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STRENGTH PROPERTIES OF GLASS FIBRE CONCRETE

Chandramouli K.[1], Srinivasa Rao P.[2], Pannirselvam N.[3], Seshadri Sekhar T.[4] and Sravana P.[2]
[1]Priyadrashini Institute of Technology for Women, Tenali, Guntur, Andhra Pradesh, India
[2]JNTU College of Engineering, Hyderabad, Andhra Pradesh, India
[3]VIT University, Vellore, India
[4]Samual George Institute of Technology, Markapur, Prakasam District, Andhra Pradesh, India
E-Mail: npannirselvam@vit.ac.in

ABSTRACT

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, erosion resistance and serviceability of concrete. Fibres impart energy absorption, toughness and impact resistance properties to fibre reinforced concrete material and these characteristics in turn improve the fracture and fatigue properties of fibre reinforced concrete research in glass fibre reinforced concrete resulted in the development of an alkali resistance fibres high dispersion that improved long term durability. This system was named alkali resistance glass fibre reinforced concrete. In the present experimental investigation the alkali resistance glass fibres has been used to study the effect on compressive, split tensile and flexural strength on M20, M30, M40 and M50 grades of concrete.

Keywords: glass fibres, strength properties, concrete.

INTRODUCTION

Concrete is the most widely used construction material has several desirable properties like high compressive strength, stiffness and durability under usual environmental factors. At the same time concrete is brittle and weak in tension. Plain concrete has two deficiencies, low tensile strength and a low strain at fracture. These shortcomings are generally overcome by reinforcing concrete. Normally reinforcement consists of continuous deformed steel bars or pre-stressing tendons. The advantage of reinforcing and pre-stressing technology utilizing steel reinforcement as high tensile steel wires have helped in overcoming the incapacity of concrete in tension but the ductility magnitude of compressive strength.

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. Due to the presence of these uniformly dispersed fibres, the cracking strength of concrete is increased and the fibres acting as crack arresters. Fibres suitable of reinforcing concrete having been produced from steel, glass and organic polymers. Many of the current applications of FRC involve the use of fibres ranging around 1% by volume of concrete. Recent attempts made it possible to incorporate relatively large volumes of steel, glass and synthetic fibres in concrete. Results of tensile tests done on concretes with glass, polypropylene and steel fibres, indicate that with such large volume of aligned fibres in concrete, there is substantial enhancement of the tensile load carrying capacity of the matrix. This may be attributed to the fact fibres suppress the localization of micro-cracks into macro-cracks and consequently the apparent tensile strength of the matrix increases.

REVIEW OF LITERATURE

Griffiths conducted study to investigate the mechanical properties of glass fibre reinforced polyester polymer concrete. The author observed that the modulus of rupture of polymer concrete containing 20% polyester resin and about 79% fine silica aggregate is about 20 MPa. The addition of about 1.5% chopped glass fibres (by weight) to the material increases the modulus of rupture by about 20% and the fracture toughness by about 55%. Glass fibres improve the strength of the material by increasing the force required for deformation and improve the toughness by increasing the energy required for crack propagation. Sorousshian reported the results of an experimental study on the relative effectiveness of different types of steel fibre in concrete. The author observed that the inclusion of fibres decreases the workability of fresh concrete and this effect is more pronounced for fibres with higher aspect ratios. The effects of fibre type on fresh mix workability, as represented both subjectively and by the inverted slump and cone time, seem to be insignificant. Crimped fibres result in slightly higher slump values when compared with straight and hooked fibres. Rao studied the effect of glass fibres on the mechanical properties of M20 and M30 grades of concrete. Babu investigated the addition of the glass fibres and concluded that there is increase in the compressive strength upto 1% by volume at higher fibre percentages and the strength decreases if the fibre content is increased significantly.

MATERIALS AND METHODS

Materials

Cement

Ordinary Portland cement of 53 grades available in local market is used in the investigation. The cement used has been tested for various proportions as per IS: 4031-1988 and found to be conforming to various specifications of IS: 12269-1987. The specific gravity was 3.02 and the fineness was 3200 cm^2/gm.

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.

Fine aggregate

River sand was used as fine aggregate. The specific gravity and fineness modulus was 2.55 and 2.93 respectively.

Glass fibre

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 857.1. The number of fibres per kg is 212 millon fibres.

Test specimens

Test specimens consisting of 150×150×150 mm cubes, 150×300 mm cylinders and 100×100×500 mm beams were cast as shown in the Figure-1 using different grade of concrete mixers as given in Table-1 and tested as per IS: 516 and 1199.

Figure-1. Specimens cast.

Table-1. Quantities of materials required per 1 cum of ordinary concrete and glass fibre concrete mixes.

Grade of concrete	**Cement** (kg)	**Fine aggregate** (kg)	**Coarse aggregate** (kg)	**Water** (ltr)	**W/C ratio**	**Glass fibres**
M 20	318	732	1118	178	0.55	0.03% by concrete volume
M 30	350	686	1137	178	0.50	
M 40	400	604	1170	164	0.40	
M 50	450	590	1142	163	0.36	

DISCUSSIONS OF TEST RESULTS

Effect of glass fibre on workability of glass fibre concrete

The workability of concrete of M20, M30, M40 and M50 grades of concretes were estimated in terms of compaction factor for addition of 0.03% of glass fibre. It was observed that the addition of glass fibres, the compaction factor of 0.93 to 0.97 was maintained for almost all grades of concrete.

Effect of glass fibre on bleeding of glass fibre concrete

On the basis of the experimental study it was concluded that addition of glass fibre in concrete gives a reduction in bleeding. A reduction in bleeding improves the surface integrity of concrete, improves its homogeneity and reduces the probability of cracks occurring where there is some restraint to settlement.

Compressive strength of ordinary concrete and glass fibre concrete mixes

Table-2 gives the compressive strength values of ordinary concrete and glass fibre concrete mixes and their values are observed to be varied from 36.60 to 54.18 N/mm^2; 42.46 to 62.31 N/mm^2 for 28 days, 39.25 to 59.96 N/$mm^{2;}$ 45.92 to 69.55 N/mm^2 for 56 days, 43.23 to 64.37 N/mm^2; 51.01 to 77.24 N/mm^2 for 90 days and 44.12 to 66.09 N/mm^2; 51.74 to 78.61 N/mm^2 for 180 days.

Table-2. Compressive, flexural and split tensile strength for different grades of concrete mixes.

Grade of concrete	No. of days	Compressive Strength (N/mm^2)		Flexural Strength ((N/mm^2)		Split tensile Strength (N/mm^2)	
		without GF	with GF	without GF	with GF	without GF	with GF
M20	28	36.60	42.46	3.52	4.08	3.62	4.20
	56	39.25	45.92	3.96	4.59	4.05	4.74
	90	43.23	51.01	4.18	4.85	4.33	5.02
	180	44.12	51.74	4.29	5.02	4.45	5.25
M30	28	41.50	48.56	4.12	4.78	4.23	4.91
	56	46.05	53.42	4.57	5.39	4.68	5.38
	90	48.85	56.67	4.96	5.62	4.89	5.74
	180	49.72	58.17	4.98	5.93	5.12	6.12
M40	28	47.92	57.50	4.72	5.52	4.78	5.59
	56	52.24	60.60	5.28	6.18	5.35	6.15
	90	56.67	66.87	5.42	6.40	5.68	6.55
	180	58.05	69.66	5.91	6.95	5.94	6.98
M50	28	54.18	62.31	5.42	6.23	5.56	6.34
	56	59.96	69.55	5.80	6.79	5.89	6.66
	90	64.37	77.24	6.43	7.52	6.39	7.54
	180	66.09	78.65	6.57	7.56	6.65	7.65

Split tensile strength of ordinary concrete and glass fibre concrete mixes

The split tensile strength values of ordinary concrete and glass fibre concrete mixes are observed from Table-2 varied from 3.62 to 5.56 N/mm^2; 4.20 to 6.34 N/mm^2 for 28 days, 4.05 to 5.89 N/mm^2; 4.74 to 6.66 N/mm^2 for 56 days, 4.33 to 6.39 N/mm^2; 5.02 to 7.54 N/mm^2 for 90 days and 4.45 to 6.65 N/mm^2; 5.25 to 7.65 N/mm^2 for 180 days, respectively.

Flexural strength of ordinary concrete and glass fibre concrete mixes

Table-2 gives the flexural values of ordinary concrete and glass fibre concrete mixes. The experimental setup is shown in Figure-2. These values are observed to be varied from 3.52 to 5.42 N/mm^2; 4.08 to 6.23 N/mm^2 for 28 days, 3.96 to 5.80 N/mm^2; 4.59 to 6.79 N/mm^2 for 56 days, 4.18 to 6.43 N/mm^2; 4.85 to 7.52 N/mm^2 for 90 days and 4.29 to 6.57 N/mm^2; 5.02 to 7.56 N/mm^2 for 180 days.

Variation of compressive strength, split tensile strength and flexural strength of the ordinary concrete and glass fibre concrete mixes compared with 28 days strength

The increase in compressive strength for all the grades of concrete mixes at 56, 90, 180 days are observed to be 20 to 25% when compared with 28 days strength. The flexural and split tensile strength for all the grades of concrete mixes at 56, 90, 180 days are observed to be 20% to 25% when compared with 28 days strength. These variations can be observed in Figures 3, 4 and 5.

Figure 2. Experimental setup.

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Variation of compressive strength, split tensile strength and flexural strength of the glass fibre concrete mixes compared with ordinary concrete mixes.

Table-3 gives the increase in compressive, split tensile and flexural strength of various grades of glass fibre concrete mixes were compared with ordinary concrete mixes of M20, M30, M40 and M50. The variation in strength of glass fibre concretes is observed to be 15 to 20% when compared with ordinary concrete.

Table-3. Percentage increase of compressive, flexural and split tensile strength of glass fibre concrete in comparison with ordinary concrete mixes.

Grade of concrete	No. of days	Compressive strength (N/mm^2)	Flexural strength (N/mm^2)	Split tensile strength (N/mm^2)
M20	28	16.01	15.91	16.02
	56	16.99	15.91	17.04
	90	18.00	16.03	15.94
	180	17.27	17.02	17.98
M30	28	17.01	16.02	16.08
	56	16.00	17.94	14.96
	90	16.01	15.09	15.03
	180	17.00	16.95	15.91
M40	28	19.99	16.95	16.95
	56	16.00	17.05	14.95
	90	18.00	18.08	17.08
	180	20.00	18.94	16.04
M50	28	15.01	14.94	14.03
	56	15.99	17.07	13.07
	90	19.99	16.95	18.00
	180	19.00	15.07	15.04

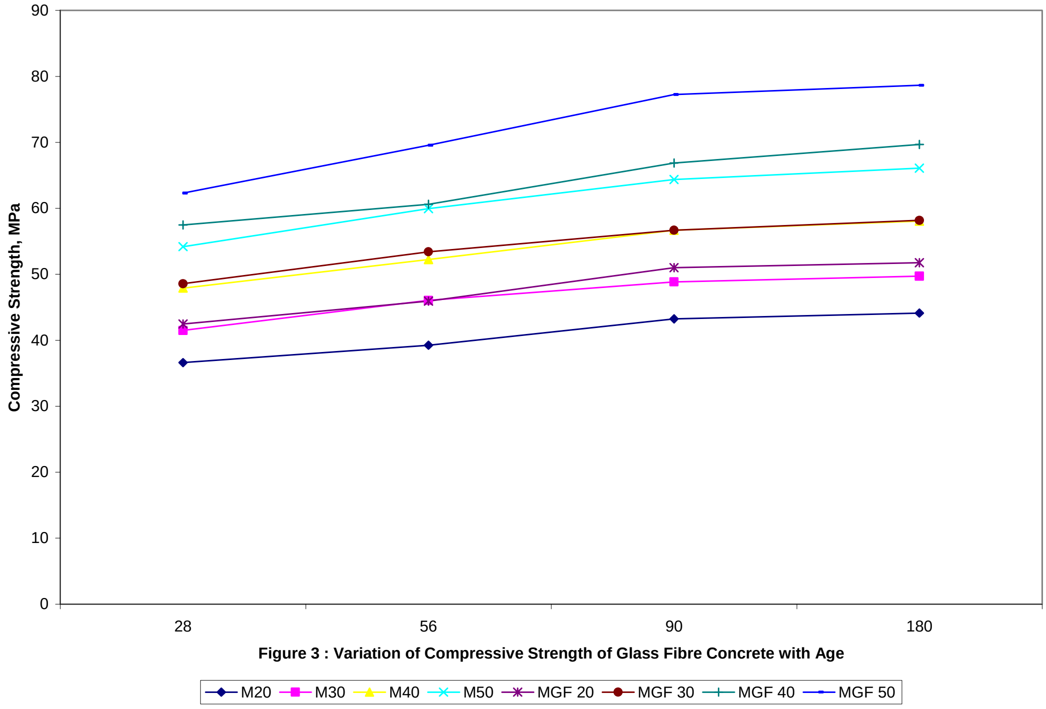

Figure 3 : Variation of Compressive Strength of Glass Fibre Concrete with Age

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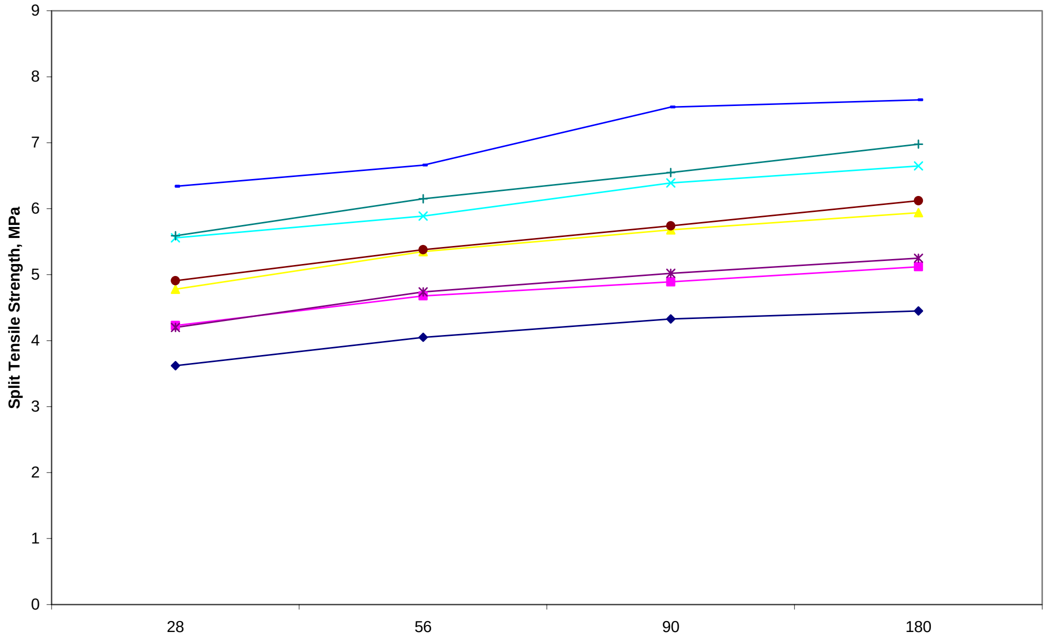

Figure 4 : Variation of Split Tensile Strength of Ordinary Concrete with age

M20 M30 M40 M50 MGF 20 MGF 30 MGF 40 MGF 50

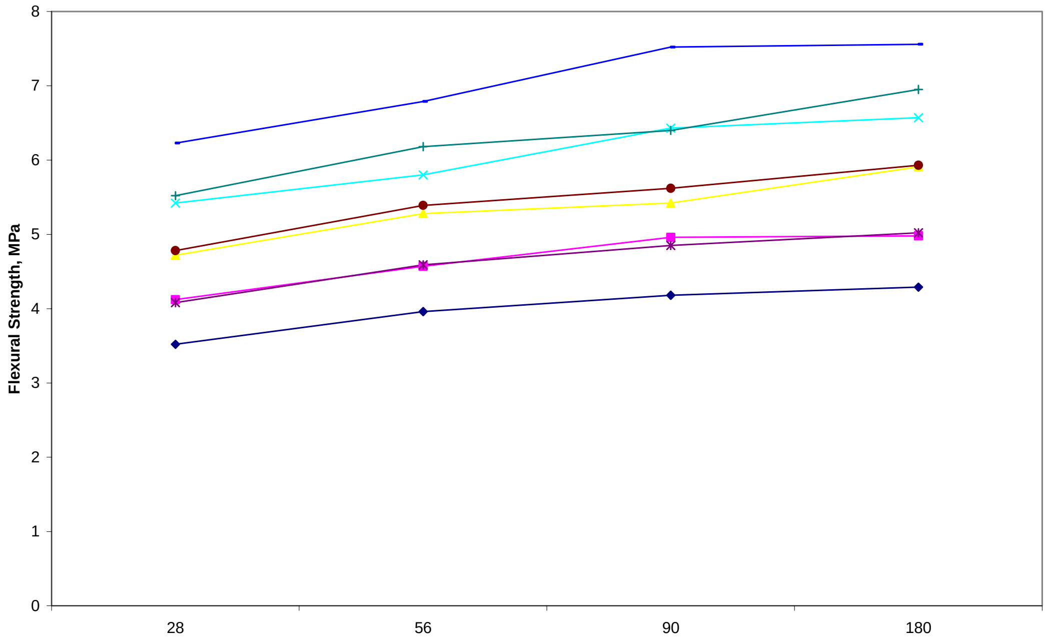

Figure 5 : Variation of Flexural Strength of Ordinary Concrete with Age

M20 M30 M40 M50 MGF 20 MGF 30 MGF 40 MGF 50

CONCLUSIONS

a) A reduction in bleeding is observed by addition of glass fibres in the glass fibre concrete mixes;
b) A reduction in bleeding improves the surface integrity of concrete, improves its homogeneity and reduces the probability of cracks;
c) The percentage increase of compressive strength of various grades of glass fibre concrete mixes compared with 28 days compressive strength is observed from 20 to 25% and
d) The percentage increase of flexural and split tensile strength of various grades of glass fibre concrete mixes compared with 28 days is observed from 15 to 20%.

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