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Experimental Investigation on Partial Replacement of Cement with Recron Fiber and Wooden Swadust in high Strength Concrete

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Abstract - *The growing concern over the environmental impact of cement production, which contributes significantly to CO_2 emissions, has prompted the exploration of alternative materials to partially replace cement in concrete. This experimental investigation evaluates the effects of replacing cement with Recron fiber (synthetic polymer fiber) and wooden fiber (natural fiber) on the mechanical and durability properties of concrete. Concrete mixes were prepared by partially replacing cement with 1%, 0.75% and 5%,10% by weight of Recron and wooden fibers, respectively. The key properties assessed include compressive strength, flexural strength, split tensile strength, workability, and durability (water absorption).*

The results indicated that the incorporation of both Recron and wooden fibers improved the mechanical properties of concrete up to a 2% replacement level. Recron fiber exhibited a more pronounced enhancement in compressive, flexural, and split tensile strengths compared to wooden fiber. Beyond 2% replacement, a decline in strength was observed, likely due to a reduction in the effective cement content and the tendency of fibers to cluster. Additionally, both types of fibers contributed to improved durability, as evidenced by reduced water absorption.

Key Words: Fresh Concrete Test, Hardened Concrete Test, Workability, Split Tensile Strength, Durability Test(HCL).

1. INTRODUCTION

Concrete is a fundamental material in the construction industry, valued for its strength, durability, and versatility in a wide range of applications, from residential buildings to large infrastructure projects. Its primary components—cement, aggregates, and water—combine to form a durable material that has become the foundation of modern construction. However, the production of cement, a key ingredient in concrete, is responsible for a significant environmental impact, contributing nearly 8% of global CO_2 emissions. This has raised concerns about the sustainability of concrete and the need to reduce its carbon footprint.To address these environmental challenges, researchers are exploring alternative materials and methods to reduce the reliance on cement without compromising concrete's performance. One promising approach is the incorporation of fibers into concrete, resulting in fiber-reinforced concrete (FRC). By partially replacing cement with fibers, it is possible to improve the material's mechanical properties, such as tensile strength, crack resistance, and durability, while also lowering its environmental impact. This thesis investigates the potential of fiber-reinforced concrete as a sustainable solution to reduce CO_2 emissions in concrete production.

1.1 Recron fiber

- Recron fiber in concrete refers to synthetic fibers made from polypropylene that are added to concrete mixes to improve its properties. Recron fibers are commonly used in fiber-reinforced concrete (FRC), a type of concrete that includes fibers to enhance its strength, durability, and crack resistance.
- Recron fibers are particularly useful in applications like pavements, industrial floors, precast elements, and construction exposed to heavy wear and harsh weather conditions. The use of these fibers reduces the reliance on steel reinforcement and enhances the performance of the concrete, contributing to its sustainability and cost-effectiveness.

1.2 Wooden Sawdust

Wood sawdust is a fine byproduct created during the cutting, grinding, or drilling of wood. It consists of small wood particles and is commonly produced in sawmills, woodworking shops, and construction sites. Though often considered waste, sawdust is used in various applications such as:

1. **Lightweight**: Wooden saw reduce the overall weight of concrete, making it suitable for applications where a lighter mix is required.
2. **Improved Insulation**: Wooden saw can provide better thermal and acoustic insulation, making the concrete more energy-efficient.
3. **Eco-Friendly**: Using waste wood saw promotes sustainability by recycling wood by-products, reducing environmental waste.
4. **Cost-Effective**: Wooden saw are often cheaper than synthetic alternatives, making them a cost-effective option for concrete reinforcement.
5. **Crack Resistance**: These saw dust can help reduce plastic shrinkage cracks in concrete, improving its overall durability.

1.3 HCL

- Using hydrochloric acid (HCL) in concrete durability testing is part of acid resistance testing, which evaluates how concrete withstands aggressive chemical environments-especially relevant for industrial floors, sewage systems, or chemical plants.
- Concrete is alkaline in nature due to calcium hydroxide ($Ca(OH)_2$) and other hydration products. Acids like HCL react with these alkaline components and degrade the concrete matrix.

2. Material And Methodology

2.1 Fine Aggregate (IS 2386 Part-1)

Table.1 Properties of Fine Aggregate

Properties	Sand
Sieve analysis	Zone II
Fineness modulus	2.871
Specific Gravity	2.64
Water Absorption	1.77
Bulk Density	1.62 (Loose) 1.76 (Compacted)

2.2 Coarse Aggregate (IS 383-1987)

Table.2 Properties of Fine Aggregate

Properties	20mm	10mm
Specific Gravity	2.88	2.99
Water Absorption	1.46%	0.29%
Aggregate Impact Value	9.21%	9.33%
Aggregate Crushing Value	11.75%	9.98%
Flakiness Index	10.89%	25.26%
Elongation Index	6.84%	7.66%
Bulk Density	1.657 (Loose) 1.75 (Compacted)	1.53 (Loose) 1.68 (Compacted)

2.4 Mix Design (IS 10262-2019)

- For M60 Grade of Concrete Mix

Table.4 Mix Proportion (per cubic meter)

Water	Cement	FA	CA	Total
153.28	383.15	817.23	1210.98	2564.64
0.40	1.00	2.13	3.16	6.69

- For M70 Grade of Concrete Mix

Table.5 Mix Proportion (per cubic meter)

Water	Cement	FA	CA	Total
155.68	385.89	854.78	1310.78	2707.13
0.40	1.00	2.21	3.39	7.01

3. RESULTS

3.1 Workability

- The concrete slump test measures the Workability of fresh concrete before it sets.
- It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows.
- The slump test is used for the measurement of a property of fresh concrete as per IS: 1199 - 1959.

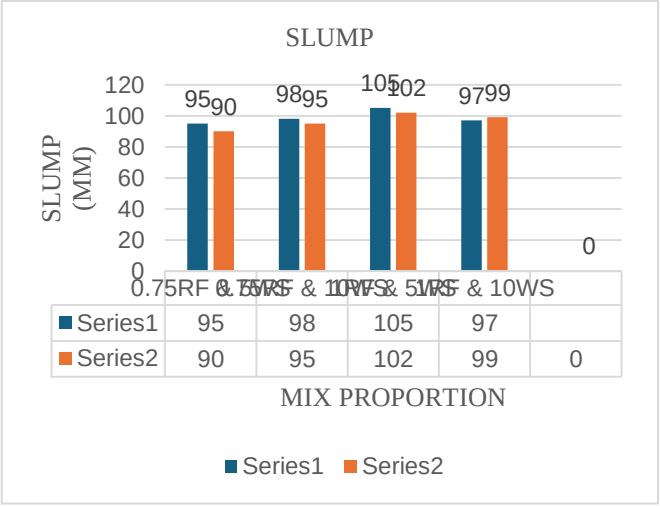

Chart -1: Slump Value Comparison

3.2 Compressive Test Results

- Determination of compressive strength using by cube where size of cube specimen is 150×150×150 mm and this test was performed on a 2000 KN capacity compression testing machine.

- Bureau of Indian Standards suggests that the compressive strength of concrete be considered as the basis for determining all properties and studying response of concrete. As such more emphasis was given on this test. The compressive strength of concrete was evaluated at the age of 7 days, 14 days and 28 days.
- The compressive strength of cube specimen is calculated using the following formula:

$$\sigma = P/A$$

Where, P = failure load

A = cross sectional area of cube in mm

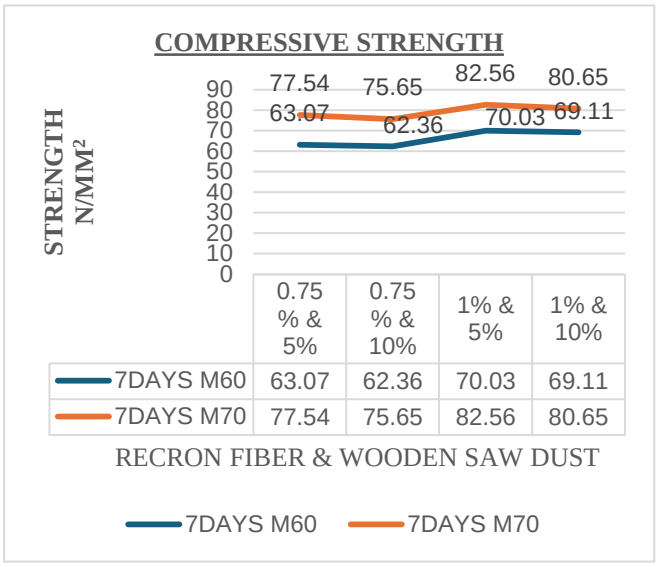

Chart -2: Compressive Test Result for 7-days

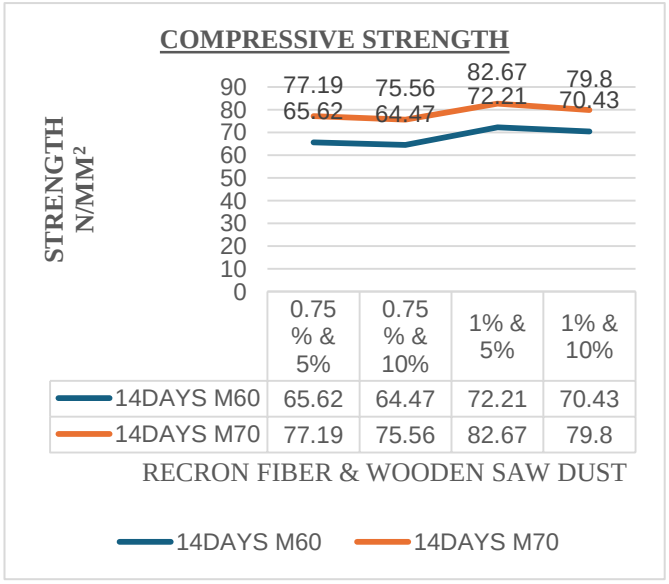

Chart -3: Compressive Test Result for 14-days

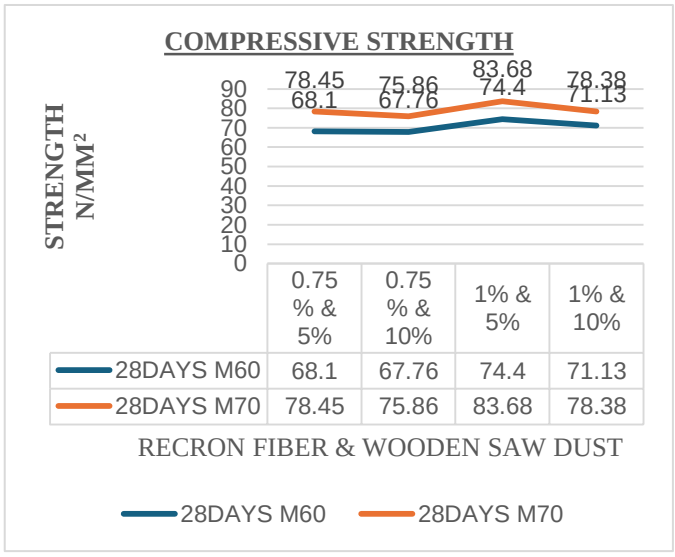

Chart -4: Compressive Test Result for 28-days

3.3 Split Tensile Test Results

- To determine the split tensile strength of concrete, cylindrical specimens measuring 150 mm in diameter and 300 mm in height were cast and tested at 28 days of age.
- The split tensile strength of concrete at 28 days was evaluated.
- The results obtained were compared with the concrete's compressive strength at the same age. During the testing procedure, the compression load will be applied along the two opposite axial lines.

$$Tsp = 2P/\ 3.14\ DL$$

Where, P = Applied Load

D =Diameter of the Specimen

L = Length of the Specimen

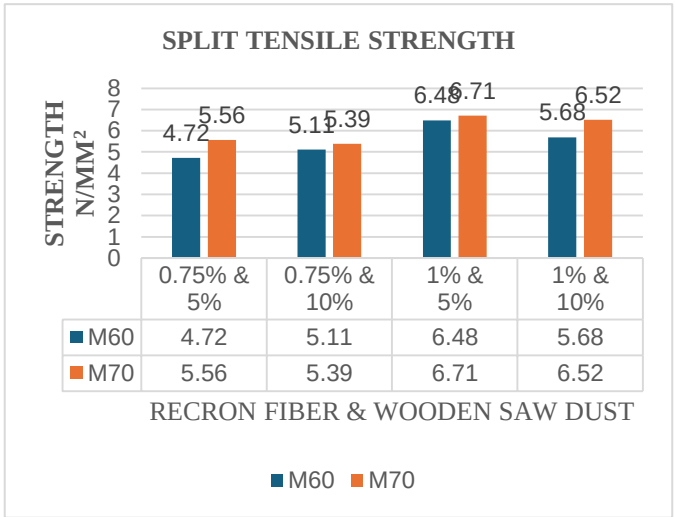

Chart -5: Split Tensile Test Result for 28-day

3.4 Durability Test Results

- To perform this test, 3% by volume of hydrochloric acid was combined with regular drinking water.
- The concrete cubes measuring 150mm were poured and allowed to cure for a duration of 28 days.
- Upon completion of the 28 days of curing for the specimens, the surfaces of the cubes were cleaned and weighed. The specimens were then submerged in an HCL acid solution.

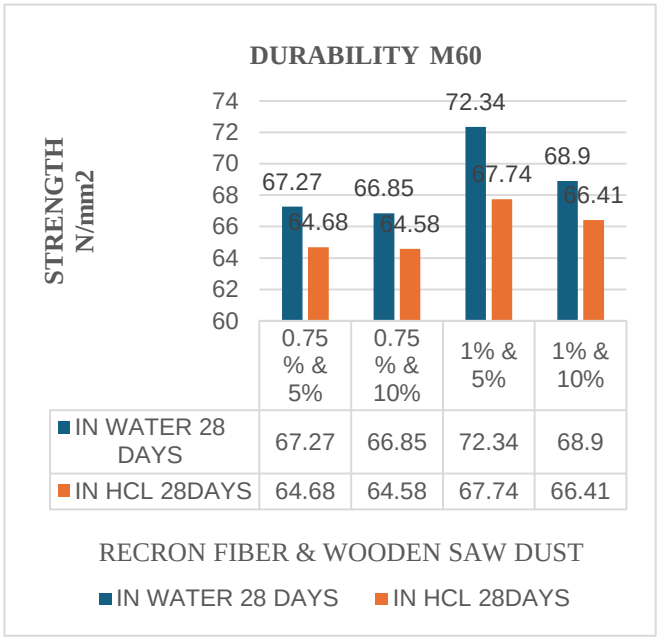

Chart -6: Durability Test Result for 28-days(M60)

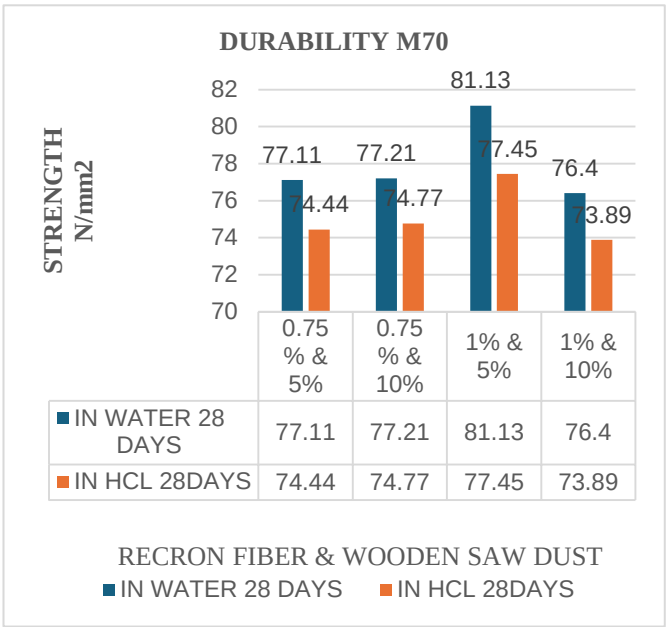

Chart -7: Durability Test Result for 28-days (M70)

4. CONCLUSIONS

1. It is observed that there is increase in workability (Slump test) for the M60 and M70 grade of Concrete treated with 1% with 5% dosage of RECRON & WOODEN respectively when compared to untreated concrete.
2. It is observed that there is increase in strength by 4.73 % & 9.0 % for the M60 & M70 grade of concrete treated with optimum dosage of RECRON & WOODEN with ageing when compared to untreated concrete.
3. The split tensile strength of concrete continues to rise, reaching increments of 6.48%, and 6.71% for the M60, and M70 concrete grades, respectively, with the substitution of cement with RECRON & WOODEN
4. It is observed that there is increase in strength rapidly at early stage treated with RECRON & WOODEN
5. In Durability test using HCL solution in concrete, Results shows that in normal M60 and M70 grade of concrete maximum loss in strength is by 5.06%, 7.56%.
6. Optimum dosage of RECRON FIBER is 1% with 5 % WOODEN.

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