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## Utilizing Plastic Waste As A Sustainable Construction Material: A Systematic Review

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**Abstract:** The exponential rise in plastic waste production presents a formidable environmental challenge. One promising avenue for mitigating this issue is integrating plastic waste into construction materials, particularly concrete. This systematic review synthesizes research conducted in India over the past five years, focusing on methodologies, outcomes, and comparative evaluations of using plastic waste in construction. The findings indicate that plastic waste can effectively replace conventional fine and coarse aggregates, promoting sustainability without compromising structural integrity. There are different types of plastic which are classified based on their physical and chemical properties. As the plastic waste is nondegradable, it must be recycled or reused. The study's objective is to study the behavior of concrete made from recycled waste plastic materials along with the study of some of the related physical and chemical properties. In this study, M20 cement concrete is considered in which recycled plastic waste is used as the replacement of fine aggregate in the concrete. Concrete cubes were cast taking 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, and 50% of plastic as partial replacement of fine aggregate and tested for 7, 14 & 28 days of compressive strength of concrete.

**Keywords - Recycled Plastic, Disposal, Aggregate, Concrete mix, Compressive Strength, Waste Management, Plastic Properties, percentage**

### I. INTRODUCTION

Plastic waste management has become an urgent global concern due to its non-biodegradable nature, contributing significantly to environmental degradation. Traditional disposal methods, such as landfilling and incineration, pose ecological hazards. The construction industry has increasingly explored innovative solutions to repurpose plastic waste as an alternative material in concrete and other building materials. Utilizing plastic waste in construction not only alleviates pollution but also reduces dependence on natural resources, fostering environmental sustainability. This systematic review evaluates contemporary research on the use of plastic waste in concrete, assessing its impact on mechanical properties, durability, and environmental benefits.

The use of plastic is consistently growing because of its versatility. The total plastic produced worldwide in 2021 was estimated at 139 million metric tons in 2024 it will increase to 220 Million metric tons, with an increase of 10% every year in the last 4 years. In India consumption of Plastics grew by 15 million tons by 2015 and is set to be the third largest producer of plastics waste in the world.

For solving the disposal of large amounts of Recycled Plastic Material, the reuse of plastic in the Concrete industry is considered the most feasible application. Recycled plastic can be used as fine and coarse aggregate in concrete. plastic waste PP (Polyethylene) and HDPE (High-Density Polyethylene) as aggregates on some properties of concrete. Their results showed that decreases in weight using plastic waste was about 2-6% of the

normal weight concrete while the compressive strength was reduced by 33% compared with the compressive strength of normal Concrete.

## II. Research Methodology

A systematic approach was adopted to identify, analyze, and compare relevant studies on integrating plastic waste into construction materials. The methodology involved:

1. **Selection Criteria:** Consideration was given to studies published between 2019 and 2024, authored by Indian researchers, focusing on plastic waste utilization in construction.
2. **Data Sources:** Peer-reviewed journals, conference proceedings, and credible research repositories such as ScienceDirect, Google Scholar, and Scopus were extensively searched.
3. **Inclusion Criteria:** Research articles that investigated the mechanical properties, workability, durability, and environmental benefits of plastic waste in construction materials were included.
4. **Exclusion Criteria:** Studies that lacked experimental data, focused solely on theoretical analysis, or did not provide quantitative results were omitted.
5. **Data Extraction:** Key parameters such as sample preparation, plastic processing techniques, replacement percentages, testing methodologies, and resultant properties were systematically documented.
6. **Evaluation Framework:** Each study was analyzed based on the experimental setup, type of plastic waste used, curing methods, mix proportions, and performance evaluation techniques.
7. **Comparative Analysis:** Findings from different studies were compared to determine optimal methodologies, limitations, and areas requiring further investigation.

## III. Literature Review

Recent studies underscore the potential of plastic waste as a viable construction material, replacing traditional aggregates in varying proportions. The following research studies highlight different methodologies and findings:

### 1. Experimental Investigation on Partial Replacement of Waste Plastic in Concrete (Arivalagan S.)

This study explores the feasibility of using plastic waste as a partial replacement for fine aggregate in concrete. The key findings indicate that replacing up to 10% of natural fine aggregate with plastic aggregate leads to higher compressive strength, while higher percentages reduce strength. The research highlights the environmental benefits of reducing plastic waste and minimizing quarrying for natural aggregates. However, challenges such as reduced modulus of elasticity and flexural strength at higher plastic content remain.

### 2. Performance Studies on Concrete with Partial Replacement of Fine Aggregate by Recycled Plastic Waste (Koushik Das & Dr. Biman Mukherjee)

This paper investigates the effects of replacing fine aggregates with 5-25% recycled plastic waste in M25 concrete. The experimental results show that 10% replacement yields comparable compressive strength to conventional concrete, but higher plastic content significantly reduces compressive strength. Additionally, the study highlights the reduction in concrete density, making it suitable for lightweight concrete applications. The findings suggest potential cost savings and sustainability benefits but emphasize the need for further durability testing.

### 3. Review Paper on the Study of Common and Plastic Aggregate (Recycled Aggregate) (Rohit Khobragade et al.)

This paper provides a comparative analysis of common aggregates and plastic aggregates. It discusses the advantages of using plastic aggregates, including inert behavior, durability, and lightweight properties. The research suggests that plastic-coated aggregates can enhance the durability of concrete structures. However, it also points out that strength reduction is a significant concern, particularly in structural applications. The paper recommends further testing to improve plastic aggregates' mechanical properties and make them more suitable for construction.

#### **4. Feasibility study of recycled plastic waste as fine aggregate in concrete (Gopi, K. S., & Srinivas, T.) (2020).**

This paper provides Recycled Plastic Waste as Coarse Aggregate in Concrete. Plastic waste was collected, shredded, and incorporated as a partial coarse aggregate replacement in concrete mixtures at varying proportions (10%, 15%, and 20%). Mechanical strength tests were conducted after curing periods of 7, 14, and 28 days. A 10% replacement level yielded optimal results, maintaining strength while enhancing environmental benefits.

#### **5. Experimental Study on Partial Sand Replacement with Plastic Granules (Mr. Dhana Lakshmi, Dr. S.Arivalagan):**

This paper provides an Experimental Study on Partial Sand Replacement with Plastic Granules. Plastic waste granules were blended with cement, sand, and coarse aggregates in proportions ranging from 5% to 20%. Workability, water absorption, and compressive strength tests were conducted. Up to 10% replacement enhanced workability without significantly affecting compressive strength, making it viable for general construction purposes.

### **IV. Comparative Analysis**

#### **Comparison of Research Methodologies:**

Studies varied in their approach to plastic waste processing, with some employing granulation while others used shredded plastic. Replacement percentages influenced workability, with granulated plastic exhibiting better flow properties than shredded plastic. Some studies emphasized curing duration and chemical resistance, while others prioritized mechanical strength. Optimal strength retention was observed in replacements ranging from 5% to 15%, ensuring sustainability without compromising performance.

#### **Comparison of Findings and Impact of Methodologies:**

Higher plastic replacement levels (beyond 15%) significantly reduced compressive strength, limiting their use in structural applications. Studies focused on mechanical properties suggested that controlled replacement (5%-10%) improved workability while maintaining structural strength. Durability assessments revealed that plastic-modified concrete exhibited superior resistance to chemical degradation and environmental wear. The influence of methodologies, including curing periods and plastic processing techniques, was evident in determining final material performance.

### **V. Conclusion and Future Directions**

The integration of plastic waste into construction materials offers a sustainable solution for managing plastic pollution while conserving natural resources. Although promising, further research is required to optimize concrete mix designs and enhance material performance. Future investigations should explore advanced treatments, chemical additives, and hybrid materials to improve plastic-concrete compatibility. Additionally, large-scale trials and field applications should be conducted to assess real-world durability and structural behavior. Establishing standardized guidelines and policy frameworks will encourage widespread adoption, fostering a more sustainable construction industry.

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