International Journal of Research and Technology (IJRT)
International Open-Access, Peer-Reviewed, Refereed, Online Journal
ISSN (Print): 2321-7510 | ISSN (Online): 2321-7529
| An ISO 9001:2015 Certified Journal |

Plastic Waste–Based Eco-Friendly Bricks: A Sustainable Construction Review

[1]Sujit Kumar Sah, [2]Mr. Durgesh Nandan Verma

[1]Research Scholar, Department of Civil Engineering, Dr. K.N. Modi University, Newai, Tonk, Rajasthan – 304021
[2]Assistant professor, Department of Civil Engineering, Dr. K.N. Modi University, Newai, Tonk, Rajasthan – 304021

ABSTRACT
The rapid increase in plastic waste generation has become a major environmental concern due to its non-biodegradable nature and limited recycling potential. At the same time, the construction industry is one of the largest consumers of natural resources and energy, contributing significantly to environmental degradation and carbon emissions. In response to these challenges, plastic waste–based eco-friendly bricks have emerged as a sustainable alternative to conventional masonry materials. This review paper critically examines the utilization of plastic waste in brick manufacturing, focusing on material types, production techniques, and performance characteristics. Various manufacturing methods, including plastic–sand composites, plastic–cement bricks, and molded plastic blocks, are reviewed with respect to their mechanical strength, water absorption, durability, and thermal properties. The environmental benefits of these bricks, such as reduced landfill disposal, conservation of natural aggregates, and lower energy requirements, are also discussed. In addition, the review highlights key challenges related to fire resistance, long-term performance, standardization, and regulatory compliance that limit large-scale adoption. By synthesizing findings from recent experimental and review studies, this paper identifies research gaps and future directions necessary for improving material performance and facilitating commercialization. Overall, plastic waste–based eco-friendly bricks demonstrate strong potential to support sustainable construction practices and circular economy principles when supported by continued research, technological refinement, and policy integration.

Keywords: Plastic waste, Eco-friendly bricks, Sustainable construction, Waste recycling, Circular economy

1.INTRODUCTION

The exponential growth in plastic production over the past few decades has emerged as one of the most pressing environmental challenges of the modern era. Plastics are extensively used due to their durability, lightweight nature, low cost, and versatility; however, these same properties render them resistant to natural degradation. As a result, large volumes of plastic waste accumulate in landfills, water bodies, and terrestrial ecosystems, causing long-term environmental pollution and posing risks to human and ecological health. Conventional plastic waste management practices—such as landfilling, incineration, and limited recycling—have proven insufficient to address the scale of the problem. Landfills demand vast land resources and allow microplastics and toxic additives to leach into soil and groundwater, while incineration contributes to greenhouse gas emissions and releases hazardous pollutants. In parallel, the construction industry is one of the largest consumers of natural resources, particularly sand, clay, and aggregates, and is responsible for significant energy consumption and carbon emissions. The dual challenges of plastic waste accumulation and resource-intensive construction practices have intensified the global search for sustainable, circular-economy-based solutions that can simultaneously reduce waste and conserve natural materials.

In this context, plastic waste–based eco-friendly bricks have gained considerable attention as a promising alternative construction material. By incorporating plastic waste into brick manufacturing—either as a binder, filler, or composite material—researchers aim to convert an environmental liability into a value-added resource. These bricks offer several potential advantages over conventional burnt clay bricks, including reduced water absorption, lower density, enhanced durability, and resistance to chemical attack. Importantly, many plastic-based brick manufacturing processes eliminate the need for high-temperature firing, thereby reducing energy consumption and associated carbon emissions. The use of plastic waste in bricks also helps mitigate excessive sand mining and clay extraction, which are known to cause riverbank erosion, loss of biodiversity, and land degradation. Over the past decade, numerous experimental and review studies have investigated different types of plastic waste, such as polyethylene, polypropylene, and polyethylene terephthalate, in combination with sand, fly ash, or cementitious materials to assess mechanical strength, durability, and environmental performance. Despite encouraging results, challenges remain related to standardization, large-scale production, fire resistance, and long-term performance. This review paper aims to critically examine existing research on plastic waste–based eco-friendly bricks, focusing on manufacturing techniques, material properties, environmental benefits, and limitations. By synthesizing current knowledge and identifying research gaps, the study seeks to highlight the role of plastic waste bricks in promoting sustainable construction practices and advancing circular economy principles within the built environment.

2. BACKGROUND AND MOTIVATION

The rapid increase in global plastic production has transformed modern lifestyles but has simultaneously created severe environmental and waste management challenges. Plastics are widely favored for their durability, low cost, and versatility; however, their resistance to biodegradation has resulted in the accumulation of massive quantities of plastic waste. In many developing and developed nations alike, inadequate segregation, limited recycling infrastructure, and inefficient waste collection systems have intensified the problem, leading to widespread land, water, and air pollution. Plastic waste clogs drainage systems, contributes to flooding in urban areas, and degrades natural ecosystems when released into rivers and oceans. Traditional disposal methods such as landfilling and incineration are increasingly viewed as unsustainable due to land scarcity, leaching of toxic substances, and greenhouse gas emissions. These environmental concerns have created an urgent need for innovative, large-scale solutions that can effectively utilize plastic waste rather than merely disposing of it.

The construction industry presents a significant opportunity to address this challenge due to its high demand for raw materials and its capacity to absorb large volumes of waste. Conventional construction materials such as burnt clay bricks and concrete blocks require substantial energy, natural resources, and water, contributing to carbon emissions and environmental degradation. The motivation behind plastic waste–based eco-friendly bricks lies in integrating waste management with sustainable construction practices under the principles of a circular economy. By converting plastic waste into construction bricks, it becomes possible to reduce landfill pressure, conserve natural resources such as clay and sand, and lower energy consumption during production. Moreover, plastic-based bricks offer functional advantages including improved durability, reduced water absorption, and lightweight characteristics, making them suitable for various non-load-bearing and low-load applications. This dual benefit—environmental protection and material innovation—forms the core motivation for ongoing research and development in plastic waste–based brick technology.

Overview of Plastic Waste

Plastic waste refers to discarded plastic materials generated from domestic, commercial, industrial, and agricultural activities. Common plastic polymers found in waste streams include polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polystyrene (PS), and polyvinyl chloride (PVC). These plastics originate from packaging materials, bottles, carry bags, food containers, consumer goods, and construction-related products. Due to their non-biodegradable nature, plastics persist in the environment for hundreds of years, fragmenting into microplastics that infiltrate soil, water bodies, and food chains. Improper disposal of plastic waste has resulted in severe ecological consequences, including harm to aquatic life, soil contamination, and adverse human health effects caused by toxic additives and microplastic ingestion. While recycling is often promoted as a solution, only a small fraction of plastic waste is effectively recycled due to contamination, high processing costs, and limited market demand for recycled products.

From a waste management perspective, plastic waste poses both a challenge and an opportunity. Its lightweight nature reduces transportation costs, and its thermoplastic properties allow it to be melted and reshaped, making it suitable for reuse in construction materials. In recent years, researchers have explored the utilization of plastic waste as a partial or complete replacement for conventional building materials, particularly in brick and block manufacturing. Different forms of plastic waste—such as shredded, granulated, or melted plastics—are combined with sand, fly ash, or cement to produce composite bricks with acceptable mechanical and durability properties. The use of plastic waste in construction not only diverts waste from landfills and open dumping sites but also reduces dependence on natural resources and energy-intensive production processes. However, variations in plastic type, quality, and composition present challenges in achieving uniform performance and standardization.

Manufacturing Techniques of Plastic Waste–Based Bricks

The manufacturing of plastic waste–based bricks involves transforming discarded plastic into a binding or composite material that can partially or fully replace conventional constituents such as clay, cement, or aggregates. The choice of manufacturing technique largely depends on the type of plastic waste used, desired mechanical properties, availability of raw materials, and intended application of the bricks. In general, the process begins with the collection and segregation of plastic waste, followed by cleaning to remove contaminants such as organic matter, labels, and dust. The plastics are then shredded or granulated into smaller sizes to ensure uniform melting or mixing. Commonly used plastics include polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET), as these thermoplastics soften upon heating and can effectively act as binders. Once prepared, the plastic waste is combined with fillers such as sand, fly ash, quarry dust, or fine aggregates, and the mixture is processed using different techniques to form bricks.

One widely adopted method is the plastic–sand brick manufacturing technique, in which shredded plastic is heated to a molten state (typically between 160°C and 250°C, depending on the polymer type) and then mixed with sand in predetermined proportions. The hot mixture is thoroughly blended to ensure uniform coating of sand particles by molten plastic, after which it is placed into molds and compacted. Upon cooling, the plastic solidifies, binding the sand particles together to form rigid bricks. This method is energy-efficient compared to conventional clay brick firing, as it eliminates the need for kilns operating at extremely high temperatures. Another approach is the plastic–cement composite technique, where plastic waste is used as a partial replacement for fine aggregates in cement-based bricks or blocks. In this method, shredded plastic is mixed with cement, sand, and water, followed by molding and curing under controlled conditions. While this technique offers improved workability and compatibility with existing construction practices, the proportion of plastic is usually limited to avoid compromising compressive strength.

In addition to these, dry and wet processing methods are also employed depending on the role of plastic in the brick matrix. In the dry process, plastic waste is used in solid form as a filler or reinforcement material mixed with other dry constituents before compaction. The wet process involves melting plastic or using plastic-derived binders to create a homogeneous mixture with other materials. Advanced manufacturing techniques include the use of extrusion and compression molding, where heated plastic composites are shaped under pressure to produce uniform bricks with controlled dimensions and surface finishes. These techniques improve density, reduce voids, and enhance mechanical performance. Overall, manufacturing techniques for plastic waste–based bricks aim to balance material performance, environmental benefits, and production feasibility. Continuous refinement of these processes is essential to ensure consistency, scalability, and compliance with construction standards, thereby enabling wider adoption of plastic waste bricks in sustainable construction.

3. LITERATURE REVIEW

The growing concern over environmental degradation and solid waste accumulation has intensified research into sustainable construction materials, particularly the reuse of plastic waste. Early studies laid the foundation for understanding how industrial and municipal wastes can be transformed into value-added building materials. Sengupta (2002) provided one of the earliest comprehensive overviews of recycling agro-industrial wastes in India, emphasizing their potential in reducing landfill pressure and conserving natural resources. This work established the conceptual basis for waste valorization in construction, highlighting environmental and economic benefits. Similarly, Jain, Kumar, and Sengupta (2011) explored the use of waste polymeric packaging materials in bituminous roads, demonstrating improved resistance to rutting and enhanced pavement performance. Although focused on road construction, this study significantly influenced later research on plastic waste utilization in building materials by proving that plastics can enhance mechanical performance when properly incorporated. These foundational works collectively underscore the feasibility of waste plastics as functional construction constituents rather than environmental liabilities.

Research attention later expanded toward the incorporation of plastic waste in masonry units such as bricks and paver blocks. Aeslina Abdul Kadir and Sarani (2012) presented an overview of waste recycling in fired clay bricks, documenting how various industrial wastes influence brick properties such as compressive strength, density, and water absorption. Their findings suggested that partial replacement of clay with waste materials could produce structurally viable bricks while reducing energy consumption during firing. Complementing this, Bhogayata, Shah, and Vyas (2012) examined the performance of concrete incorporating non-recyclable plastic waste as a constituent material. Their study revealed that while excessive plastic content negatively affected compressive strength, controlled proportions improved ductility and reduced density, making the material suitable for non-load-bearing applications. These studies collectively emphasize that optimal mix design is crucial for balancing mechanical performance and sustainability objectives in plastic-modified construction materials.

Several researchers specifically investigated plastic–soil and plastic–sand composites for brick manufacturing. Dinesh, Dinesh, and Kirubhakaran (2012) explored the utilization of waste plastic in manufacturing bricks and paver blocks, demonstrating that melted plastic can act as an effective binder when combined with sand. Their results showed significant improvements in water resistance and durability compared to conventional clay bricks. Similarly, Manetho et al. (2013) studied plastic–soil bricks and reported enhanced compressive strength and reduced water absorption, particularly when plastic content was optimized. These findings were reinforced by Puttaraj et al. (2014), who emphasized the economic viability of plastic–soil bricks due to reduced reliance on cement and clay. Together, these studies highlight plastic waste's role as a binding agent that enhances durability while lowering production costs and environmental impact.

Experimental investigations further validated the mechanical performance of plastic-based bricks. Miruthula, Kokila, and Bala Murugan (2016) conducted an experimental study on plastic–soil bricks, revealing that increased plastic content led to higher strength and better resistance to moisture ingress. Their work also demonstrated improved resistance to cracking, making such bricks suitable for low-cost housing. Thirugnanasambantham et al. (2017) focused on manufacturing and testing plastic-sand bricks, reporting superior compressive strength compared to traditional clay bricks and negligible water absorption. These properties are particularly advantageous in regions prone to heavy rainfall and moisture-related deterioration. Shrimali's study on bricks from waste plastic further supported these findings, emphasizing ease of manufacturing and environmental benefits. Collectively, these experimental studies confirm that plastic-based bricks can meet or exceed standard requirements for masonry units when appropriately designed.

Beyond bricks, several studies explored the broader application of plastic waste in concrete and paving systems. Tapkire et al. (2014) investigated recycled plastic in concrete paver blocks and observed improved toughness and impact resistance, although compressive strength decreased slightly at higher plastic contents. Sarwe (2014) extended this research by incorporating waste plastics along with steel fibers in concrete, demonstrating that fibers compensated for strength loss and significantly improved tensile and flexural performance. These findings suggest that hybrid approaches—combining plastics with reinforcing materials—can overcome limitations associated with plastic inclusion alone. Such studies expand the scope of plastic waste utilization beyond bricks, positioning it as a versatile material for diverse construction applications.

Recent research has increasingly focused on sustainability, scalability, and long-term performance. Valinejad Shoubi and Barough (2013) examined the use of PET bottles as construction elements, highlighting their potential in lightweight structures and disaster-relief housing. Manisha and Goyal (2016) discussed eco-bricks, emphasizing community-driven waste management and social sustainability. Patel and Shah (2014) further contributed by promoting waste PET bottles as construction elements, stressing resource efficiency and affordability. The most recent review by Singh et al. (2023) synthesized global research on plastic waste composite bricks, identifying challenges such as standardization, fire resistance, and large-scale adoption, while highlighting opportunities for innovation in material engineering and circular economy practices. This contemporary perspective underscores a shift from feasibility studies toward optimization, regulation, and commercialization of plastic-based construction materials.

In summary, the reviewed literature demonstrates a clear progression from exploratory studies to advanced experimental and review-based research on plastic waste utilization in construction. While early works established feasibility and environmental benefits, later studies refined mix designs, evaluated mechanical performance, and explored sustainability implications. Despite promising results, challenges remain regarding standardization, long-term durability, and widespread acceptance. Nevertheless, the collective findings strongly support plastic waste–based bricks as a viable, eco-friendly alternative to conventional masonry materials, particularly in the context of sustainable development and waste management.

Material Properties of Plastic Waste Bricks

Plastic waste bricks exhibit a range of material properties that distinguish them from conventional burnt clay bricks and concrete masonry units. One of the most critical properties is compressive strength, which determines their suitability for construction applications. Studies have shown that plastic waste bricks, particularly plastic–sand composite bricks, can achieve compressive strength values comparable to or higher than traditional clay bricks when optimal plastic-to-sand ratios are used. The molten plastic acts as an effective binder, uniformly coating the aggregate particles and forming a dense matrix. However, excessive plastic content may reduce stiffness and load-bearing capacity, limiting their use primarily to non-load-bearing and low-load structural elements.

Water absorption is another important parameter influencing durability and service life. Plastic waste bricks generally demonstrate significantly lower water absorption than conventional clay bricks due to the hydrophobic nature of plastics. Reduced water uptake minimizes issues such as efflorescence, freeze–thaw damage, and strength degradation over time, making these bricks particularly suitable for humid and water-prone environments. In addition, the lower porosity of plastic-based bricks contributes to improved resistance against chemical attack, including exposure to salts, acids, and alkalis commonly present in soil and wastewater. This enhanced durability extends the lifespan of structures while reducing maintenance requirements.

In terms of density and weight, plastic waste bricks are lighter than traditional masonry units, which reduces dead load on structures and lowers transportation and handling costs. The lightweight nature also improves ease of construction and makes them advantageous for low-cost housing and modular construction systems. Furthermore, plastic bricks offer favorable thermal and acoustic insulation properties, as plastics have low thermal conductivity and can effectively dampen sound transmission. These properties contribute to improved indoor comfort and reduced energy demand for heating and cooling. However, challenges remain regarding fire resistance, as plastics are combustible and may release toxic fumes at high temperatures.

4. RESEARCH PROBLEM

The rapid accumulation of plastic waste and the growing environmental burden of conventional construction materials present a critical sustainability challenge for the built environment. While plastic waste–based eco-friendly bricks have emerged as a promising solution to simultaneously address waste management and resource conservation, their large-scale adoption remains limited. Existing studies demonstrate that plastic waste can be effectively incorporated into brick manufacturing to achieve acceptable mechanical strength, reduced water absorption, and improved durability. However, the research landscape is fragmented, with significant variations in plastic types, mix proportions, manufacturing techniques, and testing methodologies. This lack of uniformity makes it difficult to compare results, establish performance benchmarks, and develop standardized guidelines for practical implementation.

Moreover, uncertainties persist regarding the long-term performance, fire resistance, environmental safety, and structural reliability of plastic waste bricks under diverse climatic and loading conditions. Concerns related to thermal degradation, emission of toxic gases during fire exposure, and potential microplastic release over time further complicate their acceptance in mainstream construction. In addition, limited life cycle assessment data and insufficient integration with existing building codes and standards restrict their commercialization. The core research problem, therefore, lies in critically evaluating and synthesizing existing knowledge to identify performance gaps, technological limitations, and sustainability trade-offs associated with plastic waste–based bricks. Addressing these challenges is essential to establish their technical feasibility, environmental benefits, and policy relevance, thereby enabling their safe and effective use as sustainable alternatives to conventional masonry materials.

5. CONCLUSION

Plastic waste–based eco-friendly bricks represent a promising and innovative approach to addressing two of the most pressing challenges facing modern society: the growing accumulation of plastic waste and the environmental impact of conventional construction materials. This review highlights that the utilization of plastic waste in brick manufacturing offers significant environmental benefits, including the reduction of landfill burden, conservation of natural resources such as clay and sand, and lower energy consumption compared to traditional fired bricks. Experimental studies reviewed in the literature demonstrate that plastic waste bricks can achieve satisfactory compressive strength, low water absorption, enhanced durability, and improved thermal insulation, making them suitable for various non-load-bearing and low-load construction applications. Additionally, the elimination or reduction of high-temperature firing processes contributes to decreased carbon emissions, aligning with global sustainability and circular economy objectives. However, despite these advantages, challenges remain in terms of standardization, fire resistance, long-term performance, and regulatory acceptance. Variability in plastic types, mix designs, and manufacturing techniques has led to inconsistent results across studies, underscoring the need for unified testing protocols and design standards. Furthermore, comprehensive life cycle assessments and large-scale field applications are still limited, restricting the widespread adoption of this technology. Overall, plastic waste–based eco-friendly bricks have strong potential to contribute to sustainable construction practices, provided that future research focuses on performance optimization, safety enhancement, and policy integration to facilitate their transition from experimental innovation to practical construction material.

REFERENCES

1. Aeslina Abdul Kadir, Noor Amira Sarani, "An Overview of Wastes Recycling in Fired Clay Bricks" International Journal of Integrated Engineering, Vol. 4 No. 2 (2012) p.53-69
2. Amit Gawande, G. Zamare., V.C Renge., Saurabh Tayde, G. Bharsakale.. (2012) "An overview on waste plastic utilization in asphalting of roads", Journal of Engineering Research and Studies (JERS), Vol.III, Issue II, pp 01-05
3. Bhogayata, K. D. Shah, B. A. Vyas, "Performance of concrete was using Non-Recyclable plastic wastes as concrete constituent", International Journal of Engineering Research & Technology (IJERT) vol. 1 issue 4, june-2012.
4. Dinesh A; Dinesh S; and Kirubhakaran K., "Utilisation of Waste Plastic in Manufacturing of Bricks and Paver Blocks" International Journal of Applied Engineering Research, Vol.2 (4), pp. 364- 368.
5. G. miruthula, l. Kokila, g. bala murugan Volume 6 Issue No. 4 ISSN 2321 3361.April 2016Experimental Investigation on Plastic-Soil Bricks. International Journal of Engineering Science and Computing
6. Ganesh Tapkire, Satish Parihar, Pramod Patil, Hemraj R Kumavat, "Recycled Plastic used in Concrete Paver Block" International Journal of Research in Engineering and Technology eissn: 2319-1163, Vol: 03 special issue: 09, NCETCE-2014.

6 hilesh Sarwe, "Study of Strength Property of Concrete Using Waste Plastics and Steel Fibers" Department of Civil Engineering, Jabalpur Engineering College, Jabalpur, India. International Journal of Engineering and Science (IJES)/vol 3/Issue/5/Pages/09-11/2014/.

7 Manetho P D; Pramod K; Kishor Kumar; and Shanmukha Shetty., "Utilization of Waste Plastic in Manufacturing of Plastic-Soil Bricks" International Journal of Engineering Research & Technology, Vol.3 (8), pp.529-536

8 Mojtaba Valinejad Shoubi, Azin Shakiba Barough (2013) Investigating the Application of Plastic Bottle as a Sustainable Material in the Building Construction. International Journal of Science, Engineering and Technology Research (IJSETR) 2(1): 2278 -7798.

9 Mr.N.Thirugnanasambantham, P.Tharun Kumar, .R.Sujithra, R.Selvaraman4, P.Bharathi,' Manufacturing And Testing Of Plastic Sand Bricks', International Journal of Science and Engineering Research (IJ0SER) Vol 5 Issue 4 April -2017.

10 Manisha, Nitin Goyal; "Constructing structures using eco-bricks", International Journal of Recent Trends in Engineering & Research, Vol.2(4), pp. 159-164.

11 P K Jain, Shanta Kumar & J B Sengupta, "Mitigation of rutting in bituminous roads by use of waste polymeric packaging materials" Indian Journal of Engineering & Materials Sciences Vol. 18, June 2011, pp. 233-238

12 Puttaraj M.H; Shanmukha S; NavaneethRai.P.G; and Prathima.T.B, "Utilization of Waste Plastic In Manufacturing of plastic-Soil Bricks" International Journal of Technology Enhancement and Emerging Engineering Research, Vol. 2(4), pp. 102-107.

13 Pratima Patel, Akash Shah, (2014) Sub stainable development using waste PET bottles as construction element www. wastebottleconstruction.com.

14 Sengupta J. Recycling of agro-industrial wastes for manufacturing of building materials and components in India. An over view. Civil Engineering & Construction Review 2002;15(2):23–33.

15 ShikharShrimali,' Bricks from waste plastic',International journal of advance research, Article

16 Singh, A., Srivastava, A. K., Singh, G., Singh, A. D., Singh, H. K., Kumar, A., & Singh, G. K. (2023). Utilization of Plastic Waste for Developing Composite Bricks and Enhancing Mechanical Properties: A Review on Challenges and Opportunities. Advances in Polymer Technology, 2023.