INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 2)
Available online at: www.ijariit.com

A study of concrete as patialy replacment of cement with silica fume made with glass fiber

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ABSTRACT

Extensive experimental investigation on glass fibre reinforced concrete was carried out by researchers. Glass fibre mesh is more effective in resisting bending and punching shear. Steel Fibres are most popular metallic fibres used for the production of Steel Fibre Reinforced Concrete particularly from the point of view of strength and ductility. It is observed that studies showed Glass Fibre Reinforced Concrete mixes provide improvement of high performance and high strength concretes. The present thesis would contribute to the efforts being made in the field of concrete technology towards development of concretes possessing very much enhanced and special durable properties. Based on the study, valuable advice will be given for concrete structures. It is observed from the experimental results and its analysis, that the compressive strength of concrete, splitting tensile strength of concrete increases with addition of low Percentage of glass fibers. The 0.2%, 0.45% and 0.7% addition of glass fibres into the concrete shows better result in mechanical properties and durability.

Addition of 0.2% glass fibres by weight of cement shows maximum increase in Compressive strength and Flexural strength varying 18% to 20%, and 15% to 20% respectively with respect to PC mix without fibres at 28 days of curing. The durability of concrete from the aspect of resistance to acid attack on concrete increases by adding AR-glass fibres in concrete .The glass fibres bridge across the cracks causing interconnecting voids to be minimum. UPV value found to be higher for concrete containing 0.45%GF by weight of cement. The value was 4.85 and 5.1 (km/sec.) at 56 and 90 days of curing respectively. The concrete mix containing 0.7%GF by weight of binder showed higher resistance against weight loss in H_2SO_4 solution i.e.0.69% compared with control mix of concrete without glass fibres.

Keywords: *Silica fume, Glass fiber, Workability, Compressive strength, Tensile strength, Durability.*

1. INTRODUCTION

The present day world is witnessing the construction of very challenging and difficult civil engineering structures. Quite often, concrete being the most important and widely used material is called upon to possess very high strength and sufficient workability properties. Efforts are being made in the field of concrete technology to develop such concretes with special characteristics. Researchers all over the world are attempting to develop high performance concretes by using fibres and other admixtures in concrete up to certain proportions.

In the view of the global sustainable developments, it is imperative that fibres like glass, carbon, polypropylene and aramid fibres provide improvements in tensile strength, fatigue characteristics, durability, shrinkage characteristics, impact, cavitation, corrosion resistance and serviceability of concrete.

Fibre reinforced concrete (FRC) is a concrete made primarily of hydraulic cements, aggregates and discrete reinforcing fibres. FRC is a relatively new material. This is a composite material consisting of a matrix containing a random distribution or dispersion of small fibres, either natural or artificial, having a high tensile strength.

2. MATERIALS USED

2.1 Cement

Ordinary Portland cement (OPC) from a single lot was used throughout the course of the investigation. The physical properties of the cement as determined from various tests 30 conforming to Indian Standard IS: 1489-1991(Part-1) are listed in Table 3.1. All the tests were carried out as per recommendations of IS: 4031-1988. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture

Table 3.1 properties of OPC

Characteristic Properties	Observed Value	Codal Requirements IS:8112-1989(Part 1)
Fineness (m^2/kg)	300	225 minimum
Standard consistency (%)	32	---------------
Initial Setting time (minutes)	62 minutes	30 Minimum
Final setting time (minutes)	270	600 Maximum
Specific gravity	3.15	--------------
Compressive strength (MPa) 3 days 7-days 28-days	24.6 34.3 45.2	23 Minimum 33 Minimum 43 Minimum

2.2 Coarse Aggregate

Crushed angular granite metal from a local source was used as coarse aggregate. The specific gravity was 2.71, flakiness index of 4.58 percent and elongation index of 3.96.

2.3 Fine Aggregate

River sand was used as fine aggregate. The specific gravity and fineness modulus was 2.55 and 2.93 respectively. Crushed angular granite metal from a local source was used as coarse aggregate. The specific gravity was 2.71, flakiness index of 4.58 percent and elongation index of 3.96.

2.4 Glass Fiber

The glass fibres used are of Cem-FIL Anti-Crack HD with modulus of elasticity 72 GPa, Filament diameter 14 microns, specific gravity 2.68, length 12 mm and having the aspect ratio of 857, the number of fibres per kg is 212 million fibres.

2.5. Admixtures

Water-reducing and set-retarding admixtures are permitted in order to increase the workability of the concrete and to extend the time of discharge from 60 to 90 minutes. Super plasticizer CONPLAST SP 430 is a chloride free workability retention admixture based on selected organic polymers. Designed to provide workability retention where rapid workability loss is caused by high ambient temperatures or to compensate for delays in transportation

3. MIX PROPORTIONS

Table 3.2 Mix details

MIX	OPC (%)	SILICA FUME (%)	GLASS FIBRE (%)
M1	90%	10%	0.0%
M2	90%	10%	0.2%
M3	90%	10%	0.45%
M4	90%	10%	0.7%
M5	90%	10%	0.8%
M6	90%	10%	1.0%
M7	90%	10%	1.5%
M8	90%	10%	2.0%

4. RESULT AND DISCUSSION ON EXPERIMENTAL TESTS

4.1 Workability & Compaction factor of Concrete Mixes

The workability of concrete mixes was found out by slump test as per procedure given in chapter 3. w/b ratio was kept constant 0.4 for all the concrete mixes. Super-plasticizer SP 430 was used to maintain the required slump. Dosage of super-plasticizer was varied from 1.0% to 1.25% by weight of binder depending up on the type of mix. The workability results of different concrete mixes were shown in Table 4.1

Table 4.1 Workability values for different concrete mixes

Mix no.	Description	Super plasticizer (%) by weight of binder	Slump (mm)
1	90%OPC+10%SF+0%GF	1.00	110
2	90%OPC+10%SF+0.2%GF	1.00	100
3	90%OPC+10%SF+0.45%GF	1.00	100
4	90%OPC+10%SF+0.7%GF	1.00	100
5	90%OPC+10%SF+0.8%GF	1.00	100
6	90%OPC+10%SF+1.0%GF	1.00	90
7	90%OPC+10%SF+1.50%GF	1.25	90
8	90%OPC+10%SF+2.0%GF	1.25	90

The lowest value of slump was obtained with mix 90%OPC+10%SF+2.0%GF and highest value was obtained with 90%OPC+10%SF+0%GF. There is decrease in workability of concrete with increase in glass fibre content. The content of super plasticizer was increased to maintaining required slump value. Due to high content of glass fibres it is very difficult to get required slump values without addition of super plasticizer.

4.2 Compressive Strength

The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test was conducted at curing ages of 7, 14, 28, 56 and 90 days. The compressive strength test results of all the mixes at different curing ages are shown in Table 4.2. Variation of compressive strength of all the mixes cured at 7,14,28,56 and 90 days are also shown in Fig. 4.1. Fig. 4.1 shows the variation of compressive strength of concrete mixes w.r.t control mix (90%OPC+10%SF) after 7,14,28,56 and 90 days respectively.

Table 4.2 Compressive stress (MPa) results of all mixes at different curing ages.

Mix no.	Description	7 days	14 days	28 days	56 days	90 days
1	90%OPC+10%SF+0%GF	31.00	34.00	35.00	39.00	40.20
2	90%OPC+10%SF+0.2%GF	37.00	39.00	41.60	43.90	47.80
3	90%OPC+10%SF+0.45%GF	38.30	38.40	41.20	42.60	47.40
4	90%OPC+10%SF+0.7%GF	36.20	37.80	40.10	41.60	46.10
5	90%OPC+10%SF+0.8%GF	34.10	35.90	38.50	39.30	44.30
6	90%OPC+10%SF+1.0%GF	32.00	34.20	36.50	38.40	41.50
7	90%OPC+10%SF+1.50%GF	29.00	31.30	34.20	35.20	39.40
8	90%OPC+10%SF+2.0%GF	25.60	28.00	32.00	33.40	36.80

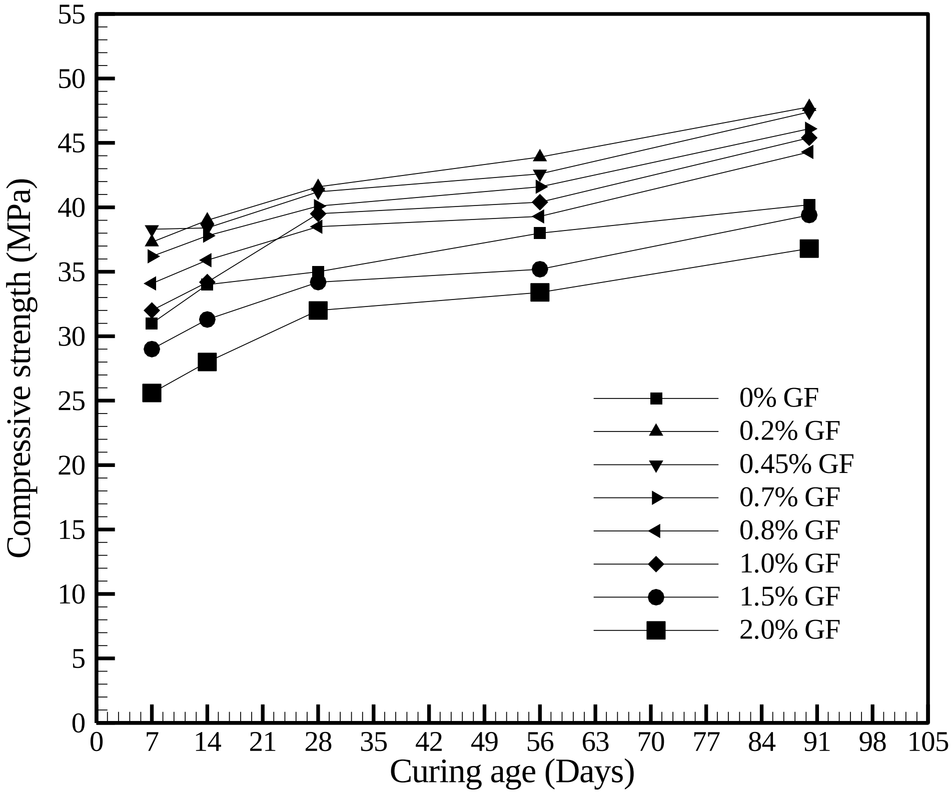

Table 4.2 shows that addition of GF 0.2% to 1.0% by weight of OPC shows increase in compressive strength of the concrete mixes compared with control mix of concrete. It can also be observed from the Fig 4.1 that the maximum compressive strength at7, 28 and 90 days of curing was obtained for a mix containing 90%OPC+10%SF with fraction of fibres 0.2% by weight of binder. Compared to control mix of concrete, concrete containing 0.2%GF the compressive strength of concrete mix was found to increase by 18% at 28 days of curing. At 2.0%GF addition, the compressive strength of concrete mix was found to decrease by 8.57% at 28 days of curing compared with control mix of concrete. The maximum value of compressive strength obtained for concrete mix with 90%OPC+10%SF+0.2%GF was 41.60 and 47.8MPa at 28 and 90 days of curing respectively.

4.3. Splitting Tensile Strength

The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 7, 14, 28, 56 and 90 days. The splitting tensile strength test results of all the mixes at different curing ages are shown in Table 4.3.Variation of splitting tensile strength of all the mixes cured at7,14, 28,56 and 90 days is also shown in Fig. 4.2. Fig. 4.2 shows the variation of splitting tensile strength of concrete mixes w.r.t control mix (90%OPC+10%SF) after 7,14, 28,56 and 90 days respectively.

Table 4.3 Splitting tensile strength (MPa) results of all mixes at different curing ages

Mix no.	Description	7 days	14 days	28 days	56 days	90 days
1	90%OPC+10%SF+0%GF	4.00	4.33	4.46	4.92	5.32
2	90%OPC+10%SF+0.2%GF	4.71	5.11	5.54	5.72	5.98
3	90%OPC+10%SF+0.45%GF	4.50	5.15	5.31	5.64	5.69
4	90%OPC+10%SF+0.7%GF	4.65	4.75	4.81	4.93	5.12
5	90%OPC+10%SF+0.8%GF	4.65	4.75	5.24	5.6	5.71
6	90%OPC+10%SF+1.0%GF	3.76	3.80	4.00	4.10	4.63
7	90%OPC+10%SF+1.50%GF	3.11	3.16	3.76	3.83	4.22
8	90%OPC+10%SF+2.0%GF	3.00	3.30	3.81	3.96	4.34

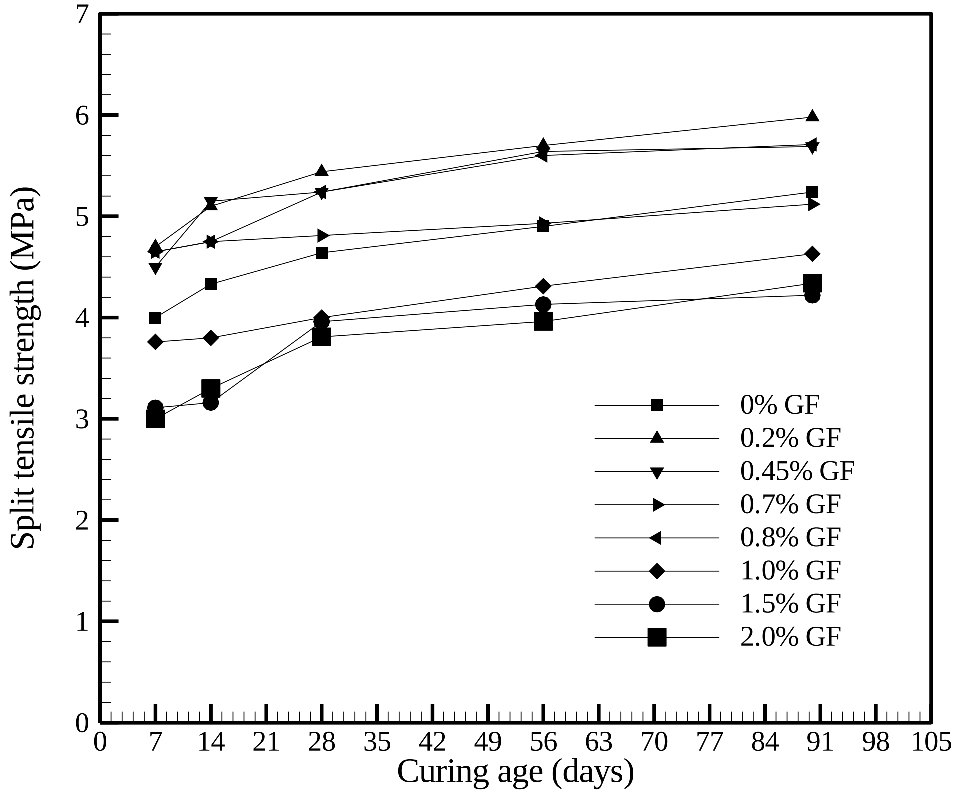

Table 4.3 Split tensile stress (MPa) results of all mixes at different curing ages

Fig.4.2 shows that the splitting tensile strength test results of glass fiber reinforced concrete shows that in general there is increases in splitting tensile strength ranging from15% to 19.5%. Glass fibres in the concrete increases splitting tensile strength and low weight fraction of glass fibres gives maximum increase in the strength. The maximum value of splitting tensile strength obtained was 5.54 MPa, for a mix with 0.2% GF addition to OPC at 28 days of curing age. At 90% OPC+10SF+0.2%GF the splitting tensile strength increased by 19.5%, for 28 days of curing compared to control mix and addition of fibres from 0.2% to 0.8% increase the splitting tensile strength and was highest with 0.2% volume fraction of fibres. At 90% OPC+10%SF with 2.0%% fibres, the splitting tensile strength was decreased by 14.57% for 28, days of curing compared to control mix. Beyond 0.8%GF addition by weight of the binder, it was observed that there is decrease in split tensile strength of concrete compared to control mix concrete at 28 days of curing.

5. DURABILITY TEST

4.4 Ultrasonic pulse velocity (UPV) Test Results

The results of the UPV tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The UPV test was conducted at curing ages of 56 and 90 days. The UPV test results of all the mixes at different curing ages are shown in Table 4.7 and 4.8.

Table 4.7 UPV values at 56 days of curing

Description	Distance (mm)	Transit time (µ sec)	Average pulse velocity (km/sec)	Quality of concrete
90%OPC+10%SF+0%GF	150	30.02	4.55	Excellent
90%OPC+10%SF+0.2%GF	150	30.47	4.80	Excellent
90%OPC+10%SF+0.45%GF	150	30.92	4.85	Excellent
90%OPC+10%SF+0.7%GF	150	30.95	4.84	Excellent
90%OPC+10%SF+0.8%GF	150	31.47	4.75	Excellent
90%OPC+10%SF+1.0%GF	150	31.37	4.35	Good
90%OPC+10%SF+1.50%GF	150	31.47	4.20	Good
90%OPC+10%SF+2.0%GF	150	32.40	4.12	Good

Table 4.8 UPV values at 90 days of curing

Description	Distance (mm)	Transit time (µ sec)	Average pulse velocity (km/sec)	Quality of concrete
90%OPC+10%SF+0%GF	150	30.45	4.79	Excellent
90%OPC+10%SF+0.2%GF	150	31.47	4.97	Excellent
90%OPC+10%SF+0.45%GF	150	31.92	5.10	Excellent
90%OPC+10%SF+0.7%GF	150	31.95	5.07	Excellent
90%OPC+10%SF+0.8%GF	150	31.47	5.01	Excellent
90%OPC+10%SF+1.0%GF	150	31.37	4.44	Good
90%OPC+10%SF+1.50%GF	150	31.47	4.32	Good
90%OPC+10%SF+2.0%GF	150	32.40	4.21	Good

Table 4.7 and 4.8 shows the UPV values at 56 and 90 days of curing. It was observed that concrete mix containing 90%0PC+10%SF+0.45%GF showed highest value of UPV than all the values i.e. 4.85(km/sec) and 5.1(km/sec) at 56 and 90 days of curing respectively. Concrete mix containing 90%OPC+10%SF+2.0%GF showed lowest UPV value i.e. 4.12(km/sec) and 4.21(km/sec) at 56 and 90 days respectively. Further, the UPV values for control mix i.e. 90%oPC+10%SF are 4.55 (km/sec) and 4.79(km/sec) at 56 and 90 days of curing respectively. Compared to control mix, concrete containing 90%0PC+10%SF+0.45%GF showed 6.18% and 6.07% more UPV value at 56 and 90 days of curing period respectively.

6. CONCLUSIONS

a. Reduction in bleeding is observed by addition of glass fibres in the concrete mixes up to 2.0% by weight of cement.
b. It was observed that as the addition of glass fibres to concrete mix increases, the workability of concrete mix was found to decrease as compared to control mix.
c. At optimum dosage of glass fibres the increase in compressive strength of glass fibre concrete mixes compared with control mix of concrete at 28 days compressive strength is observed from 18% to 20%.
d. The percentage increase of split tensile strength of glass fibre concrete mixes compared with control mix at 28 days is observed varying from 15 to 20% for 0.2% GF by weight of binder.
e. The addition of glass fibres into the concrete mixture marginally improves the compressive strength at 28 days. It is observed from the experimental results and its analysis, that the compressive strength of concrete, splitting tensile strength of concrete increases with addition of Percentage of glass fibers. The 0.2% and 0.45%addition of glass fibres into the concrete shows better result in mechanical properties and durability.
f. Addition of 0.2% by weight of cement, glass fibres shows maximum increase in Compressive strength and Flexural strength by 18% and 15% respectively with respect to PC mix without fibres at 28 days of curing.
g. The durability of concrete from the aspect of resistance to acid attack on concrete increases by adding AR-glass fibres in concrete .The glass Fibres Bridge across the cracks causing interconnecting voids to be minimum.
h. It was found that addition of the glass fibres strands improves the compressive strength, tensile strength, durability, load carrying capacity of ordinary reinforced cement concrete with small dosage levels of 0.2% & 0.45% by weight of cement.

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