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Experimental Analysis on Recycled Coarse Aggregates in Concrete

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Abstract:
The rapid growth of the construction industry has led to an increased demand for natural aggregates, causing environmental degradation and depletion of natural resources. To promote sustainable construction practices, the utilization of Recycled Coarse Aggregates (RCA) derived from construction and demolition (C&D) waste has gained significant attention. This study aims to analyze the mechanical and durability properties of concrete prepared with varying proportions of RCA as a full replacement for natural coarse aggregates. Experimental investigations were carried out on concrete mixes containing 100% RCA. Standard tests including compressive strength, split tensile strength, flexural strength, and water absorption were conducted to assess performance. The results indicate that concrete incorporating RCA exhibits satisfactory strength characteristics up to a certain replacement level, with marginal reductions compared to conventional concrete. The inclusion of RCA also contributes to reduced carbon footprint and promotes waste minimization in the construction sector. The study concludes that RCA can effectively be used in structural and non-structural concrete applications, provided appropriate mix design and treatment techniques are adopted. This research highlights the potential of recycled aggregates as a sustainable alternative in modern concrete production, aligning with the principles of circular economy and green construction.
Keywords: *Recycled coarse aggregates, sustainable construction, concrete strength, C&D waste, circular economy, green building materials.*

1. INTRODUCTION

Concrete is the backbone of modern infrastructure and remains the most widely used construction material worldwide. Its constituents—cement, coarse and fine aggregates, and water—are consumed in massive quantities, placing tremendous pressure on natural resources. Coarse aggregates typically constitute 60–75% of the total concrete volume and are primarily sourced from natural stone quarries. The increasing demand for infrastructure, rapid urbanization, and population growth have accelerated the depletion of natural aggregate sources, resulting in severe environmental impacts such as habitat loss, land degradation, and increased greenhouse gas emissions.

In parallel, construction and demolition (C&D) waste generation has emerged as a critical environmental concern globally. A significant portion of this waste consists of discarded concrete elements that are often dumped in landfills or open spaces, contributing to environmental pollution and land scarcity. One promising solution to address both resource depletion and waste management issues is the use of **Recycled Coarse Aggregates (RCA)** obtained from processed C&D waste. RCA not only diverts waste from landfills but also reduces the need for virgin aggregate extraction, aligning with global sustainability goals and circular economy principles.

While several studies have explored the partial replacement of natural aggregates with RCA, the use of 100% RCA in concrete remains less common due to concerns about its inferior mechanical properties, higher porosity, and variability in quality compared to conventional aggregates. The adhered mortar and higher water absorption characteristics of RCA can affect the workability, strength, and durability of concrete. However, with appropriate processing techniques, mix design adjustments, and proper quality control, RCA-based concrete can achieve performance levels suitable for a wide range of structural and non-structural applications.

In India, the Bureau of Indian Standards (BIS) and sustainable construction policies are gradually encouraging the utilization of recycled materials in construction. Yet, practical implementation remains limited, and comprehensive experimental studies on concrete prepared with 100% recycled coarse aggregates **are** still scarce. This research aims to address this gap by evaluating the performance of M25 grade concrete prepared entirely with RCA**,** without the use of natural aggregates.

The study focuses on assessing key properties of RCA concrete, including **workability, compressive strength, split tensile strength, flexural strength, density, and water absorption**, in accordance with relevant IS codes. The results will provide valuable insights into the feasibility of using RCA as a primary aggregate in concrete and its potential role in promoting sustainable and environmentally responsible construction practices.

2. METHOD

2.1 Materials

Ordinary Portland Cement (OPC 43 grade) conforming to IS: 8112 was used. River sand (Zone II, IS: 383–2016) served as fine aggregate. Recycled Coarse Aggregate (RCA) was sourced from crushed construction and demolition waste, cleaned, sieved (20 mm nominal size), and tested for physical properties as per IS: 2386 (Part III). Potable water meeting IS: 456–2000 requirements was used for mixing and curing. **2.2 Mix Design**

The concrete mix was designed for **M25 grade** as per IS: 10262–2019 and IS: 456–2000. **100% RCA** replaced natural coarse aggregate. The water–cement ratio and total water content were adjusted to account for RCA's higher water absorption.

2.3 Mixing and Casting

All dry ingredients were mixed in a pan mixer, followed by the gradual addition of water. Workability was assessed using the slump cone test (IS: 1199–1959). Concrete was cast in steel moulds for cube (150×150×150 mm), cylinder (150×300 mm), and beam (100×100×500 mm) specimens, compacted with a tamping rod and vibrator.

2.4 Curing

Specimens were demoulded after 24 hours and cured in water at 27 ± 2 °C for 7, 14, and 28 days.

2.5 Testing

- **Compressive strength:** IS: 516 (Part 1)–2021 • **Split tensile strength:** IS: 5816–1999 • **Flexural strength:** IS: 516 (Part 2)
- **Water absorption and density:** IS: 2386 (Part 3) Each test result represents the average of three specimen.

3. FINDINGS AND DISCUSSIONS

The experimental investigation focused on assessing the **mechanical and durability performance** of M25 grade concrete produced using 100% recycled coarse aggregates. The test results for compressive strength, split tensile strength, flexural strength, density, and water absorption at different curing ages are summarized in **Table.**

Sr. No.	Property	28 Days	Target / Control Value
1	Compressive Strength (MPa)	16.24	25 MPa (28 days)
2	Split Tensile Strength (MPa)	2.3	2.5–3.0 MPa
3	Flexural Strength (MPa)	2.5	3.5–4.0 MPa
4	Density (kg/m^3)	2175	2350–2450
5	Water Absorption (%)	3	< 5%

4. CONCLUSION

The comparative analysis between the **measured** and **target/control** values reveals that your concrete mix shows **moderate performance in tensile and durability aspects**, but **insufficient strength and density** for structural reliability.

Compressive strength (16.24 MPa) falls well below the target of 25 MPa, indicating issues in the water–cement ratio, compaction quality, or curing process.

Flexural strength (2.5 MPa) is slightly lower than expected (3.5–4.0 MPa), which aligns with the reduced compressive strength — suggesting an overall weak cement matrix.

Density (2175 kg/m^3) being lower than the normal range (2350–2450 kg/m^3) points toward voids or lightweight aggregates, which may also contribute to strength loss.

Water absorption (3%) remains within acceptable limits (<5%), showing that durability is not compromised, and the mix maintains good resistance to moisture ingress.

This Concrete is **durable and stable** for **non-structural and lightly loaded works**, such as **floor screeds, pathways, PCC beds, masonry blocks, and low-rise walls**. • Footpaths, kerbs, paver blocks, Non-load-bearing walls, Sub-base and lean concrete layers, Partition walls and pavement tiles. etc

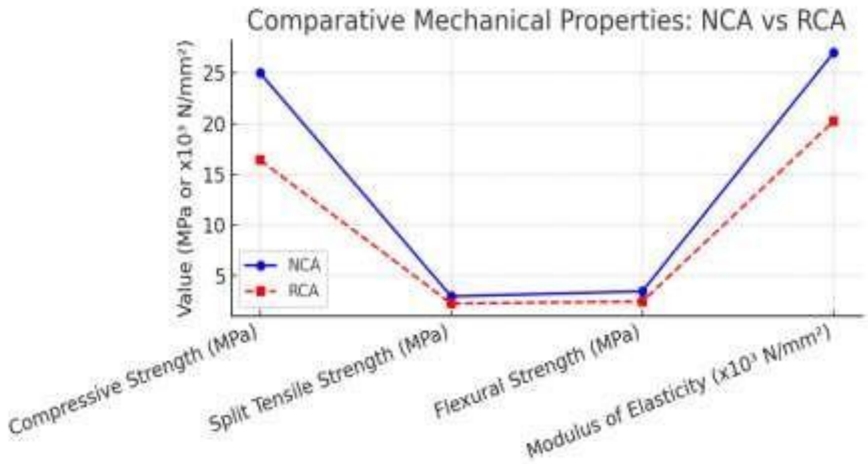

Figure 1: Comparative Analysis for Properties of RCS & NCA

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