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Developing Low-Cost Paver Blocks Using Plastic Waste and Parali (Crop Residue) Waste

Dr. Vishnu Prasad Dangi[1], Mr. Shubham Raghuvanshi[2], Dr. Arun Kumar Patel[3]

[1]Assistant Professor, Civil Engineering, RKDF University, Bhopal
[2]Research Scholar, Civil Engineering, RKDF University, Bhopal
[3]Professor, Civil Engineering, RKDF University, Bhopal

Abstract
This research work aims to develop low-cost, eco-friendly paver blocks by utilizing plastic waste and Parali (crop residue) waste, addressing two critical environmental issues: plastic pollution and stubble burning. Both forms of waste present significant ecological and public health challenges. Plastic waste, due to its non-biodegradable nature, clogs landfill and pollutes water bodies, while Parali burning contributes massively to air pollution, especially in northern India, causing severe respiratory problems and climate impacts. By repurposing these wastes into durable construction materials, the project seeks to create a sustainable alternative to conventional concrete paver blocks, reducing reliance on virgin raw materials like cement and sand. This initiative not only promotes waste valorization and cleaner air but also aims to provide a cost-effective solution for rural and urban infrastructure development, contributing to circular economy principles and sustainable construction practices. The study will focus on material formulation, strength testing, durability, and scalability.

Keyword - Plastic waste, Parali (crop residue) waste, Compressive strength, Green Concrete. Sustainable Material.

1. Introduction

The dual environmental crises of plastic pollution and stubble burning have increasingly become a threat to sustainable development. India generates over 3.5 million tonnes of plastic waste annually, of which a significant portion is not recycled. Simultaneously, the burning of agricultural residues such as Parali (paddy stubble) contributes significantly to air pollution. The former contributes to persistent pollution due to its non-biodegradable nature, while the latter releases hazardous pollutants including PM2.5, carbon monoxide, and greenhouse gases, severely affecting air quality. This research proposes an innovative and sustainable solution by utilizing these two waste materials—plastic and Parali—to develop cost-effective and eco-friendly paver blocks. Furthermore, CO_2 curing is incorporated to improve the mechanical properties of the blocks while contributing to carbon sequestration, thus addressing climate change. This research seeks to address both these issues by developing an innovative, low-cost, and sustainable construction material—paver blocks—using plastic and agricultural waste

1.1 Objectives of the Study

- To design a sustainable mix of plastic and Parali waste suitable for manufacturing paver blocks.

- To analyse the mechanical properties (compressive strength, water absorption, durability) of the blocks.
- To evaluate the effectiveness of CO_2 curing in improving strength and reducing carbon footprint.
- To perform cost analysis compared to traditional paver blocks.
- To assess the environmental impact of using waste materials and CO_2 curing.
- To develop a sustainable method of manufacturing paver blocks using plastic and Parali waste.
- To evaluate the physical and mechanical properties of these composite blocks.
- To compare the cost-effectiveness with conventional paver blocks.

1.2 Problem Statement

- **Plastic Waste**: Improper disposal of plastic waste leads to land and water pollution, with plastics taking hundreds of years to decompose. Recycling rates remain low due to contamination, mixed materials, and logistical issues.
- **Parali Burning**: Farmers in states like Punjab, Haryana, and Uttar Pradesh burn paddy stubble to quickly clear fields, resulting in toxic air pollution. Alternatives to stubble burning are expensive or impractical for small farmers.
- **Construction Industry Needs**: Traditional paver blocks made from cement and sand have high environmental costs due to energy-intensive manufacturing. The construction industry requires affordable, eco-friendly alternatives.

2. Literature Review

Preliminary investigations have demonstrated the feasibility of using plastic waste in paver blocks. For instance, a study by Shanmugavalli et al. (2017) explored the replacement of cement with plastic waste in paver blocks, highlighting potential cost reductions and waste management benefits. Additionally, research by Jacob et al. (2023) examined the properties of paver blocks made from recycled plastic, emphasizing the importance of mix design in achieving desired strength characteristics. Regarding parali, initial studies have investigated its incorporation into concrete products, suggesting improvements in certain mechanical properties. However, comprehensive studies focusing on its role in paver blocks, especially in combination with plastic waste, are scarce.

Numerous studies have shown the feasibility of incorporating waste plastic in construction materials like roads, bricks, and blocks. Thermoplastics, when melted, act as binding agents and improve the hydrophobicity and durability of the final product. Similarly, the use of agricultural waste ash as filler material has shown potential to partially replace cement and reduce reliance on virgin materials. Studies have explored plastic as a partial replacement for cement or aggregates in construction. Thermoplastics like LDPE, HDPE, and PET have shown promise in enhancing binding and water resistance. Meanwhile, the use of agricultural waste such as bagasse, rice husk ash, and coconut fibers in construction has been investigated for lightweight, thermal, and insulating properties.

CO_2 curing is an emerging technique where concrete products are cured in a CO_2-rich environment instead of water. This not only improves the early compressive strength of concrete but also sequesters CO_2, reducing the overall carbon footprint. However, very few studies have explored the combined use of plastic waste and Parali with CO_2 curing in non-load bearing construction applications, which this research aims to address.

3. Materials and Methods

3.1 Materials

1. **Plastic Waste:**
   a. Source: Municipal solid waste.
   b. Type: Mainly LDPE and HDPE.
   c. Preprocessing: Cleaning, shredding, and melting for use as a binder.
2. **Parali (Crop Residue/Stubble) Waste:**
   a. Source: Local agricultural fields.
   b. Form: Ground into fine particles or converted into ash after controlled combustion.
3. **Sand and Aggregates:**
   a. Sourced locally for filler and structure.
4. **Additives:**
   a. Sand, quarry dust or fly ash for pozzolanic activity and stabilization.
   b. Possible addition of lime or binding agents to improve structural integrity.
5. **CO_2 for Curing:**
   a. Sourced from industrial flue gas (simulated in lab-scale using pure CO_2).

3.2 Methodology Overview

Step 1: Material Collection and Preparation

1. Plastic waste and Parali are collected, cleaned, processed, and stored.
2. Parali is converted into ash via controlled burning to avoid excessive pollutant release.

Step 2: Mix Design

1. **Several mix ratios will be tested:**

A. Plastic : Parali ash : Sand : Aggregate (by weight)

- 1:1:2:3
- 1.5:1:2:2.5
- 2:0.5:2:3

B. Control mix (0% plastic and parali).

- Experimental mixes with varying percentages of plastic waste (5%, 10%, 15%) and parali (5%, 10%, 15%)

Proposed Mix Ratios (by weight):

2. Mix A: 70% plastic, 30% Parali
3. Mix B: 60% plastic, 30% Parali, 10% sand
4. Mix C: 50% plastic, 40% Parali, 10% fly ash
5. Mix D: 60% plastic, 30% Parali, 10% lime

Step 3: Molding and Casting

1. The hot melted plastic is mixed with Parali ash and aggregates.
2. The mixture is poured into steel molds (standard paver block size).
3. Blocks are demolded after cooling and initial setting.

Step 4: CO_2 Curing

1. A portion of the blocks are cured in a sealed chamber with controlled CO_2 concentration (~20%) for 24–72 hours.
2. Another set is water-cured or air-cured to act as control specimens.

Step 5: Testing
1. **Compressive Strength** (IS 15658:2006)
2. **Water Absorption** (IS 3495 Part 2)
3. **Weight and Density**
4. **Fire Resistance**

Tests will be conducted after 7, 14, and 28 days.

4. Data Analysis

Statistical tools such as ANOVA and regression analysis will be used to compare the properties of different mix designs. The results will be benchmarked against traditional paver blocks.

Key variables:
- Strength vs composition
- Durability vs environmental exposure
- Cost vs performance

5. Cost-Benefit Analysis
- **Raw Material Cost:** Significantly reduced due to the use of waste.
- **Processing Cost:** Moderate, mainly energy for melting and ash preparation.
- **CO_2 Curing Cost:** Initially high but scalable via integration with flue gas systems.
- **Labor & Equipment:** Comparable to standard paver block production.

A comprehensive cost-benefit analysis will be done comparing:

Parameter	**Traditional Paver**	**Proposed Block**
Raw Material	Cement, Sand, Gravel	Plastic Waste, Parali
Production Cost	₹30–₹40/block	₹10–₹15/block (estimated)
Environmental Impact	High CO_2 emissions	Low, waste reuse
Market Price	₹45–₹50/block	₹25–₹35/block (target)

6. Environmental Impact Assessment
1. **Waste Management**: Utilizes non-recyclable plastic and otherwise-burned stubble.
2. **Carbon Footprint**: Lower than cement-based blocks.
3. **Air Quality Improvement**: Reduction in open burning of crop residues.

Estimated that 1 tonne of paver blocks can:
- Recycle ~300 kg of plastic.
- Use ~500 kg of Parali.
- Save ~200 kg of cement emissions.

Positive Impacts:
- Reduction in plastic waste dumped in landfills.
- Prevention of open-field burning of Parali.
- Carbon capture via CO_2 curing process.
- Lower use of cement, reducing embodied carbon.

Risks:
- Incomplete combustion of Parali can release pollutants.
- Proper handling of melted plastic is crucial for worker safety.

Mitigation strategies include controlled combustion setups, personal protective equipment (PPE), and community-level awareness programs.

7. Challenges and Risk Mitigation

Challenge	**Mitigation**
Plastic melting emits fumes	Use proper ventilation and PPE
Binding issues between plastic and Parali	Optimize particle size and add binders
Public perception of quality	Certification and field demonstrations
Seasonal availability of Parali	Stockpiling and diversification of crop residues

8. Outcomes
- A cost-effective paver block design using plastic and stubble.
- Technical datasheets and guidelines for local producers.
- Environmental and economic benefits demonstrated through pilot applications.
- A scalable model for rural employment and waste reduction.

9. Future Scope
- Automation of the production process.
- Use of other agricultural residues (e.g., sugarcane bagasse, rice husk).
- Large-scale carbon credit schemes with verified CO_2 sequestration.
- Collaboration with smart city and Swachh Bharat initiatives.

10. Justification and Impact
- **Scientific**: Advancement in the field of sustainable construction materials.
- **Technological**: Development of innovative methods for waste utilization in construction.
- **Industrial**: Potential for large-scale adoption in the construction industry, leading to reduced material costs.
- **Regional Economic Growth**: Creation of new markets for agricultural residues and waste plastics.
- **Overall Welfare**: Improved waste management practices and environmental conservation.
- **Generation of Competence**: Training of personnel in sustainable construction technologies.

11. Conclusion
The development of paver blocks using plastic and Parali waste, combined with CO_2 curing, addresses critical environmental issues while providing a cost-effective construction material. This circular economy approach not only mitigates pollution but also creates economic opportunities in waste management and green construction.

12. References

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