Influence of Glass Fibres on High Performance Concrete

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***Abstract*— Normal concrete will have limited ductility, has little resistance to crack and low tensile strength. Inorder to improve these properties, an attempt was executed to study the effect of glass fibres in high performance concrete. The concrete mix design prepared is M40 grade. In this experimental investigation, glass fibres were added in different percentages such as 1%, 2%, 3%, 4%, 5% and their effect on mechanical properties of concrete were studied. A total of 54 specimens such as cubes of size 150x150x150 mm, cylinders of size 100x200 mm and prisms of size 500x100x100 mm were prepared and tests like compression test, flexural strength test, tensile strength test were carried out. Cubes and cylinders were tested in Compression Testing Machine. Prisms were tested under two point loading in Universal Testing Machine and the results were compared. From the test results, it was observed that 5% glass fibre concrete showed higher strength compared to control specimen. It is inferred that glass fibre imparts higher strength and more ductility to the concrete than plain M40 grade concrete.**

***Keywords*— Glass fibres; Silica fume; Mechanical properties.**

I. INTRODUCTION

The use of glass fibres in concrete is increasing nowadays. Normal concrete gives low strength, less resistant to crack. If glass fibres are added to concrete,it imparts high tensile strength, controls cracking and also reduces bleeding of water. Also the use of glass fibres yields higher flexural strength and improves ductility properties. Yogesh Iyer Murthy et al (2012) replaced fine aggregate by using 25µm and 5cm long glass fibre upto 1.5% in normal M30 grade concrete and found an increase in mechanical strength. P.Sangeetha et al (2010) carried out experimental investigation by wrapping Glass Fibre Reinforced Polymer(GFRP) of Mat types for 42 columns, and found that confinement of columns with GFRP wrap increased the strength and ductility of concrete columns and also found that compressive strength increases with increase in number of plies of GFRP. Sathish Kumar.V et al (2012) carried out a research to determine mechanical properties of Geopolymer Concrete Composites(GCC) containing fly ash,alkaline liquid and glass fibre ,from test results, it was observed that GCC reported higher strength in less curing time when compared with geopolymer and Portland cement concrete. Kavita S Kene et al(2012) studied the effect of steel and glass fibres in concrete and observed that by adding steel fibres at 0.5% y volume of concrete, improved brittleness of concrete. Sung Woo Lee et al(2002) studied the structural characteristics of concrete filled GFRP composite piles and observed that axial strength concrete filled GFRP tubes increases due to confinement effect given to concrete by FRP shell, and found when piles have high slenderness ratios, strength and ductility decreased and it cannot fully utilize strength gained by confinement effect.

II. MATERIALS

A. Cement

The cement used is Ordinary Portland Cement (OPC) of 53 grade. The specific gravity of cement is 3.15. For ordinary portland cement, the initial setting time is 55 minutes and final setting time is 600 minutes.

B. Aggregates

The fine aggregate (i.e) sand that is available in the local area was used in the concrete mix. Fine aggregate passing through 4.75mm size was used.

C. Glass fibres

Glass fibre increases the tensile strength by controlling the occurrence of micro cracks into macro cracks. The use of glass fibre imparts strength to concrete and durability. The glass fibres used was Cem-FIL Anti-crack HD.

TABLE I. PROPERTIES OF GLASS FIBRE

Properties	Values
Young's Modulus	93.8 GPa
Specific gravity	1.99
Poisson Ratio	0.23
Bulk Density	2.488 g/cc
Diameter	10 µm
Tensile strength	1770 MPa

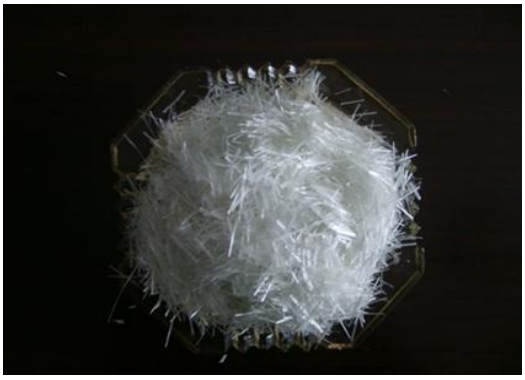

Fig. 1. Glass fibre in chopped form

III. EXPERIMENTAL PROGRAMME

A. Mix Proportion

In this study, the mix proportion used is M40. It is designed as per IS 10262:2009 code specification. The mix proportion is given in table 2.

TABLE II. MIX PROPORTION FOR HPC OF M40 GRADE

Particulars	
Cement	350 Kg/m3
Fine aggregate	896 Kg/m3
Coarse aggregate	1140 Kg/m3
Water	140 Kg/m3
Super plasticizer	7 Kg/m3

The mix proportion is 1:2.56:3.26.

B. Preparation

In this experimental investigation,totally 54 specimens were casted which includes cubes, cylinders and prisms. Glass fibres are added in varying percentages such as 1%,2%,3%,4%,5% to the concrete. A total of 18 specimens each were put for cubes of size 0.15x0.15x0.15m, cylinders of size 0.1x0.2m and prisms of size 0.5x0.1x0.1m. Silica fume is added in the range of 20% of cement. The amount of superplasticizer used for the mix is measured and mixed with water. Mixing operation was carried out till homogeneous and uniform concrete was achieved. While mixing, placing and compaction, it was observed that glass fibre is uniformly distributed.The well mixed concrete was poured into moulds for cubes to determine compression strength, cylinders to determine tensile strength, prisms to determine flexural strength. Vibrator was used to provide compaction.

C. Specimen Details

The details of specimen is given in the table 3 below.

TABLE III. WEIGHT FRACTION OF GLASS FIBRE FOR VARIOUS PERCENTAGES

Specimen name	V_1 0%	V_2 1%	V_3 2%	V_4 3%	V_5 4%	V_6 5%	Number of specimens
MC	3	3	3	3	3	3	18
MR	3	3	3	3	3	3	18
MP	3	3	3	3	3	3	18

Where, M:grade of concrete M40; C:Cube; R: Cylinder; P:Prism; V1,V2,V3,V4,V5,V6:Percentage weight fraction of glass fibre by cement.

D. Test Procedure

The specimens were taken out from mould exactly after 24 hours and immersed in a tank full of water. After 28 days, the specimens were taken out and various tests were carried out. The compressive strength test and tensile strength test were determined for cubes and cylinders respectively using Compression Testing Machine (CTM). The flexural strength test was carried out for prism using Universal Testing Machine (UTM) under two point load bending test under control.

IV. RESULTS AND DISCUSSION

A. Compressive Strength

Table 4 denotes the test results of compressive strength at 28 days. It can be seen that silica fume added concrete showed normal strength. It can be noted that addition of 1% glass fibre to concrete increased the strength by 4.13% at 28 days. Further addition of 2%,3%,4%,5% glass fibres showed improved strength by 5.99%,8.17%, 10.56%, 12.93% at 28 days respectively. It can be seen that addition of 5% glass fibre to concrete shows better and higher strength compared to normal concrete strength.

TABLE IV. COMPRESSIVE STRENGTH TEST RESULTS

Glass fibre %	Specimen	Compressive strength (N/mm^2)	Average Compressive strength (N/mm^2)
0%	0a	48	48
	0b	48.2	
	0c	47.8	
1%	1a	50	50.07
	1b	49.7	
	1c	50.5	
2%	2a	50	51.06
	2b	51.5	
	2c	51.7	
3%	3a	52.3	52.27
	3b	52	
	3c	52.5	
4%	4a	54	53.67
	4b	53.8	
	4c	53.2	
5%	5a	55	55.13
	5b	55.5	
	5c	54.9	

Fig. 2, depicts the variation of compressive strength of glass fibre concrete. By increasing the percentage of glass fibre it shows higher strength.

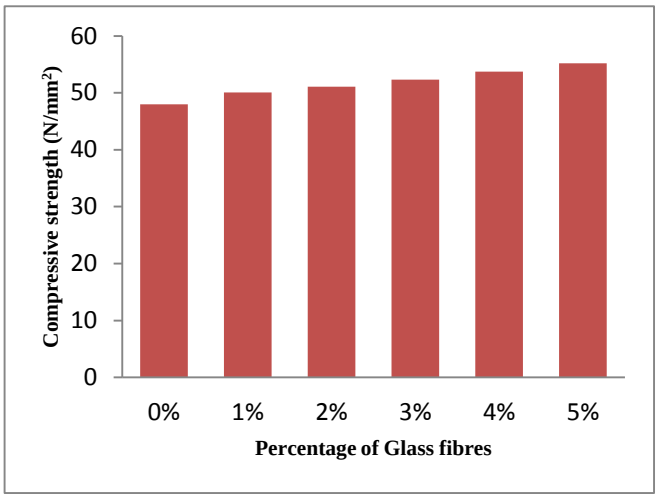

Fig. 2. Compressive strength of Glass fibres

B. Tensile Strength

Table 5 denotes the test results of tensile strength at 28 days. It can be observed that tensile strength is increased by 4.11% on addition of 1% glass fibre when compared with 0% glass fibre concrete. Similarly it can be observed that tensile strength increases by 6%, 8.16%, 10.55%, 12.94% on addition of 2%, 3%, 4%, 5% glass fibre respectively. It clearly shows that tensile strength of 5% glass fibre at 28 days shows higher strength than normal concrete.

TABLE V. TENSILE STRENGTH TEST RESULTS

Glass fibre %	Specimen	Tensile Strength (N/mm²)	Average Tensile Strength (N/mm²)
0%	0a	38.4	38.4
	0b	38.56	
	0c	38.24	
1%	1a	40	40.05
	1b	39.76	
	1c	40.4	
2%	2a	40	40.85
	2b	41.2	
	2c	41.36	
3%	3a	41.84	41.81
	3b	41.6	
	3c	42	
4%	4a	43.2	42.93
	4b	43.04	
	4c	42.56	
5%	5a	44	44.11
	5b	44.4	
	5c	43.92	

Fig. 3, depicts the variation of tensile strength of glass fibre concrete.

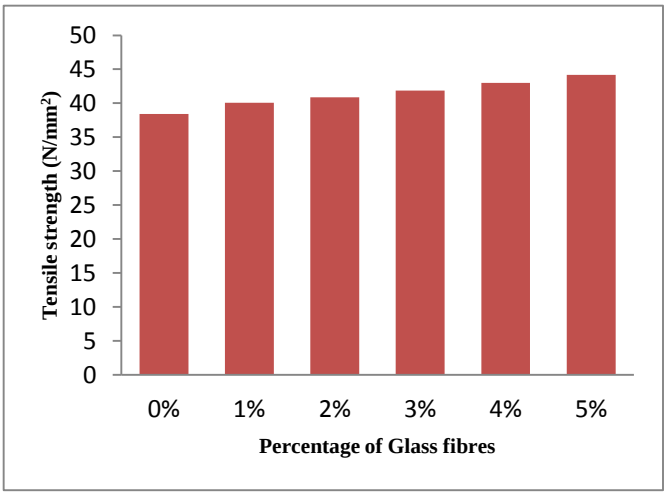

Fig. 3. Tensile strength of glass fibres

C. Flexural Strength

Table 6 denotes the 28 days flexural Strength test results of prisms. Flexural Strength increases with increasing percentage of glass fibre. The 28 days flexural Strength of 1% glass fibre concrete increases by 27.94% compared to normal 0% glass fibre prism. Also, flexural Strength increases by 41.2%, 49.66%, 55.45%, 60.38% with addition of 2%, 3%, 4%, 5% respectively at 28 days. The 28 days flexural Strength of 5% glass fibre shows higher and better strength in comparison with 0% glass fibre concrete.

TABLE VI. FLEXURAL STRENGTH TEST RESULTS

Glass Fibre %	Specimen	Flexural Strength (N/mm²)	Average Flexural strength (N/mm²)
0%	0a	0.154	0.147
	0b	0.138	
	0c	0.15	
1%	1a	0.202	0.204
	1b	0.206	
	1c	0.204	
2%	2a	0.252	0.250
	2b	0.244	
	2c	0.254	
3%	3a	0.29	0.292
	3b	0.2918	
	3c	0.294	
4%	4a	0.326	0.330
	4b	0.332	
	4c	0.33	
5%	5a	0.374	0.371
	5b	0.37	
	5c	0.368	

Fig. 4, depicts the variation of flexural Strength of glass fibre concrete.

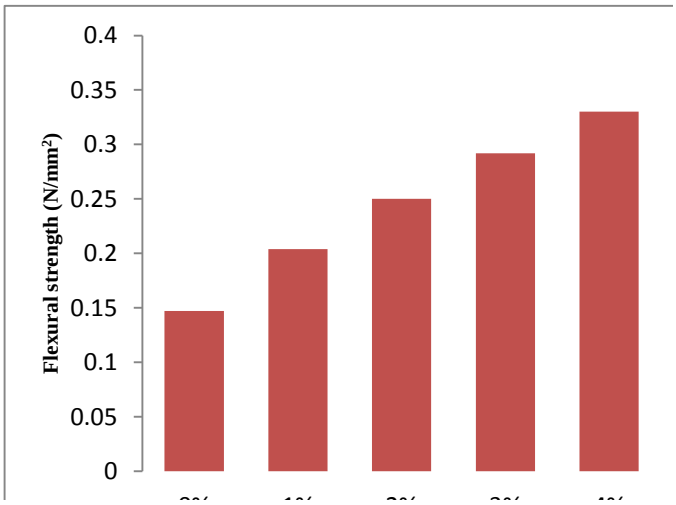

Fig. 4. Flexural strength of Glass fibres

V. CONCLUSIONS

The present work deals with the use of glass fibre in concrete which is obtained as a waste product from glass industry. The addition of glass fibre into concrete improves the mechanical strength at 28 days. From the results obtained, it is evident that mechanical strength of concrete increases with increasing percentages of glass fibre at 28 days. Therefore it is concluded that addition of 5% glass fibre to concrete showed higher mechanical strength and durability compared to control specimen.

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