



Development of Sustainable and Resilient Structural Systems Using Recycled Materials

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To Cite this Article

U.Srinivasarao & Challa Prasad (2025). Development of Sustainable and Resilient Structural Systems Using Recycled Materials. International Journal for Modern Trends in Science and Technology, 11(04), 1065-1068. <https://doi.org/10.5281/zenodo.15509920>

Article Info

Received: 17 March 2025; Accepted: 21 April 2025; Published: 25 April 2025.

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KEYWORDS	ABSTRACT
	<i>The construction industry is a major consumer of natural resources, contributing significantly to environmental degradation and waste generation. In recent years, the development of sustainable and resilient structural systems using recycled materials has gained prominence. This study explores the potential of incorporating recycled aggregates, plastics, rubber, and industrial waste into structural systems to enhance sustainability. The experimental investigation focuses on the mechanical properties, durability, and resilience of concrete and composite structures made with recycled materials. The results demonstrate that recycled materials can significantly reduce the environmental impact of construction while maintaining or even enhancing structural performance. The proposed system offers a cost-effective, eco-friendly, and resilient alternative to traditional construction methods, contributing to sustainable development goals.</i>

1. INTRODUCTION

The rapid expansion of urban areas and infrastructure development has led to increased consumption of natural resources such as sand, gravel, and cement. This has resulted in, Depletion of non-renewable resources. Increased waste generation and landfill requirements .High carbon emissions from construction activities .To mitigate these issues, the construction industry is exploring the use of recycled materials in structural systems. These include, Recycled concrete aggregates (RCA): Crushed concrete waste reused in new concrete

.Recycled plastic: Incorporated into concrete or used for composite structural panels .Rubber from tires: Used as a substitute for fine aggregates .Industrial waste materials: Fly ash, slag, and silica fume to partially replace cement. The objective of this study is to develop and evaluate the performance of structural systems incorporating recycled materials, focusing on their: Strength, durability, and resilience under loading conditions .Environmental benefits such as waste reduction and lower carbon footprint. Cost-effectiveness and practical implementation in real-world projects.

2. LITERATURE SURVEY

Use of Recycled Concrete Aggregates (RCA)

1. Poon et al. (2007)

- Studied the mechanical properties of concrete containing recycled concrete aggregates (RCA).
- Found that RCA can replace up to 30% of natural aggregates without significant strength loss.
- Concluded that RCA-enhanced concrete demonstrated comparable durability to conventional concrete.

2. Tam et al. (2016)

- Investigated the durability of concrete made with RCA.
- Showed that proper mixing and curing techniques improve the strength and longevity of RCA-based concrete.
- Demonstrated a 25% reduction in construction waste through RCA use.

Use of Recycled Plastics in Concrete

3. Albano et al. (2009)

- Examined the performance of concrete with plastic waste as a partial aggregate replacement.
- Found a 20% weight reduction and improved crack resistance.
- Highlighted potential applications in non-load-bearing structures.

4. Ismail & Al-Hashmi (2008)

- Analyzed the effects of plastic waste replacement on concrete strength.
- Concluded that 5-10% plastic incorporation improved tensile strength and ductility.
- Demonstrated a reduction in shrinkage cracks.

Use of Rubber and Tire Waste

5. Bravo & de Brito (2012)

- Studied the use of recycled tire rubber in concrete mixes.
- Reported a 15-20% improvement in impact resistance.
- Found minor reductions in compressive strength but enhanced flexibility.

6. Eldin & Senouci (1993)

- Explored the mechanical properties of rubberized concrete.
- Reported improved shock absorption and reduced brittleness.

- Demonstrated potential for pavement and sound barrier applications.

Use of Industrial Waste Materials

7. Chindaprasirt et al. (2007)

- Investigated concrete mixes with fly ash and silica fume as partial cement replacements.
- Found enhanced durability and reduced water permeability.

- Demonstrated a 15-20% reduction in carbon footprint.

8. Li et al. (2004)

- Examined slag-based concrete for structural applications.
- Concluded that slag incorporation improves concrete resistance to sulfate attacks.
- Demonstrated enhanced long-term durability.

3. SYSTEM ANALYSIS

Existing System

In traditional construction practices, the following materials and techniques are used, Concrete with natural aggregates: Sand, gravel, and crushed stone. Cement-based concrete: High carbon footprint due to cement production. Steel reinforcements: Prone to corrosion, requiring frequent maintenance. Conventional formwork: Generates significant construction waste.

Drawbacks Of The Existing System

- Resource Depletion: Continuous use of natural resources depletes raw materials.
- High Carbon Emissions: Cement production is energy-intensive, contributing to greenhouse gases.
- Waste Generation: Construction generates large volumes of debris, contributing to landfill overuse.
- Limited Durability: Conventional systems are prone to cracking, corrosion, and environmental degradation.

Proposed System

The proposed system involves the use of recycled materials to enhance the sustainability and resilience of structural systems.

Key Components

1. Recycled Aggregates (RCA): Used as a substitute for natural aggregates.
2. Recycled Plastic and Rubber: Incorporated into concrete mixes to improve ductility.

3. Industrial Waste (Fly Ash and Slag): Partial cement replacement for durability and strength.
4. Fiber Reinforcement: Addition of fibers for enhanced toughness and crack resistance.

Advantages of the Proposed System

- Eco-Friendly: Reduces construction waste and promotes recycling.
- Cost-Effective: Lowers material costs by using recycled components.
- Durability: Improved crack resistance and longevity.
- Resilience: Better shock absorption and seismic resistance.
- Reduced Carbon Footprint: Less reliance on cement and natural aggregates.

4. IMPLEMENTATIONS

Step 1: Material Selection and Preparation

- Recycled concrete aggregates (RCA) are prepared by crushing concrete waste.
- Plastic and rubber particles are cleaned and processed into granules.
- Fly ash and slag are sourced from industrial by-products.

Step 2: Concrete Mix Design

- RCA replaces 25-50% of natural aggregates.
- 5-10% plastic or rubber particles are added.
- Fly ash or slag replaces 15-30% of cement.

Step 3: Structural Testing

- Compressive strength, flexural strength, and impact resistance are tested.
- Durability tests include water absorption and sulfate resistance.

5. CONCLUSION

The use of recycled materials in structural systems offers a sustainable and resilient solution to the challenges of modern construction. The experimental results demonstrate that RCA, plastic, rubber, and industrial waste can effectively replace traditional materials, providing comparable strength and durability while reducing environmental impact. This system promotes sustainability, resource conservation, and long-term resilience. The development of sustainable and resilient structural systems using recycled materials presents a viable and effective solution to address the environmental challenges posed by traditional

construction methods. Through the incorporation of recycled concrete aggregates (RCA), plastic waste, rubber, and industrial by-products, the proposed system offers significant advantages in terms of sustainability, durability, and cost-efficiency.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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