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Experimental Investigation on Paver Block by Partially Replacing Mild Steel Lathe Waste as Fine Aggregate

Ano Leversheya C[1], Aravindh R. S[2], Rathika R[3], Joshan S. J[4], Sony P[5]

[1,2,3,4,5]*Department of Civil Engineering, Stella Mary's College of Engineering, Aruthenganvilai, Kanyakumari District, India*
Affiliated to Anna University, Chennai

Abstract: ***Paver blocks are a durable, low-maintenance form of exterior pavement widely used for roads, footpaths and parking areas. This study investigates the feasibility of using mild steel lathe waste, an industrial by-product otherwise disposed of on barren land, as a partial replacement for fine aggregate in the manufacture of concrete paver blocks. Lathe scrap, available in fibrous form from machining operations, was used to replace 20% of the fine aggregate in an M35/M40 design mix. Basic material characterization tests (specific gravity, sieve analysis, consistency, and setting time) were carried out on cement, fine aggregate and coarse aggregate, followed by casting and curing of paver block specimens for 7, 14 and 28 days. The compressive strength and weight of the modified paver blocks were compared against conventional concrete paver blocks. Results show that partial replacement with lathe scrap increased the weight of the paver block by about 1.07% and improved the 28-day compressive strength by approximately 44% relative to the conventional block, confirming that mild steel lathe waste can be effectively reused as a sustainable, cost-effective reinforcing material in pavement construction.***

Key words—Paver block, mild steel lathe waste, fine aggregate replacement, compressive strength, sustainable construction.

I. Introduction

Paver blocks are pre-cast concrete units used primarily for outdoor flooring and low-volume road construction rather than for load-bearing walls. They offer a flexible pavement surface that is durable, easy to maintain, aesthetically versatile, and resistant to skidding and wear. Because paver blocks are manufactured off-site under controlled conditions, they allow rapid construction and easy repair of damaged sections without disturbing the entire pavement.

A growing concern in the construction industry is the depletion of natural resources such as river sand, coupled with the accumulation of industrial waste that is otherwise sent to landfills. Mild steel lathe waste, generated in large quantities by machining and turning operations in workshops, is one such by-product. It is typically discarded on open or barren land, where it contributes to soil and environmental degradation. Reusing this waste as a construction material offers both an economic and an environmental benefit.

This study explores the use of mild steel lathe waste as a partial replacement for fine aggregate in the production of concrete paver blocks. The workability and compressive strength of the modified paver blocks were evaluated and compared with conventional paver blocks to assess the viability of this sustainable alternative.

1.1 Aim and Objectives

The aim of this work is to manufacture paver blocks using mild steel lathe waste as a partial replacement for fine aggregate and to evaluate their strength properties relative to conventional concrete paver blocks. The specific objectives are: (i) to replace fine aggregate with mild steel lathe waste at a fixed percentage; (ii) to compare the resulting compressive strength against a control mix and identify the optimum replacement level; (iii) to cast the final paver block using the optimum mix proportions; and (iv) to design the mix (M35/M40 grade) so as to improve the durability and effectiveness of the paver block.

1.2 Scope

The broader scope of the project is to increase the compressive strength of paver blocks while reducing dependence on conventional raw materials, thereby supporting sustainable development by diverting industrial waste from disposal and conserving natural aggregate resources.

II. Literature Review

A number of studies have examined the use of industrial and agricultural by-products as partial replacements for aggregate or cement in paver block and concrete production. Lailesh et al. [1] reported that replacing fine aggregate with waste glass at a 20% level improved the compressive strength, flexural strength, splitting tensile strength and abrasion resistance of paving blocks relative to a control sample. Singh [2] examined the substitution of cement with granite/stone polishing waste powder, noting that the fine, reactive nature of the waste made it suitable for partial cement replacement while easing an otherwise serious disposal and pollution problem.

Koganti [3] found that fine aggregate could be replaced with quarry dust up to about 20% without significant strength loss, and that glass powder and ceramic dust could similarly be used up to 20%

replacement with a modest strength gain, whereas coal dust reduced strength and was found unsuitable. Kochkal [4] investigated fly-ash lightweight aggregate as a coarse aggregate replacement and found that sintered or cold-bonded fly-ash aggregates could produce durable, freeze–thaw resistant lightweight concrete comparable to normal-weight concrete.

Khandve [5] demonstrated that up to 70% of conventional aggregate in paving blocks could be replaced with marble/gravestone waste without compromising performance, while simultaneously reducing manufacturing cost and addressing construction-waste disposal. Soliman et al. [6] studied dry-cast steel-fibre-reinforced concrete (DCSFRC) for precast pipes and found that increasing steel fibre dosage improved ultimate and post-cracking strength, with the reinforcing index correlating well with splitting tensile and flexural strength.

Additional studies on fly ash consistently report improvements in mechanical properties at moderate replacement levels: Erdem Damei et al. [7] found that a 15% fly-ash replacement in clinker markedly increased 90-day compressive strength and that finer fly-ash particles improved strength development; Kayali et al. [8] showed fly-ash lightweight aggregate concrete to be about 22% lighter and 20% stronger than normal-weight aggregate concrete, with lower drying shrinkage; Siddique [9] observed higher compressive, splitting-tensile and flexural strength when fly ash replaced sand at all curing ages; and Berrymana et al. [10] reported improved 7-day strength and a 15% gain in durability when fly ash partially replaced cement in reinforced-concrete pipe mixes. Collectively, this body of literature indicates that carefully selected industrial by-products, including metallic waste such as lathe scrap, can be used to partially replace conventional aggregate or cement without adverse effects on strength, and in many cases with measurable improvement, motivating the present investigation into mild steel lathe waste.

III. Materials and Methods

The properties of concrete, in both the fresh and hardened state, depend largely on the properties of its constituent materials. Detailed characterization tests were therefore carried out in the laboratory on each raw material before mix design and casting.

3.1 Materials

The primary materials used were mild steel lathe waste, ordinary Portland cement (OPC), fine aggregate, coarse aggregate and water.

1) Mild Steel Lathe Scrap: Lathe scrap is a fibrous waste material generated in machine-shop turning operations. In this study, lathe scrap was used to replace 20–25% of the fine aggregate by weight. Its chemical composition, dominated by iron with small percentages of carbon, silicon, manganese, sulphur, phosphorus and nickel, is given in Table 1.

Table 1: Chemical Composition of Mild Steel Lathe Waste

Constituent	Composition (%)
Carbon	0.150
Silicon	0.180
Manganese	0.450
Sulphur	0.031
Phosphorus	0.010
Nickel	0.008
Iron	99.166

2) Fine Aggregate: Locally procured river sand conforming to grading zone II of IS 383:2007 was used. The sand was sieved through a 4.75 mm sieve and washed to remove dust. Its properties are summarized in Table 2.

Table 2: Properties of Fine Aggregate

Property	Value
Specific gravity	2.53 – 2.63
Water absorption	1.57%
Bulk density	1650 kg/m³

3) Coarse Aggregate: Crushed angular coarse aggregate of maximum size 20 mm (retained on 16 mm), collected from a local quarry, was used in accordance with IS 2386:1963. Its properties are summarized in Table 3.

Table 3: Properties of Coarse Aggregate

Property	Value
Maximum aggregate size	20 mm
Specific gravity	2.70
Water absorption	0.5%
Bulk density	1510 kg/m³

4) Cement: Ordinary Portland Cement of 43 grade, conforming to IS 8112:2013, was used for all specimens. Its chemical composition is given in Table 4.

Table 4: Chemical Composition of Cement

Oxide	Mass (%)
CaO	66.33
SiO_2	18.60
Fe_2O_3	4.03
Al_2O_3	3.77
SO_3	2.67
MgO	2.13

5) Water: Potable water, free from oils, acids, alkalis, salts, sugar and organic matter, was used for both mixing and curing, in accordance with standard practice.

3.2 Methodology

The experimental programme proceeded through a literature review, collection of materials, characterization of material properties, mix design, casting of paver blocks with fine aggregate partially replaced by mild steel lathe waste, curing, strength testing, and determination of the optimum compressive strength. This sequence is summarized in Fig. 1.

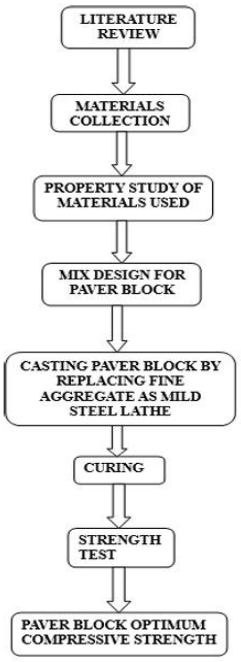

Figure 1. Methodology flow chart of the experimental programme.

3.3 Mix Design

The mix was designed as per IS 10262:2009 for M40-grade concrete using 43-grade OPC, a maximum nominal aggregate size of 20 mm, a minimum cement content of 300 kg/m³, and a maximum water–cement ratio of 0.5, targeting a slump of 50 mm under mild exposure conditions. The target mean strength was calculated as:

$$f'ck = fck + 1.65s = 20 + 1.65(4) = 26.6\ N/mm^2$$

where s = 4 N/mm² is the assumed standard deviation. A water–cement ratio of 0.50 was adopted (below the code maximum of 0.55), giving a water content of 186 L/m³ and a corresponding cement content of approximately 372–378 kg/m³, which satisfies the minimum requirement of 300 kg/m³ for mild exposure. The volume of coarse aggregate corresponding to 20 mm maximum size and a water–cement ratio of 0.50 was taken as 0.60 of the total aggregate volume, with fine aggregate making up the remaining 0.40. Based on these proportions, the mix calculation per cubic metre of concrete yielded a cement volume of 0.118 m³, a water volume of 0.186 m³, and a combined aggregate volume of 0.696 m³, corresponding to approximately 1127.5 kg of coarse aggregate and 732.2 kg of fine aggregate, a fraction of which was substituted with mild steel lathe waste.

IV. Experimental Investigations

Standard laboratory tests were performed on each constituent material to verify suitability for paver block production.

4.1 Tests on Fine Aggregate

The specific gravity of the fine aggregate, determined using a pycnometer, was found to be 2.63. Sieve analysis (Table 5) yielded a fineness modulus of 4.24, computed from the cumulative percentage retained across the IS sieve series from 4.75 mm to 150 µm.

Table 5: Sieve Analysis of Fine Aggregate

Sieve Size	% Retained	Cumulative % Retained	% Passing
4.75 mm	1.8	1.8	98.2
2 mm	16.5	18.3	81.7
1 mm	22.7	41.0	59.0
600 µm	34.0	75.0	36.0
300 µm	15.0	90.0	10.0
150 µm	8.0	98.0	2.0
Pan	2.0	100.0	0.0

4.2 Tests on Cement

The standard consistency of the cement, determined using the Vicat apparatus (Table 6), was found to be 33%. The initial and final setting times, determined per standard procedure, were 30 minutes and 480 minutes respectively, both within the permissible IS limits. The specific gravity of the cement, measured using a Le-Chatelier flask with kerosene, was found to be 3.16, indicating acceptable moisture content.

Table 6: Standard Consistency Test on Cement

Trial	Cement (g)	Water (%)	Water (mL)	Penetration (mm)
1	300	30	90	18
2	300	31	93	10
3	300	32	96	8
4	300	33	99	5

4.3 Tests on Coarse Aggregate

The specific gravity of the coarse aggregate, determined by pycnometer, was 2.70. Sieve analysis (Table VII) yielded a fineness modulus of 7.88. The water absorption test gave a value of 0.5%, indicating a relatively dense, low-porosity aggregate. The aggregate impact test yielded a dry sample weight (W1) of 650 g and a passing fraction (W2) of 110 g, corresponding to an aggregate impact value of approximately 16.9%, well within the acceptable range for pavement-quality aggregate.

Table 7: Sieve Analysis of Coarse Aggregate

Sieve Size (mm)	% Retained	Cumulative % Retained	% Passing
80	0.0	0.0	100.0
40	4.9	4.9	95.1
20	79.5	84.4	15.6
10	15.25	99.65	0.35
4.75	0.35	100.0	0.0

V. Results and Discussion

Paver block specimens were cast in three variants: conventional (control) blocks, blocks with 20% of the fine aggregate replaced by lathe scrap, and blocks with 20% replaced by lathe dust, and cured for 7, 14 and 28 days prior to testing.

5.1 Comparison of Weight

The weight of each paver block depends on the type and proportion of material replaced. Because the density and unit weight of mild steel exceed those of natural fine and coarse aggregate, paver blocks containing lathe scrap or lathe dust were consistently heavier than the conventional blocks. On average, the conventional block weighed 5.5 kg after hardening; replacement with lathe scrap and lathe dust increased the weight by approximately 1.07% and 1.03% respectively.

5.2 Comparison of Compressive Load and Strength

The ultimate compressive load applied to each specimen was recorded at 7, 14 and 28 days of curing (Table 8) and used to compute compressive strength as the ratio of ultimate load to the bearing area of the specimen.

Table 8: Comparative Compressive Load on Paver Blocks (kN)

Block Type	7 Days	14 Days	28 Days
Conventional	900	1350	1500
Lathe scrap (20%)	1300	1950	2170

The corresponding compressive strengths, calculated as ultimate load divided by bearing area, are presented in Table 9 and Fig. 2.

Table 9: Compressive Strength of Paver Blocks (kN/m²)

Block Type	7 Days	14 Days	28 Days
Conventional	30000	45000	50000
Lathe scrap (20%)	43330	65000	72330

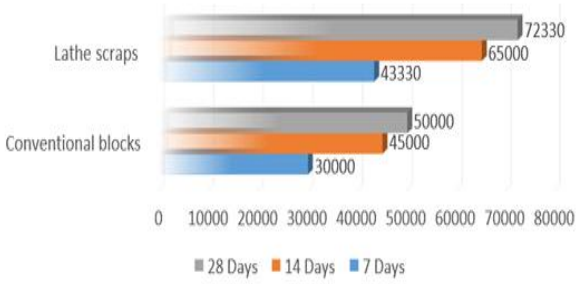

Figure 2. Compressive strength of conventional and lathe-scrap paver blocks at 7, 14 and 28 days of curing.

The 28-day compressive strength of the conventional paver block was 50000 kN/m², whereas the block with 20% lathe scrap replacement achieved 72330 kN/m², an increase of approximately 44%. A companion mix using lathe dust achieved 71000 kN/m² (about 42% higher than the control), while a separate trial replacing 20% of the fine aggregate with saw dust reduced strength to 44330 kN/m² (roughly 12% lower than the control) and reduced block weight by about 0.93%, illustrating that not all waste substitutes behave alike: metallic lathe waste acts as a reinforcing filler that increases both density and strength, whereas a lightweight organic filler such as saw dust reduces both.

These results confirm that mild steel lathe waste, when used as a partial fine-aggregate replacement, improves the compressive strength and load-bearing capacity of paver blocks relative to conventional concrete, while simultaneously repurposing an industrial waste stream that would otherwise require land disposal.

VI. Conclusion

Based on the experimental investigation, the following conclusions are drawn:

- The conventional concrete paver block had an average hardened weight of 5.5 kg; replacing 20% of the fine aggregate with lathe scrap and lathe dust increased weight by 1.07% and 1.03% respectively.
- Replacing 20% of fine aggregate with saw dust decreased the block weight by about 0.93%.
- The 28-day compressive strength increased by approximately 44% and 42% for lathe scrap and lathe dust replacement respectively, relative to the conventional block (50000 kN/m²).
- Saw-dust replacement reduced 28-day compressive strength by about 12%, making it more suitable for light pedestrian pathways than for load-bearing pavements.
- Overall, mild steel lathe waste is an effective, cost-efficient and eco-friendly substitute for a portion of fine aggregate in paver block production, offering both weight gain and strength enhancement while diverting workshop waste from open-land disposal.

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