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Experimental Performance Evaluation of Plastic Waste-Based Bricks

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Abstract
The increasing accumulation of plastic waste and the environmental impact of conventional construction materials have encouraged the exploration of sustainable alternatives in the building sector. Plastic waste–based bricks have emerged as a promising solution that integrates waste management with eco-friendly construction practices. This study presents an experimental performance evaluation of bricks manufactured using plastic waste combined with conventional materials. The experimental program focused on assessing key performance parameters, including compressive strength, water absorption, density, and durability, to determine their suitability for construction applications. Bricks were prepared using controlled mix proportions and subjected to standard curing periods, followed by laboratory testing in accordance with relevant testing procedures. The results indicate that plastic waste–based bricks exhibit satisfactory mechanical performance, low water absorption, and good resistance to moisture ingress compared to conventional clay bricks. The hydrophobic nature of plastic significantly reduces porosity, enhancing durability and service life, particularly in humid environments. In addition to technical performance, the use of plastic waste contributes to reduced landfill disposal and conservation of natural resources. The findings demonstrate that plastic waste–based bricks are viable for non-load-bearing and low-stress construction applications. This experimental evaluation supports the potential of plastic waste bricks as sustainable, cost-effective alternatives, while highlighting the need for further research on long-term performance and standardization.
Keywords: Plastic waste bricks, Experimental evaluation, Compressive strength, Water absorption, Sustainable construction

Introduction

The growing accumulation of plastic waste has emerged as a critical environmental challenge, driven by increased consumption, rapid urbanization, and inadequate waste management systems. Plastics are widely used because of their durability, lightweight nature, and cost-effectiveness; however, these same properties make them resistant to natural degradation, resulting in long-term environmental persistence. Conventional disposal practices such as landfilling and incineration are increasingly unsustainable due to land scarcity, greenhouse gas emissions, and the release of toxic by-products. At the same time, the construction industry is a major consumer of natural resources, including clay, sand, and aggregates, and contributes significantly to global carbon emissions through energy-intensive manufacturing processes, particularly in the production of fired clay bricks. This convergence of escalating plastic waste and resource depletion has intensified the need for innovative construction materials that are both environmentally responsible and technically viable. In this context, the reuse of plastic waste in brick manufacturing has gained attention as a potential solution that addresses waste reduction while supporting sustainable construction practices.

Experimental performance evaluation plays a crucial role in determining the feasibility of plastic waste–based bricks as alternatives to conventional masonry units. While several studies have proposed different mix designs and manufacturing techniques, the practical adoption of these bricks depends largely on their mechanical, durability, and functional performance under controlled testing conditions. Key properties such as compressive strength, water absorption, density, durability, and thermal behavior must meet or exceed minimum standards to ensure safety and reliability in construction applications. Experimental investigations provide empirical evidence on how variations in plastic type, particle size, proportion, and bonding mechanisms influence brick performance. Moreover, laboratory testing enables the identification of optimal mix ratios that balance strength, durability, and sustainability benefits. Despite promising experimental results reported in the literature, inconsistencies in testing methods and performance outcomes highlight the need for systematic evaluation and comparison. Therefore, an experimental assessment of plastic waste–based bricks is essential to validate their structural adequacy, understand their limitations, and establish a scientific basis for their integration into mainstream construction. This study focuses on evaluating the experimental performance of plastic waste–based bricks, contributing to the development of reliable, eco-friendly masonry materials that align with sustainable development and circular economy objectives.

Methodology

The methodology adopted for the production of plastic waste–based bricks focuses on a systematic, environmentally responsible approach to convert discarded plastic into functional construction materials. The process begins with the collection of raw materials, where non-hazardous plastic waste such as plastic bottles, grocery bags, and soft drink containers is gathered from municipal areas, households, and nearby industrial sources. Along with plastic waste, fine sand and a limited quantity of cement (where required) are collected. Careful segregation is carried out to separate usable plastic from impurities such as paper, metal fragments, and organic matter, ensuring material purity and consistency in brick quality.

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Following collection, the batching process is undertaken, which involves proportioning the plastic waste and other constituents according to the required mix design. The collected plastic is dried to remove excess moisture before further processing. The segregated plastic waste is then subjected to thermal processing (burning) in a controlled, closed container system. The plastic is heated within a temperature range of 90°C to 150°C, allowing it to soften or melt without degrading its binding properties. The closed setup is essential to minimize the release of toxic gases and to maintain environmental safety during the process.

Once the plastic reaches a molten state, the mixing process begins. Molten plastic is thoroughly mixed with fine sand in predetermined proportions to achieve uniformity in color, texture, and composition. In this study, hand mixing using a trowel is adopted to ensure proper blending before the mixture begins to set. Due to the short setting time of molten plastic, mixing is performed rapidly to maintain workability. The homogeneous mixture is then transferred to standard brick molds of size 20 × 10 × 10 cm during the moulding stage. After 24 hours, the bricks are demoulded and allowed to cure, initially by air drying and subsequently by placing them in a curing tank to attain adequate hardness and durability before testing.

Results and Discussion

This research critically analyzes the experimental results obtained from converting plastic waste into eco-friendly bricks and examines their implications for sustainable construction practices. The performance of the bricks was evaluated based on key parameters such as compressive strength, water absorption, density, and durability, which are essential for assessing their suitability for structural and non-structural applications. The findings indicate that plastic waste–based bricks exhibit satisfactory mechanical performance when compared to conventional clay bricks, particularly demonstrating lower water absorption and improved resistance to moisture-related deterioration. These advantages are primarily attributed to the hydrophobic nature of plastic, which reduces pore connectivity and enhances durability.

The discussion further highlights the influence of material composition, mix proportions, and curing conditions on the observed performance, emphasizing the importance of controlled processing to achieve consistent strength and dimensional stability. Variations in test results were examined to identify optimal mix designs and potential limitations in the production process. In addition to mechanical performance, the environmental benefits of reducing plastic waste disposal and conserving natural resources were also considered. Overall, the results confirm the practical viability of plastic waste–based bricks as a sustainable, eco-friendly, and cost-effective alternative construction material.

Compressive Strength Test

The compressive strength test for cement–plastic bricks was carried out after curing periods of 14 and 28 days. During testing, the brick specimen was placed centrally on the lower platen of

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the compression testing machine, ensuring that the load was applied on the faces parallel to those cast during molding. Proper alignment of the specimen axis with the spherically seated platen was maintained to ensure uniform load distribution, and no packing material was used between the specimen and the steel platens.
A uniformly increasing load was applied at a constant rate of approximately 13.73 N/mm² per minute until failure occurred. The maximum load sustained by the specimen at failure was recorded. The compressive strength (Fc) was then calculated using the relation:
FC = P/A
where P is the ultimate load (N) and A is the loaded area of the specimen (200 mm × 100 mm = 20,000 mm²).

- **PROCEDURE: -**

Position the brick centrally on the lower platen of the compression testing machine so that the load is applied on the faces corresponding to the original casting orientation. Ensure the specimen axis is accurately aligned with the center of the spherically seated platen, and do not use any packing material between the specimen and the steel platens. Apply the load gradually and uniformly at a constant rate of approximately 13.73 N/mm² per minute until the specimen fails and can no longer sustain the applied load.
The peak load applied to the specimen shall then be recorded.

Figure 1 Compressive strength Machine and Specimen

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Figure 2 Failure of the specimen at the maximum load

COMPRESSIVE STRENGTH FOR MIX DESIGN OF 1:3

samples	Compressive strength (N/sq.mm)
1	14
2	14.5

The table presents the compressive strength results of two brick samples. Sample 1 recorded a compressive strength of 14 N/mm², while Sample 2 showed a slightly higher value of 14.5 N/mm². These values represent the maximum compressive load each sample can withstand before failure. The marginally higher strength of Sample 2 indicates better resistance to compressive forces compared to Sample 1, suggesting improved load-bearing capacity. Such results are useful for assessing the structural performance of the bricks and their suitability for construction applications.

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COMPRESSIVE STRENGTH FOR MIX DESIGN OF 1:4

Samples	Compressive strength (N/sq.mm)
1	12
2	12.5

The table shows the compressive strength results of two samples. Sample 1 exhibits a compressive strength of 12 N/mm², while Sample 2 records a slightly higher value of 12.5 N/mm². These values represent the maximum compressive load the materials can withstand before failure. The marginally higher strength of Sample 2 indicates better resistance to compressive forces and improved load-bearing capacity compared to Sample 1. Such results are useful for assessing the structural suitability of the materials for construction applications.

COMPRESSIVE STRENGTH FOR MIX DESIGN OF 1:1:3

Samples	Compressive strength (N/sq.mm)
14 days	15.75
28 days	17.5

The table summarizes the compressive strength of the samples at 14 and 28 days of curing. The compressive strength increased from 15.75 N/mm² at 14 days to 17.5 N/mm² at 28 days. This improvement indicates continued strength development with curing time, demonstrating that the material gains better resistance to compressive loads as it hardens. Such results are important for evaluating the maturity, durability, and suitability of the material for construction applications.

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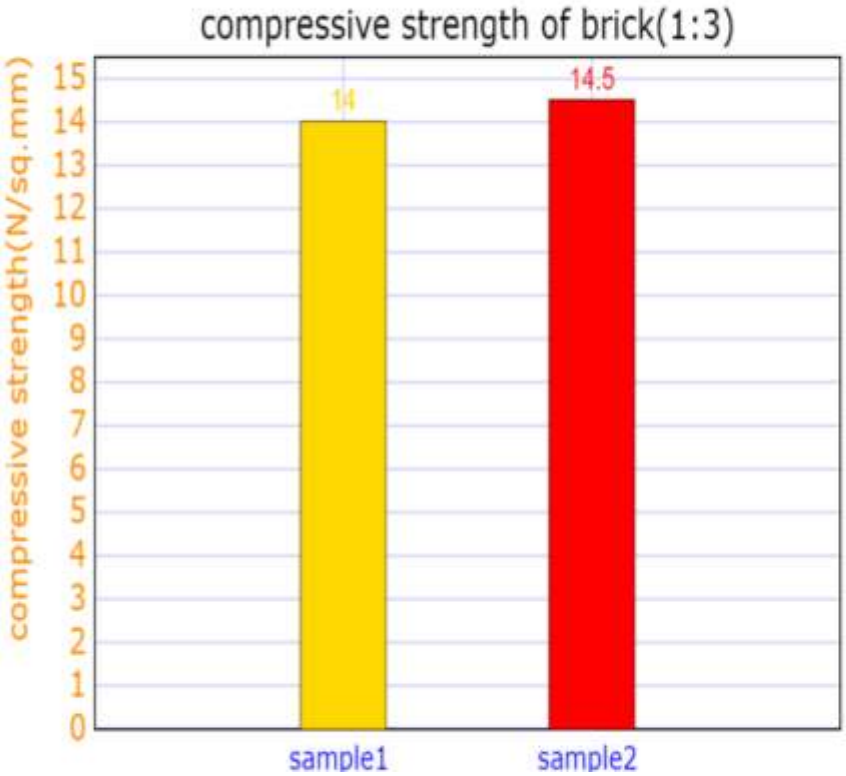

Figure 3 Compressive Strength of Brick Specimens with Mix Ratio 1:3

The compressive strength of bricks with a 1:3 mix ratio reflects their capacity to resist axial loads before failure. In this ratio, cement acts as the binding material while sand forms the major constituent. Bricks produced with a 1:3 mix generally exhibit moderate compressive strength, as the higher sand content can increase porosity and reduce density. Although such bricks may not achieve the highest strength compared to mixes with greater cement content, they offer benefits such as reduced weight and improved thermal insulation. The actual compressive strength depends on factors including material quality, manufacturing technique, curing conditions, and testing procedures. Therefore, proper engineering evaluation is required to assess their suitability for specific construction applications.

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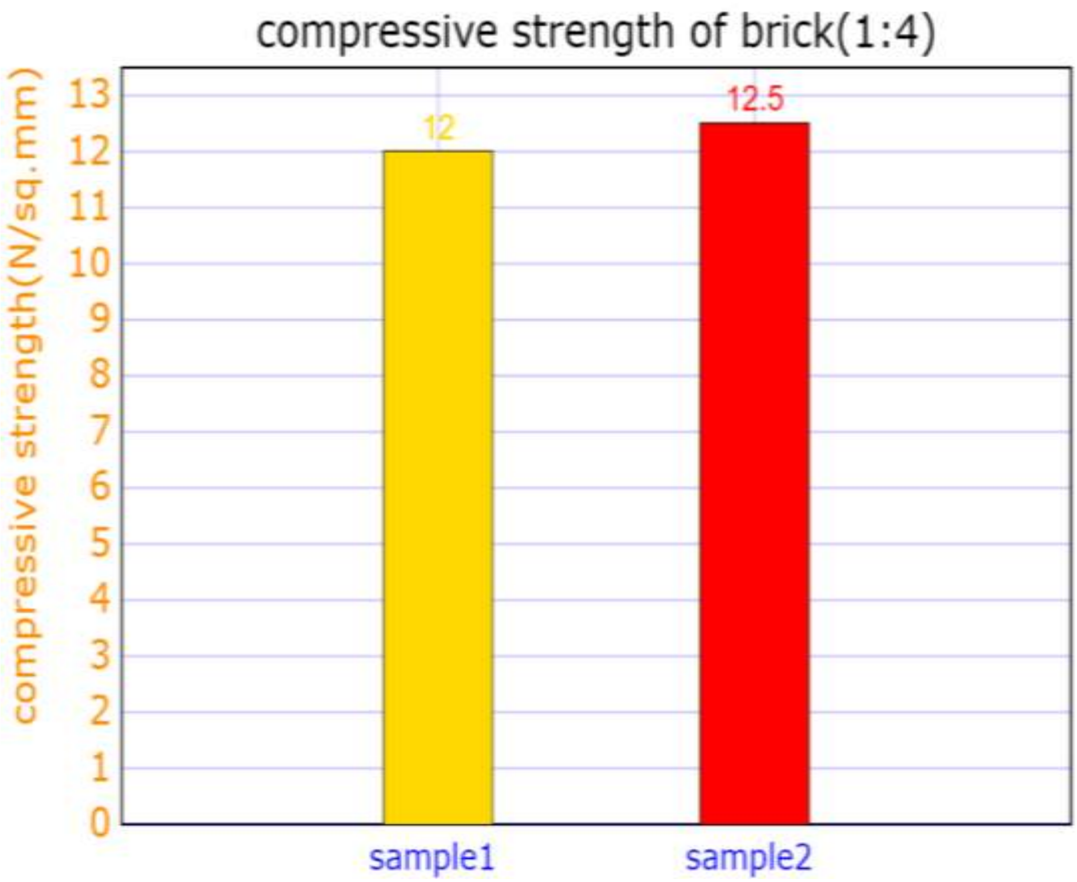

Figure 4: Compressive Strength of Brick Samples with 1:4 Mix Ratio

The compressive strength of bricks with a 1:4 mix ratio indicates their ability to withstand axial loads without failure. In this proportion, cement acts as the binder while sand constitutes the major component. Bricks produced with a 1:4 mix typically show moderate compressive strength, as the higher sand content increases porosity and reduces density. Although their strength may be lower than mixes with higher cement content, these bricks offer benefits such as reduced weight and improved thermal insulation. The actual strength performance varies with material quality, production methods, curing conditions, and testing procedures. Therefore, engineering evaluation is essential to determine their suitability for specific construction applications.

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Figure 5: Effect of Curing Period on Compressive Strength of Bricks (1:1:3 Mix)

The compressive strength of bricks with a 1:1:3 mix ratio reflects their ability to resist axial loads without failure. In this proportion, cement and lime act as binding materials, while sand improves workability and reduces shrinkage during curing. Bricks produced with this mix generally exhibit good compressive strength, resulting in dense and durable units suitable for structural applications. However, the actual strength may vary depending on material quality, manufacturing process, curing conditions, and testing methods, making engineering evaluation essential.

The water absorption test is conducted to determine the amount of moisture absorbed by bricks under severe exposure conditions. This test is important for assessing brick quality, durability, and resistance to weathering, which directly influences their long-term performance in construction.

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Water absorption for mix design (1:3)

Sample	Initial weight(kg)	Final weight(kg)	Percentage of absorption
1	3.125	3.235	3.5%
2	3.210	3.315	3.27%

The water absorption behavior of the brick samples was evaluated by measuring the change in weight before and after water immersion. Table X presents the initial dry weight, final wet weight, and percentage of water absorption for the two samples. Sample 1 showed an increase in weight from 3.125 kg to 3.235 kg, corresponding to a water absorption of 3.5%. Sample 2 increased from 3.210 kg to 3.315 kg, resulting in a slightly lower absorption of 3.27%.
Both samples exhibited low water absorption values, indicating good resistance to moisture ingress. This performance can be attributed to the presence of plastic in the brick composition, which reduces porosity and limits water penetration compared to conventional clay bricks. Low water absorption enhances durability, minimizes moisture-related deterioration, and improves performance in humid or wet conditions. Overall, the results confirm that plastic-based bricks possess favorable water absorption characteristics, making them suitable for non-load-bearing and low-stress construction applications where moisture resistance is essential.
Percentage of absorption = ((Final weight - Initial weight) / Initial weight) * 100
= ((3.235 kg - 3.125 kg) / 3.125 kg) * 100
= (0.11 kg / 3.125 kg) * 100
≈ 3.5%
For Sample 2, the initial weight was 3.210 kg, and its final weight after absorption became 3.315 kg. The percentage of absorption for Sample 2 is calculated as: Percentage of absorption = ((3.315 kg - 3.210 kg) / 3.210 kg) * 100
= (0.105 kg / 3.210 kg) * 100
≈ 3.27%
These percentage values indicate the amount of moisture absorbed by each sample during the absorption process. A higher absorption percentage reflects greater material uptake, which is directly related to the porosity of the material. Such results are important for understanding the absorption behavior and durability of the material, particularly in evaluating its suitability for applications where moisture resistance and long-term performance are critical, such as in construction and related engineering fields.

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Sample	Initial weight(kg)	Final weight(kg)	Percentage of absorption
1	3.360	3.510	4.4%
2	3.405	3.550	4.25%

Water absorption for mix design (1:4)

The moisture resistance of plastic waste bricks prepared with a 1:4 mix ratio was evaluated through a water absorption test by measuring the dry and wet weights of the specimens after immersion. As shown in Table X, Sample 1 recorded an increase in weight from 3.360 kg to 3.510 kg, corresponding to a water absorption of 4.4%. Similarly, Sample 2 increased from 3.405 kg to 3.550 kg, resulting in an absorption of 4.25%. Minor variations between the samples may be attributed to differences in compaction, plastic distribution, or internal pore structure.

Although the 1:4 mix exhibits slightly higher water absorption than mixes with greater plastic content, the values remain significantly lower than those of conventional burnt clay bricks. The presence of plastic in the brick matrix reduces porosity and limits capillary water penetration, thereby improving moisture resistance and durability. Overall, the results indicate that plastic waste bricks with a 1:4 mix ratio possess acceptable water absorption characteristics, making them suitable for non-load-bearing applications where moderate moisture exposure is expected.

For Sample 1, its initial weight was recorded as 3.360 kg. Following an absorption process, its weight increased to 3.510 kg. The percentage of absorption for Sample 1 is calculated as follows:

Percentage of absorption = ((Final weight - Initial weight) / Initial weight) * 100

= ((3.510 kg - 3.360 kg) / 3.360 kg) * 100

= (0.150 kg / 3.360 kg) * 100

≈ 4.4%

For Sample 2, the initial weight was 3.405 kg, and after undergoing an absorption process, its weight reached 3.550 kg. The percentage of absorption for Sample 2 is calculated as:

Percentage of absorption = ((Final weight - Initial weight) / Initial weight) * 100

= ((3.550 kg - 3.405 kg) / 3.405 kg) * 100

= (0.145 kg / 3.405 kg) * 100

≈ 4.25%

These percentage values represent the degree of moisture absorbed by each sample during the absorption process. Higher absorption percentages indicate a greater capacity of the material to take in fluids, reflecting its porosity and absorption behavior. Such information is important for evaluating material performance in applications where moisture interaction is critical, including construction materials and other engineering uses.

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Water absorption for mix design (1:1:3)

Sample	Initial weight(kg)	Final weight(kg)	Percentage of absorption
14 days curing	3.185	3.280	2.9%
28 days curing	3.205	3.305	3.1%

The water absorption test was conducted on brick specimens cured for 14 days and 28 days to evaluate the effect of curing time on moisture absorption. The initial dry weight and final wet weight of each specimen were measured, and the corresponding percentage of water absorption was calculated, as summarized in Table X.

After 14 days of curing, the specimen showed an increase in weight from 3.185 kg to 3.280 kg, resulting in a water absorption of 2.9%. Similarly, the specimen cured for 28 days increased from 3.205 kg to 3.305 kg, corresponding to a slightly higher absorption of 3.1%. The marginal increase in water absorption with extended curing may be attributed to minor changes in the internal pore structure due to improved bonding within the brick matrix.

Both curing periods exhibited low water absorption values, indicating good resistance to moisture ingress. The results confirm that curing time has minimal influence on the water absorption behavior of plastic waste bricks, supporting their suitability for non-load-bearing applications in environments exposed to moderate moisture.

Percentage of absorption = ((Final weight - Initial weight) / Initial weight) * 100

= ((3.280 kg - 3.185 kg) / 3.185 kg) * 100

= (0.095 kg / 3.185 kg) * 100

≈ 2.9%

Similarly, for the sample that underwent "28 days curing", its initial weight was 3.205 kg, and its final weight after the curing period reached 3.305 kg. The percentage of absorption for this sample is calculated as:

Percentage of absorption = ((Final weight - Initial weight) / Initial weight) * 100

= ((3.305 kg - 3.205 kg) / 3.205 kg) * 100

= (0.1 kg / 3.205 kg) * 100

≈ 3.1%

These percentage values represent the weight gain of the specimens due to absorption during curing. The variation between curing periods indicates differences in the amount of material absorbed over time. Such information is important for understanding material behavior during curing and for evaluating performance in construction, materials science, and manufacturing applications.

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Conclusion

This experimental study evaluated the performance of plastic waste–based bricks with the aim of assessing their suitability as sustainable construction materials. The results demonstrate that bricks manufactured using plastic waste exhibit satisfactory compressive strength, low water absorption, and good durability, indicating their potential for non-load-bearing and low-stress structural applications. The hydrophobic nature of plastic significantly reduces porosity, which limits moisture ingress and enhances resistance to environmental deterioration compared to conventional clay bricks. Experimental observations also revealed that mix proportions, plastic content, and curing duration play important roles in influencing strength development and moisture resistance, emphasizing the need for controlled production methods to achieve consistent quality. The gradual improvement in mechanical properties with increased curing time further confirms the stability and reliability of the brick matrix. In addition to technical performance, the reuse of plastic waste in brick production offers notable environmental benefits, including reduced landfill disposal, conservation of natural aggregates, and lower energy consumption. These advantages align well with sustainable construction and circular economy principles. The findings confirm that plastic waste–based bricks represent a viable and eco-friendly alternative to traditional masonry units. However, further investigations are recommended to evaluate long-term durability, fire resistance, large-scale production feasibility, and compliance with building standards to support wider adoption in the construction industry.

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