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Article

Innovative use of recycled textile fibers in building materials: A circular economy approach

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SUMMARY

The fast fashion industry is responsible for producing millions of tons of textile waste annually, contributing significantly to environmental degradation through landfill accumulation and carbon emissions. Addressing this growing challenge, the present research explores an innovative approach to repurposing textile waste by converting it into sustainable building materials. This study examines whether recycled textile fibers can enhance the mechanical and thermal performance of composite bricks with different binders, testing the hypothesis that those reinforced with epoxy resin and cement exhibit the highest mechanical strength (compressive, tensile, and flexural), while those using water-based glue and plaster of Paris (POP) demonstrate superior thermal insulation due to their porous structure. To test this hypothesis, we manually processed textile waste into fine fibers, mixed the fibers with selected binders, and molded and air-dried the mixtures into composite bricks. We then evaluated their performance by applying mechanical loads to assess compressive, tensile, and flexural strength, and by measuring heat transfer across the bricks under controlled heating conditions. Epoxy- and cement-based composites offered greater mechanical durability, while glue- and POP-based bricks provided better insulation performance. These differences suggest potential for application-specific use: epoxy and cement composites for structural or semi-structural roles and glue or POP composites for interior insulation and decorative purposes. Beyond performance, the study underscores the environmental benefits of textile reuse. Converting discarded fabrics into building materials diverts waste from landfills, supports energy efficiency, and reduces the carbon footprint of conventional construction. The findings highlight the potential of circular economy principles to drive sustainable development and guide future research in optimizing performance and scalability.

INTRODUCTION

The global apparel industry is a rapidly expanding market with significant economic influence. The global apparel market is projected to grow from $1.5 trillion in 2021 to $2 trillion by 2026, with an estimated 100 billion garments produced in 2023 alone (1,2). While fast fashion has made clothing accessible and affordable through rapid production cycles, its short product lifespan fosters a throwaway culture that leads to extensive landfill accumulation and resource depletion (3-6).

The textile and fast fashion industries represent major environmental threats through massive resource consumption, pollution, and waste generation. The fashion industry produces over 92 million tons of waste annually and consumes 79 trillion liters of water, while contributing 8-10% of global carbon emissions and 20% of industrial wastewater pollution (7,8). Textile waste management remains a global concern, with 75% of textile waste landfilled and only 25% recycled or reused (9). Thus, innovative reuse pathways have become increasingly urgent. Researchers have therefore emphasized the importance of shifting from the traditional “take, make, dispose” model toward a more circular approach that reuses and reintroduces materials into production systems (10). The circular economy encourages closed-loop systems that maximize resource use, minimize waste, and enable continual recycling, remanufacturing, and product recovery (10). Within this framework, the fashion and textile industries can transition toward sustainability by extending product lifecycles and repurposing discarded materials for new applications, reducing reliance on newly extracted raw materials and cutting environmental impact.

Research demonstrates that repurposed textiles have significant potential across multiple industries through various circular economy strategies (11-13). Textile waste can be effectively transformed into high-value applications across construction, non-woven, furniture, carpet, agriculture, and paper industries, with materials like cotton, wool, polyester, nylon, and kevlar offering excellent mechanical, thermal, and acoustic properties (11). These fibers can enhance flexibility, insulation, and impact resistance in composite materials, depending on their morphology and bonding characteristics (12). In particular, the construction sector has emerged as a promising field for large-scale textile reuse. Recycled textile waste has been successfully integrated into cement composites and insulation panels, where it enhances crack resistance, thermal regulation, and overall resource efficiency (12,13). Using textile waste in construction materials also helps divert waste from landfills, conserve natural resources, and lower energy consumption, demonstrating how waste textiles can serve as valuable raw materials in sustainable innovation.

The distinct mechanical and thermal properties of textile-reinforced composites are greatly influenced by the choice of bindings agents. Cement, white cement, and epoxy resin typically produce dense, cohesive matrices that provide high compressive and tensile strength (14-16). In contrast, plaster of Paris (POP) and water-based adhesives create lighter, more porous composites with lower strength but improved thermal insulation due to trapped air pockets that reduce heat transfer (17,18). Textile fibers themselves also play a crucial

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role in determining composite performance. Natural fibers, such as cotton and wool, tend to improve breathability and insulation because of their hollow, absorbent structures (19). In contrast, synthetic fibers like polyester and nylon enhance tensile strength, dimensional stability, and resistance to environmental degradation (20). When developing building materials, the most relevant characteristics to evaluate include compressive, tensile, and flexural strength for mechanical performance, as well as thermal conductivity (21).

Although recent advances highlight the potential of textile-reinforced composites for construction applications, systematic understanding of how different binder–fiber combinations influence both mechanical strength and thermal insulation remains limited. To address this gap, we fabricated composite bricks from recycled textile waste combined with five binders – cement, white cement, POP, epoxy resin, and water-based glue – and then systematically evaluated their performance through compressive, tensile, and flexural strength testing alongside thermal conductivity analysis. Based on this framework, we hypothesized that the textile-reinforced composite bricks incorporating epoxy resin and cement would exhibit the highest mechanical strength, specifically in compressive, tensile, and flexural tests, due to their dense and cohesive internal structure. In contrast, we expected bricks formed using water-based glue and POP to demonstrate superior thermal insulation performance, owing to their porous, fiber-rich composition and lower thermal conductivity. Consistent with this hypothesis, epoxy and cement-based composites showed superior mechanical strength, while glue and POP-based bricks exhibited enhanced thermal insulation. By advancing the understanding of textile-reinforced composites, our study provides insights that can support large-scale integration of recycled textiles in construction, thereby reducing waste generation and conserving natural resources.

RESULTS

To evaluate the feasibility of recycled textile waste as a sustainable building material, we first fabricated composite bricks using a consistent fiber mixture and different binder systems. Following an initial qualitative assessment of handling, curing, and surface characteristics during brick fabrication, we conducted a quantitative evaluation of mechanical strength and thermal insulation performance.

Qualitative assessment of handling and drying characteristics

We fabricated five types of textile-reinforced composite bricks using shredded cotton, polyester, and nylon fibers combined with cement, white cement, POP, epoxy resin, or water-based glue. Each binder possesses distinct physical and functional properties: Cement is known for its high compressive strength and durability, making it suitable for strong, stable composites. White cement combines similar strength with a smoother texture and superior aesthetics. POP offers quick setting and a fine finish but has limited tensile strength. Epoxy resin provides strong adhesive strength and excellent water resistance, forming a dense, cohesive matrix. Water-based glue is a non-toxic, eco-friendly binder with moderate adhesion, promoting flexibility but reducing overall strength **(Table 1).** These differences in binder characteristics were essential for assessing how binder selection influences the mechanical and thermal performance of textile-reinforced bricks.

Consistent with these material properties, each binder type produced distinct handling and drying characteristics **(Table 2)**. Water-based glue bricks required the longest drying period of approximately 10 days and remained lightweight with low structural rigidity. Cement and white cement bricks dried within 48 hours and formed compact, dense structures. POP bricks set within 24 hours but required an additional 48 hours of undisturbed curing to avoid cracking. They exhibited a chalky, brittle surface. Epoxy resin bricks were removed from molds after 48 hours and displayed a glossy, rigid finish.

Quantitative assessment of mechanical and thermal performance

We evaluated mechanical properties according to ASTM C 67-03a standards, which outline standardized procedures for assessing tensile, flexural, and compressive strength of brick samples (22). Specifically, we determined compressive strength by measuring the maximum load sustained by the brick before failure under axial compression, measured flexural strength using a three-point bending test, and measured tensile strength as the resistance to axial pulling forces using a universal testing machine (22). Epoxy resin bricks consistently recorded the highest mechanical strength, achieving a compressive strength of 23.50 ± 0.61 MPa, flexural strength of 7.25 ± 0.22 MPa, and tensile strength of 4.80 ± 0.18 MPa **(Figure 1A).** Cement bricks followed with 19.50 ± 0.48 MPa in compressive strength, 3.80 ± 0.21 MPa in flexural strength, and 2.20 ± 0.10 MPa in tensile strength **(Figure 1A)**. White cement bricks showed slightly lower values at 18.20 ± 0.44 MPa, 3.60 ± 0.16 MPa, and 2.05 ± 0.09 MPa, respectively, for compressive, flexural and tensile strength testing **(Figure 1A)**. POP bricks demonstrated intermediate mechanical performance with 6.30 ± 0.46 MPa compressive, 1.45 ± 0.12 MPa flexural, and 0.85 ± 0.09 MPa tensile strength **(Figure 1A)**. Water-based glue bricks exhibited the lowest values at 3.00 ± 0.40 MPa compressive, 1.10 ± 0.10 MPa flexural, and 0.55 ± 0.07 MPa tensile strength **(Figure 1A)**. The ranking of composite brick types remained consistent across all types of mechanical strength, indicating that epoxy resin, cement, and white cement binders produced the most structurally robust composites **(Figure 1A)**.

In addition to mechanical strength, we evaluated the thermal insulation performance of the composite bricks following ČSN EN ISO 10211 (730551), which assesses heat transfer through building materials by measuring the temperature rise across the specimen when one surface is exposed to a controlled external heat source (heat gun) for a fixed duration with internal temperatures recorded at 5, 10, and 15 minutes of continuous heating (23). Water-based glue bricks recorded the lowest temperatures across all time points — 34.0 ± 0.58°C, 42.5 ± 0.64°C, 48.0 ± 0.79°C, indicating the greatest resistance to heat transfer. POP bricks followed with temperatures of 36.2 ± 0.67°C, 45.0 ± 0.80°C, and 52.5 ± 0.89°C across each time point. White cement bricks reached 38.1 ± 0.59°C, 47.2 ± 0.69°C, and 54.0 ± 0.56°C at each time point, while cement bricks showed slightly higher readings of 39.0 ± 0.55°C, 48.5 ± 0.73°C, and 55.5 ± 0.52°C. Epoxy resin bricks recorded the highest internal temperatures of 40.5 ± 0.41°C, 50 ± 0.57°C, and 58.0 ± 0.69°C **(Figure 1B)**.

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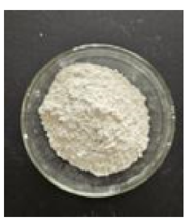
Binding Agent	Image	Properties	Role	Environmental impact
Water-Based Glue (Bergère de France)		Non-toxic, eco-friendly, and moderately adhesive	Add flexibility but reduces durability and water resistance	Minimal, due to its low chemical footprint
Cement (JK Super)		High compressive strength and durability	Provides structural stability and long-term resilience	High carbon footprint due to emissions from cement production
Plaster of Paris (POP) (JKC GypsoMaxX)		Quick setting with a smooth finish but limited tensile strength	Ideal for lightweight, aesthetic applications but unsuitable for heavy loads	Moderate, with less durability compared to cement
White Cement (JK Cement WhiteMaxX)		Combines strength with superior aesthetics	Suitable for durable and visually appealing bricks	Comparable to standard cement
Epoxy Resin (Shadow Art)		Strong adhesive strength and water resistance	Enhances toughness and resistance to environmental damage	High chemical content but offers long-term durability

Table 1: Binding agents used for brick fabrication. Properties, role and environmental impact of binding agents used in textile-reinforced brick production (11-18, 24).

DISCUSSION

To evaluate the suitability of recycled textile waste for construction applications, we investigated how binder type influences the mechanical and thermal performance of textile-reinforced bricks. The performance of these bricks was highly dependent on the type of binder. Epoxy resin bricks exhibited the highest average mechanical strengths across the tested composites **(Figure 1A).** They also surpassed the strength reported for unsaturated polyester resin (UPR) composites in prior studies, where the compressive strength reached only 3.114 MPa, with tensile and flexural strengths of 0.111 MPa and 0.134 MPa, respectively (12). This enhanced performance reflects the superior cross-linked polymer matrix of epoxy resin, which forms robust bonds with textile fibers and produces a dense, crack-resistant structure (24). Cement bricks outperformed white cement slightly, with average compressive strength of 19.50 MPa versus 18.20 MPa and average tensile strength of 2.20 MPa versus 2.05 MPa. This

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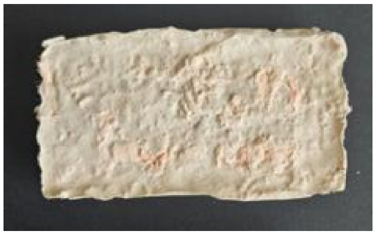
Binding Agent	Image	Drying Time	Appearance and Texture
Water-Based Glue (Bergère de France)		Fully dried within 10 days at room temperature.	Fibrous, lightweight, and slightly rough with visible textile fibers embedded in the surface
Cement (JK Super)		Required 48 hours to dry completely at room temperature.	Smooth, heavy, and robust with a solid, compact structure
Plaster of Paris (POP) (JKC GypsoMaxX)		Dried within 24 hours but remained undisturbed for an additional 48 hours to prevent surface cracking.	Chalky, lightweight, and fragile, with a powdery surface and aesthetically pleasing
White Cement (JK Cement WhiteMaxX)		Required 48 hours to dry completely at room temperature.	Dense, sturdy, and smoother than standard cement bricks, with a slightly polished appearance
Epoxy Resin (Shadow Art)		Cured at room temperature for 24 hours following manufacturer recommendations but was not demolded for an additional 48 hours to prevent warping.	Glossy, firm, and rigid, with a smooth and slightly plastic-like texture

Table 2: Qualitative analysis of fabricated composite bricks. Characteristics of textile-reinforced bricks, including drying time, surface appearance, and texture by binder type.

data is consistent with findings that ordinary Portland cement (OPC) often exhibits higher density and lower porosity than white cement, resulting in superior load-bearing capacity (14,15). White cement's finer particle size and smoother finish facilitated good fiber encapsulation, explaining its comparable average tensile and flexural strengths (2.05 and 3.60 MPa respectively). POP bricks, with an average compressive strength of 6.30 MPa and an average tensile strength of 0.85 MPa, were moderate in performance, reflecting POP's inherent brittleness. Water-based glue bricks exhibited the lowest average mechanical properties (3.00 MPa compressive, 0.55 MPa tensile), attributable to their high fiber content (3:1 ratio), which created a porous and discontinuous matrix (11,24).

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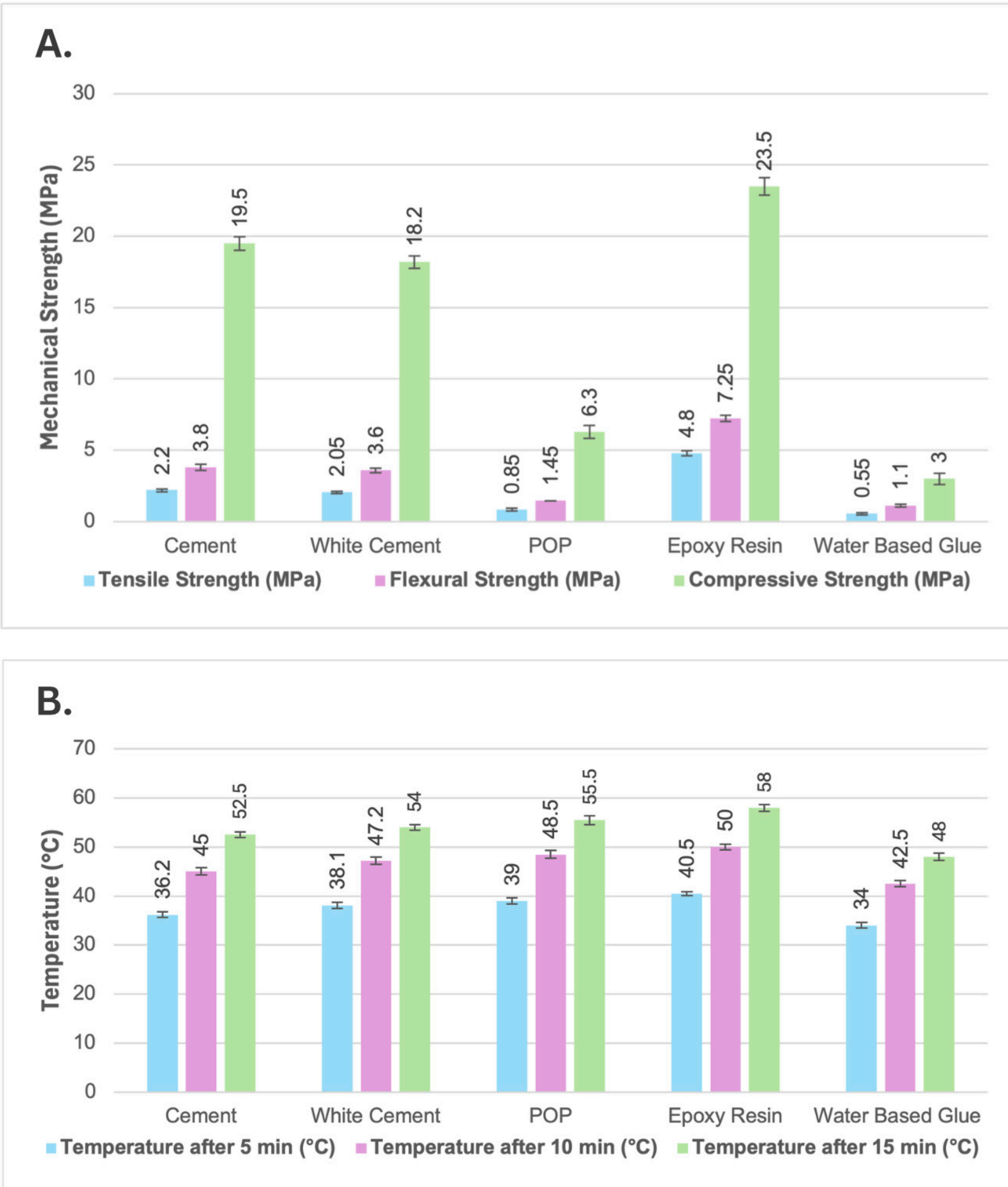

Figure 1: Mechanical strength and thermal insulation performance of textile-based composite bricks fabricated with different binders. A. Comparison of mechanical testing results, including tensile, flexural and compressive strength, of textile-based composite bricks fabricated with different binders (cement, white cement, POP, epoxy resin, water-based glue). B. Comparison of thermal conductivity testing results at 5, 10 and 15 minutes for textile-based composite bricks fabricated with different binders (cement, white cement, POP, epoxy resin, water-based glue).

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Thermal insulation results presented an opposite relationship (**Figure 1B**). Water-based glue bricks, despite their weak mechanical strength, demonstrated superior thermal resistance, recording the lowest average internal temperature of 48.0 °C after 15 minutes of heating. We attribute this performance to the high fiber content and porous structure, which traps air and impedes heat transfer, a phenomenon well-documented in studies on fiber-reinforced composites (17,18). POP and white cement bricks also exhibited good thermal insulation, with average final temperatures of 52.5 °C and 54.0 °C, respectively. Conversely, epoxy resin bricks, while mechanically superior, had the highest average internal temperature (58.0 °C), due to their dense, cross-linked matrix facilitating efficient heat conduction. These findings draw attention to the trade-off between mechanical strength and thermal insulation capacity; the strongest binders (epoxy resin, cement) not only produced the highest structural values but also the greatest thermal conductivity, whereas the weaker binders (water-based glue, POP) provided superior insulation performance. White cement bricks demonstrated balanced properties, ranking moderately high in both categories.

The type of textile used in each brick formulation can influence performance. Natural fibers, such as cotton or jute, are more porous and hydrophilic, enhancing thermal insulation but potentially reducing compressive strength with dense binders like epoxy (25). Synthetic fibers, such as nylon or polyester, offer higher tensile strength and more uniform interaction with resin-based binders, improving mechanical performance (26). In this study, we homogenized a mixture of natural (cotton) and synthetic (polyester and nylon) textile fibers which we used across all bricks, minimizing the impact of textile type; however, optimizing fiber selection for specific binders could further enhance structural or thermal performance.

Compared to global innovations, the mechanical performance of the epoxy resin and cement bricks developed in this study meets or exceeds that of fired clay bricks (5-15 MPa) and commercial textile composites, such as FabBRICK (2.3 MPa) (27, 28). The thermal insulation of water-based glue bricks also surpasses many conventional alternatives, positioning them as candidates for interior applications like partition walls and decorative elements. These results align with sustainable construction efforts worldwide, including textile-fiber-reinforced modular panels and eco-tiles combining fabric, plastic, and rubber (29). The positive influence of recycled textile fibers on mechanical and thermal properties, when combined with carefully selected binders, underscores their potential as environmentally sustainable construction materials.

It is important to note that we fabricated glue-based bricks using a different fiber-to-binder ratio (3:1) compared to the 1:3 ratio used for the other binders. This variation was necessary to ensure workable consistency and cohesive specimen formation, as lower glue content produced mixtures too viscous to mold effectively. Although this difference represents a methodological limitation, the binder type, not the binder amount, remains the primary variable under investigation. All samples were cast in identical molds, compacted under the same conditions, and evaluated for the same performance parameters, minimizing the effect of ratio variation on comparative results. The observed trends in strength and insulation align with expected binder chemistry rather than binder quantity, suggesting that the difference in proportion did not materially influence the outcomes. Future studies could, however, hold binder content constant or normalize strength values by specimen density to further refine comparisons across formulations.

The integration of recycled textile waste into building materials provides a pathway to sustainable construction solutions. The textile-reinforced bricks developed in our study display diverse mechanical and thermal properties, supporting a range of applications. Cement and epoxy resin bricks, with average compressive strengths of 19.50 MPa and 23.50 MPa, respectively, are suitable for semi-structural roles, such as non-load-bearing walls, façade cladding, and reinforced partitions. Water-based glue and POP bricks, with superior thermal insulation (average final temperatures of 48.0 °C and 52.5 °C), are ideal for interior partition walls and applications prioritizing energy efficiency. The smooth finish of white cement and epoxy resin bricks makes them viable for artistic installations, furniture panels, and modular architectural elements. The lightweight nature and high thermal resistance of water-based glue bricks make them candidates for low-cost shelters and temporary structures.

Recent studies highlight the potential of combining plastic and textile waste to create robust and thermally stable construction composites. Paving tiles made from industrial plastic waste and recycled nylon fibers have demonstrated strong mechanical performance, presenting an eco-friendly alternative to traditional materials for flooring and outdoor surfacing applications (30). Building on such innovations, this study offers foundational methods that can be adapted to explore hybrid composites involving multiple waste streams, enhancing both structural integrity and sustainability. However, for textile-reinforced bricks to be adopted at an industrial scale, several challenges must be addressed. First, material consistency remains a critical factor. The manual shredding and mixing techniques used in our study are not scalable and would need to be replaced with automated processes to ensure uniform fiber size, proper dispersion, and batch repeatability. Second, manufacturing infrastructure must evolve to include advanced molding, mixing, and curing technologies tailored for composite bricks, allowing production at commercial volumes while maintaining quality control. Third, regulatory compliance will require the development and validation of testing standards tailored specifically to textile-based bricks, as their fiber-reinforced and porous structure may influence long-term durability, load-bearing behavior, fire performance, moisture absorption, and thermal cycling differently from traditional clay or concrete bricks. These evaluations must ultimately conform to national and international building codes. Lastly, market acceptance must be cultivated through consumer education, industry collaborations, and green certification schemes. Policy support and demonstration projects will be essential in promoting trust and interest among architects, developers, and contractors.

Building upon the above, further research can expand the material's functionality and application range. Additionally, advanced material testing could be applied to benchmark textile-reinforced bricks against conventional and emerging construction materials, including assessment of mechanical, thermal, and durability under different environmental loads, water resistance over time, thermal cycling behavior, freeze-thaw durability, and creep resistance. Investigation into

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sustainable binders, such as bio-based resins, magnesium phosphate cement, or low-carbon geopolymers, could improve both the environmental profile and performance characteristics of composite bricks. These options could also be more adaptable to local material availability in different regions. Combining textile waste with other types of waste, such as post-consumer plastic, agricultural residues (e.g., rice husk ash), or industrial byproducts (e.g., fly ash), could create multi-functional bricks with enhanced mechanical properties, water resistance, or insulation (12). Since textile content may pose fire safety concerns, research into incorporating fire-retardant additives or selecting naturally flame-resistant binders would be critical to expand use in mainstream construction, especially in residential and commercial buildings. A detailed Life Cycle Assessment (LCA) will quantify the environmental advantages of textile-based bricks compared to conventional red clay or concrete bricks, focusing on embodied carbon, water footprint, energy use, and waste diversion (31). In parallel, cost-benefit studies will assess the financial viability of mass production, considering raw material sourcing, processing efficiency, and end-of-life recyclability.

The methods we established in this study, particularly regarding fiber integration, binder selection, and the observed trade-offs between strength and thermal performance, provide a solid foundation for designing next-generation eco-composites. Incorporating recycled textiles into construction not only reduces landfill burden but also creates durable, high-value materials, minimizing the need for virgin resources. The results show that textile-reinforced bricks can be tailored for specific applications, with epoxy resin and cement suitable for structural roles, and water-based glue and POP optimized for thermal insulation. By demonstrating the versatility and functionality of recycled textile-based materials, this work lays a framework for future research and the development of sustainable, eco-friendly building solutions.

MATERIALS AND METHODS

Fiber preparation and characterization

Shredded textile waste, derived from discarded garments, served as the primary material for this project **(Figure 2A)**. The textiles included both natural fibers (cotton) and synthetic fibers (polyester and nylon) sourced from household clothing. These garments were manually shredded using heavy-duty scissors into pieces approximately 1-3 cm in size. To achieve a finer, more uniform consistency, the shredded fibers were then further processed in small batches using a household mixer-grinder at medium speed for 1-2 minutes per batch. This processing step enhanced blend consistency and fiber dispersion in the final composite mixture. All textile fibers were mixed and homogenized before use to ensure uniform fiber distribution across all samples. No single-fiber formulations were prepared, allowing each brick type to contain the same representative mixture of textile waste.

Binder selection and brick fabrication

Five different binding agents were used for sustainable brick production: cement (JK Super), white cement (JK Cement WhiteMaxX), POP (JKC GypsoMaxX), epoxy resin (Shadow Art), and water-based glue (Bergère de France) **(Table 1).** Composite mixtures were created by combining the selected binders with the prepared textile fibers under controlled conditions. All mixtures were prepared at room temperature (25 ± 2 °C) to prevent premature setting or uneven curing. The same mixing duration, tools, and handling procedures were applied for each formulation. All bricks were cast to the same mold volume and compacted using the same

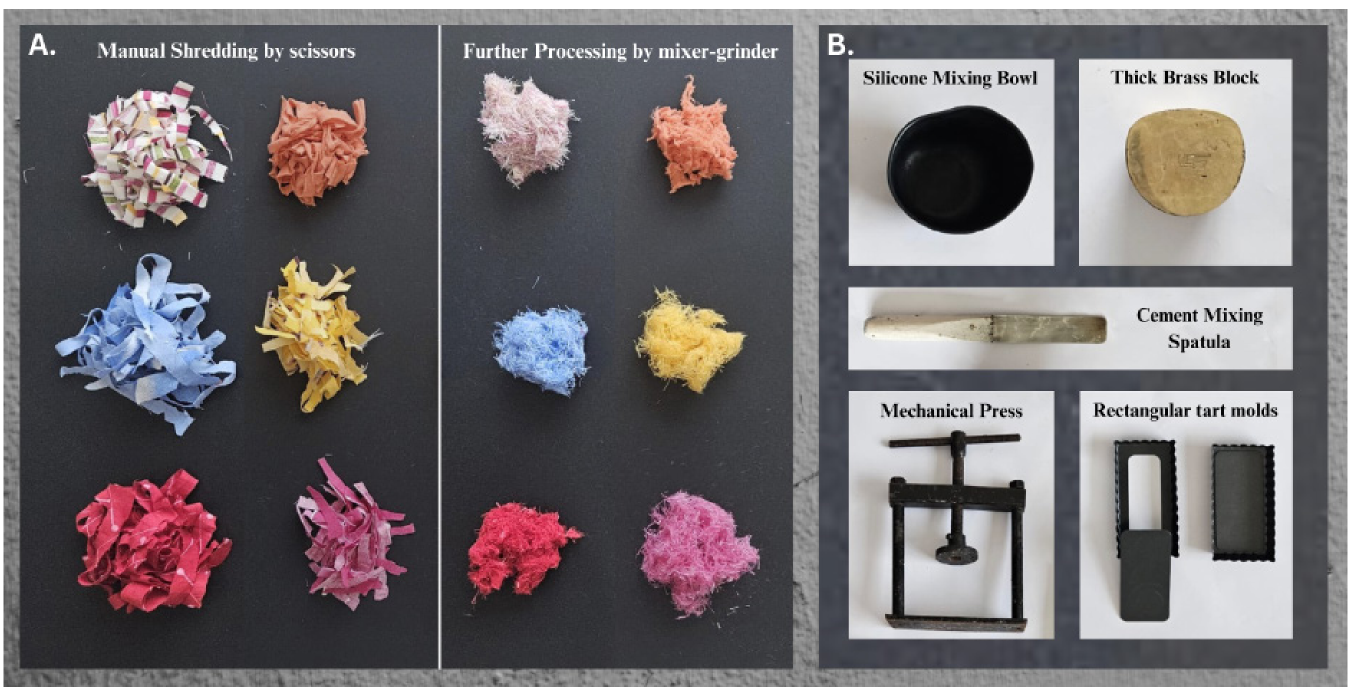

Figure 2: Shredded textile waste and tools used for mixing and molding textile composite bricks. A. Shredded cotton, polyester, and nylon fibers manually cut and processed using a household mixer-grinder to create uniform fine fibers suitable for binder integration. B. Silicone mixing bowl, cement spatula, mechanical press, brass block, and rectangular tart molds (11 cm × 6 cm × 2 cm) used for mixing and molding uniform bricks.

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procedure so that geometric volume and packing protocol were consistent across groups. All mixtures were blended manually in a silicone bowl using a cement mixing spatula **(Figure 2B)**. For bricks made with cement, white cement, POP, and epoxy resin, a fiber-to-binder ratio of 1:3 was maintained to produce mixtures with workable consistency and sufficient binder continuity for reliable curing **(Figure 3)**. For glue-based bricks, a ratio of 3:1 was used to emphasize the fiber content because preliminary test trials showed that glue at a ratio of 1:3 produced excessively stiff, poorly compactable pastes that trapped large voids and failed to form cohesive specimens suitable for mechanical testing. The higher fiber content with glue yielded a workable, compressible matrix that could be compacted uniformly in the molds and air-dried without severe cracking.

The mixing process for each binder type was tailored to suit the material's specific properties. For water-based glue, fibers were combined with the glue and small amounts of water were added gradually to maintain a consistent, slightly sticky texture. Cement was mixed with fibers and water until a paste-like consistency was achieved, with mixing done in a circular motion to ensure even distribution. POP was added to the fibers and mixed quickly to prevent premature setting, with minimal water added to retain a smooth, workable texture. White cement followed a similar process to regular cement, focusing on achieving a homogeneous blend. For epoxy resin, a curing agent was added to the resin-fiber mixture according to manufacturer guidelines. No water was added during this process to maintain proper curing, and mixing continued until a uniform consistency was obtained.

Once mixing was complete, the composite material was poured into rectangular tart molds measuring 11 cm x 6 cm x 2 cm lined with butter paper to prevent sticking **(Figure 2B)**. The material was added in layers, with each layer manually compressed using a mechanical press to eliminate air pockets and ensure uniform fiber distribution **(Figure 4)**. A thick brass block was placed beneath each mold to support the pressing force. This process continued until the molds were filled with smooth, dense bricks. The molded bricks were air-dried in a well-ventilated area for several days, depending on the binder used. To ensure uniform drying and reduce the risk of warping, the bricks were periodically flipped. Drying was considered complete when the residual moisture had evaporated and the surface of the bricks appeared uniformly matte and non-tacky

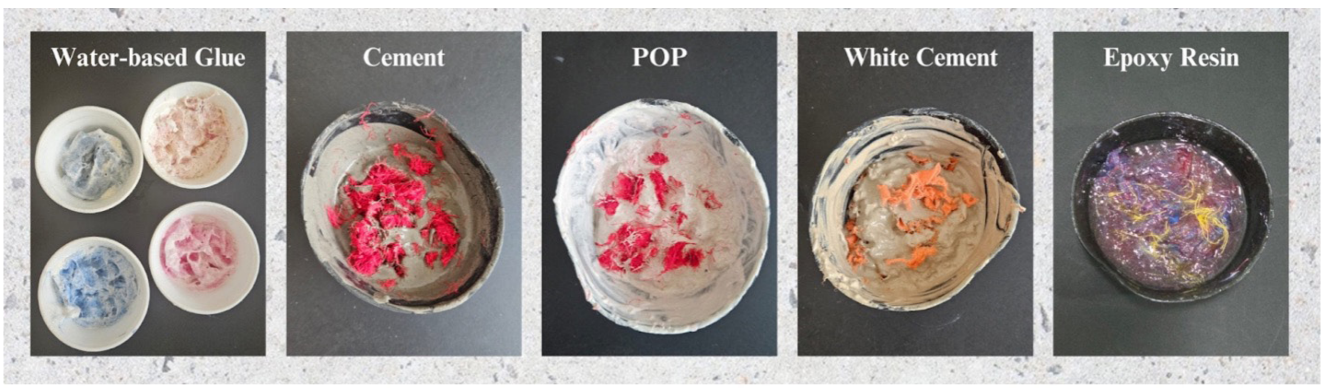

Figure 3: Formation of composite mixtures of shredded textile fibers and various binding agents. Processed textile fibers mixed with five binders (cement, white cement, POP, epoxy resin, and water-based glue) under controlled conditions for fabrication of textile-based bricks.

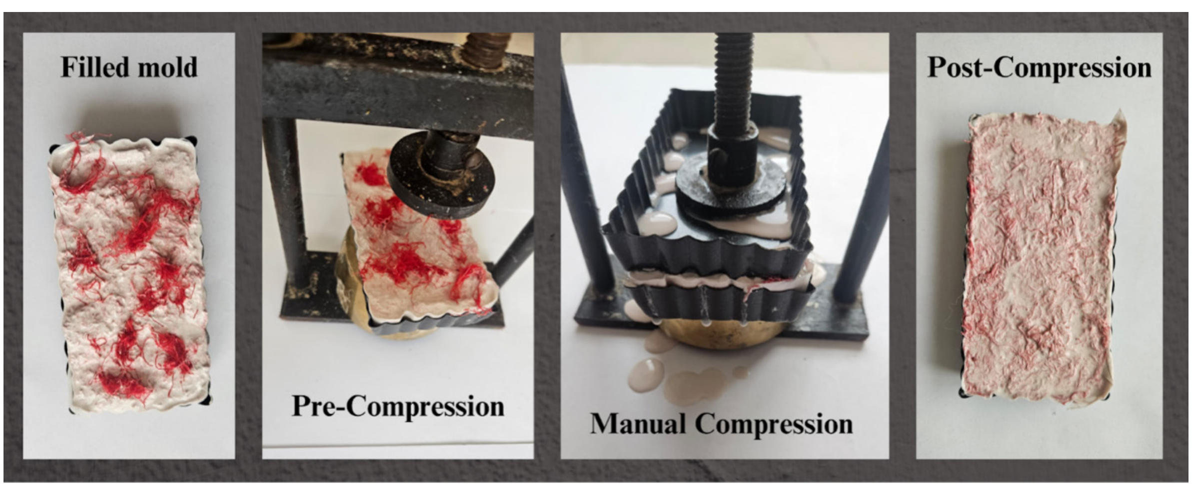

Figure 4: Step-by-step fabrication of a textile-POP composite brick through manual layering and compaction. This figure illustrates the process used to achieve uniform density and fiber distribution within the brick mold. The textile-POP mixture was added incrementally into a rectangular mold lined with butter paper, with each layer manually compressed using a mechanical press to minimize air voids. A thick brass block was placed beneath the mold to provide height support and ensure even pressure during compaction, resulting in a dense and uniformly packed composite prior to curing.

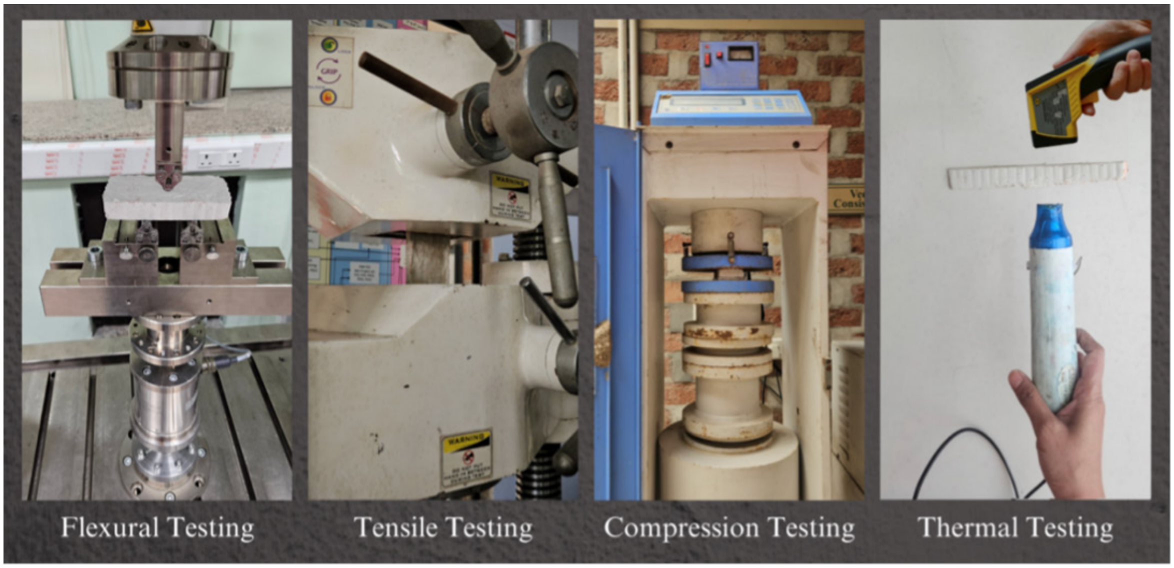

Figure 5: Mechanical and thermal testing configurations for textile-reinforced composite bricks. The figure shows setups for compressive loading, tensile pulling, and flexural (three-point bending) tests used to assess mechanical performance, alongside the thermal testing arrangement in which one surface of the brick was heated while temperature changes were recorded on the opposite face to evaluate heat transfer.

to touch. Once curing was complete, the bricks were carefully removed from the molds. The butter paper lining allowed for smooth and damage-free demolding.

Mechanical and thermal testing

All fabricated bricks were evaluated for both mechanical and thermal performance **(Figure 5)**. ASTM C 67-03a standards were adhered to for conducting mechanical tests (22). Tensile strength was measured using a Universal Testing Machine (ENKAY #EKE EC-60) to determine axial load resistance, flexural strength was assessed using a Universal Testing Machine (Zwick Roell, Germany Static UTM Z010) to evaluate bending performance, and compressive strength was determined using a BS EN Compression Machine (#36-3280/01) to assess load-bearing capacity. Thermal performance was measured following ČSN EN ISO 10211 (730551) (23). A heat gun set to 200°C (GC Electronic) was positioned 2 cm from one surface of each brick, while a temperature sensor (Etekcity #DT8380) was placed 2.5 cm from the opposite side. Internal temperatures were recorded at 5, 10, and 15 minutes of continuous heating to determine heat transfer through the material. For both mechanical and thermal tests, five specimens per brick type were analyzed to calculate average values.

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