EXPERIMENTAL STUDY ON MANUFACTURING OF BRICK USING ANT MOUND SOIL

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Abstract

This research explores the potential of using ant mound soil as a sustainable alternative to traditional clay bricks. Ant mounds, constructed by ants using a mixture of soil, saliva, and other organic materials, possess unique properties that may be advantageous in brick production. This study investigates the physical and mechanical properties of bricks made from ant mound soil, comparing them to those of conventional clay bricks. The research also examines the environmental benefits of utilizing ant mound soil, such as reducing reliance on clay mining and minimizing the ecological impact associated with traditional brick manufacturing. The findings suggest that ant mound soil has the potential to be a viable and sustainable material for brick production, offering a promising solution for eco-friendly construction practices.

Key words: Ant mound soil, Brick preparation

1.Introduction

Ant mound soil is a type of soil modified by ants through their biological activities. The soil's high strength, stability and water resistance make it an attractive alternative to traditional building materials.

Bricks manufactured from ant mound soil have gained attention in recent years due to their potential to provide sustainable and eco-friendly building. The use of ant mound soil bricks can reduce the environmental impact.

The use of ant mound soil in brick manufacturing offers a sustainable and innovative approach to construction materials. The process involves collecting and processing ant mound soil, mixing it with suitable additives, and shaping it into durable bricks. This approach not only promotes sustainable construction practices but also explores new avenues for utilizing natural resources efficiently.

1.1.Benifits of ant mound soil bricks:

<u>Construction Advantages:</u>

1.Fire Resistance:

Termite mound soil contains clay, which is incombustible and makes the bricks resistant to fire.

2.Compressive Strength:

Studies have shown that termite mound soil bricks have adequate compressive strength for construction, even exceeding certain standards.

3.Low Cost:

Utilizing readily available termite mound soil can significantly reduce construction costs, making it an attractive option for low-income housing.

4.Natural Fibers:

Termite mound soil can be mixed with natural fibers like sisal or bamboo for further strength and durability.

5.Sustainability:

Using natural materials like termite mound soil contributes to sustainable building practices.

<u>Other Advantages:</u>

1.High Water-Holding Capacity:

The soil's composition allows it to retain water, which can be beneficial in areas with limited water resources or during dry seasons.

2.Rich in Nutrients:

Termite mound soil can be richer in nutrients than surrounding soil, potentially benefiting local agriculture or as a component in potting mixes.

3.Microbial Activity:

Termite mound soil harbors beneficial microorganisms that contribute to soil health and nutrient cycling.

1.2.APPLICATIONS OF ANT MOUND SOIL BRICKS:

1.House Construction:

Termite mound soil can be used as a full replacement for clay in brick production, making it suitable for constructing houses in both rural and urban areas.

2.Low-Cost Housing:

Due to their binding properties and low cost, they are particularly promising for low-cost housing projects, especially in developing countries.

3.Stabilized Bricks:

Termite mound soil can be combined with stabilizers like cement and natural fibers to further enhance their strength and durability.

4.Roads and Paths:

In some regions, termite mound soil is used to create hard surfaces for roads and paths.

5.Dams:

Small dams have been built using soil from termite mounds.

6.Storage Structures:

Plaster made from termite mound soil is used to line storage pots for grain, protecting it from pests.

7.Threshing Floors and Other Hard Surfaces:

The soil is used to create hard surfaces for threshing floors and other structures that need a hard, pest-resistant surface.

2.Literature review

2.1.Gaugler & Mielke (1982) in "The Composition of Ant Mound"

They are from Germany. In 1982, clay bricks were used in Germany. This study focusses on reduce the environmental impact by traditional brick. The mixed proportion is:

MATERIALS	PERCENTAGE
ANT MOUND SOIL	50 %
SAND	30 %
SILT	20 %
CLAY	10 %
CEMENT (OPC)	15 %
LIME (Hydrated Lime)	2 %
WATER (Potable Water)	15 %

Table 2.1Mix proportion

The result showed that the compressive strength and durability are higher than traditional brick.

2.2. "Development of Moisture Resistant Termite Mound-Clay Bricks for Rural Structures" by Akinyemi.B, Akpenpuun.D and Timothy.D (2018)

Akinyemi.B, Akpenpuun.D and Timothy.D are from Nigeria and clay bricks, concrete bricks are used at that time. It explores using termite mound soil to create moisture resistant bricks.

The least water absorption value was 6.56% with 70% termite mound clay, 30% cement and Hydropruf additive.

The highest compressive strength achieved was 79.78 N/mm² with the same composition of 70% termite mound clay, 30% cement and Hydropruf additive.

2.3.Patel,s.(2020) Experimental investigation on ant mound soil bricks

The researcher is from Gujarat. In 2020, clay bricks, fly ash bricks, concrete bricks, sand lime bricks, perforated bricks and burnt clay bricks are used in India. The research aims to evaluate the suitability of ant mound soil as a sustainable alternative to traditional clay soil in brick production.

BRICK TYPE	WATER ABSORPTION	THERMAL RESISTANCE
ANT MOUND SOIL	15 %	0.6 W/MK
CLAY BRICK	7 %	0.5 W/MK

TABLE 2.2. TEST RESULT

They concluded with ant mound soil bricks exhibit good water absorption and thermal resistance.

2.4. "Characterization of Ant Hill Soil for Construction PurPoses" by S.S.Rao

S.S.Rao is an Indian. This study characterizes ant hill soil for construction purposes and exploring its potential as a sustainable alternative to traditional building materials. The mix proportion is

MATERIALS	PERCENTAGE
ANT MOUND SOIL	60 %
CEMENT	15 %
SAND	15 %
LIME	5 %
WATER	15 %

TABLE 2.3. MIX PROPORTION

This study shows that durability is high, prevent shrinkage and increase permeability.

5. Singh.S. K., & Kumar.R.(2020). Thermal Performance of Bricks Made from Ant Mound Soil

They are from India and this study investigates the thermal performance of bricks made from ant mound soil. They concluded with

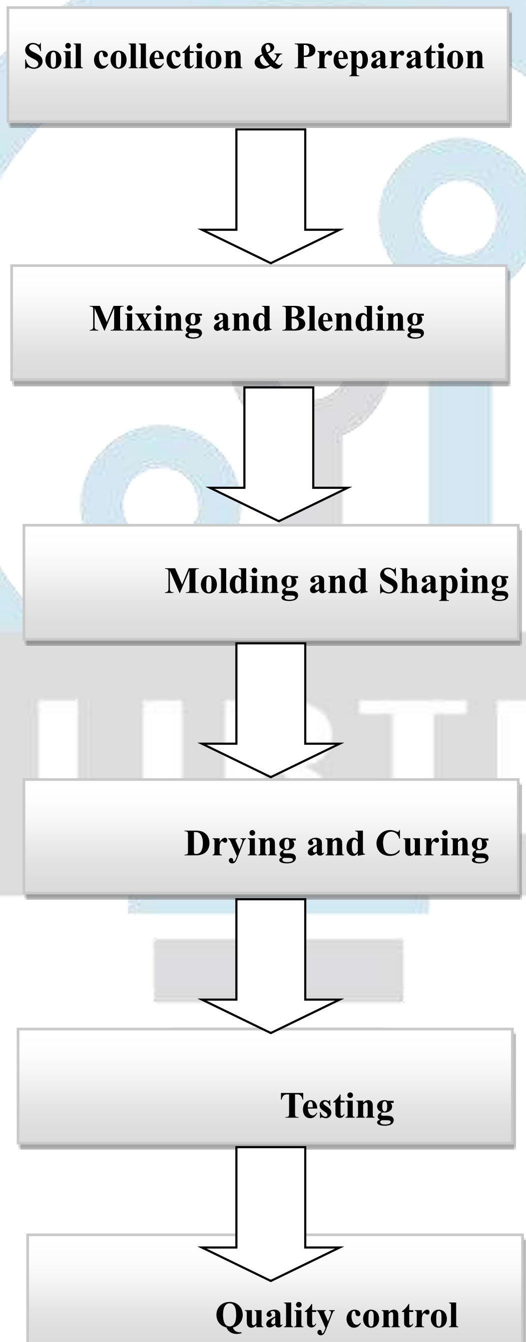
THERMAL INSULATION:

Bricks made from ant mound soil might exhibit improved thermal insulation properties due to their unique composition and structure.

ENERGY EFFICIENCY:

Using ant mound soil bricks could contribute to energy-efficient buildings by reducing heat transfer and minimizing cooling costs.

3.Methodology



3.1.SOIL COLLECTION AND PREPARATION:

1. Collect ant mound soil: Collect ant mound soil from suitable locations, ensuring minimal environmental impact.

2. Soil testing: Test the soil for its physical and chemical properties to determine its suitability for brick production.

3. Soil preparation: Prepare the soil by sieving in 0.075mm sieve to achieve the desired consistency and texture.

3.2.MIXING AND BLENDING:

1. Mixing: Mix the prepared ant mound soil (70%) with cement (10%), sand(10%) and water (Added as need to achieve desired consistency).

2. Blending: Blend the mixture thoroughly to ensure uniform distribution of all ingredients.

3.3.MOULDING AND SHAPING:

1.Moulding: Pour the blended mixture into brick molds and ensure that the molds are properly lubricated to prevent sticking.

2. Shaping: Use a vibrating table or a manual tamper to shape and compact the bricks.

3.4.DRYING AND CURING:

1. Drying: Allow the bricks to dry in a controlled environment for 7 days, maintaining a consistent temperature and low humidity which prevents crack.

2. Curing: Cure the bricks for 7 days by spraying water to prevent moisture loss and promote strength gain.

3.5.TESTING:

1.Testing: Conduct various tests such as compressive strength, water absorption and durability, to evaluate the quality of the bricks.

4.6.QUALITY CONTROL:

1.Inspection: Inspect the bricks for defects such as cracks, unevenness and improper shape.

2. Quality assurance: Ensure that the bricks meet the required standards and specifications.

4.Materials

4.1.ANT MOUND SOIL:

It is the main material used for brick production which is collected from ant mounds. The soil is sieved at 0.075mm size sieve.

Fig.4.1.1.ANT MOUND SOIL

4.2.SAND:

Sand plays a crucial role in brick manufacturing by acting as a key component and providing various benefits, including reducing shrinkage, preventing cracking, and enhancing the overall quality of the bricks. The Sand is sieved at 4.75mm Sieve.

Here's a more detailed explanation of sand's importance:

1. Preventing Shrinkage and Warping:

- Sand, particularly silica sand, helps to minimize shrinkage and warping during the drying and firing processes.
- It helps to create a more stable and less prone to shrinkage material.

2. Reducing Cracking:

- Sand addition can significantly reduce the formation of cracks during the drying process.
- Proper mixing of ant mound soil and sand ensures uniform drying and prevents stress concentrations that can lead to cracking.

3. Enhancing Brick Strength and Durability:

- Sand increases the hardness and durability of bricks, making them more resistant to wear and tear.
- The presence of sand, particularly silica, contributes to the overall structural integrity of the bricks.

4. Improving Workability and Consistency:

- Sand helps to create a more workable and consistent clay mass for brick molding.
- This improves the ease of forming bricks and ensures a more uniform shape and size.

4.3.CEMENT:

Cement plays a crucial role in bricks manufacturing, acting as the primary binding agent that holds the other ingredients together and strengthens the brick. It reacts with water to form a paste that binds sand, aggregates, and other materials, resulting in a durable and strong brick.

Here's a more detailed breakdown of cement's importance:

1.Binding Agent:

- Cement acts as the glue that binds the sand, aggregates, and other additives together, creating a cohesive structure.

2.Strength and Durability:

- The cement-water reaction results in a hardened, strong, and durable brick that can withstand various loads and environmental conditions.

4.4.WATER:

Water plays a crucial role in brick manufacturing by enabling the shaping, improving compaction, and ensuring proper bonding between bricks and mortar. It's essential for creating a workable mix, allowing for the formation of bricks and their subsequent drying and firing.

Here's a more detailed breakdown:

1. Shaping and compacting:

- Water is a key ingredient for mixing, allowing it to be molded into desired shapes.
- The correct water ratio is crucial for achieving good compaction, which leads to stronger and more durable bricks.

- Too much water can cause bricks to sag or fall and apart, while too little can make them crumble, impacting their quality.

2. Drying and Firing:

- After shaping, the bricks need to be dried to remove excess water, which prepares them for firing.
- Water in the bricks during firing can affect their strength and durability, so proper drying is essential.

5.Preparation of bricks

The preparation of ant mound soil bricks would likely follow a similar process to traditional clay brick making, with potential adjustments based on the specific properties of the ant mound soil.

Here's a general outline of the steps involved, keeping in mind that this is based on existing brick-making techniques and the limited knowledge about ant mound soil:

5.1. Identification and Collection of Ant Mound Soil:

Source Selection:

- Identify mature and preferably inactive ant mounds.
- Consider the size and accessibility of the mounds.

Soil Characterization (Initial Assessment):

- Observe the soil's texture and consistency. Note if it's predominantly clay-like.
- Collect samples from different parts of the mound for preliminary assessment.

Responsible Harvesting:

- Collect soil in a way that minimizes environmental impact.
- Avoid completely dismantling active mounds. Consider only taking a portion of the soil.

5.2. Pre-processing of the Soil:

Sorting and Cleaning:

- Remove any large debris like stones, roots, and significant amounts of visible organic matter (e.g., large pieces of dead ants, plant parts).
- Sieving the soil through a mesh can help remove larger particles.

Organic Matter Management:

- Depending on the amount of organic matter, you might need to consider methods to manage it.

Natural Decomposition:

- Spreading the soil in thin layers and allowing it to decompose for a period.

Controlled Burning (with caution):

- Carefully burning off excess organic matter.
- This needs to be done cautiously to avoid altering the soil's desirable properties.

Crushing and Pulverizing:

- Break down any large clumps of soil to achieve a more uniform and workable consistency.
- This might involve manual crushing or using simple grinding tools.

5.3.Mixing and Tempering:

Water Addition:

- Gradually add water to the soil while mixing thoroughly.
- The goal is to achieve a plastic and workable consistency suitable for molding.
- The optimal water content will depend on the clay content and other properties of the ant mound soil.

Kneading or Pugging:

- Work the soil-water mixture to ensure uniform moisture distribution and to develop plasticity.
- This process, known as tempering, helps to remove air pockets and improve the strength of the bricks.
- Traditional methods involve treading the clay with feet or using simple pugging machines.

Addition of Additives (Optional):

- Depending on the soil's properties and desired brick characteristics, you might consider adding small amounts of:

Sand:

- To improve workability and reduce shrinkage during drying and firing if the clay content is very high.

Binding Agents:

- If the soil lacks sufficient natural binding, small amounts of natural binders like plant fibers or animal manure (used traditionally in some brick making) could be explored cautiously.
- However, the unique components of ant mound soil might already provide some binding.

5.4. Molding the Bricks:

Hand Molding:

- Press the tempered soil into simple wooden or metal molds of the desired shape and size.
- Excess soil is scraped off, and the wet brick is carefully removed from the mold.

Machine Molding (for larger scale):

- If producing a larger quantity, simple hand-operated or small-scale mechanical presses could be used.

5.5 Drying the Bricks (Air Drying):

Careful Placement:

- Arrange the wet bricks on a flat, dry surface, ensuring adequate spacing for air circulation.
- Protect them from direct sunlight and rain, which can cause cracking.

Drying Period:

- Allow the bricks to air dry slowly and evenly.
- The drying time will depend on the climate, humidity, and the size of the bricks.
- This stage can take several days to weeks. Proper drying is crucial to prevent cracking during firing.

5.6. Firing the Bricks (Baking):

Kiln Construction:

- Build a simple kiln using locally available materials like mud, clay, or salvaged bricks.
- The design should allow for controlled heating and airflow.

Stacking the Bricks:

- Carefully stack the dried bricks inside the kiln, leaving space for heat circulation.

Firing Process:

- Gradually heat the kiln using fuel like wood, agricultural waste, or other locally available biomass.
- The firing temperature and duration are critical and depend on the type of clay and desired strength.
- Achieving the right temperature (typically between 800-1000°C for clay bricks) vitrifies the clay particles, resulting in hard and durable bricks.
- This stage requires experience to control the heat and ensure even firing.

Cooling:

- Allow the kiln and the fired bricks to cool down slowly to prevent thermal shock and cracking.

Considerations Specific to Ant Mound Soil:

Potential Chemical Reactions:

- The unique chemical composition of ant mound soil (including potential insect secretions and altered mineral content) might lead to different reactions during firing compared to typical clay soils.
- Experimentation with firing temperatures and durations might be necessary.

Pozzolanic Potential:

- If the ant mound soil exhibits pozzolanic properties after calcination, the firing process could activate these properties, potentially leading to stronger bricks.

Shrinkage:

- The clay content and the presence of organic matter will influence shrinkage during drying and firing.
- Adjustments to the soil mix (e.g., adding sand) might be needed to minimize cracking.

Strength and Durability Testing:

After firing, it's essential to test the strength, water absorption, and durability of the bricks to assess their suitability for construction.

6.Quality control

Quality control is crucial in the manufacturing of ant mound soil bricks to ensure they meet the required standards for strength, durability, and overall performance in construction. Here's a breakdown of the key aspects of quality control for these types of bricks:

6.1. Raw Material Quality Control:

Source Identification and Consistency:

* Identify and document the specific locations of ant mounds being used. Soil properties can vary between mounds and locations.

* Establish procedures to ensure consistency in the type of soil being collected (e.g., depth of collection, avoidance of topsoil or bottom layers if they differ significantly).

Contamination Check:

* Inspect the collected soil for unwanted materials like large stones, roots, organic debris, and other contaminants that could weaken the bricks.

* Implement sieving or other cleaning processes to remove these impurities.

Moisture Content:

* Monitor the initial moisture content of the soil, as this will affect its workability during molding and drying.

* Establish acceptable moisture content ranges for processing.

Soil Composition Analysis (Periodic):

* Periodically analyze the chemical and mineralogical composition of the ant mound soil to understand its key components (e.g., clay content, presence of natural binders). This helps in predicting the final brick properties.

6.2. Manufacturing Process Control:

Mixing and Preparation:

* Ensure that if additives like cement, sand, or fibers are used, they are measured and mixed in the correct proportions to maintain batch consistency.

* Control the amount of water added during tempering to achieve the desired plasticity for molding.

Molding:

* Regularly inspect molds for damage or wear that could affect the shape and size of the bricks.

* Ensure consistent compaction of the soil mixture within the molds to achieve uniform density.

Drying:

* Control the drying process (air drying or kiln drying) to prevent cracking. Monitor temperature and humidity levels if using a kiln.

* Ensure bricks are dried for the specified duration to reach the desired moisture content before firing (if applicable).

Firing (if applicable):

* Strictly control the temperature and duration of the firing cycle in the kiln. Inconsistent firing can lead to variations in strength and color.

* Ensure proper stacking of bricks in the kiln for uniform heat distribution.

Cooling:

* Implement a controlled cooling process to prevent thermal shock and cracking of the fired bricks.

6.3. Finished Product Quality Control Tests:

These tests are performed on representative samples of the manufactured bricks to assess their quality against established standards. Common tests include:

Dimensional Check (Shape and Size):

* Measure the length, width, and height of several bricks to ensure they conform to specified dimensions and have sharp, straight edges.

Visual Inspection:

* Check for any visible defects such as cracks, flaws, holes, or uneven surfaces.

* Assess the uniformity of color and texture.

Hardness Test:

* Attempt to scratch the brick surface with a fingernail or a moderately sharp object. A good quality brick should resist scratching.

Soundness Test (Clap Test):

* Strike two bricks together. A good quality brick should produce a clear, metallic ringing sound without breaking. A dull thud indicates potential weakness or internal flaws.

Drop Test:

* Drop bricks from a specified height (e.g., 1 meter) onto a hard surface. They should not break or develop cracks easily.

Water Absorption Test:

* Weigh a dry brick (W1).
* Immerse it in water for a specified period (usually 24 hours).
* Weigh the saturated brick (W2).
* Calculate the water absorption percentage: $\frac{W2 - W1}{W1} \times 100\%$.
* Excessive water absorption indicates high porosity and potentially lower durability. Acceptable limits should be established based on intended use.

Compressive Strength Test:

* This is a critical test to determine the load-bearing capacity of the bricks.
* A brick specimen is placed in a compression testing machine, and a load is applied until the brick fails.
* The maximum load at failure divided by the loaded area gives the compressive strength (usually expressed in MPa or N/mm^2).
* Minimum acceptable compressive strength values should be defined based on the intended application (e.g., load-bearing walls, non-load-bearing walls).
* Research suggests that ant mound soil bricks can achieve significant compressive strength, sometimes exceeding requirements for non-load-bearing walls, especially when stabilized.

Efflorescence Test:

* Immerse one end of the brick in water for a specified period and then allow it to dry in air.
* Examine the surface for white, powdery deposits (efflorescence) which indicate the presence of soluble salts that can be detrimental to the brickwork's appearance and longevity.

Durability Tests (Long-term assessment):

* These tests simulate weathering conditions to assess the long-term performance of the bricks. Examples include:

Freeze-Thaw Test:

* Subjecting bricks to repeated cycles of freezing and thawing to evaluate their resistance to damage in cold climates.

Wetting and Drying Test:

* Repeatedly wetting and drying bricks to assess their resistance to disintegration due to moisture fluctuations.

Abrasion Resistance Test:

* Evaluating the brick's ability to withstand surface wear.

6.4. Documentation and Record Keeping:

* Maintain detailed records of raw material sources, manufacturing processes, and the results of all quality control tests.
* Implement a system for batch identification and traceability.
* Regularly analyze quality control data to identify trends and areas for improvement in the manufacturing process.

By implementing a comprehensive quality control program, manufacturers can ensure that ant mound soil bricks are consistent in quality, meet the required performance standards, and provide durable and reliable construction materials.

The specific tests and standards applied may vary depending on local building codes and the intended use of the bricks.

7.Recommendations

7.1. Further research: Conduct comprehensive studies on the properties and behavior of ant mound soil bricks.

7.2. Standardization: Develop industry standards for production and quality control.

7.3. Scalability: Explore large-scale production methods.

7.4. Applications: Investigate various construction applications.

7.5. Sustainability assessments: Conduct life cycle assessments.

7.6. Awareness and education: Promote awareness among builders, architects, and policymakers.

7.7. Collaboration: Encourage industry partnerships.

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