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Experimental Investigation on the Mechanical and Durability Properties of Sustainable Bricks Manufactured Using Waste Plastic and River Sand

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Abstract: The increasing generation of waste from plastic creates a persistent solid-waste management challenge, while traditional clay brick production consumes natural resources and can impose environmental burdens. This study investigates the feasibility of converting selected waste plastics into sand-based masonry units and evaluates their physical and mechanical performance against conventional clay bricks. Waste compact discs and post-consumer plastic water bottles were cleaned, dried, reduced in size, heated, and combined with river sand. The reported experimental program used a plastic-to-sand proportion of 1:1.5 by weight for specimen preparation, with moulded specimens cooled before testing. Bulk density, water absorption, apparent porosity, and strength were also evaluated. The waste-plastic specimens showed lower density and substantially lesser water absorption and apparent porosity than the normal clay-brick specimen. In the reported comparison, the plastic-bottle specimen achieved a compressive strength of 10.6 MPa, compared with 1.77 MPa for the normal clay brick, while the compact-disc specimen reached 10.0 MPa. A separate set of project results also reported compressive strengths of 4.78 MPa and 4.65 MPa for plastic-sand bricks at 1:2 and 1:3 ratios, respectively. Overall, the findings indicate that waste-plastic–sand composites have potential as an alternative brick material, particularly where reduced water absorption, lower unit weight, and effective utilization of plastic waste are desirable. Further standardized testing is recommended before structural application.
Keywords: Waste plastic, plastic-sand brick, sustainable construction, compressive strength, absorption of water, apparent of porosity, bulk density.

I. INTRODUCTION

Plastic is widely used because it is lightweight, durable, versatile, and readily mouldable. These same characteristics become problematic after disposal because many plastic products persist for long periods in the environment. Improperly discarded plastic can accumulate in open areas, drainage systems, landfills, and water bodies, while uncontrolled burning can contribute to air pollution. Consequently, changing plastic waste into useful construction products offers a route for diverting a portion of this waste stream from disposal. Bricks remain one of the most widely used masonry materials. Conventional fired-clay bricks require suitable soil, shaping, drying, and firing, and their production is associated with usage of natural resources and thermal energy. The large volume of masonry units required in construction therefore provides an opportunity for incorporating recovered materials without changing the basic function of the product. Previous work has explored the use of waste from plastic in bricks, paver blocks, concrete, and bituminous materials. The project underlying this paper specifically examined the combination of plastic waste and sand from river to produce brick-like units. The approach relies on heating thermoplastic waste so that it can act as a binder for the sand fraction. This study systematically analyzes and presents the experimental findings reported in the project, focusing on bulk density, water absorption, apparent porosity, and compressive strength. The main objectives are to: (i) examine the feasibility of producing sand-based bricks using waste plastic; (ii) evaluate key physical and as well as mechanical features of the resulting specimens; (iii) compare their performance with conventional clay bricks; and (iv) assess whether the reported results support the use of plastic-sand composites as a potential sustainable construction material.

II. LITERATURE REVIEW

Research on waste utilization in construction has investigated both polymeric and mineral wastes as partial or complete substitutes for conventional raw materials. Studies cited in the source project include work on waste-plastic bricks and paver blocks, plastic-soil bricks, recycled plastic in concrete paver blocks, and also the use of waste materials in brick production. Generally, these researches indicate that waste streams can be converted into construction products when their processing method and resulting engineering properties are properly controlled.

The source project also discusses the distinction between thermoplastic and thermosetting polymers. Thermoplastics soften when heated and can be reshaped after cooling, making them more preferable for processes in which waste plastic is termed as a binder. The experimental program reported in the project used waste compact discs and plastic water bottles, together with river sand. The selected materials were cleaned, dried, reduced in size, heated, mixed, and moulded into test specimens.

The literature and project observations suggest that plastic can provide a binding phase around mineral particles, potentially reducing the connected pore structure of the composite. This can explain the relatively low absorption of the water and apparent porosity reported for the plastic-sand specimens. At the same time, performance depends strongly on plastic type, particle size, proportion, heating conditions, mixing efficiency, compaction, and cooling history. These factors should therefore be treated as important process variables in future optimization studies.

III. MATERIALS AND EXPERIMENTAL METHODOLOGY

A. Materials

Waste plastic was the principal recycled material. The experimental program identified two waste-plastic sources: discarded compact discs (CD) and waste plastic water bottles (PB). The plastics were washed to remove surface contaminants, dried, and cut into smaller pieces to facilitate heating and mixing. River sand was used as the mineral fraction. The reported specific gravity of the sand was 2.61 and its fineness modulus was 3.71.

B. Specimen Preparation

The cleaned plastic pieces and river sand were prepared for thermal mixing. The main experimental description reports a plastic-to-sand ratio of 1:1.5 by weight and heating at approximately 200 °C. The heated materials were blended until a reasonably homogeneous composite was obtained. The mixture was then put into moulds measuring 70.7 mm × 70.7 mm × 70.7 mm. After cooling in the mould for approximately 10 h, the sample were demolded and put in water for 24 h before testing.

The project also reports a separate comparison table for plastic-sand bricks prepared at 1:2 and 1:3 ratios. Because the reference document does not give a complete specimen-by-specimen preparation record for these two ratios, the values are presented in this paper as an additional reported dataset rather than being merged with the 1:1.5 CD/PB dataset.

C. Test Program

The reported tests covered maximum density, absorption of water, apparent porosity, and compressive strength. A normal clay brick obtained from a local source was applied as the conventional reference specimen in the CD/PB comparison. Absorption of Water was evaluated from the change in mass before and after water immersion, using the relationship $W(\%) = [(W_2 - W_1)/W_1] \times 100$, where W_1 is the initial dry mass and W_2 is the mass after immersion.

Equal strength was seen using a compression testing machine. The reported results were compared directly with the normal clay brick specimen. The source project also contains a separate table comparing plastic-sand bricks at 1:2 and 1:3 proportions with fly-ash and burnt bricks. These values are retained to avoid discarding experimental information contained in the original work.

Fig. 1. Appearance of sand-plastic specimens prepared from waste compact discs (CD) and plastic bottles (PB).

IV. RESULTS AND DISCUSSION

A. Physical Appearance and Bulk Density

The source project describes the plastic-sand specimens as having a smooth, wax-like surface. The compact-disc specimen appeared darker, whereas the plastic-bottle specimen was lighter. The reported bulk densities were 15.27 kN/m³ for the CD specimen, 14.38 kN/m³ for the PB specimen, and 20.43 kN/m³ for the normal clay brick. Thus, both waste-plastic specimens were lighter than the conventional specimen, with the plastic-bottle specimen showing the lowest reported bulk density.

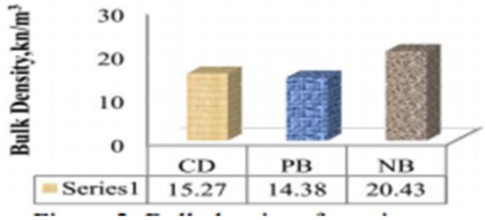

Fig. 2. Reported bulk density of CD, PB, and normal clay brick specimens

B. Water Absorption

Water absorption is an important indicator for masonry units because excessive absorption can be associated with moisture penetration and durability concerns. The reported absorption values were 4.5% for the CD specimen, 6.5% for the PB specimen, and 9.42% for the normal clay brick. The plastic-sand specimens therefore showed lower absorption than the reference clay brick. The project additionally reports a separate dataset in which the average mass gains corresponded to 2.79% and 3.28% water content for plastic-sand bricks at 1:2 and 1:3 ratios, respectively, compared with 6.42% for burnt bricks and 8.78% for fly-ash bricks.

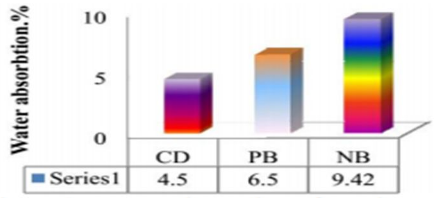

Fig. 3. Reported water absorption of CD, PB, and normal clay brick specimens.

TABLE I
REPORTED WATER ABSORPTION RESULTS FROM THE PROJECT

Brick Type	Average Mass Gain	Water Content (%)
Plastic-sand bricks (1:2)	0.075	2.79
Plastic-sand bricks (1:3)	0.094	3.28
Burnt bricks	0.212	6.42
Fly-ash bricks	0.282	8.78

C. Apparent Porosity

Apparent porosity provides an indirect indication of the volume of accessible voids in a specimen. Lower apparent porosity generally corresponds to reduced pathways for water ingress. The project reports apparent porosity values of 7.98% for the CD specimen, 12.04% for the PB specimen, and 22.24% for the normal clay brick. The lower values for the plastic-sand specimens are consistent with their lower water absorption and suggest a comparatively less permeable composite structure.

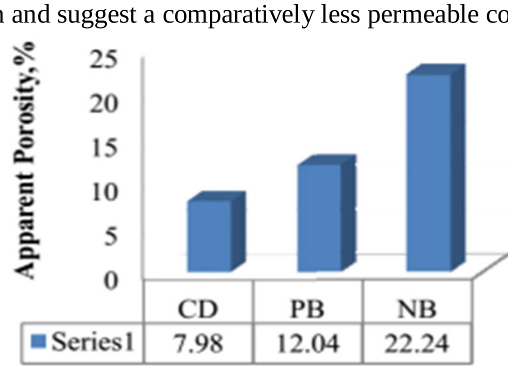

Fig. 4. Reported apparent porosity of CD, PB, and normal clay brick specimens

D. Compressive Strength

Compressive strength is a principal criterion for evaluating the suitability of a brick for load-bearing or non-load-bearing masonry applications. The reported compressive strengths were 10.0 MPa for the CD specimen, 10.6 MPa for the PB specimen, and 1.77 MPa for the normal clay brick. The plastic-bottle specimen therefore recorded the highest value in this comparison, while both plastic-based specimens substantially exceeded the reported strength of the reference clay brick.

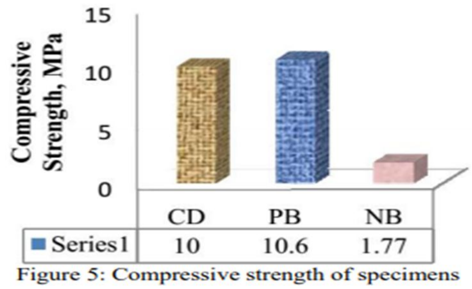

Fig. 5. Reported compressive strength of CD, PB, and normal clay brick specimens.

TABLE II
REPORTED COMPRESSIVE STRENGTH VALUES

Specimen / Brick Type	Compressive Strength (MPa)
CD plastic-sand brick	10.00
PB plastic-sand brick	10.60
Normal clay brick	1.77
Plastic-sand bricks (1:2)	4.78
Plastic-sand bricks (1:3)	4.65
Fly-ash bricks	1.30
Burnt bricks	1.20

E. Comparative Interpretation

Taken together, the reported datasets show a consistent advantage for plastic-sand composites in the measured properties. In the CD/PB dataset, the plastic-based specimens were lighter than the normal clay brick and exhibited substantially lower absorption of water and apparent porosity. They also recorded considerably higher compressive strength. In the second dataset, the 1:2 and 1:3 plastic-sand bricks again showed lower reported absorption of water and higher strength in terms of compression than the listed fly-ash and burnt brick values. These results support the feasibility of plastic waste as a binding component for sand-based masonry units. However, the results should be interpreted within the limits of the original experimental record. The project does not provide a complete statistical description of the number of specimens, replicate variability, failure modes, heating-energy consumption, or long-term exposure performance. In addition, the two reported datasets use different plastic-sand ratios and specimen descriptions. Consequently, the results demonstrate promising material behavior but should not be treated as a final specification for structural brick production. Standardized testing, repeatability studies, fire performance evaluation, dimensional stability assessment, and life-cycle analysis would strengthen future research.

V. CONCLUSIONS

This study presents an experimental assessment of bricks produced by combining waste plastic with river sand. On the basis of results reported in the source paper, the following conclusions are drawn:

1) Waste plastic can be incorporated with river sand to produce a rigid brick-like composite without relying on conventional clay firing.
2) The reported bulk density of the plastic-bottle specimen (14.38 kN/m³) was lower than that of the compact-disc specimen (15.27 kN/m³) and the normal clay brick (20.43 kN/m³).
3) Water absorption of the CD and PB specimens was reported as 4.5% and 6.5%, respectively, compared with 9.42% for the normal clay brick.

4) Apparent porosity was reported as 7.98% for CD, 12.04% for PB, and 22.24% for the normal clay brick, indicating fewer accessible voids in the plastic-sand specimens.
5) The PB specimen achieved the highest reported compressive strength of 10.6 MPa, while the CD specimen reached 10.0 MPa and the normal clay brick reached 1.77 MPa.
6) The additional project dataset reported compressive strengths of 4.78 MPa and 4.65 MPa for plastic-sand ratios of 1:2 and 1:3, respectively, indicating that mix proportion influences performance.
7) Waste-plastic–sand bricks therefore show potential as a sustainable construction material, but broader standardized testing is required before recommending them for specific structural applications.

VI. FUTURE SCOPE

Future experimental work should optimize the plastic-to-sand ratio, characterize the plastic types separately, and establish the effect of heating temperature and mixing time. Repeated specimens should be tested to quantify variability. Additional investigations should include flexural or splitting behavior, abrasion, thermal performance, fire resistance, freeze-thaw or wet-dry cycling where relevant, dimensional stability, and leaching or environmental safety. A cost and life-cycle comparison with fired clay and fly-ash bricks would also help determine the practical sustainability of the material.

VII. ACKNOWLEDGMENT

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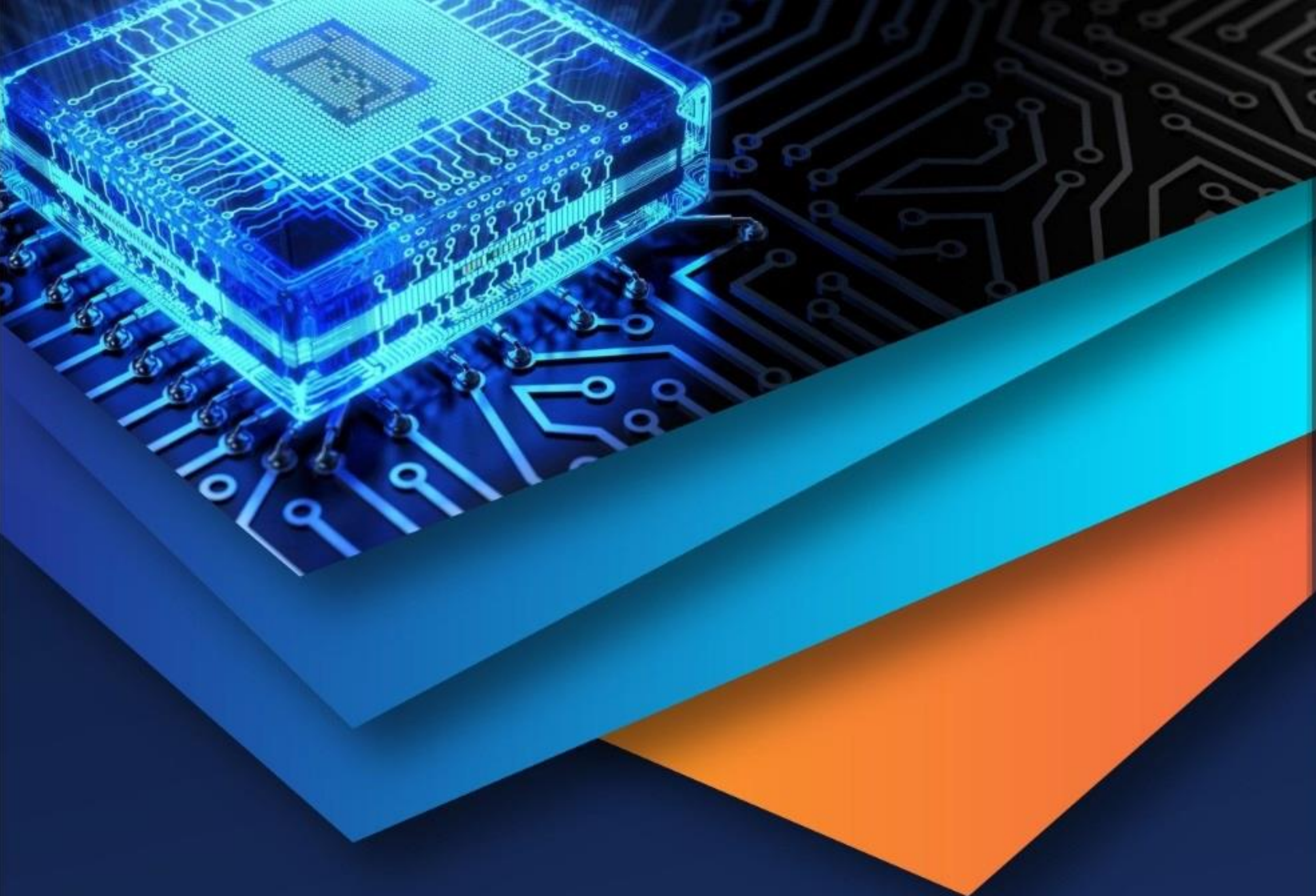

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