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# Experimental Study on Strength and Durability Characteristics of Fiber Reinforced SCC

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**ABSTRACT:** Self-Compacting Concrete (SCC) is an advanced type of concrete that flows under its own weight without the need for external vibration, ensuring complete compaction even in congested reinforcement conditions. The incorporation of Ground Granulated Blast Furnace Slag (GGBFS) in SCC reduces cement consumption, contributing to lower greenhouse gas emissions and making it an environmentally sustainable material. Additionally, the introduction of fibers enhances both the strength and durability properties of SCC. Experimental results indicate that the compressive strength of Fiber-Reinforced SCC (FR-SCC) increases linearly by 1.06, 1.11, and 1.13 times compared to conventional concrete for fiber percentages varying from 0 to 1.5% by weight of cementitious material. Similarly, the split tensile strength follows a linear increase of 1.05, 1.09, and 1.14 times under the same fiber dosage. The optimum fiber content for enhanced mechanical performance is identified as 1.5%, providing superior strength characteristics. Moreover, FR-SCC demonstrates improved resistance to aggressive environmental conditions compared to conventional concrete, thereby enhancing its durability.

**KEYWORDS:** Self-Compacting Concrete, Ground Granulated Slag, Fiber, Strength, Durability.

## I. INTRODUCTION

With growing population, industrialization, and urbanization, there is corresponding growth in the demand for infrastructure. Almost all concretes rely critically on being fully compacted. Insufficient compaction dramatically lowers ultimate performance of concrete in spite of good mix design. Concrete is the most widely consumed material in the world, after water. Placing the fresh concrete requires skilled operatives using slow, heavy, noisy, expensive, energy-consuming and often dangerous mechanical vibration to ensure adequate compaction to obtain the full strength and durability of the hardened concrete.

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same mechanical properties and durability as traditional vibrated concrete.

“Self-Compacting Concrete is defined as a concrete in which it is having a passing ability, filling ability and segregation resistance along with which can flow under its own weight without any application of external energy”.

Popularity of using self-compacting concrete (SCC) in concrete construction is increased in many countries, since SCC is effectively applied for improving durability of structures while reducing the need of skilled workers at the construction site. The development of Self Compacting Concrete can be assumed to be the most important one into the building material's domain. This is due to the benefits that this concrete offer: The technology of producing Self Compacting Concrete can be considered as an energy conservation process. Since the electricity consumption for vibration is eliminated; - use of Self Compacting Concretes increases the lifetime of the construction moulds and reduces the necessity of skilled workers; SCC can be used for all types of structures due to the fact that it can be pumped at long distances without any of its segregation. From the contractor's point of view, costly labour operations are avoided, improving the efficiency of the building site. The concrete workers avoid poker vibration which is a huge benefit for their working environment. When vibration is omitted from casting operations, the workers experience a

less strenuous work with significant less noise and vibration exposure. Faster placement with less labour. Very good finishing surfaces of the elements made with Self Compacting Concrete, which is a cut in remedial costs. SCC is believed to increase the durability compared to vibrated concrete (this is due to the lack of damage to the internal structure, which is normally associated with vibration). Construction practice and performance, combined with the health and safety benefits, makes SCC a very attractive solution for both precast concrete and civil engineering construction. SCC is mainly used in highly congested reinforced concrete structure in seismic region and to overcome the problem of storage of skilled labours for the efficient compaction of concrete. Review of literature indicates that durability of SCC largely depends on the type of mineral admixtures.

Despite its commendable strength and durability, concrete does possess weaknesses, with low tensile strength being one of them. To address this, reinforcement with alternative materials becomes essential. While traditional steel reinforcement bars serve this purpose, this research takes a different approach by utilizing fibers. Fiber Reinforced Concrete involves reinforcing concrete with fibers, whether they be continuous filaments or threads. Various fiber types, including steel, glass, natural, and synthetic, have been integrated into concrete. Initially, fibers were employed to counteract plastic and drying shrinkage in concrete. Over time, research and advancements have revealed that adding fibers to concrete can enhance properties such as flexural strength, compressive strength, tensile strength and post-crack strength.

## II. LITERATURE SURVEY

S.C. Kou, et al [1] studied the fresh and hardened properties of SCC using RCA as both fine and coarse aggregate states. For investigation prepared with 100% recycled coarse aggregates Three SCC mixes, and different levels of recycled fine aggregates were used to replacement of river sand and natural Coarse aggregate. The cement content was kept constant for all SCC mixtures. W/B ratios of 0.35, 0.40 and 0.44 were used. The experimental results indicate that the properties of the SCCs with river sand and crushed fine recycled aggregates showed only slight differences. The feasibility of max. utilizing fine and coarse recycled aggregates with rejected fly ash and Class F fly ash for SCC.

Venkataram Pai et al [2] have experimentally aimed at producing SCC mixes of M25 grade by using the Modified Nan Su method, incorporating five mineral admixtures. They have concluded that in the modified Nan Su method of developing SCC, the quantity of the powder mainly depends on the specific gravity and consistency of the powder itself. The SCC mix containing GGBS exhibiting greater strength could be because of the high pozzolonic activity of GGBS.

Pammar P.R. et al. [6] observed that the specimens made with 0.525% and 0.3% steel and glass fibers gives the more strength compare to other mix proportion and from normal concrete. Increase in % of glass reduces the compressive strength. Workability of normal concrete is more compare to fiber reinforced concrete; it was observed that % of steel increase means there is reduced in workability. From acid test it was observed that the specimens exposed to acid shows lesser compressive strength compare to unexposed to acid. The specimens made with 0.525% and 0.3% steel and glass fiber shows the better compressive strength compare to other specimens. And loss of weight was more in increased percentages of glass fiber.

Patil T.R. and Burile A.N. [8] in their studies concluded that the addition of steel fibers at 0.5 % by volume of concrete reduces the cracks under different loading conditions. The brittleness of concrete can also be improved by addition steel fibers than glass fibers. Since concrete is very weak in tension, the steel fibers are beneficial in axial-tension to increase tensile strength. Also, the ratio of compressive strength of cylinders to the compressive strength of cube was found to be nearly 3:4. Workability of concrete affected by addition of fibers. Addition of Steel fiber reduces workability of concrete in comparison to other fibers for different volume fraction. It was found that while using glass fiber in Split Tensile test the crack width goes on reducing with increasing of fiber dose.

Natalija and Kravanja [9] studied the Combined Effects of Metakaolin and Hybrid Fibers on Self-Compacting Concrete. The work focuses on the rheological, mechanical, morphological, and durability properties of synthetic and steel fiber reinforced self-compacting concrete (SCC) containing 5–15% metakaolin (M) by mass as a green replacement for Portland cement. The results show that a combination of metakaolin and hybrid fibers has a negative effect on the flowability of SCC. In contrast, the inclusion of M and hybrid fibers has a positive effect on the compressive and flexural strength of SCC. The fracture of SCC samples without fibers was brittle and sudden, unlike the fiber-reinforced SCC samples, which could still transfer a considerable load with increasing crack mouth opening deflection. Overall,

the chloride migration coefficients were reduced by up to 71% compared to the control mix. The chloride reduction is consistent with the resulting compact concrete microstructure, which exhibits a strong bond between fibers and the concrete matrix.

### III. METHODOLOGY

The chapter deals with the materials collection, which were used in the investigation. It also explains the various experimental investigations carried out for physical and chemical properties to understand the behavior.

#### Basic Tests on Materials

**Table 1: Tests on Cement**

Sl. No.	Tests	Results
1	Specific Gravity	3.16
2	Fineness	9.33%
3	Standard Consistency	32%
4	Initial Setting Time	40 min
5	Final Setting Time	285 min

**Table 2: Tests on Fine Aggregates**

Sl. No.	Tests	Results
1	Specific Gravity	2.36
2	Fineness Modulus	4.18
3	Water Absorption	1.0%

**Table 3: Tests on Coarse Aggregates**

Sl. No.	Tests	Results
1	Specific Gravity	2.60
2	Fineness Modulus	4.72
3	Water Absorption	0.5%

**Table 4: Property of Glass Fiber**

Physical Property	Value
Density	2.4 – 2.7 g/cc
Melting Point °C	500 - 750
Elongation at break	3 %
Moisture Regain	0 %

#### Mix design based on IS 10262:2019 for M30 grade

**Table 5: Mix parameters and their levels**

Variable	W/B Ratio	GGBFS	% of fiber added by weight of Cementitious Content
1	0.42	30 %	0 %
2			0.5 %
3			1.0 %
4			1.5 %

Cement	309.9 kg/m <sup>3</sup>
GGBFS	132.85 kg/m <sup>3</sup>
Water	200 kg/m <sup>3</sup>
Fine aggregate	714.5 kg/m <sup>3</sup>
Coarse aggregate	1024.76 kg/m <sup>3</sup>
Super Plasticizer	2.65 kg/m <sup>3</sup>
Water-cement ratio	0.42

FINAL MIX PROPORTION = 1:1.61: 2.31

#### IV. EXPERIMENTAL RESULTS

Table 6: Fresh Property Results for SCC Mixes

MIX	Fresh Property		
	Slump	J-Ring	V-Funnel @ T5 mins
Controlled SCC Mix	689	6 mm	1.9 sec
SCC + 0.5 % Fiber Vol.	681	6.8 mm	2.3 sec
SCC + 1.0 % Fiber Vol.	676	7.9 mm	2.5 sec
SCC + 1.5 % Fiber Vol.	663	8.8 mm	2.8 sec

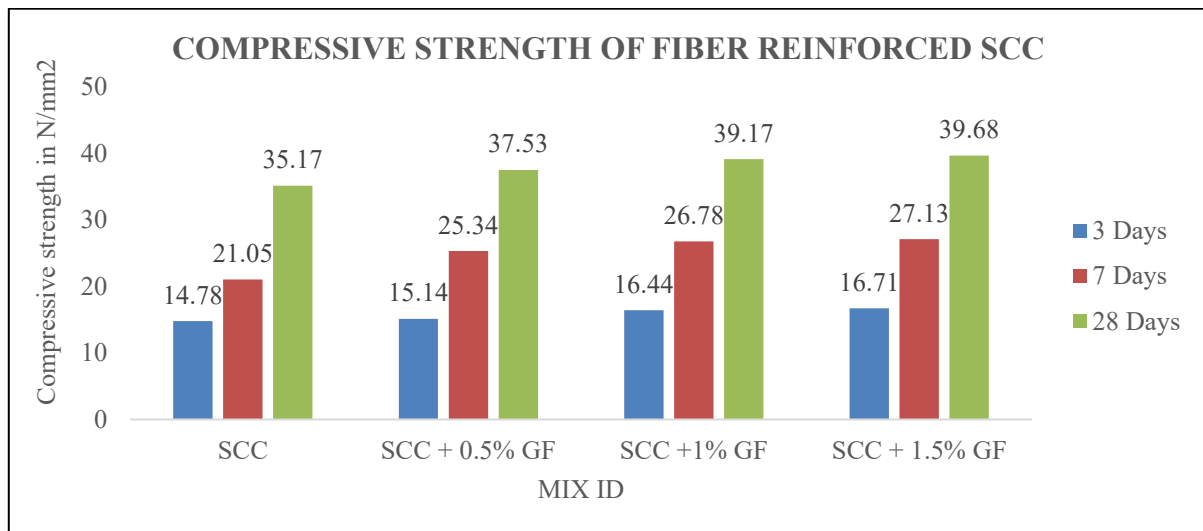
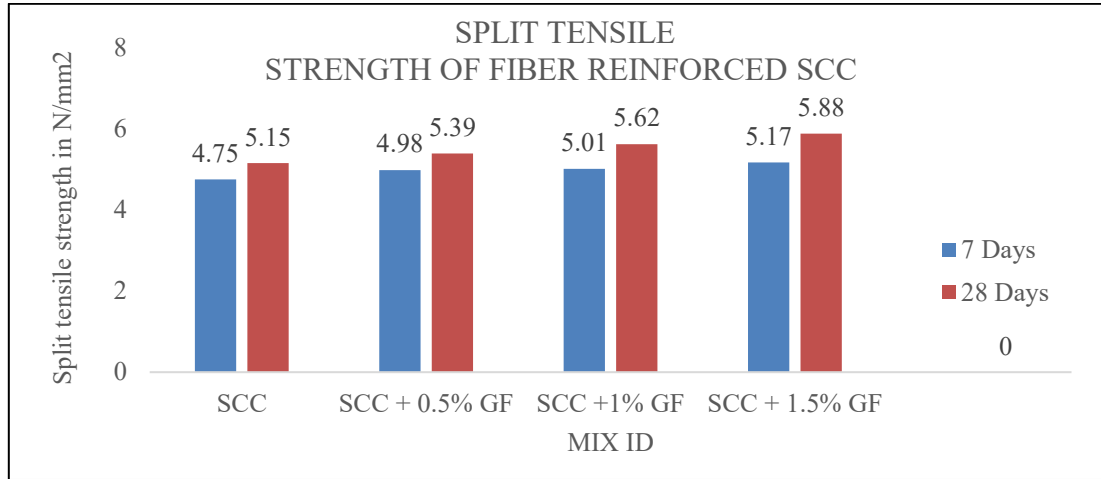


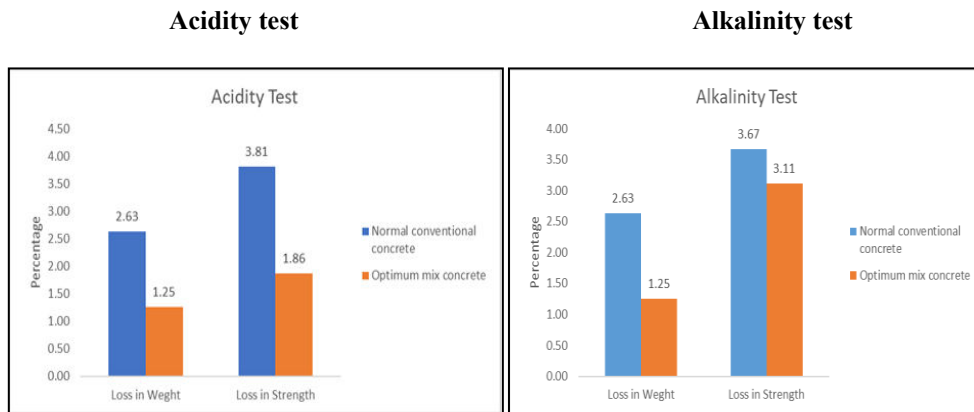
Fig1: Compressive Strength of Self Compacting Concrete with varying percentages of Glass Fiber after 3, 7 & 28 days of curing

The above graph illustrates the variation of Compressive strength of Self-compacting concrete with varying percentages of Glass fibers ranging from 0 to 1.5% by weight of cementitious content for 3, 7 & 28 days of curing. It indicates that strength value varies linearly by 1.06, 1.11 & 1.13 times than that of normal Concrete for 28 days of curing. For 1.5% replacement maximum strength is achieved among other mixes.



**Fig2: Split tensile Strength of Self Compacting Concrete with varying percentages of Glass Fiber after 7 & 28 days of curing**

The above graph illustrates the variation of Split tensile strength of Self-compacting concrete with varying percentages of Glass fibers ranging from 0 to 1.5% by weight of cementitious content for 7 & 28 days of curing. It indicates that strength value varies linearly by 1.05, 1.09 & 1.14 times than that of normal Concrete for 28 days of curing. For 1.5% replacement maximum strength is achieved among other mixes.



**Fig 3a & 3b: Acidity & Alkalinity test results**

Graph shows the variation of strength loss & weight loss in both Acidity & Alkalinity tests for Conventional SCC with 0% Glass fiber & SCC with 1.5% replacement with Glass fiber treated as Optimum Mix were tested on account of determining the Durability characteristics. It indicates that Fiber Reinforced Self-Compacting Concrete performed better under aggressive environment than compared to that of Conventional SCC.

### V. CONCLUSION

1. Incorporation of GGBFS in Self-Compacting Concrete reduces the requirement of cement content leads to possible reduction of Greenhouse Gas Emission.
2. Compressive Strength of Self-Compacting Concrete varies linearly by 1.06, 1.11 & 1.13 times than that of normal Concrete for varying fiber percentage 0 to 1.5 % by weight of cementitious content.
3. Split Tensile Strength of Self-Compacting Concrete varies linearly by 1.05, 1.09 & 1.14 times than that of normal Concrete for varying fiber percentage 0 to 1.5 % by weight of cementitious content.

4. Fiber Reinforced Self-Compacting Concrete with 1.5% of Fiber content by weight of cement shows higher strength than that of other percentages and treated as Optimum percentage of fiber addition in SCC
5. Fiber Reinforced Self-Compacting Concrete showed better results under aggressive environment than compared to that of Controlled Concrete

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