

Development of Sustainable Paver Blocks using HDPE Plastic, Quarry Dust and Flyash

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Abstract - The rapid growth of urbanization and industrialization has increased the demand for construction materials while simultaneously posing environmental challenges related to the disposal of industrial and plastic waste. This study focuses on the development of sustainable interlocking paver blocks by incorporating HDPE plastic, fly ash and quarry dust as alternatives to conventional cement and aggregates. In this approach, fly ash and quarry dust act as partial replacements for cement and natural sand, contributing to a more sustainable material mix. The proposed paver blocks not only offer effective waste management but also demonstrate adequate strength and durability for pedestrian and light-traffic areas. Additionally, the utilization of HDPE plastic, fly ash, and quarry dust helps reduce carbon footprint, minimize landfill waste, and decrease dependence on natural resources. Overall, this study presents an innovative, cost-effective, and sustainable solution that aligns with the principles of green construction and a circular economy. Rapid urbanization and industrial development have significantly increased the consumption of conventional construction materials, leading to excessive exploitation of natural resources and the accumulation of industrial and plastic waste. Addressing these environmental concerns requires sustainable alternatives that promote resource efficiency and waste utilization. This study investigates the development of eco-friendly interlocking paver blocks incorporating High-Density Polyethylene (HDPE) plastic, fly ash, and quarry dust as partial or alternative materials to conventional cement and natural aggregates. HDPE plastic is utilized as a binding component, while fly ash and quarry dust serve as supplementary materials to enhance mechanical performance and sustainability.

An experimental investigation was conducted to evaluate the physical and mechanical properties of the developed paver blocks, including compressive strength, durability characteristics, and water absorption behaviour. The results indicate that the proposed mix demonstrates satisfactory strength suitable for pedestrian walkways and light-traffic applications. Furthermore, the inclusion of HDPE significantly reduces water absorption, improving durability and resistance to environmental degradation. The use of fly ash and quarry dust contributes to improved particle packing density and reduced dependency on natural river sand and cement.

The developed paver blocks offer multiple environmental benefits, including reduction in carbon emissions, minimization of landfill waste, and conservation of natural resources. In addition, the proposed system provides a cost-effective and sustainable construction alternative aligned with the principles of green building and circular economy practices. This research highlights the potential of integrating industrial by-products and plastic waste into value-added construction materials, thereby contributing to sustainable infrastructure development.

I. INTRODUCTION:

Interlocking paver blocks have gained popularity in recent years due to their ease installation, durability and aesthetic appeal, traditionally these blocks are manufactured using cement, fine aggregate and coarse aggregates. This project focuses on developing sustainable interlocking paver blocks using HDPE plastic, fly ash, and quarry dust as primary materials. The main objective is to produce eco-friendly, cost-effective, and durable paver blocks by replacing conventional materials with industrial by-products. The construction industry plays a vital role in infrastructure development but consumes large amounts of natural resources and generates industrial waste.

The increasing accumulation of plastic waste and industrial by-products has become a major environmental concern across the globe. High-Density Polyethylene (HDPE) plastic, widely used in packaging and consumer products, is non-biodegradable and poses serious disposal problems when dumped in landfills or incinerated. Similarly, fly ash generated from thermal power plants and quarry dust produced during stone crushing operations are often discarded as waste, leading to air pollution, land degradation, and health hazards. Effective utilization of these waste materials has become essential to achieve sustainable development.

At the same time, the construction industry consumes large quantities of cement and natural aggregates, contributing significantly to carbon dioxide emissions and depletion of natural resources. Conventional concrete paver blocks of M30 grade require substantial amounts of cement and water,

increasing both environmental impact and construction cost. In recent years, sustainable construction practices have focused on replacing traditional materials with waste based alternatives without compromising strength and durability.

This project aims to develop **M20-grade equivalent sustainable paver blocks** using **HDPE plastic as a binding material**, with **fly ash and quarry dust** as filler and fine aggregate replacements. The thermoplastic nature of HDPE allows it to act as an effective binder when melted, eliminating the need for cement and water curing. Fly ash improves particle packing and strength characteristics, while quarry dust enhances density and surface finish. The proposed paver blocks are designed to achieve compressive strength comparable to M20 concrete, making them suitable for pedestrian pathways and light traffic applications. This approach not only reduces environmental pollution and material costs but also promotes efficient waste management and sustainable construction practices.

METHODOLOGY:

The methodology involves collecting waste HDPE plastic, fly ash, and quarry dust from reliable sources, followed by cleaning and shredding the HDPE plastic into small pieces to ensure uniform melting. The shredded plastic is heated to about 130–150°C until it reaches a molten state, after which fly ash and quarry dust are added in predetermined proportions and mixed thoroughly to obtain a homogeneous blend. The prepared mixture is then poured into pre-oiled paver block moulds and compacted to eliminate air voids. The moulds are allowed to cool at room temperature, after which the paver blocks are demoulded and kept in a dry condition without water curing. Finally, the developed paver blocks are tested for compressive strength, water absorption, and durability to evaluate their strength.

II. MATERIALS:

3.1 Fly Ash:

We visited NTPC (National Thermal Power Corporation) to study and collection of fly ash. Fly ash is a byproduct obtained from the combustion of pulverised coal in thermal power plants.

Location: NTPC, parawada , Anakapalle.



Fig No: 3.1 Fly Ash

3.2 Quarry Dust:

We visited a stone quarry to study the production and collection of quarry dust. Quarry dust is the by-product obtained during the crushing of stones for aggregates.

Location: Stone quarry, makavaram, thummapala



Fig No: 3.2 Quarry Dust

3.3 HDPE Plastic:

We studied High-Density Polyethylene (HDPE) plastic, a lightweight, flexible and durable thermo plastic. It is commonly used in bottle caps, milk jugs, shampoo bottles, grocery bags leading to large amounts of plastic waste.



Fig No: 3.3 HDPE Plastic

3.4 Paver Moulds:

The mould used for casting paver blocks is made of mild steel plates with a size of 200mm X 100mm X 80mm + 100mm X 100mm X 80mm. It is provided with a pressing handle to compact the concrete mix properly, which ensures uniform shape, dimensional accuracy, and improved surface finish of the blocks.

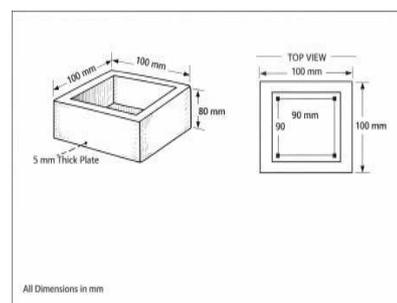


Fig No: 3.4 Paver Moulds

III. RESULTS

Table 4.1 COMPRESSIVE STRENGTH TEST RESULTS OF CONVENTIONAL PAVER BLOCK:

Description	Ratio	Curing period	Compressive strength (MPa)
Conventional	M20	3 Days	7
	M20	7 Days	13
	M20	28 Days	21

Graph Table:

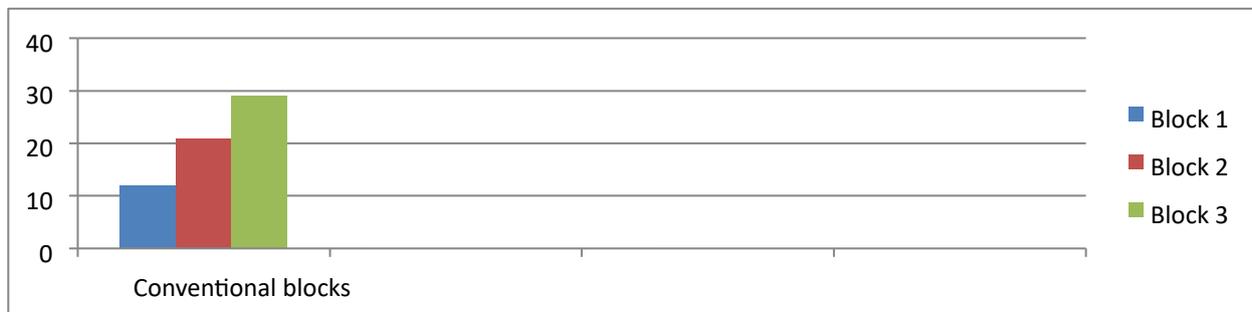
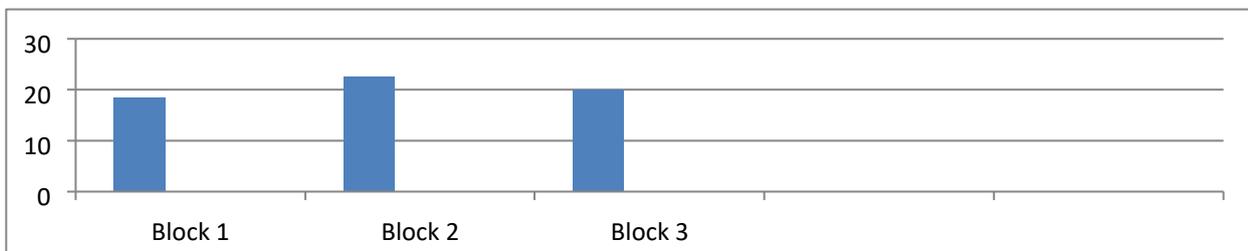
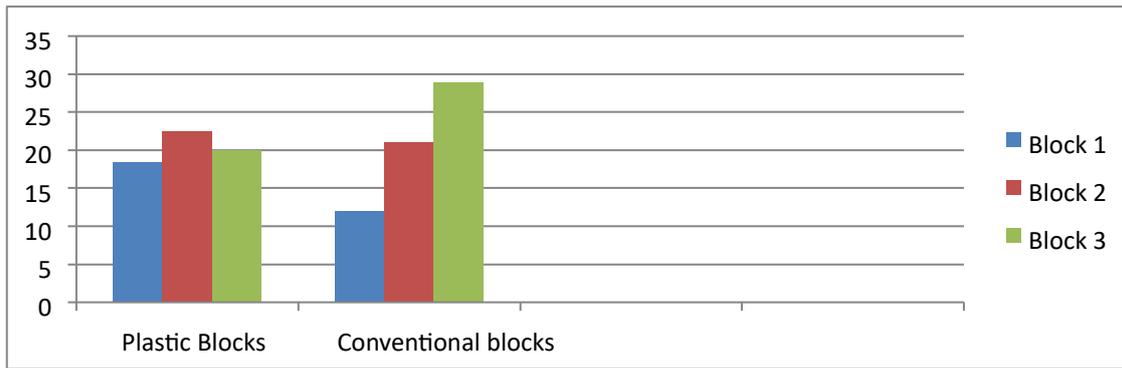


Table 4.2 Compressive Test Results:

Description	Ratio	Compressive Strength (MPa)
Block 1	50:30:20	18.5
Block 2	45:35:20	22.5
Block 3	50:20:30	20.0



COMPARISON BETWEEN CONVENTIONAL BLOCKS AND PLASTIC PAVER BLOCKS GRAPH:



V. RESULTS AND DISCUSSION:

The compressive strength test results indicate that the developed plastic-based paver blocks exhibited competitive strength compared to conventional cement concrete paver blocks. The incorporation of HDPE plastic improved the binding characteristics and enhanced the load-bearing capacity due to its ductile nature.

At 28 days, the plastic paver blocks achieved compressive strength values comparable to M20 grade concrete,

VI. COST ANALYSIS:

The cost analysis was carried out to evaluate the economic feasibility of the developed plastic waste paver blocks in comparison with conventional cement paver blocks available in the market. The cost of the plastic paver block was calculated based on the quantity of materials used and their respective market prices. The materials used for the preparation of the plastic paver block include HDPE plastic waste, quarry dust, and fly ash. Based on the material quantities and unit prices, the total production cost of one plastic paver block was found to be approximately ₹15 per block.

To understand the economic advantage of the developed block, the cost was compared with commonly used cement paver blocks of different shapes available in the market. The

demonstrating their suitability for pedestrian pathways and light traffic areas. The presence of fly ash contributed to improved particle packing and pozzolanic reaction, which enhanced the interfacial bonding within the matrix. Quarry dust acted as a fine aggregate replacement and improved density by reducing voids.

The results confirm that partial replacement of cement and sand with fly ash and quarry dust did not adversely affect strength; instead, it contributed to better structural performance when used in optimized proportions.

market survey indicates that the price of cement paver blocks varies depending on their shape, size, and manufacturing process. The average cost of conventional cement paver blocks such as zig-zag, I-shaped, rectangular, and hexagonal blocks ranges from ₹25 to ₹45 per block.

From the above comparison, it can be observed that the plastic waste paver block is significantly more economical than conventional cement paver blocks. The developed block offers nearly 60–75% reduction in cost compared to commonly available cement paver blocks. In addition to the economic benefits, the utilization of plastic waste in paver block production helps in reducing plastic pollution and promotes sustainable construction practices. Therefore, the proposed plastic waste paver block can be considered a cost-effective and environmentally sustainable alternative for pavement and pedestrian walkway applications.

Table 6.1. Cost Comparison of different paver block

S. No	Type of Paver block	Cost per block (₹)
1	Plastic paver block	15
2	Zig – Zag paver block	34
3	I – shape paver block	25
4	Rectangular paver block	30
5	Hexagonal paver block	45

VII. CONCLUSIONS:

- The study concludes that sustainable paver blocks can be effectively manufactured using waste HDPE plastic as a binding material combined with fly ash and quarry dust as filler materials. The developed paver blocks achieved compressive strength comparable to M20-grade conventional concrete, making them suitable for pedestrian pathways and light traffic applications.
- The blocks exhibited very low water absorption and good abrasion resistance, indicating enhanced durability and long service life. The elimination of cement and water curing significantly reduces carbon emissions, material cost, and construction time.
- Additionally, the utilization of plastic waste, fly ash, and quarry dust contributes to efficient waste management and minimizes environmental pollution.
- Overall, the proposed paver blocks provide an eco-friendly, economical, and sustainable alternative to conventional concrete paver blocks and demonstrate strong potential for practical implementation in pavement construction. From the experimental investigation, it is concluded that paver blocks manufactured using HDPE plastic, fly ash, and quarry dust achieved satisfactory performance corresponding to **M20-grade concrete**.
- The compressive strength of the developed paver blocks strength which meets the requirements specified in IS 15658 for paving units used in pedestrian and light traffic areas. Water absorption values were observed to be **below 1%**, which is significantly lower than conventional concrete paver blocks (5–7%), indicating excellent resistance to moisture and reduced chances of deterioration.
- Abrasion loss was minimal, confirming good surface hardness and wear resistance.
- The density of the plastic-based paver blocks was approximately **8–12% lower** than that of conventional concrete blocks, resulting in reduced self-weight and easier handling.
- The absence of cement and water curing reduced production time by nearly **40–50%** and contributed to lower carbon emissions. Overall, the results confirm that the utilization of waste HDPE plastic along with fly ash

and quarry dust produces durable, economical, and environmentally sustainable paver blocks suitable for practical pavement applications.

- The cost decreased up to 40% by using HDPE paver blocks compared to conventional paver blocks.

VIII. REFERENCES

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