Environmental Impact of Using Waste Plastic in Plain Concrete in Eco-Friendly Bricks

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering



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Section: 25A

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Dedicated

to

"We dedicate this thesis to the innocent children of Milestone School, Uttara, Dhaka, Bangladesh who tragically lost their lives in the recent fighter jet accident. May their souls rest in eternal peace. This work also stands as a humble commitment toward creating a safer, greener, and more sustainable world for the generations to come."

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ABSTRACT

The fast expansion of global infrastructure activities is an apparent consequence of the development. The focus is on eco-friendly alternatives, such as concrete bricks, for soil bricks, in the context of sustainable construction. The aim is to explore the potential of mitigating the carbon footprint and the depletion of natural resources through the use of waste plastic, stone chips, gravel, and sand from Sylhet sand and river sand in concrete blocks. This approach not only provides a durability alternative to traditional materials but also helps tackle the plastic waste problem. It addresses some of the vital issues like the overall impact of durability, structural performance, public perception, compliance with standards, and regulations. Some building projects demonstrate the viability of using plastic in concrete bricks. These constructions serve as examples of innovative use of materials, economic efficiency, and enhanced strength. The findings indicate that concrete bricks can serve for many constructions works - a clear progress when compared to traditional construction materials. In general, this method seems to solve the problem of building durable structures, and gives people an opportunity to eliminate plastic waste in an environmentally friendly manner.

Keywords: *Sustainability, Construction, Plastic, Bricks, Durability*

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CHAPTER 1
INTRODUCTION

1.1 Background and Motivations

The rapid growth of the construction industry, driven by urbanization and infrastructure expansion, has led to a significant increase in the demand for construction materials such as cement, sand, and gravel. However, this growing demand has exacerbated environmental concerns, particularly in relation to resource depletion, energy consumption, and greenhouse gas emissions [1,2]. Cement production alone accounts for approximately 8% of global CO_2 emissions, while the indiscriminate extraction of sand from rivers has caused severe ecological disruption, including riverbank erosion and biodiversity loss [3,4].

In parallel, plastic pollution has emerged as one of the most critical environmental challenges of our time. Globally, 220 million tons of plastic waste—or 28 kg per person—will be produced in 2024. 69.5 million tons, or one-third, of this waste will be improperly handled and wind up in the environment [5] and only a fraction being recycled—large volumes of plastic end up in landfills or natural ecosystems, persisting for hundreds of years [6,7]. In response to these dual challenges, sustainable construction practices are increasingly exploring the integration of waste plastic into building materials as a potential solution for both waste management and resource conservation [7-9].

Among various sustainable materials, plastic sand bricks have gained notable attention due to their promising mechanical properties, low water absorption, and contribution to the circular economy. Several studies have demonstrated that integrating thermoplastics like polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET) into sand mixtures can produce bricks with compressive strengths ranging from 8 to 15 MPa, depending on the plastic type and proportion [1,2]. These bricks exhibit reduced water permeability and enhanced durability, making them suitable for non-load-bearing structures, walkways, boundary walls, and wall decoration materials block [10,11].

This study focuses on producing eco-friendly bricks using cement, 5–10 mm stone chips, gravel (<5 mm), Sylhet sand (FM 2.67), river sand (FM 1.7), and 20% waste plastic (by volume). Sylhet sand, known for its higher fineness modulus and strength, was combined with finer river sand to achieve an optimal aggregate blend. Prior research has shown that the right combination of fine and coarse sands can enhance brick performance by improving particle packing and reducing void content [12].

The objective of this paper is to develop a sustainable, cost-effective, and structurally viable brick that supports the goals of green engineering while mitigating plastic pollution. This paper details the material characterization, fabrication process, mechanical testing, and performance evaluation of the produced bricks. Ultimately, our findings aim to contribute to the growing body of knowledge in sustainable construction and circular material design, offering practical insights for waste valorization and green infrastructure development.

1.2 Research Overview

Natural resources depletion and environment pollution caused by plastic waste are two global problems of great concern. The current study aims the manufacturing of eco-friendly bricks as an alternative solution to commercial brick. 20% waste plastic by volume was used in combination of cement, Sylhet sand, river sand, stone chips and gravel. The objective of the study was to understand the feasibility of producing eco-friendly, structural bricks at a competitive price through engineering optimization with effort on sustainability of materials. Material characterization, eco-friendly, plastic–sand brick synthesis, and mechanical property evaluations including compressive strength, water absorption/pore permeability, and durability tests were performed. Comparisons with conventional material standards determine overall structural performance reliability and practicable application of the proposed work. This study envisions the basic development of an effective green construction material. In summation, this particular research on plastic valorization and sustainable material approach for infrastructure components was expected to have surprisingly lesser global/environmental impacts. This consequently generates likely benefits for the construction sector based on pollution-prevention technologies utilizing engineered plastic waste.

This thesis is organized into five chapters, each of which systematically presents different stages of the research. A brief overview of the content of each chapter is given below:

1.3 Research Objectives

The main objective of this study is to develop sustainable, cost-effective, and structurally viable bricks by incorporating waste plastic into concrete mixtures. The specific objectives are:

- To design and fabricate hollow and plain bricks using cement, Sylhet sand, river sand, stone chips, gravel, and varying percentages of waste plastic (2.5–20% by volume).
- To evaluate the mechanical properties of the bricks, including compressive strength, dry density, and water absorption.
- To assess the environmental benefits of incorporating plastic in bricks, including reductions in raw material usage and CO_2 emissions.
- To provide practical recommendations for producing eco-friendly bricks for sustainable construction applications.

1.4 Expected Outcomes

- Development of bricks that balance structural performance with environmental sustainability.
- Reduction of plastic waste and decreased consumption of traditional raw materials like cement and sand.
- Reduction of CO_2 emission from production of cement because of the plastic materials used in varying percentage.
- Reduction of CO_2 emission from production of bricks burning by the wood or coil burning.
- Generation of data on mechanical and durability performance of plastic-incorporated bricks for potential use in construction projects.
- Contribution to the growing body of knowledge on sustainable construction materials and circular economy practices.



Figure 1: CO_2 Emission from Cement Factory

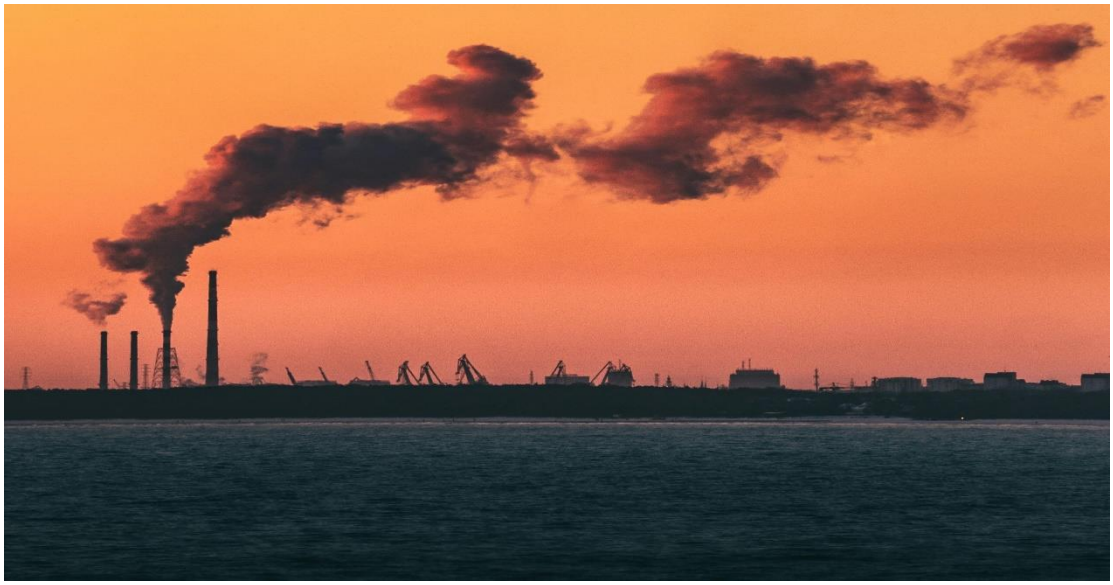


Figure 2: CO_2 Emission from Wooden or coil burn bricks.

CHAPTER 2
Literature Review

2.1 Introduction

This chapter provides a comprehensive review of existing research relevant to sustainable construction materials, with a particular focus on incorporating waste plastic into concrete and bricks. The review highlights the environmental and structural challenges associated with conventional construction materials and examines previous efforts to use recycled plastics as a partial replacement for aggregates. By analyzing both the strengths and limitations of earlier studies, this chapter identifies knowledge gaps and establishes the motivation for the present research.

2.2 Review of Related Works

2.2.1 Environmental Impact of Conventional Construction Materials

The production of cement, sand, and other construction materials contributes significantly to resource depletion and greenhouse gas emissions. Cement production alone accounts for about 8% of global CO_2 emissions, while unsustainable sand extraction disrupts ecosystems and reduces biodiversity. Studies have emphasized the urgent need for alternative materials to reduce environmental impact in the construction sector.

2.2.2 Plastic Waste and Recycling

Plastic pollution is a growing global concern, with hundreds of millions of tons of plastic waste generated annually. Only a small fraction of this waste is recycled, while the rest persists in landfills or natural environments. Researchers have explored using plastic waste in construction materials as a way to divert plastic from the environment and reduce dependence on traditional raw materials.

2.2.3 Plastic in Concrete and Bricks

Several studies have investigated the integration of thermoplastics such as polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET) into concrete and sand-based bricks. Results indicate that incorporating low percentages of plastic can produce bricks with adequate compressive strength (8–15 MPa), reduced water absorption, and enhanced durability, suitable for non-load-bearing structures. However, excessive plastic replacement can compromise mechanical properties due to poor bonding and increased void content.

2.2.4 Aggregate Optimization in Brick Production

Research has shown that combining fine and coarse aggregates can improve particle packing, reduce voids, and enhance the mechanical performance of bricks. The blending of Sylhet sand with finer river sand has been found effective in achieving an optimal aggregate mix, improving both strength and durability of eco-friendly bricks.

2.2.5 Research Gaps

Although previous studies demonstrate the feasibility of using plastic waste in construction, most focus on either small-scale experiments or specific plastic types. Limited work has been done on combining local aggregates with a higher percentage of waste plastic in both hollow and plain bricks, particularly in the context of balancing mechanical performance with environmental benefits. This research aims to address these gaps.

2.3 Summary

This chapter reviewed the existing literature on sustainable construction materials, plastic recycling, and eco-friendly brick production. Key findings indicate that low-percentage plastic incorporation can improve brick sustainability without significantly compromising strength. Identified gaps in prior research, such as limited studies on high plastic content and local aggregate optimization, provide the motivation for the present study. The next chapter will detail the methodology adopted to develop and test plastic-incorporated bricks.

CHAPTER 3
Methodology

3.1 Introduction

This chapter describes the materials, mix design, preparation procedures, and testing methods used in this study to produce and evaluate eco-friendly bricks incorporating waste plastic. Two types of bricks—hollow and plain—were prepared to investigate both performance and environmental impact. The methodology ensures reproducibility and provides a framework to assess mechanical properties, durability, and sustainability of the bricks.

3.2 Materials and Method

This study was conducted with two types of bricks (Hollow and Plain) to assess the environmental impact and performance of eco-friendly concrete bricks made with recycled plastic and locally available materials. Ordinary Portland Cement (OPC), conforming to ASTM C150 standards, was used as the main binding material. Fine aggregates consisted of a blend of 60% river sand with a fineness modulus (FM) of 1.80 and 40% Sylhet sand with an FM of 2.67. Coarse aggregates included gravel ranging from 0–5 mm (40% by volume) and stone chips ranging from 5–10 mm (60%), both having a fineness modulus of 4.44 [13]. The recycled plastic used in this study was sourced in the form of blue granulated pellets, as shown in Figure 1. These granules were processed from post-consumer plastic waste, primarily polyethylene, and manufactured to uniform sizes below 4 mm Figure 1. With a fineness modulus of 4.44, the granules ensured consistent blending within the concrete matrix. Their uniformity and stability made them suitable for replacing 2.5%, 7.5%, 12.5%, 17.5% and 20% of the total aggregate. To improve water resistance and durability, a commercial damp-proofing chemical was incorporated into the mix at a dosage of approximately 1% by the weight of cement, as recommended by the manufacturer. A water-cement ratio of 0.59 was maintained for all mixes, which is suitable for air-entrained concrete aimed at achieving an average 28-day compressive strength of 3000 psi (20.7 MPa) [14]. All dry materials were thoroughly mixed in a mechanical drum mixer. The damp-proof chemical was dissolved into the mixing water and gradually added to the dry mix to ensure even distribution.

The prepared concrete was kept 1:1.15:2.23 ratio and poured into standard rectangular molds (9.5″ × 4.5″ × 2.75″), compacted manually, and left to set for 24 hours. After demolding, the bricks were cured in clean water for 3, 7 and 28 days under ambient conditions. Various tests were conducted to assess the properties of the bricks, including compressive strength using a universal testing machine in accordance with ASTM C39, water absorption following ASTM C140, and dry density measurements. Visual inspection and dimensional checks were also carried out to ensure consistency and quality. All tests were conducted in triplicate, and average values were used in the analysis [15].



Figure 3: Stone Chips for Casting Eco-Friendly Bricks



Figure 5: Gravel for Casting Eco-Friendly Bricks



Figure 4: Cement Specific Gravity Test



Figure 6: Recycling Waste Plastic



Figure 7: Consistency and Setting Time Test of Cement



Figure 9: Slam Test of Concrete



Figure 8:Casted Eco-Friendly Bricks



Figure 10: Curing of Eco-Friendly Bricks

3.3 Materials Test Report

Table 1: Sive Analysis (Stone)

Sive Analysis (Stone)					
Sieve No.	Wt. Sand (gm)	% Retained	Cumulative % Retained	% Finer	FM
3/4"	0	0	0	100	6.19
3/8"	361	36.1	36.1	63.9	
4	504	50.4	86.5	13.5	
8	113	11.3	97.8	2.2	
16	11	1.1	98.9	1.1	
30	11	1.1	100	0	
50	0	0	100	0	
100	0	0	100	0	
Pan	0				
Total=	1000		619.3	180.7	

Table 2: Sive Analysis (Gravel)

Sive Analysis (Gravel)					
Sieve No.	Wt. Sand (gm)	% Retained	Cumulative % Retained	% Finer	FM
3/4"	0	0	0	100	4.44
3/8"	0	0	0	100	
4	11	1.1	1.1	98.9	
8	532	53.2	54.3	45.7	
16	382	38.2	92.5	7.5	
30	45	4.5	97	3	
50	21	2.1	99.1	0.9	
100	4	0.4	99.5	0.5	
Pan	5				
Total=	1000		443.5	356.5	

Table 3: Sive Analysis (Sand)

Sive Analysis (Sand)					
Sieve No.	Wt. Sand (gm)	% Retained	Cumulative % Retained	% Finer	FM
4	20	2	2	98	2.67
8	86	8.6	10.6	89.4	
16	145	14.5	25.1	74.9	
30	206	20.6	45.7	54.3	
50	395	39.5	85.2	14.8	
100	131	13.1	98.3	1.7	
Pan	17				
Total=	1000		266.9	333.1	

Table 4: Sive Analysis (Recycling Plastic)

Sive Analysis (Recycling Plastic)					
Sieve No.	Wt. Sand (gm)	% Retained	Cumulative % Retained	% Finer	FM
4	480	48	48	52	2.98
8	20	2	50	50	
16		0	50	50	
30		0	50	50	
50		0	50	50	
100		0	50	50	
Pan					
Total=	500		298	302	

Table 5: Specific Gravity (Stone)

Specific Gravity (Stone)				
A=	1420	gm		
B=	1450	gm		
C=	925	gm		
Test	Formula	Calculation	Result	Moisture Content%
Apparent Specific Gravity	(A)/(A-C)	2.87	2.87	2.11
Bulk Specific Gravity (SSD Basis)	(B)/(B-C)	2.76	2.76	
Bulk Specific Gravity (Oven Dry Basis)	(A)/(B-C)	2.70	2.70	
Absorption Capacity %	((B-A) *100)/A	2.11	2.11	

Table 6: Specific Gravity (Gravel)

Specific Gravity (Gravel)				
A=	350	gm		
B=	657	gm		
C=	873	gm		
S=	358	gm		
Test	Formula	Calculation	Result	Moisture Content%
Apparent Specific Gravity	(A)/(B+A-C)	2.61	2.61	2.29
Bulk Specific Gravity (SSD Basis)	(S)/(B+S-C)	2.52	2.52	
Bulk Specific Gravity (Oven Dry Basis)	(A)/(B+S-C)	2.46	2.46	
Absorption Capacity %	((S-A)/A) *100	2.29	2.29	

Table 7: Specific Gravity (Sand)

Specific Gravity (Sand)				
A=	289	gm		
B=	657	gm		
C=	837	gm		
S=	300	gm		
Test	Formula	Calculation	Result	Moisture Content%
Apparent Specific Gravity	(A)/(B+A-C)	2.65	2.65	3.81
Bulk Specific Gravity (SSD Basis)	(S)/(B+S-C)	2.50	2.50	
Bulk Specific Gravity (Oven Dry Basis)	(A)/(B+S-C)	2.41	2.41	
Absorption Capacity %	((S-A)/A) *100	3.81	3.81	

Table 8: Specific Gravity (Cement)

Specific Gravity (Cement)		
Pycnometer Wt., W1=	187	gm
Cement Wt., W2=	487	gm
Pycnometer + Cement + Kerosine Wt., W3=	803	gm
Pycnometer + Kerosine Wt., W4=	579	gm
W2-W1	0.79	
((W2-W1) -(W3-W4))		
Cement Specific Gravity=	3.1	

Table 9: Unit Weight (Stone)

Unit Weight (Stone)					
Condition	Wt. of Bucket (gm)	Wt. of Bucket+ Materials (gm)	Wt. of Materials (gm)	Volume of Bucket (Cum)	Unit Weight (Kg/Cum)
Shoveling =	4000	7908	3908	0.00278	1406
Rodding=	4000	8356	4356	0.00278	1567
Jiggling=	4000	8416	4416	0.00278	1588
				Average Unit Weight=	1520

Table 10: Unit Weight (Gravel)

Unit Weight (Gravel)					
Condition	Wt. of Bucket (gm)	Wt. of Bucket+ Materials (gm)	Wt. of Materials (gm)	Volume of Bucket (Cum)	Unit Weight (Kg/Cum)
Shoveling=	4000	8325	4325	0.00278	1556
Rodding=	4000	8609	4609	0.00278	1658
Jiggling=	4000	8710	4710	0.00278	1694
				Average Unit Weight=	1636

Table 11: Unit Weight (Sand)

Unit Weight (Sand)					
Condition	Wt. of Bucket (gm)	Wt. of Bucket+ Materials (gm)	Wt. of Materials (gm)	Volume of Bucket (Cum)	Unit Weight (Kg/Cum)
Shoveling =	4000	8130	4130	0.00278	1486
Rodding=	4000	8370	4370	0.00278	1572
Jiggling=	4000	8516	4516	0.00278	1624
				Average Unit Weight=	1561

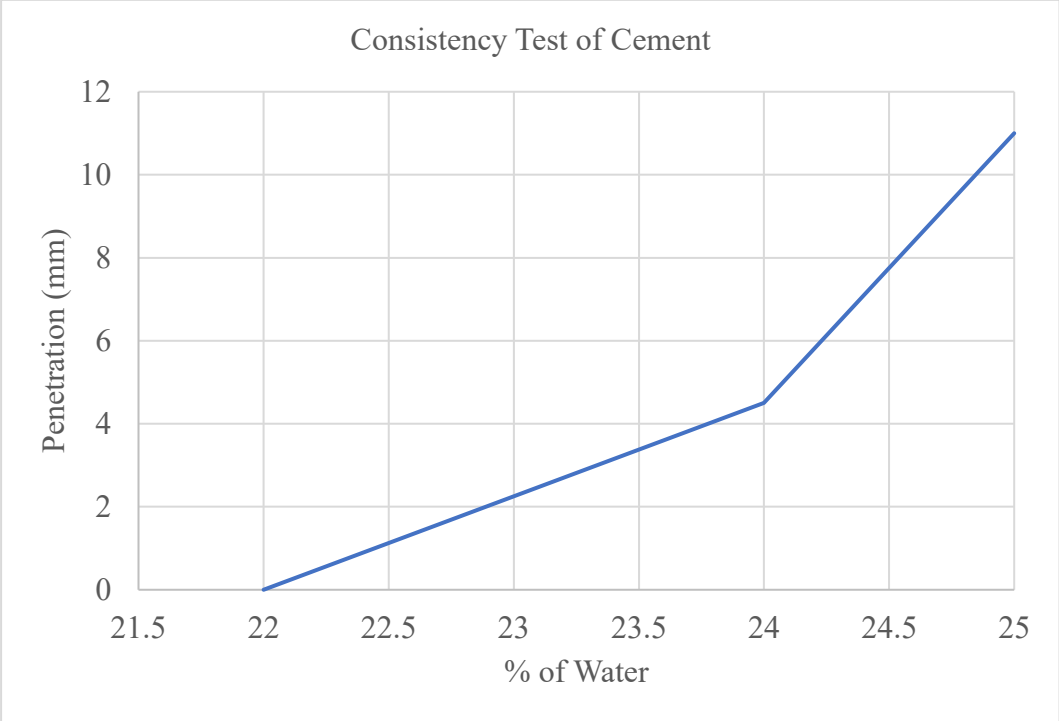


Figure 11: Normal Consistency Test of Cement

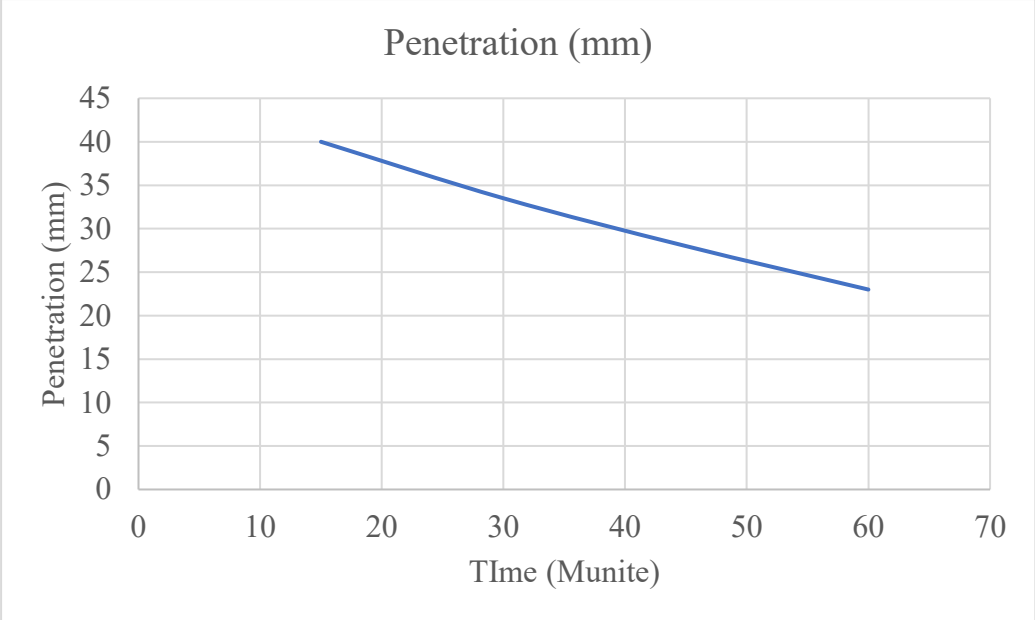


Figure 12: Penetration Test of Cement

3.4 Summary

In this chapter, the materials, mix proportions, and preparation methods of the PMRB will be presented. Two types of blocks, hollow and solid, were manufactured with a combination of two different types of sand (locally available river sand and Sylhet sand), gravel, stone chips and Ordinary Portland Cement (OPC). For partial replacement of the aggregates by volume were used waste polyethylene plastic pellets in different ratios (2.5% to 20%). The chapter also described the molding, curing and testing operations of this method and testing such as compressive strength, water uptake and dry density measurements, ensuring that the methodology allows for reproducibility and comprehensive assessment of the bricks' mechanical and environmental performance.

CHAPTER 4
Results and Discussion

4.1 Introduction

This chapter presents the experimental findings and analysis of the properties of eco-friendly concrete bricks made with recycled plastic and locally available materials. The study investigates two types of bricks—hollow and plain—under varying percentages of plastic replacement and curing durations. Key properties evaluated include compressive strength, dry density, and water absorption, which are critical indicators of the structural performance and durability of the bricks. The results are discussed in the context of optimizing plastic content for sustainable construction, highlighting both the mechanical behavior and environmental implications. This chapter also explores how curing time influences the development of strength and density, and how plastic incorporation affects water absorption and long-term durability. By comparing the performance of hollow and plain bricks, the study identifies the optimal balance between material sustainability and structural integrity, providing insights for practical applications in eco-friendly construction.

4.2 Compressive Strength

The compressive strength of both hollow and plain bricks was tested over different curing durations—specifically at 3, 7, 14, and 28 days—using varying percentages of waste plastic. The results clearly show that curing time and plastic content significantly affect the bricks' strength. With longer curing, the strength increases, while the addition of more plastic tends to reduce it. This is due to changes in the internal structure and bonding capability of the materials used [16].

In the case of hollow bricks, the highest compressive strength was observed when 2.5% of waste plastic was added, reaching 6,423.13 PSI at 28 days. As the plastic percentage increased, a steady decline in strength was recorded. For example, at 7.5% plastic, the strength dropped to 5,539.37 PSI, and by the time it reached 20%, it had decreased significantly to 3,023.09 PSI. This reduction is likely because excessive plastic weakens the brick matrix, creating voids and preventing proper bonding between cement and aggregates [17].

Plain bricks showed a similar trend, although they generally retained slightly better strength at higher plastic levels than hollow bricks. At 2.5% plastic, the 28-day strength

was 5,749.69 PSI, and it remained relatively high at 7.5% with 5,563.38 PSI. However, beyond this point, the decline became more noticeable. By 20% plastic content, the compressive strength dropped to 3,023.07 PSI—almost mirroring that of hollow bricks at the same level. This suggests that while plain bricks might accommodate plastic a bit better due to their solid structure, the negative impact of too much plastic is still evident [16].

When comparing the two types of bricks, it is evident that both reach their peak performance at 2.5% plastic content, making it the most effective level for maintaining strength while still integrating waste material. Beyond this percentage, the compressive strength diminishes steadily. This behavior is attributed to poor bonding between the plastic and the cementitious matrix, which becomes more pronounced as plastic content increases. Moreover, plastic's low water absorption may interfere with proper hydration of cement, leading to incomplete curing [18].

The graphical representations in Figure 5 visually reinforce these findings. The bars for each curing day clearly show increasing strength over time, while higher plastic content consistently corresponds to lower compressive strength. The difference in strength between 3 and 28 days is significant for all plastic levels, highlighting the importance of curing time in strength development. However, the downward slope in strength as plastic increases is just as striking, reinforcing that plastic must be used sparingly to maintain brick quality.

To sum up, incorporating 2.5% waste plastic into bricks offers a promising way to recycle plastic without compromising structural integrity. Beyond this point, the trade-off between sustainability and strength becomes too steep. Therefore, for practical applications where strength is critical, keeping plastic content low is essential. This approach allows for eco-friendly brick production while ensuring that the materials remain durable and reliable in construction settings [16-18].

Table 12: Hollow bricks strength table

Percent of Waste Plastic	Wet Weight (Kg)	Dry Weight (Kg)	3 Days	7 Days	14 Days	28 Days
2.50%	3.95	3.57	2,791.75	4,171.63	6,271.67	6,423.13
7.50%	3.84	3.41	2,640.84	3,983.29	5,813.61	5,539.37
12.50%	3.73	3.29	1,773.14	2,607.11	3,937.95	4,131.89
17.50%	3.62	3.21	1,622.23	2,439.93	3,613.39	3,729.59
20.00%	3.57	3.07	1,350.60	2,031.79	2,995.83	3,023.09

Table 13: Plain bricks strength table

Percent of Waste Plastic	Wet Weight (Kg)	Dry Weight (Kg)	3 Days	7 Days	14 Days	28 Days
2.50%	3.74	3.41	2,452.21	3,657.31	5,523.47	5,749.69
7.50%	3.63	3.29	2,376.76	3,541.15	5,331.71	5,563.38
12.50%	3.52	3.13	1,810.86	2,709.29	4,057.43	4,229.53
17.50%	3.41	3.07	1,735.41	2,607.11	3,897.67	4,069.21
20.00%	3.36	3.01	1,290.24	1,917.69	2,883.03	3,023.07

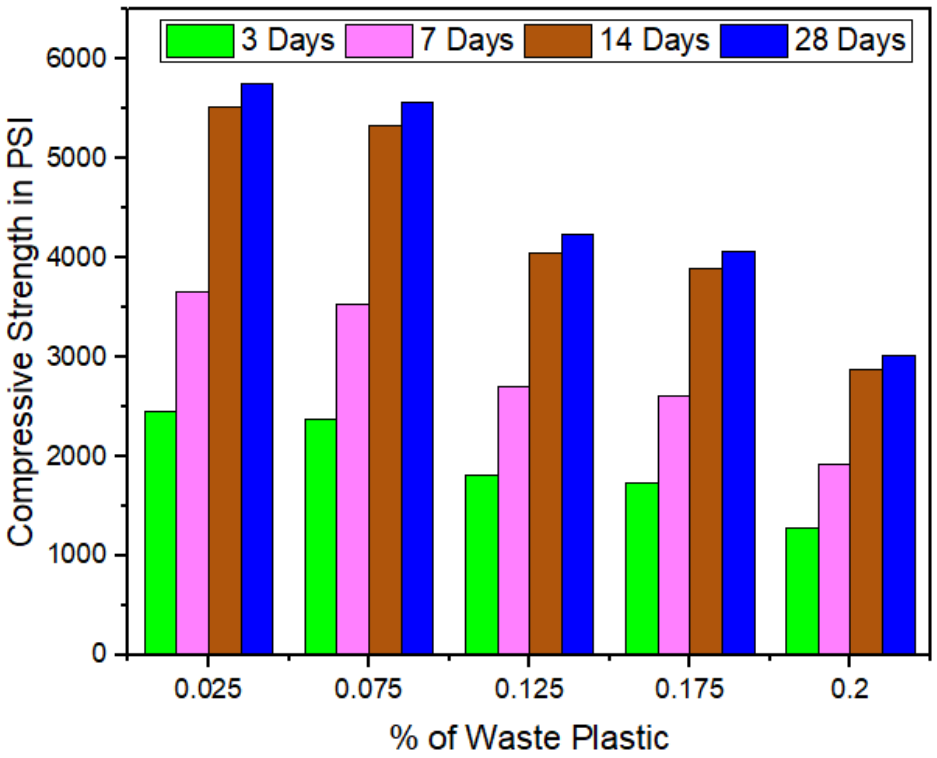


Figure 13: Graph of different days compressive strength test Hollow Bricks

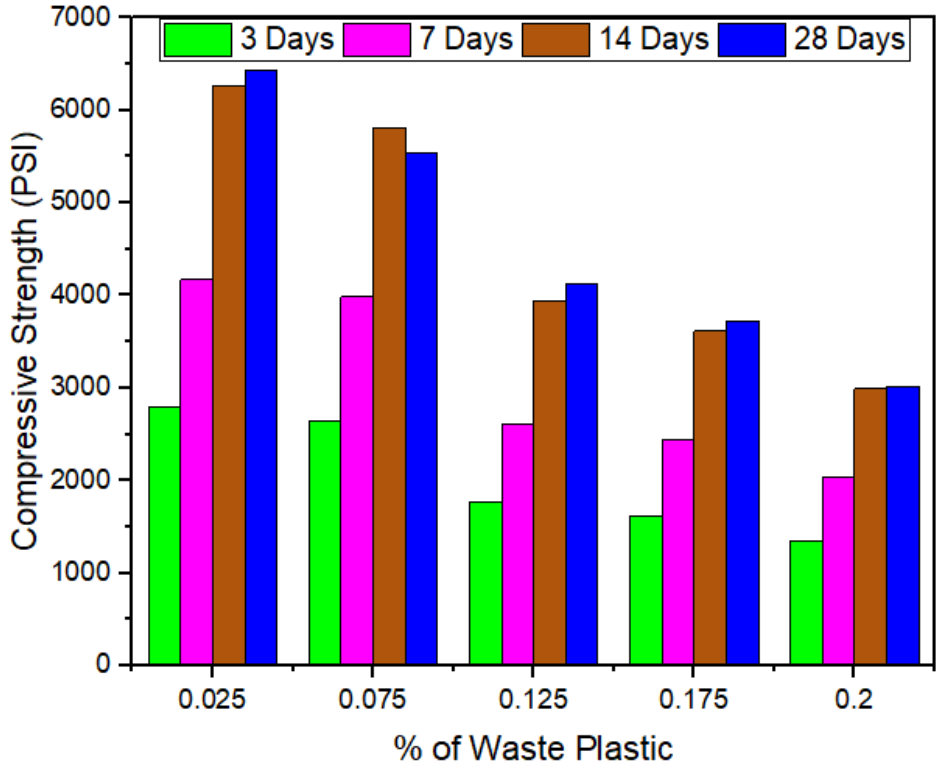


Figure 14: Graph of different days compressive strength test Hollow Bricks

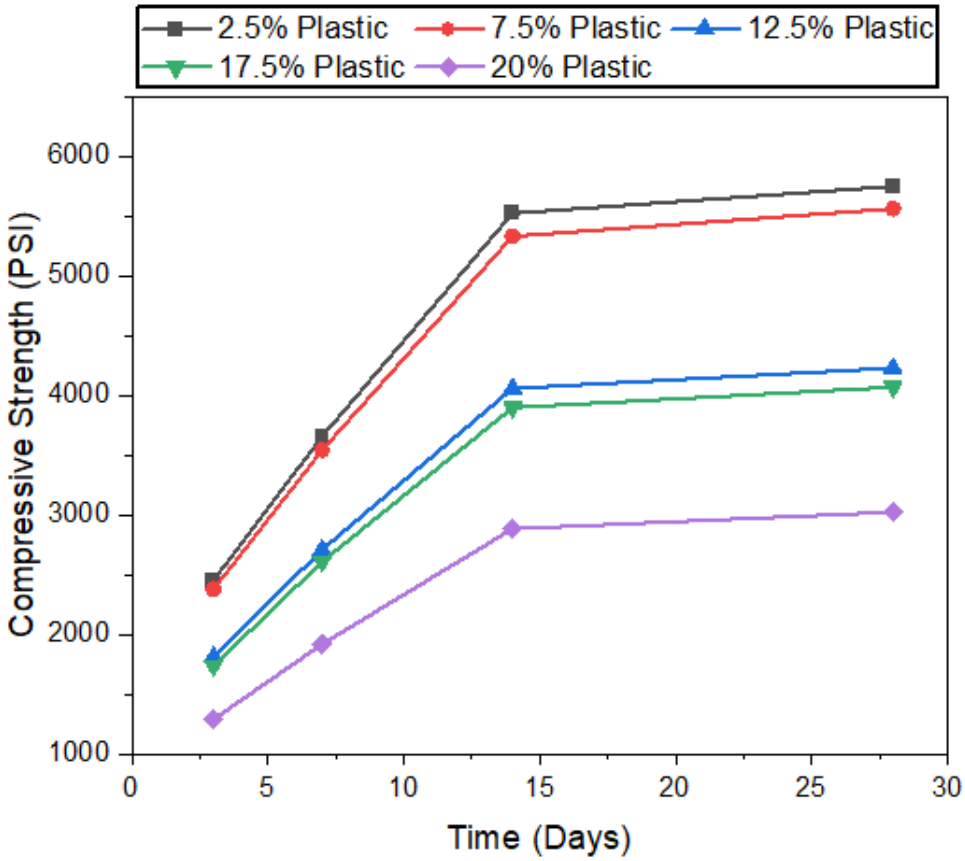


Figure 15: Graph of different days compressive strength test Plain Bricks in dry condition

4.3 Dry Density

The variation of dry density with curing time for different plastic content is illustrated in Figure 4(b). The results indicate that the dry density of concrete decreases progressively as the percentage of plastic increases. Concrete with 2.5% plastic exhibited the highest dry density throughout the curing period, reaching approximately 2,270–2,280 kg/m³ at 28 days. Conversely, the mix with 20% plastic content achieved the lowest dry density, around 2,000 kg/m³ at the same curing age. This decline can be attributed to the lower specific gravity of plastic particles compared to natural aggregates, which reduces the overall mass per unit volume of the concrete matrix [13].

The effect of curing time on dry density was relatively moderate compared to the influence of plastic content. All mixes showed a slight increase in density from 7 to 28 days due to continued hydration of cement and filling of voids by hydration products. However, the mixes with higher plastic content, particularly 17.5% and

20%, consistently demonstrated lower densities, confirming that excessive plastic replacement compromises the compactness of the concrete.

In this investigation, incorporating a small percentage of plastic (2.5–7.5%) maintained satisfactory density values, while higher proportions (above 12.5%) resulted in a more porous and lightweight concrete. This trend aligns with the fundamental principle that the introduction of lightweight plastic reduces the self-weight of the composite but can potentially influence its mechanical behavior [14].

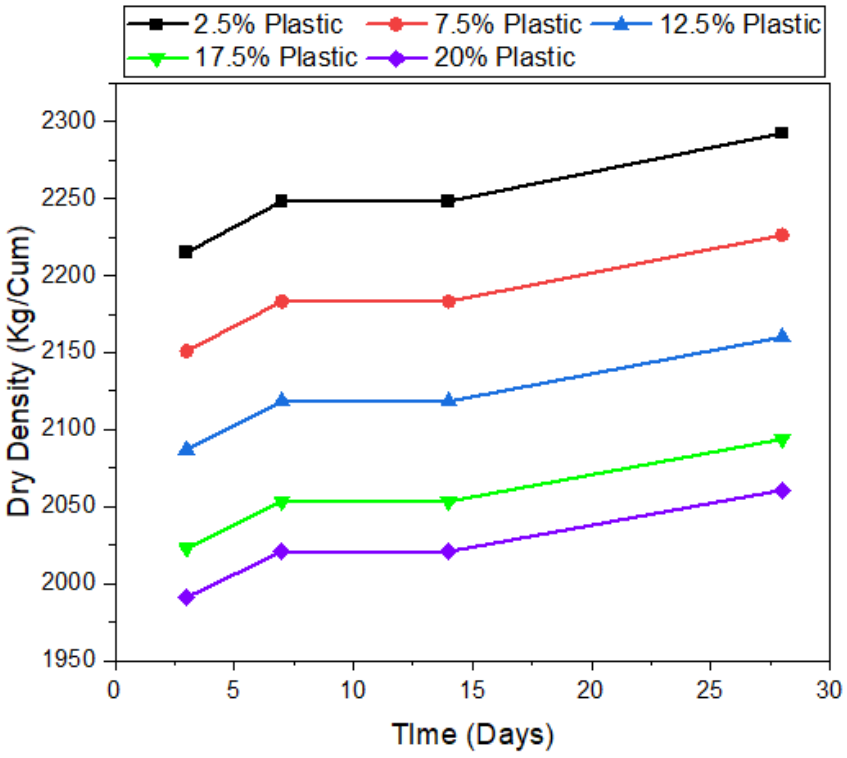


Figure 16: Result of Moisture Content

4.4 Water Absorption

The water absorption capacity of both hollow and plain bricks over 60 days is presented in Figure 5. A clear decreasing trend is observed for all mixes as curing time progresses, indicating that prolonged hydration reduces the porosity of the brick matrix. This behavior is attributed to the continuous formation of hydration products that gradually fill the capillary pores, limiting the ingress of water over time [13].

For hollow bricks (Figure 5a), the initial water absorption ranged between approximately 14–15% for the 20% plastic mix and 11–12% for the 2.5% plastic mix. By the 60th day, these values decreased to about 9–10% and 6%, respectively. Hollow bricks with higher plastic content exhibited greater water absorption due to the reduced particle packing density and the lower bonding between plastic and the cementitious matrix [14].

A similar trend is evident in plain bricks (Figure 5b), though the overall water absorption percentages were slightly higher than those of hollow bricks, ranging from around 17–18% at early ages for the 20% plastic mix to about 12% for the 2.5% plastic mix. After 60 days, these values reduced to approximately 11% and 7%, respectively. The higher absorption in plain bricks compared to hollow bricks is primarily due to the absence of voids that facilitate better compaction and lower effective surface area in hollow units [15].

In this study, the inclusion of plastic increases the water absorption capacity of bricks, with the highest absorption observed in bricks containing 20% plastic. However, the consistent reduction over time highlights the beneficial role of prolonged curing in enhancing the durability and reducing the permeability of the bricks. Optimal plastic content (2.5–7.5%) strikes a balance between sustainability and durability, while excessive replacement results in higher porosity and water absorption [19].

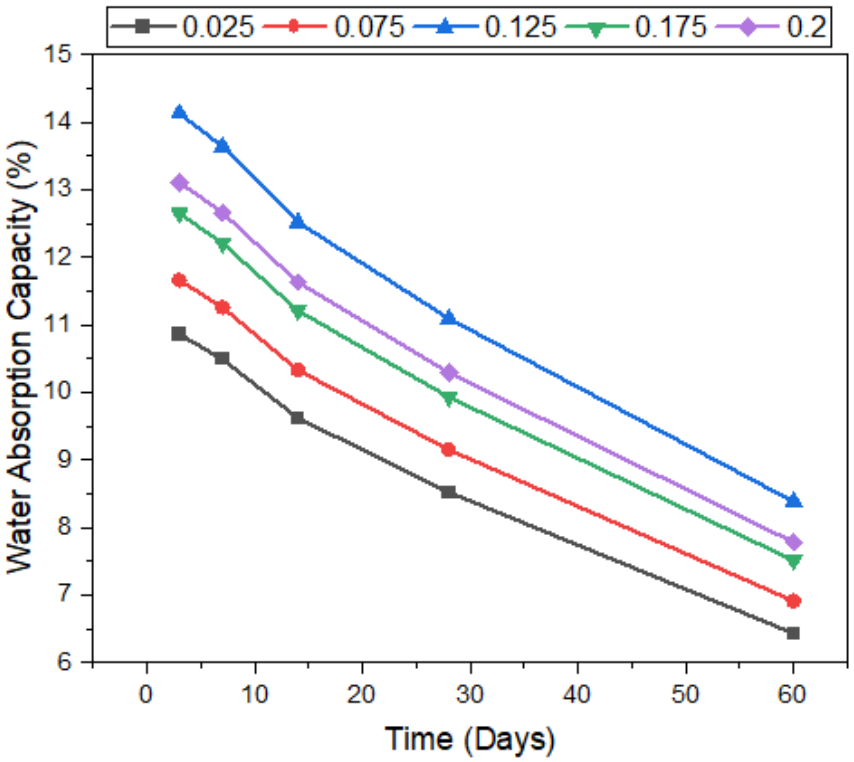


Figure 17: Water Absorption Capacity for Hollow Brick

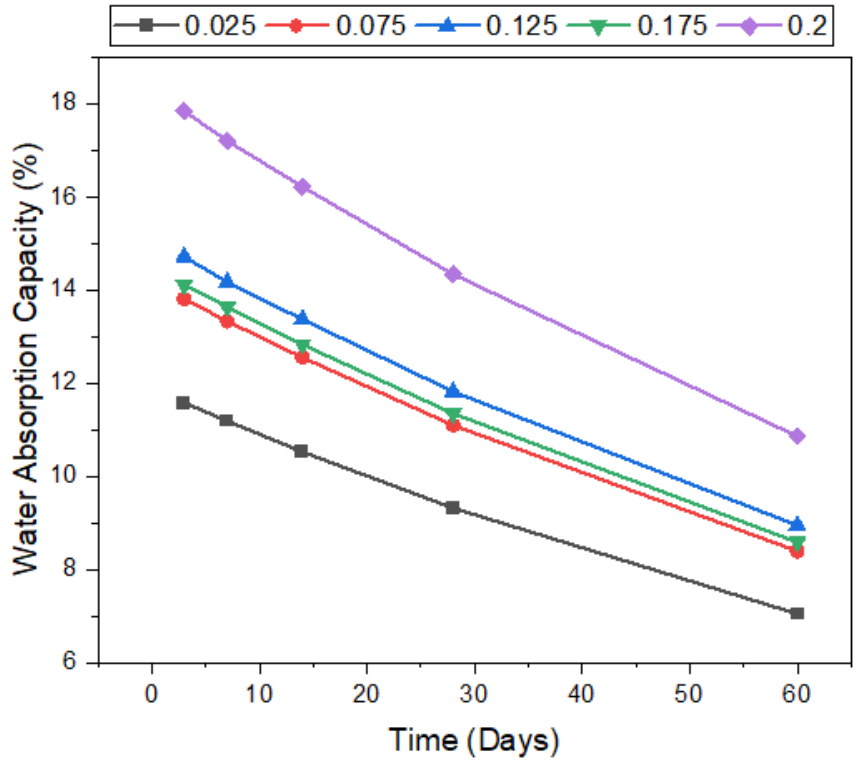


Figure 18: Water Absorption Capacity for Plain Brick

4.6 Impact on Environment

In this research investigate the amount of plastic produced globally. Every year the waste plastic produced show in figure 6 (a) frequently decrease the plastic uses [20]. On the other hand, the number of bricks produce globally over 1.6 trillion bricks in 2023 with Asia-Pacific taking over 50% of the global market due to rising urbanization in China and India. Clay bricks dominated consumption at 41%, followed by concrete and fly ash [21]. In this situation if the materials of 20% waste plastic used in these bricks the quantity of 0.32 trillion volume of bricks equal plastic decrease from the environment. Another is the cement quantity deduct from the quantity of bricks. The plastic used on concrete bricks the volume of 20% of plastic requirement for binding cement quantity decrease from concrete bricks. The Co_2 emission every year show figure in 6 (b) [22] where the materials 20% decrease the quantity of cement also decrease. The binding materials of cement reduced for 20% of materials of around 218 million ton of cement.

Cement share = (1/4.38) = 0.228= 22.8%

Cement reduced=20% × Cement total

Total materials=1.6 × 1012 × 3Kg= 4.8 × 1012 Kg = 4.8 billion ton

Cement share = 22.8%

Cement total=0.228×4.8 billion tons ≈1.094 billion tons

Reduction (20%) = 0.20×1.094 billion tons ≈ 219 million tons

In this data show every year CO_2 emission reduced for produce 219 million tons cement production. The quantity of CO_2 emission reduced possibly 85.41 million metric tons for 1.6 trillion bricks production.

Emission factor = (1,600 million tons CO_2) / (4,100 million tons cement) ≈0.39 tons CO_2 per ton of cement.

CO_2 Emissions for 219 million tons of cement= 219×0.39=85.41 million metric tons of CO_2

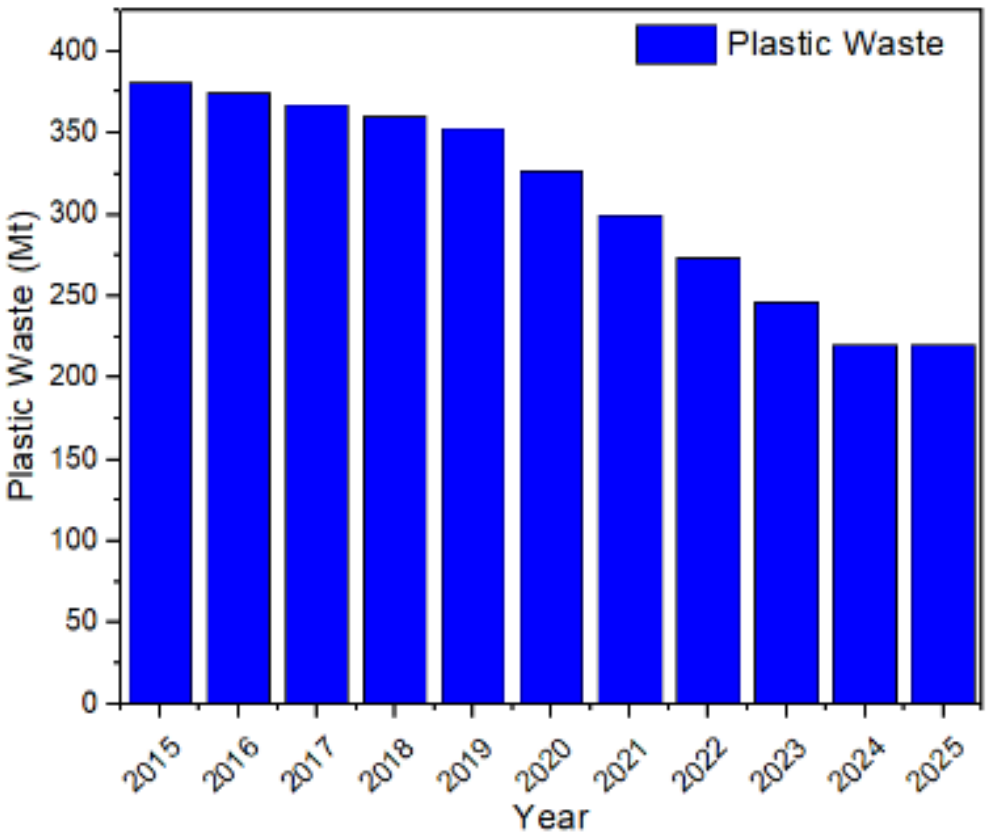


Figure 19: Annual Plastic waste

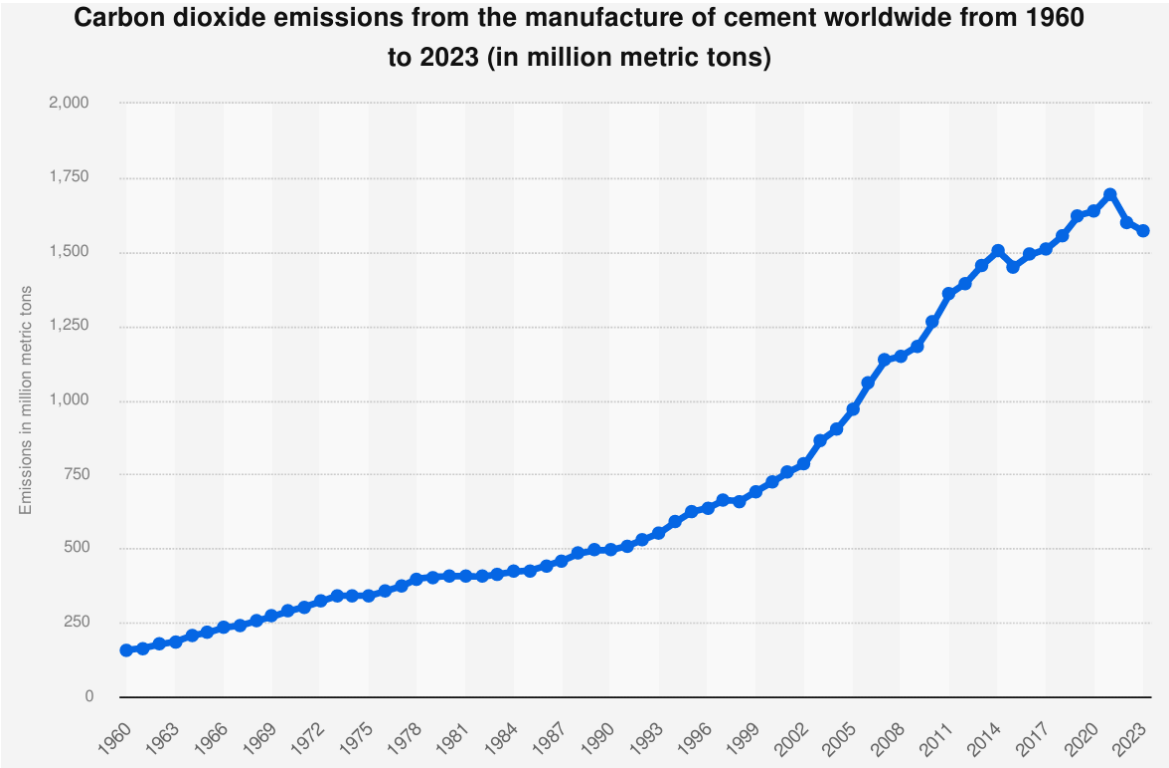


Figure 20: CO2 emission on the environment

4.7 Summary

The study analyzed the mechanical and environmental performance of hollow and plain bricks with varying percentages of recycled plastic. Compressive strength increased with curing time but decreased as plastic content rose, with the optimal strength observed at 2.5% plastic replacement. Dry density decreased progressively with higher plastic content, while water absorption was higher for bricks with more plastic but reduced over prolonged curing. Environmental assessment showed that using 20% recycled plastic in global brick production could significantly reduce cement use and CO_2 emissions, potentially saving 85.41 million metric tons of CO_2 annually. Overall, small additions of plastic (2.5–7.5%) provide a balance between structural performance and environmental benefits, whereas excessive plastic negatively affects brick quality.

CHAPTER 5
Conclusions and Future Works

5.1 Conclusions

This study demonstrates that incorporating waste plastic into hollow and plain bricks can produce durable, eco-friendly construction materials. Although increasing plastic content slightly reduces compressive strength and raises water absorption initially, all bricks showed consistent strength gain and decreased water uptake with curing time. Bricks containing up to 20% waste plastic maintained acceptable mechanical properties and moisture resistance after proper curing. This approach not only diverts plastic waste from the environment but also reduces the demand for traditional raw materials, supporting sustainable construction practices. Overall, waste plastic bricks present a promising solution for eco-friendly building materials that balance environmental benefits with structural performance.

5.2 Limitations and Recommendations for Future Works

- The experimental investigation was restricted to specific brick sizes and two types (hollow and plain), which may not represent all brick forms used in construction.
- Only polyethylene-based post-consumer plastic was tested; results may differ for other plastic types or blends.
- The study focused mainly on compressive strength, dry density, and water absorption, while properties such as thermal conductivity, fire resistance, and long-term durability were not explored.
- The environmental impact assessment relied on theoretical calculations rather than a comprehensive life-cycle analysis, which may affect accuracy.

Future studies could expand the scope by testing additional brick types and sizes to generalize the findings across broader applications. Different types of recycled plastics or combinations of plastic waste should be evaluated to optimize performance and sustainability. It is also recommended to investigate other mechanical and durability properties, including thermal insulation, fire resistance, and freeze-thaw behavior, to ensure comprehensive assessment. Lifecycle assessment (LCA) and cost-benefit analysis could provide a more accurate understanding of environmental and economic impacts. Lastly, developing standardized guidelines for plastic incorporation in construction materials could facilitate practical implementation and adoption in the industry.

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