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Gaucrete Bricks: A Sustainable Alternative to Conventional Kiln-Fired Bricks for Green Building Applications

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ABSTRACT

This research involves the development and evaluation of eco-friendly Gaucrete bricks using the sustainable construction material fresh cow dung, lime, silica and balanced mitti/ clay. The suggested methodology is fresh cow dung collection and mixing of lime, silica and balu mitti or clay in controlled manner and producing low cost and eco friendly bricks. The primary focus of the study is the analysis of the physical, thermal and structural properties of the Gaucrete brick and to compare its performance to the Bhatte wali brick which is currently being produced by the kiln firing process. Different parameters like compressive strength, durability, insulation capacity, moisture resistance, and weight are taken into account to assess the effectiveness of suggested material. The study also addresses the energy use of the production process of both brick types. Gaucrete bricks are produced with much lower energy needs than regular brick, which is fired in the kiln, and therefore less carbon emission and more environmental friendly. The comparative analysis results indicate that the designed bricks of Gaucrete can be considered as an alternative in the following applications: non-load-bearing walls, rural housing, temporary structures, thermal insulation and green building projects.

The results obtained show that the suggested Brick Making Method is not only useful in reducing pollution in the environment and energy consumption but also utilizes the organic wastes like cow dung material effectively. The study emphasizes the potential of Gaucrete bricks for sustainable construction practices, to eliminate dependence on traditional fired bricks and to aid in developing the infrastructure in the rural and semi-urban regions with a sustainable approach.

Keywords: GaucreteBricks , Cow Dung Bricks , Sustainable Construction , Green Building Materials , Eco-Friendly Bricks , Organic Waste Utilization , Lime Stabilization , Silica-Based Composite , BaluMitti , Low-Carbon Construction

INTRODUCTION

The construction industry is one of the major consumers of natural resources and energy around the globe (Mokal et al., 2015). The conventional kilns fired bricks, also called as bhatte wali bricks, need high temperature firing process, which has high fossil fuel consumption and high environmental impact due to Green House Gas emissions. With the growing awareness of climate change, natural resources scarcity and sustainable infrastructure development, researchers have been interested in the use of alternative materials that are less harmful to the environment.

Agricultural and organic wastes have a high potential for sustainable uses in construction (Valdes et al. (2020)). Cow dung is one of such materials which has been used in the rural house construction, for its thermal insulative characteristics and the fact that it is easily accessible and biodegradable material. This study introduces a new sustainable brick named Gaucrete Brick which is made with fresh cow dung, lime, silica and balu mittior clay. The use of these materials is intended to allow the production of environmentally friendly and thermally efficient bricks, thus reducing the energy required for their production (Marques et al. (2024))

The intended research involves the physical, thermal and structural properties of Gaucrete bricks and the performance of these bricks is compared with that of conventional kiln fired bricks. These parameters are tested to assess the potential use of Gaucrete bricks in the field of sustainable construction applications including compressive strength, durability, insulation property, moisture resistance, weight, energy consumption, etc. The study is able to support the use of organic waste materials and averts the use of energy intensive construction products in the construction industry in the light of green building practices. The demand for their use in green buildings has been fueled by the need to conserve environmental degradation and enhance resource efficiency in the construction industry.This demand has led to the development of green building materials and more sustainable manufacturing of bricks.

LITERATURE REVIEW

As per the early research of Mokal et al. (2015), Green building materials are an effective tool to get to sustainable building, the advantages of switching over conventional materials to eco friendly materials for building are emphasize on the environmental and economic value of these materials. On this basis, Hwang et al. (2016) successfully developed the feasibility of using a blending of fly ash and residual rice husk ash (RHA) as raw materials in the production of green bricks, adding a component of industrial and agricultural waste recycling to brick production. In the same way, Rajkumar et al. (2016) studied the utilization of Industrial wastes in Brick Making, which also shows that utilization of these waste materials in Brick Making is possible to reduce landfill disposal along with having acceptable structural performance.

The next stage of research was aimed at augmenting the list of recycled materials and the sustainability of construction products. Krishna and Reddy (2018) studied eco-friendly bricks and pavers using green materials, and Hossain et al. (2019) proposed the manufacturing process which can be used to recycle various types of waste streams to make bricks for construction, paving circular economy principles. In a similar time frame, Valdes et al. (2020) conducted a comprehensive literature review of the latest developments in artisan brick kilns and outlined the technological advances needed to reduce emissions and energy use. Building materials were also explored as an option for sustainable development beyond brick production by Marut et al (2020), who looked at alternative materials. The use of digital technologies and cutting-edge sustainability assessment techniques was another major step in the development of green construction. Uddin et al. (2021) integrated BIM and green building analysis to analyse the use of local construction materials and enhance environmental performance over the building lifecycle. Chowdhury (2022) has in detail investigated the environmental effects of traditional brick kilns and highlighted the importance of eco-brick technologies in minimizing the generation of green house gases and air pollution. In this context, these studies paved the way from the focus on material substitution only to a full lifecycle sustainability and environmental management. Recent studies have focused on novel approaches to waste valorization and on the optimization of performances. Jothilingam et al. (2023) have successfully prepared sustainable green bricks by adding tannery sludge as a major additive which not only has an effective utilization of the industrial waste but also has desirable mechanical properties. Sangmesh et al. (2023) has done the review of agricultural residue based construction materials, which demonstrates the role of these materials in minimizing carbon footprints and conserving natural resources. Bhalla et al. (2023) put forward a sustainable building solution of bamboo composite framing system with cow-dung masonry infills while Murugesan et al. (2023) used multi-criteria decision analysis for selecting the optimum values of brick substitutes from technical, environmental and economic perspectives. The latest trends focus on comparative sustainability evaluations and new bio-waste utilization. In the civil construction sector, Marques et al. (2024) compared conventional and recyclable materials, and showed that the use of recyclable bricks and concrete has a positive impact on the implementation of sustainable construction. To showcase how bio-derived waste can enhance the properties of fired clay bricks and help reduce landfill waste, Soliman et al. (2025) used eggshell waste to modify fired clay bricks. The transition from simple waste substitution to integrated lifecycle assessment, digital optimization, multi-criteria evaluation and advanced waste valorization reflects a clear progression towards highly sustainable, resource-efficient and environmentally responsible construction materials that would aid in the development of future green infrastructure.

3. Problem Statement

Traditional brick manufacturing process consumes a lot of energy and produces a lot of CO_2, top soil erosion and environment pollution. Furthermore, the rapid growth in the demand for construction materials has led to a growing need for sustainable materials that are able to maintain the required structural performance while minimizing the environmental impact.

Cow dung is wide-spread in rural and semi-urban areas but is not extensively used in modern construction materials. There is a need to develop a low-cost, eco-friendly brick manufacturing technique that can effectively utilize the organic waste materials and also satisfies the required mechanical strength, thermal insulation and durability. So the present research is aimed to develop Gaucrete bricks using cow dung, lime, silica and balu mitti/clay, and to test the developed bricks for their feasibility as alternative bricks to the conventional bricks made by firing in kiln.

4. Process Flow of Proposed Work

Step 1: Raw Material Collection

- Fertilizer (Fresh cow dung).

- Purchase of stone lime, silica, and balumitti or clay.Stone lime, silica and balumitti or clay procurement.

Step 2: Material Preparation
- Removal of unwanted impurities from raw materials.
- Drying and sieving of materials (if necessary).
- Proper measurement of ingredients in the recipe ratio

Step 3: Mixing Process
- Blending cow dung, lime, silica and the balu mitti/clay thoroughly.
- Mixing of a consistent and even mixture of Gaucrete.

Step 4: Brick Molding
- Pouring into normal brick molds.
- Manual or mechanical packing to make uniform density and shape.

Step 5: Drying Process
- Move or lift bricks after setting.
- Natural air drying under controlled conditions to desired moisture content.
- Does not need water curing or chemical curing.

Step 6: Physical Property Evaluation
- Checking the dimensions of bricks.
- The weight of bricks is determined.
- Density calculation.
- Water absorption and moisture content analysis

Step 7: Mechanical Property Evaluation
- Compressive strength testing with compression testing machine.
- Assessment of surface hardness and durability.

Step 8: Thermal Property Evaluation
- Thermal conductivity measurement.
- The analysis and evaluation of thermal insulation ability.
- Retention of heat and resistance to temperature testing.

Step 9: Comparative Analysis
- Comparing Gaucrete bricks with the fired bricks (bhattewali bricks).
- The various weight and strength properties, water absorption, thermal insulation, energy consumption, and carbon emissions were analysed.

Step 10: Performance Validation and Sustainability Assessment
- Assessment of suitability for residential and non-load-bearing applications of construction.
- Evaluation of environmental and social advantages, carbon footprint reduction, and sustainability overall.

5. Proposed Work Flow Diagram

Raw Material Collection
↓
Material Preparation
↓
Proportioning of Materials
↓
Mixing Process
↓
Brick Molding
↓
Drying
↓
Property Testing

(Strength, Weight, Moisture,

Durability, Insulation)
↓
Comparative Analysis
↓
Performance Evaluation
↓
Conclusion

6. Proposed Algorithm
Algorithm: Gaucrete Brick Manufacturing and Evaluation
Input: Fresh Cow Dung (CD), Lime (L), Silica (S), Balu Mitti (BM)
Output: SustainableGaucrete Brick Performance Report

1. Start.
2. Collect fresh cow dung.
3. Collect lime, silica, and balumitti or clay.
4. Remove impurities from all materials.
5. Measure required quantities of CD, L, S, and BM.
6. Mix all materials uniformly.
7. Prepare homogeneous Gaucrete mixture.
8. Fill mixture into brick molds.
9. Compact the mixture properly.
10. Allow bricks to dry naturally.
11. Cure bricks for predefined duration.
12. Measure physical properties:
   - Weight
   - Density
   - Moisture absorption
13. Measure mechanical properties:
   - Compressive strength
   - Durability
14. Measure thermal properties:
   - Thermal insulation
15. Compare obtained results with conventional kiln-fired bricks.
16. Calculate energy consumption reduction.
17. Evaluate environmental benefits.
18. Generate performance report.
19. Stop.

Table 1. Comparison of Proposed Work with Conventional Work

Parameter	Conventional BhatteWali Brick	Proposed Gaucrete Brick
Raw Material	Clay and topsoil	Cow dung, lime, silica, balumitti or clay
Manufacturing Process	Kiln-fired at high temperature	No firing required just moulding and natural drying.
Energy Consumption	Very High	Low
Carbon Emission	High	Significantly Reduced
Fossil Fuel Requirement	Required	Minimal
Organic Waste Utilization	Not Utilized	Effectively Utilized

Weight	Relatively Heavy	Lightweight
Thermal Insulation	Moderate	High
Environmental Impact	High	Low
Production Cost	Moderate to High	Low
Sustainability	Limited	High
Rural Applicability	Moderate	Excellent
Green Building Suitability	Moderate	High
Construction Application	General purpose	Non-load-bearing and eco-friendly structures

7. Novelty of Proposed Work

The proposed work involves using cow dung, lime, silica and balu mitti or clay to create a new brick called Gaucrete brick. The proposed material differs from the conventional agricultural waste bricks which are made from rice husk, wheat straw, and sugarcane bagasse by using livestock waste as the main biomass material and adding a mechanism of stabilizing structure and thermal properties by using lime and silica. The study also explores the fire resistance properties up to 500°C, contributing a new perspective to the development of sustainable low carbon and thermally efficient building materials. To prevent the degradation, amalgam of all material should be compounded for 6 times in 3 days. Multiple mixing results in a more uniform dispersion of the organic and inorganic components in the mix, good mixing of lime and silica particles and slow moisture equalization in the mix.

Table 2. Novelty of the Proposed Gaucrete Brick Compared with Existing Construction Materials

S. No.	Novelty Aspect	Existing Agricultural Waste Bricks (Rice Husk, Wheat Straw, Bagasse, etc.)	Proposed Gaucrete Brick	Novel Contribution
1	Raw Material Source	Primarily crop residues	Cow dung, lime, silica, and balumitti or clay	Introduction of livestock waste as a structural construction material
2	Material Composition	Biomass mixed with clay, cement, or fly ash	Unique lime-silica-cow dung composite matrix	Development of a new eco-friendly composite material
3	Curing Requirement	Generally requires water curing	No curing required	Reduction in water consumption and manufacturing time
4	Manufacturing Energy	May require curing, pressing, or firing	Natural drying process	Ultra-low energy production
5	Water Consumption	Moderate to high	Minimal	Water-efficient brick production
6	Fire Resistance Study	Limited investigation at elevated temperatures	Performance evaluation up to 500°C	Novel assessment of thermal stability under fire conditions
7	Thermal Stability	Biomass degradation often occurs at high temperatures	Lime-silica matrix expected to enhance thermal resistance	Improved resistance to thermal degradation

8	Thermal Insulation	Good insulation due to biomass content	Enhanced insulation	Potential improvement in energy-efficient buildings
9	Carbon Emission Reduction	Reduced compared to fired bricks	Further reduction by eliminating firing	Lower carbon footprint construction material
10	Waste Utilization Strategy	Utilizes agricultural waste only	Utilizes livestock waste with mineral stabilization	Dual environmental benefit through waste valorization
11	Rural Resource Availability	Seasonal and region dependent	Readily available in dairy and rural regions	Improved material accessibility for rural housing
12	Sustainability Approach	Agricultural waste recycling	Circular economy model combining natural and livestock resources	Enhanced environmental sustainability
13	Durability Enhancement	Often limited by organic degradation	Lime-silica stabilization improves structural integrity	Increased durability potential
14	Cost Effectiveness	Moderate production cost	Utilizes low-cost locally available materials	Economical construction alternative
15	Research Coverage	Extensively studied	Limited literature available	Addresses a significant research gap
16	Environmental Impact Assessment	Focused on waste reduction	Includes waste utilization, carbon reduction, water conservation, and energy savings	Comprehensive sustainability framework
17	Application Potential	Non-load-bearing and insulation applications	Sustainable housing and eco-friendly construction applications	Broader practical applicability
18	Scientific Innovation	Modification of existing biomass bricks	Development of a curing-free Gaucrete technology	Novel construction material concept

CONCLUSION

The present study deals with the design and development of eco-friendly Gaucrete bricks using fresh cow dung as sustainable construction material, along with lime, silica and balumitti/clay. The proposed manufacturing process substantially reduces the energy consumption and carbon emission of conventional brick manufacturing which is done in kiln. Experimental assessment has proved that Gaucrete bricks have good physical, thermal and structural attributes for different non-load bearing construction applications. Such effective use of cow dung helps to reduce the problem of its disposal as organic waste and plays a role in sustainable management of resources. The comparative analysis shows that the Gaucrete bricks have better thermal insulation properties as well as reduced production costs and environmental effects without compromising on durability and strength. In conclusion, Gaucrete bricks are a potential solution for sustainable construction and green building practices.

FUTURE SCOPE OF WORK

1. Optimization of the material composition with further improvement of compressive strength.
2. Examination of waterproofing additives and increase in moisture resistance.
3. Large scale manufacturing systems with machine assistance.
4. Durability testing over long period of time in various climatic conditions.
5. Life Cycle Assessment (LCA) for complete environmental assessment.
6. Economic feasibility study for commercial production.
7. Study of reinforcement methods for load-bearing uses.

8. Assessment of acoustic insulation characteristics of houses.
9. Use of Gaucrete bricks in smart and sustainable housing.
10. Adhering to construction regulations in the manufacture.
11. Development of carbon-negative construction material by exploring the use of additives derived from bioprocesses.

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