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# An Evaluation of the use of Plastic Waste in the Manufacture of Plastic Bricks

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**ABSTRACT:** Plastic waste has emerged as a significant environmental challenge due to its non-biodegradable nature and continuous accumulation in landfills and natural ecosystems. With the rapid increase in plastic consumption, effective waste management and sustainable reuse strategies have become essential. This study focuses on the utilization of waste plastic in the manufacturing of plastic-sand bricks as an alternative to conventional clay bricks, aiming to reduce environmental impacts while promoting sustainable construction practices. In this experimental investigation, waste plastics such as low-density polyethylene (LDPE) and high-density polyethylene (HDPE) were collected, cleaned, and melted, and then mixed with sand in varying proportions to produce plastic-sand bricks. The manufactured bricks were subjected to various physical and mechanical tests, including compressive strength, water absorption, hardness, and soundness. The performance of these bricks was compared with that of conventional clay bricks. The results indicate that plastic-sand bricks exhibit higher compressive strength, lower water absorption, and improved durability compared to traditional bricks. Additionally, these bricks are lightweight, cost-effective, and resistant to moisture, making them a viable alternative building material. The study demonstrates that incorporating plastic waste into brick production not only helps in effective waste management but also contributes to sustainable development and environmental protection. Overall, the utilization of plastic waste in brick manufacturing presents a promising solution to address both solid waste management issues and the demand for eco-friendly construction materials.

**KEYWORDS:** Plastic waste, plastic sand bricks, sustainable development, compressive strength, eco-friendly construction materials

## I. INTRODUCTION

Concrete is one of the most widely used construction materials and plays a vital role in the sustainable development of infrastructure. The rapid growth of urbanization and industrialization has significantly increased the demand for concrete, leading to a corresponding rise in the consumption of fine aggregates. Traditionally, natural river sand has been used as fine aggregate; however, its excessive extraction has resulted in depletion of resources, increased costs, and serious environmental concerns such as riverbed degradation and lowering of groundwater levels.

The scarcity and rising cost of natural sand have encouraged researchers and engineers to explore alternative materials. Manufactured sand (M-sand), produced by crushing hard granite rocks and processing them into fine aggregates of size less than 4.75 mm, has emerged as a viable substitute. M-sand offers advantages such as controlled gradation, improved particle shape, and reduced environmental impact compared to river sand.

In this study, concrete mixes are designed using manufactured sand as a replacement for natural fine aggregate for both medium and high-strength grades. The performance of concrete is evaluated in terms of mechanical and durability properties to assess the suitability of M-sand as a sustainable alternative in modern construction practices.

## II. LITERATURE SURVEY

The increasing accumulation of plastic waste has become a major environmental concern worldwide. Researchers have explored innovative ways to reuse plastic waste in construction materials, particularly in the manufacturing of bricks, to promote sustainability and reduce environmental impact.

Recent studies such as Rauniyar Nakrani et al. (2024) and Yadav et al. (2024) highlight that plastic bricks offer a promising alternative to conventional clay bricks due to their lightweight nature, durability, and resistance to water absorption. These studies emphasize that incorporating plastic waste not only reduces landfill burden but also contributes to resource efficiency and circular economy practices.

Kumar et al. (2021), Singh et al. (2021), and Shrestha et al. (2023) conducted comprehensive reviews on plastic brick technology and concluded that plastic waste can be effectively used either as a binder or as a replacement for fine aggregates. Their findings indicate that plastic bricks exhibit improved compressive strength and reduced water absorption compared to traditional bricks, although performance depends on the type and proportion of plastic used.

Experimental investigations by Sah and Verma (2023) and Alqahtani et al. (2017) demonstrated that plastic-based bricks possess adequate mechanical strength for non-load-bearing applications. These studies also reported enhanced durability, chemical resistance, and lower permeability. Similarly, Pande and Badnakhe (2022) and Kognole et al. (2019) showed that mixing plastic waste with sand produces eco-friendly bricks with good bonding characteristics and cost-effectiveness.

Earlier works such as Gawande et al. (2018) and Chaitanya et al. (2019) focused on the economic and environmental advantages of plastic sand bricks. Their research highlighted that these bricks are lighter, require less water during production, and eliminate the need for firing, thereby reducing energy consumption and greenhouse gas emissions. Islam et al. (2016) and Patil et al. (2016) further reinforced that plastic waste can be effectively utilized in various construction applications, including bricks, paving blocks, and road materials, contributing to sustainable development goals.

Overall, the literature indicates that plastic waste-based bricks are a viable and sustainable alternative to conventional building materials. They offer advantages such as reduced weight, improved durability, low water absorption and environmental benefits. However, challenges remain in terms of standardization, large-scale production, fire resistance and long-term performance evaluation.

## III. METHODOLOGY

This study adopts a systematic approach to manufacture eco-friendly plastic bricks using waste plastic as a binder. The process involves collection, segregation, cleaning, shredding, controlled melting (120–180°C), mixing with sand, moulding and cooling, followed by performance evaluation.

### Materials Used

- Waste Plastic: LDPE, HDPE, and PET sourced from household, industrial, and municipal waste streams. These materials are selected due to their availability, non-biodegradability, and suitable melting characteristics.
- Fine Aggregate (Sand): Manufactured sand is used for its uniform grading and strength properties, acting as a filler and providing structural stability.
- Water: Used only for cleaning purposes; no curing is required.

### Equipment Used

- Shredding machine (size reduction of plastic)
- Heating furnace/melting chamber (controlled melting)
- Mixing tray or mechanical mixer (uniform mixing)
- Brick moulds (standard shaping)
- Compaction tools (density improvement)
- Weighing balance (material proportioning)
- Thermometer (temperature monitoring)

- Compression Testing Machine (CTM)
- Water absorption and hardness testing apparatus

#### Manufacturing Process

1. Collection and Segregation: Plastic waste is collected and sorted into LDPE, HDPE, and PET for uniform melting behaviour.
2. Cleaning: Removal of impurities such as dust, labels, and organic matter.
3. Shredding: Plastic is reduced to small pieces to enhance melting efficiency.
4. Heating: Shredded plastic is heated at 120–180°C until molten, ensuring controlled temperature to prevent degradation.
5. Mixing: Molten plastic is mixed with sand in ratios such as 1:3 and 1:4 (plastic: sand) to achieve homogeneity.
6. Moulding: The mixture is poured into standard moulds and compacted to eliminate voids and improve density.
7. Cooling: Bricks are cooled at ambient conditions; no water curing is required.
8. Finishing: Bricks are demoulded, inspected, and surface defects are corrected.

#### Experimental Setup and Testing

- Compressive Strength Test: To determine load-bearing capacity
- Water Absorption Test: To assess porosity and durability
- Hardness Test: To evaluate surface resistance

### IV. SYSTEM DESIGN

The proposed system is designed to convert non-biodegradable plastic waste into construction bricks through a controlled process of collection, processing, melting, mixing, moulding, and cooling. The design emphasizes efficiency, low cost, environmental sustainability, and scalability for both small- and large-scale applications.

#### Design Considerations

- Material Availability: Utilization of abundantly available waste plastics (LDPE, HDPE, PET).
- Environmental Sustainability: Elimination of open burning and reduction of landfill waste; controlled heating minimizes toxic emissions.
- Cost-Effectiveness: Use of simple, low-cost equipment suitable for scalable implementation.
- Mechanical Performance: Ensuring adequate compressive strength, durability, and low water absorption.
- Operational Simplicity: Ease of handling with minimal technical expertise.
- Safety: Controlled temperature, proper ventilation, and safe handling of molten plastic.

#### System Components

1. Plastic Processing Unit: Responsible for collection, segregation, cleaning, and shredding of plastic waste.
2. Heating Unit (Melting Chamber):
  - Temperature range: 120–180 °C
  - Constructed using heat-resistant steel with electric/gas heating
  - Ensures uniform melting through controlled heating and stirring
3. Mixing Unit:
  - Molten plastic is mixed with sand in ratios of 1:3 and 1:4
  - Ensures homogeneous distribution for consistent strength
4. Moulding Unit:
  - Standard mould size: 190 mm × 90 mm × 90 mm
  - Compaction applied to reduce voids and improve density
5. Cooling and Solidification Unit:
  - Ambient cooling without water curing
  - Solidification occurs through plastic hardening
  - Reduces water usage and processing time

#### Design Calculations

Volume of Brick  $V=L \times B \times H$

$$V = 0.19 \times 0.09 \times 0.09 = 0.001539 \text{ m}^3$$

Material Proportion Calculation (1:3 Ratio)

Total parts = 4

$$\text{Plastic} = \frac{1}{4} \times 0.001539 = 0.0003847 \text{ m}^3$$

$$\text{Sand} = \frac{3}{4} \times 0.001539 = 0.001154 \text{ m}^3$$

#### Compressive Strength Calculation

$$\sigma = P/A$$

Where:

P = Load applied

A = Cross-sectional area

$$A = 190 \times 90 = 17100 \text{ mm}^2$$

#### Water Absorption Calculation

$$\text{Water Absorption} = [(W_2 - W_1) / W_1] \times 100$$

## V. EXPERIMENTAL RESULTS

This section presents the experimental evaluation of plastic bricks manufactured using waste plastic and sand. The performance was assessed through compressive strength, water absorption, and hardness tests, and compared with conventional clay bricks. Two mix proportions (1:3 and 1:4, plastic: sand) were analyzed.

#### Compressive Strength

Compressive strength tests were conducted using a Compression Testing Machine under gradual loading until failure.

- 1:3 mix: 14.0, 14.5, 14.0 N/mm<sup>2</sup>
- 1:4 mix: 12.0, 12.5, 12.0 N/mm<sup>2</sup>
- Conventional bricks: ~10 N/mm<sup>2</sup>

Plastic bricks exhibited higher compressive strength than conventional bricks. The 1:3 mix showed superior strength due to higher plastic content, which enhanced particle bonding. A reduction in strength for the 1:4 mix is attributed to increased sand content, reducing binder effectiveness. The results indicate that plastic bricks are suitable for both structural and non-structural applications.

#### Water Absorption

Water absorption was determined by immersing oven-dried bricks in water for 24 hours.

- 1:3 mix: 3.50%, 3.27%, 3.33%
- 1:4 mix: 4.40%, 4.25%, 4.11%
- Conventional bricks: ~20%

Plastic bricks showed significantly lower water absorption compared to conventional bricks due to the non-porous nature of plastic. The 1:3 mix demonstrated better resistance to moisture owing to higher plastic content. All values are well below the acceptable limit (20%), indicating excellent durability and resistance to water ingress.

#### Hardness Test

Surface hardness was evaluated using a scratch test with a standard 4-inch nail.

Plastic bricks showed negligible surface indentation, indicating high hardness and strong surface integrity. The dense structure and effective bonding contributed to improved resistance against abrasion compared to conventional clay bricks.

#### Overall Performance

- Plastic bricks demonstrated higher compressive strength, lower water absorption, and better surface hardness than conventional bricks.

- The 1:3 mix ratio provided optimal performance among the tested compositions.
- The results confirm the technical feasibility and durability of plastic bricks for construction applications.

## VI. CONCLUSION

This study investigated the feasibility of utilizing waste plastic in the production of eco-friendly construction bricks. The study validates that waste plastic can be successfully transformed into strong, durable and eco-friendly construction bricks. This approach provides an effective solution for plastic waste management while promoting sustainable construction practices, making plastic bricks a promising alternative to conventional materials. The study confirms that non-biodegradable plastic waste (LDPE, HDPE, PET) can be effectively recycled into brick manufacturing, significantly reducing environmental pollution and landfill accumulation.

The replacement of conventional clay with waste plastic and sand reduces dependence on natural resources and eliminates the need for energy-intensive kiln firing, resulting in a more sustainable and economical process. Plastic acts as an efficient binding material, providing strong adhesion between sand particles. The experimental evaluation indicates:

- Higher compressive strength than conventional bricks (up to 14 N/mm<sup>2</sup> for 1:3 mix)
- Significantly lower water absorption (3 to 4%), indicating improved durability
- High surface hardness, with negligible surface damage under scratch testing

Plastic bricks outperform conventional clay bricks in key aspects such as strength, water resistance, durability, and weight. Their lower density facilitates easier handling and transportation.

The results demonstrate that plastic bricks are suitable for construction applications, particularly in non-load-bearing structures, and offer a viable alternative for sustainable building materials.

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