Partially Replacement of Coarse Aggregate by Structural Demolition Waste –A Step towards Green Concrete

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Abstract - In this project, we focus on developing green concrete by partially replacing coarse aggregates with structural demolition waste. The goal is to explore the feasibility of using recycled concrete materials to reduce reliance on natural aggregates. This will involve testing the properties and performance of the resulting concrete and comparing it with conventional concrete. The motivation for using demolition waste arises from growing environmental concerns about resource extraction. Discarded concrete waste in landfills contributes to environmental degradation, so reusing it can help reduce strain on natural resources and minimize landfill waste. Previous research has shown that recycled concrete aggregates can produce concrete with satisfactory strength and durability under certain conditions. While there may be slight mechanical property variations, proper treatment and grading can lead to viable construction materials.

The environmental benefits of green concrete are significant, as it reduces the need for natural aggregates, preserves natural habitats, and lowers the carbon footprint of the construction industry. This approach supports sustainable urban development and resource conservation.

***Key Words*:** Recycled Coarse Aggregate, Compressive strength, Admixture, Silica Fumes

1. INTRODUCTION

In this project, we are focusing on developing green concrete by partially replacing coarse aggregates with demolition waste, particularly from concrete slabs. The aim is to explore the viability of using recycled concrete materials to reduce the reliance on natural aggregates in construction. This approach will help assess the properties of the green concrete produced and compare its behaviour with conventional concrete. A series of tests will be conducted to analyse the aggregate properties and performance of the concrete after replacement.

The choice to use demolition waste as a partial replacement for coarse aggregates stems from the increasing environmental concerns associated with the extraction of natural resources. Demolition waste, particularly from concrete structures, is often discarded in landfills, contributing to environmental degradation. By reusing this waste, we can reduce the strain on natural resources and minimize the amount of waste sent to landfills, making the construction industry more sustainable.

Previous research on the use of demolition waste in concrete has shown promising results. Studies have found that recycled concrete aggregates can produce concrete with satisfactory strength and durability under certain conditions. While there may be slight differences in mechanical properties compared to traditional concrete, many researchers have demonstrated that proper treatment and grading of the demolition waste can lead to viable construction materials with minimal performance trade-offs.

The environmental benefits of using green concrete with recycled aggregates are significant. By reducing the need for natural aggregates, we can preserve natural habitats and reduce the energy-intensive processes involved in mining. Additionally, incorporating demolition waste into concrete helps to decrease the carbon footprint of the construction industry, ultimately contributing to more sustainable urban development and resource conservation.

2. METHODOLOGY

I. LITERATURE REVIEW

1. Influence of silica fume on mechanical and physical properties of recycled aggregate concrete

This study examines the impact of adding silica fume (SF) to concrete mixes containing recycled aggregates. SF was used to replace Portland cement at 0%, 5%, and 10% levels. Concrete mixtures incorporating 10% SF and recycled aggregates, especially of 4/12 mm size, showed improved mechanical and physical properties. Compressive strength increased at 28 and 90 days due to the pozzolanic effect of SF. The tensile splitting strength of recycled aggregate concrete also improved with SF, while water absorption significantly decreased, particularly with 10% SF. SF usage was more effective in smaller-sized recycled aggregates.

2. Experimental Study of the Use of Demolition Wastes in the Production of High-Performance Concrete

This study investigated the use of demolition waste to produce High-Performance Concrete (HPC) by replacing natural aggregates with recycled coarse aggregates (RCA) and incorporating glass fiber and pozzolana material. The experimental results showed that 25% RCA, 5% pozzolana, and 0.5% glass fiber achieved optimal strength at 28 days, with compressive strength reaching 50.69 MPa. The use of recycled materials and pozzolan in HPC not only improves strength but also reduces environmental impact by minimizing CO2 emissions and natural aggregate extraction. This approach is promising for sustainable construction projects such as high-rise buildings, bridges, and tunnels.

3. Recycled Aggregate Concrete Made with Silica Fume: Experimental Investigation

This study examines the effects of using recycled coarse aggregate (RCA) and silica fume (SF) on recycled aggregate concrete (RAC). Results show that RCA reduces workability and mechanical performance compared to natural coarse aggregate (NCA). Adding SF further decreases workability due to its fine particles but improves compressive, tensile, and flexural strengths through its pozzolanic reaction. Optimal mechanical performance for RAC can be achieved by replacing 10-20% of cement with SF, making it comparable to NCA concrete. This study promotes the use of RCA in construction.

4. Study on Concrete Containing Recycled Aggregates Immersed in Epoxy Resin

This study focuses on recycling construction and demolition waste by using recycled aggregates (RA) in concrete mixes. Normal and recycled aggregates were immersed in epoxy resin at varying percentages (0%, 5%, 10%, and 20%) to assess their impact on concrete properties. Results show that immersing aggregates in epoxy resin improves both normal and recycled aggregates by reducing aggregate impact and crushing values. Compressive strength increased for all concrete mixtures as the percentage of resin-immersed aggregates increased. Water absorption and permeability decreased with higher percentages of resin-immersed aggregates. Overall in this study, using epoxy resin enhances concrete durability and performance.

5. Utilizing Construction and Demolition (C&D) Waste as Recycled Coarse Aggregates (RCA) with Epoxy Resin in Concrete

This research examines the potential of using recycled aggregates (RA) from construction and demolition (C&D) waste in new concrete production, emphasizing their engineering properties and the treatment of RA with epoxy resin to reduce water absorption. The study found that recycled aggregate concrete can achieve workability and compressive strength comparable to normal concrete, particularly with 20mm-sized aggregates. Results indicated that the compressive strength increased significantly after 28 days of curing, while water absorption rates were lower for the 20mm aggregates compared to larger sizes. Overall, utilizing RA offers a sustainable approach to waste management and reduces reliance on natural resources, though it may compromise concrete quality.

II. Material Selection:

Cement, Fine aggregate, coarse aggregate, Recycled coarse aggregate, Silica fumes, water, and admixture were utilized

III. Mix Proportions:

M20 mix i.e. 1:1.5:3 designs were prepared and evaluated. The % of Recycled Coarse aggregate are 10%, 15%, 20%.

IV. Testing Procedures:

Compressive Strength Test: Conducted on (150x150x150mm) cube specimens at 7, 14 and 28 days curing.

V. Density Test:

Determining the unit weight of hardened concrete to assess its compactness

VI. Analysis of results:

We tested our recycled coarse aggregate concrete samples for compressive strength. The results were compared with regular concrete.

VII. Conclusion:

We summed up our findings, highlighting the strengths and % of replacement of coarse aggregate by recycled coarse aggregate.

3. MATERIALS

I. Materials used

a) Ordinary Portland Cement 43 Grade (IS 8112)
b) Fine Aggregates (IS 383)
c) Coarse Aggregates (IS 383)
d) Recycled Coarse Aggregates
e) Silica Fumes (IS15388)
f) Plasticizers
g) Water

II. Material Properties

TABLE I. TEST ON CEMENT

Various tests were conducted to evaluate the properties of cement, ensuring compliance with IS 4031 and IS 8112 standards.

Property	Results
Fineness of cement	8.8%
Standard consistency of cement	35mm
Initial setting time of cement	35mins
Final setting time of cement	600min

TABLE II. TEST ON FINE AGGREGATES

To ensure the suitability of Fine aggregate concrete, various tests were conducted as per IS 2386 (Part IV): 1963.

Property	Results
Specific gravity of fine aggregates	2.6
Bulking of fine aggregates	23.33%

TABLE III. TEST ON COARSE AGGREGATES

To ensure the suitability of coarse aggregate (passing 20mm, retained on 10mm sieve) for concrete, various tests were conducted as per IS 2386 (Part III): 1963.

Property	Results
Specific gravity of coarse aggregate	2.65
Water absorption of coarse aggregate	0.8%

TABLE IV. TEST ON RECYCLED COARSE AGGREGATES

To ensure the suitability of coarse aggregate (passing 20mm, retained on 10mm sieve) for pervious concrete, various tests were conducted as per IS 2386 (Part III): 1963.

Property	Results
Specific gravity of recycled coarse aggregate	2.445
Water absorption of recycled coarse aggregate	4.16%

4. WORK DONE

After completing material testing, partially replaced coarsed aggregate concrete specimens were casted and tested to evaluate strength and density characteristics. The process involved mix proportioning, batching, mixing, and curing, ensuring adherence to relevant IS codes.

I. Mix Proportioning

The mix was designed following IS 10262:2019 (Concrete Mix Proportioning) and IS 456:2000 (Concrete Design). 2% of silica fumes and 0.4% admixture i.e. plasticizer is used. Variations in material and water-cement ratio were considered to determine an optimal mix balancing strength and permeability.

II. Batching and Mixing

Weigh batching was used for precise proportioning of materials. A mechanical mixer ensured uniform material distribution. Special care was taken to maintain proper bonding between ingredients.

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Fig-1: Mixing of Concrete

Fig-2: Concrete Cube Casting

III. Mix Proportions and Material Quantities

Batch 1 (10% RCA used)

For Batch 1 the concrete mix was designed following IS 10262:2019, with a 1:1.5:3 mix ratio and a water-cement ratio of 0.38. We prepared a total of 109.78 kg of material. This included 19.882 kg of cement, 29.823 kg of fine aggregate, 53.681 kg of coarse aggregate, 5.965 kg of recycled coarse aggregate, 0.398 kg of silica fumes, 7.476 litres of water and 80ml of admixture used, ensuring a well balanced mix for casting nine test cubes.

Batch 2 (15% RCA used)

For Batch 1 the concrete mix was designed following IS 10262:2019, with a 1:1.5:3 mix ratio and a water-cement ratio of 0.38. We prepared a total of 109.78 kg of material. This included 19.882 kg of cement, 29.823 kg of fine aggregate, 50.699 kg of coarse aggregate, 8.947 kg of recycled coarse aggregate, 0.398 kg of silica fumes, 7.476 litres of water and 80ml of admixture used, ensuring a well balanced mix for casting nine test cubes.

Batch 3 (20% RCA used)

For Batch 1 the concrete mix was designed following IS 10262:2019, with a 1:1.5:3 mix ratio and a water-cement ratio of 0.38. We prepared a total of 109.78 kg of material. This included 19.882 kg of cement, 29.823 kg of fine aggregate, 47.716 kg of coarse aggregate, 11.929 kg of recycled coarse aggregate, 0.398 kg of silica fumes, 7.476 litres of water and 80ml of admixture used, ensuring a well balanced mix for casting nine test cubes.

Batch 4 (0% RCA used) (Standard)

For Batch 4 (Without RCA), the concrete was mixed using a 1:1.5:3 ratio, with a water-cement ratio of 0.38. We prepared a total of 109.78 kg of material. This included 19.882 kg of cement, 29.823 kg of fine aggregate, 59.645 kg of coarse aggregate, 0.398 kg of silica fumes, 7.476 litres of water and 80ml of admixture used, ensuring a well balanced mix for casting nine test cubes.

This mix was carefully measured to maintain consistency and reliability in the experimental results.

IV. CURING

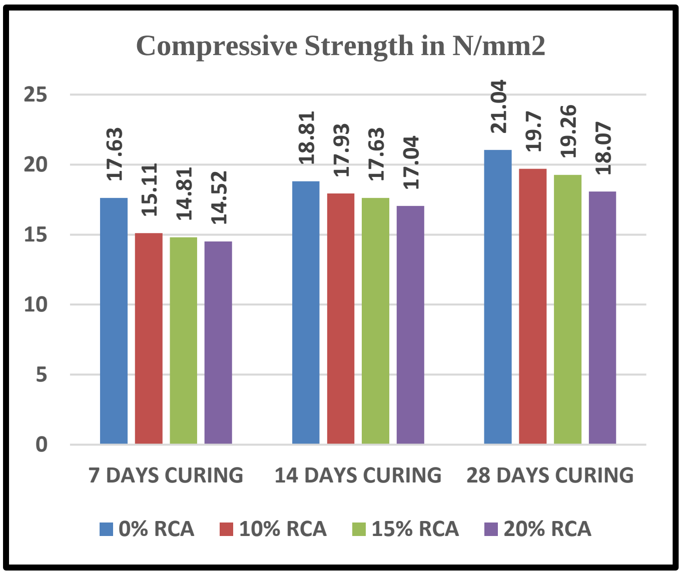
After 24 hours of casting, the cubes were removed from the moulds and placed in water for curing at room temperature, maintaining a relative humidity of 85%. The cubes were taken out from curing at intervals of 7, 14 and 28 days for testing.

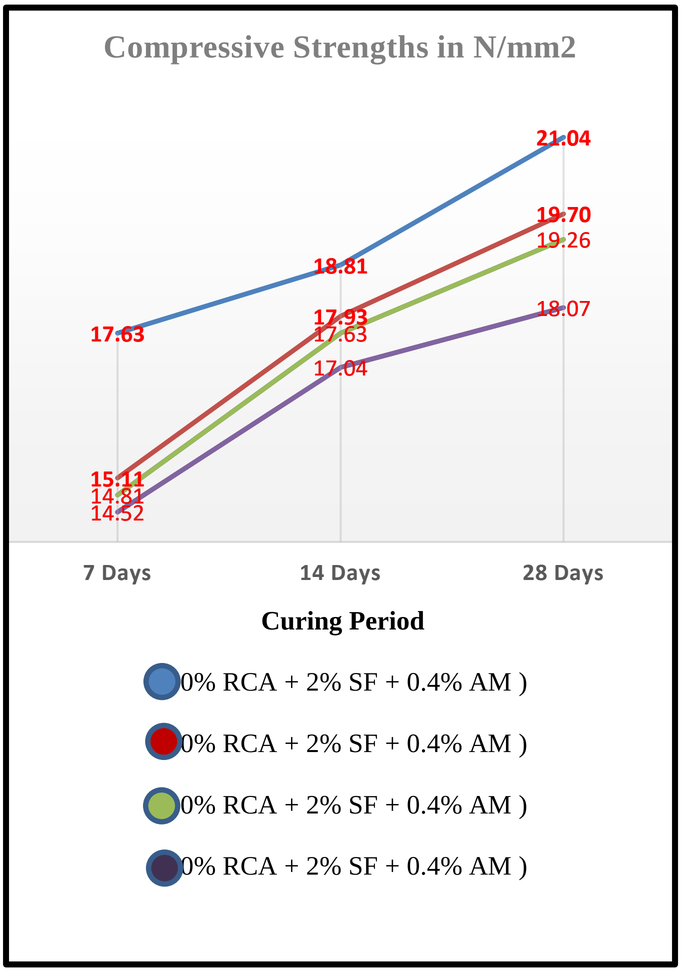
Fig-3: Concrete Cube Curing

5. RESULTS

TABLE V. COMPRESSIVE STRENGTH RESULTS

S.no.	% RCA USED	Average Compressive Strength (N/mm^2)		
		Curing Period		
		7 days	14 days	21 days
1	0% RCA	17.63	18.81	21.04
2	10% RCA	15.11	17.93	19.70
3	15% RCA	14.81	17.63	19.26
4	20% RCA	14.52	17.04	18.07





DENSITY TEST:

The average density of concrete is found to be 2500kg/m3

6. CONCLUSION

For RCA concrete if we have to increase the compressive strength, we have to add silica fumes and plasticizer for increasing the strength. In our research work, we observed that within limitations of addition of silica fumes and plasticizer the replacement of 10% and 15% is satisfactory. In our research, we have found that the average density is 2500 kg/m3.

The composition of this concrete mix incorporates cement, fine aggregate, and coarse aggregate, along with recycled coarse aggregate and silica fumes, resulting in a sustainable and high-performance blend. The inclusion of recycled coarse aggregate enhances environmental sustainability by reducing dependence on natural resources, while silica fumes contribute to improved strength and durability. Additionally, water and admixture play crucial roles in achieving the desired workability and performance characteristics. This carefully designed mix optimizes both structural integrity and eco-friendliness, making it suitable for advanced construction applications.

ABBREVIATIONS USED

RCA : Recycled Coarse Aggregate
RA : Recycled Aggregate
SF : Silica Fumes
AM : Admixture

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