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COMPRESSIVE STRENGTH PROPERTIES OF GLASS FIBER CONCRETE

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ABSTRACT

Glass Fiber 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 fibers for reinforcement instead of steel. Since the fibers 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: Fiber reinforced concrete (FRC), Glass fibers, compressive strength properties.

I. INTRODUCTION

Basically, concrete is always strong in compression and weak in tension.
Concrete is brittle and will crack with the application of increasing tensile force. Once concrete shows cracks, it can no longer carry loads. In order to make concrete capable of carrying tensile loads also, it is necessary to increase the tensile strength. To increase the strength, fibers are added in concrete.

The addition of fibers into a brittle concrete can have the effect of controlling the growth and propagation of micro cracks as the tensile strain in the concrete increases. The use of fibers in concrete has increased with the development of fast-track construction. In fact, nearly 65% of the fibers produced worldwide are now used in concrete. It offers increasing toughness and ductility, tighter crack control and improved load-carrying capacity. Different types of the fibers are available for reinforcing concrete and they are: steel, glass, acrylic, carbon, nylon, polyester, polyethylene, polypropylene, etc. Besides it natural fibers like sisal, wood cellulose, banana, jute, etc., have also been used in concrete.

Glass fiber

Alkali resistant glass fiber reinforcement is a recently a new addition to the family of fibers that impart high tensile strength, high stiffness, high chemical resistance and considerable durability to FRC (Fiber Reinforced Concrete).These fibers improve the flexural strength and energy absorption of concrete.

Glass fibers are very useful because of their high ratio of surface area to weight. The more surface is scratched, the less the resulting tenacity. Because glass has an amorphous structure, its properties are the same along the fiber and across fiber. Humidity is an important factor in tensile strength. Moisture is easily absorbed, and can worsen microscopic cracks and surface defects. FRC is the composite material consisting of a matrix containing a random distribution or dispersion of small fibers, either natural or artificial, having a high tensile strength. Due to the presence of these uniformly dispersed fibers, the cracking strength of concrete is increased and the fibers act as the crack binders. Fibers suitable of reinforcing concrete have been produced from steel, glass and organic polymers. Many of current applications of FRC involve the use of fibers ranging around 1-5%, by volume of concrete.

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II. RELATED WORK

Griffiths conducted study to investigate mechanical properties of glass fiber reinforced polyester Polymer concrete. The author observed that modulus of rupture of polymer concrete containing 20% polyester resin and about 79% fine silica aggregate is about 20 MPa. The addition of 1.5% chopped glass fibers (by weight) to the material increases the modulus of rupture by about 20% and fracture toughness by about 55%. Glass fibers improve strength of the material by increasing the force required for deformation and improve the toughness by increasing the energy required for the crack propagation.

Anjorin, Arojojoye, Komolafe (2016) concluded that the addition of glass fiber into the concrete mixture improved compressive strength after 28 days of curing. The addition of 20% of glass fiber to the concrete gave the best result in mechanical properties and durability of the concrete/glass fiber aggregate. Increase in the percentage of glass fiber in concrete/glass fiber aggregates enhanced early initial and final setting of the aggregates. Ultimate drying shrinkage decreased as the sand/cement ratio increased whilst increasing the glass fibers percentage assisted tremendously in reducing the drying shrinkage of the concrete-glass fiber aggregate.

Muthuswamy and Thirugnanam (2013) described the experimental work on Hybrid Fiber Reinforced High Performance concrete using three types of fibers namely, steel, glass and polyester fibers of a reputed brand. Silica fume was added as a mineral admixture to partially replace the cement in concrete and a super plasticizer was used to get the desired workability. Comparison with steel fiber reinforced concrete and plain concrete showed significant improvement in strengths of the hybrid fiber reinforced concrete due to the inclusion of both fibers and silica fume.

Chawla and Tekwari (2012) outline the experimental investigation conducted on the use of glass fibers with structural concrete. CEM-FILL anti crack high dispersion, alkali resistance glass fiber of diameter 14 micron, having an aspect ratio 857 was employed in percentages varying from 0.33 to 1 percent by weight in concrete and properties of this FRC, like compressive strength, flexural strength toughness, modulus of elasticity, were studied.

Chandramouli et al (2010) had conducted experimental investigation to study the effect of using the alkali resistance glass fibers on compressive, split tensile and flexural strength on M20, M30, M40 and M50 grades of concrete. The mechanical properties of glass fiber reinforced polyester polymer concrete were evaluated. The author observed that the modulus of rupture of polymer concrete containing 20 per cent polyester resin and about 79 per cent fine silica aggregate is about 20 MPa. The addition of about 1.5 per cent chopped glass fibers (by weight) to the material increases the modulus of rupture by about 20 per cent and the fracture toughness by about 55 per cent.

III. PROPOSED WORK

In proposed work following materials are used to compare the compressive strength of concrete with and without addition of glass fibers in percentage 0.5%, 1%, 1.5% and 2 % by weight. Comparison is done between M20, M25 and M30 conventional grades of concrete with concrete having different proportions of glass fibers.

IV. MATERIALS USED

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

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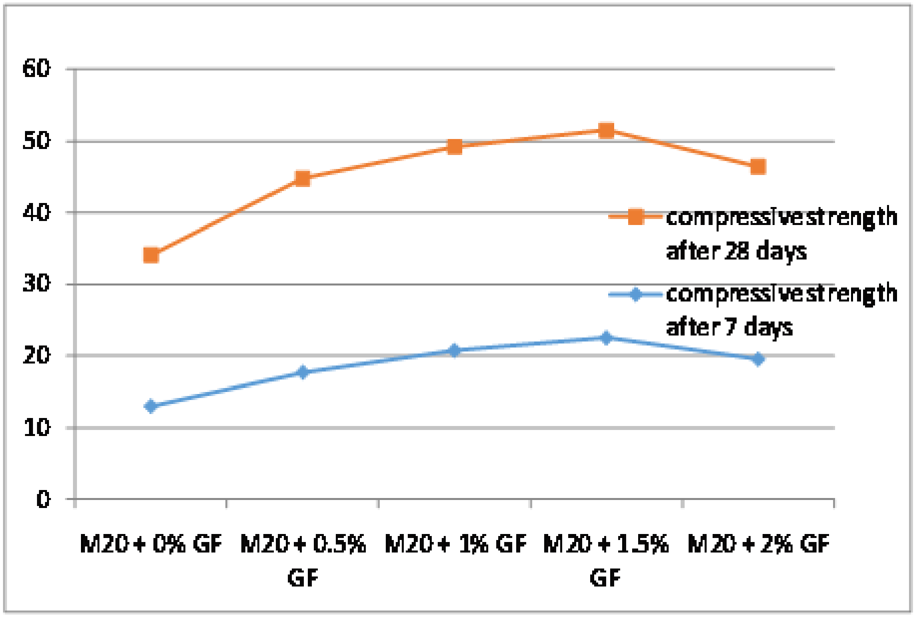
Glass Fiber
The glass fibers used are of Cem-Fill Anti-Crack HD with modulus of elasticity 72 G pa, filament diameter 14 microns, specific gravity 2.68, length 12 mm and having the aspect ratio of 857.1. The numbers of fibers per Kg is 212 million fibers.

V. METHOD
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.

VI. RESULT
The compressive strength tests are carried out on 150mm×150mm×150mm cube specimens. The effect of glass fibers on compressive strength on concrete at 7 days and 28 days and graphical representation of results are detailed below in following table:

Compressive Strength after 7 and 28 days for M20 with and without Glass Fiber

S.No.	M20 with Glass Fiber (percentage)	Compressive strength (N/mm^2)	
		7 days	28 days
1	0%	13	21.1
2	0.5%	17.7	27.06
3	1%	20.76	28.47
4	1.5%	22.54	29
5	2%	19.53	26.88



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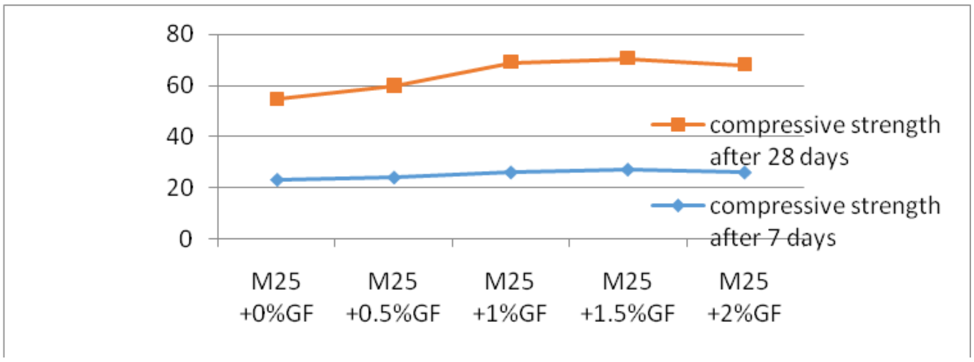
Variations in M20 after 7 and 28 days

From Table and Fig, it has been observed that the 7 days strength of M20 with 0% glass fiber is less than compressive strength of M20 with 0.5%, 1%, 1.5%and 2% glass fiber. The strength of M20 with 0% glass fibers is 13N/mm^2, with 0.5% is 17.7 N/mm^2, with 1% is 20.76 N/mm^2, with 1.5 % is 22.54 N/mm^2 and with 2% is 19.53N/mm$^{2.}$ It is also observed that at 2% glass fiber the compressive strength decreases. Similarly, compressive strength of M20 after 28 days also increases with the addition of glass fiber. That is compressive strength of M20 at 28 days; with 0% glass fiber is 21.1N/mm^2, with 0.5 % is 27.06N/mm^2, with 1% is 28.47N/mm^2, with 1.5% is 29.00N/mm^2 and with 2% is 26.88N/mm$^{2.}$ It is also seen that the compressive strength at 2% glass fiber starts decreasing.

Compressive Strength after 7 and 28 days for M25 with and without Glass Fiber

S.No.	M25 with Glass Fiber (percentage)	Compressive strength (N/mm^2)	
		7 days	28 days
1	0%	23.10	31.54
2	0.5%	24.01	35.66
3	1%	26.07	42.87
4	1.5%	27.2	43.22
5	2%	26.03	42.00



Variations in 7 and 28 days for M25

From Table and Fig, it has been observed that the 7 days strength of M25 with 0% glass fiber is less than compressive strength of M25 with 0.5%, 1%, 1.5%and 2% glass fiber. The strength of M25 with 0% glass fibers is 23.10N/mm^2, with 0.5% is 24.01 N/mm^2, with 1% is 26.07 N/mm^2, with 1.5 % is 27.2 N/mm^2 and with 2% is 26.03N/mm$^{2.}$ It is also observed that at 2% glass fiber the compressive strength starts decreasing.

Similarly, compressive strength of M25 after 28 days also increases with the addition of glass fiber. That is compressive strength of M25 at 28 days; with 0% glass fiber is 31.54N/mm^2, with 0.5 % is 35.66N/mm^2, with 1% is 42.87N/mm^2, with 1.5% is 43.22N/mm^2 and with 2% is 42.00N/mm$^{2.}$ It is also seen that the compressive strength at 2% glass fiber starts decreasing.

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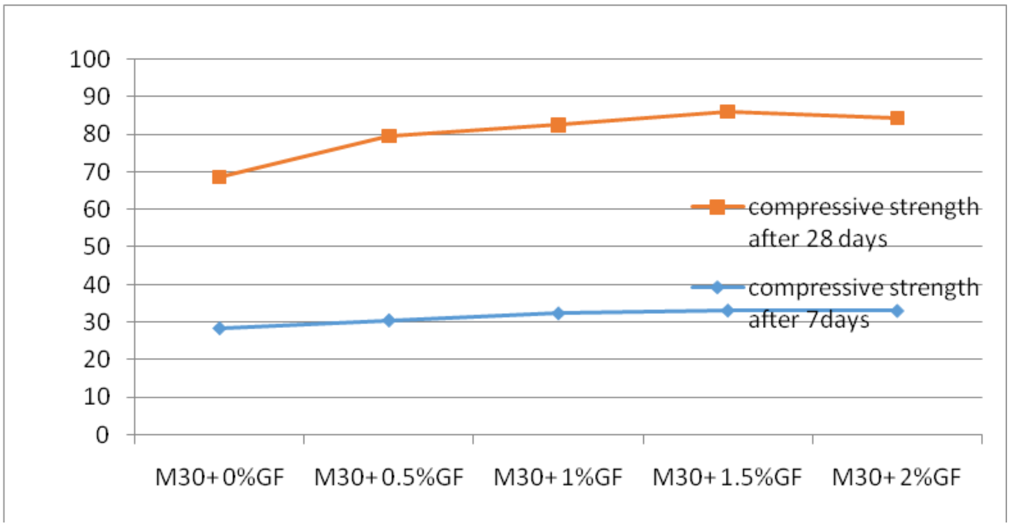
Compressive Strength after 7 and 28 days for M30 with and without Glass Fiber

S.No.	**M30 with Glass Fiber (percentage)**	**Compressive strength (N/mm^2)**	
		7 days	**28 days**
1	0%	28.30	40.30
2	0.5%	30.45	49.04
3	1%	32.33	50.22
4	1.5%	33.09	52.99
5	2%	33.00	51.34



Variations in 7 and 28 days for M30

From Table and Fig , it has been observed that the 7 days strength of M30 with 0% glass fiber is less than compressive strength of M30 with 0.5%, 1%, 1.5%and 2% glass fiber. The strength of M30 with 0% glass fibers is 28.30N/mm^2, with 0.5% is 30.45 N/mm^2, with 1% is 32.33N/mm^2, with 1.5 % is 33.09 N/mm^2 and with 2% is 33N/mm$^{2.}$ It is also observed that at 2% glass fiber the compressive strength decreases. Similarly, compressive strength of M30 after 28 days also increases with the addition of glass fiber. That is compressive strength of M30 at 28 days; with 0% glass fiber is 40.30N/mm^2, with 0.5 % is 49.04N/mm^2, with 1% is 50.22N/mm^2, with 1.5% is 52.99N/mm^2 and with 2% is 51.34N/mm$^{2.}$ It is also seen that the compressive strength at 2% glass fiber starts decreasing.

VII. CONCLUSION

The compressive strength of all the three mixes, that is M20, M25 and M30, increases with the addition of glass fibers as compared to compressive strength of conventional concrete. Tests are done after 7 days and 28 days. The compressive strength goes on increasing when the amount of glass fibers is increased in the mix. The strength of fiber reinforced concrete goes on increasing up to 1.5% fibers content, after that there is decrease in compressive strength of concrete.

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The strength of fiber reinforced concrete at 2% glass fiber may be reduced due to balling and improper mixing due to lower slump value.

The slump values of conventional concrete for M20, M25, and M30 is more and when fibers in different proportions are added, the value of slump goes on decreasing. This results in the reduction in workability and also difficulty in mixing.

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