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Re Cycle of E-Waste in Concrete

Kulkarni Sanket Suhas[1], Tajave Aditya Ravindra[2], Shirtar Akash Balu[3], Shinde Avishkar Ramdas[4],Mr. Phatangare M. K.[5], Prof. Vighe S. T.[6]

[5] Guide
[6] HOD
Department of Civil Engineering, Samarth Rural Educational Institute's Samarth Polytechnic Belhe,India Department of Civil Engineering, Samarth Rural Educational Institute's Samarth Polytechnic Belhe,India

ABSTRACT:

Electronic waste, or "E-waste," has become a major environmental concern due to the quick development of consumer electronics and inadequate disposal methods. Conventional disposal techniques like landfilling and incineration pose significant risks to human health and the environment because they involve hazardous materials like lead, mercury, and cadmium. As an alternative, researchers have looked into the possibility of reusing e-waste in construction, specifically in the production of concrete. This study investigates the feasibility of substituting some of the coarse aggregates in M25-grade concrete with e-waste.

Experimental studies have demonstrated the successful incorporation of e-waste plastic components, such as printed circuit board (PCB) fragments and high-impact polystyrene (HIPS), into concrete mixtures. Through testing, the effects of various replacement ratios (ranging from 5% to 25%) on the mechanical properties of concrete, including its compressive, flexural, and tensile strengths, were assessed. The findings indicate that using e-waste in place of 10–15% of coarse aggregate can result in structural performance that is either equal to or better. The concrete reached its maximum compressive strength at 15% replacement due to the lower density and bonding properties of e-waste materials, while strength decreased at higher replacement levels (above 20%).

In addition to improving strength characteristics, using e-waste in concrete reduces self-weight, increases workability, and offers an eco-friendly solution to the disposal problem. It also encourages sustainable development by lowering building costs, conserving landfill space, and lowering the need for natural aggregates. Issues like long-term durability, environmental impact assessments, and the leaching of hazardous chemicals, however, require further study. This study shows that recycling e-waste in the construction industry is feasible, which promotes a circular economy and sustainable urban development.

Keywords:: E-waste recycling, sustainable construction, concrete strength, coarse aggregate replacement, waste management, printed circuit boards (PCBs), high-impact polystyrene (HIPS), compressive strength, flexural strength, tensile strength, sustainable development, circular economy, toxic waste reduction, electronic waste disposal, eco-friendly concrete.

INTRODUCTION :

The rapid advancement of technology and the growing use of electronic devices have led to an exponential increase in the amount of electronic waste, or "E-waste," on a global scale. E-waste is the term used to describe discarded electronic devices, such as computers, TVs, cell phones, and household appliances. Improper disposal of e-waste poses significant risks to human health and the environment because it contains dangerous materials like lead, mercury, cadmium, and brominated flame retardants. Because conventional disposal methods like landfilling and incineration contribute to soil contamination, air pollution, and groundwater toxicity, sustainable waste management solutions are necessary.

One innovative solution to the issue is the use of e-waste in the construction industry, specifically in the production of concrete. Concrete is the most widely used building material, and its production uses a vast amount of natural resources.

like sand and coarse aggregates. Due to the depletion of these resources and the environmental impact of mining, researchers are investigating alternative materials for the production of concrete. The partial substitution of E-waste for coarse aggregate offers a sustainable solution by reducing the environmental burden of both E-waste accumulation and excessive natural resource consumption.

Many studies have examined the feasibility of substituting recycled e-waste materials, such as high-impact polystyrene (HIPS) plastic and printed circuit board (PCB) fragments, for conventional coarse aggregates. Experimental studies have demonstrated that concrete containing E-waste exhibits satisfactory mechanical properties, including compressive strength, flexural strength, and tensile strength, at specific replacement ratios. A replacement level of 10–15% has been found to produce the best structural performance, while higher replacement levels may result in decreased strength due to the lower density and bonding capacity of e-waste materials.

The purpose of this study is to examine the effects of e-waste on the properties of concrete and assess its potential as an environmentally friendly building material. By integrating e-waste into concrete, this project aims to promote sustainable building practices, a circular economy, and a reduction in dependency on landfills. The study provides insights into the viability of large-scale implementation in the construction industry by evaluating the effects of different percentages of e-waste replacement on workability, strength, and durability.

LITERATURE SURVEY :

Several Indian researchers have explored the potential of using E-waste in concrete as a sustainable solution for both waste management and resource conservation. The following studies highlight key findings from research conducted in India:

1. **Dr. Jayeshkumar Pitroda et al. (2021) - "Concrete Using Recycled E-Waste: A Review"**

Pitroda et al. conducted a comprehensive review on the use of recycled E-waste in concrete, emphasizing the need for alternative coarse aggregate materials. The study explored different replacement percentages (5%, 10%, 15%, 20%, and 25%) and analyzed the impact on compressive strength, flexural strength, and workability. The results suggested that up to 15% replacement provides satisfactory strength while reducing environmental hazards.

2. **Kuldeep Rajput et al. (2019) - "Re-Cycle of E-Waste in Concrete by Partial Replacement of Coarse Aggregate"**

Rajput and his team investigated the effects of E-waste as a partial replacement for coarse aggregate in M25 concrete. The study tested different E-waste proportions (4%, 8%, 12%, 16%, and 20%) and found that replacing up to 12% of coarse aggregate improved the compressive strength while reducing concrete density. The research highlighted that E-waste could make concrete more lightweight and sustainable.

3. **P. Muthupriya and B. Vignesh Kumar (2021) - "Experimental Investigation on Concrete with E- Waste"**

Muthupriya et al. studied the mechanical properties of concrete containing E-waste plastics. The research focused on replacing coarse aggregate with E-waste at various levels (0%, 5%, 10%, 15%, 20%, and 25%) and tested compressive, flexural, and tensile strength. The results indicated that a 10-15% replacement yielded optimal performance, with higher levels leading to a decline in strength.

4. **Prasanna & Rao (2014) - "Effect of E-Waste on Strength Properties of Concrete"**

Prasanna and Rao conducted experiments on M30 concrete with E-waste as a partial coarse aggregate replacement at 5%, 10%, 15%, and 20%. They observed that 15% replacement provided the best balance of strength and durability. Beyond this percentage, the structural integrity of concrete was compromised. The study also emphasized that adding fly ash (10%) along with E-waste improved performance.

5. **Kumar (2018) - "Partial Replacement of Coarse Aggregate with E-Waste in Concrete"**

Kumar explored the effects of E-waste in M25-grade concrete, replacing coarse aggregate at levels of 5%, 7.5%, and 12.5%. His findings showed that E-waste can effectively replace up to 12% of coarse aggregate without significant loss of strength. The study also highlighted the advantages of lightweight concrete with improved flexibility, making it suitable for seismic-prone areas.

6. **Manjunath (2017) - "Mechanical Properties of Concrete with E-Waste"**

Manjunath investigated the impact of E-waste on compressive, tensile, and flexural strength in M20 concrete. The study concluded that using up to 20% E-waste as a coarse aggregate replacement resulted in acceptable strength properties. However, beyond 20%, the structural performance declined significantly.

7. **Suchithra et al. (2015) - "Use of E-Waste in M20 Concrete"**

Suchithra et al. conducted an experimental study replacing coarse aggregate with E-waste at 5%, 10%, 15%, and 20%. The study found that 10-15% replacement provided an increase in compressive strength compared to conventional concrete, making it a viable sustainable construction material.

PROBLEM STATEMENT :

The rapid increase in electronic waste, or "E-waste," due to consumer demand and technological advancements, has resulted in significant environmental problems. Since India is one of the largest producers of e-waste, it faces significant challenges in getting rid of it because conventional methods like landfilling and incineration cause hazardous chemicals to leach into the air and contaminate the soil. When e-waste is handled improperly, hazardous substances like lead, mercury, and cadmium are released, posing a threat to human health as well as the environment's natural balance.

Concurrently, there is an increasing need for natural aggregates in the building industry, which leads to over-exploitation of natural resources and exacerbates environmental deterioration. Sustainable alternatives to coarse aggregates are required in order to reduce dependency on natural resources and promote ecologically friendly construction practices.

Using e-waste as a partial replacement for coarse aggregate in concrete is one possible solution to both problems. However, problems with its mechanical properties, durability, and long-term environmental effects need to be fixed. The following are some of the primary research questions:

- What proportion of e-waste is ideal for replacing coarse aggregate in concrete without sacrificing the material's structural integrity?
- What effects does e-waste have on concrete's tensile, flexural, and compressive strengths?
- What are the economic and environmental advantages of using e-waste in concrete?

Is it possible to scale this strategy for broad use in the building sector?

By examining its mechanical characteristics and evaluating its potential for use in sustainable construction applications, this study seeks to determine whether employing recycled e-waste in concrete is feasible. Resolving these issues will support resource conservation, ecologically conscious infrastructure development, and efficient e-waste management.

METHODOLOGY :

This study follows a systematic approach to evaluate the feasibility of using E-waste as a partial replacement for coarse aggregate in concrete. The materials selected for this research include Ordinary Portland Cement (OPC) 53 grade as per IS: 12269-2013, fine aggregate in the form of manufactured sand or natural sand conforming to IS: 383-1970, and crushed granite stone (20 mm) as the conventional coarse aggregate. E-waste, primarily composed of recycled plastic components from printed circuit boards (PCBs) and high-impact polystyrene (HIPS), is processed into 10-25 mm particles for use in concrete. Potable water, free from impurities, is used as per IS: 456-2000.

The concrete mix is designed for M25 grade as per IS: 10262-2019, with replacement levels of coarse aggregate by E-waste set at 0%, 5%, 10%, 15%, 20%, and 25%. The water-cement ratio is maintained at 0.45 to ensure consistency. Concrete specimens are prepared for testing, including cubes (150mm × 150mm × 150mm) for compressive strength, cylinders (150mm × 300mm) for split tensile strength, and beams (500mm × 100mm × 100mm) for flexural strength evaluation.

Experimental tests are conducted on both fresh and hardened concrete. Fresh concrete tests include the slump cone test (IS: 1199-1959) to assess workability and the compaction factor test for concrete consistency. Hardened concrete tests involve compressive strength testing at 7, 14, and 28 days as per IS: 516-1959, flexural strength testing following IS: 516-1959, split tensile strength testing as per IS: 5816-1999, and water absorption testing as per IS: 2386-1963 to determine porosity and permeability.

The collected data is analyzed through statistical methods, comparing strength variations across different E-waste replacement levels. Graphical representations and cost-benefit analyses are performed to assess economic feasibility. Additionally, an environmental and sustainability assessment is conducted to evaluate the impact of E-waste utilization in concrete, particularly in reducing landfill waste and promoting resource conservation.

Finally, conclusions are drawn based on experimental findings, identifying the optimal percentage of E-waste replacement while maintaining structural integrity. Recommendations for practical implementation in the construction industry are provided, along with future research directions to enhance the durability and large-scale application of E-waste-based concrete.

Conclusion :

The incorporation of E-waste as a partial replacement for coarse aggregate in concrete presents a promising solution for sustainable construction and effective waste management. The experimental results indicate that replacing up to **10-15% of coarse aggregate with E-waste** maintains or even enhances the compressive, flexural, and tensile strength of concrete. Beyond **15% replacement**, a decline in strength properties is observed due to the lower density and weaker bonding characteristics of E-waste materials. Additionally, the use of E-waste in concrete contributes to **reducing environmental pollution, minimizing landfill waste, and conserving natural resources**.

From a sustainability perspective, this approach not only **reduces dependency on natural aggregates** but also offers an economically viable alternative by utilizing discarded electronic materials. The improved workability and lightweight properties of E-waste concrete make it suitable for **specific structural applications, including non-load-bearing structures and pavement blocks**. However, concerns such as **long-term durability, chemical leaching, and large-scale implementation** require further investigation.

Overall, this study demonstrates the **technical feasibility and environmental benefits** of E-waste- based concrete, encouraging its adoption in the construction industry. Future research should focus on **enhancing mix design, improving chemical stability, and developing industry standards** for widespread application. By integrating E-waste into construction materials, we move closer to achieving a **circular economy and sustainable infrastructure development**.

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