Combined Effect of Silica Fumes and Glass Fiber in Standard Grade Concrete

Mohammad Rizwan[1]* G. Srikanth[2]

[1]PG Student Structural Engineering, Sindhura College of Engineering & Tech, Ramagundam, Kaimnagar

[2]Assistant Professor, Dept. of Civil Engineering, Sindhura College of Engineering & Tech, Ramagundam, Kaimnagar

Abstract – Concrete, the most widely used construction material has several desirable properties like high compressive strength, stiffness, durability under usual environmental factors. At the same time concrete is brittle and weak in tension. Efforts are being made in the field of concrete technology to develop high performance concretes by using fibers and other admixtures in concrete up to certain proportions. Over the decades, there has been a significant increase in the use of fiber and silica fume in concrete for improving its properties. The addition of silica fume depicts early strength gaining property and that of glass fiber control the cracking due to shrinkage. The study has been made to evaluate the effect on fresh properties and mechanical properties of M25 grade concrete made with the partial replacement of cement with silica fume at percentages as 5%, 10% and 15% with glass fiber of 6mm length at various percentages as 1%, 2% and 3% by the volume of cement. For each mix, standard sizes of cubes(150mm X 150mm X 150mm) were casted and tested for compressive strength at the age of 7, 14 and 28 days. The obtained values can be compared with the corresponding value of conventional concrete. The addition of silica fume shows early strength gaining property and that of glass fiber control the cracking due to shrinkage. The results are satisfactory for the use of 10% silica fume and 2% glass fiber in conventional M25 Concrete.

Keywords: Silica Fume (SF), Glass Fiber (GF), Concrete, Compressive Strength, Tensile Strength

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1. INTRODUCTION

Concrete is one of the most versatile building materials. It can be cast to fit any structural shape from a cylindrical water storage tank to be rectangular beam or column in a high-rise building. Conventional concrete is composed of aggregates (sand, gravel), cement, water and admixtures where it is necessary. Concrete with a uniform structure, good plasticity and the ability of deformation by form, sound and thermal insulation and the capability of quality development by admixtures, is getting more and more popular in structural industries every day. Considering all the concrete benefits, we cannot deny its weaknesses. The first fundamental problem of concrete is low tensile strength which is approximately 10%-15% of its compressive strength nevertheless this crucial problem can be solved by the reinforcement. In addition, reinforcement must be calculated to prevent brittle failure in order to have plastic behavior; the maximum standards must be respected to prevent corrosion of reinforcement.

The advantages of using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance, and long service life. The major disadvantage is that concrete develops micro cracks during curing. It is the rapid propagation of these micro cracks under applied stress that is responsible for the low tensile strength of the material. Hence fibers are added to concrete to overcome these disadvantages.

The initial interest in the use of silica fume was mainly caused by the strict enforcement of air-pollution control measures in various countries to stop release of the material into the atmosphere. Silica fume is a pozzolanic material which is a by-product of the silicon smelting process. Silica fume is known to produce a high strength concrete and is used in two different ways: as a cement replacement, in order to reduce the cement content and as an additive to improve concrete properties. Therefore, utilization of silica fume together with glass fiber provides an interesting alternative and can be termed as high strength concrete. The use of fiber in concrete increases the mechanical properties such as compressive strength. It also possesses the ability to reduce plastic shrinkage in concrete.

2. MATERIALS USED

2.1 Cement

Cement is the one of the binding materials in this project. 53 grade Ordinary Portland Cement conforming to **IS: 8112-1989.**

Properties	Values	Requirement as per IS 8112-1989
Initial setting time (min)	60	Min. 30
Final setting time (min)	300	Max. 600
Fineness (m^2/kg)	412.92	Min. 225
Specific Gravity	3.15	3.10-3.15

Table 1: Properties of Cement

2.1.1 The physical properties of cement

- Setting Time
- Soundness
- Fineness
- Strength

2.2 Silica Fume

Silica fume, also known as microsilica is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm.

Figure 1: Silica Fume

Properties	Values
Specific Gravity	2.2
Bulk Density	576, (kg/m^3)
Surface Area	20,000 (m^2/kg)
Sio2	(90-96)%
Al_2O_3	(0.5-0.8)%
Size (macron)	0.1

Table 2: Properties of Silica Fume

2.3 Fine aggregate

Natural river sand was used as fine aggregate. The properties of sand were determined by conducting tests as per **IS: 383-1970(Part-3).**

Tests	Values
Specific gravity	2.61
Water Absorption%	0.82
Fineness modulus	2.52

Table 3: Properties of fine aggregate

2.4 Glass Fiber

Glass Fiber available in the market was used in this experimentation. The length of the fiber is 6mm and the diameter of 14μ.

Figure 2: Glass Fiber

Properties	Values
Density in t/m3	2.6
Elastic Modulus GPa	72
Tensile Strength in MPa	1700
Diameter in microns	14
Length in mm	6
Specific gravity	2.6
No. of fibers in m/kg	212
Electrical conductivity	Very low
Chemical resistant	Very high
Aspect ratio	857

Table 4: Properties of Glass Fiber

2.5 Coarse aggregate

The coarse aggregate of 20 mm size was used. Test results listed below conforming **IS: 383-1970(Part-3).**

Tests	Values
Specific gravity	2.65
Water absorption%	0.19
Fineness modulus%	6.98

Table 5: Properties of Coarse aggregate

2.6 Water

Portable water free from impurities and salt used for casting and curing the concrete blocks as per **IS: 456-2000.**

3. EXPERIMENTAL PROCEDURE

3.1 Mix Proportions

In this study, silica fume was used to replace OPC 53 of M25 grade cement at various levels of 5%, 10% and 15% and the glass fiber of 1%, 2% and 3% were used with water cement (W/C) ratio 0.5.

3.2 Casting of Specimen

Initially the dry materials cement, aggregate, & sand are mixed. The liquid component of the mixture was then added to the dry materials and mixing continued for further about 3-6 minutes to manufacture the fresh concrete. The fresh concrete was cast into the moulds immediately after mixing, in three layers for cube specimens. For compaction of the specimens each layer was given 60-70 manual strokes using a tapping rod, and then vibrated for 12-15 seconds on a vibrating table. Before the fresh concrete was cast into the moulds, the slump and compaction factor was observed.

3.3 Curing of Specimen

After completion of casting process wait for 24 hours and open the moulds, take the blocks and dry it for 1-2 hours. Then after take Portable water free from impurities and salt used for curing the concrete blocks for 7, 14 and 28 days.

4. TESTING PROCEDURE

An intensive experimental program is performed to study the effect of internal curing on different types of concrete properties

1. Fresh properties(slump, compaction factor)
2. Mechanical properties like compressive strength and tensile strength

S. No	%Replacement		Fresh properties	
	GF%	SF%	Slump in mm	Compaction Factor
1	1	5	90	0.91
2	1	10	85	0.87
3	1	15	80	0.83
4	2	5	100	0.84
5	2	10	100	0.91
6	2	15	90	0.81
7	3	5	87	0.89
8	3	10	70	0.83
9	3	15	60	0.81

Table 6: Values of Slump and Compaction Factor

The cubes were tested under 200 tons compression testing machine to study the compressive strength of the cubes.

4.1 Compressive Strength Test

At the time of testing, each specimen must keep in compressive testing machine. Size of the test specimen is 150mm*150mm*150mm. The maximum load at breakage of concrete block has been observed. From the observed values the compressive strength has been calculated by using formula

Compressive strength = load / area

5. TEST RESULTS

Ratio for special concrete and compressive strength of concrete listed in table no.7 and tensile strength in table 8

Figure 3: Compressive Testing Machine

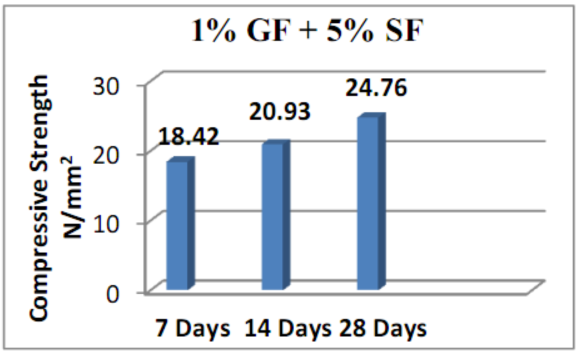
S.No	% Replacement		Compressive Strength N/mm^2		
	GF%	SF%	7Days	14Days	28 Days
1	0	0	16.05	21.02	27.35
2	1	5	18.42	20.93	24.76
3	1	10	20.58	22.35	26.42
4	1	15	22.14	24.36	28.04
5	2	5	21.96	23.72	27.22
6	2	10	22.98	26.47	29.42
7	2	15	19.49	21.56	26.54
8	3	5	20.86	23.05	24.02
9	3	10	19.58	22.35	23.86
10	3	15	18.42	20.07	22.49

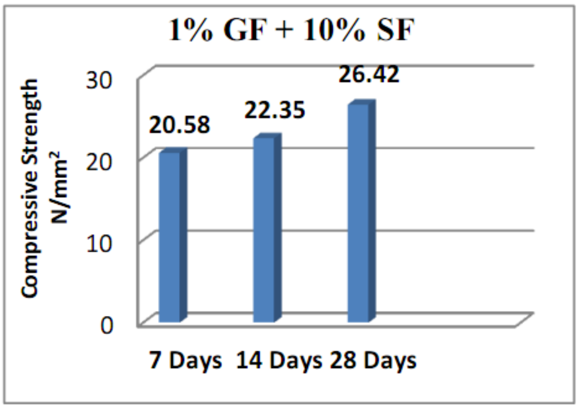
Table 7: Compressive Strength Test Result

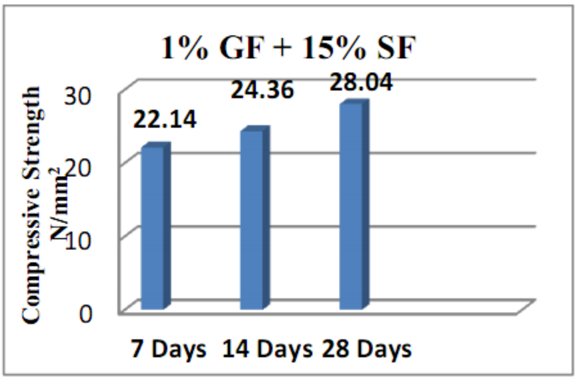
Tensile strength (N/mm2)				
GF%	SF%	7Days	14Days	28 Days
0	0	2.804	3.209	3.661
1	5	3.004	3.202	3.483
1	10	3.176	3.309	3.598
1	15	3.294	3.455	3.707
2	5	3.280	3.409	3.652
2	10	3.356	3.601	3.797
2	15	3.090	3.250	3.606
3	5	3.197	3.361	3.431
3	10	3.097	3.309	3.419
3	15	3.004	3.136	3.320

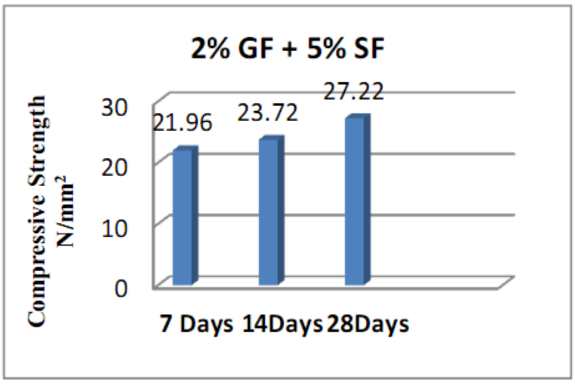
Table 8: Tensile strength test results

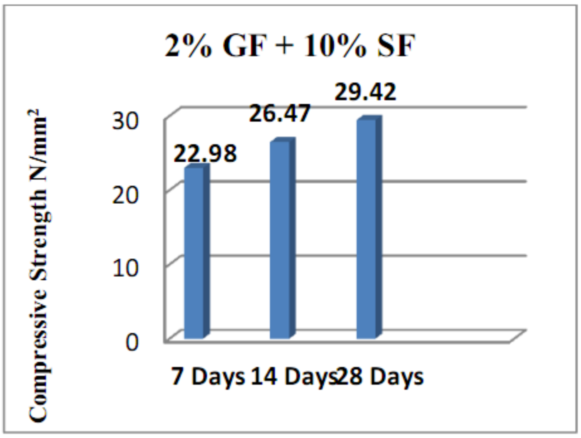
Compressive strength Graphs

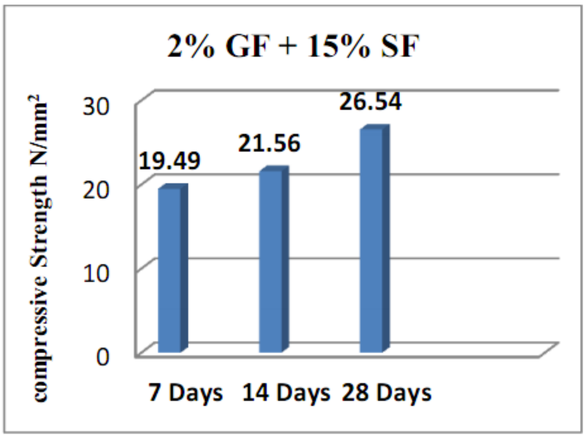


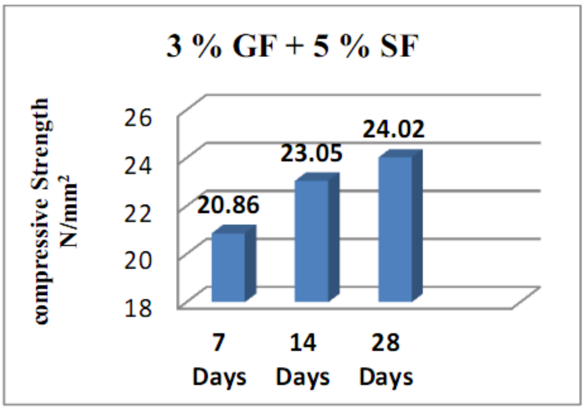


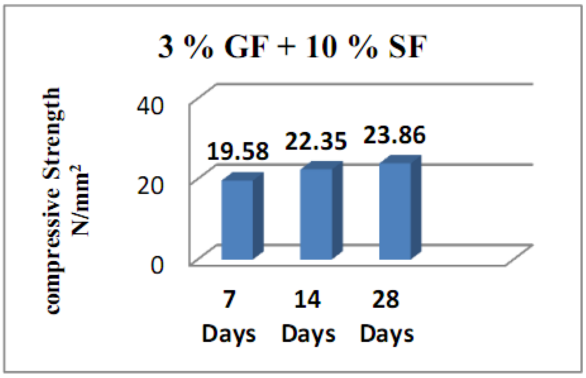


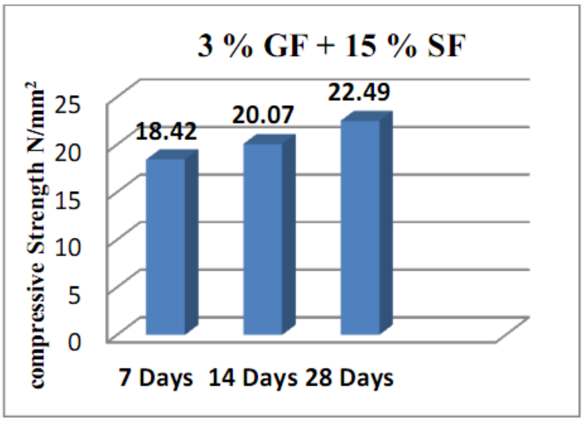




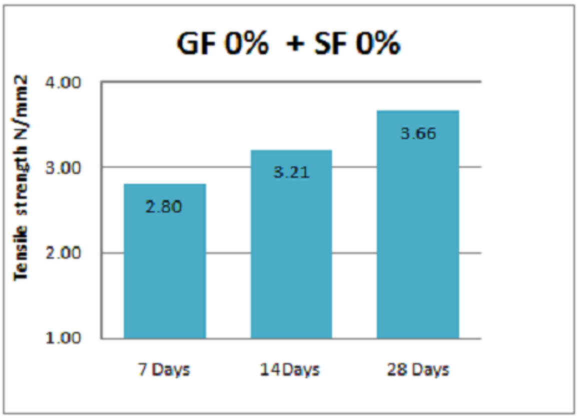


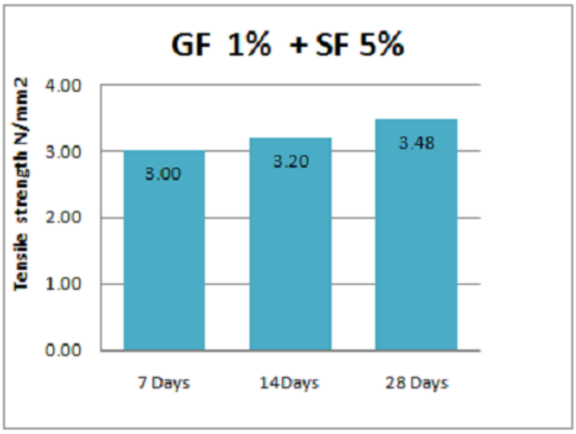


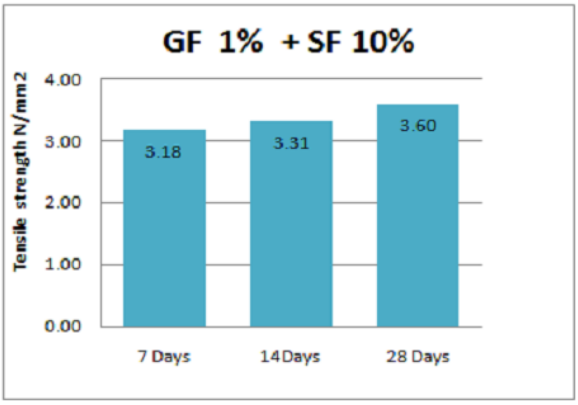


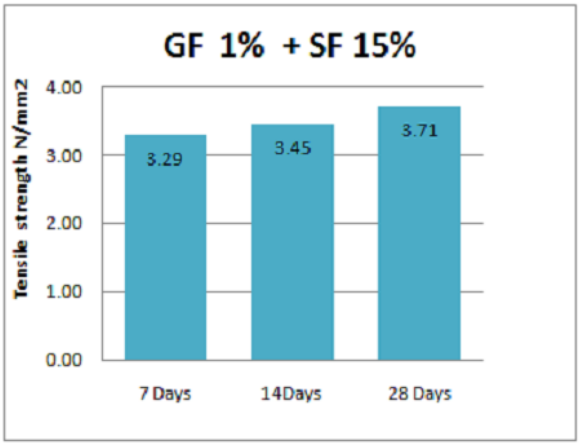


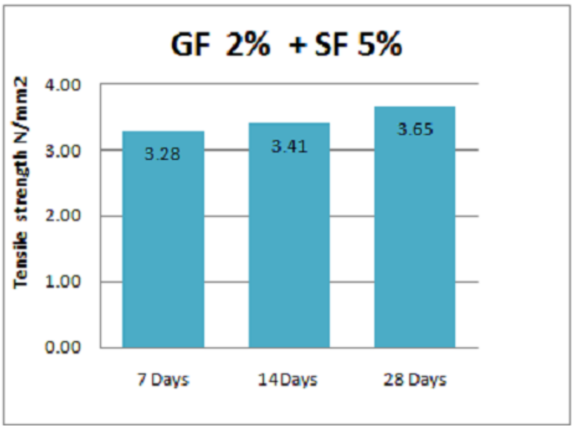
Tensile Strength

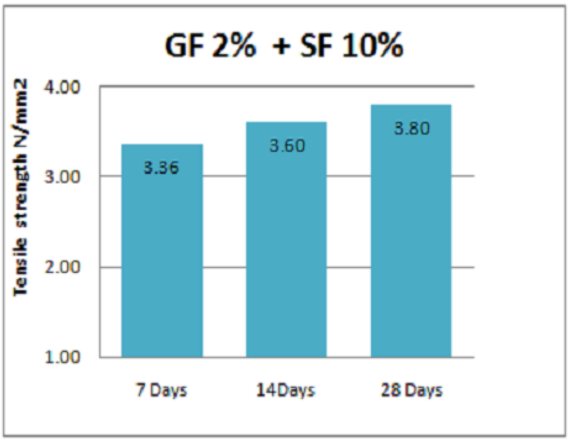


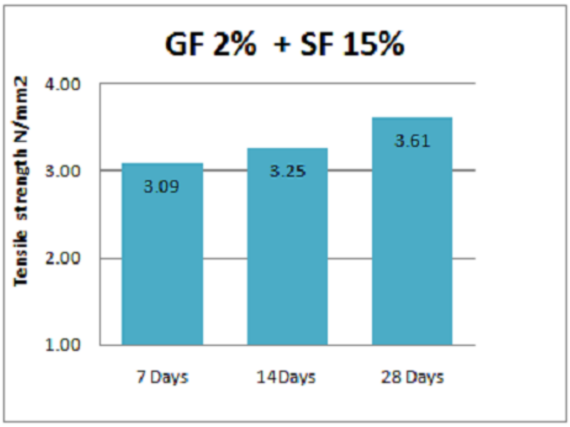


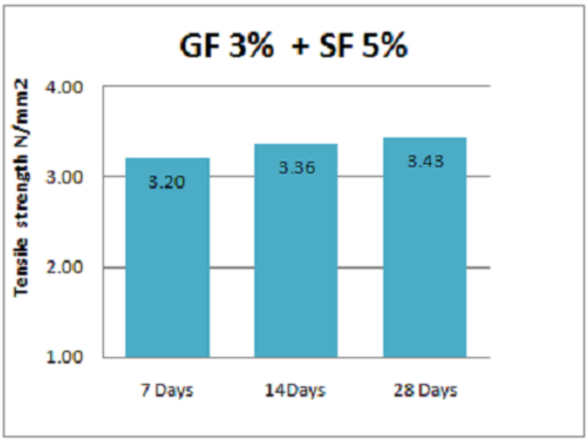

GF 1% + SF 10%
Tensile strength N/mm2
4.00
3.00
2.00
1.00
0.00
3.18
3.31
3.60
7 Days
14Days
28 Days

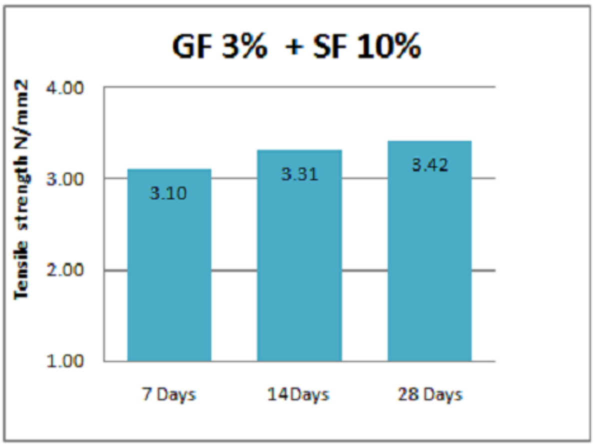

GF 1% + SF 15%
Tensile strength N/mm2
4.00
3.00
2.00
1.00
0.00
3.29
3.45
3.71
7 Days
14Days
28 Days

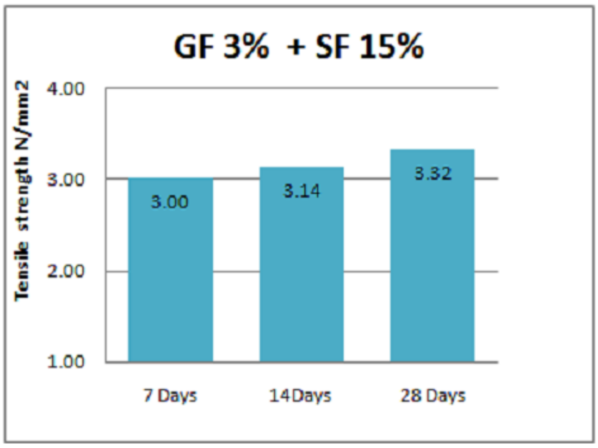

GF 2% + SF 5%
Tensile strength N/mm2
4.00
3.00
2.00
1.00
0.00
3.28
3.41
3.65
7 Days
14Days
28 Days


GF 2% + SF 10%
Tensile strength N/mm2
4.00
3.00
2.00
1.00
3.36
3.60
3.80
7 Days
14Days
28 Days


GF 2% + SF 15%
Tensile strength N/mm2
4.00
3.00
2.00
1.00
3.09
3.25
3.61
7 Days
14Days
28 Days


GF 3% + SF 5%
Tensile strength N/mm2
4.00
3.00
2.00
1.00
3.20
3.36
3.43
7 Days
14Days
28 Days


GF 3% + SF 10%
Tensile strength N/mm2
4.00
3.00
2.00
1.00
3.10
3.31
3.42
7 Days
14Days
28 Days


GF 3% + SF 15%
Tensile strength N/mm2
4.00
3.00
2.00
1.00
3.00
3.14
3.32
7 Days
14Days
28 Days

CONCLUSION

The major objective of this experimental investigation is to use silica fume and glass fiber in M25 Grade Concrete by reducing the cement content. Based on the present investigation the following conclusions are drawn:

- With the increase of percentage of Silica Fume and Glass Fiber by weight of Cement, the strength of the Concrete increases.
- Cracks could be controlled with addition of glass fiber within the optimum dosage. Excessive addition i.e., greater than 2% of glass fiber leads to crack due to the presence of voids in concrete.
- The percentage increase in compressive strength at 7 days, 14 days and 28 days of 10% silica fume with 2% glass fiber are 22.98 N/mm^2, 26.47 N/mm^2 and 29.42 N/mm^2 and tensile strength is 3.356 N/mm^2,3.601 N/mm^2,3.797 N/mm^2
- Glass fiber also helps in controlling shrinkage cracks and silica fume helps in achieving early strength gaining property.

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Corresponding Author

Mohammad Rizwan*

PG Student Structural Engineering, Sindhura College of Engineering & Tech, Ramagundam, Kaimnagar

E-Mail – ssohaan@gmail.com