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

Fire-burnt clay bricks are a common building material used in engineering practice in Uganda. This study aims at investigating the use of rice husk ash as a stabilizer in fire burnt clay bricks. The methods used to attain the objectives include soil tests including Sieve analysis and Atterberg limit tests on the soil to be used in the bricks to determine its physical properties, X-Ray Fluorescence spectroscopy on the Rice husk ash to determine the chemical composition and then tests mainly focusing on the compressive strength and water absorption parameters of the stabilized earth bricks. Some key parameters in the study include the temperature variations of the materials being used and the effect on the final mechanical properties of the brick. This research identifies that the optimal ratio of RHA to soil is 9:1 with the RHA being heated at 700^{0}C for 6 hours explaining the influence of the chemical composition of the ash on the clay minerals used when brick making. With this mix, an increase in compressive strength of up to 143.5% was deduced after stabilisation with RHA.

DECLARATION

I, Lotyang Eliud Lakara hereby declare that this is my original work, is not plagiarized and has not been submitted any other institution for any award.

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

LOTYANG ELIUD LAKARA

APPROVAL

The final year project serves as a fulfillment for the pursuit of the Bachelors' Degree of Science in Civil and Environmental Engineering at Uganda Christian University. This proposal has been submitted for examination with my approval as the project supervisor.

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

MR. ANDREW KASUMBA

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LIST OF ABBREVIATIONS

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: INTRODUCTION

1.1 BACKGROUND

Fired clay bricks have been a key building material for centuries due to their affordability, fire resistance, and ready availability (Smith, 2020). However, conventional bricks produced are prone to failure when exposed to adverse weather conditions. (Belkhir et al., 2020). The main setback 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)

The engineering community is also working to enhance the fired clay bricks' quality and affordability. Variations in production methods often lead to differences in the bricks' durability and strength. With the rising costs of conventional materials, there is a push towards integrating indigenous additives and recyclable materials to cut down production costs and improve the bricks' features, aiming to make affordable housing more accessible in light of Uganda's fast-growing population (Uganda Bureau of Statistics, 2022). This research project explores a promising alternative stabilizer for fired clay bricks which is Rice Husk Ash.

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 (Apollo, 2022) accounting for their ready availability as a pozzolanic material. The rice husks used in this study are the K98 rice husks whose main component is silica.

The combustion of rice husk in the presence of air consistently results in the creation of silica ash, which can exhibit a range of colours from grey to pink, and it contains small amounts of various inorganic element oxides. In practical terms, the specific type of ash can vary significantly depending on the combustion method used. When the temperature falls within the range of 600–800°C, it results in the formation of amorphous ash. However, at temperatures higher than this range, crystallization processes become evident. Notably, ash produced through controlled burning of rice husk, particularly within the temperature range of 550 to 800°C for a duration of one hour, causes the silica content within the ash to transition into an amorphous phase. (JAYA, 2013)

The silica present in RHA reacts with calcium hydroxide (lime) in the presence of moisture to obtain strengthening properties in the mix. (Mehta & Monteiro, 2014). Therefore, the proposed use of thermally processed rice husk ash silica in fire burnt clay bricks should be considered to obtain the optimum temperature at which the rice husk ash silica can be used as partial replacement of concrete in the fire burnt clay bricks.

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.

The primary by-product of rice milling operations, rice husks, are generated in substantial quantities. 350,000 tonnes of rice are milled in Uganda every year and of this, 20-30% is rice husks by weight with an annual production of 70,000 tonnes in Uganda, as noted by Apollo Uma et al. (2022). This abundance highlights their potential use as a pozzolanic material.

This study aims to investigate the use of rice husk ash in improving the durability of fired clay bricks, particularly in severe weather conditions, emphasizing the enhancement of the bricks' performance and resilience. It focused on the impact of thermo-processing temperature on RHA's chemical composition and pozzolanic activity to identify the optimal combination of RHA content and firing temperature to improve the compressive strength and water absorption of fired clay bricks.

1.3 OBJECTIVES OF THE RESEARCH

1.3.1 MAIN OBJECTIVE

To investigate the use of thermally processed rice husk ash silica as a stabilizer in fire burnt clay bricks.

1.3.2 SPECIFIC OBJECTIVES

- To determine the physical properties of the soil to be used for the manufacture of the bricks.
- To determine the properties of the rice husk ash formed at varying temperatures.
- To assess the mechanical properties 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 the fire burnt clay bricks?
2. What are the chemical properties of the rice husk ash to be used in bricks as well as the effect of temperature on this amount of silica content?
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 earth bricks?

1.5 JUSTIFICATION

Rice husk ash, specifically from K98 rice husks, referred to locally as 'Kaiso,' was produced through heating at various temperatures to determine the ideal temperature for creating the ash. According to Ogwang et al. (2021), the silica content in K98 rice husk ash is approximately 98%, while Hossain et al. (2015) reported it to be around 99%.

Biomass residue	SiO2%	Al2O3%	Fe2O3%	CaO%	MgO%	Na2O%	K2O%
Rice husk	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	67.2	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
Sugar cane 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	1.7
Paper mill sludge	25.7	18.86	0.87	43.51	5.15	1.56	1.31

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

Silica, a crucial component acting as a strengthening agent, plays a significant role in enhancing the compressive strength and overall durability of construction materials such as fired clay bricks. The incorporation of rice husk ash (RHA), a material high in silica content, can contribute positively to the overall compressive strength and stability of the final brick product. Compressive strength is a critical property for bricks, as it directly impacts their resilience and resistance to abrasion during use (Femi Timothy Owoeye, 2021).

When exposed to hydration conditions, clay minerals undergo a transformation that releases calcium hydroxide from Calcium Oxide present (Tuan A. et al, 2019). In the presence of moisture, the calcium hydroxide reacts with the silica present in the RHA to form calcium silicate hydrates (CSH). The formation of CSH plays a vital role in densifying the material by filling in voids within the brick structure. This densification process ultimately leads to improved mechanical properties of the fired clay brick (Ahsan & Hossain, 2018).

1.6 SCOPE

1.6.1 GEOGRAPHICAL SCOPE

The rice husks were obtained from the Doho rice scheme in Butaleja District located in the Eastern part of Uganda. The soil was obtained from a brick making site in Ntawo, Mukono as shown in Figure 16.

The tests for the X-Ray Fluorescence Spectroscopy were carried out from the Uganda Government Analytical Laboratory in Kampala, Uganda and the soil tests were carried out from Teclab Limited along Mapeera Road.

1.6.2 CONTENT SCOPE

1. The study will explore the use of RHA processed at different temperatures: 600°C, 700°C, and 800°C to identify the optimal processing temperature for RHA that results in the greatest improvement in the strength properties of the final fired clay bricks. This will involve incorporating RHA processed at these varying temperatures into the brick production process and evaluating the resulting bricks' mechanical performance
2. A comparative analysis will be conducted between locally produced fired clay bricks manufactured without RHA (control group) and bricks manufactured with RHA incorporation. This analysis will focus on engineering properties of the bricks.

1.7 IMPORTANCE OF FIRED CLAY BRICKS

Enhanced by the low production cost of fired clay bricks, they are a feasible construction material. Incorporating rice husk ash silica as a stabilizer significantly enhances the bricks' strength and longevity.

1.8 CONCEPTUAL FRAMEWORK

This study delves into the efficacy of heat-treated Rice Husk Ash (RHA) in reinforcing fired clay bricks. At its core, the research seeks to comprehend the impact of RHA's thermal treatment temperatures on its pozzolanic behaviour, thereby influencing the quality of the bricks produced, taking into account RHA's interaction with the soil utilized in brickmaking.

1.8.1 VARIABLES:

Independent Variable: Thermal Treatment Temperature of RHA (600°C, 700°C, 800°C), aiming to examine the influence of varied thermal levels on RHA's characteristics.

Dependent Variables:

1. **Characteristics of RHA**

Chemical Composition (XRF Analysis) to identify the elemental makeup, particularly the silica (SiO_2) content vital for its pozzolanic activity.

2. **Soil Characteristics**

Particle Size Distribution (Sieve Analysis) to evaluate the soil particles' size diversity, enhancing packing density and RHA interaction and plasticity Limits (Atterberg Limits) to assess soil's plasticity, affecting its moldability and adherence with RHA in brick formation.

Attributes of fired clay bricks

RHA Inclusion (10%, 20%, 30%) to explore the effect of different RHA ratios on the bricks' final qualities.

Firing Temperature, maintained consistently to focus on RHA thermal treatment's effects.

Compressive Strength to understand the maximum stress bricks can bear, reflecting their robustness.

Water Absorption to determine bricks' moisture resistance, indicative of their longevity.

1.8.2 THEORETICAL FRAMEWORK:

The Pozzolanic Reaction Theory, explaining the interaction between silica-rich RHA and calcium hydroxide in the clay, producing calcium silicate hydrate (C-S-H) gels that fortify the brick structure.

Sintering Theory, detailing how materials like clay consolidate and strengthen at elevated temperatures, with firing temperature aiding in sintering, thus enhancing the brick matrix.

1.9 RESEARCH GUIDANCE BY THEORATICAL FRAMEWORK

The foundation of employing RHA as a stabilizer was laid by the pozzolanic reaction theory, which guided the exploration into how RHA's thermal treatment affects its chemical and physical properties, thereby influencing its pozzolanic activity and its role in enhancing brick strength.

Sintering theory further informed the study by underscoring the firing temperature's role in the brick's densification process. Although the firing temperature was constant, it indirectly modulated the pozzolanic reaction's efficiency through the formation and distribution of C-S-H gels within the brick matrix.

Through scrutinizing the relationship among these variables and applying pertinent theories, the research aimed to evaluate the efficacy of heat-treated RHA as a stabilizer in fired clay bricks, seeking the optimal RHA content and thermal treatment conditions for producing robust and durable building materials.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

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.

2.2 THEORETICAL REVIEW

2.2.1 Thermoprocessing

Refers to the application of high temperatures to treat materials, altering their properties for specific applications. In the context of RHA, Thermoprocessing involves the controlled incineration of rice husks at temperatures that optimize the silica content's reactivity, enhancing its pozzolanic activity.

2.2.2 Stabilizer

In construction, a stabilizer is an additive that enhances the physical and mechanical properties of a material, such as its strength, durability, or resistance to environmental degradation.

2.2.3 Fire Burnt Clay Bricks

A traditional construction material made by shaping clay into moulds and firing them in kilns at high temperatures. This process increases the strength and durability of the bricks, making them suitable for various construction applications.

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 as broken down below:

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**

Various clays are known to 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).

Manufacturing Process of Bricks

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

1. **Clay Extraction:** As seen in Appendix A, 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 as shown in Figure 2 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.

Figure 1: A Fire-burnt brick production kiln at Ntawo brick laying site

Brick Performance Indicators

The key performance characteristics of fired clay bricks include:

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).

2.2.4 Rice Husk Ash (RHA)

Rice husk ash (RHA) is a byproduct of rice milling, predominantly composed of amorphous silica. Its proven pozzolanic characteristics make it an attractive option for enhancing construction materials. Existing studies indicate that RHA can enhance the strength and durability of various construction materials when used as an additional cementitious material (Sata, 2006). RHA is a byproduct generated during rice milling processes. RHA possesses pozzolanic properties, 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 aims to improve the overall performance characteristics of fired clay bricks.

2.4 EMPIRICAL LITERATURE REVIEW

Pozzolanic Reaction

The pozzolanic reaction describes a chemical process where a siliceous substance, lacking in inherent hydraulic activity, interacts with calcium hydroxide ($Ca(OH)_2$), a byproduct of Portland cement hydration or unreacted lime (CaO), in moist conditions to produce calcium silicate hydrate (C-S-H) gels. These gels possess cement-like properties, enhancing strength and refining the pore structure within the matrix of fired clay bricks (Fernandez-Jimenez et al., 2006).

Utilization of Rice Husk Ash as a Pozzolanic Agent: Rice husk ash, a byproduct of rice milling, is predominantly made up of silica (SiO_2) along with traces of alumina (Al_2O_3), iron oxide (Fe_2O_3), and other oxides (Shafigh et al., 2019). The amorphous silica present in RHA is highly reactive with $Ca(OH)_2$, fostering the pozzolanic reaction (Boucherie et al., 2011).

Effects on the Properties of Fired Clay Bricks: Research has delved into the effects of RHA on the performance of fired clay bricks, with findings indicating:

1. **Compressive Strength**: The structural integrity and abrasion resistance of burnt clay bricks are significantly influenced by their compressive strength. Studies by Owoeye (2021), Bouzid et al. (2014), and Wardhana et al. (2012) show that RHA incorporation can elevate the compressive strength of fired clay bricks, attributing this enhancement to the additional formation of C-S-H gels, leading to a denser, stronger brick structure.

2. **Water Absorption**: A brick's ability to absorb water is critical; excessive absorption can diminish durability due to freeze-thaw cycles, promote efflorescence, and reduce thermal insulation. Demir et al. (2011) and Uysal et al. (2010) found that RHA can decrease water absorption in fired clay bricks by filling the pores, rendering the material less permeable.

3. **Durability**: The integration of RHA has been shown to bolster the freeze-thaw and sulphate resistance of fired clay bricks, with research by Hamad et al. (2014) and Rao et al. (2016) pointing to a denser microstructure from the pozzolanic reaction as the contributing factor.

Considerations in RHA Use in Bricks

The substantial improvement in compressive strength offered by rice husk ash is often credited to its high silica content, which reacts with lime to create calcium silicate hydrate (C-S-H) gel, crucial for the material's binding and fortification (Hossain, K.M., 2011). The conditions under which the pozzolanic reaction occurs, including the ratio of rice husk ash used, curing conditions, and material quality, are vital in determining the degree of strength enhancement (Mehta, P.K., 2014). Despite RHA's beneficial aspects for improving fired clay brick properties, several challenges require attention:

Identifying the precise amount of RHA for addition is critical, as excessive amounts may hinder strength development or cause a reduction in strength (Boucherie et al., 2011). The efficacy of the pozzolanic reaction and the characteristics of resultant C-S-H gels can vary with the firing temperature. Adjustments in firing protocols for bricks containing RHA might be necessary (Demir et al., 2011).

In summary, empirical data suggests that RHA's inclusion in the production of fired clay bricks through the pozzolanic reaction offers a promising method for enhancing durability. Nevertheless, optimal RHA dosage and firing temperature require careful calibration to achieve the best outcomes. Further research is warranted to ascertain the ideal conditions for incorporating RHA into brick manufacturing.

2.5 RESEARCH GAP

Rice husk ash has been used in various research project work like stabilization of expansive soils among others. 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. 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. The incorporation of rice husk ash silica in the stabilization of fire burnt clay bricks aimed at improving the compressive strength and water absorption properties of fired clay bricks.

CHAPTER THREE: METHODOLOGY

The steps taken to achieve the objectives included tests on the soil, determining the chemical composition of the K-98 rice husk ash and tests on the rice husk ash stabilized fire-burnt earth bricks.

3.1 METHODS

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

To analyse the soil's suitability for brickmaking, two tests were conducted following the British Standard BS 1377: Part 2 (1990).

The Sieve Analysis test determined the distribution of particle sizes within the soil sample. By passing the soil through a series of sieves with progressively finer openings, information was obtained about the proportions of various grain sizes present in the soil. The methodology for preparing the soil sample involved an initial 24-hour soaking period. Subsequently, wet sieving was performed, as depicted in Figure 7, which entailed rinsing the soil through 0.075mm and 0.425mm mesh sieves.

Post-washing, the soil was oven-dried to obtain its dry weight. This step was followed by dry sieving, illustrated in Figure 6, utilizing a range of sieves from 0.075mm up to 75mm. The outcomes of the sieving process were systematically recorded, detailing the percentages retained on and passing through each sieve size. Based on these results, a particle size distribution chart was constructed, facilitating the enumeration of the soil's gravel, sand, and clay/silt content. The results are attached in Appendix B.

Figure 2: Dry sieving the soil sample through the various sieves

Figure 3: Washing the soil sample (wet sieving)

Table 2: Percentage of soil passing through the different sieves

Sieve size	75 mm	50 mm	37.5 mm	20 mm	10 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 Atterberg Limits tests measured the soil's moisture content at different plasticity states. These states are defined as Liquid Limit which is the minimum water content at which the soil transitions from a liquid state to a plastic state, Plastic Limit which is the minimum water content at which the soil transitions from a plastic state to a brittle state. The Plasticity Index is a calculated value that was derived from the Liquid Limit and Plastic Limit. It indicated the range of moisture contents over which the soil exhibits plastic behaviour.

In preparation for the tests, the soil sample was air-dried over a period of seven days. Subsequently, it was ground using a mortar and pestle until it achieved a fine consistency, with particles passing through a 0.425mm sieve. The soil was then mixed into a smooth paste and stored in an airtight bag for 24 hours to ensure homogeneity. Following this preparation, the cone penetrometer method was applied to assess the liquid and plastic limits.

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 results obtained for shrinkage limit were as follows:

Table 3: Linear shrinkage 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 value (%)	**7.43**	

The linear shrinkage from table 4 is 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.

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

To determine the chemical composition of the rice husk ash used, X-ray Fluorescence Spectroscopy was done on samples of the burnt rice husk ash as shown in Figures 3, 4 and 5. To determine the chemical composition of Rice Husk Ash (RHA) using X-ray Fluorescence Spectroscopy (XRF), the following steps were followed:

1. Preparation of the RHA Sample: Initiate the analysis by conditioning the RHA. This involves ensuring the ash is free from any moisture by adequately drying it. Subsequently, pulverize the ash to achieve a consistent powder form. This homogenization is crucial for reliable analysis. Depending on the specific XRF setup, you may need to compact the powder into disks or spread it as a thin layer for optimal measurement.
2. XRF Instrument Calibration: Prior to analysing your RHA samples, it's essential to calibrate the XRF spectrometer. Utilize standard samples with a known elemental makeup to adjust the instrument. This step is vital to guarantee the precision of the spectrometer's readings for subsequent analyses of unknown samples.
3. Conducting the Measurement: Place your prepared RHA sample into the spectrometer. The device bombards 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 captures the emitted X-rays and quantifies them. Software associated with the spectrometer interprets these measurements, identifying each element based on the energy of the emitted X-rays and calculating their concentrations within the sample. This sophisticated analysis allows for a comprehensive breakdown of the sample's elemental composition.
5. Results Interpretation and Compilation: The final phase involves deciphering the analysis outcomes. The XRF technique furnishes a detailed elemental composition of the RHA, while highlighting 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.

Figure 4: RHA produced at 600 degrees Celsius

Figure 5: RHA produced at 700 degrees Celsius

Figure 6: RHA produced at 800 degrees Celsius

3.1.3 Assessing the performance of the stabilized fire burnt clay bricks

The bricks were cured for periods of 28 days. They were then tested for the compressive strength and water absorption in accordance with the British standards.

Compressive Strength Test

The BS EN 771-1:2003 standard was followed for this test. The nominal dimensions of the bricks (200mm by 100mm by 100mm) were measured and then the mass of the bricks was measured using a balance so as to calculate the density of each brick. 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 7: Compressive strength test machine crushing the neat bricks

The test procedure done was as follows:

1. The brick's size was measured and its weight was determined with an electric scale to calculate its density.
2. The brick was then placed between the plates of the compression testing machine with its flat sides horizontal and the mortar-covered sides facing up.
3. Weight was added gradually to the brick until it failed (broke). The maximum weight it could bear before failing provided the compressive strength of the brick.

Water Absorption Tests

Water absorption refers to how much water a brick can soak up when placed in water at normal temperature for a specified time. This test checks how resistant the brick is to soaking up water, following the BS EN 771-1:2003 standard. The test procedure done was as follows:

1. The individual sample bricks were weighed and then dried them 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. The dry samples were then fully immersed in water for 24 hours.
4. After 24 hours, the wet samples were removed from water, their surfaces dried with an absorbent cloth until there was visible water left, and then weighed again.

5. The difference in weight between the dry and wet samples shows how much water each brick has absorbed.

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

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

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

Table 4: Summary of methodology

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 SIEVE ANALYSIS

The analysis conducted on January 18, 2024, at Teclab Laboratory adhered to the BS 1377: Part 2, 1990 standards. This procedure aimed to delineate the particle size distribution within the soil samples, a critical factor in classifying soils by their predominant particle sizes—gravel, sand, silt, or clay.

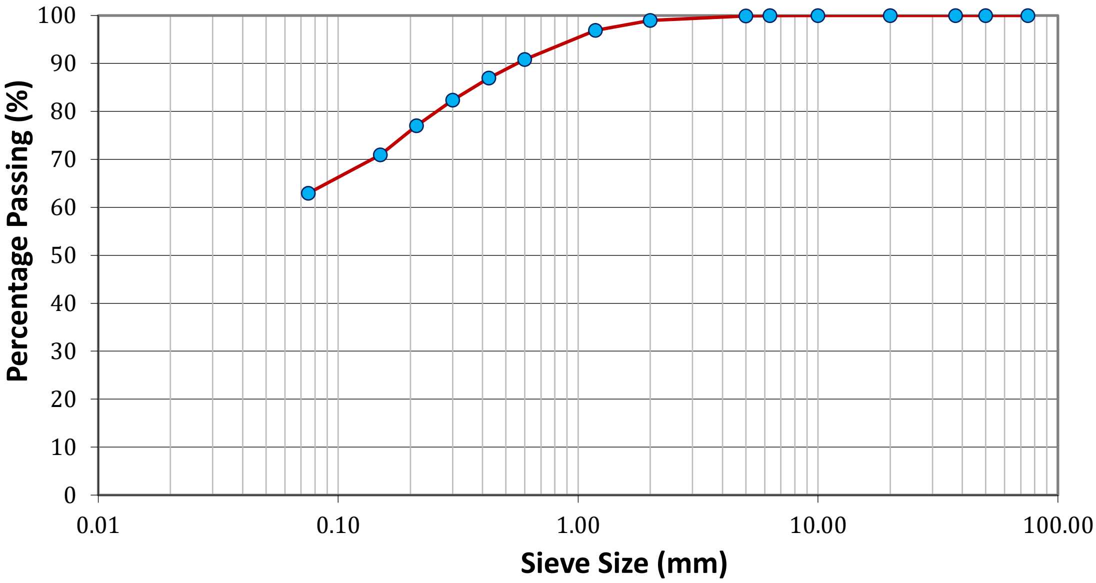


Figure 8: Particle size distribution chart

The particle size distribution indicates a predominance of silt/clay in the soil, accompanied by a moderate amount of sand and a negligible gravel content, classifying it as poorly graded. According to Suresh & Anand (2017), for soil to be deemed suitable for stabilized fire-burnt earth construction, the proportions of clay, silt, sand, and gravel should fall within 5-20%, 10-30%, and 45-75%

respectively. This suggests that the soil requires stabilization to enhance the quality of the final bricks.

The composition of soil is crucial for optimizing the properties and performance of the end product, such as fired bricks. Analysing the provided composition—0.1% Gravel, 37% Sand, and 62.9% Clay—highlights its potential for producing third-class burnt clay bricks.

Clay (62.9%), being the majority component, clay imparts moldability to the brick mix due to its plastic nature and contributes to the binding and strength of the bricks upon firing. However, excessive clay can lead to significant shrinkage during drying and firing, potentially causing cracks.

Sand (37%): The presence of sand mitigates the shrinkage associated with clay's drying and firing, acting as a structural filler to prevent cracking. The substantial sand content is advantageous, making the bricks less prone to cracking and more structurally stable.

Gravel (0.1%): The minimal gravel content has little impact on the brick's properties. Generally, gravel does not contribute positively to brick making, as large aggregates disrupt uniformity, reducing compactness and strength.

4.1.1 Suitability for Third Class Burnt Clay Bricks

Third-class burnt clay bricks, which are lower in quality compared to first and second-class bricks, are often used for temporary constructions or internal wall plastering where longevity or aesthetic appeal is not paramount. Given its high clay content, this soil sample is apt for such applications, as the demanding strength and low porosity characteristics of higher-grade bricks are not required.

4.1.2 The Use of Each Component In Brick Making

Clay allows plasticity, binds components, imparts strength and durability of the bricks. The sand in the context of brick making helps lessen shrinkage in the clay, prevents cracking of the clay and gives structure to the bricks. Since it is not of substantial amounts in the sample, generally, gravel would not be expected to help in the structure of the bricks.

4.2 ATTERBERG LIMITS

The analysis was conducted on January 19, 2024, at Teclab Laboratory, following the guidelines of BS 1377: Part 2, 1990. This examination utilized the cone penetrometer technique to ascertain the shrinkage limit, liquid limit, and plastic limit, which then facilitated the calculation of the soil's Plasticity Index.

The shrinkage limit marks the threshold beyond which soil ceases to contract in volume as its moisture content decreases, signifying the transition from a semi-solid to a solid state.

The liquid limit test aims to pinpoint the moisture level at which soil shifts from a liquid to a plastic phase, employing the cone penetrometer method. This test is crucial for identifying and categorizing fine-grained cohesive soils.

The plastic limit test determines the lowest moisture content at which soil retains its plasticity. Together, the liquid and plastic limits are instrumental in deriving the soil's Plasticity Index, with a higher index indicating finer soil particles. The results obtained were as shown in the table below.

Table 5: Summary of the Atterberg limit values

ATTERBERG LIMITS			
LL	**PL**	**PI**	**LS**
%	%	%	%
35.8	13.54	22.2	7.429

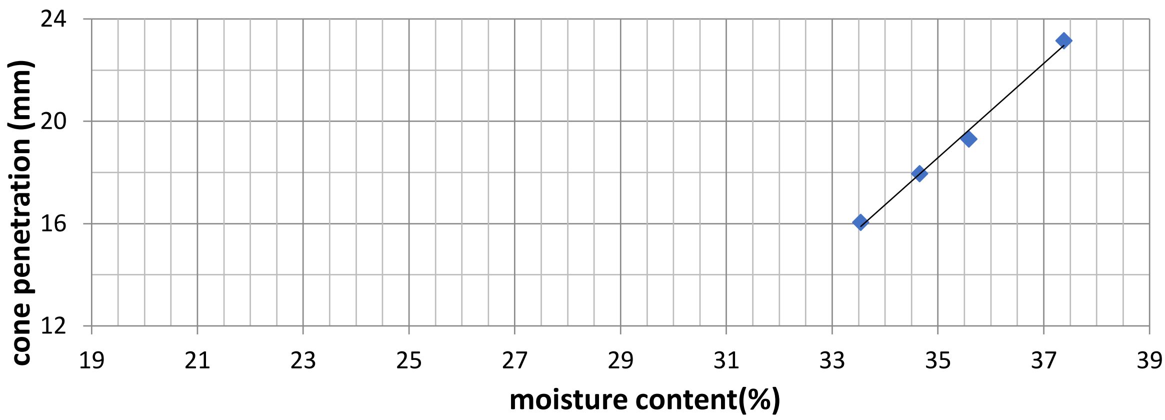


Figure 9: Flow curve

As shown on the USCS plasticity chart below, the soil occupied the portion for clay with low plasticity. With the use of AASHTO classification chart for fine grained soils passing the #200 sieve or rather the 0.075mm sieve, it was classified as Sandy lean clay.

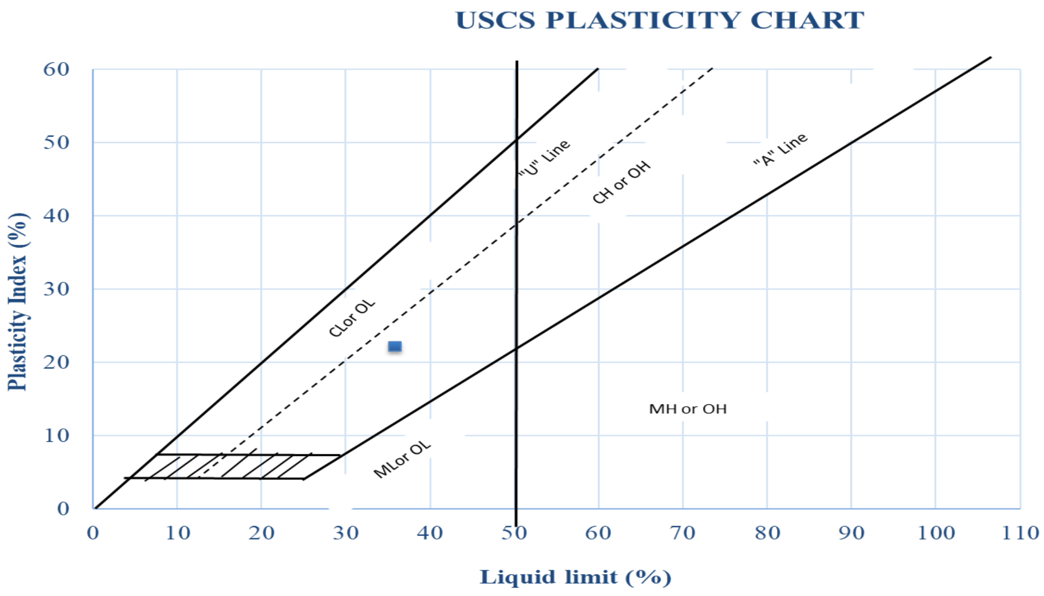


Figure 10: The A-line chart

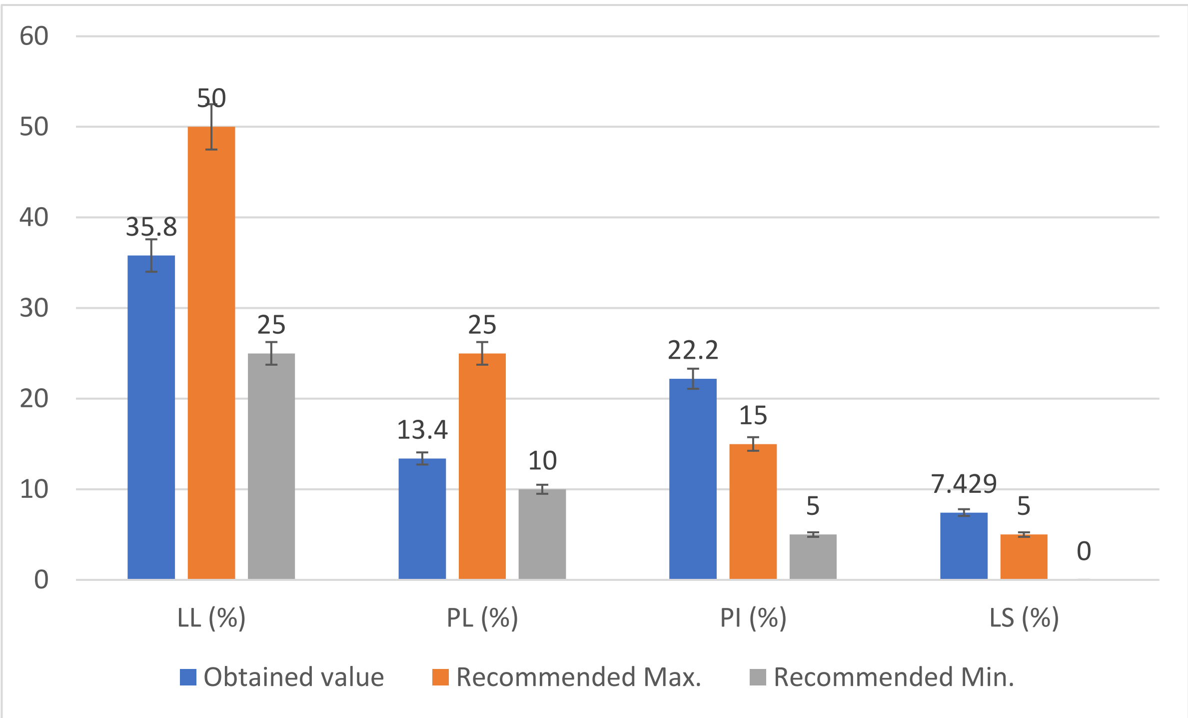


Figure 11: Atterberg limit results analysis

The liquid limit of 35.8% as shown in Figure 11 falls within the acceptable range of 25% to 50% for crafting third-class bricks, as outlined by IS standards. Although the plastic limit complies with the norms, the plasticity index, at 22.2%, surpasses the advised maximum of 15%. A higher liquid limit enhances the workability of soil during brick fabrication, facilitating the moulding process into desired form and dimensions. Conversely, a lower plastic limit contributes to the bricks' stability throughout their production, making them less prone to cracking and shrinkage. A plastic limit value within the range of 10% to 25% is recommended for optimal performance.

A liquid limit between 25% and 50% is the recommended range, with 30% to 35% providing optimal strength and workability of the bricks. A value of 35.8% was obtained, which is within the range. This liquid limit means the soil will have a good workability during brick production.

4.3 X-RAY FLUORESCENCE (XRF) SPECTROSCOPY

X-ray fluorescence (XRF) spectroscopy was done from the Government Analytical Laboratory according to ASTM D5381-93 (2021) to determine the chemical composition of the rice husks. Rice husk ash for this research project was produced after heating rice husks at temperatures ranging from 600 to 800^{O}C. For each temperature, the test was repeated to determine the variation in chemical composition of the RHA produced at different heating times.

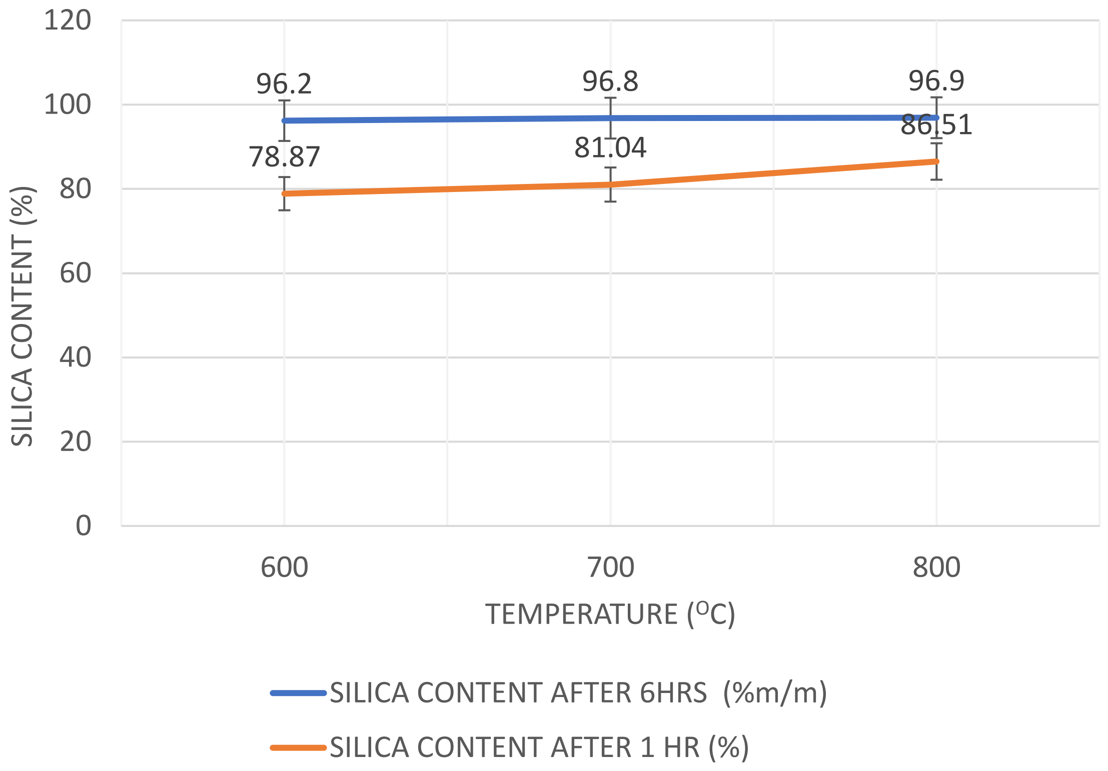


Figure 12: Graph showing the silica content variations with temperature and heating time in the RHA

As illustrated by the line graph, an increase in the temperature results into an increase in the silica content. This temperature range of 600 to 800^{0}C is the range through which we formed amorphous silica and beyond this temperature range we then started to obtain crystalline particles. Therefore, the temperature range selected was that from 600 to 800^{0}C.

The provided graph illustrates variations in the silica content of rice husk ash at assorted temperatures following durations of 1 and 6 hours. The phrase 'silica content after 6 hours (%m/m)' implies that this measure was obtained post a 6-hour period of maintaining the rice husk ash at a predetermined temperature, with '%m/m' denoting the silica percentage on a mass-to-mass basis. Likewise, 'silica content after 1 hour (%)' reflects the silica percentage identified after a 1-hour period under specific temperature conditions.

Concerning the rise in silica content with temperature increment, several underlying factors might contribute to this phenomenon. Elevated temperatures tend to facilitate the combustion of organic components within the rice husks, yielding a higher silica concentration. Moreover, thermal processing may alter the ash's physical and chemical attributes, potentially augmenting its pozzolanic activity through an increase in amorphous silica content, which exhibits higher reactivity in cement applications. Additionally, a rise in temperature may promote the conversion of any existing crystalline silica into an amorphous form, thereby enhancing the measurable 'reactive silica' content.

Determining the precise cause of these observations would necessitate an understanding of the experimental parameters, including the environment in which the ash was thermally treated (either oxidizing or reducing), the heating velocity, and the original composition of the rice husks.

The observed increase in silica content with temperature may be attributed to the combustion of organic components within the rice husk ash, which leaves behind a higher percentage of silica (Smith, 2023). Furthermore, the thermal treatment is likely to enhance the pozzolanic reactions by converting crystalline forms of silica into more reactive amorphous forms, which are preferable for use in cementitious materials (Johnson and Lu, 2023).

4.4 COMPRESSIVE STRENGTH TEST

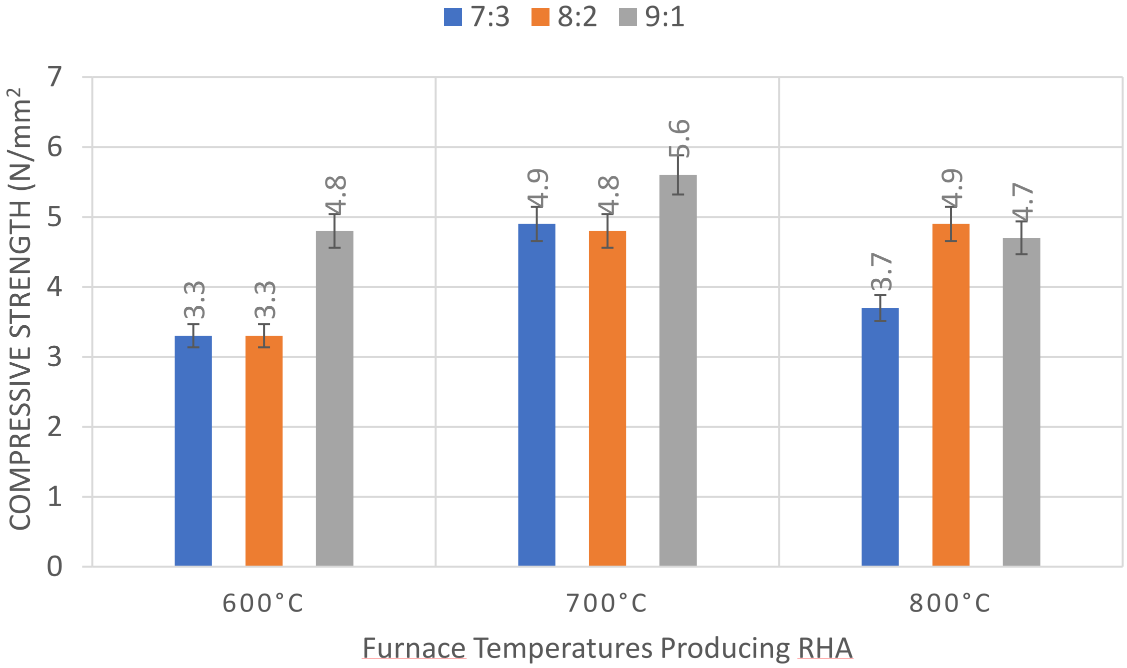
This test was carried out on 25/01/2024 at Teclab laboratories with reference to BS EN 12390:2019 and IS 3495-Part 1: 1992. This test was used to determine the maximum amount of pressure each brick was able to withstand before failure. The results obtained for compressive strength of neat earth bricks were as shown below.

Table 6: Neat brick compressive strength

COMPRESSIVE STRENGTH					
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 average compressive strength of the neat earth bricks was obtained as 2.3N/mm^2 which 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 necessitated the need to improve the compressive strength of the brick.

Figure 13: Variation in compressive strength with temperature change



The depicted graph as shown in Figure 15 illustrates the compressive strength of bricks crafted using rice husk ash (RHA) at varying temperatures of 600, 700, and 800 degrees Celsius, employing different ratios of RHA to soil: 1:9, 2:8, and 3:7 for each temperature setting. Volume batching was utilized during the brick production process.

The findings indicate a notable enhancement in the compressive strength of bricks incorporating RHA compared to conventional neat bricks. Specifically, bricks fabricated at 600 degrees Celsius with soil to RHA mixes of 7:3 and 8:2 exhibited a minimum compressive strength of 3.3N/mm^2, surpassing that of neat bricks. The compressive strength of these burnt clay bricks significantly influences their durability and abrasion resistance. (Femi Timothy Owoeye, 2021)

The apex compressive strength recorded was 5.6 N/mm^2, achieved with a 9:1 soil to RHA ratio at a production temperature of 700 degrees Celsius. Altering the soil to RHA ratios to 8:2 and 7:3 at this temperature resulted in reduced strengths of 4.8N/mm^2 and 4.9N/mm^2, respectively, due to the increased brittleness from higher proportions of fine RHA. Higher firing temperatures potentially cause RHA particles to partially melt or cluster, yielding a rougher texture and diminished surface area, along with a transformation of RHA into crystalline silica from its amorphous state.

When the RHA proportion was adjusted from 9:1 to 8:2 at 800 degrees Celsius, the compressive strength initially rose from 4.7N/mm^2 to 4.9N/mm^2, then declined to 3.7N/mm^2. The rougher texture from elevated temperatures necessitates larger RHA quantities (at an 8:2 soil to RHA ratio) for creating a more brittle brick, yet smaller RHA proportions also contributed to increased strength due to the pozzolanic reaction between RHA silica and clay minerals.

4.5 WATER ABSORPTION TEST

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. The main purpose of this test is to determine the ability of the brick to resist water absorption when immersed in water for at least 24 hours. The water absorption is the percentage of the weight of the brick after soaking which is moisture.

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

Table 7: Neat brick water absorption tests

WATER ABSORPTION				
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**

As per the standards set by BS EN 771-1:2003 and IS 3495-Part 2: 1992, bricks must exhibit a water absorption rate ranging from 12% to 20% relative to their dry weight as shown in Appendix B. The measured water absorption rate of 13.6% aligns with the BS EN 771-1:2003 stipulations, indicating satisfactory water absorption characteristics. Increased water absorption rates undermine the bricks' resilience to moisture-related degradation, while absorption rates below the prescribed threshold could lead to insufficient adhesion between bricks and mortar in construction projects.

The graph below shows the different water absorption averages obtained after carrying out triplicate testing on for individual ratios such as 9:1, 8:2 and 7:3 (soil to RHA).

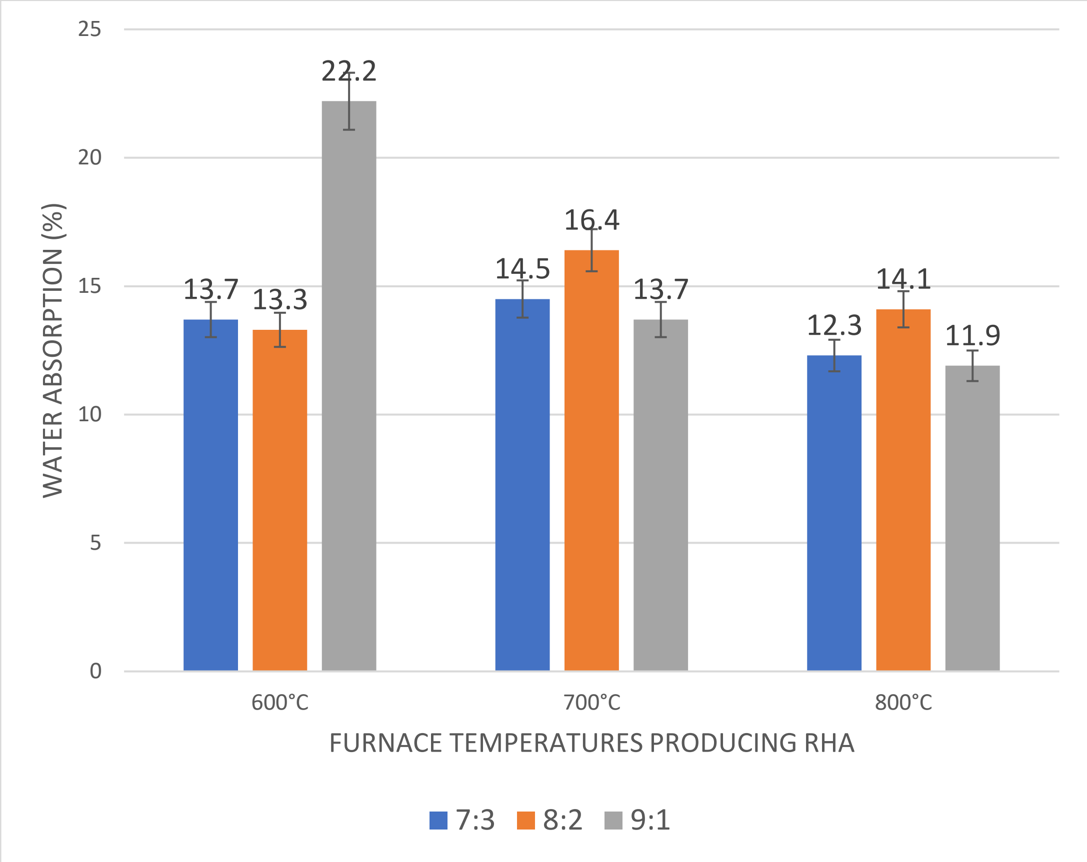


Figure 14:Graph showing the variation in water absorption of the stabilized bricks formed.

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) as shown in Appendix B. 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 while still having the strongest compressive strength parameter.

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 highest compressive 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.

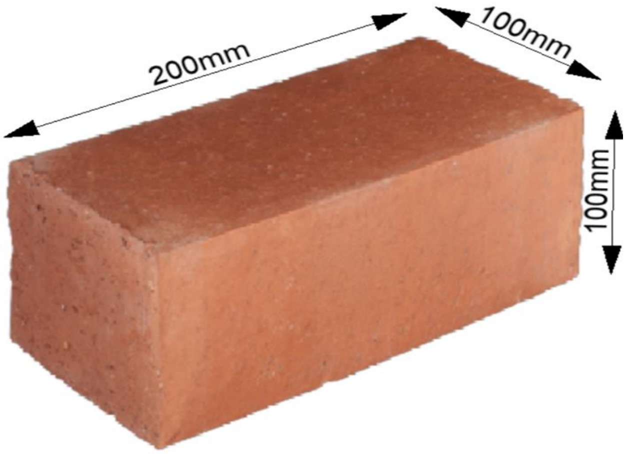


Figure 15: Dimensions of the bricks used

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The investigation into the utilization of thermally treated Rice Husk Ash (RHA) as a reinforcing agent in the manufacture of fired clay bricks yields several key insights:

1. The soil from the Ntawo Brick production area was found to have an ideal particle size composition for the crafting of fired clay bricks, featuring a substantial clay content (62.9%), moderate sand levels (37%), and minimal gravel presence (0.1%). The plasticity index (22.2%) of the soil samples indicates high malleability, facilitating the brick formation process.

2. Analysis through X-Ray Fluorescence (XRF) revealed that the silica (SO_2) concentration in the rice husk ash increases with temperature elevation from 600˚C to 800˚C, and further rises when the ash is subjected to prolonged heating from one to six hours.

3. The integration of thermally treated RHA into the clay used for brick manufacturing significantly enhances the compressive strength of the bricks across all examined temperature ranges from 600˚C to 800˚C, in comparison to bricks without RHA.

4. The optimal compressive strength (5.6KN/mm^2) was achieved with RHA processed at 700˚C, using a soil-to-RHA ratio of 9:1. Thus, 700˚C is identified as the ideal temperature for preparing RHA for inclusion in fired clay brick production, with these conditions significantly boosting the bricks' structural integrity by 143.5% and moisture regulation.

6.2 RECOMMENDATIONS

6.2.1 A Pilot Study

It is advised to do a pilot study employing bricks stabilized with rice husk ash at a 9:1 soil-to-RHA ratio, especially those produced with ash treated at 700°C, for practical construction purposes owing to their superior compressive strength and effective water absorption qualities. Suggested uses include:

- Constructing foundation plinth walls,
- Building parapet walls,
- Erecting external and internal partition walls.

6.2.2 Research on Long-term Endurance

Research is encouraged to explore the long-term endurance and functionality of RHA-enhanced bricks under varied climatic challenges, such as freeze-thaw cycles, to deepen the comprehension of their constructional applicability.

6.2.3 Lifecycle Cost Analysis

Additional investigations should aim at performing a life-cycle cost analysis to vary the environmental and economic advantages of using RHA in brick production against traditional methods. To assess the practicality of expanding RHA utilization in brick manufacturing on an industrial scale, it is recommended to examine the scalability of production, taking into account factors such as raw material availability, processing expenses, and quality assurance measures.

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APPENDIX A

Figure 16 Sample collection from the site at Ntawo

Figure 17 Weighing the neat bricks before the water absorption test

Figure 18 Measurement of the initial moisture content of the soil

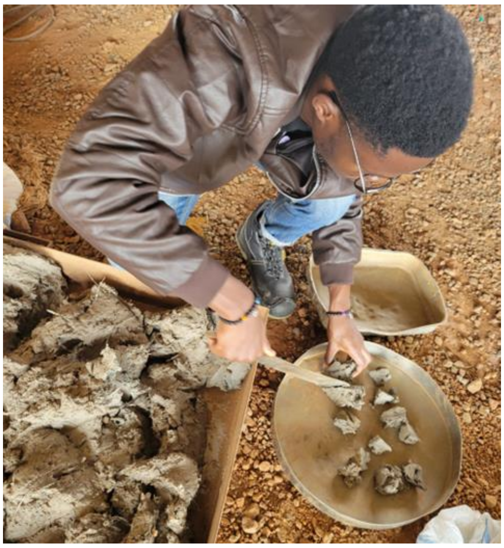


Figure 19 collection of air-dried soil sample for crushing

Figure 20 Crushing the soil sample for Atterberg limit tests

Figure 21 Making a smooth soil paste for cone penetrometer test

Figure 22 Curing of the stabilized bricks

Figure 23 Mixing of the RHA into the soil

APPENDIX B

Teclab ltd
THE ENGINEERS LABORATORY

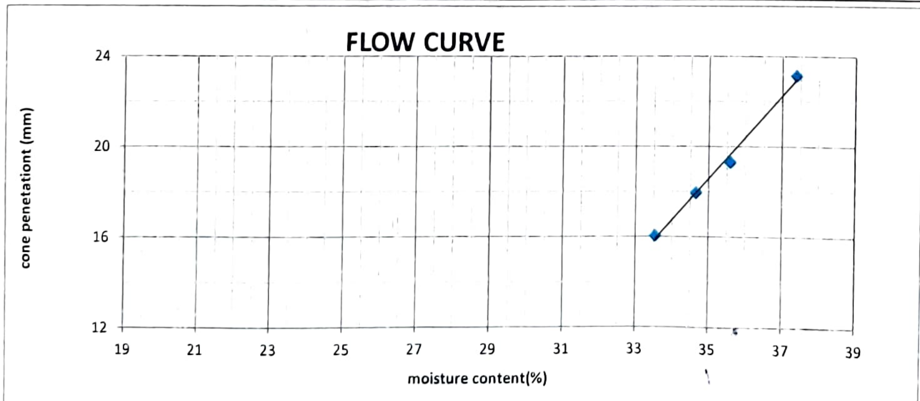
EXCELLENCE THROUGH PRECISION AND INTEGRITY

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**		
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		13.5
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):**
[signature]	[signature]	[signature] TECLAB LIMITED A GEOSCIENCES COMPANY EST. 2002

TL-TI-FORM- 08 VER00 MARCH 2018

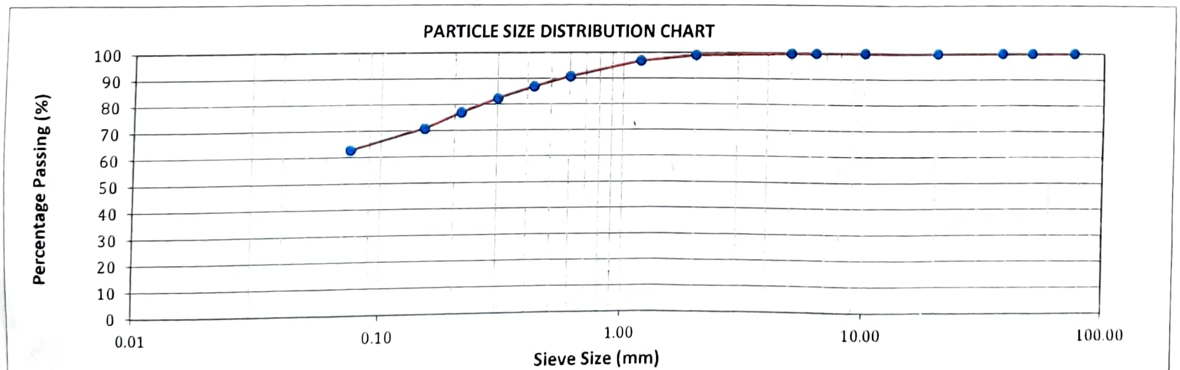
Teclab
A GEOSCIENCES COMPANY

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 **Page 1 of 1**

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★
24-00802
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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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

"Go Scientific for a Safe and Just Society"

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

02nd February 2024

THE REPUBLIC OF UGANDA

FOR GOD AND MY COUNTRY

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

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-07 **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 (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
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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 600^0C		
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	3.65	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

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 (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 **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 (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 700^0C		
Compressive Tesing Machine ID:	2 TL-COM-CTRL-002		

DATE OF CASTING	DATE OF TESTING	SAMPLE NUMBER	MEASURED SPECIMEN DIMENSIONS (mm)			CROSS SECTIONAL AREA (mm²)	WEIGHT OF SAMPLE (kg)	DENSITY OF SAMPLE (kg/m³)	FAILURE LOAD (kN)	CORRECTED FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm²)
			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
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EST. 2002

Client's Representative:

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-06 **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 (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 800^0C		
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	3.65	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
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EST. 2002

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-02 **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 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:

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CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-03 **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 (7:3) - RHA Burnt at 800^0C		
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	3.26	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 **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 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°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

CERTIFICATE OF ANALYSIS

CERTIFICATE No.: DL-17449-12 **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 (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^{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	3.87	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