Environmentally Sustainable Green Concrete Blocks and Bricks Utilizing Plastic Waste: An Innovative Solid Waste Management and Cost-Effective Construction Material Practice

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Abstracts: This study examines the affordability and ecological viability of using plastic garbage to produce green concrete blocks and bricks. According to the research conducted, adding plastic trash to certain substances for construction causes significant modifications to their characteristics. In particular, the bricks' compressive strength falls by more than half as the plastic percentage rises from 0% to 15%. Furthermore, more plastic means less water being absorbed, meaning green bricks use less water than regular ones. With no difference between the controlled and 10% plastic samples, the flexural strength decreases at 5% and 15% plastic content. Slump values are lowered due to the rise in plastic trash, which lowers workability. However, the water-absorbing decrease stays within reasonable bounds; therefore, the bricks' ability to withstand weathering is maintained. Last but not least, at 5% plastic content, the compressive strength of green concrete blocks dramatically drops; at 10% and 15%, the decline is relatively small. These results demonstrate the possibility of employing plastic trash in buildings, provided that material property compromises are carefully considered.

Keywords: Green Buildings, Sustainability, Plastic, Stabilization, Concrete and bricks, Solid Waste

1. INTRODUCTION

Plastic has permeated every facet of contemporary life, from grocery bag handles to the microchips in your computer. According to Figure 1, plastics are necessary for all modern manufacturing industries, with packaging accounting for most use (36%). Since plastic is made of a collection of components called polymeric rather than a single ingredient, it is employed in all industries. Plastic materials come in many varieties, each with extraordinarily beneficial and adaptable qualities. Two of plastics' best qualities are their resilience and durability, which enable the creation of robust goods with relatively little upkeep and extended lifespans that are very cost-effective [1]. Compared to other substances, these characteristics force humans to come into contact with plastics nearly daily. In the next ten to twenty years, the plastics sector will triple its output due to the benefits of these materials and the growing global population [2]. Subsequently, by 2050, 700 million tons of plastic will be generated worldwide, corresponding to Asia, North America, and Europe producing the most, accounting for 50, 10 and 16% of the inventory.

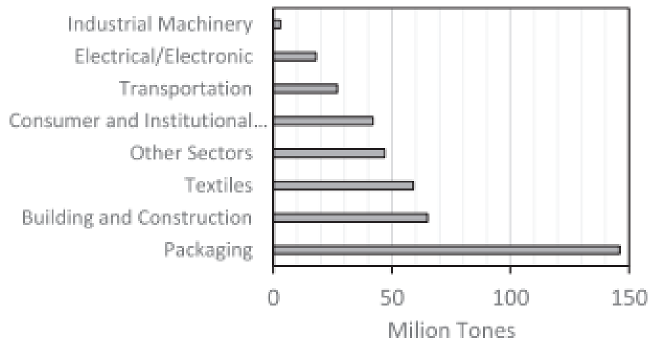

Figure 1: Primary plastic production by industrial sector, 2015 [3-4]

Every kind of plastic that people use daily ultimately ends up in the trash; tons of this material demand vast amounts of space to be stored and cannot be reused all at once [5]. Around the world, 6.5 billion tons of waste, both rubber and plastic, are produced each year; the disposal of these polymers presents a significant environmental risk because of their protracted rates of disintegration [6]. Reusing garbage has several benefits, including lowering contamination of the environment, promoting the recycling and conservation of energy throughout the production process, and assisting in preserving non-renewable natural resources [7]. One green way to reduce the amount of trash used for garbage burning is to employ plastic waste in the materials industry [8]. Investigation has demonstrated that plastic may be included in concrete; in the last few years, this material has attracted much attention [9].

The past few years have seen research on a variety of plastics, including high-density polyethene (HDPE), polypropylene (PP), and polyethene terephthalate (PET). The effects of adding plastic material to freshly mixed and hardened concrete have been studied. Research has demonstrated that workability findings can vary, with most research indicating a trend to decline as replacement value increases. While most research suggests a decrease in compressive strength, splitting tensile strength, and flexural strength, fresh concrete exhibits a rise in a slump since the replacement rate is adjusted [10–16]. The impact of substituting silica fume for cement and plastic waste for fine aggregate in concrete mixtures was investigated by Harini and Ramana (2015). In concrete, the plastic waste was substituted in the following percentages: 5%, 6%, 8%, 10%, 15%, 20% by volume, and 5%, 10%, 15% by weight of silica fume. They stated that all replacement values had a reasonable degree of workability. Additionally, it was shown that the compressive strength of the replacement levels of plastic waste as fine aggregate decreased somewhat by about 10% in comparison to the baseline mix. The substitution of silica fume raised the concrete mixes' compressive strengths by 13%, 20%, and 23% at 5%, 10%, and 15%, respectively. Compared to the control mix, the tensile strength of concrete decreased somewhat from 8% to 20% replacement and increased slightly at 5% and 6% substitution [17].

One promising strategy to lessen the number of dangers to the atmosphere, society, and health connected with extracting natural aggregates is to recycle waste plastic instead of natural aggregates [18]. Previous studies on determining the strength of concrete using waste plastic aggregate have been carried out on several occasions. There isn't much research on the long-term reliability characteristics of waste plastic aggregate-based concrete [19–21]. According to Akçaözoğlu et al. (2010), mortar samples containing 100% PET aggregates exhibited higher absorbing water values than mortars containing PET and sand aggregate [22].

Because PET only contains the atomic species of carbon, hydrogen, and oxygen, it was selected by several writers. PET's qualities indicate that a melting temperature of 260°C is necessary; consequently, heating it would not release any harmful gases. PET is more resistant to UV radiation and has strong chemical resistance [23–24]. This brick is immune to acids, salts, water, and oil. Relative to other bricks, it is more resilient and is capable of withstanding temperatures of up to 180°C. Because brick, concrete, and tiles are widely employed in buildings, these materials are utilized often. Because of this, it is expensive to use as building material. In India, commonly burned clay is primarily used to build structural walls; however, in order to reduce the cost and time associated with building, it is necessary to investigate alternatives to these bricks [26]. Plastic looked to be a cheap and valuable raw material because of its large-scale manufacture and economic revolution. Today, the use of plastic has revolutionized every industry, including the construction of structures, automotive, electronics, and farming. Municipal solid garbage contains five per cent or more plastics, which are naturally dangerous.

Brick is widely utilized for a variety of construction materials, including the creation of a building's exterior and interior [25]. These plastic blocks can reduce the amount of plastic generated. The use of these plastic bricks can consequently simultaneously advance environmentally friendly development and environmental protection. Building materials may help us meet our needs without damaging the environment since using inexpensive, portable, and environmentally friendly building materials is becoming increasingly important [26].

Producing bricks from plastic trash is an inexpensive and sustainable way to reduce environmental pollution from dumps and plastic combustion. Concrete mixed with plastic trash has produced acceptable outcomes when fine and coarse aggregates are mixed together, and the fine aggregate is partially substituted with "shredded polythene bag fibers" [27]. Additional studies were carried out in the 20th century to evaluate the viability of using crushed brick as a concrete aggregate [28-30].

The following are the objectives of the research.

- Develop a practical method for recycling discarded plastics.
- Less natural assets, like clay, produce bricks and concrete blocks.
- Reduce and reuse the production of waste plastics on land and in water to lessen the threat of pollution and water and soil degradation.
- To produce materials that the typical person can pay for.
- Reduced usage of resources that aren't renewable results in less plastic in waste flows.

MATERIAL AND METHOD

This section shows the materials and methodology used to prepare the concrete blocks and bricks in this investigation, which are as follows.

Material

The following are materials used in this research work.

Cement

Cement is a binder or material used to construct objects. It hardens, solidifies, and sticks to different materials. Cement is usually used to bind sand and gravel (aggregates), not by itself. Ordinary Portland cement 53 Grade complied with IS: 269-1969 requirements, so it was used.

Aggregate (coarse aggregate)

The aggregate, or coarse aggregate, is one of the most essential components of concrete. It gives concrete thickness. The qualities of the concrete may affect the different aggregate parameters. Concrete's coarse aggregate provides strength and uniformity to the mass of the material while also acting as a filler. A 20 mm coarse aggregate is used.

Waste Plastic

Crushed plastic particles are tiny particles that cannot be split down anymore. High-density polyethene is the main ingredient in these polymers. Concrete with plastic content can be used again for non-structural parts that don't require a lot of compressive strength. Furthermore, because of its porous nature and low absorbency from plastic, concrete may be utilized in various applications, including playing field surfaces and pavements that require proper water outflow.

Soil

The result of breaking solid granite is artificial sand. Broken sand is shaped into a cube with corners anchored, washed, and classified as a construction material. The decreased range of synthetic sand is 4.75 mm.

METHODOLOGY

- Gathering trash, plastic, soil, and cement samples from nearby factories and sites that are accessible.
- Machines from solid trash produce crushed plastic garbage.
- To create bricks and concrete blocks, plastic waste is mixed in varied amounts with soil and cement, replacing aggregate.
- Multiple laboratory tests were applied to the blocks and bricks manufactured in the laboratory area.
- Making a comparison between green and standard concrete blocks and bricks.

RESULTS AND DISCUSSION

The following are the results of the experiments performed to produce economical and cost-efficient green bricks and concrete and, ultimately, minimize the solid waste in the community.

Compression Test on Green Bricks

The following table and figure show the compression test values on the green bricks.

Table 1: Compressive strength property evaluation of the green brick

Serial No.	Soil + Plastic Waste (%)	Dimension of brick (cm)	Maximum load(KN)	Compressive strength (N/mm^2)
1	100 + 0	21×9×7.3	298.85	12.77
2	95 + 5	22×9.81×7.6	230.66	9.03
3	90 + 10	21.6×9.3×7.2	180.82	7.91
4	85 + 15	22×10×7	124.96	6.12

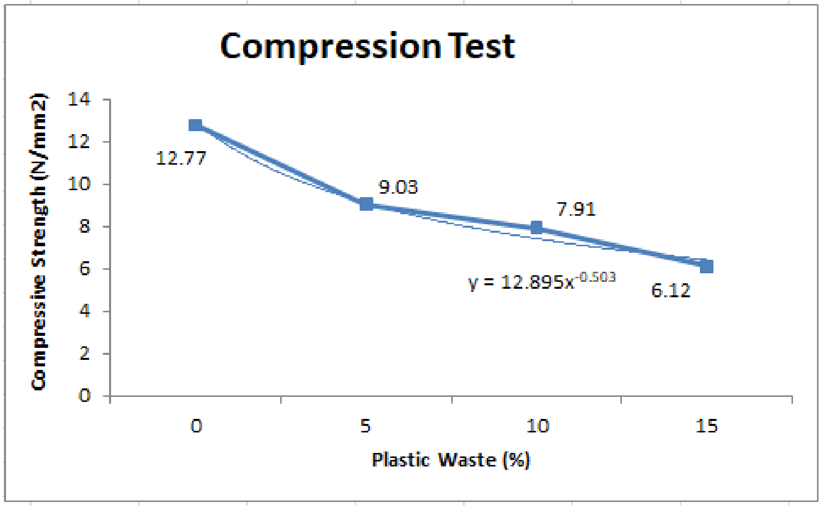

Figure 2: Compression analysis values on green bricks

DISCUSSION

Adding plastic garbage considerably changed the compression property of earth bricks. Because plastic debris is non-porous and comparatively less compressible, it tends to decrease the bricks' total porousness, which might improve their density and perhaps boost their compressive quality. Still, the kind and amount of polymer consumed determines how much of an impact this has.

Water Absorption Test on Green Bricks

The result of the water absorption test on the green brick is shown in the table and figure below.

Table 2: Water absorption test results on green bricks

Serial No.	Soil + Plastic Waste (%)	Weight of wet brick, W2 (Kg)	Weight of dry brick, W1 (Kg)	Water absorption(%)
1	100 + 0	3.81	3.43	11.07
2	95 + 5	3.31	3.01	9.96
3	90 + 10	3.15	2.90	8.62
4	85 + 15	2.88	2.66	8.27

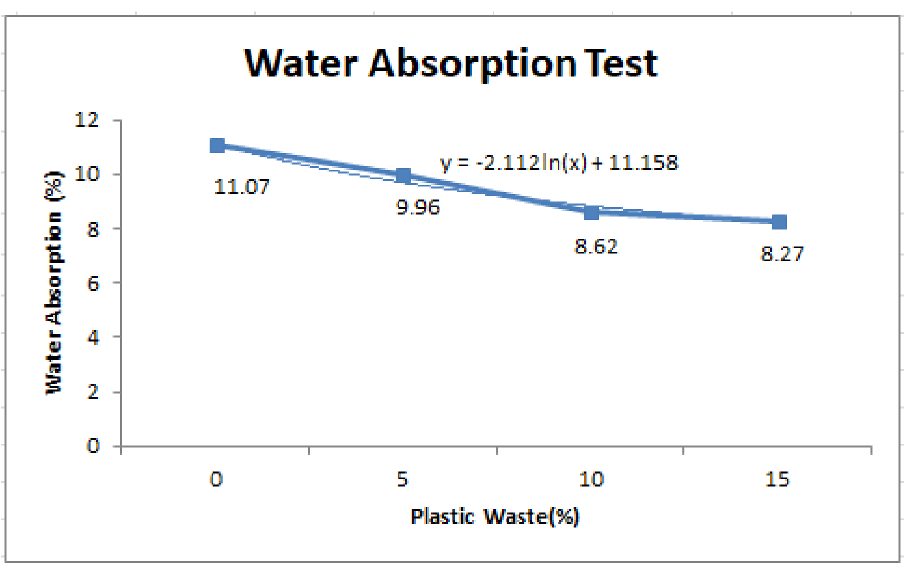

Figure 2: Water absorption values on green bricks

Discussion

Plastic debris, which is naturally damp-resistant, significantly decreases water absorbency. When bricks are made, plastic tends to plug the openings in the brick matrix, decreasing its total permeability. Compared to conventional clay bricks, this decline in porosity results in a notable drop in water absorbance rates.

Flexural strength test on green bricks

The results of the flexure strength test done on the green bricks follow.

Table 3: Flexural strength of the green bricks

Serial No.	Soil + Plastic Waste (%)	Height of brick (in/mm)	Maximum Load (KN)	Flexure Strength (psi)
1	100 + 0	3/60	9.72	1385.76
2	95 + 5	3/65	8.19	1121.11
3	90 + 10	3/63	9.42	1290.19
4	85 + 15	3/69	7.55	1135.43

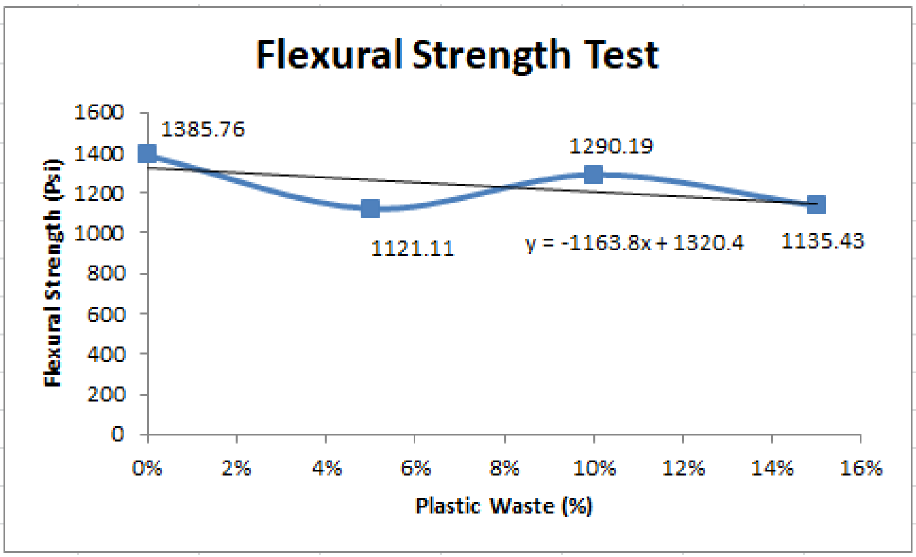

Figure 3: Water absorption values on green bricks

Discussion

The incorporation of discarded plastic garbage seriously affected the flexural strength of clay bricks. The polymer supplement, which is often less fragile and elastic than soil, improved the brick's resistance to bending. There is a lower chance of a brick breaking since the plastic can distribute stresses more uniformly throughout the brick.

Concrete Preparation

This experiment produced concrete specimens with a mix design ratio of 1:3:6 and a water-to-cement ratio of 0.51. Four 4x6x8-inch concrete block samples were made and put to the test. Afterwards, the specimens were given 28 days to cure. Blocks of strengthened concrete were subjected to various tests after 28 days to determine their quality. Concrete was mixed by hand using tools like a spatula and manual mixing techniques.

Slump Test

Following are the results of the slump test of the green concrete mortar.

Table 4: Slump Test

Serial No.	Concrete + Plastic Waste (%)	W/C Ratio	Slump (inches)
1	100 + 0	0.51	4.88”
2	95 + 5	0.51	4.46”
3	90 + 10	0.50	4.03”
4	85 + 15	0.49	3.75”

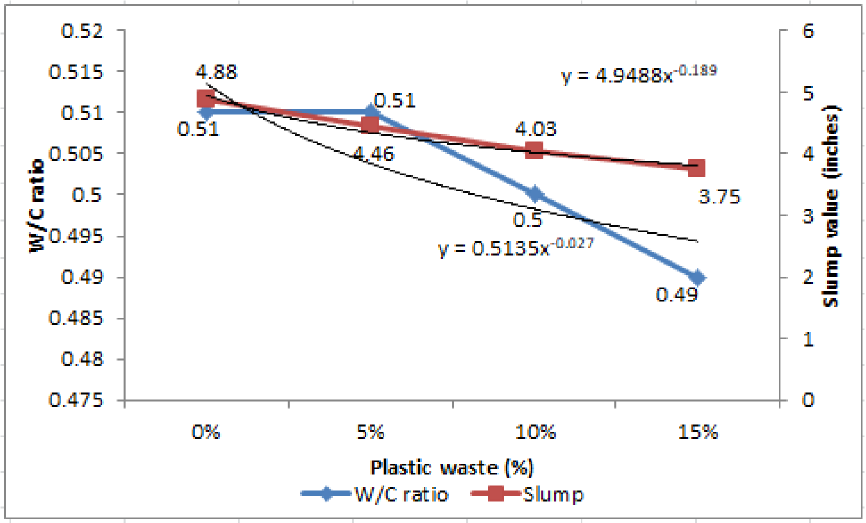

Figure 4: Slump and W/C ratio values of green concrete mortar

Discussion

The findings of the slump test showed a slight decrease in the slump value as the amount of waste plastic in the concrete mixture went from 0% to 15% as a partial substitute for conventional materials. This suggests that as the amount of plastic in the concrete mix increased, its workability declined. The water-to-cement (W/C) ratio also showed a little decrease. The less cohesiveness and stiffer structure of the plastic fragments may have contributed to the slump and W/C ratio reduction by impeding the mixture's capacity to flow and lowering workability.

Water Absorption

Following are the results of the water absorption test of green concrete blocks.

Table 6: Water absorption test result

Serial No.	Concrete + Plastic Waste (%)	Water absorption (%)
1	100 + 0	1.31
2	95 + 5	1.22
3	90 + 10	1.17
4	85 + 15	1.08

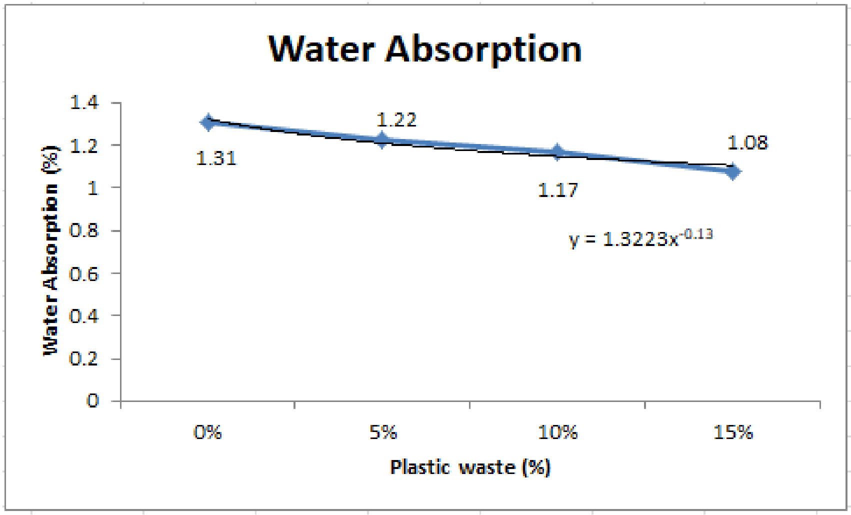

Figure 5: Water absorption values of green concrete blocks

Discussion

A progressive reduction in absorbance of water was noted as the plastic levels rose in the concrete blocks tested for water absorption, with waste plastic content ranging from 0% to 15%. This decrease in absorbing water is because plastic is hydrophobic, which lessens the permeability of the concrete. Reduced water absorption is probably the result of the increased plastic filling the pores and spaces in the concrete matrix. This implies that adding waste plastic to concrete as a partial replacement material might increase its longevity by lessening its vulnerability to water penetration.

Compressive Strength

The compressive strength values of the green concrete blocks are as follows:

Serial No.	Concrete + Plastic Waste (%)	Compressive strength (psi)	Compressive Strength (N/mm^2)
1	100 + 0	4987	34.384
2	95 + 5	2523	17.395
3	90 + 10	2445	16.857
4	85 + 15	2369	16.333

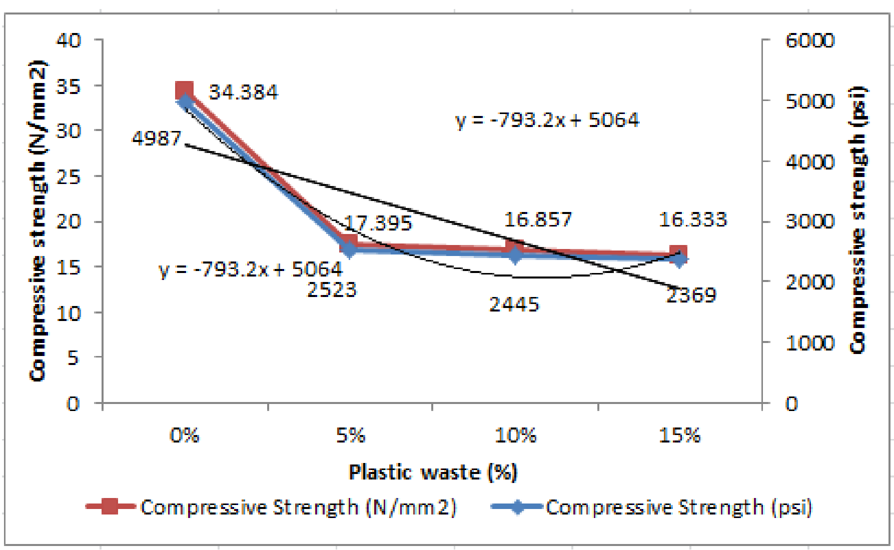

Figure 6: Compressive strength values of green concrete blocks

CONCLUSION

The following are the conclusions of the proposed investigation.

- Traditional and green bricks significantly differ in compressive strength, showing almost a 50% declination as soon as the plastic ingredients increased from 0% to 15%.

- By increasing the percentage of waste plastic content, the bricks' water absorption capacity will be reduced, so green bricks will consume less water than traditional bricks.

- The flexural strength property decreases at 5% and 15% waste plastic content while keeping the values of the controlled sample and 10% sample the same with minor differences.

- It is noted that increasing the waste plastic content replacement percentage decreased slump values, reducing workability.

- Growing plastic waste reduces the water absorption value to minor values. So, water absorption values are within limits, and the water has weatherproofing abilities.

- The compressive strength of the green concrete blocks decreases significantly at 5% waste plastic content, while the decrease at 10% and 15% is comparatively less.

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