil and tested. In addition, a control mix served as a reference, comprising solely of soil in the fired clay bricks. All tests were conducted in triplicates for accuracy and reliability.

Table 7: Summary of methodology

OBJECTIVE	**TEST**	**STANDARDS**
1	Sieve analysis	BS 1377: Part 2 1990
	Atterberg Limits	BS 1377: Part 2 1990
2	X-ray fluorescence (XRF) spectroscopy	ASTM D5381-93 (2021)
3	Compressive strength test	BS EN 771-1:2003
	Water absorption tests	BS EN 771-1:2003

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presents the results obtained from the methodology conducted for this project. The results are presented in a logical order, with figures, tables, and graphs used to illustrate key observations. Following the presentation of the results, it discusses their significance in the context of brick making and existing knowledge. It involves analysis of the findings, identifying any trends or patterns, and explaining how they relate to the initial research objectives.

4.1. Determining the physical properties of the soil to be used for making the clay bricks

4.1.1. Sieve analysis

This test was carried out on 18/01/2024 at Teclab laboratory according to BS 1377: Part 2 1990 standards. This test established the particle size distribution of the soils. Particle size distribution classified the soils; whether the soil consists of mainly gravel, sand, silt or clay size particles. The particle size distribution obtained is as shown below:

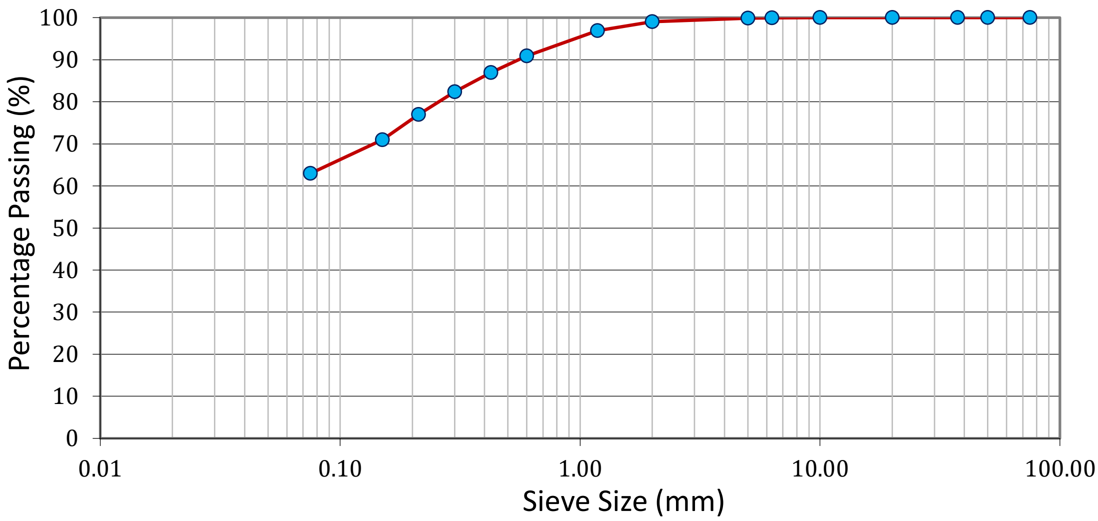

Figure 12: particle size distribution of soil obtained from Ntawo site

The soil sample contains a mix of fine to medium particles, with sizes ranging from 0.425 mm to 6.3 mm. A majority of the sample's particles are finer, as indicated by the high cumulative passing percentages for smaller sieve sizes. The presence of finer particles like silt or clay is beneficial for brick making by contributing to binding properties between particles.

A 62.9% composition of clay is observed. The clay in the soil allows the brick to be moulded and attain shape due to plasticity. It also binds the components within the brick. There is a 37% composition of sand. This sand composition lessens the shrinkage due to drying and firing in the brick. It also provides structure to the brick. The quantity of gravel of 0.1% is very small. The importance of gravel is negligible in the concept of brick making.

4.1.2. Atterberg Limits

The test was carried out on 19/01/2024 at Teclab laboratory according to BS 1377: Part 2 1990. The cone penetrometer method was used. It involved tests to determine the shrinkage limit, liquid limit and plastic limit which were obtained and then used to obtain the Plasticity index of the soil particles.

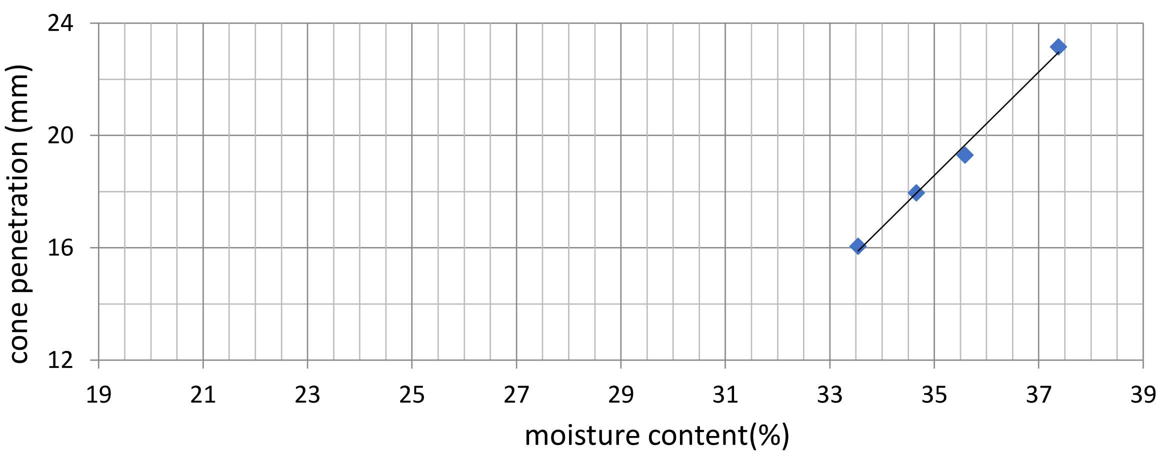

Figure 13: Atterberg limits flow curve

Reading off the 20mm cone penetration from the curve above, it shows that the liquid limit was 35.8%

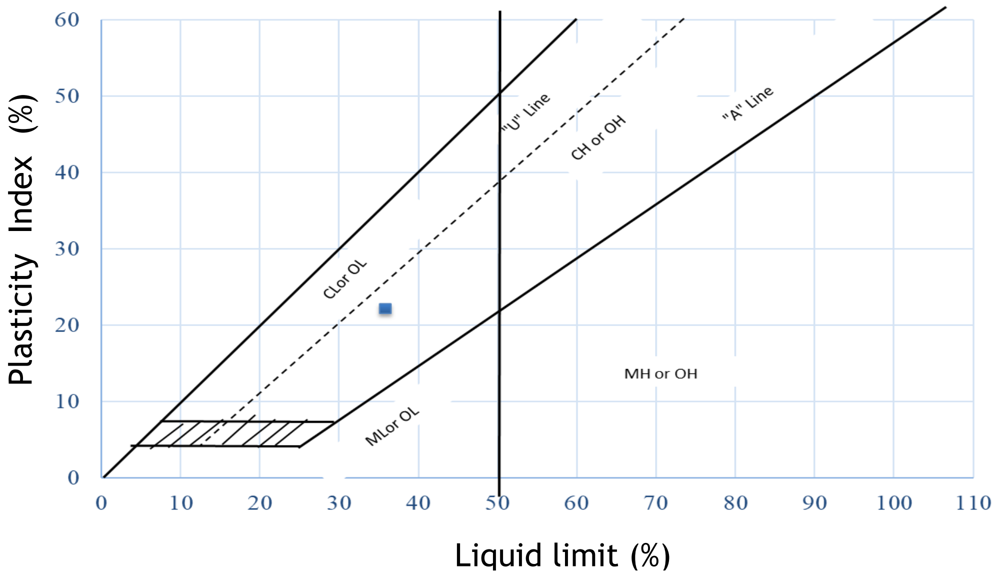

Figure 14: USCS Plasticity Chart for the soil

From the chart above, the nature of clay soil was determined to be Clay soils of low plasticity, which shows that the soil has a moderate workability. These soils tend to shrink less when exposed to drying conditions as compared to higher plasticity clay soils thus showing that they have good stability to withstand kiln firing temperatures. With the use of AASHTO classification for fine grained soils, it was classified as **Sandy lean clay**.

The liquid limit and plastic limit give an idea about the plasticity of the soil. This then demonstrates its workability and susceptibility to shrinkage. The value of liquid limit obtained, which is 35.8% is a moderate value, this shows that the soils require a moderate amount of water in the mix to become workable.

A lower plastic limit as obtained (13.54%) allows for more stability of the bricks during their production. They are more resistant to cracking and shrinkage during firing. It is recommended a value between 10% to 25% according to literature reviewed in earlier chapters.

The plasticity index obtained (22.2%) is a high value. It indicates the moisture content range through which the soil sample would exhibit plastic characteristics. These characteristics enable the soil to be workable over a longer range of moisture content and thus being suitable for brick making. A higher plasticity index allows for good workability during the production of the bricks, since the soil can easily be moulded into required shapes and sizes.

4.2. Determining the properties of the rice husk ash formed at varying temperatures and durations

4.2.1. X-ray fluorescence (XRF) spectroscopy

X-ray fluorescence (XRF) spectroscopy was carried out at the Government Analytical laboratory on 02/02/2024 according to ASTM D5381-93 (2021) to determine the chemical composition of the rice husks produced at varying temperature (600^{0}C to 800^{0}C).

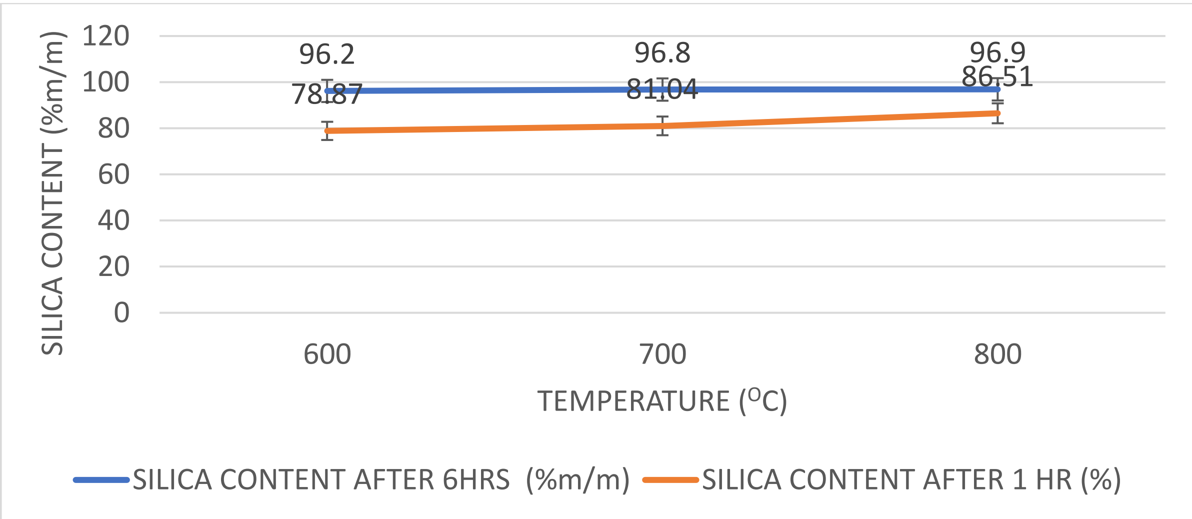

Figure 15: Variations in silica content in rice husk ash with variations in heating duration

As shown in the graph above, the silica content is observed to increase significantly from a range of 78.87% to 86.51% with increase in temperature, to a range of 96.2% to 96.9% with temperature after the heating duration was increased from 1 hour to 6 hours. With this, the heating duration of 6 hours was adopted for production of the RHA that was used in this research and design project.

As shown in the line graph below, silica content in the ash increased with increase in temperatures with a constant heating duration of 6 hours. The temperature range shown on the graph allowed for the formation of amorphous silica, but beyond this range, crystalline particles started to appear. Therefore, the research focused on the temperature range of 600 to 800 degrees Celsius, with the maximum silica content achieved at 800 degrees Celsius.

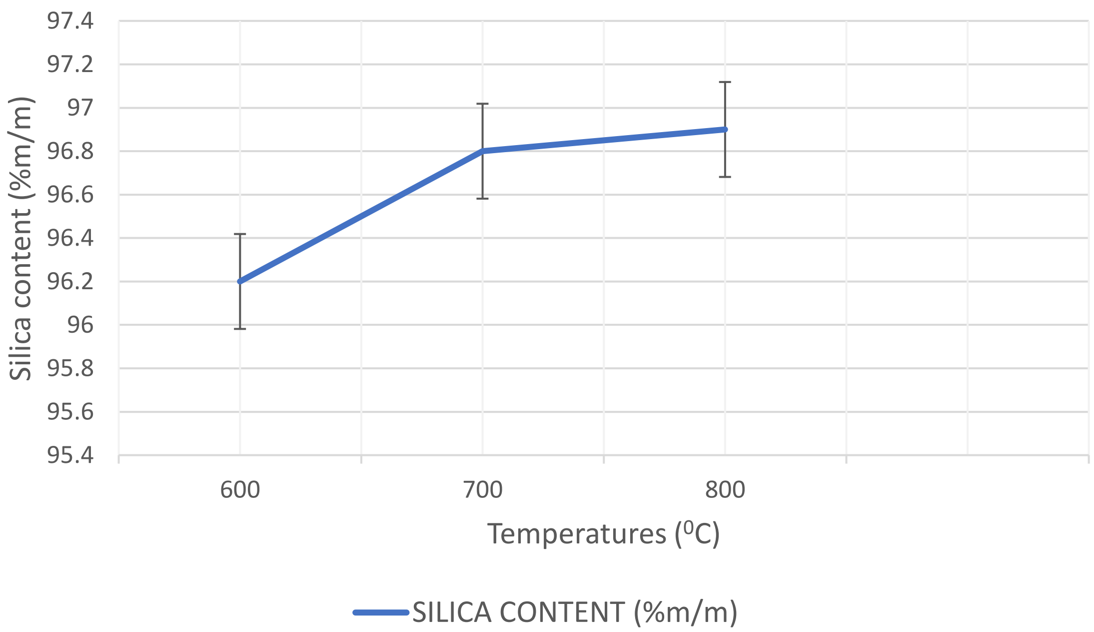

Figure 16: Variations in silica content in rice husk ash with variations in temperature after 6 hours heating duration

There is a higher increase in silica content from 600^0C to 700^0C compared to the increase registered from 700^0C to 800^0C. The observation of a rise in silica content in rice husk ash (RHA) after heating at higher temperatures (600˚C, 700˚C, and 800˚C) compared to lower temperatures is a well-established phenomenon. Rice husks are primarily composed of organic materials like cellulose and lignin, along with inorganic components, most notably silica (silicon dioxide, SiO_2) (Abdullah & Sulaiman, 2011).

During heating, the rice husks undergo thermal decomposition. Below 600˚C, Lower temperatures primarily cause the decomposition and burning off of organic matter (cellulose and lignin), leaving behind some residual carbon (Ahmad et al., 2016). Above 600˚C. As the temperature increases, the remaining organic matter decomposes further, concentrating the inorganic silica component in the ash (Chia et al., 2018).

This is because as this temperature increases, the formation of silica is reducing attributed to the phase change from amorphous to crystalline as the temperature increases at this stage, rather than formation of more silica. The observed increase in silica content in the XRF analysis aligns with the expected behaviour of rice husk ash during thermal decomposition. As the organic matter burns off at higher temperatures, the proportion of the remaining silica component increases, leading to a higher measured percentage of silicon (Si) by XRF.

4.3. Assessing the performance of the stabilized fire burnt clay bricks.

4.3.1. Compressive Strength Test

This test was carried out on 25/01/2024 at Teclab laboratories with reference to BS EN 12390:2019 and IS 3495-Part 1: 1992. In this test, the compression testing machine was used to apply pressure on each brick axially at a uniform rate of 14N/mm^2 (140kg/cm^2) per minute till failure occurred.

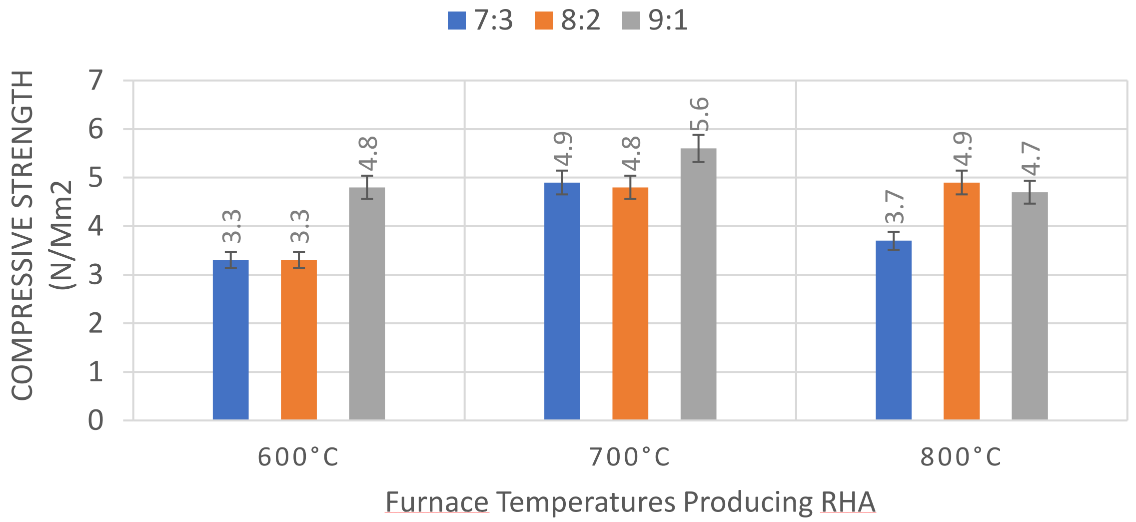

Figure 17: compressive strength of the stabilized bricks

The average compressive strength of the neat earth bricks was obtained as 2.3N/mm^2. This is below the range of 3.5N/mm^2 and 7N/mm^2, which is standard for the burnt clay bricks in accordance with the BS 3921. This therefore necessitates the need to improve the compressive strength of the brick.

The graph above shows the compressive strength obtained for bricks produced with rice husk ash (RHA) produced at 600, 700 and 800 Degrees Celsius. The ratios of RHA: Soil used in the production were varied from 1:9, 2:8 and 3:7 for each firing temperature. Batching by volume was used in the production.

There is a substantial increase in compressive strength of the bricks produced compared to the neat bricks, providing a minimum compressive strength of 3.3N/mm^2 (produced at 600^{0}C with mixes of 7:3 and 8:2 Soil: RHA ratio) compared to that of neat bricks.

The compressive strength of the burnt clay brick significantly impacts other properties, particularly its resilience and resistance to abrasion. (Femi timothy Owoeye, 2021)

From the results, it is noted that 5.6 N/mm^2 is the highest value of compressive strength and it is derived from the bricks with **9:1 ratio of soil to RHA**. With the husks produced at **700^0C**. There is a reduction in the strength for this particular temperature as the Soil: RHA ratios are increased to 8:2 and 7:3 providing values of 4.8N/mm2 and 4.9N/mm2 respectively. This is attributed to the brittleness of the brick with increase in the proportions of the fine RHA material in the mix.

Higher production temperatures lead to a partial melting or agglomeration of RHA particles, resulting in a coarser texture with a lower overall surface area. The higher temperatures are also attributed to the transformation of the RHA from amorphous to crystalline silica. The increase in proportions of RHA from 9:1 to 8:2 Soil: RHA ratio with RHA produced at 800^0C exhibits an increase in compressive strength of bricks produced from $4.7N/mm^2$ to $4.9N/mm^2$, then a decrease to $3.7N/mm^2$ was registered.

The coarser texture associated with the higher heating temperatures is attributed to have led to them requiring higher amounts of RHA (8:2 Soil: RHA ratio) to form a brittle brick. However, they as well produce an increase in compressive strength for smaller RHA proportions because of pozzolanic activity of the RHA silica and clay minerals.

4.3.2. Water Absorption test

According to the BS 3921 and IS standards, the bricks are required to have a water absorption of between 12 and 20 percent of their dry weight. The obtained value of water absorption (13.6) for the neat bricks is well within the required water absorption characteristics. A higher water absorption shows compromise in resistance to failure due to moisture attacks, while a lower water absorption than the standards show there won't be adequate bondage between the bricks and mortar during masonry works.

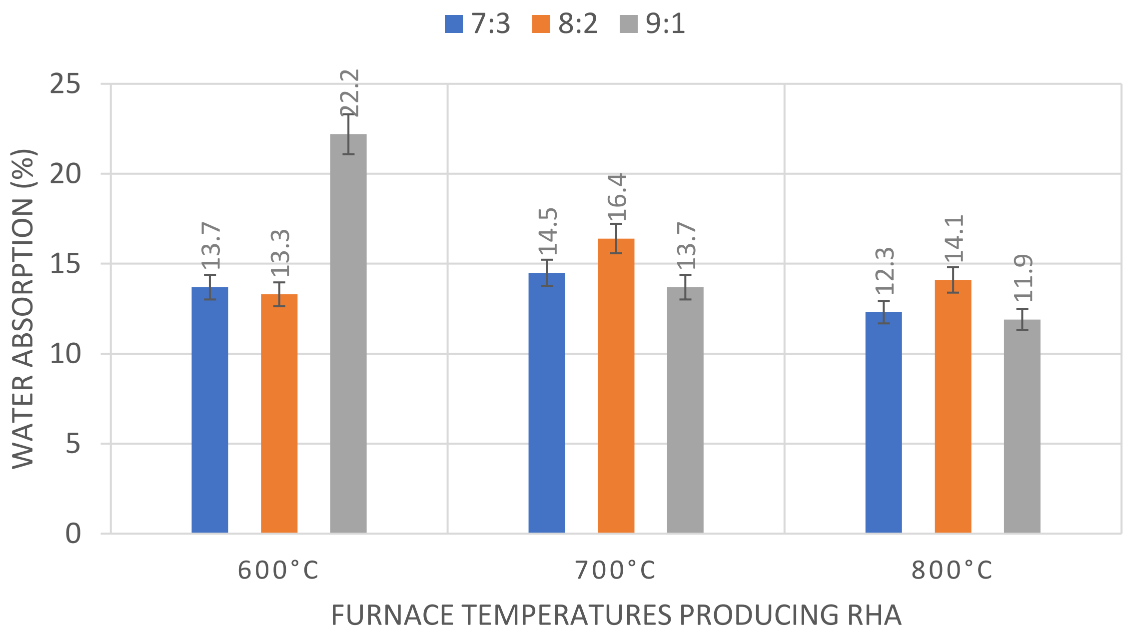

Figure 18: Water absorption of the stabilised bricks

From the results, it is shown that the highest value is 22.2% (at 600^{0}C with Soil: RHA mix of 9:1) and the lowest value is 11.9% and it is derived from the brick with (at 800^{0}C with 9:1 ratio of soil to RHA). However, the bricks with RHA heated at 700^{0}C expresses a sufficient moisture content of 13.7% which still lies within the range recommended by the BS 3921 standards for class B bricks.

CHAPTER FIVE: RESEARCH DESIGN

5.1. Mix Design

The Stabilised fire-burnt clay bricks were manufactured in accordance with the ASTM 1633-00 Stabilization standard. The method of mix design focused mainly on the strength attained by the brick after a given period of time. The optimum ration for adding RHA to the soil according to the research is 9:1 (soil: RHA) with the RHA being heated at 700^0C as shown by the results presented. This produced bricks with increased strength of $5.6N/mm^2$ and an adequate water absorption of 13.7% of the dry weight. Batching was done by volume. A control mix was done with only soil used in the production process of the bricks.

5.2. Dimensions

The dimensions used are 200mm by 100mm by 100mm based on practical use of the bricks from the field, and regular fired clay bricks. The shape is rectangular.

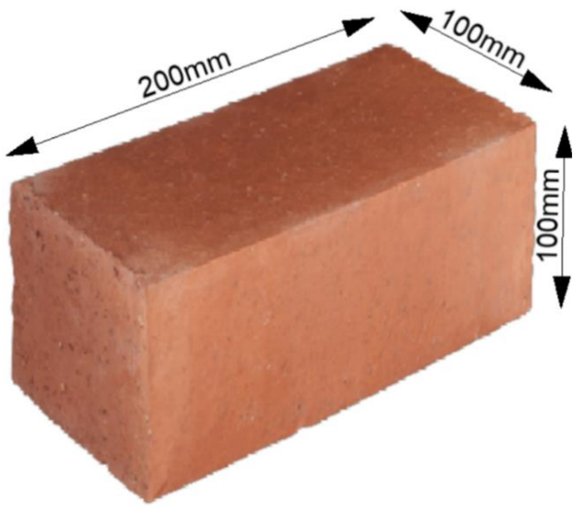

Figure 19: brick dimensions

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusion

Based on the analysis of thermally processed Rice Husk Ash (RHA) and its potential as a stabilizer in fired clay bricks, the research can draw the following conclusions:

1. The soils obtained from the Ntawo Brick making site exhibit good particle size distribution for fired clay brick making. Containing a high amount of clay (62.9%), moderate amounts of sand (37%) and negligible amounts of gravel (0.1%). The plasticity index of the soil samples collected from the site is high (22.2%), demonstrating good workability during brick-making.
2. The silica content (SO_2) of the rice husk ash is observed to increase with the increase of temperature from 600^0C to 800^0C based on XRF results. There is an increase in silica content obtained when RHA heating duration is increased from 1 hour to 6 hours.
3. Incorporating thermally processed rice husk ash (RHA) into clay brick production demonstrates notable improvements in brick compressive strength ranging from 44% to 143.5% at all the temperature ranges from 600^0C to 800^0C compared to neat bricks.
4. The highest value for compressive strength was obtained with RHA having been heated at 700^0C with an RHA: soil ratio of 1:9 and this demonstrated that the optimum temperature for production of rice husk ash to be used for fired clay brick production is 700^0C. With this mix, an increase in compressive strength of up to 143.5% was deduced after stabilisation with RHA.

Using RHA at specific conditions (700°C, 9:1 soil-to-RHA ratio) optimizes brick properties by enhancing structural integrity and moisture control.

6.2. Recommendations

6.2.1. A Pilot Study

There should be a pilot study on the application of bricks stabilized with rice husk ash with a 9:1 Soil to rice husk ratio after producing the rice husk ash at 700^0C. This is due to the observed improved compressive strength and good water absorption properties. The pilot study could be carried out on the following:

- Foundation plinth walls for building structures
- Parapet walls on buildings
- External and partition walls of buildings

6.2.2. Long-term studies

Long-term studies on the durability and performance of RHA-enhanced bricks under various environmental conditions. Investigating the long-term durability of fired clay bricks containing RHA under these conditions (e.g. freeze-thaw cycles) can enhance the overall understanding of their suitability for construction application.

6.2.3. Life-Cycle Cost Analysis

Further studies should focus on conducting a life-cycle cost analysis comparing the use of RHA with conventional brick production methods to assess the economic feasibility and environmental benefits of this approach. Scaling up production is recommended to investigate the feasibility of scaling up the utilization of RHA for brick production in an industrial setting, considering aspects like availability, processing costs, and quality control.

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APPENDIX A

Figure 20: Determining moisture content of soil using a moisture meter

Figure 21: Collecting soil samples from the field

Figure 22: Making a smooth paste for cone penetration test

Figure 23: Soil sample ready for shrinkage limit test

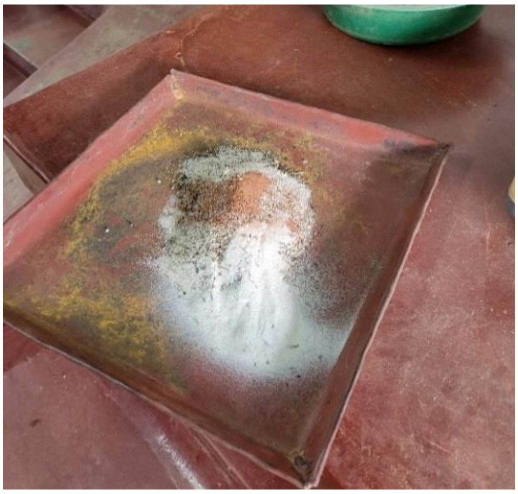


Figure 24: Oven dried soil sample for dry sieving

Figure 27: Air dried sample

Figure 28: Some stabilised fired clay brick samples with RHA

Figure 29: Neat fired clay bricks

Figure 30: Freshly made clay bricks during curing

Figure 31: Ensuring a uniform Soil-RHA mix

APPENDIX B

Teclab ltd
THE ENGINEERS LABORATORY

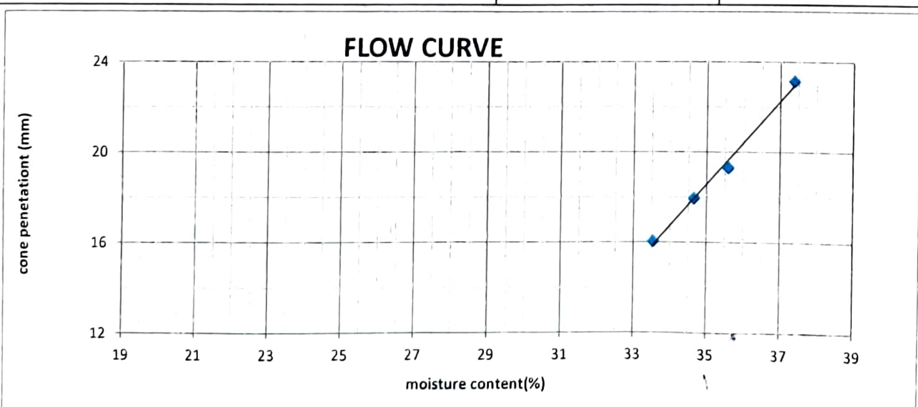
EXCELLENCE THROUGH PRECISION AND INTEGRITY

PLASTIC LIMIT AND LIQUID LIMIT (Cone Penetrometer METHOD)

Project:	ASSESSING THE THERMOPROCESSING OF RICE HUSK ASH SILICA AS A PARTIAL REPLACEMENT OF CEMENT IN COMPRESSED EARTH BRICKS
Client:	LOTYANG ELIUD LAKARA AND MBUGA SOLOMON MUNYWEEZA
Location:	NTAWO, MUKONO DISTRICT
Sampling Date:	10/01/2024
Testing Date:	19/01/2024
Depth (m):	0.75-1.25
Test Method:	Cone Penetrometer
Test Method Reference:	BS 1377 : Part 2

PLASTIC LIMIT	**Test no.**	**1**	**2**		**Average**
Container no.		**ZZ**	**PB**		13.5
Mass of wet soil + container	g	11.73	11.90		
Mass of dry soil + container	g	10.98	11.16		
Mass of container	g	5.55	5.58		
Mass of moisture	g	0.75	0.74		
Mass of dry soil	g	5.43	5.58		
Moisture content	%	13.81	13.26		

LIQUID LIMIT	**Test no.**	**1**		**2**		**3**		**4**	
Initial dial gauge reading	mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Final dial gauge reading	mm	16.10	16.00	17.90	18.00	20.10	20.00	23.20	23.10
Cone Penetration	mm	16.10	16.00	17.90	18.00	20.10	20.00	23.20	23.10
Average cone penetration	mm	16.05		17.95		19.30		23.15	
Container no.		**83**	**36**	**135**	**203**	**435**	**KT**	**122**	**P7**
Mass of wet soil + container	g	43.88	40.33	52.17	40.14	33.57	32.98	35.24	34.64
Mass of dry soil + container	g	36.44	34.03	43.47	34.43	29.07	28.57	29.66	30.01
Mass of container	g	14.29	15.22	18.71	17.72	16.37	16.23	14.76	17.60
Mass of moisture	g	7.44	6.30	8.70	5.71	4.50	4.41	5.58	4.63
Mass of dry soil	g	22.15	18.81	24.76	16.71	12.70	12.34	14.90	12.41
Moisture content	%	33.59	33.49	35.14	34.17	35.43	35.74	37.45	37.31
Average Moisture content	%	33.54		34.65		35.59		37.38	



Sample preparation

As received, sun/air dry sample sieve on 0.425 mm sieve Make paste of ~ 400g passing 0.425mm Place the paste in airtight plastic bag for 16 to 24 hours

LINEAR SHRINKAGE (BS 1377: Part 2-6.5: 1990)

Mould No.	**L04**	**L04**
Initial Length *Li* (mm)	140.0	140.0
Oven dried length *Lf* (mm)	129.7	129.5
Linear Shrinkage (%)	7.36	7.50
Average (%)	7.43	
LIQUID LIMIT	35.8	%
PLASTIC LIMIT	13.5	%
PLASTICITY INDEX	22.2	%

Remarks The material lies above the A-line in the region of clays of low plasticity ie (CL)

Technician(Signature):	**Computed by (Signature):**	**Checked by (Signature):**
		TECLAB LIMITED A GEOSCIENCES COMPANY EST. 2002

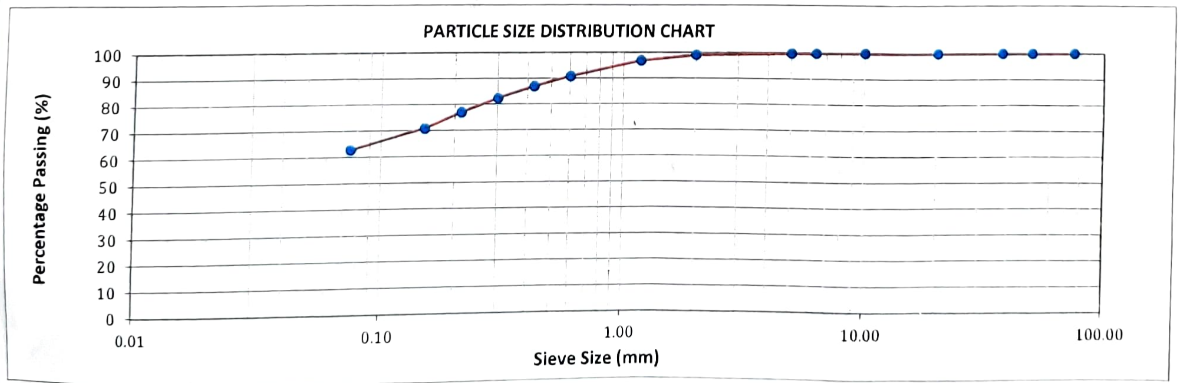
TL-TI-FORM- 08 VER00 MARCH 2018

Teclab
A GEOSCIENCES COMPANY

EXCELLENCE THROUGH PRECISION AND INTEGRITY

PARTICLE SIZE DISTRIBUTION (SIEVING)

Project:	ASSESSING THE THERMOPROCEESSING OF RICE HUSK ASH AS A PARTIAL REPLACEMENT OF CEMENT IN COMPRESSED EARTH BRICKS			
Client:	LOTYANG ELIUD LAKARA AND MBUGA SOLOMON MUNYWEEZA			
Location:	NTAWO, MUKONO DISTRICT		**Depth (m):**	0.75-1.25m
Test Method Reference:	BS 1377:Part 2:1990		**Sampling Date:**	10/01/2024
	Dry weight :	703.4	**Testing Date:**	18/01/2024
B.S. sieve (mm)	**Aperture size (mm)**	**Partial weight retained (g)**	**Percentage retained (%)**	**Percentage Passing (%)**
75.0	75.00	0.0	0.0	100
50.0	50.00	0.0	0.0	100
37.5	37.50	0.0	0.0	100
20.0	20.00	0.0	0.0	100
10	10	0.0	0.0	100
6.3	6.3	0.2	0.0	100
5.00	5.00	0.5	0.1	100
2.00	2.00	6.4	0.9	99
1.18	1.18	14.6	2.1	97
0.60	0.60	42.6	6.1	91
0.425	0.425	27.4	3.9	87
0.300	0.300	32.4	4.6	82
0.212	0.212	37.7	5.4	77
0.150	0.150	42.7	6.1	71
0.075	0.075	56.2	8.0	63
Soil Fractions:	Gravel	Sand	Clay/Silt	
%	0.1	37.0	62.9	



Technician *(Signature):*	Computed by *(Signature):*	Checked by *(Signature):*

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST 2002

TL-TI-FORM-11 VER 03, APRIL 2023 — PREVIOUS EDITION OBSOLETE

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-16841-02 **Date of Issue:** 29/01/2024

Version: 01

1. **Client Name:** LOTYANG ELIUD LAKARA AND MBUGA SOLOMON MUNYWEEZA
2. **Client Address:** N/A 3. **Client Contact:** N/A
4. **Project Title:** ASSESSING THE THERMOPROCESSING OF RICE HUSK ASH SILICA AS PARTIAL REPLACEMENT OF CEMENT IN COMPRESSED EARTH BRICKS
5. **Sample Description:** Three (03) solid bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory 7. **Date of Receipt:** 25/01/2024
8. **Nature of test:** Compressive strength of test specimens 9. **Sampling Report** N/A
11. **Test Method(s):** IS 3495 - Part 1 : 1992
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo 13. **Tested by:** MT008
14. **Attachment(s):** None
15. **Results:**

TEST RESULT FOR SOLID BRICKS

Sample type:	Regular Fired Clay Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	Not Specified	**Type of Failure:**	Satisfactory
Area of use:	Not Specified		
Compressive Tesing Machine ID:	2 **TL-COM-CTRL-002**		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m^3)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
			L	W	H						
Not Specified	25/01/2024	1	200.0	100.0	100.0	20000	3.78	1890	42.1	41.9	2.1
		2	200.0	100.0	100.0	20000	3.96	1980	45.2	45.0	2.3
		3	200.0	100.0	100.0	20000	4.01	2000	49.0	48.8	2.4
										Average Compressive Strength:	**2.3**

16. **Remarks:**

16.1 The test was carried out according to IS : 3495 - Part 1 : 1992, Testing of Common Burnt Clay Bricks : Compressive strength of test specimens

16.2 All information about the specimen furnished by the client/ client representative.

16.3 The test was carried out according to BS EN 12390:2019, Testing of hardened concrete - Part 3: Compressive strength of test specimens

16.4 All tested samples will be discarded immediately after the test.

....END OF REPORT..

Checked by:
ME003
Materials Engineer

Approved by:
Alex Ssenyondo Mulira
Technical Manager

Client's Representative:

★CERTIFIED★
24-00892
TECLAB LIMITED

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-16841-01

Date of Issue: 01/02/2024

Version: 01

1. **Client Name:** LOTYANG ELIUD LAKARA AND MBUGA SOLOMON MUNYWEEZA
2. **Client Address:** None
3. **Client Contact:** N/A
4. **Project Title:** ASSESSING THE THERMOPROCESSING OF RICE HUSK ASH SILICA AS PARTIAL REPLACEMENT OF CEMENT IN COMPRESSED EARTH BRICKS
5. **Sample Description:** Three (03) bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory
7. **Date of Receipt:** 25/01/2024
8. **Nature of test:** Water Absorption of test specimens
9. **Sampling Report:** N/A
11. **Test Method(s):** IS 3495 - Part 2: 1992 Common Burnt Clay Brick - Method for the determination of water absorption
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo
13. **Tested by:** MT008
14. **Attachment(s):** None
15. **Results:**

TEST RESULTS FOR BRICKS

Sample type:	Fired Earth Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	Not Specified		
Area of use:	Not Specified		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	INTIAL OVEN WEIGHT BEFORE SOAKING (kg)	WEIGHT AFTER SOAKING (kg)	MASS DIFFERENCE (kg)	WATER ABSORPTION (%)
			L	W	H					
Not Specified	25/01/2024	1	200.0	100.0	100.0	20000	4.49	5.05	0.6	12.5
		2	200.0	100.0	100.0	20000	3.99	4.51	0.5	13.0
		3	200.0	100.0	100.0	20000	3.98	4.59	0.6	15.3
									Average Water Absorption :	**13.6**

16. **Remarks:**

16.1 This report relates only to the samples tested.
16.2 The test was carried out according to IS 3495 (Part 2): 1992 Common Burnt Clay Brick - Method for the determination of water absorption.
16.3 The test was carried out according to IS 2185 (Part 1): 2005 Concrete Masonry Units- Method for the determination of water absorption
16.4 All tested samples will be discarded immediately after the test.

....END OF REPORT..

Checked by:
ME003
Materials Engineer

Approved by:
Alex Ssenyondo Mulira
Technical Manager

Client's Representative:

CERTIFIED
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TECLAB LIMITED

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Website: www.mia.go.ug

In any Correspondence on this subject please quote No. **GE 048/2024**
02nd February 2024

FOR GOD AND MY COUNTRY
THE REPUBLIC OF UGANDA

MINISTRY OF INTERNAL AFFAIRS
DIRECTORATE OF GOVERNMENT ANALYTICAL LABORATORY
Plot No. 2 Lourdel Road
Wandegeya,
P.O. BOX 105639
Kampala - Uganda

MR. LOTYANG ELIUD LAKARA AND MR SOLOMON MUNYWEEZA
REG NO. S20B32/286 & S16B32/044
UGANDA CHRISTIAN UNIVERSITY
P.O BOX 4, MUKONO-UGANDA
Tel: 256-784-116677

REPORT OF ANALYSIS

Description of the Samples

Three samples in a Green polythene bag containing Rice Husks Ash Samples were submitted by Mr. Lotyang Eliud Lakara, on 25th January 2024, and analysed on 31st January 2024. A summary of the sample received is shown in table below

S/N	Description	Quantity	Assigned Lab ID
1	Rice husks ash sample packed in a black polythene bag, ashed @600^{0}C for 1 hour.	01	**Sample "A" GE 048/2024**
2	Rice husks ash sample packed in a black polythene bag, ashed @700^{0}C for 1 hour	01	**Sample "A" GE 048/2024**
3	Rice husks ash sample packed in a black polythene bag, ashed @800^{0}C for 1 hour	01	**Sample "A" GE 048/2024**

Analysis Requested

Elemental analysis

Method of Analysis

Elemental analysis was done using the XRF Method.

Results of Analysis

The above sample has been analyzed with the following results as below,

Parameter	Units	Results		
		Sample A @ 600^{0}C GE 048/2024	Sample B @ 700^{0}C GE 048/2024	Sample C @ 800^{0}C GE 048/2024
Silicon dioxide	% m/m	78.87	81.04	86.51
Phosphorous pent-oxide	% m/m	7.20	5.26	5.87
Potassium Oxide	% m/m	5.49	3.38	2.03
Iron (III) Oxide	% m/m	2.60	2.20	1.01
Magnesium (II)Oxide	% m/m	2.11	2.25	1.53
Calcium Oxide	% m/m	2.33	3.90	0.71
Aluminum oxide	% m/m	0.61	1.61	1.80
Sodium oxide	% m/m	0.21	0.16	0.05
Titanium di oxide	% m/m	0.09	0.18	0.02
Sulphur trioxide	% m/m	0.45	0.02	0.03

Remarks

1. Results relate to sample analyzed and are reported as on received basis.

02/02/2024
Semalago Fredrick
Government Analyst

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Website: www.mia.go.ug

In any Correspondence on this subject please quote No. GE 048/2024

02nd February 2024

THE REPUBLIC OF UGANDA

MINISTRY OF INTERNAL AFFAIRS
DIRECTORATE OF GOVERNMENT ANALYTICAL LABORATORY
Plot No. 2 Lourdel Road
Wandegeya,
P.O. BOX 105639
Kampala - Uganda

MR. LOTYANG ELIUD LAKARA AND MR SOLOMON MUNYWEEZA
REG NO. S20B32/286 & S20B32/044
UGANDA CHRISTIAN UNIVERSITY
P.O BOX 4, MUKONO-UGANDA
Tel: 256-784-116677

REPORT OF ANALYSIS

Description of the Samples

Three samples in a Green polythene bag containing Rice Husks Ash Samples were submitted by Mr. Lotyang Eliud Lakara, on 25th January 2024, and analysed on 31st January 2024. A summary of the sample received is shown in table below

S/N	Description	Quantity	Assigned Lab ID
1	Rice husks ash sample packed in a black polythene bag, ashed @600⁰C for 6 hours.	01	Sample "A" GE 048/2024
2	Rice husks ash sample packed in a black polythene bag, ashed @700⁰C for 6 hours	01	Sample "A" GE 048/2024
3	Rice husks ash sample packed in a black polythene bag, ashed @800⁰C for 6 hours	01	Sample "A" GE 048/2024

Analysis Requested

Elemental analysis

Method of Analysis

Elemental analysis was done using the XRF Method.

Results of Analysis

The above sample has been analyzed with the following results as below,

Parameter	Units	Results		
		Sample A @ 600⁰C GE 048/2024	Sample B @ 700⁰C GE 048/2024	Sample C @ 800⁰C GE 048/2024
Silicon dioxide	% m/m	96.20	96.80	96.90
Potassium Oxide	% m/m	1.60	1.35	1.28
Calcium Oxide	% m/m	0.75	0.65	0.50
Iron (III) Oxide	% m/m	0.50	0.48	0.45
Phosphorous pent-oxide	% m/m	0.35	0.30	0.28
Aluminum oxide	% m/m	0.17	0.16	0.15
Manganese (II)Oxide	% m/m	0.10	0.08	0.07
Titanium di oxide	% m/m	0.08	0.06	0.04
Sulphur trioxide	% m/m	0.03	0.01	0.02
Sodium oxide	% m/m	0.01	0.01	0.01

Remarks

1. Results relate to sample analyzed and are reported as on received basis.

02/02/2024

Semalago Fredrick
Government Analyst

"Go Scientific for a Safe and Just Society"

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-07 **Date of Issue:** 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A 3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) solid bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory 7. **Date of Receipt:** 14/03/2024
8. **Nature of test:** Compressive strength of test specimens 9. **Sampling Report** N/A
11. **Test Method(s):** BS EN 12390-3: 2019, BS EN 12390-1: 2019 & BS EN 12390-7: 2019
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo 13. **Tested by:** MT008
14. **Attachment(s):** None
15. **Results:**

TEST RESULT FOR SOLID BRICKS

Sample type:	Regular Fired Clay Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	Not Specified	**Type of Failure:**	Satisfactory
Area of use:	Soil : RHA (9:1) - RHA Burnt at 600^0C		
Compressive Tesing Machine ID:	2 **TL-COM-CTRL-002**		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m^3)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
			L	W	H						
22/02/2024	14/03/2024	1	200.0	100.0	100.0	20000	3.91	1960	97.2	96.8	4.8
		2	200.0	100.0	100.0	20000	3.87	1940	94.8	94.4	4.7
		3	200.0	100.0	100.0	20000	3.97	1990	96.9	96.5	4.8
										Average Compressive Strength:	4.8

16. **Remarks:**

16.1 This report relates only to the samples tested.
16.2 All information about the specimen furnished by the client/ client representative.
16.3 The test was carried out according to BS EN 12390:2019, Testing of hardened concrete - Part 3: Compressive strength of test specimens
16.4 All tested samples will be discarded immediately after the test.

....END OF REPORT..

Checked by:
ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST. 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-08 **Date of Issue:** 18/03/2024

Version: 01 **Page 1 of 1**

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A **3. Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) solid bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory **7. Date of Receipt:** 14/03/2024
8. **Nature of test:** Compressive strength of test specimens **9. Sampling Report** N/A
11. **Test Method(s):** BS EN 12390-3: 2019, BS EN 12390-1: 2019 & BS EN 12390-7: 2019
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo **13. Tested by:** MT008
14. **Attachment(s):** None
15. **Results:**

TEST RESULT FOR SOLID BRICKS

Sample type:	Regular Fired Clay Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	Not Specified	**Type of Failure:**	Satisfactory
Area of use:	Soil : RHA (8:2) - RHA Burnt at 600^{0}C		
Compressive Tesing Machine ID:	2 TL-COM-CTRL-002		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m^3)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
			L	W	H						
22/02/2024	14/03/2024	1	200.0	100.0	100.0	20000	3.65	1830	59.3	59.1	3.0
		2	200.0	100.0	100.0	20000	3.63	1810	71.2	70.9	3.5
		3	200.0	100.0	100.0	20000	3.71	1860	68.3	68.0	3.4
										Average Compressive Strength:	3.3

16. **Remarks:**

16.1 This report relates only to the samples tested.
16.2 All information about the specimen furnished by the client/ client representative.
16.3 The test was carried out according to BS EN 12390:2019, Testing of hardened concrete - Part 3: Compressive strength of test specimens
16.4 All tested samples will be discarded immediately after the test.

……………………………………END OF REPORT……………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-09

Date of Issue: 18/03/2024

Page 1 of 1

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A
3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) solid bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory
7. **Date of Receipt:** 14/03/2024
8. **Nature of test:** Compressive strength of test specimens
9. **Sampling Report** N/A
11. **Test Method(s):** BS EN 12390-3: 2019, BS EN 12390-1: 2019 & BS EN 12390-7: 2019
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo
13. **Tested by:** MT008
14. **Attachment(s):** None
15. **Results:**

TEST RESULT FOR SOLID BRICKS

Sample type:	Regular Fired Clay Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	Not Specified	**Type of Failure:**	Satisfactory
Area of use:	Soil : RHA (7:3) - RHA Burnt at 600^{0}C		
Compressive Tesing Machine ID:	2 **TL-COM-CTRL-002**		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m^3)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
			L	W	H						
22/02/2024	14/03/2024	1	200.0	100.0	100.0	20000	3.71	1860	63.8	63.5	3.2
		2	200.0	100.0	100.0	20000	3.59	1790	67.8	67.5	3.4
		3	200.0	100.0	100.0	20000	3.63	1810	65.6	65.3	3.3
										Average Compressive Strength:	**3.3**

16. **Remarks:**

16.1 This report relates only to the samples tested.
16.2 All information about the specimen furnished by the client/ client representative.
16.3 The test was carried out according to BS EN 12390:2019, Testing of hardened concrete - Part 3: Compressive strength of test specimens
16.4 All tested samples will be discarded immediately after the test.

……END OF REPORT……

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-04

Date of Issue: 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A
3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) solid bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory
7. **Date of Receipt:** 14/03/2024
8. **Nature of test:** Compressive strength of test specimens
9. **Sampling Report** N/A
11. **Test Method(s):** BS EN 12390-3: 2019, BS EN 12390-1: 2019 & BS EN 12390-7: 2019
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo
13. **Tested by:** MT008
14. **Attachment(s):** None
15. **Results:**

TEST RESULT FOR SOLID BRICKS

Sample type:	Regular Fired Clay Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	Not Specified	**Type of Failure:**	Satisfactory
Area of use:	Soil : RHA (9:1) - RHA Burnt at 700^{0}C		
Compressive Tesing Machine ID:	2 TL-COM-CTRL-002		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m^3)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
			L	W	H						
22/02/2024	14/03/2024	1	200.0	100.0	100.0	20000	3.82	1910	116.5	116.0	5.8
		2	200.0	100.0	100.0	20000	3.82	1910	107.0	106.5	5.3
		3	200.0	100.0	100.0	20000	3.82	1910	117.2	116.7	5.8
										Average Compressive Strength:	5.6

16. **Remarks:**

16.1 This report relates only to the samples tested.
16.2 All information about the specimen furnished by the client/ client representative.
16.3 The test was carried out according to BS EN 12390:2019, Testing of hardened concrete - Part 3: Compressive strength of test specimens
16.4 All tested samples will be discarded immediately after the test.

……………………………………END OF REPORT……………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST. 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-05

Date of Issue: 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A
3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) solid bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory
7. **Date of Receipt:** 14/03/2024
8. **Nature of test:** Compressive strength of test specimens
9. **Sampling Report** N/A
11. **Test Method(s):** BS EN 12390-3: 2019, BS EN 12390-1: 2019 & BS EN 12390-7: 2019
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo
13. **Tested by:** MT008
14. **Attachment(s):** None
15. **Results:**

TEST RESULT FOR SOLID BRICKS

Sample type:	Regular Fired Clay Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	Not Specified	**Type of Failure:**	Satisfactory
Area of use:	Soil : RHA (8:2) - RHA Burnt at 700^{0}C		
Compressive Tesing Machine ID:	2 TL-COM-CTRL-002		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m^3)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
			L	W	H						
22/02/2024	14/03/2024	1	200.0	100.0	100.0	20000	3.65	1820	94.8	94.4	4.7
		2	200.0	100.0	100.0	20000	3.62	1810	97.5	97.1	4.9
		3	200.0	100.0	100.0	20000	3.64	1820	96.2	95.8	4.8
										Average Compressive Strength:	4.8

16. **Remarks:**

16.1 This report relates only to the samples tested.

16.2 All information about the specimen furnished by the client/ client representative.

16.3 The test was carried out according to BS EN 12390:2019, Testing of hardened concrete - Part 3: Compressive strength of test specimens

16.4 All tested samples will be discarded immediately after the test.

……………………………………………………END OF REPORT……………………………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST. 2002

Client's Representative:

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-06

Date of Issue: 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A
3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) solid bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory
7. **Date of Receipt:** 14/03/2024
8. **Nature of test:** Compressive strength of test specimens
9. **Sampling Report** N/A
11. **Test Method(s):** BS EN 12390-3: 2019, BS EN 12390-1: 2019 & BS EN 12390-7: 2019
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo
13. **Tested by:** MT008
14. **Attachment(s):** None
15. **Results:**

TEST RESULT FOR SOLID BRICKS

Sample type:	Regular Fired Clay Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	Not Specified	**Type of Failure:**	Satisfactory
Area of use:	Soil : RHA (7:3) - RHA Burnt at 700^{0}C		
Compressive Tesing Machine ID:	2 **TL-COM-CTRL-002**		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m^3)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
			L	W	H						
22/02/2024	14/03/2024	1	200.0	100.0	100.0	20000	3.45	1730	89.9	89.5	4.5
		2	200.0	100.0	100.0	20000	3.66	1830	110.4	109.9	5.5
		3	200.0	100.0	100.0	20000	3.53	1760	96.4	96.0	4.8
										Average Compressive Strength:	**4.9**

16. **Remarks:**

16.1 This report relates only to the samples tested.
16.2 All information about the specimen furnished by the client/ client representative.
16.3 The test was carried out according to BS EN 12390:2019, Testing of hardened concrete - Part 3: Compressive strength of test specimens
16.4 All tested samples will be discarded immediately after the test.

……………………………………………………END OF REPORT……………………………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-01 **Date of Issue:** 18/03/2024

Version: 01 **Page 1 of 1**

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A **3. Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) solid bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory **7. Date of Receipt:** 14/03/2024
8. **Nature of test:** Compressive strength of test specimens **9. Sampling Report** N/A
11. **Test Method(s):** BS EN 12390-3: 2019, BS EN 12390-1: 2019 & BS EN 12390-7: 2019
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo **13. Tested by:** MT003
14. **Attachment(s):** None
15. **Results:**

TEST RESULT FOR SOLID BRICKS

Sample type:	Regular Fired Clay Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	28 Days	**Type of Failure:**	Satisfactory
Area of use:	Soil : RHA (9:1) - RHA Burnt at 800^{0}C		
Compressive Tesing Machine ID:	2 **TL-COM-CTRL-002**		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m^3)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
			L	W	H						
22/02/2024	14/03/2024	1	200.0	100.0	100.0	20000	3.65	1820	92.3	91.9	4.6
		2	200.0	100.0	100.0	20000	3.66	1830	93.0	92.6	4.6
		3	200.0	100.0	100.0	20000	3.65	1830	96.2	95.8	4.8
										Average Compressive Strength:	4.7

16. **Remarks:**

16.1 This report relates only to the samples tested.

16.2 All information about the specimen furnished by the client/ client representative.

16.3 The test was carried out according to BS EN 12390:2019, Testing of hardened concrete - Part 3: Compressive strength of test specimens

16.4 All tested samples will be discarded immediately after the test.

.......................................END OF REPORT.......................................

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST. 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-02 **Date of Issue:** 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A **3. Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) solid bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory **7. Date of Receipt:** 14/03/2024
8. **Nature of test:** Compressive strength of test specimens **9. Sampling Report** N/A
11. **Test Method(s):** BS EN 12390-3: 2019, BS EN 12390-1: 2019 & BS EN 12390-7: 2019
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo **13. Tested by:** MT008
14. **Attachment(s):** None
15. **Results:**

TEST RESULT FOR SOLID BRICKS

Sample type:	Regular Fired Clay Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	Not Specified	**Type of Failure:**	Satisfactory
Area of use:	Soil : RHA (8:2) - RHA Burnt at 800^{0}C		
Compressive Tesing Machine ID:	2 TL-COM-CTRL-002		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m^3)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
			L	W	H						
22/02/2024	14/03/2024	1	200.0	100.0	100.0	20000	3.65	1820	108.4	107.9	5.4
		2	200.0	100.0	100.0	20000	3.59	1790	91.3	90.9	4.5
		3	200.0	100.0	100.0	20000	3.60	1800	96.3	95.9	4.8
Average Compressive Strength:											4.9

16. **Remarks:**

16.1 This report relates only to the samples tested.
16.2 All information about the specimen furnished by the client/ client representative.
16.3 The test was carried out according to BS EN 12390:2019, Testing of hardened concrete - Part 3: Compressive strength of test specimens
16.4 All tested samples will be discarded immediately after the test.

……………………………………………………………END OF REPORT……………………………………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
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EST. 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-03 **Date of Issue:** 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A **3. Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) solid bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory **7. Date of Receipt:** 14/03/2024
8. **Nature of test:** Compressive strength of test specimens **9. Sampling Report** N/A
11. **Test Method(s):** BS EN 12390-3: 2019, BS EN 12390-1: 2019 & BS EN 12390-7: 2019
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo **13. Tested by:** MT008
14. **Attachment(s):** None
15. **Results:**

TEST RESULT FOR SOLID BRICKS

Sample type:	Regular Fired Clay Bricks	**Curing condition:**	Tested as received
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	Not Specified	**Type of Failure:**	Satisfactory
Area of use:	Soil : RHA (7:3) - RHA Burnt at 800^{0}C		
Compressive Tesing Machine ID:	2 **TL-COM-CTRL-002**		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m^3)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
			L	W	H						
22/02/2024	14/03/2024	1	200.0	100.0	100.0	20000	3.26	1630	87.5	87.1	4.4
		2	200.0	100.0	100.0	20000	3.05	1520	68.0	67.7	3.4
		3	200.0	100.0	100.0	20000	3.18	1590	76.4	76.1	3.8
Average Compressive Strength:											3.9

16. **Remarks:**

16.1 This report relates only to the samples tested.
16.2 All information about the specimen furnished by the client/ client representative.
16.3 The test was carried out according to BS EN 12390:2019, Testing of hardened concrete - Part 3: Compressive strength of test specimens
16.4 All tested samples will be discarded immediately after the test.

…………END OF REPORT…………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-18 **Date of Issue:** 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A 3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory 7. **Date of Receipt:** 25/01/2024
8. **Nature of test:** Compressive strength of test specimens 9. **Sampling Report:** N/A
11. **Test Method(s):** IS 2185 - Part 1: 2005 Concrete Masonry Units - Method for the determination of water absorption
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo 13. **Tested by:** MT003
14. **Attachment(s):** None
15. **Results:**

TEST RESULTS FOR BRICKS

Sample type:	Fired Earth Bricks	**Curing condition:**	Standard at our facility
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	4 Days		
Area of use:	Soil : RHA 7:3) - RHA Burnt at 600^0C		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	INTIAL OVEN WEIGHT BEFORE SOAKING (kg)	WEIGHT AFTER SOAKING (kg)	MASS DIFFERENCE (kg)	WATER ABSORPTION (%)
			L	W	H					
22/02/2024	26/01/2024	1	200.0	100.0	100.0	20000	3.49	3.98	0.5	14.0
		2	200.0	100.0	100.0	20000	3.50	3.97	0.5	13.4
		3	200.0	100.0	100.0	20000	3.53	4.01	0.5	13.6
									Average Compressive Strength :	13.7

16. **Remarks:**

16.1 This report relates only to the samples tested.

16.2 All information about the specimen furnished by the client/ client representative.

16.3 The test was carried out according to IS 2185 (Part 1): 2005 Concrete Masonry Units- Method for the determination of water absorption

16.4 All tested samples will be discarded immediately after the test.

……………………………………………END OF REPORT……………………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST. 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: **DL-17449-17** **Date of Issue:** 18/03/2024

Version: **01** **Page 1 of 1**

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A **3. Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory **7. Date of Receipt:** 25/01/2024
8. **Nature of test:** Compressive strength of test specimens **9. Sampling Report:** N/A
11. **Test Method(s):** IS 2185 - Part 1: 2005 Concrete Masonry Units - Method for the determination of water absorption
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo **13. Tested by:** MT003
14. **Attachment(s):** None
15. **Results:**

TEST RESULTS FOR BRICKS

Sample type:	Fired Earth Bricks	**Curing condition:**	Standard at our facility
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	4 Days		
Area of use:	Soil : RHA 8:2) - RHA Burnt at 600^{0}C		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	INTIAL OVEN WEIGHT BEFORE SOAKING (kg)	WEIGHT AFTER SOAKING (kg)	MASS DIFFERENCE (kg)	WATER ABSORPTION (%)
			L	W	H					
22/02/2024	26/01/2024	1	200.0	100.0	100.0	20000	3.62	4.12	0.5	13.8
		2	200.0	100.0	100.0	20000	3.63	4.14	0.5	14.0
		3	200.0	100.0	100.0	20000	3.55	3.98	0.4	12.1
Average Compressive Strength :										**13.3**

16. **Remarks:**

16.1 This report relates only to the samples tested.

16.2 All information about the specimen furnished by the client/ client representative.

16.3 The test was carried out according to IS 2185 (Part 1): 2005 Concrete Masonry Units- Method for the determination of water absorption

16.4 All tested samples will be discarded immediately after the test.

……………………………………………………END OF REPORT……………………………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST. 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-16 **Date of Issue:** 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A **3. Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory **7. Date of Receipt:** 25/01/2024
8. **Nature of test:** Compressive strength of test specimens **9. Sampling Report:** N/A
11. **Test Method(s):** IS 2185 - Part 1: 2005 Concrete Masonry Units - Method for the determination of water absorption
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo **13. Tested by:** MT003
14. **Attachment(s):** None
15. **Results:**

TEST RESULTS FOR BRICKS

Sample type:	Fired Earth Bricks	**Curing condition:**	Standard at our facility
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	4 Days		
Area of use:	Soil : RHA 9:1) - RHA Burnt at 600^{0}C		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	INTIAL OVEN WEIGHT BEFORE SOAKING (kg)	WEIGHT AFTER SOAKING (kg)	MASS DIFFERENCE (kg)	WATER ABSORPTION (%)
			L	W	H					
22/02/2024	26/01/2024	1	200.0	100.0	100.0	20000	3.57	4.90	1.3	37.3
		2	200.0	100.0	100.0	20000	3.63	4.14	0.5	14.0
		3	200.0	100.0	100.0	20000	3.65	4.21	0.6	15.3
Average Compressive Strength :										22.2

16. **Remarks:**

16.1 This report relates only to the samples tested.

16.2 All information about the specimen furnished by the client/ client representative.

16.3 The test was carried out according to IS 2185 (Part 1): 2005 Concrete Masonry Units- Method for the determination of water absorption

16.4 All tested samples will be discarded immediately after the test.

....END OF REPORT..

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST. 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-15 **Date of Issue:** 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A 3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory 7. **Date of Receipt:** 25/01/2024
8. **Nature of test:** Compressive strength of test specimens 9. **Sampling Report:** N/A
11. **Test Method(s):** IS 2185 - Part 1: 2005 Concrete Masonry Units - Method for the determination of water absorption
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo 13. **Tested by:** MT003
14. **Attachment(s):** None
15. **Results:**

TEST RESULTS FOR BRICKS

Sample type:	Fired Earth Bricks	**Curing condition:**	Standard at our facility
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	4 Days		
Area of use:	Soil : RHA (7:3) - RHA Burnt at 700^{0}C		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	INTIAL OVEN WEIGHT BEFORE SOAKING (kg)	WEIGHT AFTER SOAKING (kg)	MASS DIFFERENCE (kg)	WATER ABSORPTION (%)
			L	W	H					
22/02/2024	26/01/2024	1	200.0	100.0	100.0	20000	3.39	3.85	0.5	13.6
		2	200.0	100.0	100.0	20000	3.41	3.87	0.5	13.5
		3	200.0	100.0	100.0	20000	3.44	3.92	0.5	14.0
Average Compressive Strength :										13.7

16. **Remarks:**

16.1 This report relates only to the samples tested.
16.2 All information about the specimen furnished by the client/ client representative.
16.3 The test was carried out according to IS 2185 (Part 1): 2005 Concrete Masonry Units- Method for the determination of water absorption
16.4 All tested samples will be discarded immediately after the test.

……………………………………………END OF REPORT……………………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST. 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-14

Date of Issue: 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A
3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory
7. **Date of Receipt:** 25/01/2024
8. **Nature of test:** Compressive strength of test specimens
9. **Sampling Report:** N/A
11. **Test Method(s):** IS 2185 - Part 1: 2005 Concrete Masonry Units - Method for the determination of water absorption
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo
13. **Tested by:** MT003
14. **Attachment(s):** None
15. **Results:**

TEST RESULTS FOR BRICKS

Sample type:	Fired Earth Bricks	**Curing condition:**	Standard at our facility
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	4 Days		
Area of use:	Soil : RHA (8:2) - RHA Burnt at 700^{0}C		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	INTIAL OVEN WEIGHT BEFORE SOAKING (kg)	WEIGHT AFTER SOAKING (kg)	MASS DIFFERENCE (kg)	WATER ABSORPTION (%)
			L	W	H					
22/02/2024	26/01/2024	1	200.0	100.0	100.0	20000	3.62	4.10	0.5	13.3
		2	200.0	100.0	100.0	20000	3.58	4.06	0.5	13.4
		3	200.0	100.0	100.0	20000	3.42	3.98	0.6	16.4

16. **Remarks:**

16.1 This report relates only to the samples tested.

16.2 All information about the specimen furnished by the client/ client representative.

16.3 The test was carried out according to IS 2185 (Part 1): 2005 Concrete Masonry Units- Method for the determination of water absorption

16.4 All tested samples will be discarded immediately after the test.

16.5 The average compressive strength value is not provided on this certificate because of the variability in the results which exceeds the repeatability condition (r = 9%)

……………………………………………………END OF REPORT……………………………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-13 **Date of Issue:** 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A **3. Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory **7. Date of Receipt:** 25/01/2024
8. **Nature of test:** Compressive strength of test specimens **9. Sampling Report:** N/A
11. **Test Method(s):** IS 2185 - Part 1: 2005 Concrete Masonry Units - Method for the determination of water absorption
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo **13. Tested by:** MT003
14. **Attachment(s):** None
15. **Results:**

TEST RESULTS FOR BRICKS

Sample type:	Fired Earth Bricks	**Curing condition:**	Standard at our facility
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	4 Days		
Area of use:	Soil : RHA (9:1) - RHA Burnt at 700^{0}C		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	INTIAL OVEN WEIGHT BEFORE SOAKING (kg)	WEIGHT AFTER SOAKING (kg)	MASS DIFFERENCE (kg)	WATER ABSORPTION (%)
			L	W	H					
22/02/2024	26/01/2024	1	200.0	100.0	100.0	20000	3.58	4.06	0.5	13.4
		2	200.0	100.0	100.0	20000	3.60	4.10	0.5	13.9
		3	200.0	100.0	100.0	20000	3.63	4.21	0.6	16.0

16. **Remarks:**

16.1 This report relates only to the samples tested.

16.2 All information about the specimen furnished by the client/ client representative.

16.3 The test was carried out according to IS 2185 (Part 1): 2005 Concrete Masonry Units- Method for the determination of water absorption

16.4 All tested samples will be discarded immediately after the test.

16.5 The average compressive strength value is not provided on this certificate because of the variability in the results which exceeds the repeatability condition (r = 9%)

……………………………………END OF REPORT……………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST 2002

ACCREDITED LABORATORY ISO/IEC 17025 ilac-MRA KENAS

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-12

Date of Issue: 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A
3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory
7. **Date of Receipt:** 25/01/2024
8. **Nature of test:** Compressive strength of test specimens
9. **Sampling Report:** N/A
11. **Test Method(s):** IS 2185 - Part 1: 2005 Concrete Masonry Units - Method for the determination of water absorption
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo
13. **Tested by:** MT003
14. **Attachment(s):** None
15. **Results:**

TEST RESULTS FOR BRICKS

Sample type:	Fired Earth Bricks	**Curing condition:**	Standard at our facility
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	4 Days		
Area of use:	Soil : RHA (7:3) - RHA Burnt at 800^0C		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	INTIAL OVEN WEIGHT BEFORE SOAKING (kg)	WEIGHT AFTER SOAKING (kg)	MASS DIFFERENCE (kg)	WATER ABSORPTION (%)
			L	W	H					
22/02/2024	26/01/2024	1	200.0	100.0	100.0	20000	3.19	3.65	0.5	14.4
		2	200.0	100.0	100.0	20000	3.21	3.57	0.4	11.2
		3	200.0	100.0	100.0	20000	3.42	3.80	0.4	11.1

16. **Remarks:**

16.1 This report relates only to the samples tested.

16.2 All information about the specimen furnished by the client/ client representative.

16.3 The test was carried out according to IS 2185 (Part 1): 2005 Concrete Masonry Units- Method for the determination of water absorption

16.4 All tested samples will be discarded immediately after the test.

16.5 The average compressive strength value is not provided on this certificate because of the variability in the results which exceeds the repeatability condition (r = 9%)

……………………………………END OF REPORT……………………………………

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-11 **Date of Issue:** 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A 3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory 7. **Date of Receipt:** 25/01/2024
8. **Nature of test:** Compressive strength of test specimens 9. **Sampling Report:** N/A
11. **Test Method(s):** IS 2185 - Part 1: 2005 Concrete Masonry Units - Method for the determination of water absorption
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo 13. **Tested by:** MT003
14. **Attachment(s):** None
15. **Results:**

TEST RESULTS FOR BRICKS

Sample type:	Fired Earth Bricks	**Curing condition:**	Standard at our facility
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	4 Days		
Area of use:	Soil : RHA (8:2) - RHA Burnt at 800^0C		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	INTIAL OVEN WEIGHT BEFORE SOAKING (kg)	WEIGHT AFTER SOAKING (kg)	MASS DIFFERENCE (kg)	WATER ABSORPTION (%)
			L	W	H					
22/02/2024	26/01/2024	1	200.0	100.0	100.0	20000	3.39	3.87	0.5	14.2
		2	200.0	100.0	100.0	20000	3.41	3.88	0.5	13.8
		3	200.0	100.0	100.0	20000	3.43	3.92	0.5	14.3
									Average Compressive Strength :	14.1

16. **Remarks:**
16.1 This report relates only to the samples tested.
16.2 All information about the specimen furnished by the client/ client representative.
16.3 The test was carried out according to IS 2185 (Part 1): 2005 Concrete Masonry Units- Method for the determination of water absorption
16.4 All tested samples will be discarded immediately after the test.

....END OF REPORT..

Checked by:
ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED
A GEOSCIENCES COMPANY
EST. 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-10 **Date of Issue:** 18/03/2024

Version: 01

1. **Client Name:** Mbuga Solomon Munyweeza and Lotyang Eliud Lakara
2. **Client Address:** N/A 3. **Client Contact:** N/A
4. **Project Title:** Assessing The Thermo Processing of Rice Husk Ash as a Stabilizer in Fire - Burnt Clay Bricks
5. **Sample Description:** Three (03) bricks were delivered to the laboratory for testing
6. **Condition at receipt:** Satisfactory 7. **Date of Receipt:** 25/01/2024
8. **Nature of test:** Compressive strength of test specimens 9. **Sampling Report:** N/A
11. **Test Method(s):** IS 2185 - Part 1: 2005 Concrete Masonry Units - Method for the determination of water absorption
12. **Test Location:** Teclab Ltd Headquarters, Nalukolongo 13. **Tested by:** MT003
14. **Attachment(s):** None
15. **Results:**

TEST RESULTS FOR BRICKS

Sample type:	Fired Earth Bricks	**Curing condition:**	Standard at our facility
Method of Compaction:	Not Specified	**Facility Temperature:**	24 Degrees Celsius
Testing Age:	4 Days		
Area of use:	Soil : RHA (9:1) - RHA Burnt at 800^{0}C		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm^2)	INTIAL OVEN WEIGHT BEFORE SOAKING (kg)	WEIGHT AFTER SOAKING (kg)	MASS DIFFERENCE (kg)	WATER ABSORPTION (%)
			L	W	H					
22/02/2024	26/01/2024	1	200.0	100.0	100.0	20000	3.58	4.05	0.5	13.1
		2	200.0	100.0	100.0	20000	3.62	4.07	0.5	12.4
		3	200.0	100.0	100.0	20000	3.63	4.00	0.4	10.2
									Average Compressive Strength :	**11.9**

16. **Remarks:**

16.1 This report relates only to the samples tested.

16.2 All information about the specimen furnished by the client/ client representative.

16.3 The test was carried out according to IS 2185 (Part 1): 2005 Concrete Masonry Units- Method for the determination of water absorption

16.4 All tested samples will be discarded immediately after the test.

....END OF REPORT..

Checked by:

ME003
Materials Engineer

Approved by:
Robinson Onen
Technical Manager

Client's Representative:

TECLAB LIMITED A GEOSCIENCES COMPANY EST 2002