

Exploring the Potential of Eco-Polymer Reinforced Bricks (EPR-Bricks) as Sustainable Construction Materials



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Abstract: The growing issue of plastic waste, surpassing 350 million metric tons annually, presents a significant environmental challenge, with only a small fraction being recycled. This research examines Eco-Polymer Reinforced Bricks (EPR Bricks) as an innovative approach to addressing this crisis by repurposing non-biodegradable plastic waste into durable and sustainable construction materials. The study focuses on incorporating polypropylene plastics along with other materials to produce EPR Bricks, evaluating their performance based on strength, durability, cost-effectiveness, and environmental impact. The findings demonstrate that EPR Bricks offer a promising solution to reduce plastic waste accumulation and minimise ecological damage. Furthermore, these bricks support sustainable construction practices, offering a viable alternative to traditional building materials. This research underscores the potential of EPR Bricks to contribute to environmental conservation while providing a cost-efficient and resilient building material for the construction industry.

Keywords: Eco-Polymer Bricks, Green Building, Real Estate, Bricks.

Abbreviations:

- EPR: Eco-Polymer Reinforced Bricks
- PP: Polypropylene
- FRC: Fibre Reinforced Concrete
- OPC: Ordinary Portland Cement
- PSC: Portland Slag Cement

This research introduces Eco-Polymer Reinforced Bricks (EPR Bricks) (Fig. 1), which incorporate polypropylene (PP) plastics, cement, sand, stone dust, and galvanised iron wire pieces. These bricks aim to reduce plastic waste, minimize reliance on conventional clay, and deliver superior structural performance. This paper examines the properties, benefits, and production methodology of EPR Bricks while exploring their potential as a sustainable alternative to conventional construction materials [3].



[Fig.1: Casted Eco-Polymer Reinforced Brick] [3]

I. INTRODUCTION

The exploitation of natural resources to meet increasing human demands has reached unsustainable levels, prompting a shift toward the development of alternative materials. Among these, polymers have gained prominence due to their durability, flexibility, and chemical resistance [1]. However, their non-biodegradable nature contributes significantly to environmental pollution, necessitating innovative recycling methods [2].

The construction sector, a major consumer of raw materials, offers a promising avenue for recycling plastic waste.

II. LITERATURE REVIEW

A. Polymer Use in Construction

The accumulation of plastic waste, especially polypropylene (PP), has become a significant environmental issue. PP, a thermoplastic polymer, has been explored as a potential material for enhancing the properties of concrete [4]. It is known for its high melting point, durability, chemical resistance, and cost-effectiveness, which make it a viable option for improving the mechanical properties of construction materials. The use of polymers in construction not only addresses environmental concerns but also offers a means to enhance the performance of concrete.

B. Polypropylene as a Reinforcement in Concrete

Polypropylene fibres are widely used in Fiber Reinforced Concrete (FRC) because they significantly enhance the material's tensile strength, reduce shrinkage, and improve crack resistance. Incorporating polypropylene fibres into concrete improves flexural strength and makes the material more resistant to cracking and wear [5], which are common issues in conventional concrete. The enhancement of the tensile properties of concrete by PP fibres addresses one of the key limitations of ordinary Portland cement

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(OPC)--based concrete, which has little or no tensile strength.

C. Environmental Impact and Sustainability

The environmental benefits of using waste plastics, such as polypropylene, in construction are evident. The recycling of plastics for concrete production not only reduces the environmental burden of plastic waste but also contributes to the sustainability of construction materials. Studies have shown that using recycled plastic in concrete reduces the need for natural aggregates, decreases plastic waste in landfills, and provides an eco-friendly solution for the construction industry [6]. This dual benefit of addressing plastic waste while improving concrete's properties is a significant motivation behind the growing interest in polymer-based concrete technologies.

D. Polypropylene and the Cement Matrix

One of the crucial advantages of using polypropylene fibres is their ability to bond with the cement matrix, significantly enhancing the concrete's structural integrity. The presence of PP fibres not only improves the strength of the concrete but also enhances its resistance to cracking and stress over time. This adequate bonding with cement makes polypropylene fibres an ideal reinforcement material, especially in applications where crack formation is a critical concern [7]. Furthermore, the addition of PP fibres improves the overall workability of concrete, making it easier to handle and form in various applications [8].

E. Applications of Polymer Fiber Reinforced Concrete (PFRC)

The application of Polymer Fiber Reinforced Concrete (PFRC) has been particularly promising in pavement construction, where its enhanced durability, resistance to cracks, and load-bearing capacity are highly beneficial. Studies show that PFRC significantly improves the performance of pavements by reducing the occurrence of cracks and extending their service life [9]. Furthermore, PFRC's resistance to shrinkage and creep makes it an ideal material for infrastructure that experiences heavy traffic loads [10]. The successful implementation of PFRC in pavements worldwide has proven its cost-effectiveness and long-term benefits for road and infrastructure maintenance.

F. Improving Concrete Durability and Strength

The inclusion of polypropylene fibres in concrete leads to improved durability, a crucial characteristic of any construction material. Studies have shown that PFRC enhances the material's compressive and tensile strength, making it more resilient in the face of mechanical and environmental stresses [11]. The presence of PP fibres helps prevent the formation of micro-cracks and reduces the impact of shrinkage, ultimately increasing the lifespan of concrete structures. These improvements are significant in regions with extreme weather conditions or in applications subjected to heavy loads [12].

G. Recycling Plastic Waste for Concrete Production

Recycling plastic waste into construction materials is an innovative approach that addresses two significant global challenges: the accumulation of plastic waste and the demand for sustainable construction materials [13]. By incorporating recycled plastics, specifically polypropylene fibres, into

concrete, construction companies can reduce their environmental footprint while improving the material's mechanical properties. Studies have found that recycled plastic not only replaces conventional aggregates but also helps reduce the overall carbon footprint of concrete production [14]. Moreover, the incorporation of waste plastic into concrete has been shown to reduce water absorption, making the concrete more resistant to moisture-related damage.

H. Standards and Guidelines for Material Selection

To ensure the proper selection and use of materials, adhering to standards and guidelines is crucial. The Indian Standard IS 383:2016 provides clear guidelines on selecting suitable aggregates for concrete [15]. Zone II Sand was chosen for this study, as it complies with the required gradation for concrete production. By following these established standards, the final product's durability, strength, and overall performance are optimized. Moreover, this adherence to standards ensures consistency and reliability in the properties of concrete mixtures.

The Literature highlights the multiple advantages of incorporating polypropylene fibres into concrete, particularly in enhancing its mechanical properties such as tensile strength, crack resistance, and durability. Additionally, the environmental benefits of recycling plastic waste for use in construction materials offer a sustainable solution to both plastic pollution and challenges in the construction industry. The successful application of Polymer Fiber Reinforced Concrete (PFRC) in various construction projects has proven its viability as a cost-effective and durable alternative to conventional concrete [16]. Future research could focus on optimizing the mixed designs of PFRC and exploring its potential applications in other areas of construction, such as building materials and infrastructure projects [17].

III. METHODOLOGY

A. Material Preparation

The first step in the brick manufacturing process involves thoroughly cleaning polypropylene plastics to remove contaminants. After washing, the plastics were crushed into smaller fragments and then sieved to obtain uniform particle sizes within the range of 2.36 mm to 4.76 mm. Simultaneously, cement, sand, stone dust, and galvanized iron wire pieces were measured according to the desired proportions for the mix. The proper proportions were critical to ensure that each component contributes optimally to the overall properties of the brick.

B. Mixing

The prepared materials were uniformly blended in a mechanical mixer to ensure a homogenous distribution of all components, including water, maintaining a specific water-cement ratio (0.30 to 0.45) [18]. The aim was to create a consistent mixture where each ingredient was properly integrated, ensuring reliable bonding between the particles.



The mixing process was conducted for a fixed duration to achieve a uniform consistency, which is crucial for the structural properties of the bricks.

C. Casting

After mixing, the material was transferred into metal moulds designed to produce bricks of standardized dimensions (250 mm × 125 mm × 75 mm). The moulds were carefully filled with the material mixture, ensuring that each mould cavity was filled. The mixture was compacted within the moulds to eliminate air pockets and enhance the density of the bricks. Proper compaction using a hydraulic press enhances the compressive strength of the final product.

D. Curing

Once cast, the bricks were subjected to a curing process for 28 days. A minimum of 7 days of curing is recommended for the manufacturing of EPR Bricks. The curing period is crucial for the hydration of the cement, which leads to the hardening and strengthening of the material. The bricks were stored in a controlled environment with appropriate humidity and temperature, allowing the mixture to cure at a steady pace. This curing period ensured that the bricks reached their maximum strength and durability, as specified in IS 383:2016.

E. Testing

To assess the mechanical properties of the bricks, the compressive strength was measured using a compression testing machine. The bricks were subjected to gradual loading until failure to determine their maximum load-bearing capacity. This test provided valuable data on the performance of the bricks, particularly their suitability for construction applications. The results of the compressive strength test were compared to standard benchmarks to evaluate the effectiveness of the polypropylene inclusion and other material components.

IV. MATERIALS

A. Polypropylene Plastic (PP)

Polypropylene was selected for its high melting point, chemical resistance, and cost-effectiveness. The material's durability and flexibility made it a suitable choice for reinforcing the composite material. Recycled polypropylene plastics were sourced, cleaned, and then subjected to sieving to achieve a particle size range of 2.36 mm to 4.76 mm. This sieving process ensured the uniformity of the material, which is essential for achieving consistent results during brick manufacturing (Fig. 2).



[Fig.2: Sample of Polypropylene Plastic (PP)]

B. Cement

Portland Pozzolana Cement (PPC) was used as the binding agent in the brick mixture. Known for its superior durability and sustainable properties, PPC was chosen to provide long-lasting strength to the final product. Additionally, PPC contributes to a lower environmental impact due to its reduced carbon footprint compared to ordinary Portland cement. The cement was measured in precise quantities to ensure the correct mixture ratio.

C. Sand

Zone II graded sand (as per IS 383:2016) was employed for its optimum particle size distribution, which enhances the compressive strength and workability of the mix. The gradation of sand ensures that the final brick possesses a uniform texture and superior mechanical properties. The sand was carefully selected to meet the standards specified for construction materials.

D. Stone Dust

Waste stone dust, sourced from construction sites, was incorporated into the mix to reduce reliance on virgin raw materials and minimize environmental impact. The use of stone dust not only helps in conserving natural resources but also improves the overall strength of the composite material. The dust particles were processed to ensure they adhered well to the other components, contributing to the cohesiveness of the final product.

E. Galvanized Iron Wire Pieces

Short pieces of galvanized iron wire, ranging from 2 to 2.5 cm, were uniformly mixed into the material blend to enhance tensile strength. The wire pieces act as reinforcements within the brick, preventing cracking and improving the structural integrity. Galvanized iron was chosen for its corrosion resistance, ensuring the long-term durability of the bricks.

V. ANALYSIS AND TESTING PROCESS

Compressive strength refers to the maximum load a material can endure before failure, applied along the material's axis to compress it. The Compression Test is a mechanical procedure to evaluate a material's resistance to compression without excessive deformation or failure. During the test, a progressively increasing compressive force is applied, and the material's response is measured. The test helps determine critical material properties, such as compressive strength, Elastic Modulus, Plastic Deformation, and Strain.

After a detailed study of various polymers, Polypropylene (PP), a thermoplastic polymer, was selected for the EPR brick. PP was chosen for its durability, strength, and recyclability, making it an ideal material for sustainable construction. Three different compositions of Portland Slag Cement (PSC), polypropylene plastic, sand, stone dust, and steel fibre reinforcement were used to create trial samples of bricks, each with standard dimensions of 10 x 5 x 3 inches. (Fig. 3). The bricks were cast and then cured for 28 days before undergoing both field and



laboratory tests. The weight of the sample EPR Brick is 3.72 kg. (Fig. 4).



[Fig.3: Dimension of Casted EPR Brick]



[Fig.4: Weight Measurement of Casted EPR Brick]

The best composition (Fig. 5) was selected based on the most favourable test results obtained after the 28-day curing period. To measure the compressive strength, we used a Compression Testing Machine manufactured by Lawrence & Mayo (India) (P) Ltd., which provides readings in Kilonewtons (kN). These readings were converted to N/mm² by multiplying the value by 1000 and dividing by the surface area of the brick.



[Fig.5: Materials Used for Mixing]

The Initial Hairline Crack Strength of the EPR brick was recorded at 6.22 N/mm², and the Final break point crack appeared at 795 KN (Fig. 6), which is equal to the compressive strength of 25.44 N/mm². These values confirm the high durability of the EPR brick, demonstrating its ability to withstand significant compressive forces, making it a viable and reliable construction material for various applications.



[Fig.6: Final Breakpoint Reading at Compression Testing Machine (795 KN)]

VI. RESULT AND DISCUSSIONS

A. Compressive Strength

EPR Bricks exhibited a compressive strength of 25.44 N/mm² (Fig. 7) after 28 days, which is significantly higher than conventional red clay bricks (12.35 N/mm²) and fly ash bricks (18.88 N/mm²). This remarkable performance highlights their suitability for high-stress applications in construction, such as high-rise buildings and industrial facilities.



[Fig.7: EPR Brick Post Final Compression Test]

B. Cost Analysis

The affordability of EPR Bricks is one of their most attractive features. Priced at



approximately ₹9 per unit, they are more cost-effective compared to red clay bricks (₹12) and fly ash bricks (₹11 to ₹12). The use of recycled materials and energy-efficient manufacturing processes contributes to this cost advantage, making EPR Bricks an ideal choice for affordable housing and large-scale construction projects.

C. Environmental Impact

The production of EPR Bricks eliminates the need for kiln firing, which is a significant source of carbon emissions in traditional brick manufacturing. By repurposing plastic waste, these bricks also help reduce landfill accumulation and promote a circular economy [19]. This dual impact aligns with the global Sustainable Development Goals, making EPR Bricks a pioneering solution in eco-friendly construction.

D. Economic and Real Estate Implications

As highlighted in, the Indian real estate market is increasingly prioritizing cost-effective and sustainable building materials. EPR Bricks addresses these demands by offering an affordable, durable, and environmentally responsible alternative. Their superior compressive strength makes them suitable for a wide range of applications, from affordable housing projects to high-rise buildings. Moreover, their eco-friendly production process aligns with green building certifications, catering to the rising demand for sustainable housing solutions in urban and suburban areas [20].

VII. ADVANTAGES OF EPR BRICK

A. Sustainability

Recycling plastic waste into construction materials significantly reduces environmental hazards. This process converts non-biodegradable waste into a valuable resource, aligning with circular economic principles and reducing pollution caused by plastic accumulation in landfills.

B. Economic Viability

The production of EPR Bricks incurs lower costs compared to conventional clay bricks due to the use of recycled materials and energy-efficient manufacturing processes [21]. This cost advantage makes EPR Bricks particularly suitable for affordable housing projects, where budget constraints often dictate material choices.

C. Superior Performance

EPR Bricks exhibit a compressive strength of 25.44 N/mm², far exceeding the strength of traditional red clay bricks and fly ash bricks. This superior structural performance ensures their adaptability for a wide range of applications, including residential, industrial, and infrastructural projects.

D. Eco-Friendliness

Unlike conventional bricks, the production of EPR Bricks does not involve kiln firing, a process that contributes significantly to carbon emissions. By eliminating this energy-intensive step, EPR Bricks reduce their

environmental footprint while supporting sustainable development goals.

VIII. CONCLUSION

EPR Bricks represent a transformative advancement for the construction industry, addressing two of its most critical challenges: escalating material costs and the need for sustainable building practices. By repurposing plastic waste into durable, cost-effective building materials, EPR Bricks offer a viable alternative to traditional construction materials, such as clay bricks. Their lower production costs, combined with enhanced compressive strength, make them particularly attractive for affordable housing projects, where cost constraints are often a concern. Moreover, their ability to withstand impact from a height of 14 feet without sustaining significant damage further demonstrates their durability and robustness.

The integration of EPR Bricks in construction not only reduces reliance on traditional building materials but also contributes to the broader goal of environmental conservation. These bricks significantly reduce the carbon footprint associated with construction activities by utilizing waste plastic, which would otherwise contribute to environmental pollution. As the demand for sustainable building practices continues to rise, EPR Bricks aligns well with the global shift toward green construction, emphasizing the importance of recycling and utilizing eco-friendly materials.

Moreover, the potential for widespread adoption of EPR Bricks in diverse construction projects, ranging from residential to industrial and infrastructural developments, is substantial. Their superior durability and compressive strength ensure their suitability for a wide range of applications, including demanding construction environments such as high-rise buildings and large-scale infrastructure projects. This versatility makes EPR Bricks not just a niche solution but a mainstream alternative that can be integrated across various segments of the real estate and construction sectors.

In addition to the environmental and cost benefits, the use of EPR Bricks can stimulate economic growth by fostering the development of a new industry centred around plastic waste recycling. The production and use of EPR Bricks could lead to the creation of new jobs and stimulate local economies, particularly in areas where plastic waste is abundant. This economic benefit, combined with the environmental advantages, makes EPR Bricks an essential part of India's push toward achieving sustainable development goals.

To fully realise the potential of EPR Bricks, further research is necessary to optimise the production process, explore the use of alternative polymers, and evaluate the long-term performance and durability of these bricks under various environmental conditions. Such research will help refine production techniques, ensuring that EPR Bricks maintain their structural integrity over time, making them a reliable and sustainable building material for the future.



Overall, EPR Bricks presents a promising future for the construction industry, offering a solution that balances economic, environmental, and social considerations. As their adoption continues to grow, they will undoubtedly play a critical role in shaping the future of construction and real estate development, promoting a sustainable, cost-effective, and eco-friendly built environment.

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

The Authors - Mr. Sayan Ghar, along Mrs. Bidisha Dey, declare that Eco-Polymer Reinforced Bricks (EPR Bricks) are our exclusive intellectual property. *A patent application for this innovation has been filed under the Indian Patent Act with the Patent Application Number 202431030057. Unauthorized use of the name "EPR Bricks" or any related intellectual property (<https://iponline.ipindia.gov.in/>) is strictly prohibited.*

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