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EXPERIMENTAL STUDY ON RECYCLED AGGREGATES CONCRETE USING WATER REDUCING ADMIXTURE

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Abstract: ***Today, the construction sector generates a significant volume of demolition waste as a result of ongoing reconstruction and redevelopment projects. Getting rid of this waste has turned into a significant environmental issue. Meanwhile, the use of natural aggregates in concrete is steadily declining due to extensive construction activities. To address these issues, Recycled Concrete Aggregates (RCA) can serve as a substitute for natural aggregates in concrete.***

For this project, recycled aggregate concrete was produced by substituting natural coarse aggregate with 0%, 25%, 50%, and 75% recycled aggregate. A water-reducing admixture was also incorporated to enhance workability and strength. Concrete cube specimens were subjected to compressive strength tests following 7 days of curing. The results of the experiment indicated that compressive strength declines with a higher percentage of recycled aggregate. Replacing 25% of the concrete with RCA yielded results nearly equivalent to normal concrete and outperformed the 50% and 75% replacement levels. This study demonstrates that recycled aggregate is suitable for use in concrete, supporting sustainable and environmentally friendly construction.

Keywords: *Recycled Concrete Aggregate(RCA),Recycled Concrete Aggregate(RCA),Water-Reducing Admixture, Sustainble Concrete, Compressive Strength, Workability,Green Concrete,Construction and Demolition*

I INTRODUCTION

Concrete is among the most crucial materials in the construction industry. Natural aggregates serve as the primary components in concrete, yet they are depleting daily due to accelerating urbanization and ongoing construction projects. Meanwhile, tearing down old buildings and structures generates a significant amount of concrete waste. Much of this waste ends up in landfills, leading to environmental pollution and disposal challenges. This problem can be addressed by crushing demolished concrete and reusing it as Recycled Concrete Aggregate (RCA). RCA contributes to lowering environmental pollution and preserving natural resources. However, recycled aggregates absorb more water due to adhered old mortar, which can impact the strength and workability of concrete. In this project, recycled aggregate was incorporated at varying percentages alongside a water-reducing admixture to investigate its impact on the mechanical properties and workability of concrete mixes.

II PHYSICAL PROPERTIES OF MATERIALS & METHODOLOGY

To establish a thorough comparative baseline, the physical and engineering properties of both standard and recycled materials were tested in accordance with relevant Indian Standard codes (IS 2386).

Table 1: Physical Properties of Aggregates and Cement

PROPERTY / TEST TYPE	CEMENT (OPC 53)	FINE AGGREGATE (CRUSHED SAND)	NATURAL COARSE AGGREGATE (20MM)	RECYCLED CONCRETE AGGREGATE (RCA)
Specific Gravity	3.15	2.62	2.74	2.42
Water Absorption (%)	--	1.80%	0.65%	4.85%
Fineness Modulus	--	2.85	7.12	6.95
Crushing Value (%)	--	--	18.5%	24.2%
Impact Value (%)	--	--	14.2%	19.8%

2.1 ROLE OF WATER REDUCING ADMIXTURE

The water-reducing admixture is essential in recycled aggregate concrete, as RCA absorbs more water than natural aggregate due to its porous structure and the presence of old mortar matrix. The chemical admixture enhances workability without raising the total water content, promoting optimal mixing, flow, and compaction of the fresh concrete. It also helps reduce the net water requirement, which supports maintaining a lower water-cement ratio and enhances the final compressive strength. Moreover, the admixture improves the bonding in the interfacial transition zone (ITZ) between the fresh cement paste and the recycled aggregate particles, reducing segregation and bleeding to form a compact, long-lasting concrete structure.

2.2 MIX PROPORTIONS

Table 2: Mix Design Proportions for Concrete Series

MIX DESIGNATION	CEMENT (KG)	SAND (KG)	NATURAL AGGREGATE (KG)	RCA (KG)	WATER (L)	ADMIXTURE (ML)
Normal Concrete (0% RCA)	7.00	10.50	21.00	0.00	3.15	35.00
25% RCA Replacement	7.00	10.50	15.75	5.25	3.15	35.00
50% RCA Replacement	5.25	7.87	7.88	7.88	2.36	26.25
75% RCA Replacement	5.25	7.87	5.25	15.75	2.36	26.25

2.3 FRESH CONCRETE PROPERTIES (WORKABILITY)

Workability tests were measured through standard Slump Cone measurements to evaluate the performance of fresh concrete incorporating chemical plasticizers and porous RCA particles.

Table 3: Fresh Concrete Slump Test Results

MIX SERIES DESIGNATION	RCA REPLACEMENT (%)	WATER-CEMENT (W/C) RATIO	ADMIXTURE DOSAGE (%)	MEASURED SLUMP VALUE (MM)	WORKABILITY DESCRIPTION
Control Mix	0%	0.45	0.5%	95 mm	Medium-High (Good Flow)
RCA-25	25%	0.45	0.5%	80 mm	Medium (Satisfactory)
RCA-50	50%	0.45	0.5%	65 mm	Low-Medium (Stiff)
RCA-75	75%	0.45	0.5%	45 mm	Low (Very Stiff)

2.4 COMPRESSIVE STRENGTH EVALUATION

The 150 mm cube specimens were tested for compressive strength right after the 7-day curing period, using a digital Compressive Testing Machine (CTM), following established testing standards. The ultimate compressive strength was calculated using the classical formula:

$$fc = P / A$$

III EXPERIMENTAL TEST RESULTS

Table 4: 7-Day Mechanical Testing and Compressive Strength

MIX SERIES	SPECIMEN 1 (KN)	SPECIMEN 2 (KN)	SPECIMEN 3 (KN)	AVERAGE FAILURE LOAD (KN)	COMPRESSIVE STRENGTH (MPA)
0% RCA (Control)	720.0	705.0	715.0	713.3	**31.70**
25% RCA	529.0	515.0	504.0	516.0	**22.93**
50% RCA	271.0	226.0	290.0	263.3	**11.70**
75% RCA	141.0	136.0	171.0	149.3	**6.64**

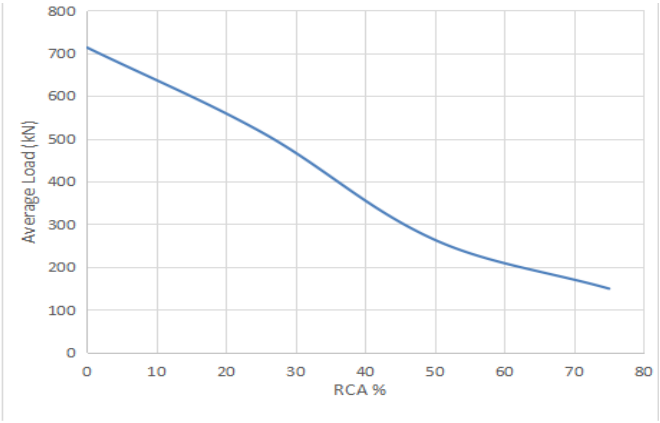
Compressive Strength Test Results (7-Day Curing)

A compressive strength test was performed on concrete cube samples cured for seven days to assess how Recycled Concrete Aggregate (RCA) influences the strength properties of concrete. As shown in Table 1, compressive strength declines gradually as the percentage of RCA replacement increases. The control mix with 0% RCA showed the highest average failure load of 713.3 kN and a compressive strength of 31.70 MPa. Upon incorporation of 25% RCA, the average failure load dropped to 516.0 kN, yielding a compressive strength of 22.93 MPa. Replacing natural aggregate with 50% RCA further lowered the average failure load to 263.3 kN and the compressive strength to 11.70 MPa. The concrete mix containing 75% RCA showed the lowest average failure load at 149.3 kN and a compressive strength of 6.64 MPa. The decrease in strength is due to increased water absorption, reduced density, and the presence of residual mortar on

recycled aggregates, all of which negatively impact the bond between the cement paste and aggregate particles. While the water-reducing admixture enhanced mix workability, higher RCA replacement levels led to a notable decrease in compressive strength. The results show that RCA can be used effectively even at lower replacement rates, but higher replacement levels may significantly weaken the strength of concrete.

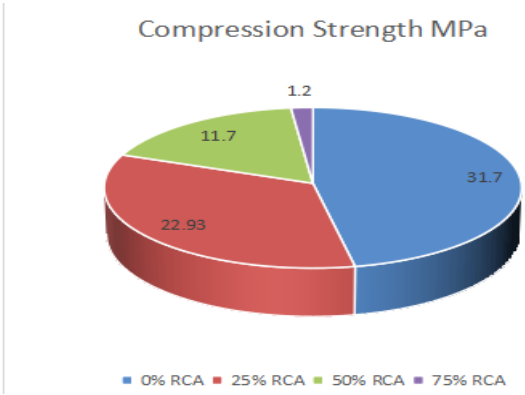
Figure 1: Load Testing via Digital Compression Testing Machine (CTM)

The compressive strength of concrete specimens was tested on day seven of curing to assess the concrete's early-age strength development. The specimens were taken out of the curing tank and subjected to testing via a Compression Testing Machine (CTM), following applicable IS standards. The maximum load at failure was measured, and the compressive strength was determined for each specimen. The results were employed to evaluate how recycled aggregates and water-reducing admixture affect the strength properties of concrete.



Graph 1: Workability Slump Curve across alternative RCA blending stages

Graph 1 illustrates how replacing conventional aggregate with Recycled Concrete Aggregate (RCA) affects the average load-carrying capacity of concrete samples. The findings show that as RCA content rises, the average load declines consistently. The control mix with 0% RCA attained the highest average load of roughly 710 kN. When RCA substitution reached 25%, the average load dropped to around 520 kN. Additional increments in RCA contentup to 37.5%, 50%, 60%, and 75%led to average loads of approximately 380 kN, 265 kN, 205 kN, and 150 kN, respectively. This decrease in load-carrying capacity is due to the presence of adhered mortar, greater water absorption, and higher porosity in recycled aggregates, all of which impair the bond between the aggregate and cement paste. Nevertheless, adding a water-reducing admixture helped preserve the workability and overall performance of the concrete mixes. The results indicate that lower to moderate RCA substitution can be effectively utilized in concrete manufacturing, but higher replacement rates may cause notable declines in strength and load-bearing ability.



Graph 2: 7-Day Concrete Compressive Strength Comparison (MPa)

Graph 2 shows the compressive strength of concrete samples made with varying percentages of Recycled Concrete Aggregate (RCA). The findings show that compressive strength declines with a higher percentage of RCA. The control mix containing 0% RCA attained the highest compressive strength at 31.7 MPa, highlighting the better performance of natural aggregates. Using 25% RCA resulted in a compressive strength of 22.93 MPa, showing a moderate decline in strength. Replacing with 50% RCA yielded a compressive strength of 11.7 MPa, whereas the mix with 75% RCA showed the weakest strength at 1.2 MPa. This reduction in compressive strength is due to increased porosity, reduced density, and the presence of adhered mortar on recycled aggregates, all of which impair the bond between the aggregate and the cement matrix. While adding a water-reducing admixture enhanced the concrete's workability, it did not fully offset the strength loss that occurred at higher RCA replacement rates. The findings indicate that concrete production can accommodate lower percentages of RCA without compromising strength, but higher substitution levels noticeably reduce compressive strength.

3.1 DOCUMENTED SITE PHOTOGRAPHS

Figure 2: Recycled Aggregate Processing Plant, Pimpri-Chinchwad, Pune

Figure 3: Casting of 150mm x 150mm x 150mm Concrete Cube Specimens

3.2 RESULT ANALYSIS AND DISCUSSION

The analysis reveals a distinct negative correlation between the proportion of recycled concrete aggregate (RCA) and the compressive strength of concrete. The control concrete with 0% RCA attained the highest compressive strength of 31.70 MPa because natural aggregates offer better quality, greater density, and stronger bonding properties. The concrete mix with 25% RCA achieved a compressive strength of 22.93 MPa, showing that a moderate substitution of natural aggregate can still deliver adequate mechanical performance for many structural and non-structural uses.

When the RCA replacement level rose to 50%, the compressive strength dropped sharply to 11.70 MPa. This decrease is due to the greater amount of old, adhered mortar on the recycled aggregates, leading to increased porosity and water absorption. The recycled aggregates have a rough and uneven surface, which impairs the bond between the aggregate particles and the cement paste, ultimately lowering the concrete's overall strength. A compressive strength of 6.64 MPa, the lowest recorded, was observed when 75% of the original aggregate was replaced with RCA. At this replacement level, the concrete matrix had a greater volume of weak interfacial transition zones (ITZs), leading to lower load transfer efficiency and earlier failure under compression. The higher porosity and micro-cracking in the recycled aggregate particles additionally led to the decline in mechanical properties.

A decline in strength exceeding 50% RCA substitution is closely linked to the lower specific gravity and increased water absorption of recycled aggregates. These characteristics result in a less dense concrete structure with more internal voids, thereby reducing its durability and strength. Nevertheless, adding a water-reducing admixture enhanced the workability of all concrete mixes and helped ensure proper compaction during casting. The admixture lowered the mix's water requirement and improved the dispersion of cement particles, leading to better consistency and cohesion.

The slump test showed that workability remained acceptable even with the higher RCA content. Ensuring proper workability led to consistent placement and reduced segregation, both critical for attaining dependable strength gain. While the admixture mitigated certain negative effects of RCA, it was inadequate to fully counteract the strength loss at higher replacement rates.

The experimental findings indicate that RCA replacement levels up to 25% offer a practical compromise between sustainability and mechanical performance. Greater replacement rates could be appropriate for low-strength uses, pavements, and non-load-bearing components where lower compressive strength is tolerable. The study shows that using recycled concrete aggregatewhen paired with appropriate admixturescan support sustainable construction by cutting down on construction waste and preserving natural aggregate supplies.

IV CONCLUSION

This study's findings indicate that recycled concrete aggregate (RCA) can serve as a partial substitute for natural coarse aggregates, especially when used alongside a water-reducing admixture. However, as the percentage of RCA increased, the compressive strength of concrete decreased. The control mix demonstrated the greatest strength, whereas the mixes with RCA showed comparatively lower values. Of all the replacement levels tested, the concrete containing 25% RCA performed best, demonstrating strong strength and performance comparable to traditional concrete. In contrast, higher replacement levels of 50% and 75% RCA led to a notable decrease in strength, rendering these mixes better suited for non-structural uses rather than load-bearing components. Using the water-reducing admixture enhanced the workability of the concrete mix and contributed to improved compaction during casting. The study shows that a moderate level of RCA can be effectively

incorporated into concrete production, aiding in waste management while also lowering the use of natural aggregates.

REFERENCES

"Sustainable Use of Recycled Aggregate in Concrete," International Journal of Innovations in Engineering Research and Technology (IJIERT), 2023.

"An Investigation Analysis on Recycled Aggregate Concrete Using PP Fibers," IJSRD Journal, 2022.

Bureau of Indian Standards, IS 456:2000 - Plain and Reinforced Concrete — Code of Practice, New Delhi, India.

Bureau of Indian Standards, IS 10262:2019 - Concrete Mix Proportioning — Guidelines, New Delhi, India.

M. S. Shetty, Concrete Technology: Theory and Practice, S. Chand Publications, New Delhi.