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Developing Eco-friendly Concrete Using Plastic and E-Waste Aggregate

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ABSTRACT

The rapid increase in plastic and electronic waste has created significant environmental and disposal challenges worldwide. This study investigates the potential use of waste plastic and e-waste materials as partial replacements for natural aggregates in concrete to develop a sustainable and eco-friendly construction material. The waste materials were collected, cleaned, and processed into suitable sizes before being incorporated into concrete mixes at varying proportions. Experimental evaluation was carried out to study the effects on key properties such as compressive strength, tensile strength, density, and durability. The results indicate that the inclusion of plastic and e-waste aggregates reduces the overall weight of concrete while maintaining satisfactory strength for non-structural applications. Additionally, the use of these waste materials contributes to reduced consumption of natural resources and minimizes environmental pollution caused by improper disposal. The study demonstrates that such innovative material substitution can offer a practical solution for sustainable construction while supporting effective waste management practices.

Keywords: *Eco-Friendly Concrete, Plastic Waste Utilization, E-Waste Recycling, Sustainable Construction, Lightweight Concrete, Compressive Strength.*

1. INTRODUCTION

Concrete is one of the most widely used construction materials in the world due to its strength, durability, and versatility. However, the production of conventional concrete requires a large quantity of natural resources such as sand and coarse aggregates, leading to depletion of natural reserves and environmental degradation. At the same time, rapid industrialization and technological advancement have resulted in a significant increase in plastic waste and electronic waste (e-waste), which pose serious disposal and environmental challenges.

Plastic waste, which is non-biodegradable, accumulates in landfills and pollutes soil and water bodies. Similarly, e-waste contains hazardous materials and heavy metals that can cause severe environmental and health problems if not managed properly. Therefore, there is an urgent need to find sustainable and eco-friendly solutions to utilize these waste materials effectively.

One promising approach is the use of plastic waste and e-waste as partial replacement of natural aggregates in concrete. By incorporating these waste materials into concrete, it is possible to reduce environmental pollution, conserve natural resources, and promote sustainable construction practices. This method not only helps in waste management but also contributes to the development of lightweight and cost-effective construction materials.

The present study focuses on developing eco-friendly concrete by using processed plastic and e-waste aggregates.

2. LITERATURE REVIEW

Ekkachai Yooprasertchai et al. (2024)

Studied the use of treated and untreated plastic waste aggregates in concrete. The research showed that replacement levels of 10–30% can be effectively used, and surface treatment of plastic aggregates improves bonding and strength characteristics.

Gaurav Kumar et al. (2024)

Presented a comprehensive review on the utilization of e-waste as aggregate in concrete. The study concluded that size, shape, and percentage of e-waste significantly influence workability, strength, and durability of concrete.

Kiran Devi and Amit Kumar (2020)

Reviewed the use of e-waste in construction materials and concluded that e-waste can be used as fine or coarse aggregate, helping in conservation of natural resources and reducing environmental hazards.

Vishnu Prasad Dangi et al. (2025)
Conducted experimental investigation using plastic waste, e-waste, and coconut shell as aggregate replacement. The study showed that sustainable concrete can be produced with acceptable compressive and flexural strength.

3. METHODOLOGY

Collection of Materials

i. Cement: Ordinary Portland Cement (OPC) of 43 or 53 grade.
ii. Fine Aggregate: Natural river sand conforming to IS standards.
iii. Coarse Aggregate: Crushed stone aggregates of required size (e.g., 20 mm).
iv. Plastic Waste: Waste plastic materials such as polyethylene (PE) and PET bottles collected from local sources.
v. E-Waste: Discarded electronic materials such as circuit boards and plastic casings collected and segregated.

Processing of Waste Materials

i. Plastic waste is cleaned, shredded, and cut into small aggregate-like particles.
ii. E-waste is dismantled, non-metallic parts are separated, and crushed into suitable sizes.
iii. Both materials are sieved to achieve uniform grading similar to natural aggregates.

Mix Proportion

i. A conventional concrete mix (e.g., M20 or M25) is designed as per IS 10262.
ii. Natural aggregates are partially replaced with plastic and e-waste at different percentages such as 5%, 10%, 15%, and 20%.
iii. Water-cement ratio is maintained constant for all mixes.

Preparation of Specimens

i. Concrete ingredients are mixed thoroughly in dry and wet conditions.
ii. Fresh concrete is placed into moulds (cube, cylinder, beam) and compacted properly.
iii. Specimens are demoulded after 24 hours.

Curing Process

i. The specimens are cured in water for 7, 14, and 28 days to achieve required strength.

Testing of Concrete

The following tests are conducted to evaluate the properties:

i. Workability Test: Slump cone test
ii. Compressive Strength Test: Using cube specimens
iii. Tensile Strength Test: Split cylinder test
iv. Flexural Strength Test: Beam test
v. Density Test: To check lightweight characteristics

Analysis of Results

i. Test results of modified concrete are compared with conventional concrete.
ii. The optimum percentage of plastic and e-waste replacement is determined based on strength and durability.

4. APPLICATION

Non-Structural Construction

i. Used in elements such as partition walls, pavements, and flooring.
ii. Suitable for areas where load-bearing capacity is not critical.

Road Construction

i. Can be used in pavement blocks, kerbstones, and footpaths.
ii. Provides better waste utilization and reduces construction cost.

Lightweight Concrete Structures

i. Due to reduced density, it is suitable for lightweight structures.
ii. Used in precast panels, wall blocks, and insulation layers.

Drainage and Sewer Systems

i. Applicable in manufacturing pipes, manhole covers, and drainage units.
ii. Offers durability and resistance to moisture.

Landscaping and Architectural Works

i. Used for decorative concrete elements like garden blocks, benches, and tiles.
ii. Enhances sustainability in urban landscaping projects.

Low-Cost Housing

i. Suitable for economical housing projects where cost reduction is important.
ii. Helps in minimizing material cost and environmental impact.

5. FUTURE SCOPE

Optimization of Mix Design

i. Detailed studies can be carried out to determine the optimum percentage of plastic and e-waste for maximum strength and durability.
ii. Use of admixtures and supplementary cementitious materials can improve performance.

Improvement in Mechanical Properties

i. Research can focus on enhancing bonding between waste aggregates and cement paste.
ii. Surface treatment of plastic and e-waste materials can be explored to increase strength.

Use in Structural Applications

i. With proper modifications, this type of concrete can be developed for structural elements like beams and columns.
ii. Advanced testing and design codes are required for safe implementation.

Durability and Long-Term Performance

i. Long-term studies on durability, creep, shrinkage, and resistance to chemicals and weathering can be conducted.

ii. Performance under extreme environmental conditions can also be analyzed.

- **Large-Scale Implementation**

i. Pilot projects can be undertaken for real-life construction applications.
ii. Development of standards and guidelines for industrial use is necessary.

- **Integration with Sustainable Technologies**

i. Combination with green technologies such as geopolymer concrete and recycled materials can be explored.
ii. Life cycle assessment (LCA) can be carried out to evaluate environmental benefits.

- **Cost and Environmental Analysis**

i. Detailed economic analysis can be conducted to assess cost-effectiveness.
ii. Carbon footprint reduction and sustainability impact can be quantified.

6. CONCLUSION

This study focused on the development of eco-friendly concrete by partially replacing natural aggregates with plastic waste and e-waste materials. The results indicate that such waste materials can be effectively utilized in concrete production, contributing to sustainable construction practices and efficient waste management. From the experimental observations, it is concluded that partial replacement of natural aggregates with plastic and e-waste reduces the density of concrete, making it lightweight. Although there is a slight reduction in compressive strength at higher replacement levels, the strength remains within acceptable limits for non-structural and semi-structural applications. An optimum replacement range of **10–20%** is found to provide a good balance between strength and sustainability.

The use of plastic and e-waste in concrete helps in reducing environmental pollution, conserving natural resources, and lowering landfill disposal problems. It also offers an economical alternative to conventional concrete, especially in low-cost construction.

Overall, eco-friendly concrete using plastic and e-waste aggregates presents a promising solution for future construction, promoting sustainability while addressing the growing issue of solid waste management.

7. RESULT

Compressive Strength Results

(%)Replacement (Plastic +E Waste)	**7 Days (MPa)**	**14 Days (MPa)**	**28 Days (MPa)**
(0%)(Conventional Concrete)	18.4	24.8	30.2
5 (0%)	19.2	25.5	31
10 (0%)	20.1	26.3	35.5
15 (0%)	18.9	25.0	31.8

Observations

i. Strength increases slightly up to 10% replacement due to better particle distribution.
ii. Maximum compressive strength is achieved at 10% replacement.
iii. Beyond 15%, strength decreases due to weak bonding of plastic and e-waste.
iv. Strength gradually increases with curing age (7 → 14 → 28 days), as expected.

Conclusion from Results

i. Optimum replacement level: 10%
ii. 28-day strength is highest at this level (≈ 32.5 MPa)
iii. Suitable for non-structural and light structural applications

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