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#### “PARTIAL REPLACEMENT OF NATURAL AGGREGATE WITH RECYCLED AGGREGATE ”

**Sajan Tirpude<sup>1</sup>, Sakshee Choure<sup>2</sup>, Dr. Manish Dubey<sup>3</sup>, Mr. Khaitan Agarwal<sup>4</sup>**

<sup>1-4</sup> B. Tech Student, SISTecR, Bhopal, <sup>2</sup>Associate Professor, Civil Engineering Department, SISTecR, Bhopal

#### ABSTRACT

*The increasing demand for sustainable construction materials has led to the exploration of recycled concrete aggregates (RCA) as a partial replacement for natural coarse aggregates (NCA) in concrete. This study investigates the performance of M30 grade concrete with RCA replacement levels of 0%, 20%, and 40%. Recycled aggregates were obtained from construction and demolition waste, processed, and tested for key properties such as specific gravity, water absorption, and strength indices. Concrete mixes were designed as per standard guidelines, and compressive strength tests were conducted at 7 and 28 days. The results indicate that RCA exhibits higher water absorption and slightly lower strength characteristics compared to natural aggregates. However, the compressive strength of concrete with 20% RCA replacement remains close to the control mix (approximately 31 MPa at 28 days), showing only marginal reduction. At 40% replacement, a moderate decrease in strength is observed, yet the values remain within acceptable limits for M30 grade concrete. The study concludes that RCA can be effectively used up to 20% replacement without significant loss of performance, while up to 40% replacement is feasible for practical applications with slight compromise in strength. The use of recycled aggregates contributes to sustainable construction by conserving natural resources and reducing environmental impact.*

**Key Words:** Recycled Concrete Aggregate (RCA), Natural Aggregate (NCA), M30 Grade Concrete, Compressive Strength, Sustainable Construction, Aggregate Replacement

#### I. INTRODUCTION

The expansion of infrastructure development worldwide has significantly intensified the consumption of construction materials, especially natural aggregates used in concrete production. Concrete, composed of cement, water, and fine and coarse aggregates, is one of the most widely utilized construction materials due to its strength, durability, versatility, and cost-effectiveness. It plays a crucial role in the development of infrastructure such as buildings, bridges, pavements, and foundations. When mixed in appropriate proportions, concrete undergoes hydration, forming a hardened mass with significant compressive strength. Reinforced concrete further enhances its performance by incorporating steel reinforcement to resist tensile stresses. Despite these advantages, the environmental impact associated with concrete production, especially due to cement manufacturing and excessive extraction of natural aggregates, has become a major concern [1].

In recent years, sustainable construction practices have gained importance, focusing on reducing environmental degradation and promoting efficient resource utilization. One such approach is the use of recycled aggregates obtained from construction and demolition waste. Recycled aggregates are produced by crushing and processing waste materials such as old concrete and asphalt, making them suitable for reuse in new construction applications. This practice not only reduces the burden on landfills but also conserves natural aggregate resources and minimizes energy consumption associated with quarrying activities [2].

The concept of replacing natural aggregates with recycled aggregates in concrete has emerged as a promising solution

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to address sustainability challenges. Particularly in M30 grade concrete, which is commonly used for structural applications, it is essential to evaluate the mechanical and durability properties when recycled aggregates are incorporated. The performance of such concrete depends on factors like aggregate quality, replacement percentage, and mix design.

This study aims to investigate the feasibility of replacing natural aggregates with recycled aggregates in M30 grade concrete, with a focus on strength characteristics and overall performance. By adopting this approach, the construction industry can move toward more sustainable practices while maintaining structural integrity and functionality. The integration of recycled materials in concrete not only contributes to environmental conservation but also supports the development of eco-friendly infrastructure [3].

## II. LITERATURE REVIEW

Several researchers have investigated the use of recycled aggregates (RA) as a partial or full replacement for natural aggregates (NA) in concrete to enhance sustainability while maintaining structural performance.

Poon et al. [4] studied the properties of recycled aggregate concrete and observed that the compressive strength decreases slightly with an increase in recycled aggregate content due to the presence of adhered mortar. However, they concluded that up to 20–30% replacement can be effectively used without significant loss in strength for structural applications.

Kou and Poon [5] further examined the long-term durability of recycled aggregate concrete and reported that although water absorption and porosity increase with higher RA content, proper mix design and the use of supplementary cementitious materials can significantly improve durability performance.

Rahal [6] investigated the mechanical properties of recycled aggregate concrete and found that compressive strength and modulus of elasticity decrease with increasing replacement levels. However, the study highlighted that concrete with 25% recycled aggregate exhibits comparable performance to conventional concrete, making it suitable for moderate strength applications like M30 grade.

Ettxeberria et al. [7] evaluated the influence of recycled coarse aggregates on concrete properties and concluded that up to 30% replacement provides satisfactory strength and durability. Beyond this level, a notable reduction in mechanical properties was observed due to weaker interfacial transition zones.

Tabsh and Abdelfatah [8] conducted experimental studies on recycled aggregate concrete and reported that while there is a reduction in compressive and tensile strength, the values remain within acceptable limits for structural use when replacement levels are controlled. They emphasized the importance of quality control in recycled aggregates.

Katz [9] analyzed the performance of concrete made with recycled aggregates and highlighted that the primary factors affecting strength are aggregate quality, water absorption, and adhered mortar content. The study suggested that pre-treatment of recycled aggregates can enhance their performance and make them more suitable for structural-grade concrete.

Overall, the reviewed literature indicates that recycled aggregates can be effectively utilized in concrete production, particularly for moderate strength grades such as M30, provided that the replacement percentage is optimized and proper mix design techniques are adopted.

## III. METHODOLOGY

The study focuses on evaluating the replacement of natural coarse aggregate (NCA) with recycled concrete aggregate (RCA) in M30 grade concrete. Materials used include Ordinary Portland Cement (OPC), natural aggregates, recycled aggregates obtained from demolished concrete, and natural sand. The recycled aggregates were processed through crushing and sieving to achieve the required size and remove impurities.

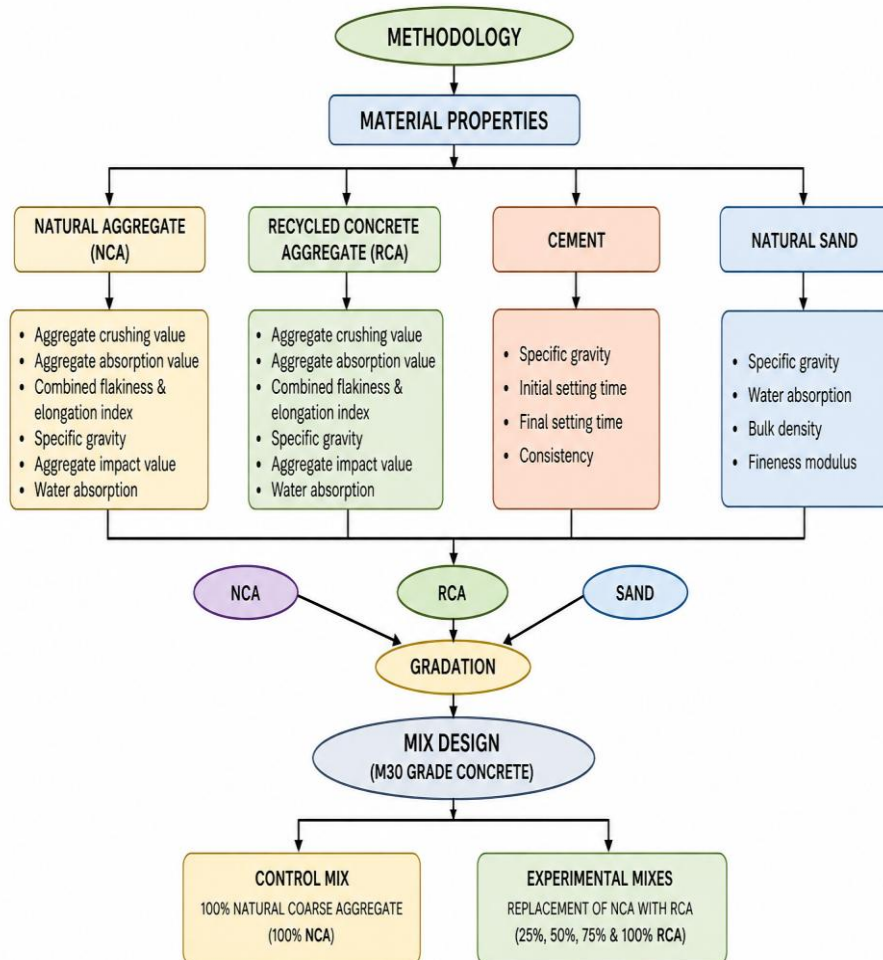
Material characterization was carried out to determine essential properties. Tests on natural and recycled aggregates included aggregate crushing value, impact value, water absorption, specific gravity, and flakiness and elongation index.

Cement was tested for specific gravity, consistency, and setting time, while fine aggregate was evaluated for specific gravity, water absorption, bulk density, and fineness modulus to ensure compliance with standard requirements.

Gradation analysis of aggregates was performed to obtain proper particle size distribution, followed by M30 mix design as per IS 10262 guidelines to achieve the desired strength and workability.

Concrete mixes were prepared with different replacement levels of natural coarse aggregate by recycled aggregate. Two primary mixes were considered: control mix with 100% natural coarse aggregate (NCA) and an experimental mix with 100% recycled concrete aggregate (RCA). Additional intermediate replacement levels (such as 25%, 50%, and 75%) may also be considered to study gradual performance variation.

Batching, mixing, casting, and compaction of concrete specimens were performed under controlled laboratory conditions. Standard cube specimens were cast and cured for 7, 14, and 28 days. After curing, tests such as compressive strength were conducted to evaluate the performance of each mix.



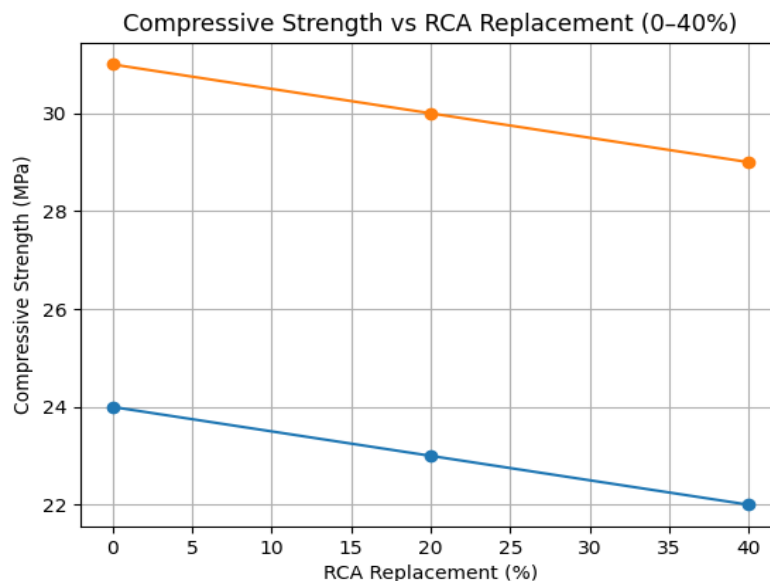
The results obtained were compared to assess the effect of recycled aggregate replacement on the mechanical properties of M30 concrete. This systematic methodology ensures a comprehensive evaluation of recycled aggregates as a sustainable alternative to natural aggregates in concrete production.

#### IV. DESIGN AND CONSTRUCTION PROCESS

This analysis evaluates the performance of M30 grade concrete with replacement of natural coarse aggregate (NCA) by recycled concrete aggregate (RCA) at 0%, 20%, and 40%. The results indicate that compressive strength remains close to target mean strength (~31 MPa) with only marginal reduction up to 20% replacement, while at 40% the strength drops but still remains within acceptable structural limits.

**Compressive Strength Results**

| RCA Replacement (%) | 7-Day Strength (MPa) | 28-Day Strength (Mpa) |
|---------------------|----------------------|-----------------------|
| 0%                  | 24                   | 31                    |
| 20%                 | 23                   | 30                    |
| 40%                 | 22                   | 29                    |

**Graphical Representation**

Discussion: The 28-day compressive strength for control mix is approximately 31 MPa. With 20% replacement, the strength remains close (around 30 MPa), showing only about 3% reduction, which is negligible. At 40% replacement, the strength reduces to around 29 MPa (~6–7% reduction), still acceptable for M30 grade applications. Thus, RCA can be safely used up to 20% with minimal impact and up to 40% with moderate but acceptable reduction in strength.

**V. RESULT AND CONCLUSION**

The present study evaluated the feasibility of replacing natural coarse aggregate (NCA) with recycled concrete aggregate (RCA) in M30 grade concrete at replacement levels of 0%, 20%, and 40%. The results indicate that recycled aggregates possess comparatively higher water absorption and slightly inferior mechanical properties due to the presence of adhered mortar. Despite these differences, the overall performance of concrete remains satisfactory within the investigated range.

The compressive strength of the control mix achieved approximately 31 MPa at 28 days. With 20% replacement of RCA, the strength showed only a marginal reduction (around 3%), indicating that such replacement has negligible impact on structural performance. At 40% replacement, the strength reduction was more noticeable (around 6–7%), yet the obtained values still satisfy the requirements of M30 grade concrete.

Based on the findings, it can be concluded that recycled aggregates can be effectively utilized up to 20% replacement without significant compromise in strength, while up to 40% replacement can also be adopted with acceptable performance for many structural applications. This approach contributes to sustainable construction by reducing dependence on natural resources and promoting the reuse of construction and demolition waste, thereby minimizing environmental impact.

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