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Optimization of Alccofine-1203 Modified Recycled Aggregate Concrete for Sustainable Concrete in Construction

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Abstract: *The increasing use of natural aggregates and Portland cement in concrete production raises significant environmental concerns due to resource depletion, high energy consumption, and construction and demolition waste generation. This study investigates the combined use of recycled coarse aggregate (RCA) and Alccofine-1203 in sustainable M30-grade concrete. Natural coarse aggregate was replaced by 30% RCA, while cement was partially replaced with Alccofine-1203 at 0%, 5%, 10%, and 15%. Conventional M30 concrete was used as the control mix.*
The experimental programme evaluated slump, density, compressive strength, split tensile strength, flexural strength, water absorption, and sorptivity. The results showed that 30% RCA reduced the mechanical strength and increased water absorption and sorptivity compared with conventional concrete. However, incorporating Alccofine-1203 significantly improved the performance of RCA concrete up to an optimum replacement level.
The mix containing 30% RCA and 10% Alccofine-1203 (RAC-A10) achieved the best overall performance, with a 28-day compressive strength of 44.44 MPa, split tensile strength of 4.08 MPa, and flexural strength of 5.78 MPa. It also exhibited the lowest water absorption of 4.35% and sorptivity of 0.094 mm/min½ among the investigated mixes. The improved performance is attributed to the ultrafine particle packing and secondary hydration reactions of Alccofine-1203, which refine the pore structure, reduce capillary porosity, and strengthen the interfacial transition zone. The study demonstrates that replacing natural aggregate with 30% RCA and cement with 10% Alccofine-1203 can produce sustainable structural concrete with improved mechanical and durability properties

Key Words: *Recycled aggregate concrete, Alccofine-1203, sustainable concrete, compressive strength, sorptivity, water absorption*

1. INTRODUCTION

Concrete is the most widely used construction material because of its availability, versatility, durability and ability to accommodate a wide range of structural applications. However, conventional concrete production requires substantial quantities of Portland cement and natural aggregates. The extraction of natural aggregates contributes to depletion of finite resources, landscape degradation and environmental disturbances, while cement manufacture is associated with considerable energy consumption and greenhouse-gas emissions.

Environmental sustainability has become a major concern in the construction industry due to the extensive consumption of natural resources and the large quantities of waste generated during construction activities. These impacts can occur throughout the entire life cycle of construction projects, creating significant environmental challenges. Despite various efforts, effective management of construction and demolition waste remains difficult to achieve. The reuse and recycling of construction materials offer promising solutions for addressing these challenges by reducing the demand for natural resources, minimizing waste generation. adopting sustainable practices based on material recovery, reuse, and recycling can contribute significantly to improving waste management.

Supplementary cementitious materials provide another route toward sustainable concrete production. Alccofine-1203 is an ultrafine supplementary cementitious material with high fineness and high reactivity. Previous investigations have reported beneficial mechanical and durability performance from Alccofine-containing concrete, with several studies identifying replacement levels around 10–15% as effective depending on the concrete system.

The combination of recycled aggregate and Alccofine-1203 is particularly attractive because the weaknesses introduced by recycled aggregate may potentially be compensated for by the pore-refining and particle-packing effects of Alccofine. Earlier research has investigated recycled aggregate together with Alccofine, but the combined optimization of a fixed 30% recycled coarse aggregate replacement with different Alccofine-1203 contents for M30 concrete

1.1 Concept of Recycled Aggregate in Concrete

The rapid growth of the construction industry has resulted in extensive consumption of natural aggregates and a corresponding increase in construction and demolition (C&D) waste. Conventional disposal of concrete waste in landfills occupies valuable land resources and can cause environmental problems. Recycled coarse aggregate (RCA) is primarily obtained by crushing, screening, and processing waste concrete from demolished structures, pavements, and other construction activities. In sustainable concrete technology, RCA is commonly introduced at partial replacement levels rather than completely replacing natural aggregate. The optimum replacement level depends on the quality of RCA, source concrete, processing method, aggregate properties, water-to-binder ratio, and mix design. Thus, recycled aggregate concrete represents an important approach toward developing resource-efficient and environmentally sustainable construction materials. Its effective utilization can reduce dependence on natural aggregates, divert C&D waste from landfills, conserve natural resources, and support circular-economy principles in the construction sector.

1.2 Construction and Demolition (C&D) Waste Scenario in Andhra Pradesh

Andhra Pradesh is experiencing rapid urbanization, infrastructure development, road construction, housing projects, and redevelopment activities, which have contributed to an increasing generation of construction and demolition (C&D) waste. Major urban centres such as Visakhapatnam, Vijayawada, Guntur, Tirupati, and Nellore are witnessing considerable construction activity, resulting in increased quantities of concrete debris, bricks, mortar, soil, asphalt, and other construction materials. The implementation of the Construction and Demolition Waste Management Rules, 2016 provides a regulatory framework for the collection, transportation, processing, recycling, and reuse of C&D waste in India. For Andhra Pradesh, strengthening decentralized collection and processing facilities, particularly around rapidly developing urban areas, can improve the recovery of reusable construction materials

1.3 Necessity of the Project

The rapid growth of construction activities has increased the consumption of natural aggregates and Portland cement, while simultaneously generating large quantities of construction and demolition (C&D) waste. Conventional disposal of this waste creates environmental problems and places additional pressure on landfill facilities and natural resources. Therefore, effective utilization of C&D waste in concrete is essential for promoting sustainable construction practices.
Recycled coarse aggregate (RCA) obtained from processed concrete waste provides a potential alternative to natural coarse aggregate. However, the use of RCA can adversely affect concrete performance because of its higher water absorption, adhered mortar, surface roughness, and weaker interfacial transition zone. The project is necessary to investigate the combined use of recycled coarse aggregate and Alccofine-1203 in M30-grade concrete and to identify an optimum combination that provides satisfactory mechanical and durability performance. The study can contribute to reducing C&D waste, conserving natural aggregates, lowering cement consumption, and promoting environmentally sustainable and resource-efficient concrete technology.

2. LITERATURE REVIEW

2.1 Literature Survey on Recycled Aggregate Concrete

1. Oikonomopoulou et al. (2022) investigated the effect of mechanically treated recycled aggregates on the long-term mechanical and durability properties of concrete. The treatment reduced adhered mortar on RCA and resulted in improved long-term compressive strength, while also reducing shrinkage and mass loss compared with untreated recycled aggregate concrete.
2. Mathur et al. (2023) experimentally investigated the use of recycled coarse aggregate (RCA) in M30-grade concrete as a partial replacement for natural coarse aggregate. Their study demonstrated the feasibility of utilizing processed construction and demolition waste for producing sustainable concrete and highlighted the potential of RCA to reduce the environmental impact associated with natural aggregate consumption.
3. Sharma et al. (2024) developed low-carbon recycled aggregate concrete using carbonation-treated recycled aggregates and Alccofine. The study investigated the combined effect of recycled aggregate treatment and Alccofine on concrete performance and demonstrated the potential of this approach for producing low-carbon and environmentally friendly concrete

2.2 Literature Survey on Alccofine-1203

1. Sagar and Sivakumar (2022) reviewed the application of Alccofine-1203 as a supplementary cementitious material in concrete. Their study reported that the ultrafine nature and high reactivity of Alccofine can enhance hydration, early-

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age strength, permeability resistance, and durability. The authors identified approximately 8–12% replacement as a promising range for improving concrete performance.
2. Kumaar et al. (2023) experimentally investigated the influence of Alccofine-1203 in M30-grade concrete, focusing on its mechanical and durability characteristics. The study reported that Alccofine improved compressive strength and reduced water absorption by enhancing particle packing and refining the pore structure. The highest compressive strength was obtained at 15% Alccofine replacement, demonstrating its potential as a supplementary cementitious material.
3. Mani et al. (2024) investigated the use of Alccofine-1203 as a sustainable supplementary cementitious material for printable concrete. Cement was partially replaced with 2%, 4%, 6%, 8%, and 10% Alccofine-1203. The study reported improvements in workability and mechanical performance, with notable flowability at 6% replacement. The authors highlighted the potential of Alccofine-1203 for reducing cement consumption in advanced sustainable concrete applications.
4. Hanumesh et al. (2025) experimentally evaluated different Alccofine-1203 replacement ratios in M20 concrete, using 5%, 10%, and 15% replacement levels. The study focused on the effect of Alccofine on the mechanical properties of concrete and demonstrated its potential to optimize conventional concrete through partial cement replacement.

2.3 Research Gap

1. Limited combined investigation: Most existing studies look at coarse aggregate (RCA) and Alccofine-1203 separately. Little research has examined how RCA and Alccofine-1203 together affect concrete.
2. Lack of optimum replacement level: The best Alccofine-1203 amount that improves 30 % RCA concrete performance is not well known, for M30-grade concrete.
3. Insufficient durability assessment: Prior studies mainly focus on strength. Few studies evaluate water absorption and sorptivity of RCA–Alccofine concrete.
4. Limited comprehensive performance evaluation: The joint effect of RCA and Alccofine-1203 on split tensile and flexural strengths needs more systematic study at different Alccofine replacement levels.
5. Need for structural concrete: More research is needed to create an optimized mix that uses C&D waste cuts aggregate and Portland cement use and still keeps solid mechanical and durability performance.

The present research addresses these gaps by experimentally investigating M30-grade recycled aggregate concrete containing 30% RCA and 0%, 5%, 10%, and 15% Alccofine-1203 as partial cement replacement. The study evaluates fresh properties, density, compressive strength, split tensile strength, flexural strength, water absorption, and sorptivity to identify the optimum Alccofine-1203 replacement level and assess its potential for producing sustainable structural concrete.

3. OBJECTIVES

1. To develop M30-grade recycled aggregate concrete containing 30% recycled coarse aggregate.
2. To investigate the influence of 5%, 10% and 15% Alccofine-1203 replacement of cement.
3. To evaluate the effect of Alccofine-1203 on workability and density.
4. To determine compressive, split tensile and flexural strengths.
5. To evaluate water absorption and sorptivity.
6. To identify the optimum Alccofine-1203 replacement level for 30% RCA concrete.
7. To assess the potential of the optimized mix as a sustainable green concrete.

4. MATERIALS & METHODOLOGY

4.1 Materials

Cement: Ordinary Portland cement was considered as the primary binder for producing the M30 concrete. The cement should be characterized for specific gravity, standard consistency, initial and final setting times and fineness before concrete production.

Alccofine-1203: Alccofine-1203 was used as a partial replacement for cement. It is an ultrafine supplementary cementitious material. Its very fine particle size provides a filler effect and can improve particle packing and the microstructure of hardened concrete. For the present study, Alccofine-1203 replacement levels were selected as 0%, 5%, 10% and 15% by weight of the cementitious binder.

Fine Aggregate: Natural fine aggregate conforming to the applicable requirements for concrete production was used. The material should be tested for specific gravity, water absorption, fineness modulus and grading before mix preparation

Natural Coarse Aggregate: Crushed natural coarse aggregate of nominal maximum size 20 mm was used as the conventional coarse aggregate.

Recycled Coarse Aggregate: Recycled coarse aggregate was obtained from processed concrete construction and demolition waste. The recycled aggregate was cleaned to remove unwanted materials and graded before use. Important characteristics such as specific gravity, water absorption, aggregate impact value, crushing value and particle-size distribution should be determined. The recycled coarse aggregate replaced 30% of the total natural coarse aggregate by weight in the recycled aggregate concrete mixtures.

Water: Potable water suitable for concrete production and curing was used.

Fig-1: Ingredients of concrete

4.2 Preliminary Test Results of materials

Table-1: Test Results of Cement

S.No	Characteristics	IS Code	Test results	IS:12269-1897 specifications
01	Fineness (IS sieve No: 90 µm)	IS 4031 (Part 1): 1988	3.0 %	<10%
02	Consistency	IS 4031 (Part 5): 1988	28 %	-
03	Initial setting time (minutes)	IS 4031 (Part 5): 1988	35min	>30 minutes
04	Final setting time (minutes)		230min	<600 minutes
05	Specific gravity	IS 4031 (Part 4): 1988	3.14	3.15

Table-2: Test Results of Fine Aggregate

S.No	Property	Test results	IS:2386-1963 Specifications
01	Fineness modulus	2.70	-
02	Specific gravity	2.60	2.6 – 2.8
03	Water absorption	0.69 %	-
04	Bulk density	1475kg/m³(untraded)	-
		1624kg/m³(ridded)	-

Table-3: Test Results of Coarse Aggregate

S.No	Property	Test results	IS:2386-1963 Specifications
01	Fineness modulus	3.53	-
02	Specific gravity	2.7	2.6-2.8
	Water Absorption (%)	0.80 %	< 5.0
03	Abrasion test	34%	40%
04	Crushing value	22%	<30%
05	Bulk density	1483kg/m³(untraded)	-
		1563kg/m³(ridded)	-

Table-4: Test Results of Recycled Coarse Aggregate

S.No	Property	Test results	IS:2386-1963 Specifications
01	Fineness modulus	7.19	-
02	Specific gravity	2.65	2.6-2.8
	Water Absorption (%)	6.0 %	< 8.0
03	Impact Test	27 %	< 40%
04	Crushing value	26 %	< 30%
05	Bulk density	1483 kg/m³(untraded)	-
		1563kg/m³(ridded)	-

4.3 Mix Design (M30)

The mix design was developed considering the requirements of IS 10262:2019 for concrete mix proportioning. IS 10262:2019 provides guidelines for proportioning concrete to achieve specified strength, workability and durability requirements.

Target Mean Strength f′ck = fck + 1.65S

Assuming S = 5 N/mm²:, f′ck = 30 + (1.65 × 5) = 38.25 N/mm², target mean strength = 38.25 N/mm².

Water-Cementitious Material Ratio, Water = 180 kg/m³, Total cementitious material = 400 kg/m³

W/C = 180 / 400 = 0.45 Mix Propotion 1: 1.83: 2.86

The concrete was designed for M30 grade. The experimental programme consisted of a conventional control concrete and recycled aggregate concrete containing 30% RCA. Alccofine-1203 was subsequently introduced as a partial replacement for cement.

Table-5: Proposed mix designation

S.No	Mix ID	Alccofine-1203	RCA	Description
1	CC	0%	0%	Conventional M30 concrete
2	RAC-30%	0%	30%	M30 concrete with 30% RCA
3	RAC-A5%	5%	30%	30% RCA + 5% Alccofine
4	RAC-A10%	10%	30%	30% RCA + 10% Alccofine
5	RAC-A15%	15%	30%	30% RCA + 15% Alccofine

Table-6: Preliminary quantities of materials per M³

S. No	Mix ID	Cement (kg/m³)	Alccofine (kg/m³)	Water (kg/m³)	Fine Aggregate (kg/m³)	Natural CA (kg/m³)	RCA (kg/m³)
1	CC	400	0	180	713	1071	0
2	RAC-30%	400	0	180	713	750	321
3	RAC-A5%	380	20	180	713	750	321
4	RAC-A10%	360	40	180	712	750	321
5	RAC-A15%	340	60	180	712	750	321

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4.4 Preparation of Test Specimens

Batching: The required quantities of cement, aggregates, recycled coarse aggregate, mineral admixtures, and other additives were accurately measured by weight according to the designed mix proportions. All materials were carefully checked and proportioned to maintain consistency and accuracy between different concrete mixes.

Mixing: The batched materials were mixed thoroughly in a mechanical mixer to obtain a uniform and homogeneous concrete mixture. Water were added gradually during mixing to achieve the required workability and ensure proper dispersion of all constituents.

Casting: The fresh concrete was placed into properly cleaned and oiled moulds in layers, with each layer compacted adequately to eliminate entrapped air. The specimens were finished smoothly at the top surface and kept undisturbed for approximately 24 hours.

Curing: After demoulding, the specimens were subjected to the specified curing regime until the respective testing ages. For self-curing specimens, the concrete was maintained under ambient conditions to evaluate its strength and durability performance without conventional water curing.

Fig-2: Batching, Mixing, Casting Curing of Test Specimens

5. EXPERIMENTAL PROGRAM

The experimental programme was divided into fresh concrete, mechanical strength and durability-related investigations

5.1. Fresh Concrete

Slump Test: The slump test was conducted to assess the workability of fresh concrete. The reduction in slump with increasing Alccofine content is generally associated with the high fineness and increased surface area of the ultrafine particles

Table-7: Test Results of Slump Cone

S. No	Mix ID	Slump (mm)	Workability
1	CC	98	Good
2	RAC-30 %	95	Good
3	RAC-A5 %	90	Good
4	RAC-A10 %	85	Good
5	RAC-A15 %	78	Satisfactory

Fig-3: Slump Cone Test

5.2. Hardened Concrete

Density: The density of hardened concrete specimens was determined to assess the effect of RCA and Alccofine-1203 on unit mass

Table-8: Density Test Results

S. No	Mix ID	Fresh Density (kg/m³)
1	CC	2400
2	RAC-30 %	2395
3	RAC-A5 %	2400
4	RAC-A10 %	2450
5	RAC-A15 %	2390

Compressive Strength

The compressive strength of concrete specimens was determined using a compression testing machine in accordance with IS 516. The cube specimens were placed centrally between the loading plates and subjected to a gradually increasing compressive load until failure occurred. The compressive strength was calculated by dividing the maximum load at failure by the loaded cross-sectional area of the specimen and expressed in MPa (N/mm²). 150 mm × 150 mm × 150 mm concrete cubes were cast for compressive strength testing. The specimens were demoulded after approximately 24 h and cured in water. Compressive strength was evaluated at 7, 14 and 28 days.

Fig-4: Compressive Strength Test

Table-9: Compressive Strength Test Results

S. No	Mix ID	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
1	CC	22.8	28.4	38.50
2	RAC-30 %	24.2	30.4	40.12
3	RAC-A5 %	25.6	32.0	42.55
4	RAC-A10 %	27.0	33.8	44.44
5	RAC-A15 %	26.3	33.0	39.5

Split Tensile Strength

Cylindrical specimens (150 mm*300 mm) were used for determining split tensile strength at 28 days. The test provides an indication of the tensile resistance of the concrete.

Table-10: Split Tensile Strength Test Results

Fig-5: Split Tensile Strength Test

S. No	Mix ID	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
1	CC	2.35	2.82	3.55
2	RAC-30 %	2.42	2.91	3.68
3	RAC-A5 %	2.52	3.03	3.88
4	RAC-A10 %	2.68	3.22	4.08
5	RAC-A15 %	2.58	3.10	3.76

Flexural Strength

Beam specimens were tested at 28 days to determine flexural strength. The test evaluates the resistance of concrete to bending stresses and provides complementary information to compressive and split tensile strength.

Table-11: Flexural Strength Test Results

Fig-6: Flexural Strength Test

S. No	Mix ID	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
1	CC	3.95	4.55	5.20
2	RAC-30 %	4.02	4.65	5.35
3	RAC-A5 %	4.15	4.82	5.55
4	RAC-A10 %	4.32	5.02	5.78
5	RAC-A15 %	4.20	4.88	5.48

5.3. Durabilité Tests

Water Absorption

Water absorption was evaluated after curing to assess the accessible pore structure and permeability-related behavior of the concrete.

Sorptivity

Sorptivity was evaluated to quantify the rate of capillary suction of water into the concrete. Lower sorptivity indicates lower capillary water uptake and generally reflects a more refined and less connected pore system

Table-12: Water absorption Test Results

S. No	Mix ID	Water Absorption (%)
1	CC	4.82
2	RAC-30 %	5.36
3	RAC-A5 %	4.91
4	RAC-A10 %	4.35
5	RAC-A15 %	4.62

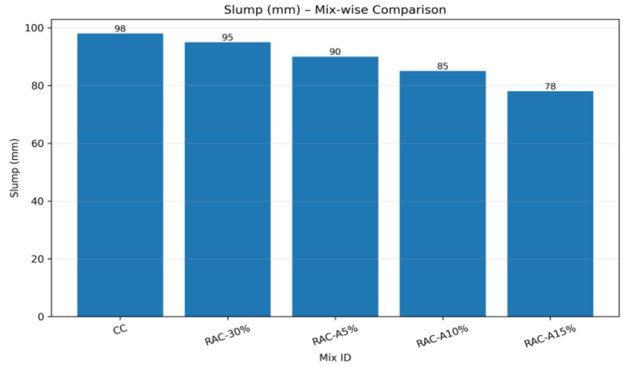
Table-13: Sorptivity Test Results

S. No	Mix ID	Sorptivity (mm/√min)
1	CC	0.105
2	RAC-30 %	0.119
3	RAC-A5 %	0.108
4	RAC-A10 %	0.094
5	RAC-A15 %	0.101

6. RESULT ANALYSIS

Slump Cone: This shows that when recycled aggregate and admixture are added the fresh concrete becomes harder to work with. However the RAC-A5% and RAC-A10% mixes still have workability while RAC-A15% has much less workability

Fresh density: Fresh density is between 2390 and 2450 kg/m³. RAC-A10% gives the density of 2450 kg/m³ about 2.08% more than CC



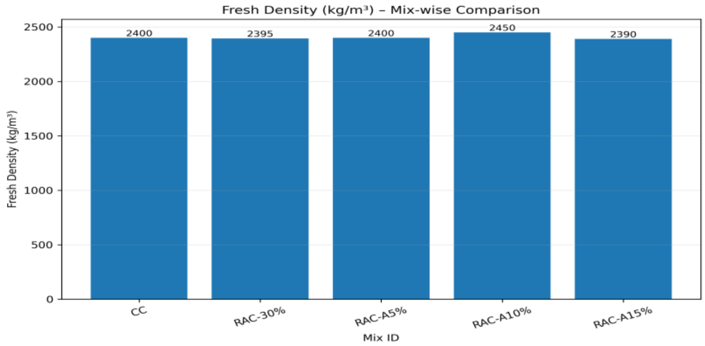


Fig-7: R A Graph of Slump Cone Test Result

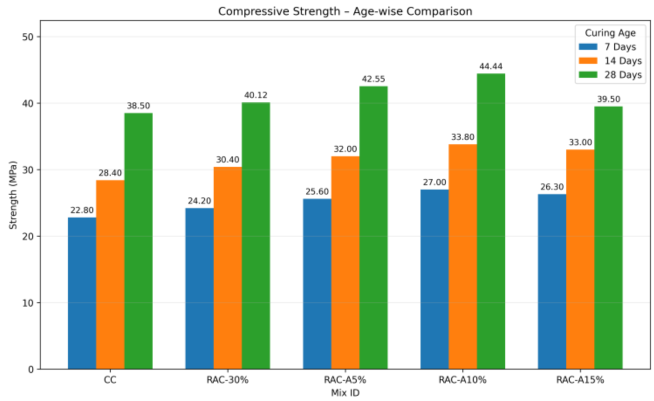
Fig-8: R A Graph of Density Test Result

Compressive Strength Test: The use of Alccofine led to an improvement. RAC-A5 reached 42.55 MPa after 28 days. Rac-A10 got the highest compressive strength of 44.44 MPa. Compared to CC RAC-A10 had a rise of about 15.43% after 28 days. This improvement comes from the small particles of Alccofine filling spaces and its strong ability to react which helps create more C-S-H gel.

Split Tensile Strength Test: Adding Alccofine also made the tensile strength better. RAC-A5 had 3.88 MPa and RAC-A10 had the result of 4.08 MPa after 28 days. Compared to CC this is a gain of 14.93%.

Flexural Strength test: RAC-A5 had 5.55 MPa and RAC-A10 had the flexural strength of 5.78 MPa after 28 days. This is an increase of about 11.15% compared to CC.

Water absorption: When Alccofine was added water absorption dropped a lot. RAC-A5 had 4.91%. Rac-A10 had the lowest water absorption of 4.35%.Compared to RAC-30 RAC-A10 had a reduction in water absorption of about 18.84%. This drop shows a change in the way the tiny spaces are structured because of Alccofine.



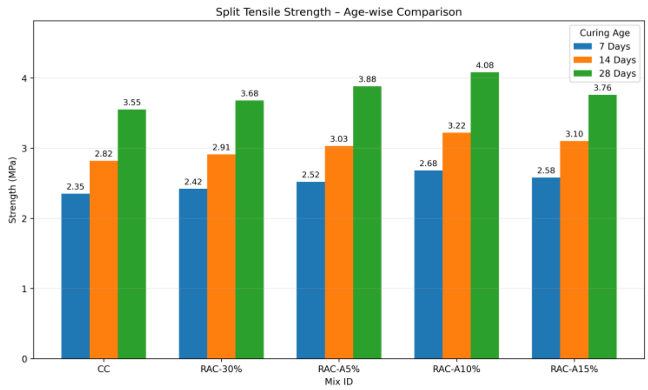
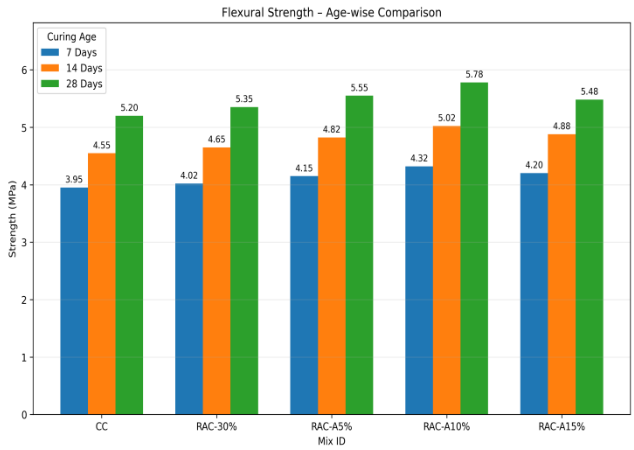


Fig-7: R A Graph of Compressive Strength Test

Fig-8: R A Graph of Split Tensile Strength Test



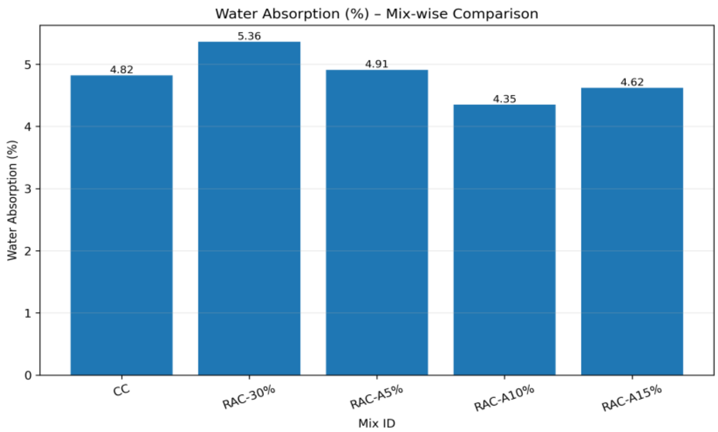


Fig-9: R A Graph of Flexural Strength Test

Fig-10: R A Graph of Water absorption Test

7. CONCLUSION :

Workability – Slump: The slump goes down slowly from 98 mm for CC to 78 mm for RAC-A15%. This shows that when recycled aggregate and admixture are added the fresh concrete becomes harder to work with. However the RAC-A5% and RAC-A10% mixes still have workability while RAC-A15% has much less workability.

Fresh density: Fresh density is between 2390 and 2450 kg/m³. RAC-A10% gives the density of 2450 kg/m³ about 2.08% more than CC. The change is small which means that adding the modified recycled aggregate system does not change the density of concrete a lot.

Compressive strength Compressive strength keeps going up until RAC-A10% at all curing times. The highest 28-day strength is 44.44 MPa, compared to 38.50 MPa for CC. This is an increase of about 15.43%. When the replacement is 15% the strength drops to 39.50 MPa. This means that 10% is the level within the range that was tested.

Split tensile strength: The 28-day split tensile strength goes up from 3.55 MPa for CC to 4.08 MPa for RAC-A10%, which's an increase of about 14.93%. Then it goes down to 3.76 MPa at RAC-A15% following the pattern as compressive strength.

Flexural strength: Flexural strength also goes up as the replacement increases up to RAC-A10%. The 28-day value increases from 5.20 MPa to 5.78 MPa, which's an increase of about 11.15%. At RAC-A15% the value goes down to 5.48 MPa.

Water absorption: Water absorption is the highest for RAC-30% at 5.36%. It drops a lot at higher optimized replacement levels. RAC-A10% has the value at 4.35%, which is 9.75% less than CC. Less water absorption means resistance to water and a much denser internal structure.

Sorptivity: Sorptivity is similar. CC has a sorptivity of 0.105 mm/√min while RAC-A10% has the value of 0.094 mm/√min. This is a drop of 10.48%. This means less water is drawn into the concrete at the replacement level.

Overall conclusion

The results show that RAC-A10% is the best. At this level the concrete has the compressive strength, split tensile strength and flexural strength. It also has the water absorption and sorptivity. When the replacement goes to 15% the strength goes down. The values are still better than or equal to the control mix, for some properties.

8. FUTURE SCOPE

Higher RCA replacement levels: Future studies may look at RCA replacement levels beyond 30%, such as 40%, 50% 60% and 100% to find out where recycled aggregate stops being useful.

Optimization of Alccofine content: Alccofine-1203 replacement levels between 10% and 15% for instance 11%, 12%, 13% and 14% can be tested to find the percentage.

Long-term durability: More work can be done on penetration, carbonation, sulphate resistance, acid attack, freeze-thaw resistance and permeability.

Long-term strength: Compressive, split tensile and flexural strengths can be checked at 56, 90 180 and 365 days to see how RCA–Alccofine concrete holds up over time.

Microstructural investigation: Tools such as SEM, EDS, XRD and FTIR can be used to look at the microstructure, hydration products, pore refinement and the interfacial transition zones.

Sustainability assessment: A life-cycle assessment (LCA) can be done to measure how much aggregate use, waste, energy and carbon emissions are cut.

Practical field applications: The optimized M30 concrete that contains 30% RCA and 10% Alccofine-1203 can be tried on structural parts like beams, slabs, columns, pavements and precast pieces.

Economic analysis: Future work can include a cost-benefit analysis to see if using RCA and Alccofine-1203 is cheaper, than normal M30 concrete.

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