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Sustainable Conversion of waste foundry sand into Paver blocks

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Abstract—Waste foundry sand (WFS) is a by-product of metal casting industries and poses a significant disposal challenge due to its volume and chemical composition. This study investigates the feasibility of utilizing waste foundry sand as a partial replacement for fine aggregate in the production of interlocking paver blocks. The paver blocks were cast using a 1:1:1 mix ratio (cement: fine aggregate: coarse aggregate) with dimensions of 200 mm × 100 mm × 80 mm (ZIG-ZAG shape), incorporating 400 g of plastic waste per batch to enhance sustainability. The foundry soil sample was tested and showed a pH of 7.85, moisture content of 3.07%, organic matter of 6.9%, silica (SiO_2) of 21.80 mg/kg, and iron content of 1.21 mg/kg. The produced paver blocks were tested for compressive strength and water absorption as per IS: 15658–2006. The average compressive strength achieved was 17.27 N/mm² and average water absorption was 3.33%, which comply with standard requirements. The results confirm that waste foundry sand and plastic waste can be successfully incorporated into paver block production, offering an eco-friendly and cost-effective solution for construction materials.

Index Terms—Waste Foundry Sand, Interlocking Paver Blocks, Plastic Waste, Compressive Strength, Water Absorption, Sustainable Construction, IS: 15658.

I. INTRODUCTION

Rapid industrialization and urbanization have led to a sharp increase in the generation of industrial by-products and solid wastes. Among these, waste foundry sand (WFS) is generated in large quantities from iron, steel, and non-ferrous metal casting industries. According to estimates, foundries worldwide generate millions of tons of used foundry sand annually, most of which is sent to landfills, causing environmental concerns including soil contamination and groundwater pollution.

At the same time, the construction industry is constantly seeking sustainable alternatives to conventional materials such as river sand, which is becoming scarcer due to over-dredging. Paver blocks, widely used for road pavements, pedestrian walkways, parking areas, and landscaping, require significant quantities of fine aggregate. The incorporation of WFS as a substitute for natural fine aggregate in paver blocks presents an innovative and environmentally responsible approach.

Furthermore, plastic waste is another growing environmental crisis. Discarded plastic, if not properly managed, leads to land and water pollution. The use of shredded or chip plastic waste as an additive in paver block manufacturing can help divert plastic waste from landfills while potentially improving the properties of the blocks.

This research aims to study the properties of waste foundry sand through laboratory analysis, and to evaluate the mechanical performance (compressive strength and water absorption) of interlocking paver blocks made with a 1:1:1 ratio of cement, coarse aggregate, and waste foundry sand, supplemented with 400 g of plastic waste per batch. The paver mould dimensions used are 200 mm × 100 mm × 80 mm in a ZIG-ZAG interlocking shape, tested as per IS: 15658–2006.

II. LITERATURE SURVEY

Several researchers have explored the use of waste foundry sand (WFS) and plastic waste in construction materials, particularly in concrete and pavement applications.

Siddique et al. (2010) investigated the use of used foundry sand as a fine aggregate replacement in concrete. Their study found that up to 30% replacement of natural sand with WFS resulted in comparable or improved compressive strength, with the added benefit of reducing industrial waste disposal. They concluded that WFS is a viable eco-friendly substitute in concrete manufacturing.

Guney et al. (2010) examined the influence of WFS on the strength and durability of concrete. Their results showed that concrete mixes with WFS exhibited acceptable workability and strength, and that the silica content present in WFS contributed positively to long-term strength development through pozzolanic activity.

Basar and Deveci Aksoy (2012) evaluated the effect of WFS on the mechanical and microstructural properties of self-compacting concrete (SCC). They noted that 10–20% WFS replacement maintained acceptable compressive and split tensile strength values, and microscopic analysis revealed good bonding between WFS particles and the cement matrix.

Prabhu et al. (2014) conducted a study on paver blocks made with partial replacement of fine aggregate with WFS. The study found that paver blocks with up to 25% WFS replacement met IS: 15658 requirements for compressive strength and water absorption, indicating the suitability of WFS in paving block applications.

Regarding plastic waste, Rai et al. (2012) and Bhogayata and Arora (2017) reported that the addition of shredded plastic waste in concrete improved toughness, reduced density, and enhanced post-crack behaviour. However, very high percentages of plastic reduced compressive strength. A controlled addition of 1–3% by weight showed positive contributions.

Bhardwaj and Kumar (2017) reviewed multiple studies on WFS and concluded that waste foundry sand, when chemically characterized, shows a high silica content (typically 80–95% SiO_2), low organic content, and near-neutral pH — properties that make it suitable for construction applications. Their review also endorsed the co-utilization of WFS and other wastes in composite building products.

The literature collectively supports the feasibility of using WFS as a fine aggregate substitute and plastic waste as an additive in paver block manufacturing. The present study extends this knowledge by combining both materials in a 1:1:1 mix ratio with 400 g of plastic waste chips in a ZIG-ZAG interlocking paver block.

III. MATERIALS AND METHODS

A. Materials Used

The following materials were used in the fabrication of interlocking paver blocks:

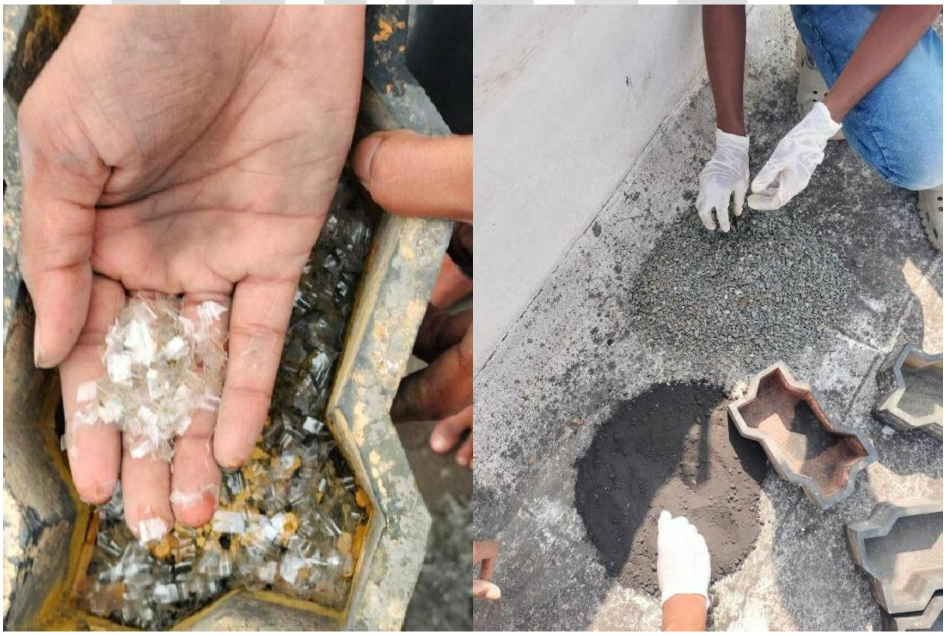
(i) Ordinary Portland Cement as the binding material.

(ii) Coarse aggregate (crushed stone chips) as structural aggregate.

(iii) Waste foundry sand (WFS) collected from a local foundry

(iv) Plastic waste chips (400 g per batch) collected from discarded plastic waste.

(v) Water (potable) for mixing.



B. Waste Foundry Sand Characterization

The WFS sample was tested at Alpha Labs & Technologies, Coimbatore (Report No. ALT/3681/2025, dated 14.10.2025). The laboratory analysis results of the foundry soil are presented in Table 1.

TABLE I: FOUNDRY SAND CHARACTERIZATION RESULTS

S.No	Test Parameter	Unit	Test Protocol	Result
1	pH	-	IS 2711	7.85
2	Moisture	%	IS 1773:2022	3.07
3	Organic Matter	%	IS 2720 Part:22	6.9
4	Silica as SiO_2	mg/kg	In House Method	21.80
5	Iron	mg/kg	In House Method	1.21

C. Mix Design and Mould

A mix ratio of 1:1:1 (Cement: Coarse Aggregate: Waste Foundry Sand) by weight was adopted. The mould dimensions were 200 mm × 100 mm × 80 mm in ZIG-ZAG interlocking shape. Additionally, 400 g of plastic waste chips (chip aggregate) was added per batch to the mix to improve sustainability and utilize waste plastic. The fresh mix was filled into moulds, compacted using vibration, and demoulded after 24 hours. The specimens were then water-cured for 28 days before testing.

IV. TEST RESULTS AND DISCUSSION

A. Compressive Strength

The paver blocks were tested for compressive strength as per IS: 15658–2006. Three specimens (ZIG-ZAG shape, 200 × 100 × 80 mm) were tested. The results are presented in Table 2.

TABLE II: COMPRESSIVE STRENGTH TEST RESULTS

Sl.No	Nom. Area (Sq.mm)	Thickness (mm)	Failure Load (kN)	Comp. Strength (N/mm²)	Corr. Factor	Final Comp. Strength (N/mm²)
1	20500	80	274.2	13.37	1.18	15.77
2	20500	80	336.1	16.39	1.18	19.34
3	20500	80	290.6	14.17	1.18	16.72
Average Compressive Strength (N/mm²)						**17.27**

The average compressive strength of 17.27 N/mm² satisfies the minimum requirement of 15 N/mm² for Category C paver blocks as per IS: 15658–2006 (for light traffic applications). This indicates that the combination of WFS and plastic waste chips does not significantly impair the structural performance of the paver blocks.

B. Water Absorption

The water absorption test was conducted as per IS: 15658–2006. Results are shown in Table 3.

TABLE III: WATER ABSORPTION TEST RESULTS

Sl.No	Nom. Area (Sq.mm)	Water Absorption (% by wt)	Requirement as per IS:15658-2006
1	20500	3.50	
2	20500	2.80	Shall not exceed 6% by mass; individual samples restricted to 7%
3	20500	3.70	
Average Water Absorption (%)		**3.33**	**Complies**

The average water absorption of 3.33% is well within the permissible limit of 6% (individual limit 7%) as per IS: 15658–2006. The relatively low water absorption indicates good compaction and a dense microstructure, which is partly attributed to the fine particle size of waste foundry sand filling inter-aggregate voids.

C. Discussion

The foundry sand characterization showed a near-neutral pH (7.85), confirming it is not highly alkaline or acidic and is safe for use in construction materials. The silica content ($SiO2$ = 21.80 mg/kg) and low iron content (1.21 mg/kg) suggest chemical compatibility with cement. The low moisture content (3.07%) and moderate organic matter (6.9%) indicate that the WFS can be directly used with minor drying.

The compressive strength results (avg. 17.27 N/mm²) and water absorption results (avg. 3.33%) both comply with IS: 15658–2006, demonstrating that the paver blocks manufactured with WFS and 400 g of plastic waste chips are suitable for light-to-medium traffic applications. The plastic waste chips act as micro-reinforcement, improving toughness without severely compromising strength.

V. CONCLUSION

This study successfully demonstrated the conversion of waste foundry sand (WFS) into interlocking paver blocks using a 1:1:1 mix ratio (cement: coarse aggregate: WFS) with the addition of 400 g of plastic waste chips per batch. Based on the test results, the following conclusions are drawn:

1. Waste foundry sand from Sri Ramakrishnan Engineering College, Thudiyalur showed acceptable chemical properties — neutral pH (7.85), low moisture (3.07%), and moderate silica content — making it suitable for use as a fine aggregate substitute in construction.

2. The interlocking paver blocks (200 mm × 100 mm × 80 mm, ZIG-ZAG shape) achieved an average compressive strength of 17.27 N/mm², meeting IS: 15658–2006 requirements for paver blocks.

3. The average water absorption of 3.33% is well within the 6% limit specified by IS: 15658–2006, indicating good durability and density of the blocks.

4. The incorporation of plastic waste chips into the mix enhances the sustainability of the product by diverting two types of industrial and municipal waste — foundry sand and plastic — from landfills.

5. This research promotes eco-friendly and cost-effective construction practices by valorizing

industrial by-products, contributing to sustainable development goals (SDGs) and circular economy principles.

Future work may explore varying proportions of WFS, higher plastic waste percentages, and supplementary cementitious materials (SCMs) to further optimize block performance.

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