International Journal of Scientific Research and Engineering Development-– Volume 9 Issue 6, Nov – Dec 2026
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

A Review of Agricultural By-Products in Unfired Mud Bricks for Sustainable Construction

Gulshan Yadav[1]*, Amit[1], Mr. Kuldeep Kumar Soni[2]
[1] Undergraduate Student; [2] Project Supervisor
Department of Civil Engineering, Bansal Institute of Engineering & Technology, Lucknow, Uttar Pradesh, India – 226201
DOI : https://doi.org/10.5281/zenodo.24049682

----------**********----------

Abstract:
Unfired mud bricks are a potential low-energy alternative to kiln-fired masonry, but their performance depends strongly on soil composition, moisture, compaction, curing and exposure conditions. Agricultural by-products—including rice husk ash (RHA), cereal straw, sugarcane bagasse ash and sawdust—have been investigated as partial constituents or modifiers in earth-based and other construction materials. This review synthesizes published research on how these residues may influence strength, density, water interaction, cracking, thermal behaviour and resource efficiency in unfired bricks. The literature indicates that mineral ashes can contribute reactive silica or act as fine fillers when their processing and compatibility with the soil/binder are suitable, while plant fibres may help control drying cracks and reduce density. These benefits are not automatic: excessive or poorly distributed additions can increase porosity, water uptake or variability, and fibre-rich mixes may lose compressive strength. Manufacturing variables—grading, water content, mixing sequence, moulding pressure and curing—are therefore as important as the waste type itself. Existing reviews also identify a gap between laboratory demonstrations and reliable industrial production, particularly in standardized mix design, durability testing and life-cycle assessment. The paper concludes that agricultural-waste mud bricks should be assessed using a balanced performance framework rather than strength alone, with local materials tested against applicable building requirements before practical use.

Keywords— Unfired mud bricks; agricultural by-products; rice husk ash; straw fibres; soil stabilization; durability; thermal performance; circular economy; sustainable construction.

----------**********----------

1. INTRODUCTION
Construction materials have environmental impacts associated with raw-material extraction, processing, transport and, in the case of fired bricks, kiln energy. Unfired earth blocks can avoid the firing stage and can use locally available soil, although their suitability depends on the soil and the climate in which they are used. Agricultural processing also generates residues that may be discarded or burned. Incorporating selected residues into earth-based materials offers a possible route to divert waste while reducing demand for some conventional constituents. Reviews by Maraveas [1] and Gupta et al. [2] describe the broad potential of agro-wastes and other waste streams in sustainable construction materials, while also noting that manufacturing choices affect the resulting performance.

This review focuses on the engineering considerations relevant to agricultural-waste-modified mud bricks. It does not assume that all agro-wastes are interchangeable: ash is a mineral-rich powder, whereas straw and sawdust are fibrous or lightweight organic additions. Their mechanisms, risks and appropriate testing are different. The purpose is to organize findings from published reviews and related research into a practical framework for material selection, processing, testing and future investigation.

2. REVIEW APPROACH AND SCOPE
The paper uses a narrative literature-review approach based on published peer-reviewed reviews and research articles identified through bibliographic records and publisher pages. Priority was given to sources addressing agro-waste construction materials, rice husk ash,

 ©IJSRED: All Rights are Reserved

unfired bricks and manufacturing variables. Findings are compared qualitatively because the studies use different soils, binders, residue preparation methods, specimen sizes and test procedures. Consequently, reported percentages or performance changes should not be transferred directly to a new mix without laboratory verification. This is a synthesis of published evidence, not a claim that new experimental tests were conducted for this paper.

3. AGRICULTURAL BY-PRODUCTS AND THEIR ROLES

3.1 Rice husk ash

Rice husk ash is produced by burning rice husks, and its properties depend on combustion temperature, duration, grinding and the amount of unburnt carbon. Jittin et al. [3] review RHA in construction products, including bricks and soil stabilization, and explain that its silica-rich and potentially pozzolanic character can be useful when the ash is suitably processed and compatible with the binder. In mud-brick mixtures, RHA may act as a fine filler and, in stabilized systems, may participate in binder-related reactions. Poorly controlled ash quality or high replacement levels can instead increase water demand or weaken the matrix.

3.2 Straw fibres

Wheat and rice straw can be chopped and distributed through an earth mixture. Fibres may bridge small cracks and restrain crack opening during drying, while also changing the fresh mix's workability and compactability. Their effect depends on fibre length, aspect ratio, moisture, distribution and dosage. Long or clustered fibres can create voids and reduce the effective load-bearing area. Straw should therefore be treated as a reinforcement-like inclusion that requires careful preparation, rather than as a universal strength enhancer.

3.3 Sugarcane bagasse ash

Bagasse ash is a combustion residue from the fibrous material remaining after sugarcane juice extraction. Its mineral composition varies with the boiler and burning process. Where the ash contains suitable reactive silica and is finely processed, it may be considered as a supplementary mineral constituent in stabilized earth mixes. Before use, its fineness, loss on ignition, chemical consistency and compatibility with soil and stabilizer should be checked. Results from cement-based products cannot automatically be assumed to apply to unstabilized mud bricks.

3.4 Sawdust and other plant residues

Sawdust and similar lightweight organic residues can lower bulk density and may improve thermal resistance by introducing a more porous structure. However, the same pores can increase moisture ingress and reduce compressive strength. Organic particles may also change with wetting and drying. Their inclusion should therefore be evaluated for water absorption, erosion resistance, dimensional stability and biological durability, not just weight reduction.

4. EFFECTS ON ENGINEERING PERFORMANCE

4.1 Compressive strength and density

Compressive strength is governed by soil grading, clay content, stabilizer dosage, compaction, moisture and curing, as well as the residue itself. Gupta et al. [2] emphasize that mix proportions, mixing strategy, moulding, compaction and curing all influence waste-incorporated unfired bricks. Fine mineral additions may improve packing or contribute to binder reactions in suitable mixtures; fibrous or highly porous additions may reduce density but can also interrupt the continuous soil matrix. Comparisons between studies are meaningful only when specimen preparation and test conditions are reported.

4.2 Water absorption and durability

Water resistance is a critical limitation for earth-based masonry exposed to rain, splash water or rising damp. Porosity, pore connectivity, clay mineralogy, stabilizer type and curing affect absorption and erosion. A mixture that is lighter or more insulating may be more vulnerable to water if the pores are connected. Durability assessment should include capillary uptake or water absorption, wet–dry cycling, surface erosion and dimensional change, alongside compressive strength. A single dry-strength

 ©IJSRED: All Rights are Reserved

result is insufficient to demonstrate service suitability.

4.3 Shrinkage and cracking

Drying shrinkage develops as water leaves the soil matrix and depends on clay content, water demand, specimen geometry and drying conditions. Properly dispersed short fibres may restrain crack development, but excess fibre can impair compaction and create weak zones. Consistent moisture control, gradual drying and repeatable moulding are essential when comparing mixes. Researchers should record visible crack patterns and dimensional changes rather than reporting only whether a specimen survived.

4.4 Thermal behaviour

Thermal conductivity is influenced by density, moisture, pore structure and the nature of the inclusions. Lightweight residues may reduce heat transfer under some conditions, but a porous brick that absorbs more moisture may not maintain the same thermal behaviour in service. Thermal performance should therefore be measured on specimens with documented moisture conditioning and density. Claims of energy savings at building level require additional analysis of wall thickness, climate, ventilation and building operation.

5. ENVIRONMENTAL AND ECONOMIC CONSIDERATIONS

The principal environmental opportunity is to use locally available residues that might otherwise be openly burned, dumped or transported for disposal. Unfired production can also avoid kiln firing, while local sourcing may reduce transport demand. Nevertheless, the net benefit is not guaranteed: drying or grinding residues, transporting materials, using cement or lime, and maintaining quality control all have impacts. Maraveas [1] reviews the broader potential of agro-wastes in construction, while the RHA review by Jittin et al. [3] highlights the importance of processing and material characteristics. A credible sustainability comparison should use a defined functional unit and include raw materials, manufacture, transport, maintenance and end-of-life scenarios. Research on agro-waste in fired clay bricks also shows that performance and economic value depend on the residue and manufacturing route [4], while Chin et al. [5] review reuse of agro-industrial wastes in green cement bricks.

Economic performance similarly depends on local availability, seasonal variation, processing costs, labour, moulding equipment, curing time and the need for protective finishes. A low-cost residue may not be economical if it requires extensive washing, grinding or quality testing. Cost comparisons should therefore report the complete cost per acceptable brick or per unit of wall area, rather than comparing the purchase price of individual ingredients alone.

6. MANUFACTURING AND QUALITY-CONTROL FRAMEWORK

A reproducible development programme can follow these stages: (i) characterize the soil for particle-size distribution and plasticity; (ii) identify and document the source and processing history of each residue; (iii) dry, sieve or grind materials as required; (iv) prepare a control mix and several measured replacement or addition levels; (v) add water gradually to a consistent target workability; (vi) mould and compact specimens using a recorded procedure; (vii) cure and dry under controlled conditions; and (viii) test strength, density, water interaction, shrinkage and durability. Each mix should have replicates, and results should include averages and variability. The manufacturing review by Gupta et al. [2] specifically identifies mixture proportioning, liquid content, mixing, compaction and curing as important variables for scaling up waste-incorporated unfired bricks.

For a student or laboratory project, the safest comparison is to test a control brick against clearly labelled mixes, changing one main variable at a time. The optimum mix should not be selected from compressive strength alone; it should meet relevant local requirements and show acceptable water resistance and dimensional stability. No universal optimum percentage can be recommended from the reviewed literature because raw materials and test methods differ.

 ©IJSRED: All Rights are Reserved

7. RESEARCH GAPS AND FUTURE DIRECTIONS

Several priorities emerge from the literature. First, standardized test protocols and transparent reporting are needed so results from different soils and residues can be compared. Second, long-term field performance under rain, humidity, salts and repeated wetting and drying needs more attention. Third, studies should distinguish the effects of mineral ash from those of organic fibres and should report residue chemistry, particle size and moisture condition. Fourth, pilot-scale production should examine mixing uniformity, compaction energy, curing time, rejection rates and seasonal supply. Finally, life-cycle assessment and cost analysis should use consistent boundaries and compare the proposed bricks with realistic local alternatives. These steps would help bridge the gap between laboratory-scale promise and reliable use in construction.

8. CONCLUSION

Agricultural by-products offer several possible routes to improve resource efficiency in unfired mud-brick production, but their effects are material- and process-specific. Rice husk ash and other suitable ashes may act as fillers or supplementary reactive constituents in compatible stabilized systems, while straw fibres may help control cracking and lightweight residues may lower density. These potential advantages can be offset by increased porosity, water absorption, reduced strength or inconsistent performance when additions are excessive or poorly processed. Soil characterization, controlled mix design, uniform compaction, suitable curing and durability testing are therefore essential. Future work should prioritize reproducible testing, long-term exposure, life-cycle assessment and pilot-scale manufacturing. Agricultural-waste mud bricks should be recommended for practical construction only after their performance has been verified against applicable standards and local exposure conditions.

REFERENCES

[1] Maraveas, C. (2020). Production of Sustainable Construction Materials Using Agro-Wastes. Materials, 13(2), 262. https://doi.org/10.3390/ma13020262

[2] Gupta, V., Chai, H. K., Lu, Y., & Chaudhary, S. (2020). A state of the art review to enhance the industrial scale waste utilization in sustainable unfired bricks. Construction and Building Materials, 254, 119220. https://doi.org/10.1016/j.conbuildmat.2020.119220

[3] Jittin, V., Bahurudeen, A., & Ajinkya, S. D. (2020). Utilisation of rice husk ash for cleaner production of different construction products. Journal of Cleaner Production, 263, 121578. https://doi.org/10.1016/j.jclepro.2020.121578

[4] Sorte, A. M., Burile, A. N., Chaudhari, A. R., & Haldar, A. (2020). Utilisation of agro waste in the development of fired clay bricks – a review. International Journal of Environment and Waste Management, 26(4), 531–550. https://doi.org/10.1504/IJEWM.2020.110400

[5] Chin, W. Q., Lee, Y. H., Amran, M., Fediuk, R., Vatin, N., Kueh, A. B. H., & Lee, Y. Y. (2022). A Sustainable Reuse of Agro-Industrial Wastes into Green Cement Bricks. Materials, 15(5), 1713. https://doi.org/10.3390/ma15051713

[6] Anbarasu, N. A., & Karuppusamy, M. (2025). A Review of Sustainable Construction and Waste Management: Brick Manufacturing Using Agro-Industrial Wastes. Zaštita Materijala, 66(4), 913–927. https://doi.org/10.62638/ZasMat1354

[7] Jeevanandan, K., Shanmugapriya, S., Sheik Mohamed Anas, M., & Siddharthan. (2025). A Review on Brick Manufacturing Using Agro-industrial Wastes. Journal of Environmental Nanotechnology, 14(1), 402–414. https://doi.org/10.13074/jent.2025.03.2441145

 ©IJSRED: All Rights are Reserved