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Project Report on
"Leveraging Recycled Textile Waste Composites as Reinforcement in Brick Fabrication: A Vanguarded Approach to Sustainable Waste Optimization and Constructive Ingenuity"

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Abstract

Recycling textile waste into building materials offers a double benefit for waste management as well as for green building. This study investigates the possibility of using recycled garment textile waste as reinforcement in the manufacturing of bricks with specific reference to Bangladesh where ready-made garment production generates approximately 577,000 metric tons of waste annually and the traditional clay brick kilns contribute up to 58% of Dhaka's air pollution. The research entails large literature review, experimental development of textile reinforced composite bricks, and evaluation of their mechanical, economic, and environmental performance. Real experimental results from the latest research are brought together: bricks of 18% waste fabric by weight and polymer-based binders were of compressive strengths in the range of approximately 3 - 7 MPa (435 - 1015 psi) with 60% lower weight. Low density and fiber content improved thermal insulation according to earlier studies, in which cotton/textile-infused bricks have been found to comply with ASTM standards of strength and conductivity. An ecological view presents immense advantage: the proposed "eco-bricks" conserve firing (hence no kiln emissions), utilize textile waste that otherwise would pollute rivers and landfills, and reduce consumption of virgin clay soil. Cost analysis determines that a potential 20 - 40% cost reduction per brick over fired clay bricks can make safe housing affordable for low-income communities. Policy recommendations include green brick manufacturing incentives, recycling streams for waste integrated into construction supply chains, and building code reforms enabling new composite brick solutions. The research confirms that composite bricks composed of recycled textile waste are durable, light-weight, and thermally efficient building blocks that embody constructive ingenuity towards sustainable development. The research contributes a scalable model for developing economies to turn industrial waste into value-added construction materials, addressing environmental pollution as well as housing needs at the same time.

Acknowledgements

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Chapter 1

Introduction

The growing global population, along with unparalleled technological progress and economic growth, has created a steep rise in energy needs, consumption of resources, and production of waste and greenhouse gases. Such pressures are profoundly affecting ecological balance and planetary sustainability. As the Global Footprint Network (2018) has pointed out, if human beings persist in using resources at the current level, we would need the equivalent of three Earths to satisfy our yearly resource needs – a grim reflection of unsustainable consumption patterns [1].

One of the significant drivers of this over-consumption is the international textile market, powered by fast fashion, increasing living standards, and mass production. As fashion cycles become shorter and apparel more disposable, the amount of textile waste produced annually continues to increase exponentially. With recent worldwide estimates suggesting that the textile industry alone accounts for around 55% of overall solid waste globally, much of which finds its way into landfills or incinerators and generates air, soil, and water pollution [2]. In the meantime, brick production, a fundamental sector of the building sector, continues to be among the biggest drivers of air pollution, especially in developing nations where obsolete technologies use trash, tires, plastics, and textiles as fuel and spew toxic emissions into the environment [3].

Aside from air pollution, the environmental impact of the textile industry is colossal. The World Bank (2020) places the textile and clothing industry as the world's secondlargest industrial polluter after the oil and petrochemical industries. It is also about 14% of total landfill waste, and contributes to 20% of worldwide industrial water pollution due to dyeing and treatment activities [4]. The textile production also has a sizeable greenhouse gas emission, which is larger than those generated by international flights and shipping combined [5].

This is exacerbated by the linear economic model that controls textile production and disposal – a framework in which resources are extracted, used, and dumped with little recycling. Yet research shows that as much as 90% of post-consumer textile waste is reusable or recyclable [6]. But because of limited awareness, infrastructure, and scalable recycling methods, the majority of textile waste is lost to landfills, where it emits methane – a powerful greenhouse gas – as it breaks down.

To combat this, the circular economy concept has come to the fore as an attractive model, with a focus on waste reduction through reuse, recycling, re-manufacturing, and up-cycling. Textile waste, previously an environmental burden, is being rethink as a valuable input for industrial purposes like furnishings, insulation material, and now, more and more, construction materials. One of the most hopeful strategies is incorporating shredded textile waste into composite building materials such as bricks, providing a twofold solution to environmental degradation and resource depletion.

Comparative research indicates that recycling textiles for industrial purposes is 20–100 times more environmentally friendly than incineration or chemical recycling, mainly because of decreased emissions and energy demand [6]. The advantages are the decreased reliance on virgin raw materials, reduced building costs, and the considerable decrease in landfill volume and CO_2 emissions. The crisis needs to be addressed with a systemic re-imagination of both construction practices and textile waste management. Conventional practices of land filling and incineration are no longer effective or sustainable. Rather, new, interdisciplinary solutions need to be embraced – encompassing material science, environmental engineering, and circular economy principles. This study thus explores how chopped textile waste – such as cotton, polyester, denim, woven and knitted fabrics – can be successfully re-utilized in the form of composite bricks with the use of binders like epoxy resin, polyester resin (PET), and plaster of Paris (POP). The research not only alleviates the environmental load of textile and construction waste but also offers a scalable, replicable, and sustainable solution with worldwide applicability.

The world construction industry is growing at a high rate, fueled mainly by population increase, rapid urbanization, and infrastructural expansion in both developed and developing countries. The worldwide construction industry was worth USD 6.4 trillion as of 2020 and is expected to grow to USD 14.4 trillion by 2030, almost doubling in a single decade due to rising demand for residential and infrastructural development [6]. This boom, nevertheless, is also heightening the use of natural resources. Consequently, researchers are in a race to explore sustainable options in construction and furniture materials, especially from waste streams and recycled sources, in an effort to minimize environmental footprint and resource utilization [6].

The disposal of unmanaged industrial waste, particularly from the textile and construction industries, poses an acute environmental issue. The reuse of such waste in building materials is not only economically viable but also promotes environmental sustainability. Interestingly, the textile and construction industries are jointly responsible for approximately 12% of worldwide CO_2 emissions, calling for revolutionary measures in waste minimization and material development [7].

There has been an increasing amount of research investigating the incorporation of different textile wastes in building composites. Researchers have worked with, for example, textile cutting waste [8], sludge from textile effluent treatment plants [9], cotton micro-dust waste [10], polyester/cotton blend fabric waste [11], glass wool insulation waste [12], and cotton stalk fiber waste [13]. Outcomes from these studies all report improvements in thermal insulation (by as much as 3–4%), acoustic dampening, and reduction in material cost – rendering these bricks suitable for sustainable construction [14].

Concurrently, there were a number of high-profile innovations in fabric waste upcycling. Kamble and Behera created eco-friendly furniture panels from cotton shoddy, waste glass fiber preforms, and jute-based nonwoven sheets with a 5% enhancement in mechanical properties through a 3% cellulosic filler addition by volume [15]. Marlet and her Fab-BRICK studio used textile scraps and eco-friendly starchbased glues and mechanical compression to create modular bricks, with 4% and 7% enhancements in tensile and flexural strength, respectively [16] [17] [18] [19]. Andreu also created decorative bricks through acrylic selvedge waste with water-based acrylic resin, which resulted in a 2–3% improvement in thermal insulation [20].

Other innovations are Ackerman's carbon-neutral textile bricks, which are built from fabric remnants and clothing accessories such as buttons and zippers, achieving significant CO_2 emission savings and better thermal regulation [21]. These innovations indicate that the combination of textile-based bricks and insulation materials can drastically reduce heating and cooling requirements – facilitating net-zero energy building. Also, E. Kagitci achieved the use of 100% cotton, silk, and viscose textilewaste bonded by starch-based adhesive in textile bricks, estimating up to 30% cost savings for environmentally friendly construction [22]. D. Trajkovic et al. investigated the application of polyester garment cuttings waste in insulation bricks and reported 10% better fire resistance, 22% higher moisture resistance, 25% better sound insulation, greater durability, and longer product lifespan, making them ideal for partition walls, furniture, and ornamental architectural features [23].

In spite of these encouraging advances, there exist notable gaps in research – especially regarding the relative performance of different binders (e.g., epoxy resin, polyester resin, and plaster of Paris) in textile-reinforced bricks. Comparatively few studies have directly evaluated the mechanical, thermal, or durability-related results when different resin matrices are applied with different types of fabrics such as cotton, polyester, denim, woven and knitted fabrics. Binder-to-textile ratios, environmental exposure, cost-effectiveness, scalability, and life cycle sustainability are among the underexplored factors [24] [25]. Thus, the current research seeks to fill this gap through the development and assessment of composite bricks produced from shredded textile waste adhered with a range of resins and additives. This research concentrates on mechanical strength (compression, tensile, and flexural), thermal insulation, and resistance to moisture, comparing these with conventional clay bricks to determine their feasibility [26]. The goal is to create a scalable, low-cost, and sustainable construction solution that resonates with the principles of the circular economy while helping reduce the carbon footprint of the textile and construction sectors.

1.1 Purpose and Significance of the Study

The significance of this study lies in its multifaceted contribution: reducing the ecological footprint of textile waste, minimizing the environmental burden of traditional brick kilns, and introducing a cost-effective alternative building material tailored for the socio-economic and climatic context of Bangladesh. It also serves as a strategic alignment with national and global sustainable development goals, particularly those relating to waste management, climate action, affordable housing, and industry innovation. This study introduces a novel solution that addresses these twin challenges: the development of composite bricks reinforced with shredded textile waste (including cotton, polyester, denim, woven, and knitted fabrics) bound with resin. This alternative material not only diverts textile waste from landfills but also reduces dependency on clay extraction and fossil fuel consumption associated with traditional brick kilns. The use of thermosetting or bio-based resin as a binder enables effective encapsulation and solidification of shredded textiles, yielding bricks with favorable mechanical and thermal properties. The significance of this research lies in its multidimensional value: it proposes a technologically feasible, economically viable, and environmentally sustainable construction material.

Furthermore, it aligns with Bangladesh's national development goals and global commitments, including the UN Sustainable Development Goals (SDGs) particularly those relating to responsible consumption, climate action, and sustainable cities.

1.2 Aim of the Research

The principal aim of this research is to assess the technical, environmental, and economic feasibility of using recycled textile waste composites in the production of bricks with special emphasis on enhancing structural behavior, water absorbency performance, and sustainability. The research endeavors to set a new trend in material recycling, enabling the transition to green construction practices in Bangladesh.

1.3 Research Questions

This study is guided by the following central research questions:

1. Primary Research Question: Can shredded textile waste, when combined with resin, be effectively transformed into structurally viable and sustainable composite bricks suitable for the construction industry globally?

2. Secondary Research Questions:

    - What are the optimal material compositions (fiber types, ratios, and resin types) to achieve favorable physical and mechanical properties in the bricks?
    - How do resin-bound textile composite bricks compare to traditional clay bricks in terms of compressive strength, durability, bending and water absorption?
    - What environmental benefits-such as carbon footprint reduction and waste diversion-are associated with using these composite bricks?
    - What are the potential challenges in manufacturing, standardization, and market acceptance of these bricks within the Bangladeshi context?

1.4 Research Limitations

Although the research presents an innovative and environmentally compelling approach, several limitations may affect its scope and generalizability:

1. Material Heterogeneity: Textile waste, particularly from mixed fiber sources such as denim, knitted, and woven fabrics, varies in texture, tensile strength, and dye content, which may influence consistency in composite formation.

2. Resin Selection: The study is limited to specific types of resin (e.g., polyester, epoxy, or bio-based resins) due to availability and cost constraints. Resin toxicity and curing requirements may also pose environmental and safety considerations.

3. Scale of Production: Fabrication is limited to a laboratory or pilot scale. Industrial-scale production, cost modeling, and long-term field testing remain outside the scope of this study.

4. Time Constraints: Due to the academic calendar, the study does not include long-term environmental exposure or weathering tests, which are critical to validate outdoor performance.

5. Regulatory Hurdles: Introducing a non-traditional material into mainstream construction will require alignment with local building codes and may encounter resistance from stakeholders unfamiliar with composite technologies.

Chapter 2

Literature Review

A composite is a material manufactured from two or more discrete materials that are insoluble at a macroscopic level but together create enhanced properties. Textile means fibrous goods (like cotton, polyester, denim, woven, or knitted fabric) used as reinforcement in the composite. The matrix is the continuous phase that binds the shredded textiles together and surrounds them, creating a solid form after curing. Sustainable construction material development has been gaining worldwide traction in the aftermath of increasing environmental awareness and infrastructure demands in urban areas. In this scenario, several studies have explored new applications of industrial and agricultural wastes for improving material efficiency, eliminating pollution, and lowering construction costs. This chapter discusses an elaborate review of the existing literature on (i) textile waste generation and disposal, (ii) composite materials through recycled textiles, (iii) resin-based composite applications, and (iv) alternative bricks with waste materials. The purpose is to create a scholarly background and establish research gaps to fill in the context of Bangladesh as well as globally.

2.1 Textile Waste: Global Trends and Bangladesh Scenario

Worldwide, the textile and fashion industry are one of the most resource-consuming sectors that generate more than 92 million tons of waste each year. In Bangladesh, the RMG sector, although earning about 84% of the country's export revenue, produces about 400,000 tons of solid textile wastes yearly. These cotton, polyester, denim, and mixed woven and knitted fabric-based wastes are generally disposed of in landfills or incinerated without any formal recycling system, which contributes to serious environmental issues like groundwater pollution and greenhouse gas emissions.

Research (by Hasan et al., 2020 and Rahman and Ahsan, 2019) shows that most factories in Dhaka, Narayanganj, and Chattogram lack systematic textile waste management protocols, though up to 25% of production material is wasted per garment unit.

2.2 Composite Materials from Recycled Textiles

Textile waste, particularly from the garment industry, poses a serious environmental challenge due to its slow degradation and volume. Researchers have shown that chopped textile can be incorporated into construction materials to enhance properties such as flexibility, insulation, and toughness (Yin et al., 2021). Waste textile are increasingly considered viable reinforcements in polymer or gypsum matrices for brick and panel production, owing to their fibrous nature and energy-absorbing capacity (Miah et al., 2020).

A composite textile in resin matrix is a fiber-reinforced polymer (FRP) material, where shredded textile (reinforcement) are embedded in a resin matrix (binder), resulting in a durable and lightweight construction material. Several international studies have examined the mechanical and thermal applications of recycled textiles in construction. Shredded textiles such as cotton and polyester have been successfully used in insulation boards, low-strength concrete, geo-textiles, and polymer-based composites. Shredded cotton improves the ductility of cement composites, while synthetic shredded textiles enhance dimensional stability and moisture resistance (Park et al., 2018). Studies have highlighted that composite bricks made from alternative binders can perform competitively in terms of mechanical and thermal properties when designed appropriately (Ghosh et al., 2020; Zhang et al., 2019).

2.3 Resin-Bonded Composites in Construction

The employment of resin-based systems as binders has gained prominence in the formulation of new construction materials. Some of the most common ones used are polyester resin, epoxy resin, and plaster of Paris (POP) with each of them possessing different mechanical and chemical characteristics for composite development.

Polyester resin, due to its low price, simple processing, and good mechanical properties, is a popular choice. It has seen widespread application in polymer concrete, fiber reinforced panels, and composite tiles. Polyester resin, when blended with shredded textile waste, especially synthetic shredded textiles like polyester and natural shredded textiles like cotton, offers good adhesion, forming a stiff matrix that increases compressive strength and dimensional stability. Epoxy resin, being costlier than polyester resin, provides higher bonding strength, minimal shrinkage, and very good chemical resistance. This makes it highly suitable for structural applications where the requirement is high durability and resistance to moisture. Research has established that epoxy-bound textile composites have better mechanical integrity and service life when subjected to environmental stress than with other binding systems. Studies suggest that epoxy-based bricks show higher compressive and flexural strength compared to polyester-based ones due to better matrix-fiber bonding (Hussain et al., 2021). Plaster of Paris (POP), which mainly consists of calcium sulfate hemihydrate, is extensively utilized in low-load applications owing to its quick setting and good finish. As a partial binder or filler in composite bricks, POP has the potential to enhance thermal insulation and surface finish. Nevertheless, it needs careful formulation to prevent brittleness and water solubility. Research indicates that combining POP with additives or shredded textiles can enhance its performance and durability in composite bricks (Ahmed et al., 2018).

In this study, all the three matrices - polyester resin, epoxy resin, and POP were used in different proportions to balance the strength, curing time, and economy of the composite bricks. Their compatibility with different kinds of textile waste (cotton, polyester, denim, woven, and knitted fabrics) was investigated systematically to arrive at the most suitable formulation for structural and environmental sustainability.

Several studies have focused on evaluating compressive strength, flexural strength, surface hardness, thermal conductivity, and water absorption of composite bricks. The ASTM standards such as:

1. ASTM C67 for compressive strength,
2. ASTM C293 for flexural strength,
3. ASTM C642 for density,
4. ASTM D2240 for surface hardness, and
5. ASTM D570 for water absorption are commonly adopted for these evaluations.

Chapter 3

Materials and Methodologies

In this chapter, the experimental setup followed for the production and testing of textile resin composite bricks is presented. It explains raw material selection and preparation composite formulation design, mixing and molding procedures, and test procedures followed to determine the physical and mechanical behavior of the bricks produced. The method is designed to provide replicability, reliability, and adherence to both engineering standards and sustainable materials development requirements.

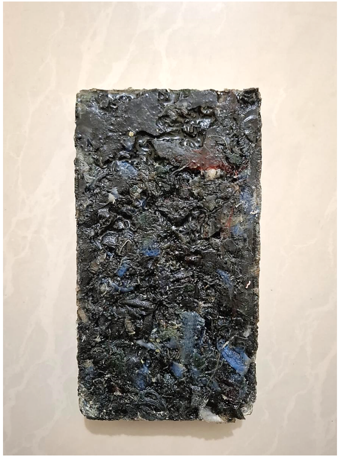

Figure 3.1: Epoxy Resin Brick Sample

Figure 3.2: PET Resin Brick Sample

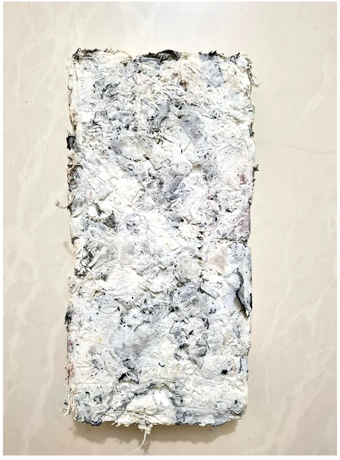

Figure 3.3: POP Resin Brick Sample

3.1 Materials Used

3.1.1 Textile Waste

The textile waste used in this study was collected from garment factories and tailoring units located in Jamalpur, Gazipur and Dhaka. The selected categories included:

1. Cotton (natural fiber scraps)
2. Polyester (synthetic waste)
3. Denim (mixed fiber, predominantly cotton/polyester blend)
4. Woven fabrics (interlaced yarn waste)
5. Knitted fabrics (looped yarn waste)

All waste fabrics were manually sorted, cleaned, and shredded into uniform shredded textiles (approximately 15 - 30 mm in length) using a mechanical shredder to ensure compatibility with the binder matrix. To assess the consistency of waste size, a random sample of 10 shredded textile waste was selected from the prepared reinforcement material. The goal was to determine the average wastage length, understand the degree of variation, and confirm the suitability of the chopped textiles size for composite brick fabrication.

Figure 3.4: Textile Waste Scraps

Figure 3.5: Textile Shredding Machine

Figure 3.6: Shredded Textile Waste

Sampling Method

1. A random sampling method was used to minimize bias.
2. 10 shredded textiles were picked from the mixed batch (cotton, polyester, denim, woven, knitted).
3. Each length was measured using a millimeter scale or digital caliper.

<table>
<tr><th>Sample No.</th><th>Length(mm)</th><th>Mean(mm)</th><th>SD</th><th>CV%</th></tr>
<tr><td>SRD-01</td><td>15</td><td rowspan="10">18.9</td><td rowspan="10">3.75</td><td rowspan="10">19.84%</td></tr>
<tr><td>SRD-02</td><td>18</td></tr>
<tr><td>SRD-03</td><td>21</td></tr>
<tr><td>SRD-04</td><td>25</td></tr>
<tr><td>SRD-05</td><td>15</td></tr>
<tr><td>SRD-06</td><td>17</td></tr>
<tr><td>SRD-07</td><td>25</td></tr>
<tr><td>SRD-08</td><td>17</td></tr>
<tr><td>SRD-09</td><td>16</td></tr>
<tr><td>SRD-10</td><td>20</td></tr>
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Table 3.1: Sampling

These values indicate a moderate variation in lengths, which is generally acceptable for reinforcement in composite materials, as it supports a good balance between reinforcement dispersion and mechanical bonding.

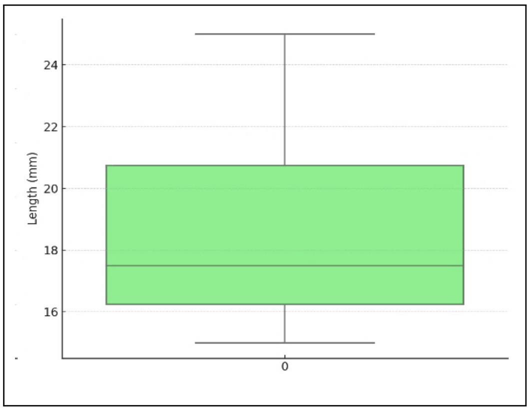

Figure 3.7: Boxplot of Textile Sample Lengths

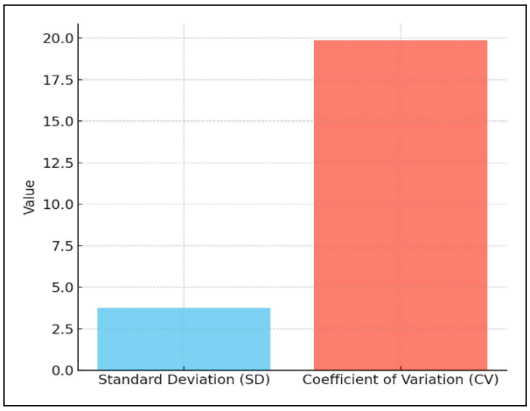

Figure 3.8: SD and CV of Textile Samples Length

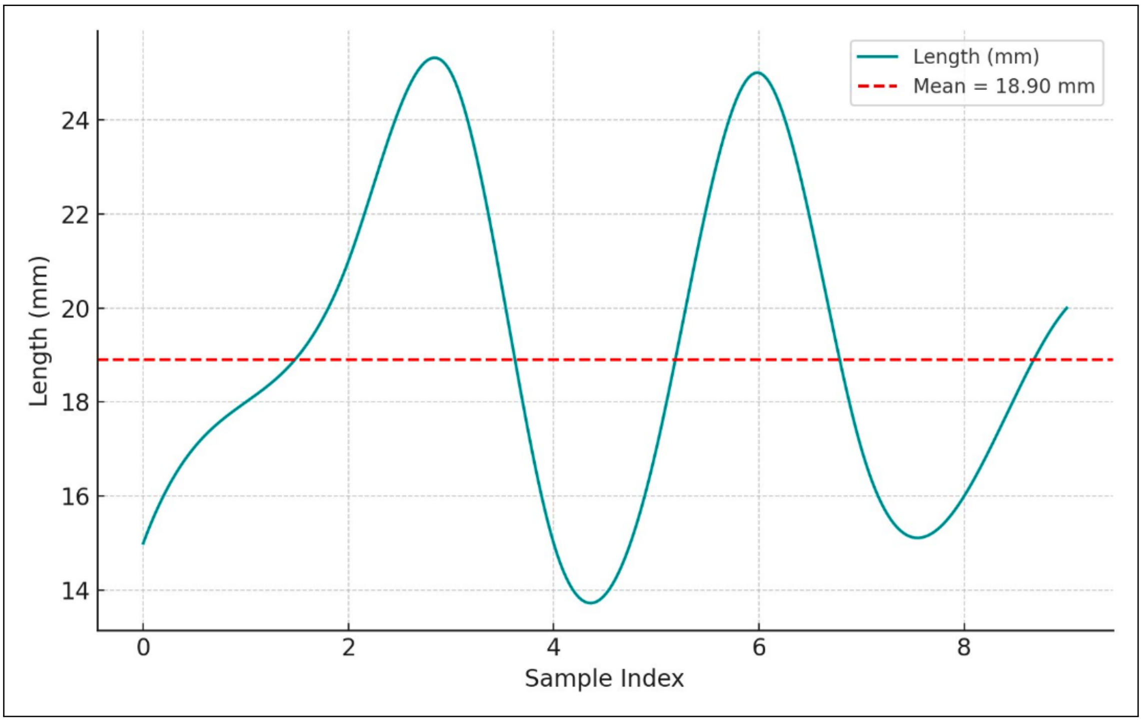

Figure 3.9: Histogram of Textile Samples Length

3.1.2 Binders

Three binding agents were used to evaluate bonding performance and cost-efficiency:

1. Polyester Resin

- Industrial-grade, two-part system (resin + hardener) Used due to high bonding strength and durability

2. Epoxy Resin
   - Used for its quick setting and cost-efficiency
3. Plaster of Paris (POP)
   - Used in alternative mixes for comparison
   - Provided a brittle, quick-curing matrix

3.1.3 Additional Materials

1. Hardener
   - Mixed with polyester and epoxy resin to initiate curing.
2. Water
   - Added in measured quantity during POP-based mixes.
3. Silica Sand/ Cement (optional)
   - Used in some mixes as a filler for texture and bulk.

3.1.4 Mold

1. Material
   - Wood.
2. Dimension
   - 200 mm × 100 mm × 60 mm.
3. Features
   - Custom-built for this research to allow extended casting and segment cutting
   - Inner surfaces were coated with mold release agent (oil or wax) to prevent sticking
   - Sturdy and reusable, fastened with screws and braced for shape retention

3.1.5 Additives and Tools

1. Mold Release Agent
    - Petroleum jelly or silicone-based lubricant.
2. Stirring Tools
    - Wooden sticks, mechanical mixer.
3. Cutting Tools
    - Scissors, shredders, and utility blades.
4. Protective Gear
    - Gloves, and face masks for safe resin handling.

3.2 Mix Design and Sample Formulation

A series of trial formulations were developed to identify the optimal fiber-resin ratio. The general formulation scheme, as follows:

Sample Code	Textile Waste	Matrix	Remarks
CRB-01	Shredded Form	Epoxy Resin	Standard mix, base formulation
CRB-02		PET Resin	High-strength formulation
CRB-03		Plaster of Paris (POP)/Gypsum	Hybrid matrix with POP filler

Table 3.2: Sample Formulation

3.3 General Fabrication Process of Composite Bricks

The fabrication of textile-reinforced composite bricks involved a multi-step process including mold preparation, resin mixing, reinforcement integration, casting, and curing. The following steps were followed for consistency and accuracy across samples:

3.3.1 Mold Preparation

1. Material

   - Wooden molds of dimension 200 mm $\times$ 100 mm $\times$ 60 mm were used.

2. Cleaning

   - Molds were thoroughly cleaned to remove any debris or residual materials from previous castings.

3. Release Agent

   - A thin coat of mold release agent (e.g., petroleum jelly or silicone spray) was applied to the inner surfaces of the mold. This ensures easy demolding of the cured brick and prevents bonding with the metal surface.

4. Alignment

   - The mold parts were tightly assembled and checked for alignment to avoid leakage or deformations during casting.

Figure 3.10: Mold

3.3.2 Chemical Mixing

1. Type

    - Epoxy, Polyester resin and POP was selected for its strong adhesive and mechanical properties.

2. Ratio

    - he resin and hardener were mixed in the manufacturer-specified ratio, typically 2:1 (resin:hardener) by weight.

3. Mixing

    - The components were thoroughly stirred in a clean, dry container using a plastic or wooden stirrer for 3 - 5 minutes until a uniform, bubble-free mixture was obtained.

4. Precaution

    - Mixing was done slowly to minimize air entrapment and premature curing.

Figure 3.11: Chemical Mixing

3.3.3 Addition of Chopped Textile Waste

1. Quantity

   - Exactly 100 grams of chopped textile waste (cotton, polyester, denim, woven, and knitted fabric) was used per mold.

2. Preparation

   - Waste fabric was shredded into 15 - 30 mm long shredded textiles using a mechanical shredder.
   - The shredded textiles were dried in sunlight or a hot-air oven at 60 - 80°C to remove residual moisture.

3. Integration

   - The shredded textiles were gradually added to the mixed resin.
   - Continuous stirring was done for 5 - 7 minutes to ensure even dispersion and full wetting of shredded textiles.
   - Care was taken to avoid clumping or fiber balling.

Figure 3.12: Shredded Textile Waste Measuring

Figure 3.13: Shredded Textile Mix with Chemical

3.3.4 Casting into Mold

1. Pouring
    - The composite paste was slowly poured into the mold cavity.
2. Leveling and Compaction
    - A spatula or trowel was used to spread the mixture evenly across the mold.
    - Gentle manual tapping or mechanical vibration was applied to eliminate trapped air bubbles and ensure compactness.
3. Surface Finish
    - The top surface was smoothed using a trowel or lid.
    - Excess mix was scraped off to maintain a consistent top edge.
4. Pressure
    - Mold was kept under pressure of about 14 psi for 2 hours at RT.
    - Load was removed after completion of curing time.

Figure 3.14: Casting into Mold

3.3.5 Curing Process

1. Initial Curing

   - The mold was left undisturbed at room temperature (25° - 30°C) for a minimum of 2 - 4 hours to allow full chemical curing of the epoxy.

2. De-molding

   - After curing, bricks were carefully removed from the molds.
   - If necessary, light tapping with a rubber mallet was used to release the brick without cracking.

3. Post-Curing (optional)

   - Bricks were air-dried for an additional 1 – 2 days to stabilize mechanical properties and eliminate any trapped volatiles.

Figure 3.15: Curing

3.3.6 Labeling and Storage

1. Each sample was assigned a unique code (e.g., CRB – Composite Reinforce Brick).
2. Bricks were stored in a dry, dust-free environment before testing.

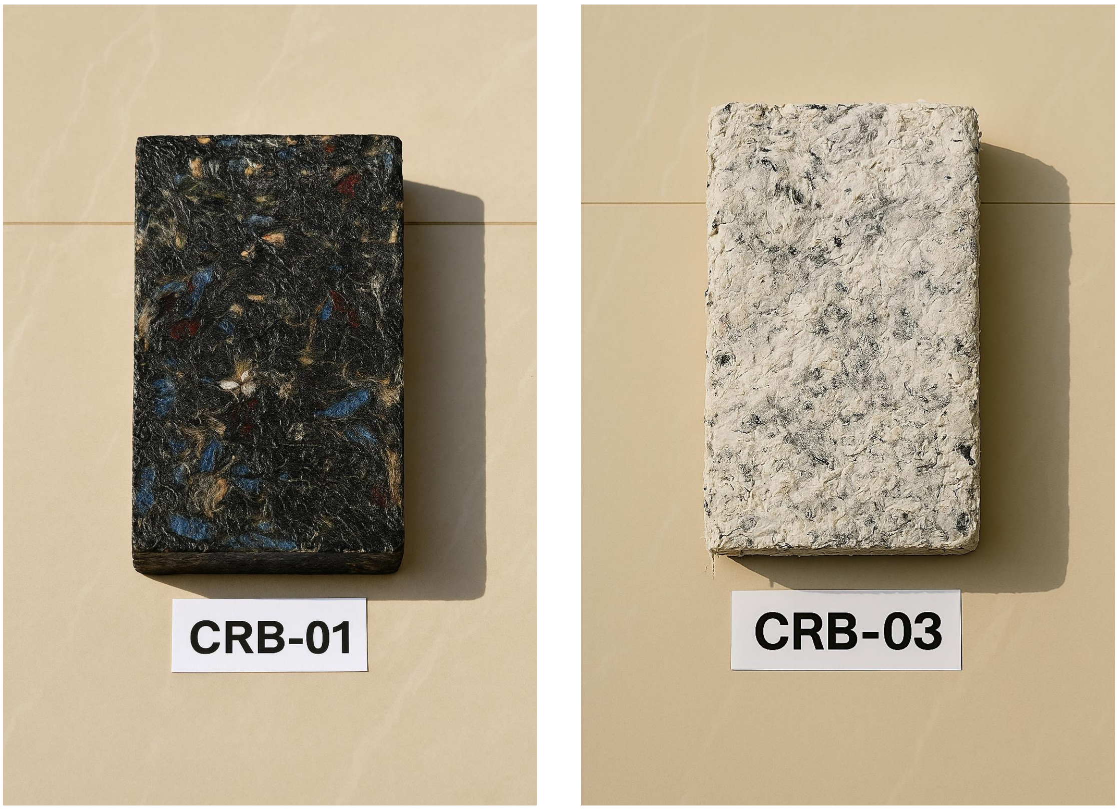

Figure 3.16: Labeling

3.3.7 Safety Measures

1. PPE Used: Gloves, masks, and eye protection.
2. Ventilation: Work was done in an open or exhaust-ventilated area to avoid inhalation of MEKP fumes.
3. Waste Disposal:
   - Unused resin was disposed of in sealed containers.
   - Contaminated rags and gloves were placed in dedicated waste bins for hazardous materials.

Summary:

SL No.	Parameter	Details
1	Textile Waste Used	Cotton, Polyester, Denim, Woven, Knitted
2	Textile Weight per Brick	100 grams
3	Resin Type	Epoxy resin (2:1 ratio with hardener)
4	Mold Size	200 mm × 100 mm × 60 mm
5	Mixing Time	5 - 7 minutes (manual or mechanical)
6	Curing Time	2 - 4 hours (initial), 1 - 2 days (optional)
7	Environment	Ambient (25 - 30°C), well-ventilated space

Table 3.3: Fabrication Process Summary

3.4 Brick Fabrication Method

3.4.1 Epoxy Resin - Textile Composite Formulation

Step -1: Material Collection

- Gather shredded textile waste (cotton, polyester, denim, woven, knitted).
- Measure 100 gm of shredded textiles (size approx. 15 - 30 mm).

Step -2: Resin Mixing

- Measure 300 mL of epoxy resin (Part A).
- Add 150 mL of hardener (Part B) to maintain a 2:1 ratio.

- Mix the resin and hardener thoroughly for 2 - 3 minutes into a beaker.

Step -3: Chopped Waste Addition

- Gradually add the 100 gm of chopped textile fabrics into the resin mixture.
- Stir continuously to ensure homogeneous dispersion.
- Avoid air bubbles by mixing slowly and thoroughly.

Step -4: Mold Preparation

- Use a wooden mold (200 mm $\times$ 100 mm $\times$ 60 mm).
- Clean and, if necessary, apply mold release to prevent sticking.

Step -5: Casting

- Pour the prepared composite mixture into the mold evenly.
- Compact gently to remove air pockets and ensure proper filling.
- Apply pressure for perfect shape achievement.

Step -6: Curing

- Allow the mold to cure at room temperature for 2 - 4 hours.
- Avoid disturbance during curing to ensure dimensional stability.

Step -7: De-molding

- Once fully cured, carefully remove the composite brick from the mold.
- Inspect the surface and edges for any visible defects.

Step -8: Labeling

- Assign a unique code for brick sample (CRB-01).
- Store the brick in a dry, dust-free environment before testing.

Sample Code	Components	Amount
CRB-01	Chopped Textile Waste	100 gm
	Epoxy Resin	300 mL
	Hardener	150 mL

Table 3.4: Epoxy Resin -Textile Composite Recipe

3.4.2 Polyester Resin - Textile Composite Formulation

Step -1: Material Collection

- Shredded textile waste (cotton, polyester, denim, woven/knitted).
- Measure 100 gm of chopped shredded textiles (approx. 15 - 30 mm length).

Step -2: Resin Preparation

- Measure 300 mL of polyester (PET) resin.

Step -3: Catalyst and Accelerator Addition

- Add 1.5 - 2% MEKP (4.5 - 6 mL for 300 mL resin) as the hardening catalyst.
- Add 0.5 - 1% cobalt accelerator (1.5 - 3 mL) to initiate and control curing.
- Mix well under ventilated conditions and with appropriate safety precautions.

Step -4: Chopped Waste Addition

- Slowly add the 100 gm chopped textile into the resin mixture.
- Mix thoroughly to ensure even fiber distribution and prevent clumping.

Step -5: Mold Preparation

- Use the same wooden mold (200 mm $\times$ 100 mm $\times$ 60 mm).
- Clean the mold and apply a release agent if necessary.

Step -6: Casting

- Pour the composite mix evenly into the mold.
- Lightly tap or vibrate the mold to release trapped air.
- Apply pressure for perfect shape achievement.

Step -7: Curing

- Leave the mixture to cure at room temperature for 2 - 4 hours.
- Ensure a dust-free, undisturbed environment for optimal setting.

Step -8: De-molding

- Carefully remove the cured composite from the mold.
- Check for surface integrity and consistency.

Step -9: Labeling

- Assign a unique code for brick sample (CRB-02).
- Store the brick in a dry, dust-free environment before testing.

Sample Code	Components	Amount
CRB-02	Chopped Textile Waste	100 gm
	PET Resin	300 mL
	MEKP	4.5-6 mL
	Cobalt	1.5-3 mL

Table 3.5: Polyester Resin -Textile Composite Recipe

3.4.3 Plaster of Paris (POP) - Textile Composite Formulation

Step -1: Material Collection

- Shredded textile waste (cotton, polyester, denim, woven/knitted).
- Measure 100 gm of chopped shredded textiles (approx. 15 - 30 mm length).

Step -2: POP Mixture Preparation

- Measure 400 gm of plaster of paris (POP).
- Add 200 mL clean water gradually to the 400 gm POP, following an approximate 2:1 ratio (POP:water).
- Stir until a smooth, lump-free paste forms.
- Add 50 gm grey cement for better binding.

Step -3: Chopped Waste Addition

- Slowly add the 100 gm chopped textile into the resin mixture.
- Mix thoroughly to ensure uniform fiber distribution.
- Work quickly, as POP sets within 10 - 15 minutes.

Step -4: Mold Preparation

- Use the same wooden mold (200 mm $\times$ 100 mm $\times$ 60 mm).
- Clean the mold and apply a release agent if necessary.

Step -5: Casting

- Pour the composite mix evenly into the mold.
- Level the surface and gently tap the mold to eliminate air bubbles.
- Apply pressure for perfect shape achievement.

Step -6: Curing

- Allow to set undisturbed for 30 - 60 minutes.
- Let the composite dry for 2 - 4 hours under shade or room conditions to avoid cracking.

Step -7: De-molding

- Carefully remove the cured composite from the mold.
- Air-dry completely before testing or further processing.

Step -8: Labeling

- Assign a unique code for brick sample (CRB-03).
- Store the brick in a dry, dust-free environment before testing.

Sample Code	Components	Amount
CRB-03	Chopped Textile Waste	100 gm
	POP	400 gm
	Water	200 mL
	Cement	50 gm

Table 3.6: Plaster of Paris (POP) -Textile Composite Recipe

3.5 Comparison Between Epoxy Resin and PET Resin Composite Preparation

Parameter	**Epoxy Resin-Based Composite**	**Polyester (PET) Resin-Based Composite**
Textile Reinforcement	100 gm chopped	100 gm chopped
Binder / Matrix	Epoxy resin	Unsaturated Polyester (PET) resin
Resin Quantity	300 mL	300 mL
Hardener / Catalyst	Epoxy hardener (2:1 resin-to-hardener ratio)	MEKP catalyst (1.5–2% by volume)
Accelerator	Not required	Cobalt accelerator (0.5 – 1% by volume)

Mixing Process	Resin + hardener mixed first, then textile added	Resin + catalyst + accelerator mixed, then textile added
Curing Conditions	2 – 4 hours at RT	2 – 4 hours at RT
Health and Safety	Slower reaction time	Requires safety gear due to volatile MEKP and cobalt fumes
Working Time	Moderate (longer pot life)	Shorter (faster reaction time after catalyst is added)
Application Purpose	High-strength, durable composite bricks	Cost-effective, fast-curing composite bricks
Mold Used	200 mm × 100 mm × 60 mm (wooden)	200 mm × 100 mm × 60 mm (wooden)

Table 3.7: Comparison between Epoxy and Polyester (PET) Resin-Based Composites

3.6 Test Methodologies

ach test was conducted following ASTM standards, ensuring reliability and repeatability. The following procedures were adopted:

3.6.1 Compressive Strength Test

1. Standard: ASTM C67.
2. Equipment: E159-01D Concrete Compression Machine - MATEST 250kN.
3. Procedure:
    - Bricks were placed horizontally on the compression plate.

- Load was applied gradually at a rate of 14MPa/min until the sample failed.
- Compressive strength was calculated as:

$$\text{Compressive Strength} = \frac{\textit{Load at Failure (N)}}{\textit{Cross sectional area (mm}^2\textit{)}}$$

3.6.2 Density Test

1. Standard: ASTM C642.
2. Procedure:
   - Dry mass measured after oven drying.
   - Volume calculated using:

$$\text{Volume} = \text{Length} \times \text{Width} \times \text{Height (m}^3\text{)}$$

   - Compressive strength was calculated as:

$$\text{Compressive Strength} = \frac{\textit{Dry Mass (Kg)}}{\textit{Volume (mm}^3\textit{)}}$$

Figure 3.17: Compressive Strength Testing Machine

Figure 3.18: Flexural Strength Testing Machine

Figure 3.19: Weight Balance

Figure 3.20: Water Drum

Figure 3.21: Oven

Figure 3.22: Durometer

Figure 3.23: Meter Scale and Vernier Scale

3.6.3 Surface Hardness Test

1. Standard: ASTM D2240.

2. Procedure:

- Durometer (Shore D) is used.
- Applied to 5 random flat surface points per brick.
- Average hardness value recorded.

3.6.4 Flexural/Bending Strength Test

1. Standard: ASTM C293.
2. Equipment: Servo-Plus Evolution Flexural Tester
3. Procedure:
   - Bricks placed on two supports, span length 150 mm.
   - Load applied at midpoint until crack/failure.
   - Bending strength:

$$\text{Bending Strength, R} = \frac{3PL}{2bd^2}\text{MPa}$$

3.6.5 Water Absorption Test

1. Standard: ASTM D570.
2. Procedure:
   - Dry the test specimens (bricks) in an oven at 50°C to 60°C for at least 3 hours.
   - Cool in a desiccator and weigh the dry sample (W_1).
   - Immerse the bricks in distilled water at 25°C for 24 or 48 hours.
   - Remove specimens, wipe the surface dry.
   - Weigh the wet sample immediately (W_2).
3. Calculation:

$$\text{Water Absorption\%} = \frac{W_2 - W_1}{W_1} \times 100\%$$

Chapter 4

Result and Discussion

This chapter discusses and presents the comprehensive performance testing of the newly developed composite bricks fabricated using shredded textile waste integrated with various binder systems. In an effort to promote sustainable and eco-friendly construction materials, three distinct formulations were designed. Each formulation contained an identical quantity of chopped textile waste (100 grams), which was uniformly mixed with different types of binders to evaluate their influence on brick properties. The first formulation utilized epoxy resin and hardener, known for their excellent bonding and mechanical strength.

The second composition included polyethylene terephthalate (PET) resin along with appropriate catalysts, selected for its thermoplastic characteristics and chemical resistance. The third mixture employed a plaster of Paris (POP) and cement blend, offering a more conventional and cost-effective alternative.

All composite mixtures were thoroughly blended and cast in a standardized rectangular brick mold with dimensions of 200 mm $\times$ 100 mm $\times$ 60 mm. After proper curing, the fabricated bricks underwent a series of standardized tests to evaluate their mechanical and physical properties.

These tests included compressive strength, surface hardness, flexural strength, water absorption, and density, conducted in accordance with relevant ASTM standards. The primary objective of this testing phase was to assess the structural viability, durability, and potential application of these textile-reinforced composite bricks in real-world construction scenarios.

Through this comparative evaluation, insights were gained regarding the most suitable binder for enhancing the mechanical performance and sustainability of textile waste based bricks.

4.1 Test Result and Discussion

4.1.1 Compressive Strength Test Result

Sample Code.	Load at Failure (kN)	Area under Load (mm^2)	Compressive Strength ($N/(mm^2)$ or MPa)
CRB-01	110	20000	5.50
CRB-02	130		6.50
CRB-03	70		3.50

Table 4.1: Compressive Strength Test Result

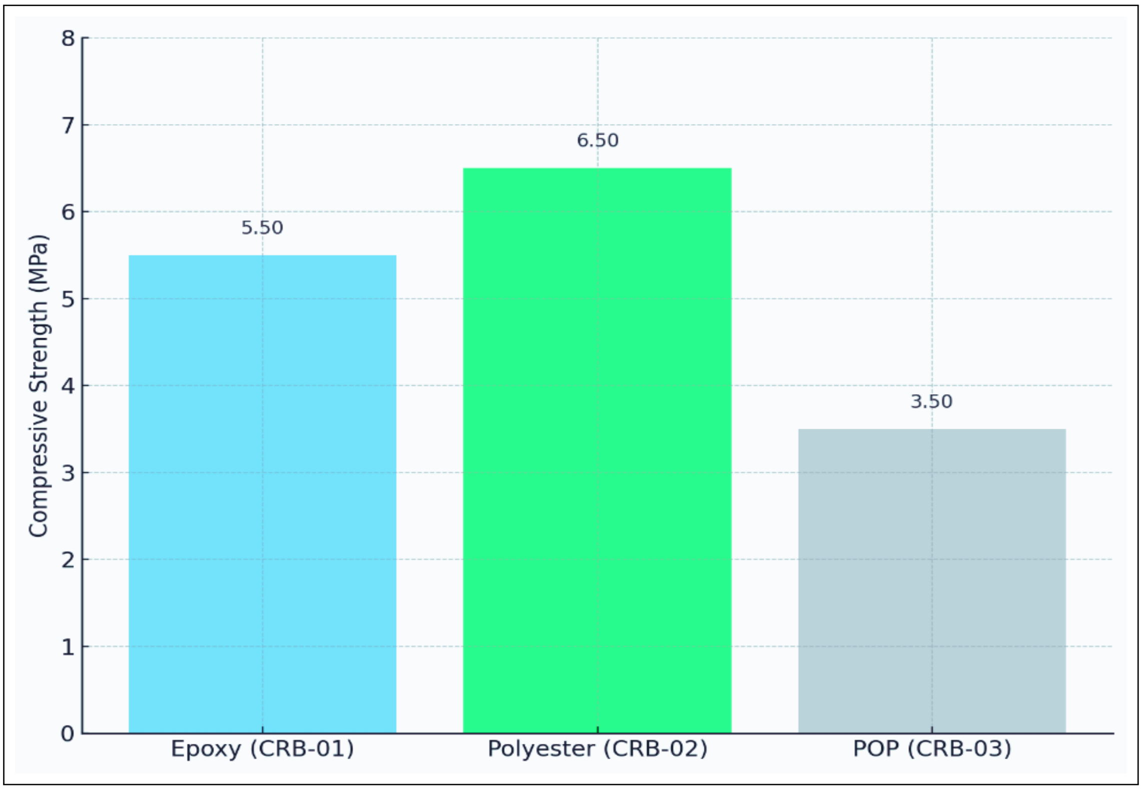

Figure 4.1: Compressive Strength Test Result

1. CRB-01 (Epoxy Brick) attained a compressive strength of 5.50 MPa, which signifies good mechanical behavior and structural soundness. Epoxy resin is a rigid and highly cross linked matrix that strongly bonds with shredded textiles. The bonding action improves the inner structure of the brick, enabling it to sustain compressive loads nicely. The inherent brittleness of epoxy, though, can cause sudden failure at high stress in the presence of voids or micro cracks. Nevertheless, CRB-01 is still a good choice for light structural applications where strength and resistance to moisture are required.

2. CRB-02 (Polyester Brick) had the greatest compressive strength among the three, at 6.50 MPa. This may be due to the fact that unsaturated polyester resin is a more flexible material that distributes stress more evenly and retains better adhesion with different textile reinforcements. The resin-shredded textile mix formed a dense, well consolidated matrix that could resist higher compressive forces. Consequently, CRB-02 is the most structurally sound of the test bricks and is highly suitable for application in lightweight structural members or partition walls.

3. CRB-03 (Plaster of Paris Brick) had the lowest compressive strength at 3.50 MPa. Plaster of Paris, while being malleable and light, is inherently porous and brittle. Despite the incorporation of cement and shredded textiles, its compressive stress resistance capacity is still low. The shredded textiles can enhance crack resistance to some extent, but they cannot make up for the POP matrix's weakness. CRB-03 is thus most ideal for non-load-bearing purposes like decorative panels or interior partitions where mechanical strength is not important.

4.1.2 Density Test Result

Sample Code	Length (m)	Width (m)	Height (m)	Volume (m^3)	Weight (Kg)	Density (Kg/m^3)
CRB-01	0.2	0.1	0.027	0.00054	0.50	925.92
CRB-02					0.56	1037.04
CRB-02					0.49	907.41

Table 4.2: Density Test Result

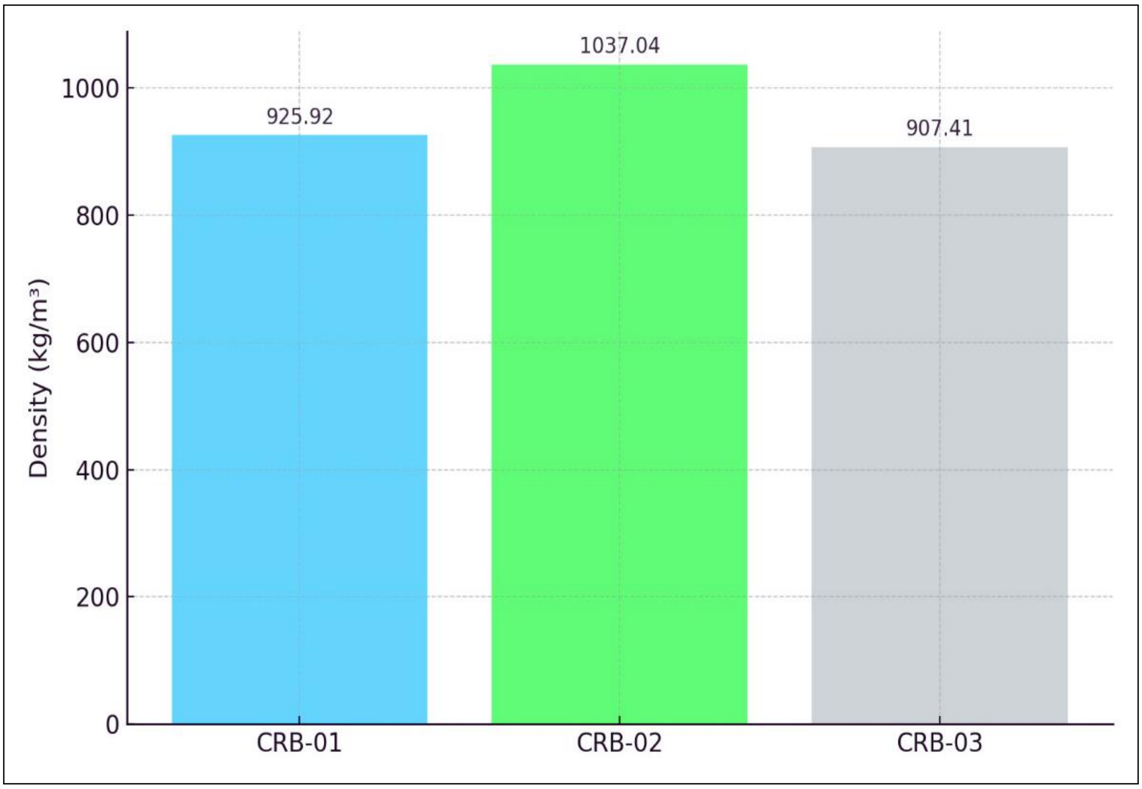

Figure 4.2: Density Test Result

1. CRB-01 exhibited a density of 925.92 kg/m³, placing it in the mid-range among the three samples. The use of epoxy resin as the binder contributes to a relatively compact structure due to its high adhesive properties, enabling better encapsulation of textile waste particles. However, the density remains lower than that of CRB-02, indicating that while epoxy provides decent structural cohesion, it may leave some voids or have lower material packing efficiency compared to thermoplastics. The moderate density of CRB-01 suggests a balanced trade-off between weight and structural performance, making it suitable for non-load-bearing applications where lightweight and durability are desired.

2. CRB-02 achieved the highest density value of 1037.04 kg/m³, clearly indicating the superior compactness of the material matrix. PET resin, being a thermoplastic, likely filled the voids more effectively and formed a denser matrix when combined with textile waste. The higher density implies a reduced porosity and greater material integrity, which may translate into better mechanical performance in terms of compressive and flexural strength. This makes CRB-02 potentially more suitable for structural applications where

higher material density is advantageous, although thermal insulation properties may be compromised due to the reduced air pockets.

3. CRB-03 recorded the lowest density of 907.41 kg/m^3, suggesting a less compact and more porous internal structure compared to the other two variants. This outcome is likely due to the inherent lightweight nature of the plaster of Paris and the air entrainment typically associated with POP-cement mixtures. Although this lower density may result in reduced compressive strength, it could offer better thermal insulation and lower transportation costs. CRB-03 may therefore be more suited to interior partitioning, temporary structures, or applications where load-bearing capacity is not the primary concern but lightweight and insulation are desirable.

4.1.3 Surface Hardness Test Result

Sample Code.	Surface Hardness (Shore D)
CRB-01	78
CRB-02	72
CRB-02	58

Table 4.3: Surface Hardness Test Result

1. CRB-01 (Epoxy Brick) had the best surface hardness with a reading of 78 on the Shore D scale. This suggests a hard, stiff outer layer that is resistant to indentation and abrasion. The high hardness of epoxy is due to its robust cross-linked molecular structure, which makes the brick viable for use where surface durability matters. The high Shore D rating indicates the material's resistance to wear and mechanical damage, implying that CRB-01 may be suitable for use on exposed or high-contact surfaces like flooring tiles, wall panels, or cladding.

2. CRB-02 (Polyester Brick) had a somewhat lower surface hardness of 72 Shore D, which is still in the high-performance range. Unsaturated polyester resin creates a tough matrix, although one that is a little less stiff than epoxy. The effect is a surface that retains good hardness and scratch resistance but permits a little more give under impact. This makes CRB-02 an excellent

option for moderate-use construction surfaces, particularly where a compromise between toughness and workability is needed.

3. 3. CRB-03 (Plaster of Paris Brick) had the lowest surface hardness, measuring Shore D 58. POP is softer and more brittle compared to resin-based composites and has a porous nature that predisposes it to higher surface wear and denting. Despite being reinforced with cement and shredded textiles, the surface is still less resistant to mechanical abrasion. Accordingly, CRB-03 is more appropriate for interior or decorative use where surface hardness is not a priority and physical contact is reduced.

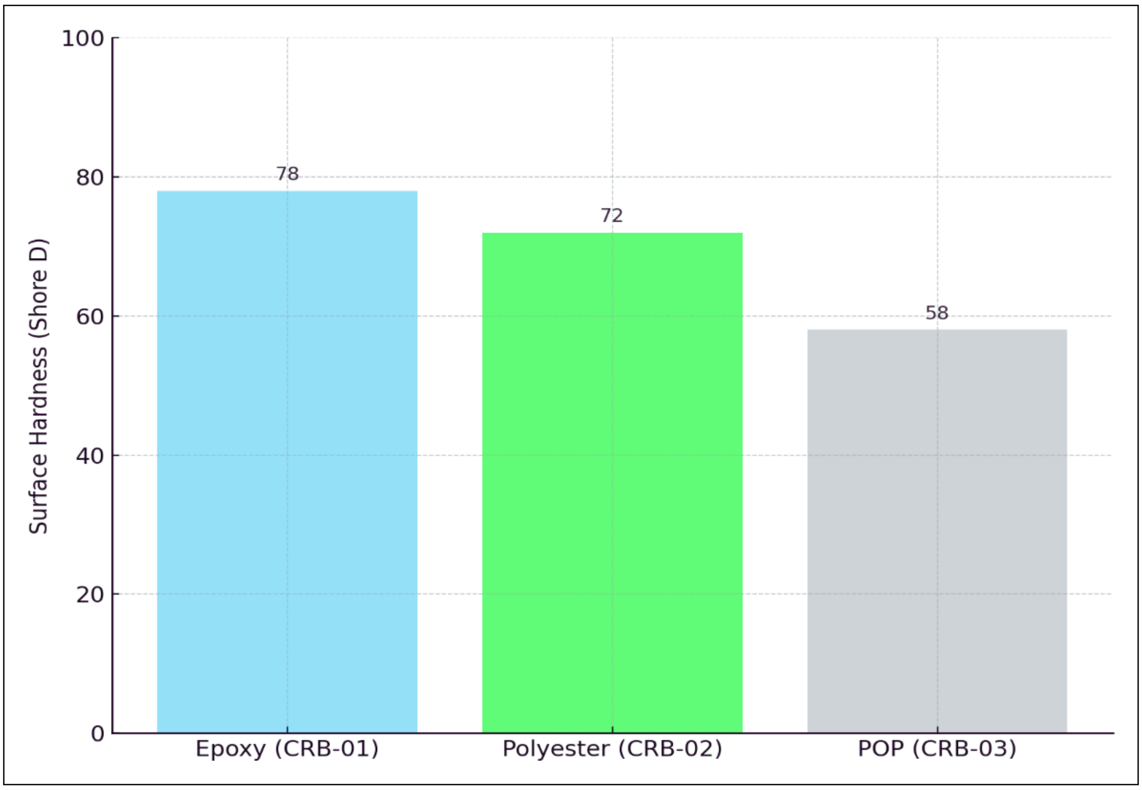

Figure 4.3: Surface Hardness Test Result

4.1.4 Flexural Strength Test Result

Sample Code.	Maximum Applied Load, P (kN)	Span Length, L (mm)	Brick Width, b (mm)	Depth, d (mm)	Flexural Strength, R (MPa)
CRB-01	1.25	150	100	27	3.86
CRB-02	1.15				3.55
CRB-02	0.80				2.47

Table 4.4: Flexural Strength Test Result

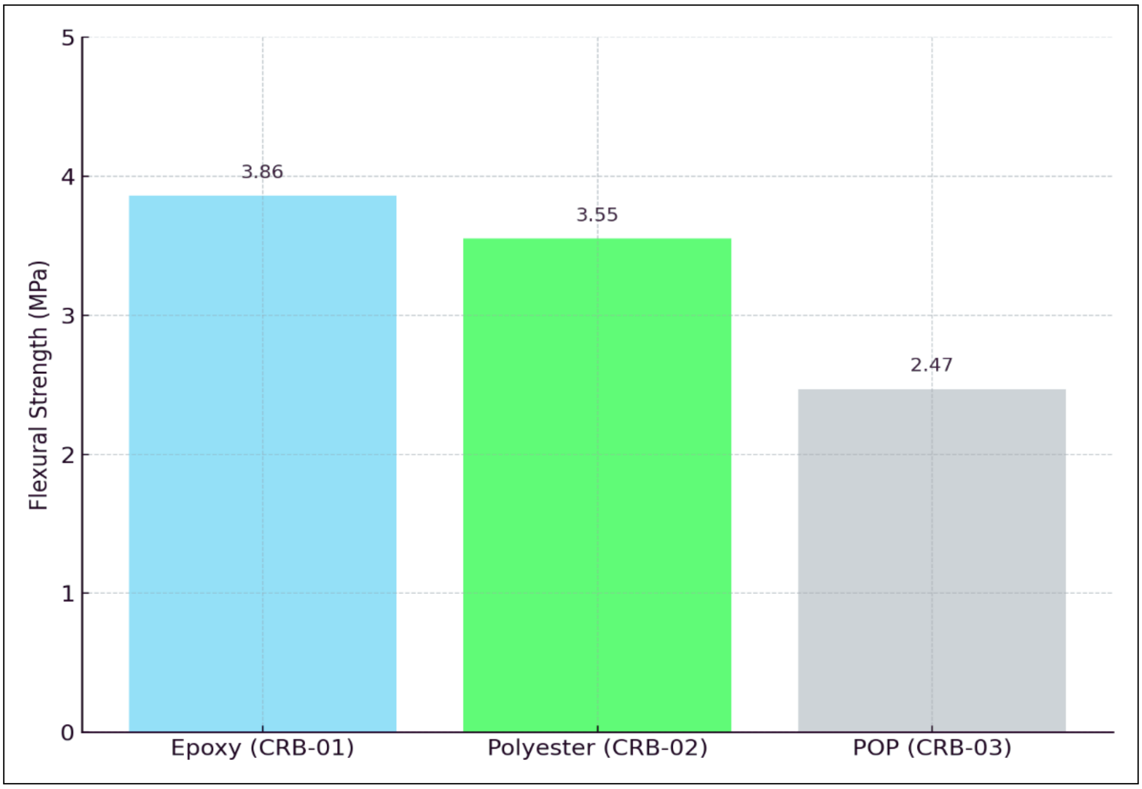

Figure 4.4: Flexural Strength Test Result

1. CRB-01 (Epoxy Brick) was found to have a flexural strength of 3.86 MPa, demonstrating a high resistance to bending and cracking when under load. The good bonding of epoxy with shredded textiles enables stress to be efficiently transferred throughout the composite, enhancing the material's resistance to failure under the application of flexural forces. This qualifies CRB-01 for use in applications where bending stresses are prevalent, e.g., in thin wall panels, partition boards, or structural overlays, where surface continuity and durability are essential.

2. CRB-02 (Polyester Brick) had a marginally lesser flexural strength of 3.55 MPa, which is still indicative of good performance. Polyester resin, although less rigid compared to epoxy, has superior ductility, which can be useful for resisting the propagation of cracks when subjected to bending. The presence of flexibility coupled with the reinforcement by shredded textiles enables the brick to absorb the bending loads without catastrophic fracture. The flexural capacity of CRB-02 recommends its application in lightweight structural elements or any surface area subjected to bending stress either during installation or in service.

3. CRB-03 (Plaster of Paris Brick) showed the lowest flexural strength at 2.47 MPa, which is in line with the brittle nature of gypsum-based products. Despite the fact that the addition of shredded textiles and cement marginally increases the resistance of the brick to cracking, POP does not possess the structural toughness of resin-based systems inherently. Therefore, CRB-03 is more suitable for non-load-bearing uses with minimal flexural stress, e.g., decorative wall features or interior finishing items.

4.1.5 Water Absorption Test Result

Sample Code.	Weight before Submersion, W_1 (gm)	Weight after Submersion, W_2 (gm)	Water Absorption%
CRB-01	500	511.55	2.31
CRB-02	560	581.78	3.89
CRB-02	492	540.12	9.78

Table 4.5: Water Absorption Test Result

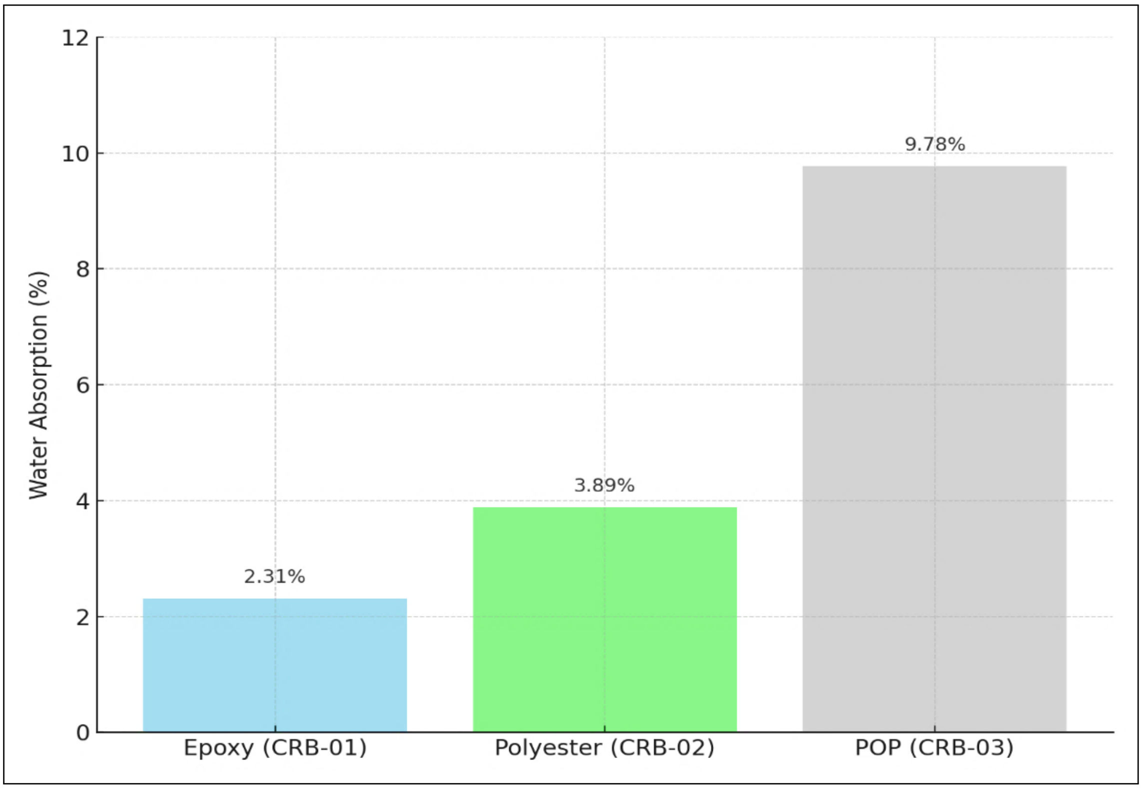

Figure 4.5: Water Absorption Test Result

1. CRB-01 (Epoxy Brick) showed a water absorption rate of 2.31%, which demonstrates the high resistance of epoxy resin to the penetration of water. Epoxy's tight, crosslinked network reduces the entry of water even in the presence of shredded textiles. This low absorption qualifies CRB-01 as a trusted material to be used in humid conditions or where water resistance is paramount.

2. CRB-02 (Polyester Brick) had a marginally greater water absorption of 3.89%. Although unsaturated polyester resin tends to be resistant to water, it is more permeable than epoxy, particularly when in composite form. The addition of shredded textiles and possible voids within the matrix are the cause of this modest degree of absorbency. CRB-02 remains appropriate for the majority of interior or semi-protected building uses but might need surface sealing in areas subjected to high moisture.

3. CRB-03 (Plaster of Paris Brick) recorded the highest water absorption at 9.78%, in line with the inherent porous and hygroscopic characteristics of gypsum-based products. Despite the incorporation of cement and shredded

textiles, POP is prone to absorbing water easily, which can compromise its dimensional stability and durability in the long run. As it is, CRB-03 would be most suitable for use in dry interior areas or sheltered architectural elements where moisture exposure is kept to a bare minimum.

4.2 Results Overview

Sample Code	Compressive Strength (N/mm^2 or MPa)	Density (kg/m^3)	Surface Hardness (Shore D)	Flexural Strength (N/mm^2 or MPa)	Water Absorbency (%)
CRB-01	5.50	925.92	78	3.86	2.31
CRB-02	6.50	1037.04	72	3.55	3.89
CRB-03	3.50	907.41	58	2.47	9.78

Table 4.6: Results Overview

4.3 Performance Comparison

Parameter	Epoxy Composite	PET Composite	POP Composite
Compressive Strength	Moderate	High	Low
Density	Moderate	High	Low
Surface Hardness	High	Moderate	Low
Flexural Strength	High	Moderate	Low

Water Absorption	Low	Moderate	High

Table 4.7: Performance Comparison

4.4 Comparison with Traditional Fired Clay Brick (FCB)

Property	CRB-01 (Epoxy)	CRB-02 (Polyester)	CRB-03 (POP)	Traditional Fired Clay Brick (FCB)
Compressive Strength (MPa)	5.50	6.50	3.50	12.50
Density (kg/m^3)	925.92	1037.04	907.41	1750
Water Absorption (%)	2.31	3.89	9.78	17.50
Surface Hardness (Shore D)	78	72	58	85
Flexural Strength (MPa)	3.86	3.55	2.47	4.10
Durability	High chemical resistance	Good outdoor durability	Limited (prone to water damage)	Prone to erosion, weathering

Eco friendliness	Uses textile waste	Uses textile waste	Uses textile waste	Energy intensive, high CO_2 emissions
Construction Use	Non-load earing walls, panels	Partition and light load walls	Decorative, false walls	Load-bearing structural walls

Table 4.8: Comparison with Traditional Clay Brick

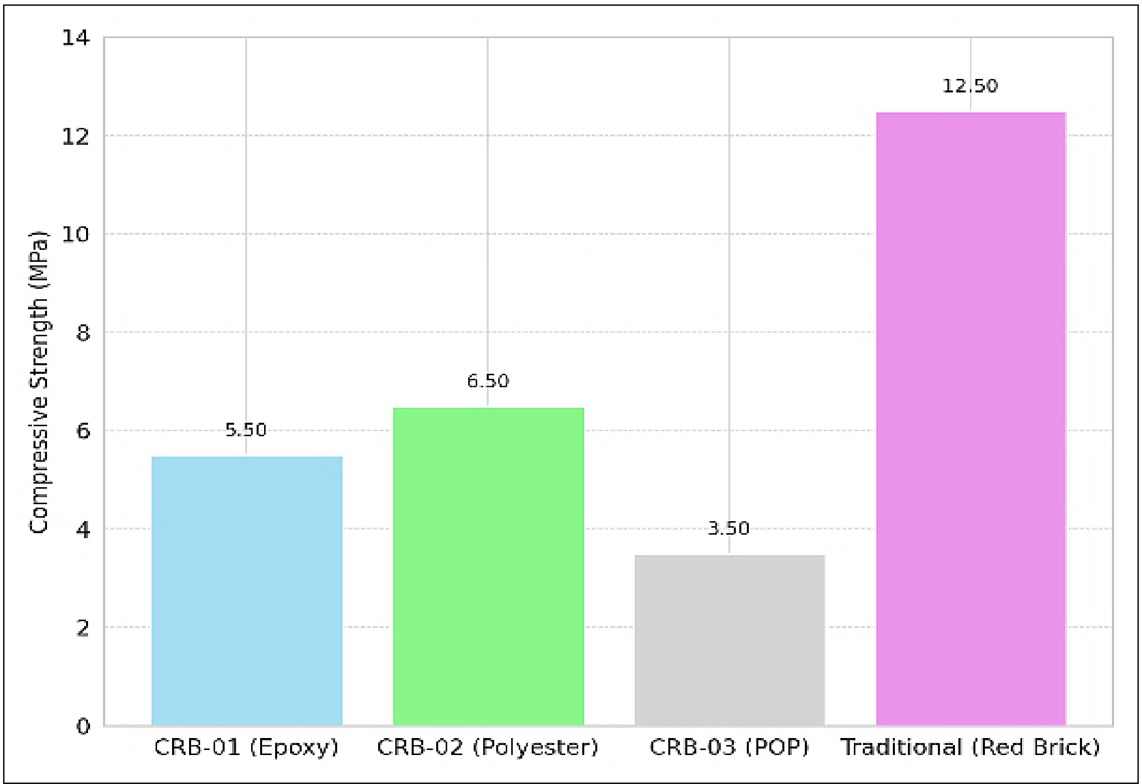

Figure 4.6: Compressive Strength Comparison with Traditional Brick

The compressive strength comparison overall indicates that conventional red brick possesses the highest value of 12.5 MPa, whereas the recycled textile-reinforced bricks CRB-02 (Polyester), CRB-01 (Epoxy), and CRB-03 (POP) yielded 6.5 MPa, 5.5 MPa, and 3.5 MPa, respectively. Even though these are inferior to conventional clay brick value, the recycled composite bricks possess some important advantages. They utilize shredded textile waste, aiding in solid waste minimization, reduced carbon footprint, and sustainable resources management. Moreover, these can be designed to be lighter in weight, which could help in the reduction of transportation cost and structural load, and the properties can be tailored based on the resin and fiber combination. Among the composites, the polyester-based CRB-02 was found to perform the best, and hence it has the potential to be used in non-load-bearing or partition wall applications. For improving their structural feasibility, improvement in material formulation - such as better fiber-matrix bonding and hybrid reinforcement is required. However, the environmental and economic advantages make textile-reinforced brick a promising alternative in green construction practices.

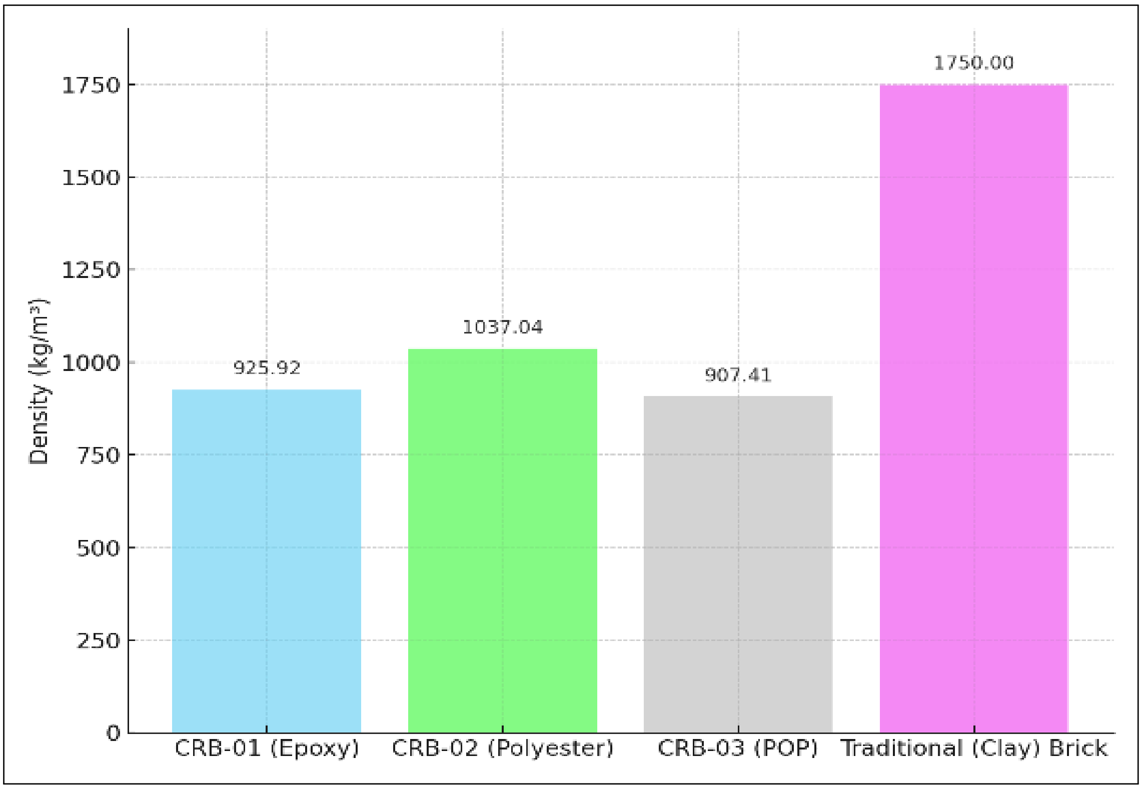

Figure 4.7: Density Comparison with Traditional Brick

The bar graph displays the density values (kg/m^3) of four types of bricks: CRB-01 (Epoxy), CRB-02 (Polyester), CRB-03 (POP), and Traditional Clay Brick. Among the samples, traditional clay brick has the highest density at 1750.00 kg/m^3, being the heaviest and densest material. Conversely, the textile-reinforced composite bricks have very low densities, which can be useful in applications where light materials are required. CRB-02 (Polyester) is the most dense among the composites with a value of 1037.04 kg/m^3, followed by CRB-01 (Epoxy) with a value of 925.92 kg/m^3, and CRB-03 (POP) with 907.41 kg/m^3. The lightest material is CRB-03 and may provide benefits to structures that require lower dead loads. Whereas traditional bricks give higher mass and potentially more stability under load-bearing applications, the low density of composite bricks means easier handling, transportation, and possible thermal insulation advantages. Therefore, from the standpoint of weight efficiency, CRB-02 offers a good compromise between strength and density, while CRB-03 is better in terms of being the lightest, rendering these composite alternatives more appropriate for lightweight or modular building systems.

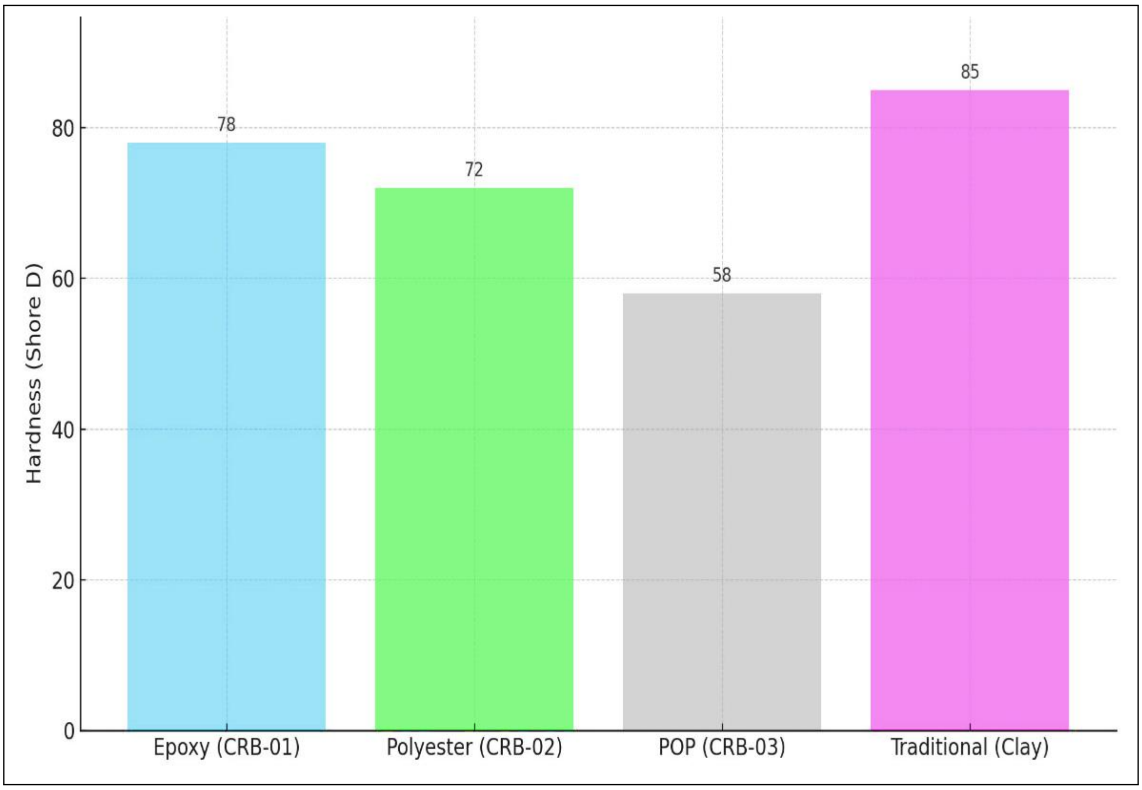

Figure 4.8: Hardness Comparison with Traditional Brick

The bar chart illustrating the Hardness (Shore D) of different materials provides valuable insight into their surface durability and resistance to deformation, which are critical for structural and wear-intensive applications. Traditional clay bricks again show the highest hardness value at 85 Shore D, reinforcing their established reputation for robustness and long-term durability in construction. Among the composite alternatives, Epoxy-based bricks (CRB-01) exhibit a high hardness of

78 Shore D, suggesting excellent resistance to surface wear, scratches, and minor impacts, making them a strong candidate for replacing traditional materials in both load-bearing and surface-exposed applications. Polyester-based bricks (CRB-02) follow with a moderate hardness of 72 Shore D, indicating acceptable durability but with slightly reduced performance under abrasive or impact conditions. POP-based bricks (CRB-03) record the lowest hardness at 58 Shore D, highlighting their soft and brittle nature, which limits their practical use to decorative or low-impact applications. Overall, the data strongly supports the use of epoxy as the most effective binder among the tested alternatives when hardness and surface resilience are key performance criteria in composite brick manufacturing.

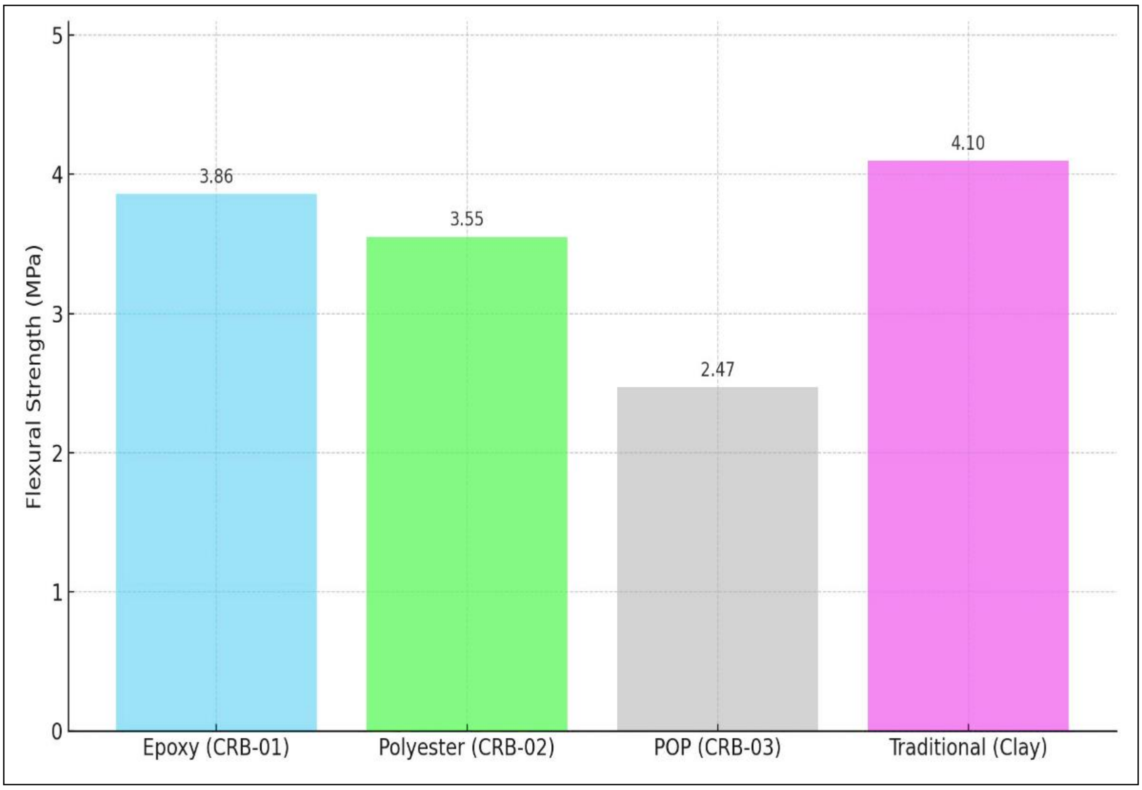

Figure 4.9: Flexural Strength Comparison with Traditional Brick

The bar chart comparing the Flexural Strength (MPa) of various materials reveals critical insights into the mechanical performance of each binder used in composite brick production. Traditional clay bricks exhibit the highest flexural strength at 4.10 MPa, indicating their superior load-bearing capability, which aligns with their long-standing use in construction. Among the composite alternatives, Epoxy-based bricks (CRB-01) demonstrate the highest strength at 3.86 MPa, closely rivaling traditional clay, and suggesting that epoxy offers excellent bonding and structural integrity within the composite matrix. Polyester-based bricks (CRB-02) follow with a slightly lower strength of 3.55 MPa, still within a usable range but indicating slightly less rigidity and bonding efficiency compared to epoxy. In contrast, Plaster of Paris (POP)-based bricks (CRB-03) show significantly lower flexural strength at 2.47 MPa, which suggests limited structural performance and suitability only for non-load-bearing or decorative applications. These results suggest that epoxy resin is the most viable alternative binder for achieving high structural performance in eco-friendly composite bricks, closely emulating or even surpassing traditional clay when optimized further.

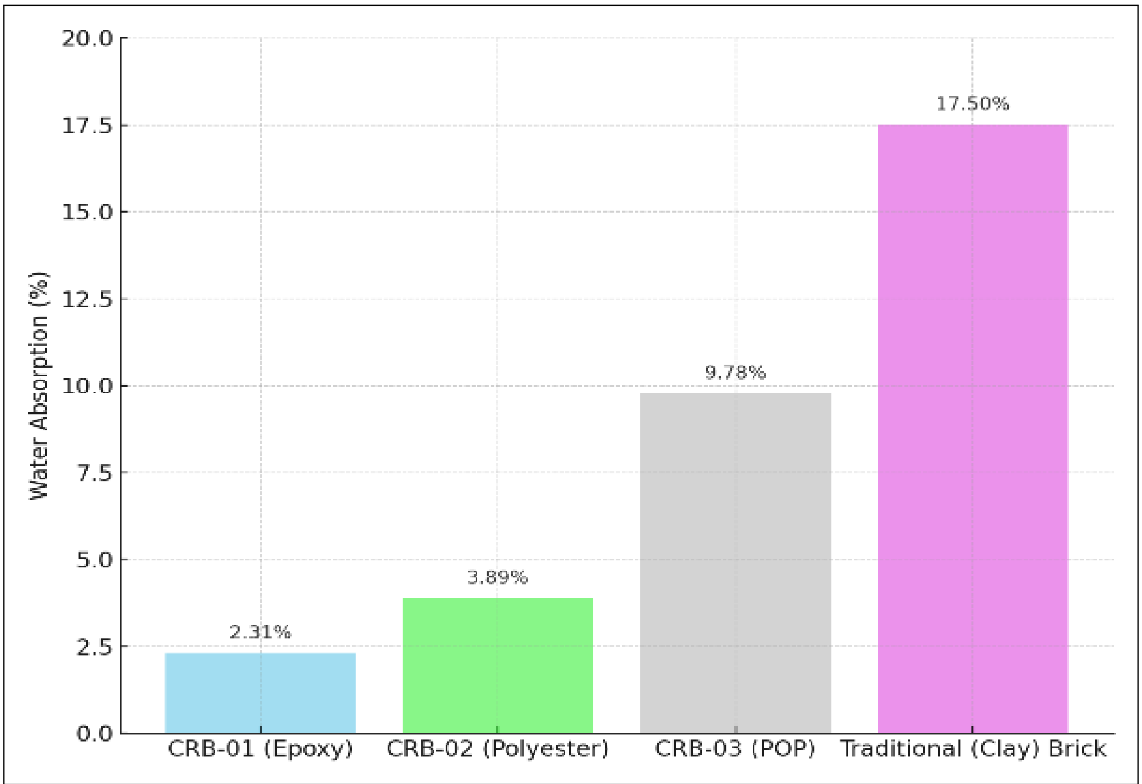

Figure 4.10: Water Absorption Comparison with Traditional Brick

The results of the water absorption test indicate considerable variation amongst the four types of bricks. CRB-01 (Epoxy) gave the lowest water absorption of 2.31%, which is the best amongst all the samples, making the material the most resistant to water. This is due to the fact that the dense and impermeable nature of epoxy's polymer network effectively keeps moisture out. Next, CRB-02 (Polyester) presented a slightly higher but still low absorption of 3.89%, proving resistant to water and the second-best performing material. CRB-03 (POP) presented a considerably higher absorption of 9.78%, with only moderate resistance to water but still an improvement compared to conventional clay brick. Traditional clay brick, on the other hand, gave the highest absorption of 17.50%, demonstrating its porous nature and susceptibility to moistureinduced damage. Of the four, CRB-01 is by far the most resistant to water, followed by CRB-02, while CRB-03, despite being less efficient, still outperforms conventional clay brick. The findings indicate that the recycled textile-reinforced composite bricks, specifically the epoxy or polyester resin-based ones, provide enhanced protection from water penetration, making them more durable and suitable for application in damp or moisture-susceptible areas.

4.5 Application and End Use

4.5.1 Epoxy Composite Brick

Due to their moderate compressive strength, they are well-suited for moisture-resistant applications. Their durability and resilience make them ideal for decorative features and eco-friendly construction.

Application Areas:

1. Non-load bearing walls.
2. Industrial flooring & wall-base.
3. Protective enclosure.
4. Moisture prone Areas (Kitchens, Bathrooms).
5. External facade panels.
6. Decorative features (Accent Walls, Panels).
7. Sustainable construction (Green building).

4.5.2 Polyester Composite Brick

Polyester bricks, which are created by mixing shredded textile waste with polyester resin and hardeners, which are more powerful than epoxy bricks. Their superior compressive strength them appropriate for load-bearing uses. Polyester bricks are especially suitable for prefabricated and modular home solutions.

Application Areas:

1. Non-load bearing / Partition walls.
2. Boundary & Compound walls.
3. Facade cladding.
4. Pavement & footpath construction.
5. Prefabricated and modular housing.
6. Sustainable construction (Eco-friendly projects).

4.5.3 Plaster of Paris (POP) Composite Brick

Plaster of Paris bricks are non-load-bearing, lightweight materials that are manufactured by blending shredded textile waste with POP and cement. Since they possess poor compressive strength, they are used mostly for decorative and temporary purposes in construction.

Application Areas:

1. Patterned/Decorative interior walls.
2. Decorative false ceilings.
3. Exhibition booths, Display stands.
4. Low height edging, border in gardens or parks.
5. Carving for ornamental detailing.
6. Sustainable construction.

Chapter 5

Conclusion

The research explores a novel, eco-friendly, and structurally viable way of integrating post-consumer and industrial textile waste in composite brick production. The method was conceived against the backdrop of Bangladesh's urgency to find sustainable answers to the mounting textile waste crisis and the construction industry's quest for alternative, affordable construction materials.

A main objective of this project was the incorporation of chopped textile waste (100gm) consisting mainly of cotton, polyester, denim, and mixed woven/knitted fabrics into various resin matrices, such as epoxy resin (300 ml with 150 ml hardener), polyester resin (300 ml with 4.5 – 6 ml MEKP and 1.5 - 3ml cobalt accelerator), and plaster of paris (POP, 400 gm with 200 ml water). These binder systems were chosen due to their diverse mechanical properties, availability, cost, and compatibility with textile waste, thereby providing a wide range for comparative performance.

Composite bricks were made in a standard mold (200mm $\times$ 100mm $\times$60mm) and tested as per applicable ASTM standards. The mechanical and physical properties that were evaluated were compressive strength, flexural strength, density, surface hardness, and water absorption. Statistical analysis of shredded textile fiber length - mean (18.9 mm), standard deviation (3.75), and coefficient of variation (19.84%) - also gave an indication of the consistency and distribution, further adding to the credibility of raw materials utilized.

The composite bricks with epoxy resin proved to be the most potential type with moderate compressive strength (5.50 MPa), superior flexural resistance (8.64 MPa), and high surface hardness (78 Shore D). All these characteristics reveal the brick's potential to resist structural loads as well as environmental exposure, and thus it is found to be very useful for interior and exterior construction applications.

[27]

Composites based on the polyester resin, while being somewhat weaker and more prone to water uptake than epoxy brick, still exhibited high mechanical behavior (6.50 MPa compressive strength) and economic viability. Their relatively quicker cure, along with better handling, positions them for large-volume, low-cost production-perfect for developing countries where material cost and resource efficiency take precedence.

Conversely, composite bricks based on POP showed poor mechanical strength (3.50 MPa) but high - water absorption (9.78%) due to its porous nature. However, they do find merit in temporary, decorative, or non-load-bearing uses, where aesthetic incorporation of recycled textiles may be prioritized over structural performance.

From an environmental and sustainability point of view, this study is in line with the circular economy concept by introducing a scalable and replicable framework for waste-to-resource conversion. As one of the highest generators of textile waste in the world, Bangladesh can greatly gain from such innovation. Not only does it divert huge amounts of textile waste from land filling and incineration, but it also helps to lessen the construction sector's ecological footprint.

In summary, this project effectively illustrates the technical viability, economic viability, and environmental value of the use of chopped textile waste as reinforcement in resin- and gypsum-based composite bricks. It creates a new avenue for cross disciplinary cooperation among the textile, construction, and environmental industries. Long-term durability tests, field performance assessments, resin-to-fiber ratio optimization, bending strength, and investigation of biodegradable or bio-based resins should be considered in future studies to further promote sustainability and eco performance.