
FROM WASTE TO WALL: EXPLORING THE ARCHITECTURAL POTENTIAL OF RECYCLED PLASTIC BRICKS IN AFFORDABLE HOUSING DESIGN

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ABSTRACT

Sub-Saharan Africa faces a chronic housing deficit, with Nigeria alone requiring an estimated 28 million additional dwelling units. The spiralling cost of conventional masonry materials fired clay bricks, sandcrete blocks, and Portland cement continues to place safe, dignified housing beyond the reach of low-income households. Simultaneously, unmanaged plastic waste, particularly low-density polyethylene plastic from sachets, bags, and films, accumulates in Nigerian urban environments, contributing to flooding, disease, and environmental degradation. This paper explores the architectural potential of recycled plastic bricks produced primarily from plastic waste as an alternative masonry material for affordable housing design. Through a structured synthesis of recent experimental literature, the study evaluates whether recycled plastic bricks can meet the structural, environmental, and functional requirements of affordable residential construction in developing country contexts. Findings indicate that plastic-sand composite bricks can achieve structural performance adequate for non-load-bearing walls, internal partitions, boundary structures, and pedestrian paving in single-storey housing meeting and often exceeding the Nigerian Building Code minimum thresholds for these applications. Beyond structural adequacy, recycled plastic bricks offer lower embodied energy, superior moisture resistance, reduced dead load, and improved thermal comfort compared to conventional sandcrete blocks. Processing variables, including uniform melting, mix proportioning, and compaction, significantly influence performance and must be standardised for architectural adoption. The study concludes that recycled plastic bricks represent a credible, locally available, and environmentally responsive material for affordable housing in Nigeria, offering architects and housing practitioners a viable alternative to conventional masonry that simultaneously addresses the twin crises of housing scarcity and plastic waste pollution.

Keywords

Affordable Housing; Recycled Plastic Bricks; Sustainable Masonry; Architectural Design; Low-Cost Housing; Nigeria; Plastic Waste; Built Environment

Introduction

Sub-Saharan Africa confronts one of the world's most severe affordable housing crises. Nigeria alone faces an estimated deficit of 28 million housing units, driven by rapid urbanisation, population growth, and the rising cost of conventional building materials (UN-Habitat, 2023). In cities such as Lagos, Ibadan, Kano, and Port Harcourt, low-income households spend disproportionate shares of their income on housing, frequently settling for structurally inadequate or informal dwellings due to the unaffordability of standard masonry construction. Conventional materials fired clay bricks, sandcrete blocks, and Portland cement are energy-intensive to produce, subject to supply chain volatility, and increasingly expensive. Plastics are a petrochemical substance made from fossil fuel and gas used in large quantities in developed and developing countries (Vaverkova, 2019). Authors opined that global plastic production has risen sharply, and mismanaged plastic waste now threatens terrestrial and marine ecosystems (Lamba et al., 2021; Santos et al., 2023). However, their resistance to biodegradation has resulted in large accumulations in landfills, waterways, and open environments. Reports by organizations such as the United Nations Environment Programme (UNEP, 2021) indicate that plastic waste constitutes a substantial proportion of municipal solid waste streams globally, with low recycling rates in many developing countries. Low-density polyethylene plastic, widely available from sachets and packaging waste in Nigerian cities, is particularly problematic because of its resistance to biodegradation, limited recycling infrastructure, and environmental persistence (Lamba et al., 2021; Sakr & AbouZeid, 2025). In parallel, the construction sector faces pressure to reduce its environmental footprint from energy-intensive materials such as fired clay bricks and Portland cement (Lamba et al., 2021; Messahel et al., 2023).

Recent research explores using waste plastics as components of construction materials either as binder, aggregate, or filler in bricks, blocks, concrete, pavements, and insulation products (Lamba et al., 2021; Haba et al., 2025; Messahel et al., 2023). Within this broader trend, plastic waste is being repurposed into bricks and composite blocks, sometimes as a molten binder and sometimes as a dispersed phase in earthen or cement mixture, with promising though variable compressive strength results (Abdalla et al., 2025; Johnson & Garba, 2025; Pankyes et al., 2025). This approach represents a waste-to-resource strategy, potentially reducing environmental pollution while offering an alternative masonry material. Over the past decade, experimental investigations have examined the mechanical and physical properties of recycled plastic bricks, particularly their compressive strength performance.

The growing interest in recycled plastic bricks reflects broader sustainability paradigms, including circular economy principles that promote material reuse and lifecycle optimization. According to the Ellen MacArthur Foundation (2019), circular construction models encourage the reintegration of waste materials into productive cycles, reducing reliance on virgin resources. recycled plastic brick production aligns conceptually with this model by transforming post-consumer plastic waste into functional construction units. Despite increasing research attention, there remains a need for systematic integration of available evidence concerning the compressive strength performance of recycled plastic bricks. Such synthesis is critical for determining their structural viability and informing professional practice. Conventional bricks consume natural aggregates and, in the case of fired clay, topsoil and significant thermal energy, contributing to greenhouse gas emissions and resource depletion (Lamba et al., 2021; Messahel et al., 2023). Numerous experimental studies have now produced bricks and blocks from recycled plastic or mixed thermoplastic waste, but compressive strength outcomes depend strongly on mix proportion, plastic type, production

method, and testing standards (Lamba et al., 2021; Saud et al., 2025; Abdalla et al., 2025; Johnson & Garba, 2025; Pankyes et al., 2025). Reported strengths range from low-strength, lightweight recycled plastic bricks (~1.2 MPa) suitable only for non-load-bearing use (Johnson & Garba, 2025; Pankyes et al., 2025) li However, there is limited qualitative synthesis focused specifically on compressive strength behavior of recycled plastic-based bricks and how it relates to composition, processing, and potential applications. By incorporating recycled plastic plastics, the bricks produced may exhibit improved properties such as thermal insulation by reducing heat transfer and energy consumption.

This study contributes to environmental sustainability by examining the feasibility of converting plastic waste into construction materials. By promoting waste diversion from landfills and open environments, recycled plastic brick production supports circular economy principles and resource efficiency strategies (Ellen MacArthur Foundation, 2019). The integration of plastic waste into masonry units may also reduce demand for virgin clay and aggregates, thereby reducing ecological degradation associated with extraction activities. Reusing recycled plastic in bricks can divert plastic from landfills and open dumping, reduce demand for conventional masonry materials, and support circular-economy objectives (Lamba et al., 2021; Santos et al., 2023; Muntaha & Keitsch, 2024). From a technical perspective, understanding the compressive strength performance of recycled plastic bricks is essential for evaluating their suitability as alternative masonry materials, clarifying the compressive strength ranges achievable with different plastic contents and production routes is essential for defining structurally appropriate uses and informing emerging standards (Saud et al., 2025; Abdalla et al., 2025; Yadav et al., 2024).

Affordable Housing and the Search for Alternative Masonry Materials

The Affordable Housing Crisis and Material Challenges in Nigeria

Compressive strength is a fundamental mechanical property that quantifies a building block's ability to resist axial loads applied parallel to its surface. For a brick or block, it represents the highest compressive stress the material can endure before failure or crushing occurs. In standardized testing, units are subjected to gradually increasing load using a universal testing machine until structural collapse, with results expressed in megapascals (MPa) or newtons per square millimeter (N/mm²). These tests are guided by well-established standards to ensure consistency and comparability across studies. Compressive strength is strongly linked to bulk density and pore structure. According to Wang et al. (2021) In fired clay bodies, higher apparent porosity and water absorption correspond to lower compressive strength; bricks with lower porosity and higher density (e.g., 1.9 g/cm³ vs. 1.68 g/cm³) achieved strengths of ~34–55 MPa compared with ~20–39 MPa for more porous mixes. Fired clay bricks with added concrete waste showed slightly increased porosity and water absorption and a corresponding decrease in strength, but still above 7 MPa (Gencel et al., 2020). For mortars and concretes, show that reducing total porosity and transforming harmful large pores into finer, discontinuous pores yields higher compressive strength.

Requirements for Alternative Masonry Materials in Affordable Housing

The compressive strength of building bricks is influenced by multiple interacting factors that determine internal structure, density, and load transfer mechanisms. These include material density, porosity, binder–aggregate interaction, and processing conditions.

1. Structural Adequacy

Density influences compressive strength because higher density reduces intra-material voids and improves particle contact, facilitating better load transfer. In plastic-sand composites, optimal compacting during moulding reduces void content and increases strength. According to Al-Sinan & Bubshait (2022) excessive plastic content without adequate compaction can create internal voids that weaken the unit.

2. Cost-Effectiveness and Local Availability

Porosity is the proportion of internal void spaces which adversely affects compressive strength because voids serve as stress concentration sites under load. A Study done show that plastic-sand bricks with high plastic ratios tend to have increased porosity, which contributes to reduced compressive strength compared with lower plastic ratios or conventional units (Al-Sinan & Bubshait, 2022).

3. Durability and Moisture Resistance in Tropical Climates

Nigeria's tropical climate characterised by high humidity, heavy rainfall, and elevated temperatures places specific demands on housing materials. Conventional sandcrete blocks absorb significant moisture, leading to efflorescence, mould growth, wall dampness, and structural weakening over time. An ideal alternative material for Nigerian housing should demonstrate low water absorption, resistance to moisture ingress, and stability under sustained thermal exposure. The hydrophobic nature of recycled plastic bricks, which consistently achieves water absorption rates below 1 percent in experimental studies, makes them particularly well-suited to the Nigerian climate (Kumi-Larbi et al., 2018; Debele et al., 2024; Iftikhar et al., 2023).

4. Thermal Performance and Workability

Aggregate particles such as sand affect compressive performance through their gradation and texture. Well-graded aggregates improve packing density and reduce weak zones, enhancing both compressive strength and stability of the composite (Al-Sinan & Bubshait, 2022)

Recycled Plastic Bricks: Properties, Production and Structural Performance

Low-density polyethylene plastic from packaging and film waste is increasingly incorporated into construction materials as binder or aggregate replacement, making it the principal raw material for recycled plastic brick production.

Material Properties of Recycled Plastic Bricks

Recycled plastic is a semi-crystalline thermoplastic and is characterized by the following key physical properties::

- i. Low density and high flexibility: Recycled plastic typically shows a density around 0.91–0.93 g/cm³ and very high elongation at break (~450%), reflecting a ductile, flexible behavior with a low elastic modulus (~245 MPa) and tensile strength ~12 MPa (Alim et., al, 2020)..

- ii. Melting/processing temperature: Construction composites using plastic waste commonly melt it at about 120–170 °C for film waste (Zegardlo et. al, 2025) and up to 250 °C for mixed HDPE/plastic binders(Thiam et., al , 2021). This relatively low melting range enables hot-melt processing with simple equipment.
- iii. Thermal stability: Recycled plastic has good water-vapor barrier and thermal stability as a polyolefin, though multiple recycling cycles tend to decrease crystallinity and mechanical performance (Lim et., al , 2021; Alim et., al , 2020).

Structural Performance of Recycled Plastic Bricks

Recycled plastic exhibits mechanical behaviour that differs fundamentally from traditional mineral binders such as cement and clay. Cementitious systems develop strength through hydration reactions that form rigid calcium silicate hydrate mix, whereas recycled plastic forms a purely physical bond based on encapsulation and mechanical interlocking of aggregates (Al-Sinan & Bubshait, 2022). Consequently, compressive performance in plastic composites depends more on particle packing, density, and interfacial contact than on chemical cohesion.

Alim et al.,(2020) posited that in its virgin form, recycled plastic is a ductile, low-stiffness polymer with a modulus of approximately 245 MPa and tensile strength around 12 MPa . While this ductility enhances deformation capacity, it limits inherent rigidity. Repeated recycling further reduces mechanical performance by increasing melt flow index and decreasing tensile and impact strength, often producing more brittle fracture characteristics due to reduced crystallinity (Lim et al., 2021; Rezakalla, 2022). These changes are critical where recycled plastic is used in brick composites. When used as a binder in sand composites, recycled plastic alters stress–strain response toward ductile behavior. Increasing plastic content generally improves toughness but may reduce stiffness and compressive strength if excessive polymer leads to void formation or poor compaction (Shrestha et al., 2023). This establishes a clear strength–ductility trade-off requiring optimized mix proportions.

Empirical findings show that properly compacted plastic-bonded sand blocks can reach compressive strengths up to about 27 MPa, with strength increasing alongside density and finer aggregate gradation (Kumi-Larbi et al., 2020). Similarly, HDPE/plastic binders at 50–60% content have produced composites exceeding 10 MPa compressive strength with observable post-peak load capacity (Thiam et al., 2021). However, lower plastic contents (~25%) under moderate pressing pressures yield strengths around 4.1 MPa, indicating suitability mainly for light or non-load-bearing applications (Debele et al., 2024). In contrast, when recycled plastic replaces fine aggregate rather than acting as binder, compressive strength reductions of 35–50% have been reported due to low stiffness and weak load transfer at the interface (Vivek et al., 2021; Varghese et al., 2025). Nonetheless, low-dosage additions (3–5%) may still meet performance thresholds for non-structural applications such as road base and embankment fills (Arulrajah et al., 2017). Overall, recycled plastic enhances ductility but reduces stiffness relative to conventional binders. Its effectiveness in brick production depends primarily on density control, aggregate interaction, and optimized plastic proportion.

Production Methods and Quality Factors

Recycled plastic is chemically inert and hydrophobic; therefore, its bonding with mineral aggregates is mechanical rather than chemical. When melted, recycled plastic flows around sand or gravel particles and solidifies into a continuous matrix that binds them through encapsulation and interlocking. Bond efficiency depends on temperature control, aggregate gradation, surface texture, mixing uniformity, and compaction during moulding.

Studies show that well-processed plastic-sand composites develop a dense plastic matrix with minimal voids, enabling strong interfacial contact. Optimized plastic-sand-gravel mixtures have achieved compressive strengths up to 39 MPa, attributed to effective particle encapsulation and high density (Zegardlo et al., 2025). Similarly, Plastic Waste Crete systems containing 60% melted HDPE/recycled plastic exhibited fewer capillary pores and higher compressive and tensile strengths than more porous mixes (Thiam et al., 2021). These findings confirm that void reduction and matrix continuity directly enhance strength. When recycled plastic is introduced as dispersed particles rather than as a continuous binder, weak interfacial adhesion and voids promote stress concentration and reduced tensile or flexural performance (Siddique et al., 2022; Arulrajah et al., 2017). Surface modification strategies further demonstrate this principle: sand-coated plastic aggregates improve stress transfer and compressive strength compared to uncoated plastics, highlighting the importance of surface roughness for mechanical interlock (Varghese et al., 2025).

Performance as a Molten Binder System

As a thermoplastic binder, recycled plastic contains aggregates and provides mechanical interlock, improving ductility but reducing stiffness compared to cementitious systems (Al-Sinan & Bubshait, 2022; Shrestha et al., 2023). Optimized plastic-sand-gravel systems have achieved compressive strengths between 11–39 MPa, with peak performance (~39.5 MPa) at about 40% recyclate (Varghese et al., 2025). plastic-bonded sand blocks produced via hot-melt methods reach ~27 MPa (Kumi-Larbi et al., 2018). HDPE/plastic binders at 50–60% plastic content consistently exceed 10 MPa (Thiam et al., 2021), while recycled plastic paver tiles demonstrate adequate strength and very low water absorption (~0.3%) for pedestrian use (Debele et al., 2024). These findings indicate that moderate plastic contents (~10–40%) can achieve sufficient compressive strength for non-load-bearing and selected moderate-load applications (Al-Sinan & Bubshait, 2022).

Performance as Partial Aggregate Replacement

When recycled plastic replaces sand as a partial aggregate in cement-based bricks, structural performance is lower but still meets housing design requirements in many applications. Replacing 5–20 percent of fine aggregate with plastic reduces compressive strength by 23–50 percent compared to conventional units (Vivek et al., 2023; Dolores et al., 2020). At replacement levels of 10–20 percent, resulting strengths typically exceed 2.5 MPa, meeting the NBC minimum for non-load-bearing residential walling. This makes cement-plastic composite bricks a viable option for internal partition walls, infill panels, and low-traffic paving in affordable housing schemes. The advantage of this approach for Nigerian housing practitioners is compatibility with existing sandcrete block production equipment and familiar construction methods, potentially lowering the barriers to adoption compared to the hot-melt binder system.

Material Requirements for Affordable Housing in Nigeria

Plastic waste is now used in bricks, blocks, concrete, pavers and tiles as binder, aggregate or fine-aggregate replacement to reduce landfilling and natural resource use (Lamba et al., 2021). For masonry and block-like units, two main routes dominate:

- (1) plastic-bonded sand/aggregate products (cementless), and
- (2) cement/earth bricks with plastic as partial sand or binder replacement (Dolores et al., 2020; Lamba et al., 2021).

Recycled plastic is especially attractive because of its low melting point and film/sachet availability, enabling simple melting-and-mixing technologies in low-resource settings (Kumi-Larbi et al., 2018; Nnorom et al., 2023; Desyani et al., 2023).

Recycled Plastic as a Component in Brick Production

Recycled plastic bricks have gained attention as a sustainable construction material due to its low melting point, availability from waste streams (bags, sachets, films), and compatibility with simple fabrication techniques (Kumi Larbi et al., 2018; Nnorom et al., 2023). In brick production, recycled plastic can be incorporated in three main forms:

- i. Flakes or pellets – Recycled plastic is shredded into small pieces before being mixed with sand, soil, or cement.
- ii. Melted recycled plastic as a binder – Heat is applied to convert recycled plastic into a molten phase that coats aggregates and solidifies upon cooling.
- iii. Composite mixes – Recycled plastic combined with cement, earth, or other binders, either partially replacing sand or acting as a secondary binder.

Typical mix ratios vary by application: cementless plastic-sand blocks often use 25–40% recycled plastic by weight relative to aggregates, whereas partial sand replacements in concrete or mortar commonly use 5–20% recycled plastic (Dolores et al., 2020; Nursyamsi et al., 2019).

Production methods include:

- i. Melting and casting – Recycled plastic is melted and mixed with aggregates, then poured or pressed into molds. This method allows for high-density, durable units if temperature and mixing are controlled.
- ii. Compression moulding – The heated mix is pressed under high pressure (3–5 MPa) to reduce voids, improve particle bonding, and enhance compressive strength (Debele et al., 2024)

Tale 1; Showing Recycled Plastic as a Component in Brick Production

Recycled Plastic as a Component in Brick Production

System	Plastic Role	Compressive Strength	Suitability	Source
Recycled sand plastic-interlocking bricks	Molten binder	Up to ~31 MPa	Light structural/paving	Nnorom et al., 2023
Recycled bonded sand plastic-blocks	Molten binder	Up to ~27 MPa	Blocks/pavers	Kumi Larbi et al., 2018
Recycled sand pavers + basalt fibre	Molten binder	≥ 20 N/mm ²	Light traffic	Iftikhar et al., 2023
Flexible recycled plastic paver tiles	Molten binder	~4.1 MPa	Park/outdoor pedestrian	Debele et al., 2024
Pure recycled plastic bricks	Sole binder	~1.2 N/mm ²	Non-load-bearing	Johnson & Garba, 2025; Pankyes et al., 2025
Light concrete bricks (20% recycled plastic)	Sand replacement	3.5–4 MPa	Non-load-bearing	Nursyamsi et al., 2019
CHB with 10% recycled plastic	Sand replacement	Above local CHB	Non-load-bearing	Dolores et al., 2020
Paving blocks (5–15% recycled plastic)	Sand replacement	Mostly >12.5 MPa	Non-load-bearing	Andalas Univ & Jakarta State Poly, 2023

Architectural Implications: From Structural Data to Design Application

The compressive strength of recycled plastic bricks varies widely depending on whether recycled plastic acts as a binder, partial aggregate replacement, or is combined with cement/earth. Key observations include:

Recycled plastic as molten binder: Sand–recycled plastic bricks achieve 20–31 MPa, suitable for light structural or paving applications (Kumi Larbi et al., 2018; Nnorom et al., 2023; Iftikhar et al., 2023). Addition of basalt fibers can further improve strength and reduce brittleness.

Plastic-only bricks: Units made entirely from molten recycled plastic or plastic waste achieve 1–1.5 MPa compressive strength, sufficient for non-load-bearing walls (Johnson & Garba, 2025; Pankyes et al., 2025).

Partial aggregate replacement: 5–20% recycled plastic replacing sand in concrete or mortar reduces compressive strength by 23–50% but may still meet non-load-bearing standards (Dolores et al., 2020; Vivek et al., 2023; Varghese et al., 2025).

Overall, the relationship between plastic content and compressive strength is non-linear. Moderate plastic content improves ductility and encapsulates aggregates effectively, while excessive plastic content creates large continuous polymer phases and voids, reducing stiffness and load-bearing capacity.

Key Factors Influencing Architectural Suitability

Several factors critically affect the mechanical performance of recycled plastic bricks:

- i. **Plastic percentage:** Moderate dosages optimize ductility and compressive strength. Exceeding these levels can weaken bricks, increase water absorption, and create voids (Saud et al., 2025).
- ii. **Aggregate type and gradation:** Fine, well-graded sand increases density and strength, while coarse gravel inclusions improve load distribution in cement-plastic mixes (Thiam et al., 2021).
- iii. **Production and compaction method:** Adequate heating ensures the recycled plastic melts and coats aggregates uniformly. High compaction pressures reduce voids and enhance bonding. Manual pressing or uneven heating results in weak zones (Debele et al., 2024; Lamba et al., 2021).
- iv. **Curing conditions:** Plastic-only units are air-dried, whereas cement or earth-based units require water curing for target strength. Improper curing can reduce mechanical performance significantly (Thiam et al., 2021; Dolores et al., 2020).
- v. **Testing standards and specimen type:** Measured strength varies with testing procedures and codes, such as ASTM C902 for pavers, SNI for concrete bricks, or local CHB standards (Nursyamsi et al., 2019).

Additional Properties Relevant to Housing Design

- i. **Water absorption – Moisture resistance:** Recycled plastic's hydrophobic nature results in very low water uptake (<1%), improving durability in humid or outdoor conditions (Kumi Larbi et al., 2018; Nnorom et al., 2023; Debele et al., 2024).
- ii. **Density –** Increases in recycled plastic reduce density, making bricks lighter and easier to handle, but excessive plastic content reduces compressive strength (Dolores et al., 2020; Lokman et al., 2025).
- iii. **Thermal and acoustic insulation –** Polymer content and entrained air improve insulation and sound absorption compared to conventional masonry (Saud et al., 2025; Kadhane et al., 2022).

Advantages and Constraints for Architectural Adoption

Advantages:

- i. **Diverts plastic waste from landfills and reduces demand for fired clay or cement** (Lamba et al., 2021; Kumi Larbi et al., 2018).

- ii. Can achieve compressive strengths comparable to conventional bricks when used as molten binder with well-graded sand (Kumi Larbi et al., 2018; Nnorom et al., 2023).
- iii. Very low water absorption and good abrasion resistance make recycled plastic units suitable for outdoor pavements and walls (Debele et al., 2024; Iftikhar et al., 2023).
- iv. Lighter weight and better thermal insulation enhance building efficiency and handling (Saud et al., 2025).

Limitations:

- i. Reduced fire resistance and strength softening at high temperatures; high plastic content increases voids and reduces structural reliability (Iftikhar et al., 2023; Dolores et al., 2020).
- ii. Heterogeneity of waste sources and absence of standardized processing methods lead to inconsistent performance across studies (Lamba et al., 2021).

Conclusion and Recommendations for Architectural Practice

Summary: Recycled Plastic Bricks and Affordable Housing Design

This study critically reviewed the use of recycled plastic waste in brick and block production, with a focus on compressive strength, production techniques, material properties, and practical applications. The synthesis of multiple studies revealed that recycled plastic can serve both as a binder and a partial aggregate replacement, offering sustainable alternatives to conventional masonry materials. The review highlighted the mechanisms through which recycled plastic interacts with aggregates, the optimal mix ratios for achieving sufficient strength, and the trade-offs between ductility, density, and compressive performance.

Key patterns observed include:

- i. Molten recycled plastic as binder: High compressive strengths (20–31 MPa) are achievable, suitable for light structural walls, paving blocks, and non-load-bearing construction.
- ii. Recycled plastic as partial aggregate replacement: Strength decreases with high plastic content (1–5 MPa for >30% replacement), restricting applications to lightweight or non-structural units.
- iii. Influencing factors: Particle size, aggregate type, plastic content, mixing uniformity, compaction, curing, and environmental conditions are critical for mechanical performance and durability.
- iv. Environmental impact: recycled plastic bricks contribute to circular economy principles by diverting plastic waste from landfills, reducing demand for fired clay and cement, and lowering embodied energy in construction

Architectural Viability: What the Evidence Shows

From the reviewed literature, recycled plastic bricks have demonstrated compressive strengths suitable for a range of applications, including non-load-bearing walls, partitions, pedestrian pavements, and certain light structural uses. The strength achieved depends heavily on the specific mix design and production methods employed, with studies reporting optimal performance in molten plastic-sand systems or carefully proportioned plastic-cement

composites (Kumi Larbi et al., 2018; Nnorom et al., 2023). These findings indicate that recycled plastic bricks can serve as a viable alternative to traditional masonry materials when properly designed and processed.

Moderate incorporation of recycled plastic, typically in the range of 10–30% of the total aggregate weight, has been shown to maximize both ductility and inter-particle bonding, leading to enhanced compressive strength. Conversely, excessive plastic content tends to reduce stiffness and increase void formation, which compromises the load-bearing performance of the masonry units (Saud et al., 2025; Dolores et al., 2020). This highlights the critical need for careful mix proportioning to balance flexibility and strength in polymer-modified bricks.

Another notable advantage of recycled plastic in brick production is its hydrophobic nature, which consistently reduces water absorption to less than 1% in many reported studies. This property enhances the durability of recycled plastic bricks, making them particularly suitable for outdoor applications such as pavements and garden structures, where moisture resistance is essential (Debele et al., 2024; Kadhane et al., 2022).

Finally, the production process plays a vital role in determining the performance of recycled plastic masonry units. Proper melting, uniform mixing, and adequate compaction are essential to achieve strong interfacial bonding between the polymer and aggregates. Suboptimal processing, such as insufficient heating or uneven compaction, results in weak bonding, increased voids, and premature failure under load (Iftikhar et al., 2023; Thiam et al., 2021). This emphasizes that both material selection and processing quality are crucial to the success of recycled plastic brick applications.

Recommendations for Architects, Developers and Policymakers

For architects, engineers, and builders, the use of recycled plastic in brick and block production requires careful consideration of material proportioning and production methods. Moderate incorporation of recycled plastic, typically between 10–30% by weight of the aggregate, is recommended to balance compressive strength and ductility, ensuring the units perform adequately under expected loads. Depending on the intended application, recycled plastic can function either as a molten binder for sand or as a partial replacement for fine aggregate, with the choice influencing both strength and workability.

Optimizing production is critical for consistent performance. Uniform heating, thorough mixing, and proper compaction are essential to ensure strong interfacial bonding between the polymer and aggregates, while appropriate curing conditions must be maintained to achieve target mechanical properties. Application-specific guidance suggests that high-plastic-content bricks are suitable for non-load-bearing walls and partitions, whereas moderate plastic content combined with well-graded sand is preferable for light structural walls and pedestrian pavements. For outdoor surfaces, molten plastic-sand bricks with low water absorption and optional fibre reinforcement offer durability against environmental exposure.

Safety considerations are also important. High-plastic-content units should be avoided in environments subject to elevated temperatures unless thermal stabilizers or fibre reinforcement are incorporated to reduce softening or deformation risks (Iftikhar et al., 2023). Finally, the development and adoption of local quality standards for recycled plastic brick production is encouraged to ensure reproducibility, safety, and broader acceptance of these sustainable construction materials.

Directions for Future Research

Despite promising results, the following research gaps remain and warrant investigation:

1. Long-term durability studies: Evaluate weathering, freeze-thaw cycles, UV exposure, and load-bearing lifespan of recycled plastic bricks in real environments.
2. Standardized testing protocols: Establish internationally recognized standards for mix ratios, mechanical testing, and curing methods, allowing comparability across studies.
3. Hybrid reinforcement strategies: Explore fiber reinforcement, surface coatings, or hybrid polymer blends to improve high-temperature performance, tensile properties, and load-bearing capacity.
4. Life-cycle and environmental assessment: Quantify embodied energy, carbon footprint, and sustainability benefits relative to traditional masonry units.
5. Scalability and industrial adoption: Study large-scale production, cost-effectiveness, and supply chain feasibility for recycled plastic-based construction materials in urban and low-resource contexts.

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