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# Experimental Investigation on Silica Fume with 3S Recron Fibers

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**ABSTRACT:** This abstract summarizes an experimental investigation evaluating the synergistic effects of incorporating silica fume and Recron 3S fibers into concrete to enhance its mechanical and non-destructive properties. Cement was partially replaced with silica fume at an optimized dosage to exploit its micro-filling capabilities and pozzolanic reactivity, while Recron 3S polypropylene micro-fibers were integrated to provide a three-dimensional reinforcing network. The core focus of this research was to assess the combined impact of these materials on compressive strength, split tensile strength, and Ultrasonic Pulse Velocity (UPV). Standard concrete specimens, including cubes and cylinders, were cast and subjected to rigorous curing regimes before testing at designated intervals. The experimental results revealed a profound increase in compressive strength, driven by the densification of the microstructure from the silica fume. Simultaneously, the inclusion of Recron 3S fibers significantly enhanced the split tensile strength, effectively arresting early micro-cracks and shifting the failure mode from brittle to ductile. Furthermore, UPV testing demonstrated a marked increase in pulse velocity across the modified specimens, confirming a highly dense, homogeneous matrix with reduced internal voids and superior structural integrity. Ultimately, the dual application of silica fume and Recron 3S fibers proves to be an exceptionally viable approach for producing high-performance, durable concrete suitable for severe structural environments.

**KEYWORDS:-**Silica Fume, Recron 3S Fibers, Compressive Strength, Split Tensile Strength, Ultrasonic Pulse Velocity (UPV), Microstructure, Durability.

## I. INTRODUCTION

Concrete is a flexible, intricate composite material that literally underpins modern global infrastructure and urban growth. It is made by carefully combining coarse and fine aggregates, Portland cement, water, and specific chemical or mineral additives in exact proportions. The process of hydration, which is the chemical reaction between water and cement, produces a binding paste that gradually hardens into a stone-like substance over time. In its fresh state, concrete is highly workable, enabling it to be readily shaped into complex architectural forms, structural columns, and large-scale transportation surfaces. Once cured, it offers exceptional compressive strength, structural stability, fire resistance, and enduring durability across a range of environmental conditions. In the end, its cost-effectiveness, the ease of sourcing raw materials locally, and its versatility make it the most commonly consumed manufactured material on Earth.

Silica fume, also known as micro-silica, is an extremely fine byproduct produced during the industrial manufacturing of silicon metal or ferrosilicon alloys. This mineral admixture is made up of ultrafine, spherical particles of high-purity amorphous silicon dioxide, measuring about one hundred times smaller than typical cement particles. When mixed into wet concrete, it functions as a highly reactive pozzolan that chemically converts weak hydration byproducts into a dense calcium silicate hydrate gel. At the same time, its small physical size enables it to act as an effective micro-filler, fitting snugly into the spaces between cement paste and aggregate particles. This combined mechanical and chemical process significantly lowers internal porosity, forming a non-porous structural matrix with greatly enhanced

compressive strength. Therefore, silica fume is highly prized for use in engineering high-performance concrete structures designed to endure harsh chemical conditions and severe structural stresses.

Recron 3S fibers are state-of-the-art, engineered synthetic micro-reinforcements designed specifically to improve the secondary mechanical performance of concrete and plaster mortars. Manufactured from high-quality polypropylene materials, these discrete micro-fibers disperse uniformly in three dimensions throughout the wet mix to create an interlocking structural grid. Their primary engineering function is to intercept and arrest the formation of microscopic hairline cracks during the critical early plastic and drying shrinkage stages. By absorbing localized tensile stresses, they prevent small internal fissures from expanding into large, continuous structural failures that compromise the building. Furthermore, the inclusion of these non-corrosive fibers significantly increases the finished concrete's overall toughness, energy absorption capacity, and resistance to dynamic impact or surface abrasion. This makes Recron 3S fibers an essential, cost-effective addition for minimizing water permeability, reducing surface spalling, and extending the service life of modern pavements and industrial floors.

## II. OBJECTIVES

To optimize the partial replacement of cement with silica fume for microstructural densification, integrate a three-dimensional network of Recron 3S polypropylene micro-fibers to mitigate brittle failure modes, and evaluate their synergistic impact on the concrete's mechanical and non-destructive properties through compressive, split tensile, and Ultrasonic Pulse Velocity (UPV) testing.

## III. MATERIALS

- a) **Cement**:- A fine binding powder that sets and hardens when mixed with water through a chemical process called hydration. It acts as the primary hydraulic glue in construction, holding all the loose stones and sand together. Once cured, it provides the essential compressive strength needed to bind the entire concrete matrix.
- b) **Fine Aggregate**:- Small, granular mineral particles, typically consisting of natural sand or crushed stone, that pass through a standard 4.75mm sieve. Its primary role is to fill the microscopic voids existing between the larger coarse aggregates in a mix. By packing these spaces, it ensures a smooth, workable consistency and helps create a dense, solid final structure.
- c) **Coarse Aggregate**:- Larger fragments of rock, such as crushed stone, gravel, or boulders, that are retained on a 4.75mm sieve. This material forms the robust, skeletal backbone of the concrete mix, providing bulk volume and heavy-duty stability. It is the main component responsible for resisting mechanical wear, heavy loads, and structural pressures.
- d) **Water**:- The vital liquid ingredient that triggers the chemical reaction required for the cementitious binder to set and harden. It also acts as a lubricant during mixing, making the fresh concrete fluid enough to be poured and molded easily. Using the correct ratio is critical, as too much water dilutes the mix, while too little stalls the curing process.
- e) **Silicafume** :- An ultrafine, pozzolanic byproduct captured from the production of silicon and ferrosilicon alloys. Because its particles are extremely small, it chemically reacts with cement byproducts to fill the tiniest microscopic pores. This dense packing significantly enhances the concrete's ultimate strength and creates high resistance to chemical attacks.
- f) **3s Recron Fibers**:- Engineered polypropylene micro-reinforcements specifically designed to be dispersed uniformly throughout a concrete mix. They function as a secondary internal web that arrests micro-cracks caused by shrinkage and thermal changes while the concrete is fresh. By bridging these tiny gaps, they dramatically improve the material's impact resistance, durability, and overall tensile flexibility.

## IV. RESULTS AND DISCUSSIONS

**a. Compressive strength test:** The compression test on concrete cubes is a basic quality control method used to measure the highest compressive strength a cured concrete mix can withstand before failing structurally. Standard concrete samples, usually molded in 150 mm×150 mm× 150 mm forms, are typically cured in water for designated durations most often 7 and 28 days to facilitate adequate chemical hydration.

**Table 1:- Compressive Strength Results of Concrete with Partial replacement of cement with Silicafume**

S.No	% of Silicafume	Compressive Strength Results, N/mm <sup>2</sup>	
		7 days	28 days
1	0%	26.61	39.43
2	5%	29.03	42.38
3	7.5%	31.98	45.76
4	12.5%	29.15	42.06

**Table 2:- Compressive Strength Results of Concrete 3S Recron Fibers**

S.No	% of 3SRF	Compressive Strength Results, N/mm <sup>2</sup>	
		7 days	28 days
1	0%	26.61	39.43
2	0.25%	27.42	40.66
3	0.5%	28.26	41.45
4	0.75%	29.06	42.24
5	1%	27.88	41.37
6	1.25%	27.49	40.98

**Table 3:- Combined Compressive Strength result of concrete.**

S.No	Combined Replacement(s)	Compressive Strength Results, N/mm <sup>2</sup>	
		7 days	28 days
1	0%	26.61	39.43
2	7.5%SF+0.75%3SRF	30.66	45.02

**b. Split tensile strength:** At 7 weeks and 28 days old, the specimen, measuring 300 mm in length and 150 mm in diameter, was placed horizontally between the loading platens of a Compression Testing Machine (CTM). A compressive load is applied evenly and radially around the cylinder's entire length until it fractures along its vertical diameter.

**Table 4:- Split tensile Strength Results of Concrete with Partial replacement of cement with Silicafume.**

S.No	% of Silicafume	Split tensile Strength Results, N/mm <sup>2</sup>	
		7 days	28 days
1	0%	2.58	3.84
2	5%	2.89	4.23
3	7.5%	3.67	5.21
4	12.5%	2.93	4.26

**Table 5:- Split tensile Strength Results of Concrete 3S Recron Fibers.**

S.No	% of 3SRF	Split tensile Strength Results, N/mm <sup>2</sup>	
		7 days	28 days
1	0%	2.58	3.84
2	0.25%	2.67	3.96
3	0.5%	2.83	4.08
4	0.75%	2.91	4.21
5	1%	3.15	4.46
6	1.25%	2.79	4.05

**Table 6:- Combined Split tensile Strength result of concrete.**

S.No	Combined Replacement(s)	Split tensile Strength Results, N/mm <sup>2</sup>	
		7 days	28 days
1	0%	2.58	3.84
2	7.5%SF+0.75%3SRF	3.34	4.72

**c. Ultrasonic Pulse Velocity:-** During the test, a standard concrete cylinder usually 150 mm in diameter and 300 mm long is positioned horizontally between the compression machine's loading plates. High-density plywood strips are placed between the specimen and the plates to ensure even load distribution and avoid concentrated crushing at the contact areas. As the machine exerts a vertical compressive force over the full length of the cylinder, it generates a uniform lateral tensile stress at right angles to the plane of the vertical load.

**Table 7:- Ultrasonic Pulse Velocity Results of Concrete with Partial replacement of cement with Silicafume.**

S.No	% of Silicafume	Ultrasonic Pulse Velocity Results, m/s	
		28 days	Quality of concrete
1	0%	4469	Good
2	5%	4638	Excellent
3	7.5%	4729	Excellent
4	12.5%	4645	Excellent

**Table 8:- Ultrasonic Pulse Velocity Results of Concrete 3S Recron Fibers.**

S.No	% of 3SRF	Ultrasonic Pulse Velocity Results, m/s	
		28 days	Quality of concrete
1	0%	4469	Good
2	0.25%	4584	Excellent
3	0.5%	4691	Excellent
4	0.75%	4772	Excellent
5	1%	4704	Excellent
6	1.25%	4623	Excellent

**Table 9:- Combined Ultrasonic Pulse Velocity result of concrete.**

S.No	Combined Replacement(s)	Ultrasonic Pulse Velocity Results, m/s	
		28 days	Quality of concrete
1	0%	4469	Good
2	7.5%SF+0.75%3SRF	4882	Excellent

### V. CONCLUSION

1. The compressive strength for conventional concrete for 7 and 28 days is 26.61 and 39.43 N/mm<sup>2</sup>.
2. At 7.5% replacement of cement with silicafume the compressive strength for 7 and 28 days is 31.98 and 45.76 N/mm<sup>2</sup>.
3. At 0.75% 3S Recron fibers the compressive strength for 7 and 28 days is 29.06 and 42.24 N/mm<sup>2</sup>.
4. At 7.5%SF+0.75%3SRF the combined replacement of concrete the compressive strength for 7 and 28 days is 30.66 and 45.02N/mm<sup>2</sup>.
5. The Split tensile strength for conventional concrete for 7 and 28 days is 2.58 and 3.84 N/mm<sup>2</sup>.
6. At 7.5% replacement of cement with Silicafume the Split tensile strength for 7 and 28 days is 3.67and 5.21 N/mm<sup>2</sup>.
7. At 0.75% 3S Recron fibers the Split tensile strength for 7 and 28 days is 2.91 and 4.21 N/mm<sup>2</sup>.
8. At 7.5%SF+0.75%3SRF the combined replacement of concrete the Split tensile strength for 7 and 28 days is 3.34 and 4.72 N/mm<sup>2</sup>.
9. The Ultra pulse velocity for conventional concrete for 28 days is 4469 m/s.
10. At 7.5% replacement of cement with silicafume the Ultra pulse velocity for 28 days is 4729 m/s.
11. At 0.75% 3S Recron fibers the Ultra pulse velocity for 28 days is 4772 m/s.
12. At 7.5%SF+0.75%3SRF the combined replacement of concrete the Ultra pulse velocity for 28 days is 4882 m/s.

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