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# Development of Eco-Friendly Eco Lite Bricks using Waste Plastic Powder and Waste Glass Powder

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**Abstract**

Recycling plastic waste is vital for addressing environmental pollution, conserving resources, and promoting sustainability. With advancements in recycling technologies and increased awareness, it is possible to mitigate the harmful effects of plastic waste while creating new opportunities for innovation and economic growth. This study explores Eco Lite Bricks, an innovative building material made from waste plastic powder, glass powder, cement, and a foaming agent. These bricks provide a sustainable waste management solution and offer improved insulation and reduced density. Preliminary results show that Eco Lite Bricks have favorable mechanical properties and durability, making them a viable alternative to traditional bricks, enhancing construction industry sustainability and addressing waste disposal issues.

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## Introduction

Plastic waste has become one of the most pressing environmental crises of our era, with its effects rippling across ecosystems, wildlife, human health, and the global economy. While the convenience and adaptability of plastics have driven their widespread use, the scale of overproduction and overconsumption has tipped the balance, making the detrimental impacts far greater than the initial advantages. This growing issue demands urgent attention and action to mitigate its far-reaching consequences. Plastic waste has emerged as a global sustainability threat, affecting ecosystems, human health, and economies. Its persistence in the environment, combined with unsustainable disposal practices, poses significant challenges. Plastics take hundreds of years to degrade, leading to accumulation in landfills and natural habitats. Also, degraded plastics break into tiny particles (micro-plastics) that contaminate water, air, and soil, infiltrating food chains. Incinerating plastic releases harmful gases like dioxins, furans, and carbon monoxide, contributing to air pollution and respiratory illnesses.

Globally, the packaging sector accounts for approximately 42% of total plastic consumption, making it the largest end-use market for plastics[1,2] I During 2023-2024, India produced around 9.3 million tons of plastic waste each year, highlighting its role as a major contributor to global plastic pollution. This

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staggering number represents nearly 20% of the global plastic waste total, underscores the critical importance of implementing effective waste management strategies and sustainable solutions to address this growing environmental crisis. The plastic waste generated in India as per the information provided by MoEFCC, India given in the fig 1.

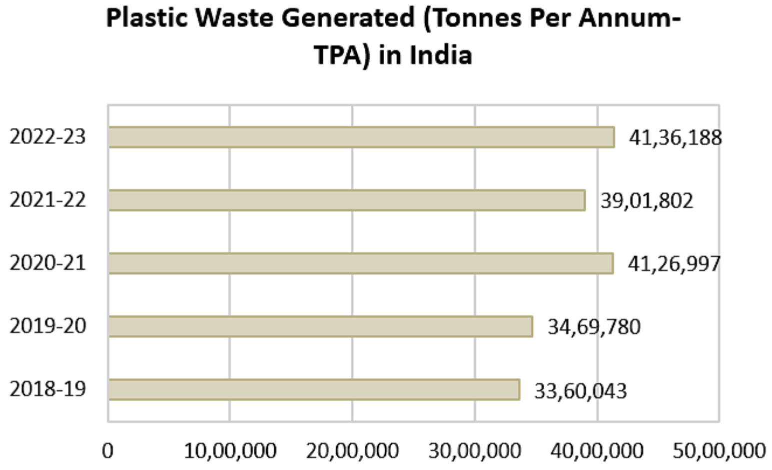


**Fig. 1: Plastic Waste Generated (Tonnes Per Annum- TPA) in India**

Recycling the plastic waste is a critical step toward mitigating the detrimental effects of plastic pollution on the environment, human health, and the economy. With the exponential growth in plastic production and its widespread use, efficient recycling practices are essential to address the challenges posed by plastic waste.[3] The incorporation of plastic waste in construction presents an innovative and effective solution to reducing plastic pollution while promoting sustainable building practices. By repurposing plastic waste into construction materials, this approach not only diverts waste from landfills and the environment but also contributes to resource conservation and the development of eco-friendly infrastructure.

Recycling plastic into brick manufacturing is a novel and green initiative to addressing plastic waste, which is a significant environmental concern. This process transforms non-biodegradable plastic waste into useful construction materials, offering numerous benefits for sustainability and waste management. The development of Eco Lite bricks using waste materials is an innovative approach that addresses both environmental and construction industry challenges. This approach utilizes industrial and waste plastic as a key material in brick production, significantly reducing pollution, energy consumption, and raw material extraction.[3] The development of Eco-Lite Bricks has represented a major advancement in sustainable construction materials, offering a solution to the environmental challenges linked to conventional clay and cement bricks, including resource depletion and pollution. Manufactured using recycled or sustainable materials, these bricks help minimize waste and lower the environmental impact of the construction industry.[4,5]

India's economy is growing rapidly, with a target annual growth rate of 9%.[6] This growth, coupled with increasing urbanization and population, is driving the demand for housing, infrastructure, and commercial buildings. The building construction sector is projected to grow at 6.6% annually until 2030, as 80% of the infrastructure required for India in 2030 is yet to be built.[6] This will significantly increase the demand for bricks and other construction materials. Traditional brick manufacturing in India relies heavily on agricultural clay, which is extracted from topsoil. This practice depletes fertile land, negatively impacting agriculture and food security. Also, the brick industry is energy-intensive and contributes to air pollution, deforestation (due to the use of firewood in kilns), and greenhouse gas emissions.[7,8]

Growing urbanization generates large volumes of waste such as fly ash, slag, plastic, and construction debris. Using these wastes to make Eco Lite bricks helps in managing waste effectively, thus reducing the burden on landfills. The development of Eco Lite bricks using waste materials offers a sustainable, eco-friendly alternative to traditional construction materials. By addressing both waste management and the environmental impacts of the construction industry, this innovation paves the way for a more sustainable future.[9] Their lightweight design improves transportation and handling efficiency, while their thermal properties enhance insulation, leading to energy savings and increased comfort. As communities prioritize sustainability, Eco Light Bricks represent a major step towards greener construction practices.[10]

A practical investigation was conducted to develop a building brick, using waste glass powder & waste plastic which enhances the energy efficiency of the building while simultaneously promoting sustainability.[11] Implement measures to address soil erosion, fostering environmental sustainability and supporting soil health.[12,13] By recycling waste, the goal was to reduce pollution, benefiting both the environment and the economy. Additionally, the experiment studied effect of foaming agent on the strength of bricks.

Studies have been conducted on manufacturing bricks using waste glass powder and plastic materials. The impact of these additives on compressive strength, density, and water absorption capacity has been analyzed. High-Density Polyethylene (HDPE) was incorporated into cement at varying percentages to produce plastic bricks. Researchers assessed the bricks mechanical and physical properties, including compressive strength, density, and water absorption behavior. The experimental data demonstrated that compressive strength values remained within the 2000 psi (13.79 MPa) specification limit for HDPE concentrations not exceeding 35%.[14] Several studies have examined the influence of waste glass additives on both the physical characteristics and mechanical performance of brick specimens. Brick specimens were manufactured by substituting natural clay with waste glass at replacement levels of 2%, 4%, 10%, 16%, 30%, and 40% by weight. Results indicated that incremental additions of waste glass consistently enhanced compressive strength while simultaneously decreasing water absorption in the brick specimens.[15] Recent studies have investigated the incorporation of waste glass powder (WGP) as a partial clay substitute in the production of fired clay bricks. The optimum WGP content was found to be 20% by weight, leading to an 8.5% water absorption rate and a 77% improvement in compressive strength. The study included comprehensive compressive strength analysis of innovative brick formulations incorporating waste plastic, sand, and glass in varying proportions. The optimal composition was identified as a 3:4:1 plastic-sand-glass mixture, achieving 7.45 MPa compressive strength.[17] Also investigation was conducted on the substitution of glass powder as a partial clay replacement in traditional fired brick manufacturing processes. The results showed that substituting 5-15% of clay with glass powder reduced water absorption by 9-16%, with higher replacement percentages yielding greater improvements in impermeability. However, when plastic powder was used as a replacement (5%–20%), water absorption increased by 9%–17%. This indicates that while glass powder enhances the durability of fired clay bricks, excessive plastic powder content may negatively impact their water resistance.[18] A study has been conducted on a composite brick (190×90×90 mm), incorporating fly ash, polymer, glass powder, and gypsum as constituent materials. The incorporation of plastic in the mix has significantly reduced thermal conductivity while enhancing resilience against seismic forces.[19]

**Table 1: Specification of Cement**

| Properties | Results | Standard Specifications |
|---|---|---|
| Specific Gravity | 3.16 | 3.15 |
| Setting time (Initial) | 35min | Not less than 30 minutes |
| Setting time (Final) | 540min | Not more than 600 minutes |
| Fineness Test | 6.6% | Should not exceed 10% |
| Normal consistency of Cement | 28% | 33% |

## Materials and Methods

### Materials

#### Cement

In this study, UltraTech OPC 53 Grade cement was employed. This sort of cement has a specific gravity of 3.16 and with a standard consistency is 28%.

#### Waste Glass Powder

Waste Glass Powder is a finely ground material produced from recycled glass. It is increasingly being used in various industries, particularly in construction, to promote sustainability and reduce waste. By integrating waste glass powder into construction materials like bricks and concrete, industries can reduce landfill contributions while also improving the strength and quality of the final products.[20,21] It is conveyed by crushing or pounding waste glass into fine particles, which are then organized, assembled by size, and use in various current applications. it including high silica content and controlled particle size scattering, make it suitable.

**Table 2: Specification of Waste Glass Powder**

| Tests | Protocol | Result |
|---|---|---|
| Loss on Ignition (LOI) @ 550°C | IS 1917:PART 1:1991 | 0.32% |
| Silica as SiO2 | (Reaff.2006) | 75.31% |
| Alumina as Al2O3 | | 1.11% |
| Calcium as CaO | | 8.83% |
| Magnesium as MgO | | 2.80% |
| Sodium as Na2O | | 10.77% |
| Potassium as K2O | | 0.41% |

#### Waste Plastic Powder

Waste plastic powder is created by collecting, cleaning, shredding, and grinding plastic waste (such as polyethylene, polypropylene, and other plastics) into a fine powder form. It is made by crushing plastic waste and milled into little particles, regularly going from micrometres to millimetres in size. It includes various types of plastics, it includes Polyethylene Terephthalate (PET), Polyvinyl Chloride (PVC), Polystyrene (PS) and Polypropylene (PP). Waste plastic powder represents a promising avenue for promoting sustainability in construction and manufacturing.[22] By converting plastic waste into usable materials, it not only helps reduce pollution but also contributes to the development of lightweight, durable, and energy-efficient products. When used in combination with other waste materials, like glass powder or foaming agents, waste plastic powder offers a pathway to creating environmentally-friendly building solutions while reducing the environmental burden of plastic waste.[23,24] T This study utilized plastic particles that passed through a 2.36 mm sieve.

#### Foaming Agent (As Admixture)

A foaming agent, when incorporated as an admixture in brick mortar, plays a vital role in enhancing the material's properties, particularly by reducing density and improving insulation. It functions by introducing air bubbles into the mortar mix, resulting in a lightweight, energy-efficient material. This method is widely employed in the production of lightweight concrete, foam bricks, and energy-efficient masonry. For lightweight brick production, the foaming agent works by trapping air within the concrete mixture. When water is added, it generates a stable foam, which is then blended with cement slurry to create a durable and lightweight construction material. This process not only reduces the overall weight of the bricks but also enhances their thermal and acoustic insulation properties.

**Table 3: Specification of Foaming Agent**

| Brand Name | Marjanol® |
|---|---|
| Classification | Animal protein- based agent |
| Usage | Construction |
| Purity | 95% |
| Colour | Dark Brown |
| pH | 8.0-9.0 |

#### Water

The quality of water used in concrete production is crucial for ensuring consistency and quality control in the final product. High-quality water for both mixing and curing is essential to maintain the desired properties of eco-friendly bricks, which is critical for achieving optimal performance. Impurities in water, such as organic materials, oils, or excessive minerals, can disrupt the hydration process, negatively impacting the strength and durability of the concrete. Incorporating glass powder into the mix can enhance the concrete's performance by contributing to pozzolanic activity. Water in the mix activates these pozzolanic properties, promoting better bonding and the formation of additional compounds that improve strength and durability. While plastic particles do not participate in the hydration reaction, they still play a role in the overall mix design. The water used must ensure that the plastic particles are adequately wetted and evenly dispersed throughout the concrete, which helps achieve uniformity and workability in the final product. This careful balance of materials and water quality is key to producing high-performance, eco-friendly bricks.

**Experimental Investigation**

In this study, a trial-and-error approach was employed for the mix design. Five distinct brick compositions were prepared, as illustrated in Figure 2, with the quantities of cement and foaming agent kept constant across all mixes. The proportions of waste glass powder and waste plastic powder were adjusted by ±5% in each composition to evaluate their impact on the final product. This method allowed for a systematic exploration of how varying the amounts of these waste materials influences the properties of the bricks. The details of mix compositions are shown in Table 4.

**Table 4: Mix Proportion**

| Mix Ratios | | | | | |
|---|---|---|---|---|---|
| **Materials** | **M**I | **M** II | **M** III | **M** IV | **M** V |
| Cement | 50% | 50% | 50% | 50% | 50% |
| Waste Glass Powder | 20% | 25% | 30% | 35% | 40% |
| Waste Plastic Powder | 30% | 25% | 20% | 15% | 10% |
| Foaming Agent (1:6) | 8ml of foaming agent with 48ml of water | | | | |
| Water | w/c Ratio 0.45 | | | | |

**Casting and Curing**

The test specimens were cast in 200 mm × 100 mm × 60 mm moulds The prepared mixture was carefully poured into these moulds and compacted to remove any air voids. The samples were then left undisturbed for 24 hours to allow the mixture to harden and gain its initial strength. After this initial setting period, the demoulded samples were placed in water for curing. The curing process lasted for 7, 14, 21, and 28 days, depending on the required testing age. This water curing ensures continuous hydration, enabling the samples to develop sufficient strength over time and achieve their full potential in terms of durability and performance.

**Results**

**Tests on Bricks**

**Water Absorption Test**

Water absorption is a critical property to evaluate in lightweight bricks, as it directly impacts their durability, strength, and thermal performance. Lightweight bricks are inherently porous due to the use of foaming agents, which increases water absorption. The use of materials such as recycled plastics, glass powder, can influence water absorption rates. Standard bricks typically exhibit water absorption rates less than 12%, while lightweight bricks, owing to their porous structure, often show higher absorption rates, sometimes exceeding 20%, depending on the materials used and the manufacturing process.[25]

The inclusion of waste glass and plastic can influence the water absorption rates of bricks.[20] High water absorption often indicates increased porosity, which may compromise the bond between the brick and mortar, resulting in problems like creep and shrinkage and shorten its lifespan. Increasing the glass powder content in the composite sample leads to a reduction in the water absorption rate. Table 5 and fig 3 shows the average water absorption of the brick for different mix proportions. It is observed from the results that water absorption percentage decreases with increase in percentage of glass powder.

**Table 5: Average water absorption for different mix proportions.**

| Mix | % of Water Absorption |
|---|---|
| M I | 5.459 |
| M II | 4.733 |
| M III | 4.985 |
| M IV | 4.811 |
| M V | 4.129 |

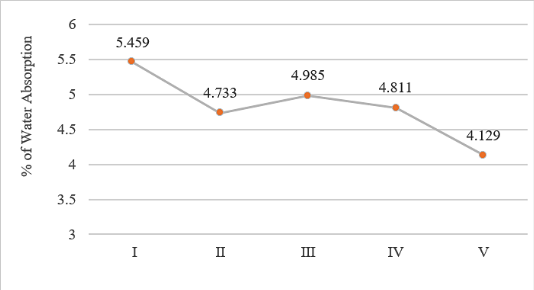


**Fig 3: Water Absorption of Bricks**

### Test on Density

Density is determined in accordance with IS 1528: Part 15: 2020. As a fundamental physical property, density provides insight into the amount of material present within a given volume. The density of bricks produced using a combination of waste glass powder, waste plastic powder, and foaming agents can vary significantly depending on the mix design and proportions of these materials. Typically, bricks incorporating these components exhibit densities ranging from 1,400 to 1,500 kg/m³, influenced by the specific ratios of the materials used.[26] Incorporating these materials improves the bricks' thermal and acoustic insulation characteristics, broadening their potential applications. The dimensions of the brick studied were 0.2 m x 0.1 m x 0.06 m. The foaming agent, in particular, introduces air voids into the mix, which substantially reduces the overall density of the bricks. The density of eco-lite bricks increases as the glass powder content rises and the plastic powder content decreases. This trend occurs because glass powder contributes to a denser and more compact structure, while plastic powder, being lighter, reduces overall density when present in higher proportions. Results are given in Table 6

**Table 6: Density for different mix proportions.**

| Mix | Average Dry Weight (kg) | Volume ($m^3$) | Density ($kg/m^3$) |
|---|---|---|---|
| M I | 1.740 | 0.0012 | 1450 |
| M II | 1.761 | 0.0012 | 1468 |
| M III | 1.765 | 0.0012 | 1470 |
| M IV | 1.782 | 0.0012 | 1485 |
| M V | 1.816 | 0.0012 | 1513 |

### Compression Strength Evaluation

Compressive strength serves as a key indicator of lightweight bricks' structural integrity and their applicability in construction projects. The compressive strength of lightweight bricks, tested in compliance with IS 3495 (Part 1): 1992, serves as the primary determinant of their structural performance and construction applicability. While there is no specific IS code exclusively for lightweight bricks, they are generally expected to meet the same standards as conventional bricks, depending on their application. However, lightweight bricks often have lower compressive strength (ranging from 2.5 to 7.5 MPa) due to their porous structure and reduced density. The proportion of waste materials (such as glass powder, plastic powder) and binders (like cement) significantly affects the compressive strength. While lightweight bricks may have lower compressive strength compared to conventional bricks, they offer advantages such as reduced weight, better insulation, and eco-friendliness.

The type and proportion of materials used, such as glass powder, plastic powder, and foaming agents, have a significant impact on the compressive strength of lightweight bricks. Generally, lightweight bricks made with waste materials like plastic and glass tend to have lower compressive strength compared to traditional concrete or clay bricks. However, the inclusion of these waste materials is primarily aimed at enhancing sustainability and reducing the environmental footprint of construction materials.[27,28]

Specimens were tested for compressive strength after curing periods of 7, 14, and 28 days. The compressive strength characteristics of bricks across different mix formulations are illustrated in Table 7 and Figure 4. The results indicate that compressive strength increases with higher glass powder content but decreases with higher waste plastic content. Bricks with a higher proportion of glass powder and lower plastic powder tend to have increased compressive strength.[29] The pozzolanic activity of glass powder enhances the strength, while lower plastic content reduces porosity.[30] On the contrary, greater proportions of waste plastic powder weaken compressive strength. Figure 5 presents the variation in compressive strength relative to brick weight. This decline can be attributed to the plastic's lower binding capacity compared to traditional materials and its tendency to create weak points in the structure, compromising overall strength.

The compressive strength of first-class bricks typically ranges from 10 to 14 N/mm². Based on the test results, it was observed that Mix 2 to Mix 5 achieved compressive strengths comparable to those of first-class bricks. Since the study aimed to develop a mix composition that optimizes the use of waste plastic and waste glass, the Mix 2 can be identified as the better mix composition. This mix not only meets the strength requirements of first-class bricks but also effectively incorporates waste materials, aligning with the goal of creating sustainable and eco-friendly construction materials.

**Table 7: Average compressive strength for different mix proportions.**

| Mix Ratios | | | | | |
|---|---|---|---|---|---|
| **Age (Days)** | **M** I | **M** II | **M**III | **M** IV | **M** V |
| 7 Days (N/mm$^2$) | 5.53 | 6.57 | 6.42 | 7.35 | 8.50 |
| 14 Days (N/mm$^2$) | 7.68 | 8.92 | 8.82 | 10.15 | 11.67 |
| 28 Days (N/mm$^2$) | 8.53 | 9.76 | 9.81 | 11.22 | 12.92 |

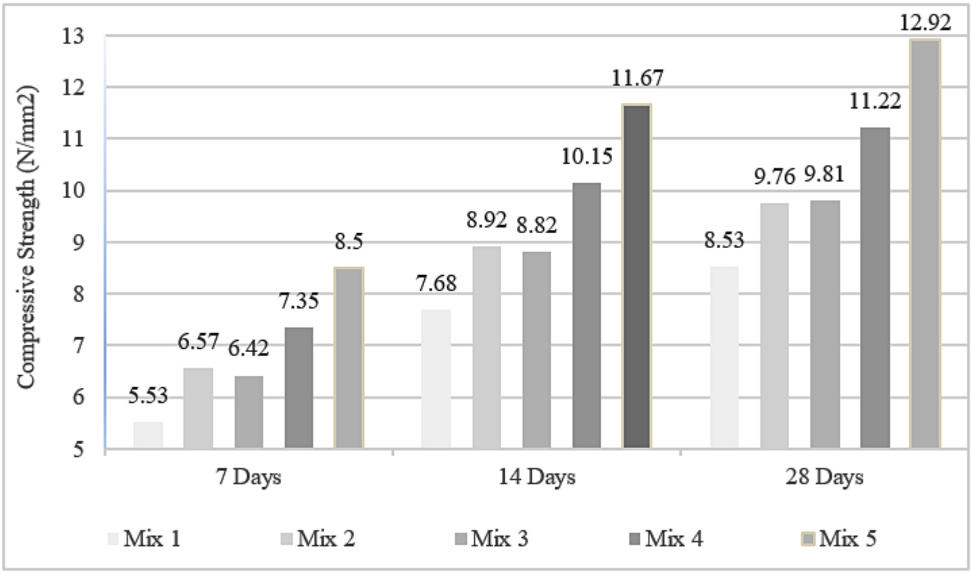


**Fig. 3: Compressive strength of different mix combinations**

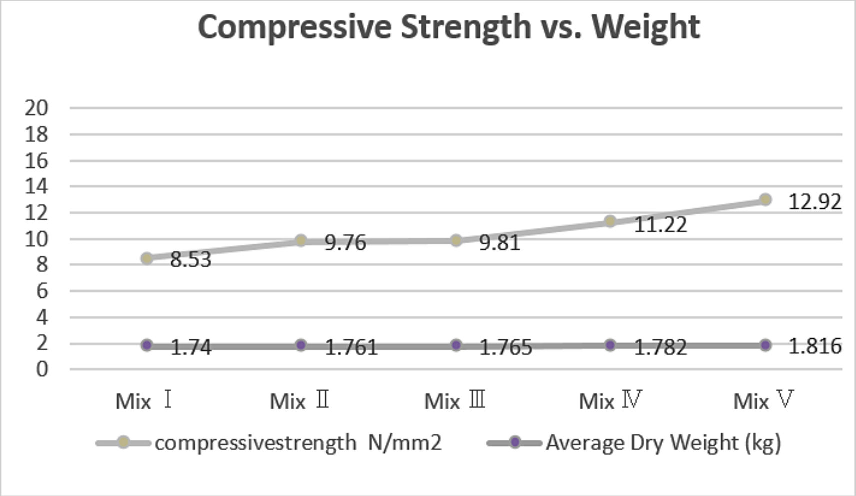


**Fig. 4: Compressive strength vs Weight of the bricks**

## Discussion

The compressive strength of bricks improves as more waste glass powder is incorporated and waste plastic powder is reduced. This is due to the glass powder's pozzolanic properties, which enhance binding and create a denser, stronger material. While Mix 5 achieves the highest compressive strength, Mix 2 is preferred because it strikes a balance in the use of both waste glass and waste plastic.Water absorption values, ranging from 4.129% to 5.459%, indicate variations in porosity and hydrophilicity among the mixes. The higher water absorption in Mix I, with more waste plastic, highlights the impact of porosity on a material's ability to absorb water. Waste plastic, being more porous, creates a more open structure, allowing for greater water uptake. On the other hand, the higher waste glass powder content in Mix V results in a denser structure, reducing the material's ability to absorb water and contributing to lower porosity.

Mix V, with its higher density, would indeed be stronger and more suited for structural applications, where load-bearing capacity and durability are essential. Its denser structure provides the necessary strength for buildings or walls that need to withstand significant forces. On the other hand, Mix II, with its lower density, offers enhanced thermal insulation, which is a valuable property for energy-efficient buildings. These bricks could be ideal for non-load-bearing walls, partitioning, or even as cladding material, where insulation is a priority over strength. Mix 2 provides a sustainable solution by optimizing the incorporation of waste materials while maintaining sufficient compressive strength for practical applications. This approach supports resource efficiency and environmental sustainability without significantly compromising performance, making it an ideal choice for eco-friendly construction.

## Conclusion

The key objectives of the study were successfully met, underscoring the critical role of recycling waste materials for construction applications. The experiments demonstrated that incorporating waste glass powder and waste plastic into building blocks not only improves their energy efficiency but also supports the overarching goal of advancing sustainable building practices. This approach highlights the potential of using waste materials to create eco-friendly, high-performance construction solutions.

The results highlight the potential of materials like waste glass powder and waste plastic to revolutionize the construction industry by sustainable approach that addresses both plastic waste management and the need for eco-friendly construction materials, leading to lower carbon footprints and more efficient resource utilization. Replacing virgin resources (e.g., clay, sand) with waste materials in brick production lowers environmental demand for natural raw materials.

Plastic waste exhibits non-biodegradable characteristics, persisting in ecosystems for centuries, whereas glass waste, while chemically inert, requires extremely prolonged periods for natural decomposition. By incorporating these materials into bricks, the volume of waste sent to landfills is significantly reduced. This approach not only reduces the accumulation of these harmful materials in landfills but also promotes sustainable waste management by transforming them into valuable construction products.

Future research in this area could focus on optimizing the mix design, improving material durability, and expanding the applicability of these eco-friendly blocks across various construction scenarios. Continued efforts in this direction could further enhance their performance, paving the way for a greener and more sustainable construction industry.

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**Ethics Statement**
This research did not involve human participants, animal subjects, or any material that requires ethical approval.

**Informed Consent Statement**
This study did not involve human participants, and therefore, informed consent was not required.

**Author Contributions**

- **Geena George:** Conceptualization, Methodology, writing, and final approval of the manuscript
- **Ubhale Shivanand Akhilesh:** Resources, Data Collection, Analysis,

## References

1. Rumana Hossain Md Tasbirul Islam *et.al*; Plastic Waste Management in India; Challenges, Opportunities and Road map for Circular Economy, *Sustainability* 2022,14(8) https://doi.org/10.3390/su14084425
2. Abdul Rafey, Faisal Zia Siddiqui, A review of plastic waste management in India – challenges and opportunities, *International Journal of Environmental Analytical Chemistry* 2021, 103(16) https://doi.org/10.1080/03067319.2021.1917560
3. Shelby Browning, Betsy Beymer-Farris, Jeffrey R Seaym, Addressing the challenges associated with plastic waste disposal and management in developing countries, *Current Opinion in Chemical Engineering* 2021,32 https://doi.org/10.1016/j.coche.2021.100682
4. Md. Golam Kibria, Nahid Imtiaz Masuk *et.al*; Plastic Waste: Challenges and Opportunities to Mitigate Pollution and Effective Management, *Int J Environ Res* 2023, 17(20), https://doi.org/10.1007/s41742-023-00507-z
5. Joan Nyika, Megersa Dinka, Recycling plastic waste materials for building and construction materials: A minireview, *Materials Today: Proceedings*, 2022, 62(6) https://doi.org/10.1016/j.matpr.2022.04.226
6. Nabil Hossiney, Pranab Das, Mothi Krishna Mohan, Jaison George, In plant production of bricks containing waste foundry sand-A study with Belguam foundry industry, *Case Studies in Construction Materials,* 2018,9 https://doi.org/10.1016/j.cscm.2018.e00170
7. D. Muheise-Araalia, S. Pavia, Properties of unfired, illitic-clay bricks for sustainable

construction, *Construction and Building materials,*2021,265,121118, https://doi.org/10.1016/j.conbuildmat.2020.121118

8. Putu Cinthya Pratiwi Kardita, Muhammad Maheswara Aryasatya,*et.al*; ,Material innovation and performance analysis of eco -friendly brick, *AIP Conf. Proc.* 2024,3110, 020059 , https://doi.org/10.1063/5.0204740
9. Rishabh Kumar, Mohit Kumar, Inder Kumar, Deepa Srivastava, A review on utilization of plastic waste materials in bricks manufacturing process, *Materials Today: Proceedings* 2021, 46 ,6775-6780 https://doi.org/10.1016/j.matpr.2021.04.337
10. Sherif H. Helmy,Ahmed M. Tahwia ,Mohamed G. Mahdy, Development and characterization of sustainable concrete incorporating a high volume of industrial waste materials, *Construction and Building Materials,* 2023, 365, 130160 https://doi.org/10.1016/j.conbuildmat.2022.130160
11. Aneke Frank Ikechukwu, Celumusa Shabangu, Strength and durability performance of masonry bricks produced with crushed glass and melted PET plastics, *Case Studies in Construction Materials*, 2021, 14 https://doi.org/10.1016/j.cscm.2021.e00542
12. Ebadi Jamkhaneh, M., Ahmadi, M., Shokri Amiri, M. Sustainable reuse of inorganic materials in eco-friendly clay bricks: Special focus on mechanical and durability assessment. *J. Mater. Civ. Eng.* 2021, 33(6), 04021111 https://doi.org/10.1061/(ASCE)MT.1943-5533.0003737
13. Sherif H Helmy, Ahamed M Tahwiah *et.al*, The Use of Recycled Tire Rubber, Crushed Glass, and Crushed Clay Brick in Lightweight Concrete Production: A Review, *Sustainability*, 2023, 15(13), 10060 https://doi.org/10.3390/su151310060
14. Sabiha Sarwar, Molla Rahman Shaibur, Mohammed Sadid Hossain, *et.al*; Preparation of environmental friendly plastic brick from high-density polyethylene waste, *Case Studies in Chemical and Environmental Engineering*, 2023, 7, 100291, https://doi.org/10.1016/j.cscee.2022.100291.
15. Hasan, M.R., Siddika, A., Akanda, M.P.A. *et al*. Effects of waste glass addition on the physical and mechanical properties of brick. *Innov. Infrastruct. Solut.* 2021, 6, 36. https://doi.org/10.1007/s41062-020-00401-z
16. Tripathi, M., Chauhan, V.B. Evaluation of waste glass powder to replace the clay in fired brick manufacturing as a construction material. *Innov. Infrastruct. Solut.* 6, 134 (2021). https://doi.org/10.1007/s41062-021-00492-2
17. Badiea A.Mahyoub,,Amer H.Abdu ,Adel A. Ahmed, Ibtisam M. Kama, Utilization of plastic and glass waste mixed with sand as an alternative brick materials, *Zastita Materijala,* 2023,64 (4), https://doi.org/10.5937/zasmat2304392M
18. Rasool Dakhil Mohsin, Hayder Al-Khazraj, Sajid Kamil Zemam,*et.al*; Investigation of Wastes Plastic and Glass to enhance physical - mechanical properties of Fired Clay Brick, *Civil and Environmental Engineering*, 2023, 19(1) DOI: 10.2478/cee-2023-0022
19. Singh, A., Srivastava, A.K., Kumar, A. *et al*. Design for low thermal conductivity and low vibrational impact without efflorescence of the composite bricks developed by waste plastic resin/fly ash/glass powder/gypsum. *Int J Interact Des Manuf* 19, 949–960 (2025). https://doi.org/10.1007/s12008-023-01582-4
20. Anand Zanwar, Yogesh D Patil, Utilization of waste glass powder as a cementitious material in concrete, *IOP Conference Series: Materials Science and Engineering* 2021 , 1070 012040 http://dx.doi.org/10.1088/1757-899X/1070/1/012040
21. Abdel Tawab OF, Amin MR, Ibrahim MM, Abdel Wahab M, Abd El Rahman EN, *et al*. Recycling Waste Plastic Bags as a Replacement for Cement in Production of Building Bricks and Concrete Blocks. *J Waste Resour Recycl* 2020, 2(1), 202 https://www.researchgate.net/publication/339613441
22. Athithan, V., Natarajan, L.T.,Reuse of plastic waste as building materials to enhance sustainability in construction: a review. *Innov. Infrastruct. Solut*. 2023,8, 204 https://doi.org/10.1007/s41062-023-01169-8
23. Lamba, P., Kaur, D.P., Raj, S. *et al*; Recycling/reuse of plastic waste as construction material for sustainable development: a review. *Environ Sci Pollut Res*, 2023 ,29, 86156–86179. https://doi.org/10.1007/

s11356-021-16980-y

24. M Y Nurain Izzati, A Suraya Hani, S Shahiron *et.al*; Strength and water absorption properties of lightweight concrete brick, *IOP Conference Series: Materials Science and Engineering* 2018,513 012005 10.1088/1757-899X/513/1/012005
25. Izzati, M.N., Hani, A.S., Shahiron, S., Shah, A.S., Hairi,*et.al*; Strength and water absorption properties of lightweight concrete brick. In *IOP Conference Series: Materials Science and Engineering* 2019,513( 1), 012005 http://dx.doi.org/10.1088/1757-899X/513/1/012005
26. Singh, A., Srivastava, A.K., Kumar, A. *et al* , Design and development of plentiful fly ash-based glass powder-reinforced plastic composite bricks for low water absorption and high compressive and flexural strength. *Int J Interact Des Manuf* 2023,19, 939–948 https://doi.org/10.1007/s12008-023-01580-6
27. Aleena, J K and Sumaiha, S. and Aswathy, J., Sarath, S, An Experimental Study on Partial Replacement of M-Sand with Glass Powder in Plastic Sand Bricks. *IJRAR March* 2021, 8(1) https://ssrn.com/abstract=3867077
28. Prathik Kulkarni, Vikas Ravekar, P. Rama Rao *et.al*, Recycling of waste HDPE and PP plastic in preparation of plastic brick and *its mechanical properties, Cleaner Materials* 2022,5 https://doi.org/10.1016/j.clema.2022.100113
29. Singh, A., Srivastava, A.K., Singh, G., *et.al*; Utilization of Plastic Waste for Developing Composite Bricks and Enhancing Mechanical Properties: A Review on Challenges and Opportunities. *Advances in Polymer Technology*, 2023, 6867755. https://doi.org/10.1155/2023/6867755.
30. Md Raquibul Hasan, Ayesha Siddika,*et.al*, Effects of waste glass addition pm the physical and mechanical properties of brick, *Innovative Infrastructure Solution*, 2021, 6(36) https://doi.org/10.1007/s41062-020-00401-z