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AN EXPERIMENTAL STUDY ON M20 GRADE CONCRETE WITH REPLACEMENT OF RECYCLING AGGREGATE

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ABSTRACT

This study explores the use of recycled concrete aggregate (RCA) in M20 grade concrete, focusing on the effects of RCA substitution on the material's properties. Various percentages of RCA (0%, 10%, 20%, 30%, and 100%) were tested to assess their impact on compressive strength, workability, and durability. Results show that compressive strength decreases with increased RCA, but a 10% replacement maintains acceptable performance. Workability decreases with higher RCA content, though adjustments can improve it. The study demonstrates the potential of RCA as a sustainable alternative for M20 grade concrete. The rising demand for natural aggregates in the construction industry has led to the depletion of natural resources and increased environmental concerns. This study explores the feasibility and performance of M20 grade concrete by partially replacing natural aggregates with recycled aggregates derived from construction and demolition waste. The experimental investigation evaluates the mechanical and durability properties of concrete mixes with varying percentages of recycled coarse aggregates.

Keywords: M20 Grade Concrete, Recycled Aggregate Concrete Mix Design As Workability, Mechanical Properties, Compressive Strength, Split Tensile Strength, And Water Absorption.

I. INTRODUCTION

Concrete is one of the most widely used construction materials globally due to its versatility, strength, and durability. However, the increasing demand for natural aggregates and the environmental concerns associated with their extraction have led to the exploration of alternative materials. One such alternative is the use of recycled aggregates (RAs), which are derived from construction and demolition waste. The replacement of natural aggregates with recycled aggregates in concrete has gained significant attention as it presents a potential solution to both waste management and the reduction of environmental impacts. M20 grade concrete, which is commonly used for medium-strength construction works, has been the focus of many studies to assess the viability of using recycled aggregates in its mix design.

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1.1 Need for the Study

Environmental Concerns: The construction industry is a major contributor to environmental issues due to excessive mining of natural aggregates and accumulation of demolition waste.

Resource Scarcity: With the increasing demand for infrastructure, natural aggregate sources are depleting rapidly. Sustainability: Utilizing recycled aggregates can promote sustainable construction by reducing the demand for virgin materials and minimizing landfill waste. Cost Reduction: Recycled aggregates can potentially reduce the cost of concrete production, especially in areas where natural aggregates are expensive or scarce.

1.2 History of Study

Research on recycled aggregate concrete (RAC) began in the mid-20th century, primarily in Europe and Japan. Since then, numerous studies have been conducted to evaluate the mechanical and durability properties of RAC. Early investigations showed that while recycled aggregates generally produce concrete with slightly lower strength than natural aggregates, they can be effectively used in structural and non-structural applications when properly processed. Over the years, advancements in processing techniques, standards, and mix designs have improved the quality and acceptability of recycled aggregates in concrete production.

1.3 Scope of the Work

This study aims to: Evaluate the feasibility of using recycled coarse aggregates in M20 grade concrete. Analyze the mechanical properties such as compressive strength, workability, and durability of concrete with varying percentages of recycled aggregate replacement. Determine the optimal replacement level of recycled aggregates that provides acceptable strength and performance. Provide recommendations for practical implementation in construction projects.

1.4 Objective of the Study

1. To partially replace natural coarse aggregates with recycled aggregates in M20 grade concrete.
2. To assess the workability of concrete with different replacement levels (e.g., 0%, 10%,20%,30% and 100%).
3. To evaluate the compressive strength of recycled aggregate concrete at 7, 14, and 28 days.
4. To compare the performance of recycled aggregate concrete with conventional concrete.
5. To encourage the use of environmentally friendly construction practices. Previous research studies.

Several researchers have studied the effects of replacing natural aggregates with recycled aggregates in concrete, focusing on strength, durability, and workability. Some key findings from previous research include:

1. Katz (2003) – Investigated the properties of recycled aggregate concrete and found that although the compressive strength was slightly lower than conventional concrete, the recycled aggregates could be effectively used for structural applications when processed correctly.
2. Tam et al. (2007) – Conducted experiments using 100% recycled aggregates and concluded that concrete made with recycled aggregate showed acceptable performance, especially for non-structural elements.
3. Padmini et al. (2009) – Studied the durability of recycled aggregate concrete and observed that the water absorption and permeability were higher, but could be managed with proper mix design.

II. METHODS AND MATERIALS

2.1 Methodology

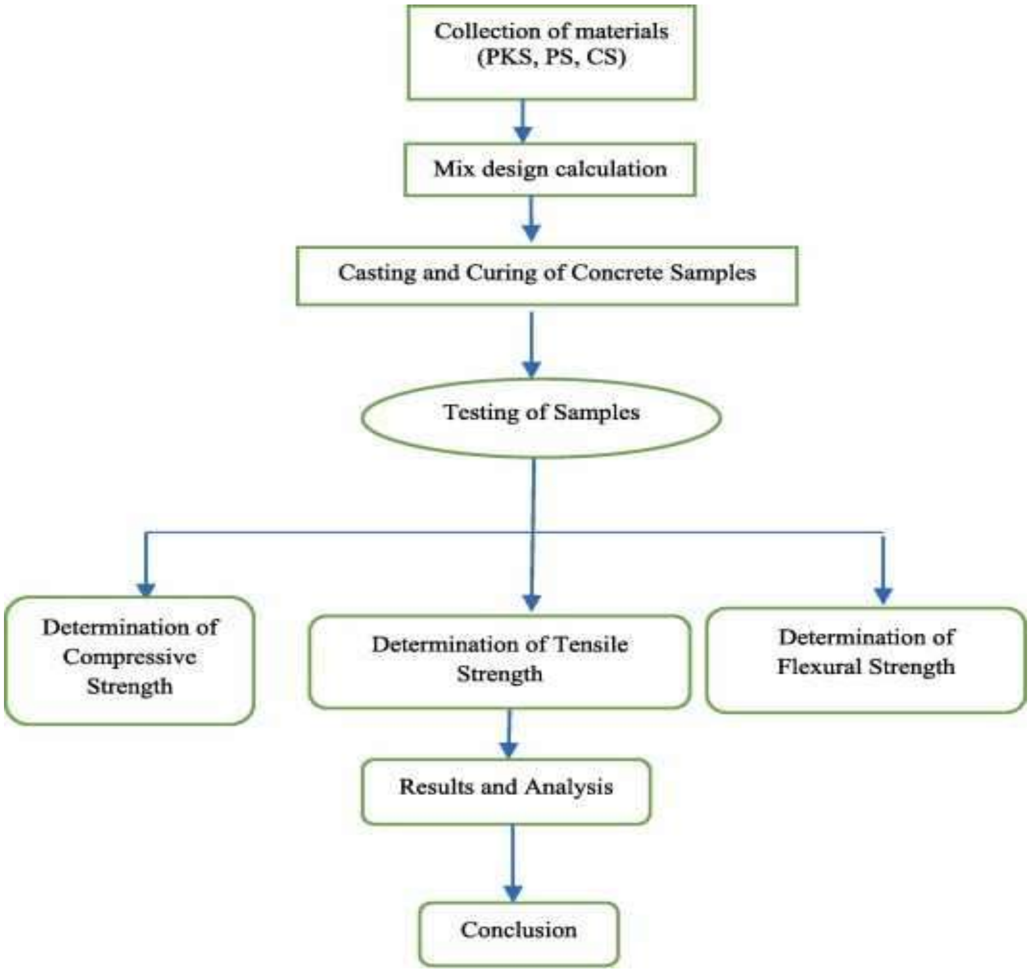
2.2. MATERIAL USED

2.2.1. Cement

1. Type: Ordinary Portland Cement (OPC) – 43 or 53 Grade
2. Function: Acts as a binder in concrete.
3. Conforming Standard: IS 12269:2013

2.2.2 Fine Aggregate (Sand)

1. Type: Natural river sand or manufactured sand (M-sand)
2. Zone: Confirmed as per IS 383:2016 (usually Zone II)
3. Function: Fills voids and contributes to the strength and workability.



2.2.3 Coarse Aggregate

1. Type:
   - Natural Coarse Aggregate (NCA) – Typically crushed stone
   - Recycled Coarse Aggregate (RCA) – Derived from demolished concrete structures
2. Replacement Levels: RCA is used as a partial/full replacement for NCA (e.g., 0%, 10%, 20%, 30%, 40% and 100%)

2.2.4 Water

1. Type: Clean, potable water
2. Standard: As per IS 456:2000
3. Function: Hydration of cement and workability of the mix

2.2.5 Admixtures (Optional)

1. Type: Superplasticizer (if required to improve workability)
2. Standard: IS 9103:1999
3. Brand Examples: Fosroc, Sika, BASF, etc.

2.2. 6 Recycled Aggregate (RCA) Details)

1. Source: Demolition waste (concrete blocks, old building structures)
2. Properties Tested:
   - Specific gravity
   - Water absorption
   - Crushing value
   - Los Angeles abrasion value

2.2.7 Concrete Mix Design

1. Grade: M20 (nominal mix 1:1.5:3 or design mix as per IS 10262:2019),
2. Water-Cement Ratio: Usually around 0.5

Fig 1: Recycling Agg

Fig 2: Coarse Agg

Fig 3: Fine Agg

Fig 4: Cement

Table 1: Quantity of materials

% of replacement	0%	10%	20%	30%
Cement(kg)	4.86	4.86	4.86	4.86
Fine aggregate (kg)	8.073	7.266	6.459	5.652
Coarse aggregate (kg) Normal agg Recycling agg	9.200	9.200	9.200	9.200

BATCHING AND MIXING OF MATERIALS

Batching is the process of measuring materials for making concrete. Accurate batching is critical for the strength and durability of the concrete.

1. Method Used: Weight batching (preferred over volume batching for better accuracy)
2. Materials Batching:

- Cement: Measured in kg
- Fine aggregate and coarse aggregates: Measured by weight using digital weighing balance
- Water: Measured by volume (liters), converted to equivalent weight

For M20 Grade Concrete (Design mix or Nominal mix 1:1.5:3):

1. Mix Ratio (by weight): Cement : Fine Aggregate : Coarse Aggregate
2. Water-Cement Ratio: Generally kept at 0.45–0.50 depending on desired workability

Example for 1 m^3 (approximate values):

Cement: 320 kg

Fine Aggregate: 640 kg

Coarse Aggregate: 1280 kg (including RCA in proportions)

Water: 160 liters

MIXING OF MATERIALS

Proper mixing ensures uniform distribution of materials in the concrete and improves its strength and quality. Dry Mixing: Cement, fine aggregate, and coarse aggregates (including RCA) are dry mixed for 2 minutes until uniform color is observed. Addition of Water: Water (and admixture, if used) is added gradually to the dry mix. Wet Mixing: The mix is continued for another 2–3 minutes until a homogenous concrete mix is obtained.

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Concrete mixing



0% concrete cubes curing compressive strength test

Cracked concrete brick

III. RESLUSTS AND DISCUSSION

3.1. Materials properties

The materials used in this study were tested for their physical properties as per Indian Standard specifications. All materials were sourced from reputable suppliers or obtained locally, and their characteristics are detailed above 2.1.

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Table 2: Properties of materials

Material characteristic	Coarse aggregate	Fine aggregate	Cement
Fineness(mm)	20	2.75	6
Specific gravity	2.736	2.656	1.44
Density kg/m3	2726	2392	1440
Water absorption(%)	1.22	1.124	

3.2. Test on fresh concrete

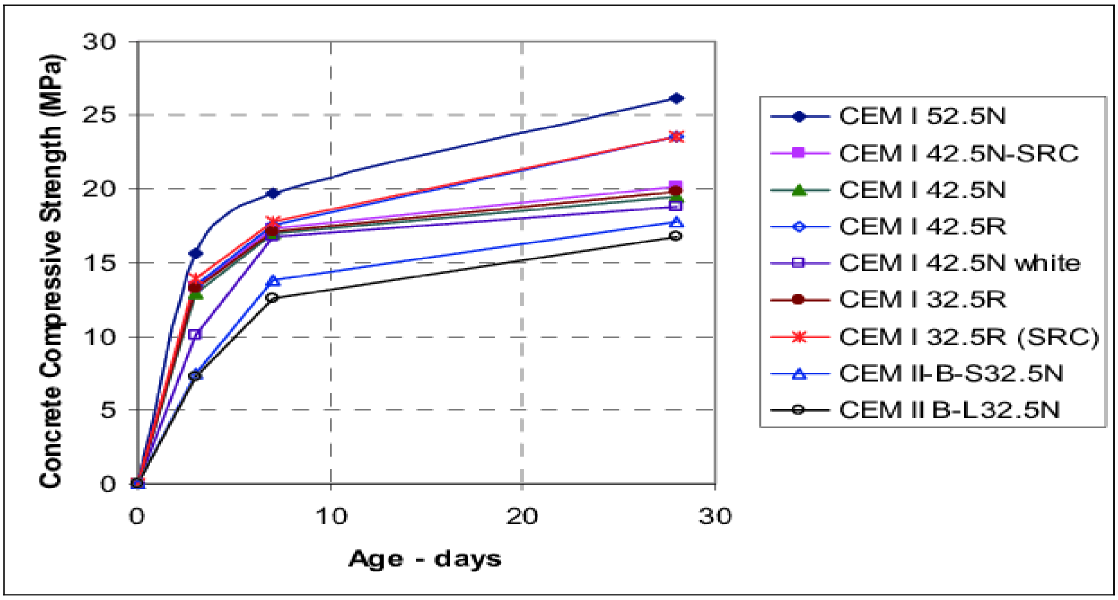
To evaluate the workability and handling characteristics of M20 grade concrete incorporating recycled coarse aggregate (RCA), tests on fresh concrete were conducted. These tests are crucial for assessing the consistency, mobility, cohesiveness, and segregation resistance of concrete in its plastic state.

Table 3: Values of fresh concrete

% of replacement	0%	10%	20%	30%
Slump cone test (mm)	60	90	50	30
Compaction factor test	0.93	0.91	0.841	0.821

3.3. Compressive strength

Testing is the only way to determine whether a concrete mix has enough compressive strength, or load-bearing capacity, for the intended use. These tests are conducted on cylindrical concrete specimens using a machine that compresses the cylinders until they crack or break completely. Generally the higher the psi rating, or the weight under which a square inch of concrete surface area will fail, the stronger and more durable the concrete will be. Note that concrete cylinders are usually tested 28 days after casting as a quality-control check to determine if compressive strength levels are acceptable. Although concrete will continue to gain strength after 28 days, enough hydration has taken place during this time frame to provide a good estimate of the final strength.



3.4. Crack propagation in harden concrete

1. Rapid urbanization leads to large-scale demolition waste → potential use as recycled coarse aggregate (RCA).
2. M20 grade concrete is commonly used → cost-effective and widely applied.
3. Objective: Study the effect of partial/full replacement of natural aggregate with recycled aggregate on mechanical properties and crack propagation in hardened concrete.

IV. CONCLUSION

The experimental study on M20 grade concrete with partial replacement of natural aggregates by recycled aggregates indicates that the use of recycled aggregates can be a viable alternative to conventional materials in concrete production. The replacement of natural aggregates with recycled aggregates up to a certain limit (typically around 30-40%) has been shown to have a minimal negative impact on the compressive strength, workability, and durability of concrete. Key conclusions drawn from the study are as follows:

Workability: The slump of concrete slightly decreased with higher percentages of recycled aggregates due to their higher water absorption and rough texture. However, the workability remained within acceptable limits for general construction purposes.

Compressive Strength: Concrete with up to 50% recycled aggregate replacement showed compressive strength comparable to conventional concrete. Beyond this level, a gradual reduction in strength was observed, though it remained within usable limits for non-structural applications.

Tensile Strength and Durability: Similar trends were observed in split tensile strength and water absorption tests. Moderate replacements (up to 50%) provided results close to the control mix, while higher replacements led to increased porosity and reduced performance.

Sustainability Impact: The use of recycled aggregates contributes to sustainable construction practices by reducing the demand for natural resources and minimizing construction and demolition waste. In conclusion, recycled aggregates can be recommended as a sustainable alternative to natural coarse aggregates, especially up to 50% replacement in M20 grade concrete. They are suitable for non-critical structural components, pavements, and low-load applications, offering both environmental and economic benefits.

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