

Experimental Investigation On The Mechanical Performance Of Recycled Aggregate Concrete With And Without Natural Fibres

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ABSTRACT

This study begins by introducing the basic components of concrete and addressing environmental concerns associated with its production, particularly the depletion of natural aggregates and the challenges of construction waste disposal. As potential solutions recycled aggregate concrete (RAC) and fiber-reinforced concrete (FRC) are explored for their ability to enhance sustainability. A comprehensive review of existing literature follows, covering natural fibers, their treatment methods, recycled coarse aggregates, and the potential benefits of combining these materials in concrete. The study then defines its objectives and scope, focusing on evaluating the effects of natural fibers and recycled aggregates on the compressive strength, workability, and density of concrete, while also assessing their role in promoting environmental sustainability.

The research methodology includes a detailed explanation of the materials used, concrete mix proportions, and the sourcing and treatment of corn straw fibers. The process of mixing concrete with these fibers, compaction, curing, and the various tests conducted—such as compressive strength tests, rebound hammer tests, flexural strength tests, water absorption tests, and sulphate attack tests—are outlined. Experimental work involves the mix design for M25 grade concrete, preliminary testing, and the casting and testing of concrete cubes and beams. Finally, the study presents the experimental results, including compressive strength trends, rebound hammer test findings, 7-day and 28-day strength measurements, water absorption data, flexural strength results, and sulphate attack test outcomes, offering insights into the performance of fiber-reinforced recycled aggregate concrete

Keywords: Recycled Aggregate Concrete (RAC), Natural Fiber Reinforcement, Corn Straw Fiber, Mechanical Properties of Concrete, Sustainable Construction Materials

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1. INTRODUCTION

1.1. GENERAL

Concrete is a composite material consisting of binder (cement), aggregates, and water. Aggregates, although often considered inert, constitute approximately 60–80% of the volume and 70–85% of the weight of concrete, significantly influencing its thermal properties, elasticity, and dimensional stability. Aggregates are broadly classified into coarse and fine types based on particle size.

Concrete is widely used in construction due to its strength, durability, cost-effectiveness, and adaptability. However, the extensive use of natural aggregates (NA) has led to environmental concerns, including depletion of natural resources, increased CO₂ emissions, and accumulation of demolition waste in landfills. The large-scale production of cement and aggregates consumes non-renewable resources and contributes to environmental pollution.

To address these challenges, recycled aggregate concrete (RAC) has emerged as a sustainable alternative. RAC utilizes processed construction and demolition waste, which is crushed, screened, and graded before being used to partially or fully replace natural aggregates. This approach promotes resource conservation and reduces environmental impact.

In recent years, fiber-reinforced concrete (FRC) has gained significant attention in structural and pavement applications due to its enhanced tensile strength, fracture toughness, and durability compared to conventional concrete. High-performance FRC, characterized by a low water–binder ratio and high binder content, offers superior compressive strength and reduced permeability. The incorporation of discrete fibers further improves the tensile behavior and crack resistance of concrete.

Natural fibers, particularly those derived from agricultural waste, have shown potential as sustainable reinforcement

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materials. Studies indicate that these fibers improve ductility and toughness of concrete composites. However, their durability remains a critical concern, as natural fibers are susceptible to degradation in the alkaline cement matrix due to processes such as mineralization, alkaline hydrolysis, and cell wall deterioration. This degradation can lead to reduced long-term performance and increased brittleness. Plant-based natural fibers primarily consist of cellulose (60–80%), which provides strength and rigidity. Hemicellulose and lignin contribute to structural integrity and resistance to biological degradation, while minor components such as pectin, waxes, and oils influence flexibility and surface properties. These constituents play a crucial role in determining the behavior of fibers within the cement matrix.

Overall, the integration of recycled aggregates and natural fibers in concrete presents a promising pathway toward sustainable construction. However, challenges related to durability, bonding, and long-term performance require further investigation to optimize their practical applications.

1.2. OBJECTIVE

- To evaluate the mechanical properties of corn straw fiber-reinforced recycled aggregate concrete for compressive strength and flexural strength.
- To optimize the proportion of corn straw fibers and recycled coarse aggregate for enhancing strength and durability
- To assess the durability of corn straw fiber-reinforced recycled aggregate concrete by water absorption and sulfate attack resistance tests.

1.3. RESEARCH GAP

Existing research has not thoroughly investigated a wide range of curing times, such as 7, 21, 28, and 56 days, to evaluate long-term gains in strength and water resistance. Through a methodical analysis of bricks during these drying times, this study fills this gap. Research on fine aggregates for masonry bricks that range in size from 4.75 mm to 300 microns is scarce. This study closes this gap by assessing the possibilities of fine recycled aggregates. The Indian construction sector depends on compliance to Indian Standard Code IS 2185 (Part 1): 2005, which is not evaluated in many studies that concentrate on regional or international standards. This study ensures compliance to these guidelines. The ways that recycled aggregate bricks reduce their environmental effect and support the circular economy have received little attention. This study emphasizes how they may reduce resource consumption, encourage sustainable building methods, and repurpose waste from development and deconstruction.

LITERATURE REVIEW

2.1 Natural Fibres in Concrete

Natural fiber composites (NFCs) have gained attention due to their sustainability, biodegradability, and improved mechanical performance. Aditya et al. (2024) highlighted

that chemical surface treatments such as alkali, acetylation, and isocyanate significantly enhance fiber–matrix adhesion, leading to improved tensile strength and durability. Life cycle assessments confirm that NFCs have a lower carbon footprint compared to synthetic materials. Babar et al. (2022) demonstrated that coir fibers improve compressive, tensile, and flexural strength while enhancing ductility and impact resistance. However, challenges such as reduced workability, increased porosity, and water absorption were observed, necessitating surface treatment for better compatibility.

Fan et al. (2020) emphasized the biodegradability of NFCs but identified durability issues under environmental exposure, limiting large-scale applications. Similarly, Hamidon et al. (2019) reported that alkali treatment (6% NaOH) significantly improves fiber strength and reduces water absorption, although treatment duration and concentration must be optimized.

Hechmi et al. (2022) observed that bamboo silk fiber improves concrete performance, with optimal results at 0.5% fiber content, enhancing compressive, tensile, and flexural strength along with durability indicators such as electrical resistivity.

2.2 Treatment of Natural Fibres

Surface modification of natural fibers plays a crucial role in improving their performance in cementitious composites. Asim et al. (2022) reported that treated fibers exhibit enhanced interfacial bonding and mechanical properties due to increased surface roughness.

Bernard et al. (2024) analyzed chemical, thermal, and hybrid treatments for sisal fiber-reinforced concrete and concluded that appropriate treatment significantly improves compressive and flexural strength. Advanced approaches, including bacterial treatment, also showed potential for crack healing and strength recovery.

Mohammad et al. (2016) and Narayana et al. (2021) emphasized that alkali and silane treatments enhance fiber–matrix bonding and reduce moisture absorption, although excessive treatment can negatively affect fiber properties.

2.3 Recycled Aggregate Concrete (RAC)

The use of recycled aggregates (RA) is a sustainable solution to reduce natural resource depletion. Hamed et al. (2022) applied machine learning techniques and found that Random Forest models effectively predict compressive strength of RAC, with only minor strength reductions.

Madhavi et al. (2024) highlighted the environmental benefits of multi-generation recycled aggregates, emphasizing reduced CO₂ emissions and embodied energy. Qinghe et al. (2021) reported increased shrinkage with higher RA content, which can be mitigated through pre-soaking techniques.

Tao et al. (2021) demonstrated that hybrid recycled powder improves compressive strength and microstructure due to pozzolanic reactions. Vahidi et al. (2024) confirmed that high-quality recycled aggregates can replace natural aggregates without significant performance loss.

Yiwen et al. (2022) and Yingwu et al. (2020) emphasized the importance of treatment methods in improving

durability and pore structure of RAC, while Zhen et al. (2014) and Zhihui et al. (2024) highlighted that optimized RA content (around 30%) ensures a balance between strength and durability.

2.4 Combined Use of Natural Fibres and Recycled Aggregates

The integration of natural fibers with recycled aggregates has shown promising results in sustainable concrete development. Liew et al. (2017) demonstrated that supplementary cementitious materials (SCMs) such as fly ash and rice husk ash enhance performance and reduce environmental impact.

Shahjalal et al. (2023) studied fiber-reinforced recycled aggregate concrete (FRRAC) incorporating crumb rubber and reported improved ductility, crack resistance, and energy absorption, although compressive strength decreased slightly.

Vikas et al. (2024) found that combining recycled aggregates with rice straw ash improved compressive, tensile, and flexural strength, with optimal performance at moderate replacement levels. Microstructural analysis confirmed improved bonding and durability.

2.5 Research Gaps

- Despite significant advancements, several research gaps remain:
- Limited studies on combined effects of natural fibers and recycled aggregates
- Insufficient understanding of fiber treatment optimization
- Durability concerns of natural fibers in alkaline environments
- Need for advanced techniques such as machine learning for mix optimization
- Lack of standardized guidelines for large-scale application

2.6 Summary

The literature indicates that natural fibers and recycled aggregates significantly enhance the sustainability of concrete while improving mechanical properties. Fiber treatments and hybrid material approaches further optimize performance. However, challenges related to durability, bonding, and optimization require further research to enable widespread practical implementation.

METHODOLOGY

3.1. METHODOLOGY:

3.1.1 Sourcing of materials

The natural coarse and fine aggregates and cement were sourced from the commercial supply of crushed quarried natural aggregate. The recycled aggregates were sourced from a demolished structure, and the concrete was crushed using a jackhammer to sizes of 20-30mm. The crushed aggregate was treated by washing it in a rotating cylinder for three hours.

3.1.2 Mixing of concrete with sugarcane fibers

The dry cement and aggregates were mixed in proportion by hand in a mixing tray for five minutes. Mixing continued for a few more minutes while about 80% of the water was added. The mixing then continued for another few minutes, during which the fibers were gradually added to the concrete over a period of 2–3 minutes while stirring. Finally, the remaining water was added, and the mixing continued for an additional two minutes. This process ensured the complete distribution of fibers throughout the concrete mix.

3.1.3 Compaction

The compaction procedure for cube testing is essential to ensure the concrete is uniformly dense, free of voids, and can accurately reflect its strength when tested. Here is the typical procedure:

Filling the Mold: Fill the cube mold in layers, usually three layers for a standard cube mold.

- For each layer, use a standard compaction rod (usually 16 mm in diameter and 600 mm long) to tamp the concrete 35 times per layer. Ensure the rod reaches all areas of the mold.
- In the case of vibratory compaction, use a vibrating table or handheld vibrator until the concrete is uniformly compacted and no air bubbles are visible on the surface.

3.1.4. Curing

The curing procedure for concrete cube testing as per IS 456: 2000 (Indian Standard for Plain and Reinforced Concrete) is as follows:

- After casting and compacting, cover the cube molds with a non- absorbent sheet, damp burlap, or moist Hessian cloth to prevent moisture loss.
- Keep the cubes at a temperature of $27 \pm 2^\circ\text{C}$ and relative humidity of at least 90% for the first 24 hours.
- After 24 ± 0.5 hours, carefully remove the cubes from their molds.
- Take precautions to avoid damaging the cube edges during demolding.
- Place the demolded cubes in a curing tank or water bath that is maintained at a temperature of $27 \pm 2^\circ\text{C}$.
- Ensure that the cubes remain fully submerged in water and that the water level always remains above them.
- Continue curing the cubes in water until the required testing age, commonly 7, 14, or 28 days as per IS 456.
- Curing for 28 days is typically done to assess the compressive strength for quality control.

Table 3.1: Cube Specimen Description

S.No	Recycled Aggregate (RCA) %	Corn Straw Fiber (SF) % (by volume)
1	0%	0%, 1%, 2%, 3%
2	25%	0%, 1%, 2%, 3%
3	50%	0%, 1%, 2%, 3%
4	75%	0%, 1%, 2%, 3%
5	100%	0%, 1%, 2%, 3%



Figure 4.2: Corn Straw Fibres

4.0 MATERIAL PROPERTIES

4.1. STUDY OF MATERIALS

4.1.1. CEMENT

Ordinary Portland Cement (OPC) 53 grade and recycled fine aggregates (RFA) from construction and demolition (C&D) waste, this study aims to create an environmentally friendly mortar mix. Because of its high strength and rapid setting, OPC 53 is chosen to ensure that masonry bricks have the necessary compressive strength.

4.1.2. AGGREGATES

The materials used are natural coarse aggregate of size 20 to 30 mm and fine aggregate of size 75 micron to 4.75 mm from the local market, recycled aggregate from the demolished structure, cement, water, sugarcane fibres with Diameter 1.50 mm Aspect Ratio 90 with 135 mm in length and standard cube moulds of size 150x150x150mm. The equipment used were tamping rod for compaction, weighing balance for accurate measurement, mixing tray for mixing concrete components, curing system and compression testing machine.



Figure 4.1: Fine aggregate and coarse aggregate

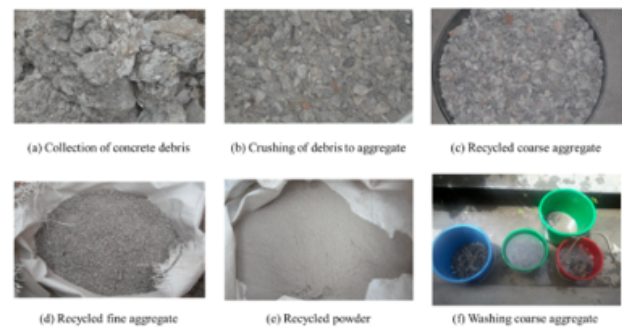


Figure 4.3: Recycled coarse aggregate

4.2. TEST ON MATERIALS

4.2.1. SPECIFIC GRAVITY TEST

In this test 2 kg of aggregate sample is taken, washed to remove fines and then placed in the wire basket. The wire basket is then immersed in water, which is at a temperature of 220C to 320C. Immediately after immersion the entrapped air is removed from the sample by lifting the basket 25 mm above the base of the tank and allowing it to drop, 25 times at a rate of about one drop per second. The basket, with aggregate are kept completely immersed in water for a period of 24 ± 0.5 hour. The basket and aggregate are weighed while suspended in water, which is at a temperature of 220C to 320C.

The basket and aggregates are removed from water and dried with dry absorbent cloth. The surface dried aggregates are also weighed. The aggregate is placed in a shallow tray and heated to about 1100C in the oven for 24 hours. Later, it is cooled in an airtight container and weighed. The following results are obtained:

M-sand = 2.76, 20 mm Aggregate = 2.67, Cement = 3.15 and RCA = 2.435

4.2.2. WATER ABSORPTION TEST

For this test 2 kg of aggregate sample is taken, washed to remove fines and then placed in the wire basket. The wire basket is then immersed in water, which is at a temperature

of 220C to 320C. Immediately after immersion the entrapped air is removed from the sample by lifting the basket 25 mm above the base of the tank and allowing it to drop, 25 times at a rate of about one drop per second. The basket, with aggregate are kept completely immersed in water for a period of 24 ± 0.5 hour. The basket and aggregate are weighed while suspended in water, which is at a temperature of 220C to 320C. The basket and aggregates are removed from water and dried with dry absorbent cloth. The surface dried aggregates are also weighed. The aggregate is placed in a shallow tray and heated to 100 to 1100C in the oven for 24 ± 0.5 hours. Later, it is cooled in an airtight container and weighed.

M-sand = 2%, 20 mm aggregate = 1.5% and RCA = 1%

4.2.3. IMPACT TEST

The test sample shall consist of aggregate the whole of which passes a 12.5 mm IS Sieve and is retained on a 10 mm IS Sieve. The aggregate comprising the test sample shall be dried in an oven for a period of four hours at a temperature of 100 to 110°C and cooled. The measure shall be filled about one-third full with the aggregate and tamped with 25 strokes of the rounded end of the tamping rod. Further similar quantity of aggregate shall be added and a further tamping of 25 strokes given. The measure shall finally be filled to overflowing, tamped 25 times and the surplus aggregate struck off, using the tamping rod as a straight edge. The net weight of aggregate in the measure shall be determined to the nearest gram (Weight A). The impact machine shall rest without wedging or packing upon the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical. The cup shall be fixed firmly in position on the base of the machine and the whole of the test sample placed in it and compacted by a single tamping of 25 strokes of the tamping rod. The hammer shall be raised until its lower face is 380 mm above the upper surface of the aggregate in the cup, and allowed to fall freely on to the aggregate. The test sample shall be subjected to a total of 15 such blows each being delivered at an interval of not less than one second. The crushed aggregate shall then be removed from the cup and the whole of it sieved on the 2.36 mm IS Sieve until no further significant amount passes in one minute. The fraction passing the sieve shall be weighed to an accuracy of 0.1 g (Weight. B). The fraction retained on the sieve shall also be weighed (Weight C) and, if the total weight (C+B) is less than the initial weight (Weight A) by more than one gram, the result shall be discarded and a fresh test made. Two tests shall be made. 20 mm aggregate = 12.5 % and RCA = 14.5%

5.0 CASTING OF CUBES

5.1. CASTING OF CUBES USING RECYCLED AGGREGATE MORTAR

5.1.1. MIX PROPORTION FOR M25 GRADE SPEIMENS:

The proposed study looked into the process of making bricks with recycled aggregate mortar. A mix ratio of 1:3

was utilized, with performance ensured through precise mix design and manual mixing to achieve uniformity. A water-cement ratio of 0.45 was maintained for the preparation of the mortar. The 53 grade Ordinary Portland Cement (OPC) was selected because of its remarkable strength and quick-setting qualities, which are essential for producing long-lasting and superior bricks. In order to guarantee uniform particle distribution and consistent mortar performance, the fine aggregates used is 1.62 mm and the coarse aggregate is 2.56 mm. Figure 5.1 shows couple the prepared recycled aggregate mortar, mixed with cement, fibres, fine aggregate and recycled course aggregate



Figure 5.1: Casted cubes specimens

EXPERIMENTAL INVESTIGATION

6.1. TESTS ON RECYCLED AGGREGATE BLOCKS

The study utilized the Indian Standard Code IS 2185 (Part 1): 2005, titled "Indian Standard Concrete Masonry Units – Specification, Part 1: Hollow and Solid Concrete Blocks". The standard provides the specifications and guidelines for conducting tests to evaluate the quality and performance of the recycled aggregate mortar bricks. The results of the study were assessed based on compliance with the IS 2185 (Part 1): 2005 standards. The following tests were conducted on the bricks made with recycled aggregate mortar:

6.1.1. COMPRESSIVE STRENGTH TEST

Prepare concrete cubes of the required size, typically 150 mm x 150 mm x 150 mm, as per IS 516. Follow standard mixing, casting, compacting, and curing methods as per IS 456. Measure the sides of the cube to ensure they meet the specified dimensions (150 mm). Check for any visible cracks, damages, or irregularities on the surface that may affect the test. Place the cube centrally on the lower platen of the compression testing machine. Align the specimen so that the load will be applied perpendicularly to the casting direction (top face of the cube). Gradually apply load to the cube at a constant rate of 140 kg/cm² per minute (equivalent to 1.4 N/mm² per second). Continue applying load without any shock or abrupt increase until the cube fails or fractures. Record the maximum load (in Newtons) that the cube withstands before failure. Calculate the compressive strength using the formula.

6.1.2. REBOUND HAMMER TEST

The Rebound Hammer Test, also known as the Schmidt Hammer Test, is a non-destructive testing (NDT) method used to assess the compressive strength of concrete by measuring the surface hardness. Gradually push the hammer against the surface until the plunger strikes and releases the hammer impact. Note the rebound number displayed on the hammer's scale. Perform at least 10–12 readings for a single test area and discard outliers. Take readings in a grid pattern to get uniform results. Record all rebound values in a tabulated format. Compute the average of the valid readings. Compare the rebound number with the standard correlation chart provided in IS 13311 (Part 2): 1992. Use the IS 13311 correlation chart to determine the compressive strength (MPa) based on the rebound number. Different correlation curves are used depending on:

1. The angle of testing (horizontal, vertical downward, or vertical upward).
2. The type of concrete (wet, dry, carbonated surface).

6.1.3 FLEXURAL STRENGTH TEST

The Flexural Strength Test is conducted to determine the bending strength (modulus of rupture) of concrete. Prepare a concrete mix as per the design mix proportion. Clean and oil the inner surface of the beam molds to prevent sticking. Fill the mold with fresh concrete in two layers, each layer being compacted using a tamping rod (25 blows per layer). Strike off excess concrete using a trowel and level the surface. Mark the specimen with identification details before curing. Keep the molded beam at a room temperature ($27 \pm 2^\circ\text{C}$) for 24 hours. After demolding, immerse the beam in a water tank and cure it for 28 days. Remove the beam from the curing tank and wipe off excess water. Place the beam on the flexural testing machine with support span of 600 mm (for 150 mm beams) or 400 mm (for 100 mm beams). Ensure the beam is centered on the machine. The load should be applied without shock and at a uniform rate until failure occurs. Flexural strength is tested using two loading methods:

1. Three-Point Loading Test (Central Point Load Method)
 - Load is applied at the mid-span of the beam.
 - The beam fails in bending along its weakest section.
 - Four-Point Loading Test (Two-Point Load Method)
 - Two equal loads are applied at one-third spans from each end.
 - This method gives a pure bending zone and is preferred for research.

Load is applied at a rate of 1.8 kN/min for 150 mm beams and 0.8 kN/min for 100 mm beams. Note the maximum load (P) at failure and observe the type of failure (brittle or gradual).

6.1.4. WATER ABSORPTION TEST

The Water Absorption Test is conducted to determine the porosity and permeability of concrete by measuring the amount of water absorbed by a concrete sample. This test helps assess the durability and resistance of concrete to moisture-related damage. Select a concrete specimen that has been properly cured for 28 days. Wipe off any loose dust or particles from the surface. Place the specimen inside a drying oven at $100^\circ\text{C} - 110^\circ\text{C}$. Keep it inside the oven for 24 hours until it reaches a constant weight. After drying, remove the sample and cool it to room temperature in a dry atmosphere. Weigh the completely dry specimen (W_1 in grams). Completely immerse the specimen in clean water at room temperature ($27 \pm 2^\circ\text{C}$). Keep it submerged for 24 hours. Remove the specimen from water and wipe off any excess surface water using a damp cloth. Immediately weigh the saturated surface-dry specimen (W_2 in grams). This weight includes the water absorbed by the specimen. Acceptance Criteria (IS 2185: 2005 & IS 456: 2000). For concrete blocks (IS 2185: 2005), the maximum allowable water absorption:

- Normal-weight blocks: $<10\%$ by mass.
- Light-weight blocks: $<15\%$ by mass.
 - As per IS 456: 2000, lower water absorption indicates better durability and resistance to permeability.

6.1.5. SULPHATE ATTACK TEST

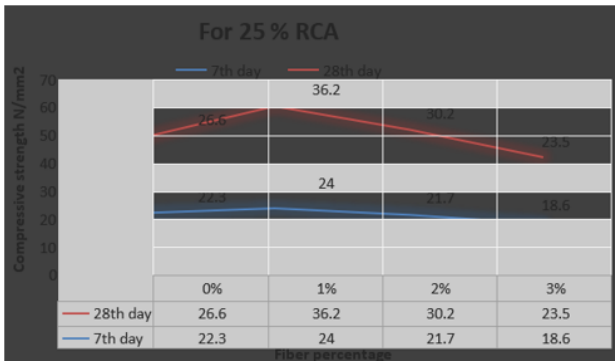
Sulphate Attack Test is conducted to evaluate the resistance of concrete to sulphate ions, which can cause expansion, cracking, and deterioration over time. This test is essential for structures exposed to sulphate-rich environments, such as marine structures, sewage treatment plants, and foundations in sulphate-rich soils. Cast concrete cubes ($100 \text{ mm} \times 100 \text{ mm} \times 100 \text{ mm}$) or prisms ($75 \text{ mm} \times 75 \text{ mm} \times 285 \text{ mm}$) as per IS 516: 2020. Cure the specimens in normal water for 28 days before exposure. Prepare a 5% solution of sodium sulphate (Na_2SO_4) or magnesium sulphate (MgSO_4) in distilled water. The pH of the solution should be maintained between 6.0 and 8.0. Remove the specimens from normal curing and weigh them (W_1) before immersion. Fully immerse the specimens in the sulphate solution for a specific exposure period (typically 90 days or longer for accelerated testing). Replace the sulphate solution every 15 days to maintain concentration. Store the solution at room temperature ($27 \pm 2^\circ\text{C}$). Regularly inspect specimens for cracking, spalling, and discoloration. Measure weight loss (%) and dimensional changes (expansion %) using a length comparator.

RESULT AND DISCUSSION

7.1. RESULTS AND OBSERVATIONS

The experimental test results were obtained for each specimen configuration at curing periods of 7, 21, 28, and 56 days. For every sample configuration, three specimens were tested at each curing age. The mentioned results represent the average of the three specimens tested for each individual configuration. The results of the experimental

study on recycled aggregate mortar bricks are presented below:



7.1.1. 7TH DAY COMPRESSIVE STRENGTH RESULTS [N/mm²]

25% RCA with 1% fiber gives the highest strength (24 N/mm²). Higher RCA ($\geq 50\%$) and fiber ($\geq 2\%$) result in reduced strength. Optimal mix recommendation: Use $\leq 25\%$ RCA with 1% fiber for best performance

Table 7.1: Compressive strength test results of 7th day recycled coarse aggregate specimen

RCA/FIBER	0%	1%	2%	3%
0%	16	18.7	17.4	15.6
25%	22.3	24	21.7	18.6
50%	20	22.7	20	16.2
75%	20	22.2	18.4	14.7
100%	15.8	17.8	15.4	13.3

7.1.2. 28TH DAY COMPRESSIVE STRENGTH RESULTS [N/mm²]

1% fiber content is the best choice for strength enhancement. 25% RCA with 1% fiber achieves the highest compressive strength. Excessive fiber ($\geq 2\%$) reduces strength due to poor workability and weak bonding. For long-term durability, limiting RCA to 25%-50% with 1% fiber is ideal.

Table 7.2: Compressive strength test results of 28th day recycled coarse aggregate specimen

RCA/FIBER	0%	1%	2%	3%
0%	25.8	33.3	28.4	23.5
25%	26.6	36.2	30.2	25.8
50%	25.2	32.4	27.6	22
75%	24.4	31.5	22.3	18.7
100%	23.1	30.6	19.5	16.7

7.1.3. REBOUND HAMMER TEST RESULTS [N/mm²]

1% fiber content provides the highest strength across all RCA levels. Beyond 1% fiber, strength decreases due to poor fiber dispersion and void formation. Highest recorded strength: 28 N/mm² at 25% RCA with 1% fiber at 3% fiber, strength drops significantly, indicating excess fiber negatively affects the mix.

Table 7.3: Rebound hammer test results on recycled coarse aggregate specimen

RCA/FIBER	0%	1%	2%	3%
0%	20	25	21	18
25%	21	28	22	17
50%	19	24	17	16

75%	18	23	15	15
100%	17	22	14	14

7.1.1. WATER ABSORPTION TEST RESULTS [N/mm²]

Water absorption increases with fiber content across all RCA levels. At 0% RCA, water absorption starts at 3.3% (0% fiber) and rises to 4.2% (3% fiber). At 100% RCA, absorption is highest, increasing from 4.5% (0% fiber) to 5.2% (3% fiber). This indicates that higher fiber percentages increase porosity, leading to more water absorption.

Table 7.4: Water Absorption test results on recycled coarse aggregate specimen

RCA/FIBER	0%	1%	2%	3%
0%	3.3	3.5	4.1	4.2
25%	3.8	4.1	4.4	4.4
50%	4	4.3	4.5	4.5
75%	4.2	4.6	4.8	4.8
100%	4.5	4.8	4.9	5.2

7.1.1. FLEXURAL STRENGTH TEST RESULTS [N/mm²]

Flexural strength increases with curing age, as expected. At 7 days: 3.75 N/mm², indicating early strength gain. At 28 days: 5.28 N/mm², showing significant improvement. Strength increased by ~40.8% from 7 to 28 days, highlighting proper hydration and matrix development

Table 7.5: Flexural strength test results on recycled coarse aggregate specimen

DAYS	FLEXURAL STRENGTH
7	3.75
28	5.28

7	3.75
28	5.28

7.1.1. SULPHATE ATTACK TEST RESULTS [N/mm²]

Weight loss due to sulphate attack: 2%. Acceptable weight loss range: Usually, <5% is considered good resistance. Indicates moderate resistance to sulphate exposure.

Table 7.6: Sulphate attack test results on recycled coarse aggregate

SULPHATE ATTACK TEST	
Weight loss	2 %

CONCLUSION:

The proposed study has verified the results against established norms and requirements, offering useful insights into the performance of fibres in recycled aggregate concrete. The wide range of information gathered during the study supports the conclusions that this concrete is appropriate for usage in construction. Here are the key findings from the study:

- The highest compressive strength was observed for 25% RCA with 1% fiber (24 N/mm²) at 7 days.
- The highest strength was achieved with 25% RCA and 1% fiber (36.2 N/mm²) at 28 days.
- Increasing fiber content beyond 1% generally led to a decline in compressive strength, indicating an optimal fiber dosage for strength enhancement.
- The highest rebound strength was recorded for 25% RCA with 1% fiber (28 N/mm²).
- In water absorption test, 100% RCA with 3% fiber showed the highest absorption (5.2%), indicating reduced durability.
- The least water absorption was observed in 0% RCA and 0% fiber (3.3%), confirming that recycled aggregates and organic fibers increase porosity.
- The highest Flexural strength was observed for 25% RCA with 1% fiber (3.75 N/mm²) at 7 days.
- The highest Flexural strength was observed for 25% RCA with 1% fiber (5.28 N/mm²) at 28 days.
- Sulphate attack resistance was within IS 456:2000 & IS 1343:2012 limits, with weight loss of 2 % remaining below 5%, ensuring durability.

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