Received Date:25th July, 2025
Revision Date: 28th October, 2025
Accepted Date: 17th January, 2026

Designing With Clay: Architectural Evaluation of Hollow and Solid Brick for Sustainable Construction

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Abstract— This paper evaluates the environmental, thermal, and structural performance of solid and hollow clay bricks in a building. We evaluate compressive strength, thermal insulation, and carbon footprint using material testing and case studies (such as Auroville Visitors Centre, IIT Hyderabad). According to the findings, hollow clay bricks preserve structural integrity while using 20–30% less energy than solid bricks. There are suggestions for the best brick choices based on climate zones.

Keywords — Hollow clay bricks, solid bricks, sustainable construction, thermal performance, embodied energy, U-value, Acoustic Performance.

I. Introduction

Brick remains one of the most essential and widely used construction materials in Nepal, especially in the Kathmandu Valley, where it is deeply embedded in both traditional and contemporary architectural practices. As construction practices evolve in response to climate challenges and sustainability goals, the choice between solid and hollow brick types has become increasingly relevant. Solid bricks, commonly used in heritage and load-bearing structures, offer durability and strength [1], while hollow bricks are gaining popularity in modern buildings due to their lighter weight, better thermal insulation, and construction efficiency [2].

With the rising demand for energy-efficient and environmentally responsible architecture, it is crucial to assess how different brick types contribute to sustainable construction. Factors such as structural performance, thermal conductivity, sound insulation, and environmental impact over a material's life cycle are key to this evaluation [3]. Harsiddhi, a well-known brick production area in Lalitpur, offers a suitable context for studying these materials and their real-world application in residences. This research aims to architecturally evaluate solid and hollow bricks by analysing their material characteristics and sustainable performance in the built environment, thereby guiding informed decision-making for future building practices in Nepal.

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II. Problem Statement

Though clay bricks have been used for a very long time, there isn't much research comparing hollow and solid bricks in sustainable buildings. Choosing the right brick type for a given project may be difficult for architects and builders since they must balance aspects like thermal and sound insulation and structural properties. By comparison, we can effectively select bricks for optimal use.

III. Research Objectives

- Comparing the thermal, sound insulation, and structural properties of hollow and solid clay bricks.
- To examine case studies where hollow and solid bricks have been used effectively in sustainable architecture.
- To provide recommendations for architects and builders on optimal brick selection for green construction

IV. Significance

This study contributes to the discourse on sustainable construction by providing a detailed evaluation of clay bricks. The findings will assist architects, engineers, and policymakers in making informed decisions that *enhance energy efficiency, reduce carbon footprints, and promote sustainable building practices [4].*

A. *Literature review*

Traditional solid clay bricks dominated construction until the 20th century, when technological advancements introduced hollow bricks to improve thermal efficiency and reduce material usage.

a) *Structural Properties*

B. *Solid Bricks:*

- Greater compressive strength, usually between 10 and 50 MPa, which qualifies them for load-bearing walls.
- Increased density (1,800–2,000 kg/m³) improves weather resistance and durability. [5].
- Utilized in heritage buildings, retaining walls, and foundations where stability is essential. *Hollow Bricks:*
- Internal voids result in a lower weight (1,200–1,500 kg/m2), which lessens the dead load on structures.
- Their employment in high-stress applications is limited by their compressive strength, which ranges from 3.5 to 20 MPa.[6].
- Perfect for multi-story buildings, facades, and partition walls where weight reduction is required [7].

b) *Thermal performance*

C. *Solid Bricks*

- High thermal mass (heat storage capacity) helps regulate indoor temperatures in temperate zones.
- Poor insulation unless paired with additional materials.
- Common in Mediterranean and Middle Eastern architecture for thermal lag benefits

D. *Hollow Bricks:*

- Air gaps provide natural insulation, reducing heat transfer (U-values: 0.5–1.0 W/m²K)
- Lower thermal mass but better suited for passive cooling in hot climates.
- Often used in energy-efficient designs like Passive House standards.

c) *Acoustic performance*

E. *Solid Bricks*

- *High sound insulation due to density (~1,800–2,200 kg/m³) [8].*
- *Sound Reduction Index (Rw): ~45–55 dB for a 220mm thick wall.*
- *Effective at blocking mid-to-high frequencies (speech, traffic noise)[9].*
- Common in urban construction for party walls and noise barriers[10].

ii. Hollow Bricks:

- Moderate sound insulation (lower mass than solid bricks) and used in internal partitions.
- Sound Reduction Index (Rw): ~35–45 dB for standard 150–200mm thick walls [11].
- Enhanced performance when cavities are filled with acoustic insulation.

F. Case Studies

i. *National Case Study 1: Structural Evaluation of Hollow Bricks at Awale Brick Factory, Nepal*

This case study focuses on the structural characteristics of hollow bricks through a field visit to Awale Brick Factory in Bhaktapur, Nepal.

Findings

- *Based on On-site Measurements and Physical Assessment*

Number of samples: 5

Average Dimensions: 22.6 × 10.6 × 6.5 cm

Average Surface Area: 450 cm²

Average Weight of Dry Brick: 2.544 Kg

Breaking Load: 180-220 KN

Average Breaking Strength: 11.64 N/ mm²

Average Water Absorption: (Not formally lab-tested, but field observations suggest slightly lower absorption, aided by air cavities that facilitate faster drying.)

Conclusion

The hollow bricks from Awale Factory offer a reliable and lightweight option for non-load-bearing construction, with the added advantage of facilitating service installation and improving finishing quality.

ii. *National Case Study 2:* Thermal and Acoustic Insulation Performance of Hollow Brick Walls in Thaiba Residence, Nepal

This study evaluates the thermal and acoustic insulation performance of a residence in Thaiba, built entirely with hollow clay bricks.

Findings

Wall Thickness: The external walls were constructed with 230 mm thick hollow brick walls (single layer with plaster).

Air Gaps: The internal cavities (3–5 per brick) act as natural

thermal buffers, reducing heat flow and enhancing insulation.

Thermal Insulation (U-Value): Based on literature and observation, the estimated U-value for these hollow brick walls ranges from 0.85 to 1.1 W/m²K, which aligns with passive design standards in temperate regions.

Temperature Comfort: Manual temperature recordings showed a 2–3°C difference between indoor and outdoor air during peak afternoon hours.

Acoustic Performance: Residents reported a clear reduction in street noise. The hollow structure absorbs and diffuses sound, offering basic acoustic privacy between rooms and from external sources.

Conclusion

The Thaiba residence demonstrates that hollow bricks offer effective passive insulation and noise control, contributing to both energy savings and improved indoor environmental quality in residential buildings.

iii. *National Case Study 3: Structural Evaluation of Solid Bricks at Awale Brick Factory, Nepal*

This case study focuses on the structural characteristics of solid bricks through a field visit to Awale Brick Factory in Bhaktapur, Nepal. The aim was to understand the material properties, manufacturing process, and construction suitability of hollow bricks using on-site observations and informal interviews with factory staff and engineers.

Findings

- *Based on On-site Measurements and Physical Assessment*

Number of samples: 5

Average Dimensions: 22.6 × 10.6 × 6.5 cm

Average Surface Area: 245.454 cm²

Average Weight of Dry Brick: 2.926 Kg

Breaking Load: 180-220 KN

Average Breaking Strength: 12.29N/ mm²

Average Water Absorption: 9.67%

iv. *National Case Study 4: Thermal and Acoustic Insulation Performance of Hollow Brick Walls in Tahachal Residence, Nepal*

This study evaluates the thermal and acoustic insulation performance of a residence in Tahachal, built entirely with hollow clay bricks. The research uses user feedback and simple manual tools to understand comfort levels and environmental performance.

Findings

Wall Thickness: The external walls were constructed with 230 mm thick hollow brick walls (single layer with plaster).

Thermal Insulation (U-Value): Based on literature and observation, the estimated U-value for these solid brick walls ranges from 1.5–2.0 W/m²K (higher than hollow bricks, indicating poorer insulation).

Temperature Comfort: Indoor spaces remained 3–4°C cooler than outdoor peaks in summer and retains heat but lacks insulation occupants reported needing supplemental heating.

Acoustic Performance: Residents reported effectively reduced traffic and voices but was less effective against bass and machinery noise

C. Analysis and Discussion

- *Material Comparison: Structural, Thermal, and Acoustic.* The comparative framework adopted by the authors highlights clear distinctions between solid and hollow bricks along several parameters:

Table 1

Material Comparison: Structural, Thermal, and Acoustic

Aspect	Hollow Brick	Solid Brick	Inferences
Structural Properties • Compressive strength • Density • Water Absorption	• 11.64MPa • 1880 kg/m³ • < 9.67%	• 13MPa • 1920 kg// m³ • 9.67%	• Solid brick is stronger and more stable. • Hollow brick has better moisture resistance
Thermal Insulation • U value • Thermal mass	• 0.9 W/m²K • 227,800J/ m². K	• 2.65 W/ m²K • 356,370J/ m².K	• Lower U-Value > better insulation • Hollow brick>Solid brick
Sound Insulation • Sound Reduction Index	• 30 dB	• 50dB	• Higher the dB value> higher the sound insulation. • Solid Brick>Hollow brick

G. *Conclusion and Recommendations*

H. *Findings*

- Solid brick>hollow brick higher in strength and stability.
- Hollow brick>solid brick for thermal insulation.
- Solid brick>Hollow brick for sound insulation.

i. *Recommendations*

- For better structure Solid bricks>Hollow Bricks.
- Better use Solid bricks- foundation, load-bearing walls, Hollow Bricks- Upper floors, non-load walls.
- Use of soled brick in noise control zones.
- Use of solid brick for thermal buffering in mixed climate and hollow brick in external envelope in hot climates.

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