Strength Aspects of Glass Fibre Reinforced Concrete

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ABSTRACT- Glass Fibre Reinforced concrete (GFRC) is a recent introduction in the field of concrete technology. It has been extensively used in over 100 countries since its introduction in 1980's. This product is covered by international standards and has been practiced all over the world. GFRC has advantage of being light weight and thereby reducing the overall cost of construction there by bringing economy in construction. This work is only an accumulation of information about GFRC from all over the internet and some text books. GFRC is concrete that uses glass fibres for reinforcement instead of steel. It is typically cast in a thin section of around ½" to ¾". Since the fibres cannot rust like steel, there is no need for a protective concrete cover thickness to prevent rusting. With the thin, hollow construction of GFRC products, they can weigh a fraction of weight of traditional precast concrete.

Keywords: Fibre reinforced concrete (FRC), Glass fibres, High performance concrete, Strength properties.

1 INTRODUCTION

Concrete is the most widely used man-made construction material in the world, and is second only to water as the most utilized substance on the planet. It is obtained by mixing cementing materials, water and aggregates, and sometimes admixtures, in required proportions [1]. The mixture when placed in forms and allowed to cure hardens into a rock-like mass known as concrete. The strength, durability and other characteristics of concrete depend upon the properties of its ingredients, on the proportions of mix, the method of compaction and other controls during placing, compaction and curing [5]. Fiber reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity [2]. Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Fibre-reinforced normal concrete are mostly used for on-ground floors and pavements, but can be considered for a wide range of construction parts (beams, pliers, foundations etc) either alone or with hand-tied rebars [1]. Concrete reinforced with fibres (which are usually steel, glass or "plastic" fibres) is less expensive than hand-tied rebar, while still increasing the tensile strength many times. Shape, dimension and length of fibre is important. A thin and short fibre, for example short hair-shaped glass fibre, will only be effective the first hours after pouring the concrete (reduces cracking while the concrete is stiffening) but will not increase the concrete tensile strength. [2]

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2 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 decrease if the fibre content is increased significantly.

3 MATERIALS AND METHODS

3.1 Materials

Cement

Pozzolana Portland cement is used in the project work, as it is readily available in local market. The cement used in the project work has been tested for various proportions as per IS: 4031-1988 and found to be conforming to various specifications of IS: 1489-1991[8]. The specific gravity was

3.02 and the fineness was 3200 cm2/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 % and elongation index of 3.96 %. The coarse aggregate used in the project work are 20 mm down grade.

Fine Aggregate

River white sand was used as fine aggregate. The specific gravity was 2.55 and fineness modulus was 2.93 respectively. The fine aggregate used in the project work is 4.75 mm down grade.

Glass Fibre

The glass fibres used are of Cem-Fil Anti-Crak 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[7]. The numbers of fibres per Kg is 212 million fibres [3] [4].

3.2 Methods

Workability

The workability tests were performed using standard sizes of Slump Moulds as per IS: 1199 - 1999 and Compaction Factor apparatus which was developed in UK and is described in IS: 1199 - 1999[9].

Compressive Strength

The Steel mould of size 150 x 150 x 150 mm is well tighten and oiled thoroughly. They were allowed for curing in a curing tank for 28 days and they were tested in 200-tonnes electro hydraulic closed loop machine. The test procedures were used as per IS: 516-1979[10].

Flexural Strength

The Steel mould of size 500 x 100 x 100 mm is well tighten and oiled thoroughly. They were allowed for curing in a curing tank for 28 days and they were tested in universal testing machine. The test procedures were used as per IS 516-1979[10].

Split Tensile Strength

The specimens shall be cylinder with 150 mm in diameter and 300 mm long and is well tighten and oiled thoroughly. They were allowed for curing in a curing tank for 28 days and they were tested in universal testing machine. The test procedure were used as per IS 5816-1999[11].

4 RESULTS AND DISCUSSIONS

4.1 Effect of Glass fibres on the workability of GFRC

Slump test: The Slump test was conducted as per IS: 1199-1999. The results of Slump test M-20, M-30 and M-40 grades of concrete without and with Glass Fibres were 30 mm and 10 mm respectively. From the experimental results it was observed that on the addition of 0.03% of Glass Fibres to concrete there was substantial amount of loss in the slump. Hence, the workability decreases with the increase in volume of fibres.

Compaction factor: The Compaction Factor test was conducted as per IS: 1199-1999. The results of Compaction Factor test are tabulated in table 2 and represented in fig 1, from the above values, it is observed that the workability of concrete decreases with the addition of Glass Fibres. Hence this difficulty can be overcome by using chemical admixtures like plasticizers or super-plasticizers.

4.2 Compressive strength of ordinary concrete and Glass fibre reinforced concrete mixes

From the data tabulated in the table-3 and represented in fig 2, it is observed that the Compressive strength of M-20, M-30 and M-40 grade concrete without and with Glass Fibres at 3, 7 and 28 days, the values are observed to be varied from “12.00 N/mm² to 20.66 N/mm² for 3 days”, “24.14 N/mm² to 25.20 N/mm² for 7 days” and “30.37 N/mm² to 38.89 N/mm² for 28 days”, “16.74 N/mm² to 27.48 N/mm² for 3 days”, “28.30 N/mm² to 30.45 N/mm² for 7 days” and “40.30 N/mm² to 49.04 N/mm² for 28 days” and “22.15 N/mm² to 30.70 N/mm² for 3 days”, “32.30 N/mm² to 40.67 N/mm² for 7 days” and “49.60 N/mm² to 61.2 N/mm² for 28 days”, respectively

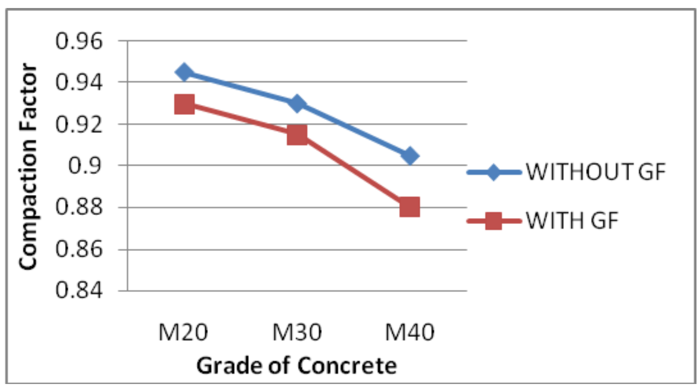

Fig.1 Variation of Compaction Factor without and with Glass Fibres.

4.3 Flexural strength of ordinary concrete and Glass fibre reinforced concrete mixes

The data obtained from the Flexural strength test is tabulated in the table-3 and represented in fig 3, in which it is observed that the values of Flexural strength of M-20, M-30 and M-40 grade concrete without and with Glass Fibres at 3, 7 and 28 days, the values are observed to be varied from “6.17 N/mm² to 10.83 N/mm² for 3 days”, “8.58 N/mm² to 14.17 N/mm² for 7 days” and “14.33 N/mm² to 18.75 N/mm² for 28 days”, “8.92 N/mm² to 12.33 N/mm² for 3 days”, “10.20 N/mm² to 13.83 N/mm² for 7 days” and “15.58 N/mm² to 20.08 N/mm² for 28 days” and “10.67 N/mm² to 13.83 N/mm² for 3 days”, “14.67 N/mm² to 16.83 N/mm² for 7 days” and “16.67

N/mm^2 to 21.57 N/mm^2 for 28 days" respectively.

4.4 Split tensile strength of ordinary concrete and Glass fibre reinforced concrete mixes

From the experimental results obtained, the values are noted in the table-3 and represented in fig 4, it is observed that the values of Split tensile strength of M-20, M-30 and M-40 grade concrete without and with Glass Fibres at 3, 7 and 28 days, the values are observed to be varied from "1.54 N/mm^2 to 1.94 N/mm^2 for 3 days", "2.09 N/mm^2 to 2.78 N/mm^2 for 7 days" and "3.16 N/mm^2 to 4.10 N/mm^2 for 28 days", "2.19 N/mm^2 to 2.64 N/mm^2 for 3 days", "3.21 N/mm^2 to 3.80 N/mm^2 for 7 days" and "4.10 N/mm^2 to 5.18 N/mm^2 for 28 days" and "2.64 N/mm^2 to 3.45 N/mm^2 for 3 days", "3.77 N/mm^2 to 5.02 N/mm^2 for 7 days" and "4.34 N/mm^2 to 5.65 N/mm^2 for 28 days", respectively

4.5 Variation of Compressive strength, Flexural strength and Split tensile strength of Glass fibre reinforced concrete mixes compared with ordinary concrete mixes.

Table 4 gives the increase in Compressive, Flexural and Split tensile strength of various grades of Glass fibre reinforced concrete mixes were compared with ordinary concrete mixes of M-20, M-30 and M-40.

TABLE-1. QUANTITIES OF MATERIALS REQUIRED PER 1 CUM OF ORDINARY CONCRETE AND GLASS FIBRE CONCRETE MIXES [12] [6]

Grade Of Concrete	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregates (Kg)	Water (ltr)	W/C ratio	Glass Fibres
M 20	338.18	722.41	1132.42	186	0.55	0.03 % by volume of concrete
M 30	413.33	661.90	1131.33	186	0.45	
M 40	465.00	628.54	1121.86	186	0.40	

TABLE-2 VALUES OF COMPACTION FACTOR FOR DIFFERENT CONCRETE MIXES

CONCRETE MIX	COMPACTION FATOR	
	WIHOUT GF	WITH GF
M 20	0.945	0.930
M 30	0.930	0.915
M 30	0.905	0.880

TABLE-3. COMPRESSIVE, FLEXURAL AND SPLIT TENSILE STRENGTH FOR DIFFERENT GRADES OF CONCRETE MIXES

Grade Of Concrete	Days Of Curing	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
M-20	03	12.00	20.66	6.17	10.83	1.54	1.94
	07	24.14	25.22	8.58	14.17	2.09	2.78
	28	30.07	38.89	14.33	18.75	3.16	4.10
M-30	03	16.74	27.48	8.92	12.33	2.19	2.64
	07	28.30	30.45	10.20	13.83	3.21	3.80
	28	40.30	49.04	15.58	20.08	4.10	5.18
M-40	03	22.15	30.70	10.67	13.33	2.64	3.45
	07	32.30	40.67	14.67	16.83	3.77	5.02
	28	49.60	61.20	16.67	21.57	4.34	5.65

TABLE-4. PERCENTAGE INCREASE OF COMPRESSIVE, FLEXURAL AND SPLIT TENSILE STRENGTH OF GLASS FIBRE REINFORCED CONCRETE IN COMPARISON WITH ORDINARY CONCRETE MIXES.

Grade Of Concrete	Days Of Curing	Compressive Strength (%)	Flexural Strength (%)	Split Tensile Strength (%)
M-20	03	72.16	75.53	25.97
	07	4.48	65.15	33.01
	28	29.33	30.84	29.75
M-30	03	64.16	38.23	20.55
	07	7.60	35.60	18.40
	28	21.70	28.90	26.34
M-40	03	38.60	24.93	30.68
	07	26.00	14.72	33.16
	28	23.40	29.40	30.18

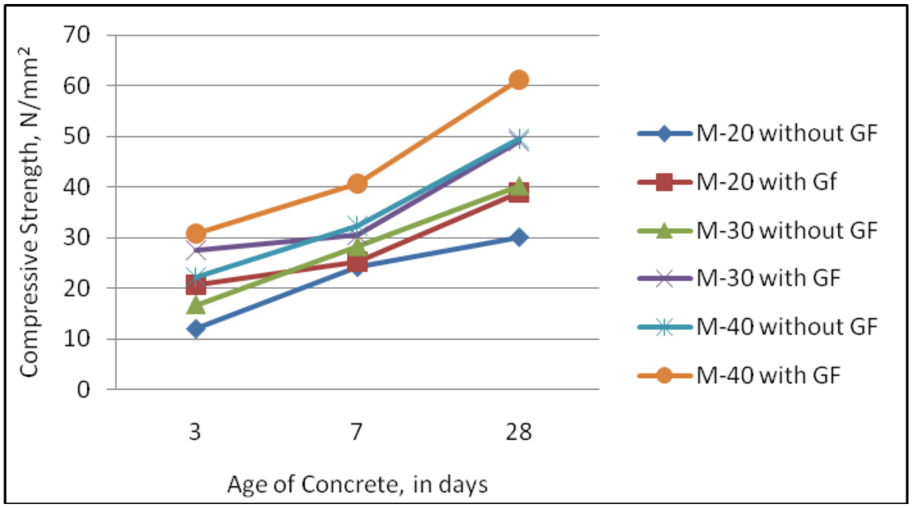

Fig.2. Variation of compressive strength of ordinary concrete and Glass fibre reinforced concrete with age in days.

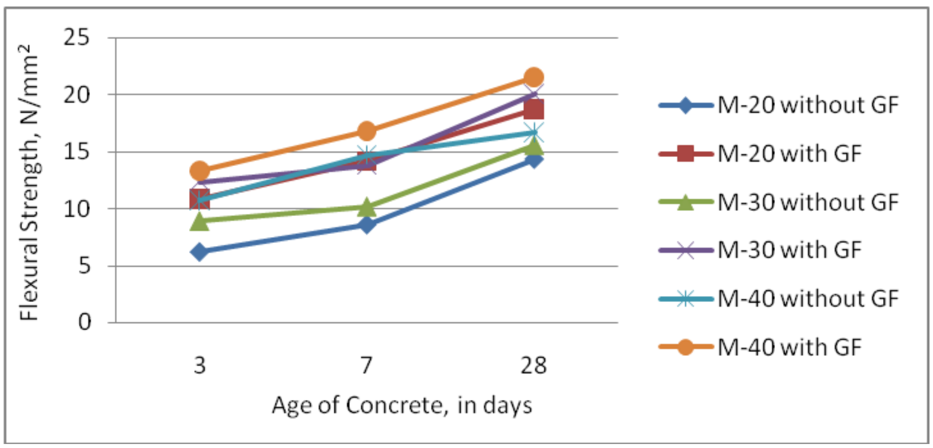

Fig.3. Variation of flexural strength of ordinary concrete and Glass fibre reinforced concrete with age in days.

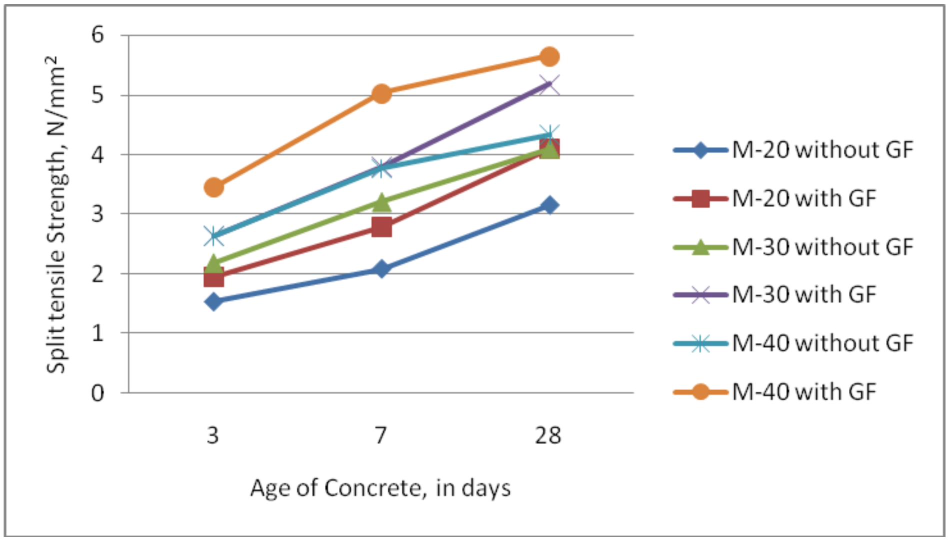

Fig.4 variation of Split tensile strength of ordinary concrete and Glass fibre reinforced concrete with Age.

5. CONCLUSION

- It has been observed that the workability of concrete decreases with the addition of Glass Fibres. But this difficulty can be overcome by using plasticizers or super-plasticizers.
- The increase in Compression strength, Flexural strength, Split tensile strength for M-20, M-30 and M-40 grade of concrete at 3, 7 and 28 days are observed to be 20% to 30%, 25% to 30% and 25% to30% respectively when compared with 28 days strength of Plain Concrete
- It has been also observed that there is gradual increase in early strength for Compression and Flexural strength of Glass Fibre Reinforced Concrete as compared to Plain Concrete, and there is sudden increase in ultimate strength for Split tensile strength of Glass Fibre Reinforced Concrete as compared to Plain Concrete.

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