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SUSTAINABLE UTILIZATION OF BIOMEDICAL WASTE IN PAVEMENT BLOCKS: A CIRCULAR ECONOMY APPROACH

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Abstract

The COVID-19 pandemic led to an unprecedented rise in the generation of biomedical waste, particularly disposable face masks, gloves, and saline bottles made predominantly of non-biodegradable polypropylene. Improper disposal of these materials poses severe environmental and health hazards. This study presents an innovative and sustainable approach by incorporating sterilized biomedical plastic waste into the production of concrete pavement blocks. The primary objective is to explore the feasibility of recycling biomedical plastic waste as a partial substitute for coarse aggregates in concrete without significantly compromising the mechanical properties of the blocks.

Concrete blocks were prepared by replacing natural aggregates with shredded biomedical plastic waste at varying percentages (5%, 10%, 15%, and 20%). Comprehensive tests including compressive strength and water absorption were conducted to evaluate the structural and durability performance. The results demonstrated that blocks with up to 15% replacement exhibited acceptable strength and reduced water absorption, confirming the potential of this technique for low-load applications. This study contributes toward pollution mitigation, resource conservation, and the advancement of circular economy practices in construction.

Keywords: Biomedical Waste, Pavement Blocks, Plastic Recycling, Sustainable Construction, Face Masks, Circular Economy.

Introduction

The generation of biomedical waste has seen a significant upsurge during and posts the COVID-19 pandemic due to the widespread use of disposable personal protective equipment (PPE) including face masks, gloves, aprons, and saline bottles. According to the Central Pollution Control Board

(CPCB), India generated approximately 180 tons of biomedical waste daily during peak pandemic months, a substantial portion of which consisted of non-biodegradable plastic.

Conventional disposal methods such as incineration and land filling are neither sustainable nor environmentally benign. This surge in plastic-based biomedical waste demands innovative waste management solutions that are both safe and economically viable. One such solution is the recycling of sterilized plastic waste into construction materials, particularly pavement blocks. Pavement blocks are widely used in walkways, footpaths, and low-traffic roads, making them an ideal candidate for integrating recycled materials.

This study aims to assess the mechanical performance, durability, and economic feasibility of using sterilized and shredded biomedical plastic waste in pavement block production. It supports the United Nations Sustainable Development Goals (SDGs), particularly SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production).

Literature Review

Various studies have investigated the reuse of plastic waste in construction materials. Key findings include:

- **Ramachandra (2021)**: Demonstrated that plastic sand blocks are economical and suitable for light load-bearing structures.
- **Subhani & Ali (2023)**: Investigated the incorporation of face masks in concrete. Their study showed acceptable strength with proper processing.
- **Agrawal et al.**: Discussed India's plastic waste crisis and encouraged plastic use in eco-friendly infrastructure.
- **Salvi (2021)**: Found that paver blocks made with plastic waste retained their shape and were water-resistant.
- **Phate & Kamale (2024)**: Analyzed mechanical properties of paver blocks incorporating biomedical waste masks and found satisfactory strength and safety with proper sterilization.
- **Uma & Srinuswamy**: Explored the effect of varying plastic content and plastic-to-sand ratios in paver blocks, identifying an optimal mix for strength and workability.

These studies provide a solid foundation for incorporating biomedical plastic waste into construction products, supporting sustainability and innovation.

Methodology

The methodology followed in this research consists of the following steps:

- **Waste Collection:** Biomedical plastic items, including used face masks and saline bottles, were collected from hospitals and public areas under controlled and safe procedures.
- **Disinfection:** The collected materials were immersed in a 1% sodium hypochlorite solution for 24 hours to eliminate biological contamination. They were then washed with clean water and sun-dried for 48 hours.
- **Shredding:** Dried plastics were cut into 5–10 mm long fibers using a mechanical shredder.
- **Concrete Mix Design:** M20 grade concrete mix was designed using IS 10262 guidelines. Shredded plastic waste was used to replace coarse aggregates at 5%, 10%, 15%, and 20% by weight.

- **Casting and Curing:** Concrete was poured into standard paver block molds and vibrated to remove air voids. The blocks were cured in water for 28 days.
- **Testing Procedures:**
  - **Compressive Strength**: Evaluated using a compression testing machine as per IS 516.
  - **Water Absorption**: Tested as per IS 2185 to assess porosity and durability.

Materials Used

- **Cement:** Ordinary Portland Cement (OPC), 43 grade conforming to IS 8112.
- **Fine Aggregate:** Clean, river sand passing through 4.75 mm sieve.
- **Coarse Aggregate:** Crushed stone aggregates of 10 mm size.
- **Biomedical Waste Plastic:** Disinfected and shredded face masks and saline bottles.
- **Water:** Portable clean water used for mixing and curing.

Material quality was verified using standard physical and chemical tests to ensure compatibility and performance.

Fig. Final Product

Results & Discussion:

Compressive Strength (28 Days):

Replacement (%)	Strength (N/mm^2)
0% (Control)	30.49
5%	29.94
10%	29.62
15%	29.17
20%	28.29

Strength decreased marginally with increasing plastic content. However, even at 15%, the strength remained within acceptable limits for pedestrian and light vehicle pavements.

Water Absorption (%):

Replacement (%)	Absorption (%)
0%	6.8
5%	6.0
10%	5.6
15%	4.7
20%	4.2

Water absorption decreased with higher plastic content due to reduced porosity. This enhances durability, especially in wet environments.

Tests Conducted:

Fig Compressive Test Conducted

Fig Water Absorption Test

Cost Analysis

A comparative cost analysis was performed to evaluate economic feasibility:

- **Standard Paver Block Cost:** ₹22/unit
- **Biomedical Paver Block Cost:** ₹20/unit (due to lower material cost)
- **Savings for 260 Blocks:** ₹520
- **Production Cost per Block:** ₹17.50
- **Selling Price:** ₹20
- **Cost-Benefit Ratio:** 0.79 (indicating favorable economics)

This proves that biomedical paver blocks are both eco-friendly and commercially viable.

Advantages

- Effective recycling of biomedical plastic waste.
- Reduction in construction raw material demand.
- Improved durability due to lower water absorption.
- Supports public health and safety through safe disposal.
- Aligns with national sustainability and Swachh Bharat missions.

Limitations

- Requires proper sterilization to avoid health risks.
- Public perception may hinder adoption due to biomedical origin.
- Lack of standard specifications and codes for such materials.
- Reduced compressive strength beyond 15% plastic replacement.

Future Scope

- Incorporation of additional biomedical waste types (e.g., gloves, aprons).
- Use of automated and scalable sterilization techniques.
- Development of standard codes and testing guidelines.
- Life Cycle Assessment (LCA) to analyze long-term sustainability.
- Applications in public and municipal infrastructure under Smart City programs.

Conclusion

The reuse of sterilized biomedical plastic waste in concrete pavement blocks offers an innovative and sustainable approach to waste management. This method not only helps reduce plastic pollution and landfill burden but also contributes to cost-effective and durable construction practices. Experimental results indicate that up to 15% replacement of coarse aggregates with shredded biomedical plastic waste yields blocks with satisfactory mechanical properties and superior water resistance.

Future work should focus on standardization, field application, and scaling up production to transform this pilot study into a mainstream practice supporting circular economy and eco-conscious construction.

References:

1. http://www.ijirset.com/upload/2019/april/114_Manufacturing.pdf
2. https://ijcrt.org/papers/IJCRT2205654.pdf
3. https://iopscience.iop.org/article/10.1088/1755-1315/1268/1/012063/pdf
4. https://www.conserve-energy-future.com/recyclingplastic.php
5. https://www.e-education.psu.edu/eme807/node/624
6. Linkofresearchpaper:10.1016/j.cscee.2020.100052
7. Kajanan Selvaranjana, Satheeskumar Navaratnamb, Pathmanathan RajeevcNishanthan RavintherakumarandIn; Environmental challenges inducedbyextensiveuseoffacemasksduringCOVID-19:Areviewand potential solutions; Elsevier; 3
8. Linkofresearchpaper:https://doi.org/10.1016/j.scitotenv.2021.145527
9. Mohammad Saberian, Jie Li, Shannon Kilmartin-Lynch, Mahdi Boroujeni; RepurposingofCOVID-19single-usefacemasksfor pavements base/subbase; Elsevier; 769
10. Linkofresearchpaper:10.1016/j.scitotenv.2020.140279.