An Experimental Investigation on Self- Compacting Concrete with Addition of Glass Fiber

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***Abstract—* This study investigates the impact of incorporating 1% glass fiber into Self- Compacting Concrete (SCC), with a focus on durability, microstructure analysis, and flexural strength. Durability tests were performed to evaluate the long-term performance of fiber-reinforced SCC under different environmental conditions. Advanced imaging techniques were used for microstructure analysis to examine the internal composition and distribution of fibers within the concrete matrix. Flexural strength tests were conducted to measure the improvement in mechanical properties due to the glass fiber addition. The results indicate that adding 1% glass fiber notably enhances the durability, refines the microstructure, and boosts the flexural strength of SCC, making it a promising material for sustainable and resilient construction.**

***Index Terms-* Self Compacting Concrete, Glass Fiber, M25 Grade of Concrete, Durability Testing, SEM Analysis, Flexural strength test**

I. INTRODUCTION

Self-Compacting Concrete (SCC) is a type of concrete that flows under its own weight to completely fill the formwork, producing a dense and homogeneous material without the need for vibration. SCC contains thesame basic components as traditional concrete—cement, water, and aggregates such as sand and gravel—butincludes a higher proportion of fine aggregates and morewater-reducing agents. To prevent issues like bleeding and segregation, SCC mixtures often incorporate admixtures such as superplasticizers and viscosity modifiers. Properly designed SCC maintains its plasticity and stability, avoiding segregation and ensuring strengthwithout honeycombing.

II. OBJECTIVE

- To analyse the durability, micro structure and flexural strength of SCC which is prepared by using glass fibre 1%
- To evaluate the durability properties like water absorption test, sorptivity test, acid resistance test at the 1% of glass fibre.
- To study the micro structure of the SCC and SCC-1% GF.
- To analyse the flexural behaviour of SCC and SCC-1% GF beam.

III. MATERIALS USED

A. CEMENT

Ordinary Portland cement 53 grade cement isused. Its characteristics are given below.

TABLE 1: TEST VALUES OF OPC 53 GRADE CEMENT

CHARACTERISTICS	VALUES
CONSISTENCY	32%
FINENESS (BY SIEVE METHOD)	4%(Residue)
INITIAL SETTING TIME	33min
FINAL SETTING TIME	410min
SPECIFIC GRAVITY	3.15

B. AGGREGATES

Fine aggregate m-sand is used. Coarse aggregate 20mm size is used.

TABLE 2: TEST VALUES OF FINE AGGREGATE

CHARACTERISTICS	VALUES
SPECIFIC GRAVITY	2.507
FINENESS MODULUS	2.44

WATER ABSORPTION	1.5%
BULK DENSITY	1632.9kg/m3
GRADING ZONE	II

TABLE 3: TEST VALUES OF COARSE AGGREGATE

CHARACTERISTICS	VALUES
SPECIFIC GRAVITY	2.665
IMPACT VALUE	12.5%
CRUSHING VALUE	19.6%
WATER ABSORPTION	0.5%
BULK DENSITY	1558.5kg/m3
FINENESS MODULUS	7.54

C. WATER

The quality of water used is potable water standard which is available is the laboratory for mixing and curing which is used for reinforced concrete structures.

D. MINERAL ADMIXTURE

FLYASH

Class F fly ash obtained from thermal power plantis used for the process.

TABLE 4: TEST VALUES OF CLASS F FLYASH

CHARACTERISTICS	VALUES
CONSISTENCY	43%
FINENESS	8% (Residue)
SPECIFIC GRAVITY	2.3

E. MINERAL ADMIXTURE

Poly carboxylic ether is used. Dosage of super plasticizer is 1% of cementations material.

F. GLASS FIBER:

The glass fibre used shall be CEM FIL anticrack high -

Quality Alkali – Resistant glass fibre which is designed to reinforce cementations and other alkaline matrix.

TABLE 5: PROPERTIES OF GLASS FIBER

PROPERTIES	VALUES
LENGTH	12mm
FILAMENT DIAMETER	14microns
SPECIFIC GRAVITY	2.68
MODULUS OF ELASTICITY	72GPA

IV. MIX PROPORTION FOR M25 GRADE CONCRETE

INGREDIENTS	QUANTITY
CEMENT	300kg/m^3
FLYASH	167.5 kg/m^3
FINE AGGREGATE	895.1 kg/m^3
COARSE AGGREGATE	604.6 kg/m^3
WATER	200 litres/m^3
SUPER PLASTICIZER	3.7 litres/m^3

TABLE 6: MIX PROPORTION FOR SCC

MIX	GLASS FIBER
SCC	0
SCC-1% GF	1%

V. EXPERIMENTAL INVESTIGATION

5.1 TESTING FOR DURABILITY PROPERTIESOF SCC

Concrete durability is defined as “the ability of concrete to resist weathering action, chemical attack, abrasion, and other conditions of service.” Tests such asacid resistance test, sulphate attack test, water absorption test, chloride attack test and sorptivity are commonly specified.

5.1.1 WATER ABSORPTION TEST

Cubes of size 100mm were cast for two different mixes. All specimens were removed 24 hours after casting and subsequently water cured for 15, 30 days. Samples were removed from water and wiped out any traces of water with damp cloth and difference in weightwas measured.

TABLE 7 WATER ABSORPTION TEST RESULT

SPECIMEN	AGE OF CONCRETE	AVERAGE WATER ABSORPTION (%)
SCC	15 days	2.05
	30 days	2.1
C-1%GF	15 days	1.998
	30 days	2.062

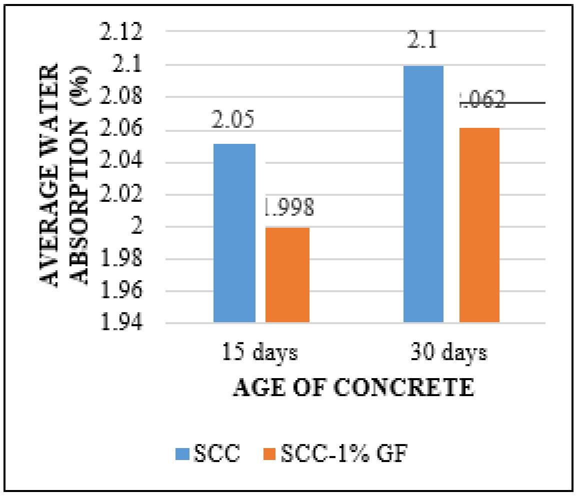


FIG 1 WATER ABSORPTION TEST GRAPH

5.1.1 ACID RESISTANCE TEST (HCl)

The concrete cube specimens of various concrete mixtures of size 100 mm were cast and cured and the specimens were removed from the curing tank and allowed to dry for one day. The weights of concretecube specimen were taken. The acid attack test on concrete cube was conducted by immersing the cubes inthe acid water for the age of 15, 30 days. Hydrochloric acid (HCl) with pH of about 2 at 5% weight of water wasadded to water in which the concrete cubes were stored.

TABLE 8 DECREASE IN WEIGHT AFTER ACID ATTACK RESULT

SPECIMEN	AGE OF CONCRETE	AVERAGE DECREASE IN WEIGHT (%)
SCC	15 days	2.521
	30 days	2.459
SCC-1% GF	15 days	2.498
	30 days	2.517

FIG 2 DECREASE IN WEIGHT AFTER ACID ATTACK GRAPH

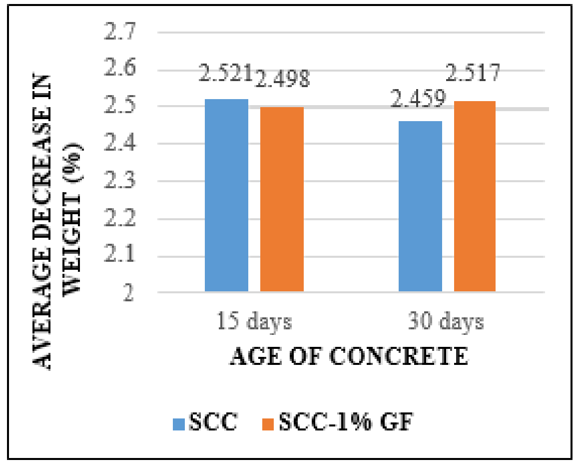


TABLE 9 LOSS OF COMPRESSIVE STRENGTHAFTER ACID ATTACK (HCl)

SPECIMEN	AGE OF CONCRETE	AVERAGE DECREASE IN STRENGTH AFTER ACID ATTACK (N/mm^2)	RESIDUAL STRENGTH (N/mm^2)
SCC	15 days	12.48	87.52
	30 days	13.21	86.79
C-1%GF	15 days	14.02	85.98
	30 days	13.03	86.97

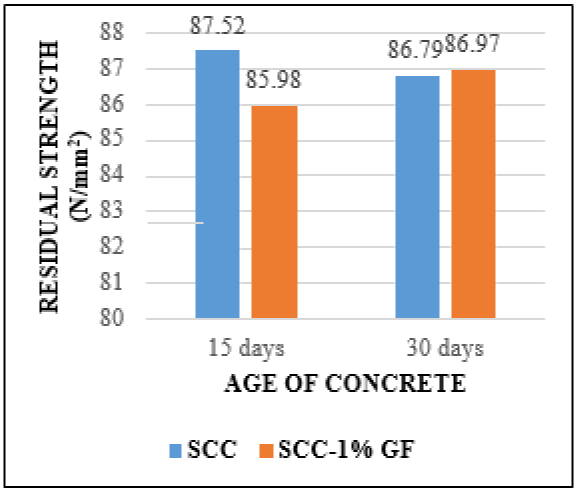


FIG 3 LOSS OF COMPRESSIVE STRENGTH AFTER ACID ATTACK (HCl) GRAPH

5.1.1 SULPHATE ATTACK TEST (Na2SO4)

The resistance of concrete to sulphate attacks was studied by determining the loss of compressive strength or variation in compressive strength of concrete cubes immersed in sulphate water having 5% of sodium sulphate (Na2SO4) by weight of water and those which are not immersed in sulphate water. The concrete cubes of 100mm size were cured and dried for one day were immersed in 5% Na2SO4.The concentration of sulphate water was maintained throughout the period.

TABLE 10 DECREASE IN WEIGTH AFTER SULPHATE ATTACK RESULT

SPECIMEN	AGE OF CONCRETE	AVERAGE DECREASE IN WEIGHT (%)
SCC	15 days	2.056
	30 days	2.125
SCC-1% GF	15 days	2.038
	30 days	2.116

FIG 4 DECREASE IN WEIGTH AFTER SULPHATE ATTACK GRAPH

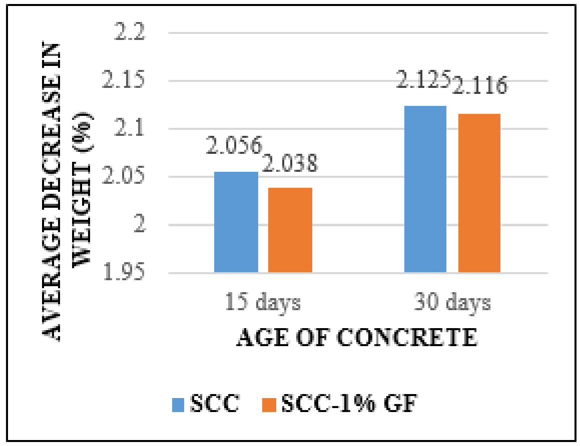


TABLE 11 LOSS OF COMPRESSIVE STRENGTH AFTER SULPHATE ATTACK (Na2SO4)

ECIMEN	AGE OF CONCRETE	AVERAGE DECREASE IN STRENGTH AFTER ATTACK (N/mm²)	RESIDUAL STRENGTH (N/mm²)
SCC	15 days	13.21	86.79
	30 days	13.87	86.13
C-1%GF	15 days	12.59	87.41
	30 days	12.73	87.27

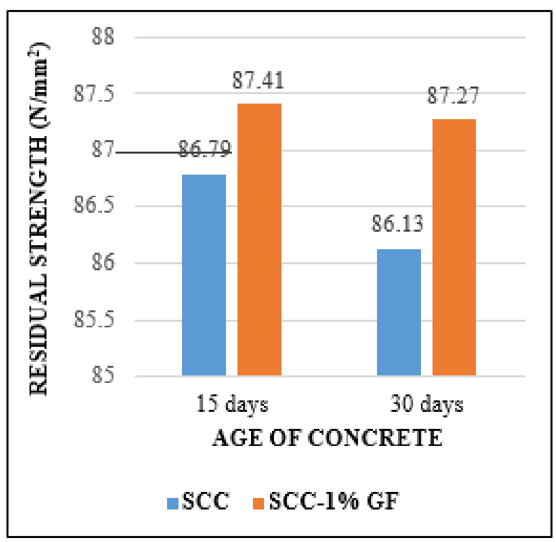


FIG 5 LOSS OF COMPRESSIVE STRENGTH AFTER SULPHATE ATTACK (Na2SO4) GRAPH

5.1.1 SORPTIVITY

Sorptivity test for cylinder discs at 30days forfour specimens were conducted as per ASTM C1585-13.

$S = I/t^{0.5}$

Here S= sorptivity in mm, t = elapsed time in minutes

$I = \Delta w/Ad$

Δw = change in weight = W2-W1; A = surface area of the specimen reference through which water penetrated;d= density of water.

FIG 6 SORPTIVITY TEST FOR SCC (SPECIMEN- 1) @ 30 DAYS RESULT CHART

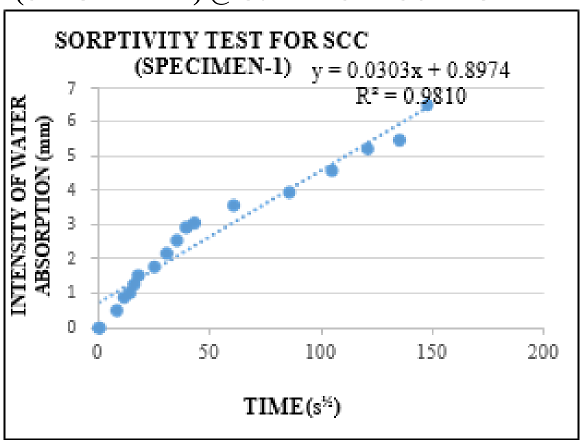


FIG 7 SORPTIVITY TEST FOR SCC (SPECIMEN- 2) @ 30 DAYS RESULT CHART

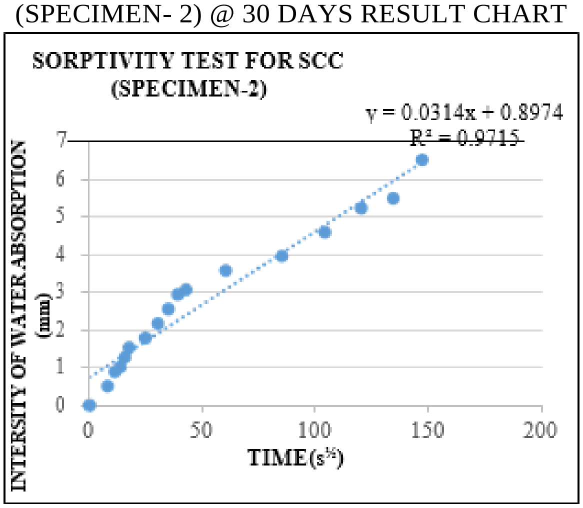


FIG 7 SORPTIVITY TEST FOR SCC (SPECIMEN-2) @ 30 DAYS RESULT CHART

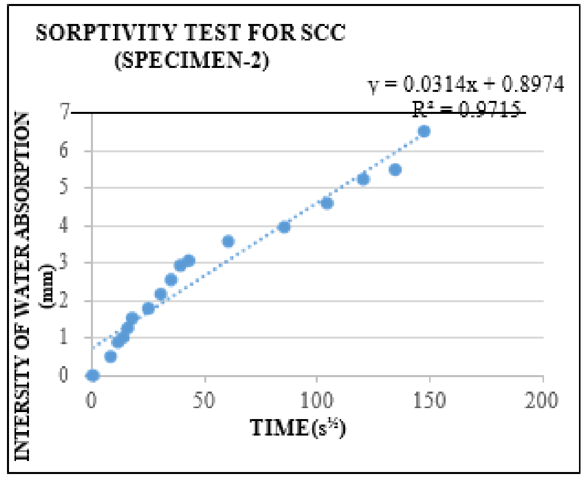


FIG 8 SORPTIVITY TEST FOR SCC-1% GF (SPECIMEN-1) @ 30 DAYS RESULT CHART

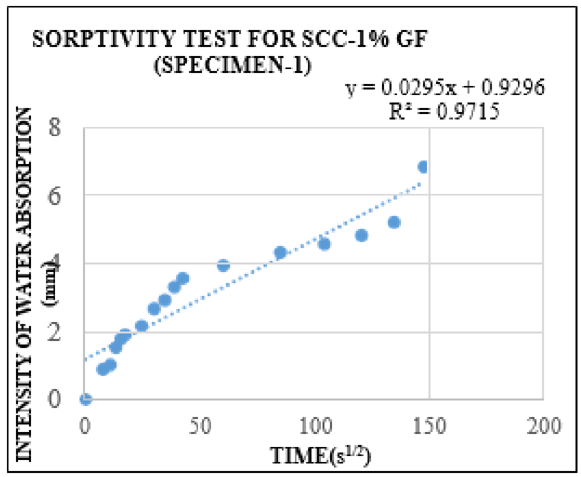


FIG 9 SORPTIVITY TEST FOR SCC-1% GF (SPECIMEN-2) @ 30 DAYS CHART

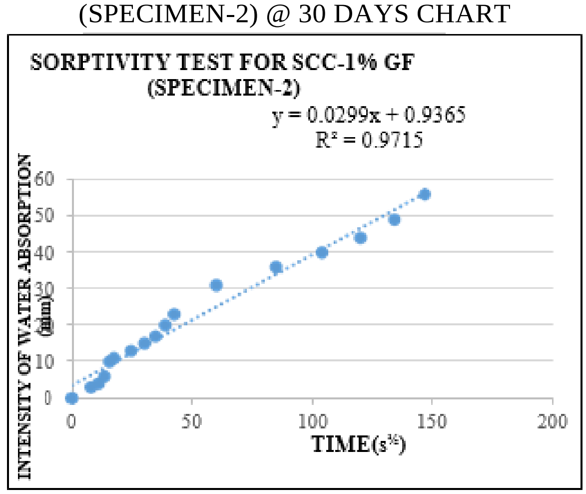
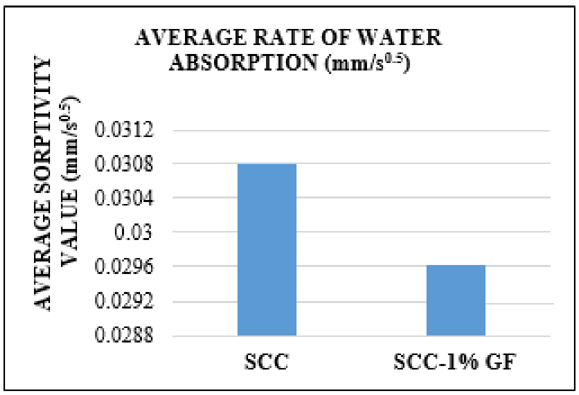


TABLE 12 AVERAGE RATE OF ABSORPTION RESULT

Mix	SORPTIVITY VALUE FOR SPECIMEN 1 (mm/s$^{0.5}$)	SORPTIVITY VALUE FOR SPECIMEN 2 (mm/s$^{0.5}$)	AVERAGE SORPTIVITY VALUE (mm/s$^{0.5}$)
SCC	0.0303	0.0314	0.0308
SCC - 1% GF	0.0295	0.0299	0.0297

FIG 10 AVERAGE RATE OF ABSORPTION RESULT GRAPH



5.2 MICRO STRUCTURE ANALYSIS

5.2.1 SEM ANALYSIS OF SCC

When comparing Self-Compacting Concrete (SCC) with and without 1% glass fiber using SEM analysis, you will observe differences in microstructural features and performance characteristics due to the presence of glass fibers.

- SCC typically exhibits a well-distributedmatrix with a dense and uniform microstructure due to its high workability andlack of segregation.
- SEM can reveal hydration products such as calcium silicate hydrate (C-S-H) gel, which contributes to the strength and stability ofSCC. The morphology and distribution of these products help in understanding the hydration process.

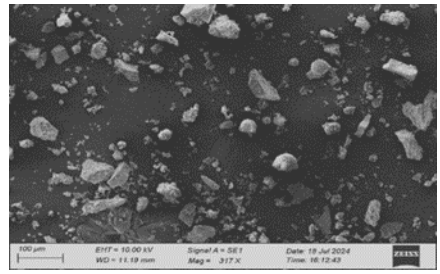


FIG 11 SEM IMAGES OF SCC

5.2.2 SEM ANALYSIS OF SCC-1% GF

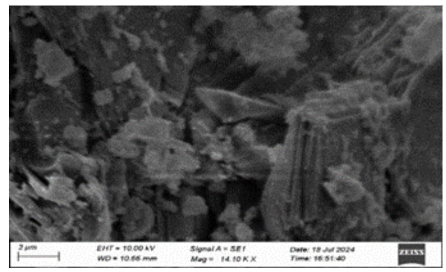


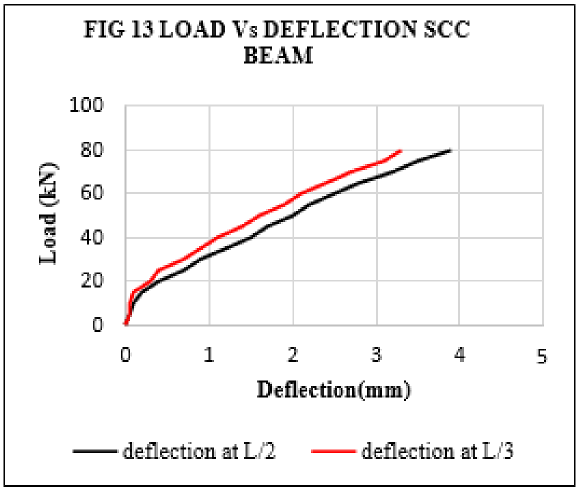
FIG 12 SEM IMAGES OF SCC-1% GF

- SEM images would reveal the dispersion of glass fibers throughout the concrete matrix. Ideally, the fibers should be well-distributed and not clumped together.
- The addition of glass fibers, can improve the properties of the Interfacial Transition Zone (ITZ) by enhancing the bonding between the aggregate and the cement paste and increasing resistance to crack propagation.

5.3 FLEXURAL BEHAVIOR OF BEAM

The flexural behavior of concrete wasdetermined according to Indian Standard 516:1959. The specifications are:

- Size of beam: 1000 mm x 150 mm x 150mm
- Top reinforcement: 2 nos' of 10mm diameter bars
- Bottom reinforcement: 2 nos' of 12mm diameter bars
- Shear reinforcement: 6mm # 2 legged stirrups @ 150 mm C/C
- Cover block: 25 mm
- Grade of steel: Fe500 HYSD



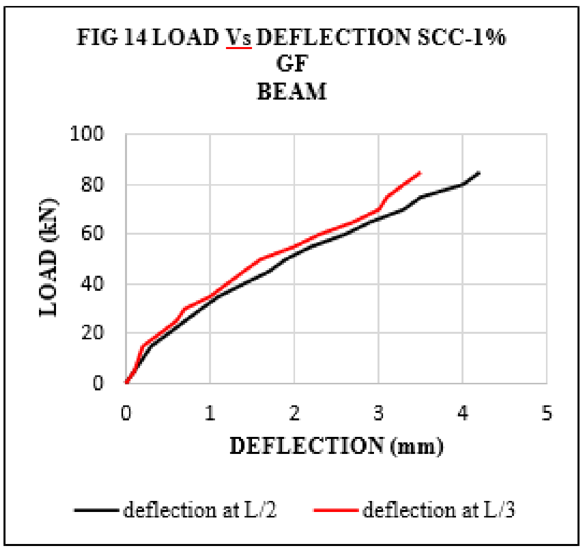


TABLE 13 TEST RESULTS FOR SCC & SCC-1%GF BEAM

PARAMETER	SCC	SCC-1% GF
FIRST CRACK	35kN	40kN
ULTIMATE LOAD	80kN	90kN
MAX DEFLECTION	3.9mm	4.3mm

CONCLUSION

- The optimal fiber content was found to be around 1% by volume, providing a good balance between improved performance and workability.
- Water absorption decreases in SCC-1% GF when compared to SCC of about 4%.
- After an acid attack test, SCC-1% GF exhibits about 1.75% higher compressive strength compared to SCC specimens.
- Compared to SCC specimen, the SCC-1% GF specimen's shows greater compressive strength of about 1.32% after sulphate attack test.
- From the sorptivity test results, the rate of absorption of SCC -1% GF specimen is less than SCC specimen of about 2.5%. Lower sorptivity indicates better resistance to water ingress.
- SEM analysis of Self-Compacting Concrete (SCC) and SCC with 1% glass fiber addition provides important insights into their microstructure, distribution, and bonding characteristics.
- In SCC-1% GF beam, the ultimate load is increased by 1.125 times in comparison with SCC.
- SCC-1% GF beam shows less deflection than the SCC beam. Incorporating 1% glass fiber into self-compacting concrete can improve its flexural strength and decrease deflection, resulting in a stronger material suitable for structural uses.

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