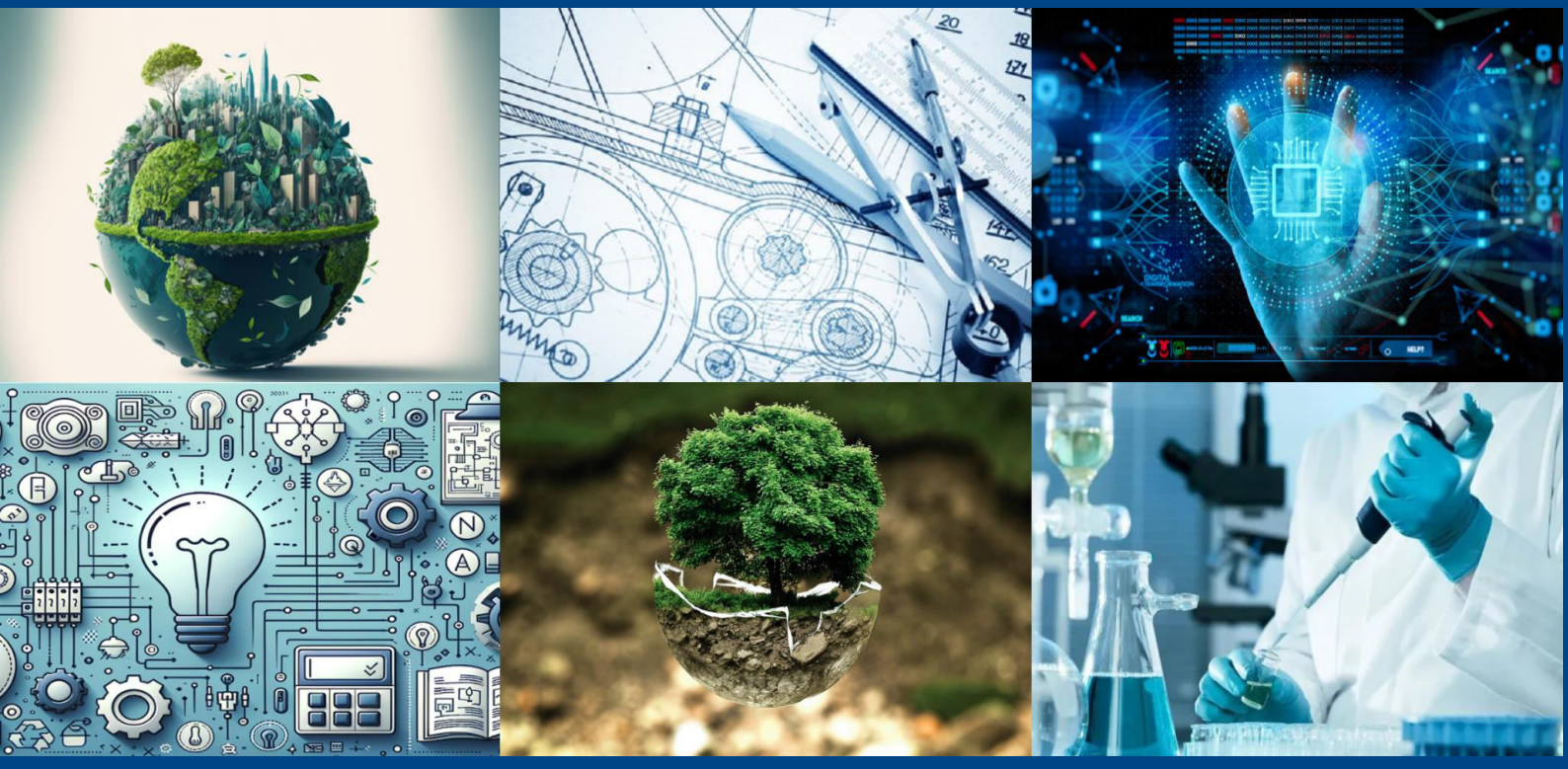
ISSN: 2582-7219

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 9.864

Volume 9, Issue 8, August 2026

© 2026 IJMRSET | Volume 9, Issue 8, August 2026| DOI:10.15680/IJMRSET.2026.0908040

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 9.864| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Development of Interlocking Lightweight Bricks for Building Applications

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ABSTRACT: The construction industry is seeking sustainable alternatives to conventional materials due to environmental concerns and the depletion of natural resources. Traditional clay bricks cause soil erosion, high energy use, and increased carbon emissions. This project develops interlocking lightweight bricks using sugarcane bagasse, construction waste, and a herbal antifungal coating as an eco-friendly solution. Sugarcane bagasse serves as a lightweight fibrous material, while construction waste partially replaces natural aggregates to promote recycling. The interlocking design reduces mortar use, lowering cost, time, and material consumption. A neem-based herbal coating improves water resistance, prevents fungal growth, and enhances durability. The bricks are tested for compressive strength, water absorption, and weight compared with conventional bricks. Results show that agricultural and construction waste significantly reduce brick weight while maintaining acceptable strength for non-load-bearing applications, and the herbal coating improves moisture resistance and long-term durability

I. INTRODUCTION

The construction industry faces growing pressure to adopt sustainable and cost-effective building materials in response to environmental degradation and the depletion of natural resources. Conventional clay bricks, widely used in construction, contribute significantly to soil erosion, high energy consumption during manufacturing, and increased carbon emissions. These drawbacks highlight the urgent need for alternative materials that are both environmentally friendly and economically viable. This study addresses this need by developing interlocking lightweight bricks that incorporate sugarcane bagasse and construction waste. Sugarcane bagasse, an agricultural by-product, serves as a lightweight fibrous material, while construction waste partially replaces natural aggregates, promoting recycling and reducing landfill burden. The interlocking brick design minimizes the reliance on mortar, thereby lowering construction cost, time, and material usage. In addition, a natural neem-based herbal coating is applied to enhance water resistance, prevent fungal growth, and improve long-term durability

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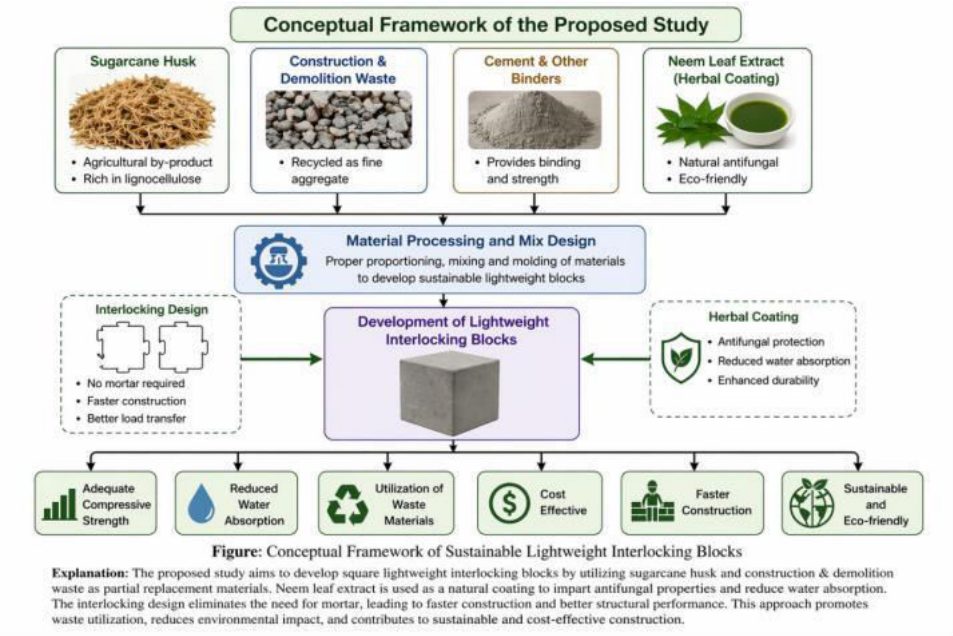

Figure: Conceptual Framework of Sustainable Lightweight Interlocking Blocks

Explanation: The proposed study aims to develop square lightweight interlocking blocks by utilizing sugarcane husk and construction & demolition waste as partial replacement materials. Neem leaf extract is used as a natural coating to impart antifungal properties and reduce water absorption. The interlocking design eliminates the need for mortar, leading to faster construction and better structural performance. This approach promotes waste utilization, reduces environmental impact, and contributes to sustainable and cost-effective construction.

Figure 1: Conceptual Framework of Sustainable Lightweight Interlocking Blocks

The objective of this project is to evaluate the feasibility and performance of these bricks through tests of compressive strength, water absorption, and weight comparison with conventional bricks. The findings aim to demonstrate a sustainable, low-cost alternative suitable for non-load bearing building applications, contributing to greener construction practices.

II. LITERATURE REVIEW

Conventional clay brick production poses significant environmental problems, including soil erosion, high energy consumption, and increased carbon emissions, which have driven the search for sustainable alternatives. Sugarcane bagasse has emerged as a promising lightweight material for brick manufacturing. Studies report that incorporating bagasse produces lighter bricks with low thermal conductivity and compressive strengths above 3.2 MPa, although strength declines if the dosage exceeds an optimum level. Similarly, construction and demolition waste has been successfully used as a partial replacement for natural aggregates, with bricks containing up to 30% replacement achieving strengths comparable to conventional bricks. zenodo+3Beyond materials, brick design also affects construction efficiency. Interlocking bricks reduces the quantity of mortar required for bonding, thereby lowering cost, time, and material consumption while improving structural strength. However, few studies have combined agricultural and construction waste in a single interlocking brick design, and the use of natural herbal coatings to enhance moisture resistance and antifungal durability remains largely unexplored. This study addresses this gap by developing interlocking lightweight bricks using sugarcane bagasse, construction waste, and a neem-based herbal coating.

Sugarcane Bagasse Ash (SCBA)

Bahurudeen & Santhanam (2015), Materials and Structures → The study emphasized that controlled burning of bagasse produces amorphous silica, which enhances pozzolanic activity. Improper burning leads to crystalline silica, reducing effectiveness. Rashad **(2015), Construction and Building Materials** → This review compiled various experimental findings and concluded that SCBA enhances long-term strength and durability. It reduces environmental impact by lowering cement usage. However, performance depends on burning temperature and particle size, making processing a critical factor. **Madurwar et et al. (2013), IJET** → The study replaced clay with SCA in brick production. Experimental results showed a reduction in density, making bricks lightweight. Compressive strength remained within acceptable limits for non-load-bearing structures, making it suitable for low-cost housing.

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Rice Husk Ash (RHA)

Habeeb & Mahmud (2010), Construction and Building Materials → Experimental analysis showed that RHA improves compressive strength due to better particle packing and reduces water absorption significantly. **Kartini (2008), International Journal of Civil Engineering** → Found that RHA-based materials are suitable for lightweight structural applications.

Construction and Demolition Waste

Medina et al. (2014) → Found that ceramic waste improves thermal resistance and reduces density of bricks Tam **(2009)**

→ Compared recycled and natural aggregates and found similar structural performance. **Debieb & Kenai (2008)** → Showed that recycled concrete aggregates can be used effectively in structural concrete with minimal strength reduction.

Interlocking Brick Technology

Maini (2010) → Explained advantages of interlocking soil blocks for low-cost housing, **Oti et al. (2009)** → Demonstrated that unfired bricks can achieve sufficient strength. Jayasinghe **& Kamaladasa (2007)** → Showed that interlocking blocks have adequate compressive strength **Thanoon et al. (2004)** → Developed systems that reduce construction time and labor cost. **Venkatarama Reddy (2004)** → Highlighted benefits such as reduced mortar usage and faster construction. **Adam & Agib (2001)** → Provided guidelines for interlocking block construction and design.

Herbal Antifungal Coatings

Adeyemi et al. (2021) → Demonstrated that bio-based additives improve durability and microbial resistance in construction materials. **Nazzaro et al. (2013)** → Confirmed antibacterial and antifungal effectiveness of essential oils. **Singh et al. (2012)** → Studied natural antifungal compounds and found effective inhibition of fungal growth on materials. **Bakkali et al. (2008)** → Explained the mechanism of antimicrobial action of essential oils.

Theme	Author(s)	Year	Journal	Key Finding / Contribution
SCBA	Bahurudeen & Santhanam	2015	Materials and Structures	Controlled burning of bagasse produces amorphous silica, enhancing pozzolanic activity; improper burning reduces effectiveness
SCBA	Rashad	2015	Construction and Building Materials	SCBA enhances long-term strength and durability and reduces cement usage; performance depends on burning temperature and particle size
SCBA	Madurwar et al.	2013	IJET	Replacing clay with SCBA reduces density, producing lightweight bricks with acceptable strength for non-load bearing, low-cost housing
RHA	Habeeb & Mahmud	2010	Construction and Building Materials	RHA improves compressive strength through better particle packing and reduces water absorption
RHA	Kartini	2008	International Journal of Civil Engineering	RHA-based materials are suitable for lightweight structural applications

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C&D Waste	Medina et al.	2014	—	Ceramic waste improves thermal resistance and reduces brick density
C&D Waste	Tam	2009	—	Recycled and natural aggregates show similar structural performance
C&D Waste	Debieb & Kenai	2008	—	Recycled concrete aggregates can be used effectively in structural concrete with minimal strength reduction
Interlocking	Maini	2010	—	Interlocking soil blocks are advantageous for low-cost housing
Interlocking	Oti et al.	2009	—	Unfired bricks can achieve sufficient strength
Interlocking	Jayasinghe & Kamaladasa	2007	—	Interlocking blocks possess adequate compressive strength
Interlocking	Thanoon et al.	2004	—	Systems reduce construction time and labor cost
Interlocking	Venkatarama Reddy	2004	—	Reduced mortar usage and faster construction
Interlocking	Adam & Agib	2001	—	Guidelines for interlocking block construction and design
Herbal Coating	Adeyemi et al.	2021	—	Bio-based additives improve durability and microbial resistance in construction materials
Herbal Coating	Nazzaro et al.	2013	—	Essential oils show antibacterial and antifungal effectiveness
Herbal Coating	Singh et al.	2012	—	Natural antifungal compounds inhibit fungal growth on materials
Herbal Coating	Bakkali et al.	2008	—	Mechanism of antimicrobial action of essential oils

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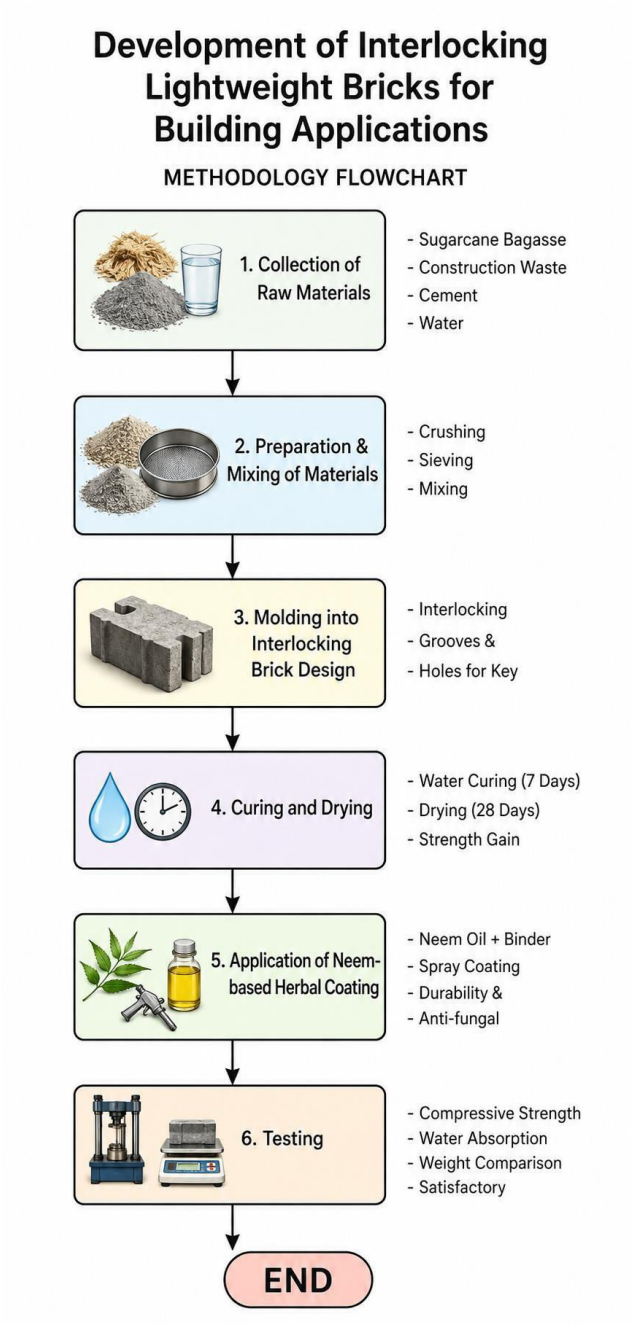
III. METHODOLOGY



3.1 Materials

The raw materials used in this study were sugarcane bagasse, construction waste, cement (as binder), water, and a neem-based herbal coating. Sugarcane bagasse was collected from a local sugar mill, sun-dried, and shredded into short fibers to serve as a lightweight aggregate. Construction waste (crushed brick and concrete debris) was collected from a demolition site, cleaned of impurities, and crushed to a suitable aggregate size. Ordinary Portland cement was used as a binding material, and potable water was used for mixing and curing.

3.2 Mix Proportions

The bricks were prepared by partially replacing natural aggregates with sugarcane bagasse and construction waste. Several mixed proportions were adopted to study the effect of each material on brick properties. The bagasse content

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was varied within a range found suitable in the literature, and construction waste was used as a partial replacement for coarse aggregate. A control mix without waste materials was also prepared for comparison.

3.3 Brick Production

The dry materials were mixed thoroughly to achieve a uniform blend. Water was then added gradually, and the mixture was stirred until a workable consistency was obtained. The wet mix was placed into an interlocking brick mold and compacted to ensure proper filling and densification. The molded bricks were removed and subjected to a curing period, during which they were kept moist to allow the cement to hydrate and gain strength. After curing, the bricks were dried to remove excess moisture.

3.4 Application of Herbal Coating

A natural neem-based herbal coating was prepared and applied to the surface of the cured bricks. The coating was intended to improve water resistance, prevent fungal growth, and enhance the long-term durability of the bricks. Coated bricks were allowed to dry before testing.

3.5 Testing of Bricks

The performance of the developed bricks was evaluated through the following tests:

- **Compressive strength:** Bricks were tested in a compression testing machine to determine their load-bearing capacity, and results were compared with conventional bricks.
- **Water absorption:** The increase in weight of oven-dried bricks after immersion in water was measured to assess moisture resistance.
- **Weight comparison:** The weight of the developed bricks was compared with that of conventional bricks to evaluate the lightweight benefit.

IV. CONCLUSION AND FUTURE WORK

This study successfully developed interlocking lightweight bricks using sugarcane bagasse, construction waste, and a neem-based herbal antifungal coating as sustainable alternatives to conventional clay bricks. The incorporation of sugarcane bagasse and construction waste significantly reduced the weight of the bricks while maintaining acceptable compressive strength for non-load-bearing applications. The interlocking design minimized the requirement for mortar, thereby reducing construction cost, time, and material consumption. Furthermore, the application of the herbal coating improved water resistance, prevented fungal growth, and enhanced the long-term durability of the bricks. The test results confirmed that agricultural and construction waste can be effectively utilized in brick manufacturing, contributing to waste management and the reduction of environmental impact. Overall, the developed bricks offer a cost-effective, lightweight, and eco-friendly solution suitable for low-cost and sustainable building construction.

Future Work:- Future research can build on this study in several directions:

- **Structural applications:** Investigate the feasibility of using the developed bricks for load-bearing walls by optimizing the mix proportions to achieve higher compressive strength.
- **Material variations:** Explore the use of other agricultural by-products, such as rice husk ash and fly ash, in combination with sugarcane bagasse.
- **Long-term durability:** Conduct extended durability studies, including exposure to weathering, freeze–thaw cycles, and aggressive chemical environments.
- **Thermal performance:** Evaluate the thermal insulation properties of the bricks to quantify their energy-saving potential in buildings.
- **Coating optimization:** Study the long-term effectiveness of various herbal coating formulations and their resistance to different fungal species.

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