Transforming Plastic Waste into Paver Blocks: A Sustainable Solution

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Abstract -*Using waste plastic in paver block production addresses both plastic pollution and the need for construction materials. The process involves shredding plastic waste and mixing it with sand, cement, and aggregate to create durable blocks. By incorporating waste plastic, we divert it from landfills and oceans, reducing the demand for virgin materials like concrete. This initiative promotes greener construction practices and contributes to a more sustainable economy. Our research focused on replacing course aggregate with plastic aggregate in M30 concrete mixtures. We experimented with different proportions of plastic aggregate, ranging from 0 , 5% ,10%, and 15%, to study its impact on compressive strength. The zigzag-shaped paver blocks were tested for strength after 7 and 28 days, with curing and without curing. After 28 days of curing and non curing, the compressive strength of the paver blocks ranged from 11.74 N/mm² to 34.71 N/mm². Our goal is to reduce costs, improve durability, and mitigate pollution by utilizing waste plastic in concrete paver block production.*

Key Words: **Paver Block, Compressive Strength, Waste Plastic, Workability**

1. INTRODUCTION

Plastic pollution has become a severe global issue, prompting the search for innovative solutions. One promising idea is to turn plastic waste into paver blocks, offering a sustainable alternative to traditional construction materials. This approach addresses both plastic pollution and the demand for eco-friendly products. Plastic waste, which currently clogs landfills and oceans, can be repurposed into durable paver blocks, reducing the need for natural resources like sand and gravel. These blocks are lightweight, strong, and weather-resistant, requiring minimal maintenance. Integrating the production of plastic paver blocks into waste management systems offers economic benefits and promotes environmental stewardship. This paper explores the science, technology, and benefits of this approach, highlighting its potential to foster a circular economy and create a cleaner, greener future.

1.1 Concrete Paver Blocks

Concrete paver blocks with a grade of M30 are designed to withstand heavy loads and provide durable surfacing solutions for various applications such as driveways, walkways, patios, and roads. The "M30" designation indicates a concrete mix with a compressive strength of 30 megapascals (MPa), ensuring robustness and resistance to wear and tear. These blocks are typically manufactured using high-quality aggregates, cement, and admixtures, meeting stringent industry standards for strength and durability. They offer excellent load-bearing capacity and longevity, making them ideal for both residential and commercial projects requiring reliable paving solutions.

1.2 Waste Plastic

Waste plastic poses a significant environmental threat, clogging landfills and polluting oceans. Its persistence in the environment for hundreds of years exacerbates this issue. Improper disposal leads to harmful consequences for wildlife, marine ecosystems, and human health. Plastic waste also contributes to greenhouse gas emissions during production and decomposition. Recycling offers a partial solution, but it's not yet widespread or efficient enough to address the magnitude of the problem. To tackle this crisis, we need comprehensive strategies like reducing single-use plastics, promoting biodegradable alternatives, and investing in advanced recycling technologies. Moreover, raising awareness and fostering a culture of responsible consumption and waste management are crucial steps toward a sustainable future.

Figure1: Waste Plastic

1.2 OBJECTIVE

- To produce cost-effective paver blocks and eco-friendly paver blocks.
- To determine the suitability of waste plastic in the development of paver blocks.
- To examine the weight of waste plastic paving blocks to traditional paving blocks.
- To compare results of conventional waste plastic paving blocks.

2. LITERATURE REVIEW

Ashwini Manjunath BT. et al. (2021)
The study explores using E-Plastic Waste as a partial replacement for coarse aggregate in interlocking concrete paver blocks (ICPB) to address landfill issues, pollution, and resource conservation. E-Plastic Waste from devices like computers, TVs, and radios is tested in experimental mixes with 10%, 20%, and 30% increments to produce M25 grade ICPBs. These blocks are tested per Indian standards (IS 15658:2006) and compared with conventional pavers, highlighting the potential benefits of incorporating E-Plastic Waste in construction.

Pooja Bhatia, Akash Sahu et al. (2022)
This project aims to replace cement in paving stones with plastic waste to reduce costs and repurpose the 300 million tonnes of plastic waste generated annually. By incorporating different amounts of plastic waste with fine aggregates, paving stones were produced and tested. The analysis showed that this method is both practical and effective for recycling plastic waste in paving stone manufacturing, providing a sustainable alternative to traditional concrete pavers.

Rajat Agrawal et al. (2022)
The study found that a 1:4 ratio of plastic waste to M-sand yielded superior compressive strength in road pavers, with reduced plastic amounts leading to decreased strength. Recycling PET into road pavers is promising for sustainable construction in India. This method, involving mixing plastic waste with heated sand, produces durable pavers, addressing plastic pollution and promoting the circular economy. This innovative approach enhances mechanical properties for load-bearing applications, supporting eco-friendly and sustainable infrastructure development in India.

Adetoye Olubunmi et al. (2023)
This study investigates substituting plastic waste for coarse aggregates in concrete pavement blocks to address plastic waste and promote sustainability. Testing various replacement percentages (0%, 5%, 10%, 15%) found that 10% yielded optimal results by reducing water absorption. Plastic-infused concrete is recommended for non-load-bearing structures like footpaths and water retaining systems, offering cost and environmental benefits. This approach reduces reliance on natural aggregates, supports resource conservation, and aligns with Sustainable Development Goals, fostering sustainable construction practices.

Padmakumar Radhakrishnan et al. (2023)
The research focuses on sustainable development goals, specifically on recycling and reuse of materials in bituminous pavement construction. The study evaluates the performance of bituminous paver blocks using sustainable materials and reclaimed asphalt pavement through various tests. Funding for the research was provided by the ALL-INDIA COUNCIL FOR TECHNICAL EDUCATION, New Delhi under the RPS-NDF Scheme .The research suggests that jointing materials could enhance the performance of bituminous blocks and improve load transfer, warranting further study.

3. METHODOLOGY AND EXPERIMENTATION

The methodology involves shredding waste plastic into small pieces, mixing it with aggregate and binding agents, then compressing the mixture into paver block molds. Experimentation includes varying plastic-to-aggregate ratios, binder types, and compression pressures to optimize block strength and durability. Testing involves assessing block performance under various conditions such as load-bearing capacity, weathering, and durability against chemical degradation. Additionally, environmental impact assessments are conducted to ensure the sustainability of the process.

3.1 Material selection and its properties

To manufacture everyday concrete paver blocks and plastic aggregate paver blocks, you need cement, quarry dust, coarse aggregates, water, and waste plastic bags. For regular concrete paver blocks, waste plastic is not used, whereas plastic paver blocks incorporate waste plastic along with water. After conducting various assessments on the materials used, the following observations were made.

Table 1: Properties of materials

	Properties of material	Observation
Cement	Specific Gravity	3.15
	Consistency	31%
	Fineness	7
	Initial Setting Time	30 minutes
	Final Setting Time	600 minutes
Fine	Size	Less than 4.75mm

Aggregate	Specific gravity	2.7
	Water Absorption	1.5%
	Shape	Angular, Rough
	Density	1600 kg/m³
Coarse Aggregate	Size	More than 4.75mm
	Specific gravity	2.65
	Water Absorption	0.7%
	Shape	Angular, Rough
	Density	1560 kg/m³

3.2 Waste Plastic Aggregate

Waste plastic aggregate refers to crushed or shredded plastic materials that are used as a substitute for traditional aggregates (such as sand, gravel, or crushed stone) in construction applications. These plastic aggregates can be derived from various sources of waste plastic, including bottles, bags, containers, and packaging materials. They are often used in projects like road construction, paving, and building foundations as a means to reduce the demand for natural resources, minimize plastic pollution, and provide an environmentally friendly alternative for disposing of plastic waste.

Figure1: Plastic Aggregate

Table 2: Properties of Waste Plastic Aggregate

	Properties of material	**Observation**
Plastic Aggregate	Size	More Than 4.75mm
	Specific gravity	1.56
	Water Absorption	1.70%
	Shape	Angular, Rough
	Density	520 kg/m³

3.3 Concrete Mix Design M30

The technique described aims to achieve the desired compressive strength and durability of concrete after 28 days of curing. Concrete mix designs are prepared for M30 grade according to IS 10262-2000 and IS 456-2000 standards, for both normal concrete and plastic pavement blocks. A water-cement ratio of 0.43 is used for regular concrete, while no additional moisture is added for plastic paver blocks. Rectangular molds with a volume of 0.0027 m³ each are prepared for casting blocks. The volume of materials required per cubic meter is determined by the IS method. Based on the mold's capacity, the quantities of each material required for each regular and plastic paver block are calculated as follows.

Properties of Materials:

Specific Gravity of Cement (for OPC Grade 43) = 3.15

Specific Gravity of Coarse Aggregate = 2.68

Specific Gravity of Fine Aggregate = 2.4

Here F.A. adopt for zone II

Target Mean Strength :

$f_{ck}' = f_{ck} + 1.65S$

Where,

f_{ck}' = Target Mean Compressive Strength at 28 days, in N/mm^2

f_{ck}=characteristic compressive strength of the concrete at 28 days, in N/mm^2

S = Standard deviation (N/mm^2) (from Table No. 2 of IS 10262:2019)

$f_{ck}' = 30 + (1.65 \times 5) = 38.25\ N/mm^2$

Water Cement ratio:

w/c =0.43 (From curve 2 in IS 10262:2019)

Water Content:

Water Content for 20 mm Size of Aggregate in 186 kg/m³
Slump adopt in R.C.C = 75mm

Each ± 25mm, water content ± 3%

186kg/m³ water content for Slump 50mm

As we adopted slump value of 75mm,

Hence for 75mm = 186 + 186 X (3/100) = 192 ltr

Cement Content:

For severe concreting conditions maximum water cement ratio for M30 Grade of

Concrete (from Table No. 5 of IS 456:2000), W/C = 0.43

So, we adopt W/C = 0.43

192/C = 0.43

C = 445.53 kg/m^3

Volume of Aggregates:

For 20 mm aggregates in Zone (II) is Volume of Coarse Aggregate per unit volume =0.62

(from Table No. 5 of IS 10262:2019)

The Proportion of volume of coarse aggregates to that of total aggregates is increased at the rate of 0.01 for every decrease in water – cement/cementitious materials ratio by 0.05 and decreased at the rate of 0.01 for every increase in water – cement ratio by 0.05. (From clause 5.5.1 of IS 10262:2019)

Hence, Volume of C.A. = 0.62 + 0.14 = 0.634

F.A = 1 – 0.63 = Total Value – Volume of C.A.

F.A. = 0.366

Total Aggregate Content:

Aggregate = [Total Content – Air Content] – [Cement + Water]

= [1 – 0.01] – [(121.90 X 0.001) + (0.000192)]

= 0.656

Then,

C.A. = 0.656 X 0.634 X 2.68 X 1000 = 1114.62 kg/m^3

F.A. = 0.656X 0.366 X 2.4 X 1000 = 576.23 kg/m^3

Healing Agent = 4.5 kg/m^3

Volume of the Mould = 0.240*0.120*0.08

= 0.00230m^3

Table-3: Amount of constituents

Material	Ordinary paver block (kg)	5% Plastic Aggregate (kg)	10% Plastic Aggregate (kg)	15% Plastic Aggregate (kg)
Cement	1.026	1.026	1.026kg	1.026kg
Fine Aggregate	1.327	1.327	1.327	1.327
Coarse Aggregate	2.568	2.440	2.312	2.183
Water	0.44 lit	0.44 lit	0.44 lit	0.44 lit
Waste Plastic	0	0.128	0.256	0.385

For the current investigation, three cubes of each volume proportion totaling 0.00234 cubic meters are to be cast. The concrete process entails batching, mixing, placing, and subsequent curing for several days.

In the scenario of plastic paver block production, shredded waste plastic will be processed, and the resulting crushed plastic will be incorporated into the other ingredients used to manufacture the plastic paver block.

Figure 2: Casting of paver blocks

4. RESULT AND DISCUSSION

The compressive strength of both ordinary concrete blocks and plastic paver blocks was tested using a Compression Testing Machine (CTM). The blocks were placed on the machine's platform, and a gradually applied compressive force was exerted on them at a rate of 30N/sq.mm/minute until failure occurred. The load at which failure happened was recorded, and then divided by the cross-sectional area of the block to determine its compressive strength.

Test results for both types of blocks, including those subjected to 7 days and 28 days of curing, as well as those without curing, are presented in the table below.

Figure 4: Compression testing machine

Table 4: Compressive strength for 7-day curing and non-curing

Waste plastic Aggregate in %	7 Days Compressive Strength in N/mm2	
	Non-curing	Curing
0	16.89	21.52
5	16.31	18.78
10	13.07	13.71
15	9.66	10.93

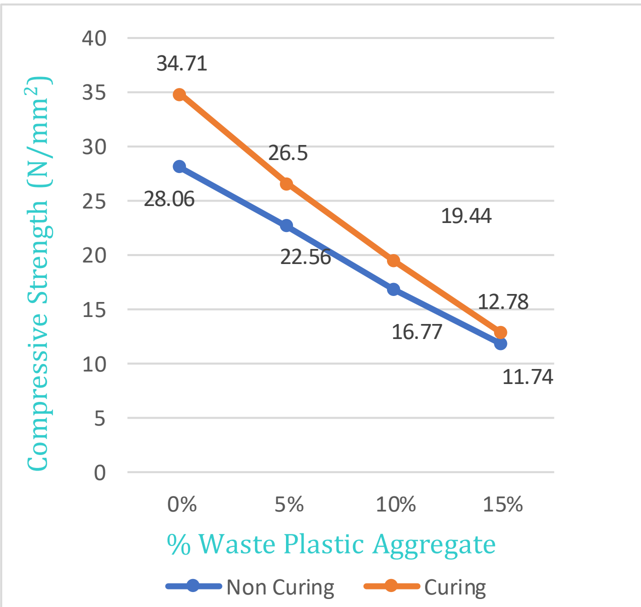

Figure 5: Compressive strength for 7-day curing and non-curing

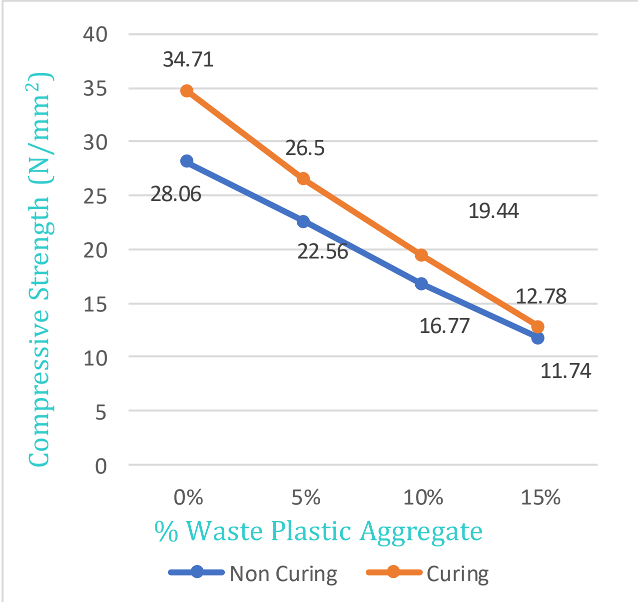

Figure 6: Compressive strength for 28-day curing and non-curing

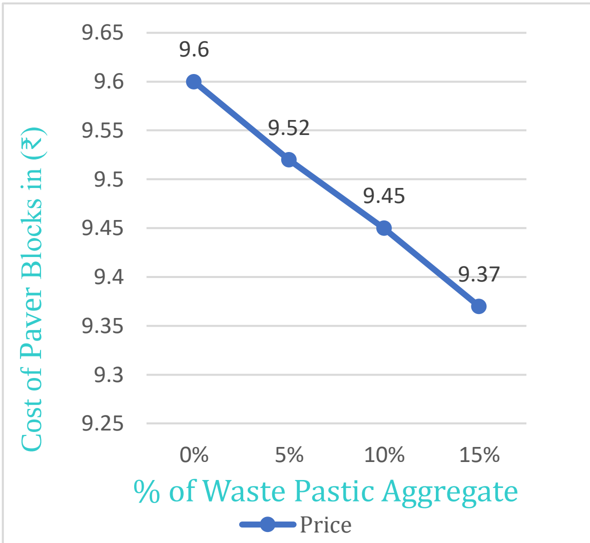

Figure 7: Cost of One Paver Blocks

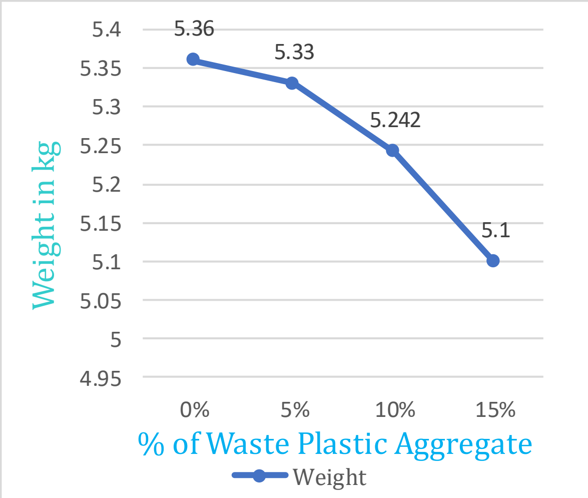

Figure 8: Weight of One Paver Blocks

The outputs of the study show that by recycling plastic, we create durable and eco-friendly pavers. This process reduces pollution and conserves resources. These blocks are sturdy and long-lasting, perfect for roads and walkways. Recycling plastic into pavers helps tackle environmental issues while promoting a greener future. It's a win-win solution for both the planet and communities.

5. CONCLUSIONS

- The Compressive strength of Paver Blocks on mixing 5% waste plastic aggregate is 26.5 N/mm^2. which is better than the compressive strength of the other paver.
- Using waste plastic to produce paver blocks provides a productive method for disposing of plastic waste.
- It reduces up to 256 kg of plastic over 1000 blocks.
- As percentages of plastic aggregate content increase, paver blocks cost of 0%, 5%, 10%, and 15% content of plastic decrease gradually respectively.
- As percentages of plastic aggregate content increase, weight of paver blocks of 0%, 5%, 10%, and 15% content of plastic decreases gradually respectively.
- While the compressive strength may be lower compared to concrete paver blocks, these plastic waste-based paver blocks are suitable for applications such as gardens, pedestrian paths, and cycleways.
- These plastic waste-based paver blocks are suitable for use in non-traffic and light-traffic roads.

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