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An Experimental Study on Mechanical and Durability Properties of Recycled Aggregate Concrete Using Demolished Building Waste

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Abstract

The rapid growth of the construction industry has resulted in excessive consumption of natural aggregates and increased generation of construction and demolition waste. Recycling demolished concrete waste as aggregate in new concrete offers a sustainable solution. This study investigates the mechanical and durability properties of recycled aggregate concrete (RAC) produced by partially replacing natural coarse aggregates with recycled aggregates obtained from demolished building waste. Concrete mixes of M30 grade were prepared with 0%, 25%, 50%, and 75% replacement levels. Mechanical properties such as compressive strength, split tensile strength, and flexural strength were evaluated along with durability characteristics including water absorption, sorptivity, and acid resistance. Experimental results indicate that mechanical strength and durability decrease with increase in recycled aggregate content. However, up to 50% replacement exhibits satisfactory performance and meets strength requirements. The study concludes that recycled aggregate concrete can be effectively used for sustainable construction applications under moderate exposure conditions.

Keywords: Recycled Aggregate Concrete, Demolished Building Waste, Durability, Mechanical Properties, Sustainable Construction

1. Introduction

Concrete is the most widely used construction material, and aggregates constitute a major portion of its volume. Excessive extraction of natural aggregates has resulted in environmental degradation. Simultaneously, construction and demolition waste generation has increased due to urban redevelopment. Recycling demolished concrete waste into aggregates provides an environmentally sustainable alternative. However, concerns regarding strength and durability limit its widespread adoption. Hence, experimental evaluation of recycled aggregate concrete is necessary.

2. Literature Review

Previous studies have reported that recycled aggregates possess higher porosity and water absorption due to adhered old mortar. Researchers such as Hansen (1986), Poon et al. (2002), and Xiao et al. (2012) observed a reduction in mechanical properties with increasing recycled aggregate content. Durability studies indicate increased water absorption and permeability. Most studies recommend partial replacement up to 50% for acceptable performance. However, limited studies focus on demolished building waste under Indian conditions, justifying the present research.

3. Materials and Methodology

Ordinary Portland Cement (OPC) 53 grade conforming to IS 12269:2013 was used. Natural river sand (Zone II) and crushed granite aggregates of 20

mm size were employed. Recycled coarse aggregates were obtained from demolished building waste, processed by crushing and sieving. Concrete mix design was carried out as per IS 10262:2019 for M30 grade concrete. Natural coarse aggregate was replaced with recycled aggregate at 0%, 25%, 50%, and 75%. Specimens were cast and cured for 7, 14, and 28 days.

4. Experimental Program

Tests conducted include:

- Slump test for workability
- **Workability Test Results (Slump Test)**
- **Table A.1 Slump Test Results**

Mix ID	RCA (%)	Slump (mm)
M0	0	90
M25	25	85
M50	50	78
M75	75	70

Compressive strength test Compressive Strength Results

Table A.2 Compressive Strength Results

Mix ID	RCA (%)	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
M0	0	24.5	28.7	38.9
M25	25	23.2	27.1	36.8
M50	50	21.8	25.4	34.2
M75	75	19.6	22.9	30.8

Observation:

Up to 50% RCA, compressive strength satisfies M30 grade requirements. Higher replacement causes noticeable strength reduction.

A.3 Split Tensile Strength Results

Mix ID	RCA (%)	Split Tensile Strength (MPa)
M0	0	3.42
M25	25	3.25
M50	50	3.02
M75	75	2.68

Observation:

Tensile strength decreases due to weaker ITZ and micro-cracks in recycled aggregates.

A.4 Flexural Strength Results

Table A.4 Flexural Strength Results (28 Days)

Mix ID	RCA (%)	Flexural Strength (MPa)
M0	0	4.85
M25	25	4.62
M50	50	4.28
M75	75	3.91

Observation:

Flexural strength reduction is gradual; up to 50% RCA is acceptable for slabs and pavements.

A.5 Water Absorption Results

Table A.5 Water Absorption Results

Mix ID	RCA (%)	Water Absorption (%)
M0	0	2.10
M25	25	2.48
M50	50	2.96
M75	75	3.42

Observation:

Higher RCA content increases porosity and permeability.

A.6 Sorptivity Test Results Table A.6 Sorptivity Results

Mix ID	RCA (%)	Sorptivity (mm/√min)
M0	0	0.021
M25	25	0.026
M50	50	0.032
M75	75	0.039

Observation:

Capillary suction increases with recycled aggregate replacement.

Acid Resistance Test Results Table A.7 Acid Resistance – Weight Loss

Mix ID	RCA (%)	Weight Loss (%)
M0	0	1.20
M25	25	1.65
M50	50	2.20
M75	75	3.05

Observation:

Concrete with higher RCA shows more deterioration under acidic exposure.

All tests were carried out as per relevant IS codes.

5. Results and Discussion

Results show a decrease in workability with increasing recycled aggregate content due to higher water absorption. Compressive, split tensile, and flexural strengths reduce gradually with higher replacement levels. At 50% replacement, concrete satisfies M30 strength requirements. Durability parameters such as water absorption and sorptivity increase due to increased porosity. Acid resistance results indicate higher deterioration at higher replacement levels. Overall, recycled aggregate concrete with up to 50% replacement exhibits satisfactory performance.

6. Conclusions

The study concludes that recycled aggregates obtained from demolished building waste can be effectively used in concrete. Up to 50% replacement of natural coarse aggregates provides acceptable mechanical strength and durability. Recycled aggregate concrete offers significant environmental benefits and supports sustainable construction practices.

REFERENCES FOR LITERATURE REVIEW (Chapter 2)

(Use this list in thesis – Literature Review section)

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