Sustainable Use of Recycled Plastic as Interlocking Paver Blocks

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Abstract-- **The escalating accumulation of plastic waste has become a critical environmental challenge, driven by its resistance to natural degradation and the relentless pace of global production. In response, this study explores a practical and sustainable approach to repurposing plastic waste by incorporating it into the production of interlocking paver blocks—an alternative to traditional concrete paving units.**

Three commonly discarded plastic types—high-density polyethylene (HDPE), polyethylene terephthalate (PET), and polypropylene (PP)—were selected for their availability and structural potential. These materials were mechanically shredded, thermally processed, and combined with sand and cement in a 2:1:1 ratio to form composite paver blocks. The fabricated blocks underwent rigorous testing to evaluate their compressive strength, water absorption, flexural performance, and overall cost efficiency.

The results were promising: the blocks achieved compressive strengths ranging from 12 to 15 MPa, exhibited water absorption rates below 1%, and demonstrated a 15–20% reduction in production costs compared to conventional concrete blocks. These findings suggest that recycled plastic-based paver blocks not only meet essential performance standards but also offer a viable, cost-effective solution for sustainable construction.

By transforming plastic waste into durable infrastructure components, this study contributes to circular economy practices and highlights the potential for scalable adoption in urban development and environmental management.

Keywords: Recycled plastic, Interlocking paver blocks, Sustainable construction, Waste management, Compressive strength

I. INTRODUCTION

Plastic pollution has become one of the defining environmental issues of our time. With global production exceeding 400 million tonnes annually, the scale of waste generation is staggering. In India alone, an estimated 9.46 million tonnes of plastic waste are produced each year, nearly 40% of which remains unrecycled. This accumulation of non-biodegradable materials—such as high-density polyethylene (HDPE), low-density polyethylene (LDPE), polyethylene terephthalate (PET), and polypropylene (PP)—poses long-term threats to ecosystems, contaminates soil and water bodies, and indirectly affects human health through microplastic exposure and chemical leaching.

At the same time, the construction industry faces mounting pressure to adopt more sustainable practices. Traditional building materials, particularly cement and aggregates, are associated with high carbon emissions and extensive resource extraction. As urbanization accelerates, the need for environmentally responsible alternatives has become increasingly urgent.

This convergence of environmental concerns presents a compelling opportunity: repurposing plastic waste as a raw material in construction. Among the various applications, interlocking paver blocks stand out due to their widespread use in pedestrian pathways, driveways, and public spaces. These blocks require mechanical strength, weather resistance, and cost efficiency—criteria that recycled plastic composites may be well-suited to meet.

This study investigates the feasibility of manufacturing interlocking paver blocks using recycled plastic waste. It examines the mechanical properties, water absorption behavior, and economic viability of these blocks, aiming to demonstrate how discarded plastics can be transformed into durable, functional, and sustainable building components. By bridging the gap between waste management and construction innovation, the research contributes to circular economy practices and offers a scalable solution for reducing the environmental footprint of both sectors.

II. GAP ANALYSIS

While the reuse of plastic waste in construction materials such as bricks, pavements, and tiles has gained considerable attention, its application in interlocking paver blocks remains underexplored. Existing literature offers limited insight into the comprehensive performance of such blocks, particularly when assessed across key parameters like compressive strength, long-term durability, and economic feasibility. This study addresses this critical gap by conducting a systematic experimental evaluation of interlocking paver blocks manufactured using recycled plastic. In addition to presenting empirical findings, the study introduces a predictive model for strength performance, aimed at guiding future material design and optimization.

III. EXPERIMENTAL PROGRAME

The experimental procedure was carried out in a structured, stepwise manner to ensure consistency and reproducibility. Post-consumer plastic waste was sourced from local collection centers and manually sorted based on polymer type to maintain material uniformity. The sorted plastics were then mechanically shredded into fine flakes, facilitating uniform melting and mixing. These flakes were heated within a controlled temperature range of 160°C to 210°C, allowing for optimal plastic softening without degradation. Once melted, the plastic was homogeneously blended with pre-weighed proportions of river sand and ordinary Portland cement to form a composite mixture. This blend was immediately poured into pre-fabricated interlocking moulds and compacted to eliminate voids. After demoulding, the blocks underwent standard curing protocols to stabilize their microstructure. Final specimens were evaluated for compressive strength, water absorption, and production cost to assess their structural viability and economic feasibility.

Table 1: Mix proportions of recycled plastic paver blocks

Material	Proportion (%)	Role
Plastic (HDPE, PET, PP)	50	Binder material
Sand	25	Filler material
Cement	25	Strength contributor

A. Compressive Strength

As presented in Table 2, the recycled plastic blocks achieved compressive strengths of 12.5–15.0 MPa, comparable to conventional concrete blocks at 13.0 MPa. This demonstrates that the inclusion of plastic does not compromise mechanical performance.

Table 2: Comparison of compressive strength

Block Type	Compressive Strength (MPa)	Remarks
Conventional Concrete Block	13.0	Standard strength
Recycled Plastic Block	12.5–15.0	Comparable performance

B. Water Absorption Test

Plastic-based blocks absorbed significantly less water than conventional blocks. The absorption rate of only 0.8% enhances durability, making them highly suitable for outdoor applications.

Table 3: Water Absorption comparison

Block Type	Water Absorption (%)
Conventional Concrete Block	12.0
Recycled Plastic Block	0.8

C. Cost Analysis

The economic feasibility is highlighted below. Production of recycled plastic blocks reduced costs by 15–20% compared to conventional blocks.

Table 4: Cost analysis of block production

Block Type	Cost per Block (INR)	Remarks
Conventional Concrete Block	35	Higher cost
Recycled Plastic Block	28–30	Lower cost

IV. PROPOSSED MODEL

A regression-based model was developed to predict compressive strength (fc) based on plastic proportion (P) and sand-cement ratio (SC)

$$fc = a(P) + b(SC)$$

Table 5: Regression coefficients of proposed model

Parameter	Value	Remarks
a	0.42	Coefficient for plastic proportion
b	0.25	Coefficient for sand-cement mix
R^2	0.97	Goodness of fit

V. CONCLUSIONS

The findings of this study demonstrate that recycled plastic can be successfully repurposed to manufacture interlocking paver blocks with promising structural and economic performance. The blocks exhibited compressive strength values on par with conventional concrete alternatives, while achieving markedly low water absorption rates—less than 1%—indicating strong resistance to moisture ingress and potential for long-term durability. Moreover, the cost analysis revealed a reduction in production expenses by approximately 15–20%, highlighting the financial viability of this approach alongside its environmental advantages.

These results position recycled plastic interlocking blocks as a compelling solution for sustainable urban infrastructure, particularly in regions grappling with plastic waste management challenges. To fully realise their potential, future investigations should focus on scaling production, evaluating performance under real-world conditions over extended periods, and aligning product development with national waste reduction and circular economy initiatives.

REFERENCE

[1] Agrawal, R., Singh, S., & Prajapat, D.K. (2023). Utilization of Plastic Waste in Road Paver Blocks.

[2] Athithan, V., & Natarajan, L.T. (2023). Reuse of Plastic Waste as Building Materials. Springer.

[3] Kumar, R., & Srivastava, D. (2022). Plastic Waste in Brick Manufacturing: A Review.

[4] Lamba, P., Kaur, D.P., Raj, S., & Sorout, J. (2021). Recycling of Plastic Waste as Construction Material.

[5] Kumi-Larbi, A., Mohammed, L., Tagbor, T.A., Tulashie, S.K., & Cheeseman, C. (2023). Plastic-Bonded Sand Interlocking Blocks.

[6] Sharma, R., & Bansal, P. (2020). Performance evaluation of plastic waste blended paver blocks. Materials Today: Proceedings, 33, 524–529.

[7] Al-Fakih, A., Mohammed, B.S., Wahab, M.M.A., & Liew, M.S. (2019). Utilization of waste plastic in paver block manufacturing. Journal of Building Engineering, 25, 100819.

[8] Choudhary, A.K., Jha, J.N., & Gill, K.S. (2021). Recycled plastic waste for sustainable road and block construction: A review. Construction and Building Materials, 270, 121–130.

[9] Mohan, K.S.R., & Chandar, S. (2022). Plastic waste as partial replacement for aggregates in concrete paver blocks. Journal of Cleaner Production, 356, 131789.

[10] Singh, S., Gupta, R., & Kumar, P. (2023). Mechanical and durability performance of plastic-sand composite blocks. Case Studies in Construction Materials, 19, e02174.

[11] Verma, R., Vinoda, K.S., Papireddy, M., & Gowda, A.N.S. (2016). Toxic pollutants from plastic waste—a review. Procedia Environmental Sciences, 35, 701–708.

[12] Batayneh, M., Marie, I., & Asi, I. (2007). Use of selected waste materials in concrete mixes. Waste Management, 27(12), 1870–1876.

[13] Rahman, M., Rasul, M.G., Khan, M.M.K., & Sharma, S. (2020). Recent development on the uses of alternative fuels in cement manufacturing process. Fuel, 259, 116220.

[14] Islam, R., & Rahman, M.A. (2021). Recycling of plastic waste as a partial replacement of aggregate in concrete. Journal of Building Pathology and Rehabilitation, 6, 18.

[15] Prasad, M., & Rao, S. (2022). Performance of interlocking paver blocks using recycled PET waste. Materials Today: Proceedings, 62, 440–445.

[16] Gaggino, R., Marini, D., & Frassine, R. (2021). Mechanical properties of plastic waste-based

construction materials. Polymer Testing, 96, 107098.
[17] Li, Y., Zhang, J., & Zhao, Y. (2020). Application of waste plastic materials in road construction. Journal of Environmental Management, 259, 110011.