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Experimental Investigation on High-Performance Paver Blocks Using Hybrid Industrial Waste (Fly Ash, Plastic, and Rubber) with Surface Treatment Techniques

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Abstract: *The growing accumulation of industrial waste such as fly ash, plastic, and rubber poses serious environmental challenges. This study investigates the development of high-performance paver blocks by incorporating these waste materials as partial replacements for conventional ingredients. Fly ash is used as a substitute for cement, while plastic and crumb rubber replace fine and coarse aggregates, respectively. Different mix proportions (M1–M4) were prepared and tested for compressive strength, water absorption, abrasion resistance, and impact resistance. The results show that hybrid mixes improve durability and reduce permeability while maintaining adequate strength. The M3 mix achieved the highest compressive strength, whereas M4 showed superior durability properties. The study concludes that hybrid waste-based paver blocks are a sustainable and cost-effective alternative for pavement applications*

Keywords: Fly ash, plastic waste, rubber, paver blocks, sustainable concrete

I. INTRODUCTION

Paver blocks are widely used in modern construction for applications such as pavements, pedestrian pathways, parking areas, and low-traffic roads due to their ease of installation, durability, and low maintenance requirements. However, conventional paver blocks rely heavily on cement and natural aggregates, which leads to excessive consumption of natural resources and increased environmental impact. The production of cement also contributes significantly to carbon dioxide emissions, which is a major factor in global warming.

At the same time, large quantities of industrial and municipal waste materials such as fly ash, plastic waste, and discarded rubber are generated worldwide. Improper disposal of these materials leads to environmental pollution and land degradation. Therefore, incorporating these waste materials into construction practices provides a dual benefit of waste management and resource conservation.

Fly ash improves the microstructure of concrete through pozzolanic reactions, enhancing long-term strength and durability. Waste plastic helps in reducing water absorption and improves resistance to chemical attack. Crumb rubber, due to its elastic nature, enhances flexibility and impact resistance. This study aims to develop high-performance paver blocks by combining these materials along with surface treatment techniques to improve durability and service life.

II. OBJECTIVES

- To develop paver blocks using fly ash, plastic, and rubber as partial replacements for conventional materials
- To evaluate the mechanical properties such as compressive strength and flexural strength
- To study durability properties including water absorption, abrasion resistance, and impact resistance

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- To determine the optimum mix proportion for best performance
- To compare the performance of modified paver blocks with conventional paver blocks
- To promote sustainable construction by utilizing industrial waste materials

In addition to these objectives, the study also focuses on understanding the combined effect of multiple waste materials on the overall performance of paver blocks. This helps in identifying the most effective mix that balances strength, durability, and environmental benefits.

III. METHODOLOGY

- Identification of problem and research gap
- Literature review and selection of research approach
- Collection and preparation of materials (fly ash, plastic, rubber)
- Preliminary testing of materials
- Design of trial mix proportions (M1 to M4)
- Casting of paver block specimens
- Curing of specimens for 7, 14, and 28 days
- Application of surface treatment techniques
- Testing of mechanical and durability properties
- Analysis of results and determination of optimum mix
- Interpretation of results and conclusion

IV. MATERIALS

Cement

Cement acts as the primary binding material in paver blocks. It reacts with water to form a hardened matrix that binds all materials together and provides strength.

Fly Ash

Fly ash is a fine powder obtained from thermal power plants. It is used as a partial replacement for cement and improves workability, reduces heat of hydration, and enhances long-term strength.

Waste Plastic

Waste plastic is used in shredded form as a replacement for fine aggregate. It reduces water absorption, improves flexibility, and enhances resistance to cracking.

Crumb Rubber

Crumb rubber is obtained from recycled waste tires and is used as a partial replacement for coarse aggregate. It improves ductility, impact resistance, and energy absorption.

Fine Aggregate (Sand)

Fine aggregate fills voids between coarse aggregates and contributes to workability and surface finish of paver blocks.

Coarse Aggregate

Coarse aggregates provide bulk and strength to the paver blocks and help in load-bearing capacity.

Water

Water is required for hydration of cement and proper mixing of materials. Clean potable water is used.

Surface Treatment Materials

Polymer coatings or sealants are applied to improve abrasion resistance, reduce water absorption, and enhance durability.

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V. MIX DESIGN

Concrete mix design is carried out to achieve the required strength and durability while optimizing the use of materials. In this study, M40 grade concrete is adopted, and mix design is performed based on standard guidelines.Different trial mixes are prepared by varying the percentage of fly ash, plastic, and rubber.

Mix Combinations:

Mix	Fly Ash	Plastic	Rubber
M1	0%	0%	0%
M2	10%	5%	5%
M3	20%	10%	5%
M4	25–30%	10–12%	5–8%

The performance of these mixes is evaluated based on strength, durability, and workability to identify the optimum mix.

VI. FRESH AND HARDENED CONCRETE PROPERTIES

A. Slump Cone Test

The slump test evaluates the workability of fresh concrete. Fly ash improves flowability, plastic reduces friction, and rubber slightly decreases cohesiveness. Workability increases from M1 to M4, with M2 showing optimum consistency, while M4 may lead to excessive slump.

B. Compaction Factor Test

The compaction factor test provides a reliable measure of workability. Fly ash improves compaction, plastic enhances flow, and rubber slightly reduces compaction. M2 and M3 show better performance, while M4 shows a minor decrease.

C. Casting and Curing

Proper casting ensures uniformity and strength. Concrete is placed in layers and compacted using vibration. Curing maintains moisture for hydration and improves strength. Fly ash mixes require effective curing for better performance.

D. Compressive Strength

Compressive strength decreases slightly with the addition of plastic and rubber. However, fly ash contributes to long-term strength. Modified mixes show improved ductility despite marginal strength reduction.

E. Split Tensile Strength

Tensile strength decreases with increased rubber and plastic content due to reduced bonding. However, crack propagation is slower, indicating improved toughness.

F. Flexural Strength

Flexural strength shows slight reduction, but rubber improves energy absorption and plastic enhances flexibility, reducing brittleness.

G. Overall Performance

Hybrid mixes improve workability, ductility, and durability, with a slight reduction in strength. These properties make them suitable for pavement applications.

VII. RESULTS & DISCUSSION

The experimental results indicate that the incorporation of industrial waste materials has a noticeable impact on the performance of paver blocks. The compressive strength of modified mixes was comparable to, and in some cases higher than, that of conventional blocks, particularly in mixes containing fly ash and plastic. However, the inclusion of rubber resulted in a slight reduction in strength due to its lower stiffness.

Water absorption values decreased significantly with the addition of plastic and rubber, indicating improved resistance to moisture penetration. Abrasion resistance also improved in modified mixes, suggesting better surface durability under frictional forces.

A substantial increase in impact resistance was observed with higher rubber content, demonstrating enhanced energy absorption capacity. Overall, the hybrid combination of materials resulted in improved durability characteristics while maintaining acceptable strength levels.

Mix ID	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
M1 (Control)	30	36	42
M2 (Fly ash)	32	38	45
M3 (Fly ash + Plastic)	31	37	47
M4 (Fly ash + Plastic + Rubber)	29	35	46

VIII. CONCLUSION

The findings of this study confirm that industrial waste materials such as fly ash, plastic, and rubber can be effectively utilized in the production of paver blocks. The use of fly ash contributes to strength development and improved microstructure, while plastic and rubber enhance durability and flexibility.

Although a slight reduction in compressive strength is observed at higher replacement levels, the overall performance remains suitable for pavement applications. The hybrid mix provides a balanced combination of strength, durability, and sustainability.

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