STRENGTH BEHAVIOUR OF GLASS FIBER REINFORCED CONCRETE

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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 concrete by using fibers and other admixtures in concrete up to certain proportion. In the view of the global sustainable developments, it is imperative that fibers like glass, carbon, polypropylene and aramid fibers provide improvements in tensile strength, fatigue characteristics, durability, shrinkage characteristics, impact, cavitation, erosion resistance and serviceability of concrete. Fibers impact energy absorption, toughness and impact resistance properties to fiber reinforced concrete material and these characteristics in turn improve the fracture and fatigue properties of fiber reinforced concrete. The research in glass fiber reinforced concrete resulted in the development of alkali resistant fibers with high dispersion capacity that improved long term durability. This system was named alkali resistant glass fiber reinforced concrete. In the present experimental investigation, the alkali resistant glass fibers have been used to study the effect on compressive, split tensile and flexural strength on M30 grade of concrete. The present work outlines the experimental investigation conducted on the use of glass fiber with structural concrete. CEMFIL Anti-Crack High Dispertion, alkali resistant glass fiber of diameter 14 micron, having an aspect ratio of 855 was employed in percentages varying from 0.02 to 0.1 in concrete and the properties of this fiber reinforced concrete like compressive strength, split tensile strength and flexural strength were studied.*

Key Words: **Glass fiber reinforced concrete (GFRC), compressive strength, flexural strength, split tensile strength**

1.INTRODUCTION

Glass fiber reinforced concrete (GFRC) consists of a cementitious fine-grained concrete reinforced with alkali-resistant glass fibers. The use of glass fibers instead of steel makes components of the structure thinner, more streamlines and ultimately lighter than concrete members with metal reinforcement. These properties mean GFRC is used above all in the manufacturing and design of very thin walled, light weight facades and similar components.

Glass wool which is commonly known as "fiberglass" today, however was invented in 1938 by Russell Games Slayter as a a material to be used in insulation. It is marked under the trade name of fiber glass which has become generalised trademark. Glass fiber is also called fiber glass. Fiber glass is light weight, extremely strong and robust material. Although its strength properties are somewhat lower than carbon fiber and it is less stiff, the material is far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are also very favourable when compared to metals and it can be formed using moulding processes. Glass is the oldest and most familiar performance fiber. Fibers have been manufactured from glass since 1930s. Concrete is the most widely used construction material and it has several desirable properties like high compressive strength, stiffness and durability under usual environmental conditions. At the same time concrete is weak in tension. Plain concrete has two deficiencies- low tensile strength and low strain at facture. These short comings are generally overcome by reinforcing the concrete. Normally reinforcement consists of continuous deformed bars or pre-stressing tendons. The advantages of reinforcing and pre-stressing technology utilising steel reinforcement as high tensile steel wires have helped in overcoming the incapacity of concrete in tension and the ductility magnitude of compressive strength.

Fiber reinforced concrete is a concrete made primarily of hydraulic cement, aggregates and discrete reinforcing fibers. FRC is a relatively new material. This a 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 this uniformly dispersed fibers, the cracking strength of concrete is increased and the fibers act as crack arresters. Fibers suitable of reinforcing concrete having been produced from steel, glass and organic polymers. Many of the current application of FRC involves the use of fiber ranging around 1% by volume of concrete. Recent attempts made it possible to incorporate relatively large volumes steel, glass, synthetic fibers in concrete. Results of tensile tests done on concretes with glass, polypropylene and steel fibers indicate that with such a large volume of aligned fibers in concrete there is substantial enhancement of the tensile load carrying capacity of the matrix. This may be attributed to the fact fibers supress the localisation of micro-cracks in to macro-cracks and consequently the apparent tensile strength of the matrix increases.

2. LITERATURE REVIEW

Experiments have been carried out by several authors using fibers of glass, carbon, asbestos, polypropylene etc there by leading to various inferences out of which some are stated below:

Experimental Result on Standard Concrete studied by G. Barluenga, F. Hernandez- Olivares (2007). They observed that results of maximum crack length pointed out that low amounts of the AR- glass fiber studied can control cracking due to drying shrinkage at early ages, acting as a local reinforcement, when concrete cracks. When a crack grows perpendicular to a fiber, its cracking control capacity is high and can limit crack growth. If the crack appears parallel to a fiber, it can progress easier, producing debonding between fiber and concrete matrix. Further research on the interaction between short fibers and concrete matrix at early age is needed in order to understand the cracking control ability of low amounts of fibers.

P Sravana, P Srinivasa Rao, T Seshadri Sekhar (2010) studied, Flexural Behaviour of Glass Fiber Reinforced Self Compacting Concrete Slabs. They observed that the ultimate flexural strength of the glass fiber reinforced self-compacting concrete beams at 0.03% are on higher side when compared with other beams having glass fibers 0%, 0.06% and 0.1%. The presence of glass fibers in glass fibers reinforced self-compacting concrete slabs have not improved any flexural strength. Development of multiple cracks and micro cracks is prevented with the use of glass fibers.

Strength Properties of Glass Fiber Concrete studied by Chandramouli K., Srinivasa Rao P., Pannirselvam N., Sesadri Shekhar T. and Sravana P (2010). They found that higher percentages of glass fibrs from 1% affect the workability of concrete and may require the use of super plasticisers (workability agents) to maintain the workability. The compressive strength, split tensile strength and flexural strength of 'Cemfil anti-crack HD' fiber concrete is found to be maximum at 1.5% of fiber. A reduction of bleeding is observed by addition of glass fibers in the glass fiber concrete mixes. A reduction in bleeding improves the surface integrity of concrete, improves its homogeneity and reduces the probability of cracks. The percentage increase of compressive strength of various grades of glass fiber concrete mixes compared with 28 days compressive strength is observed from 20 to 25% and the percentage increase of flexural and split tensile strength of various grades of glass fiber concrete mixes compared with 28 days is observed from 15 to 20 %.

Studies of GFRC composites- strength and behaviour studied by B.L.P Swami, A. K. Asthana, U. Masood (2010) and they concluded that higher percentage of glass fibers from 1% affect workability of concrete and may require the use of super plasticisers to maintain the workability. The compressive strength, split tensile strength, and flexural strength of 'Cemfil Anti-Crack HD' fiber concrete is found to be maximum at 1.5% of fiber. The ductility characteristics have improved with the addition of glass fibers. Cracks can be controlled by introducing glass fibers.

Glass Fiber Reinforced Concrete use in Construction studied by Pahtiwan N. Shakor, Prof S. S. Pimplikar (2011) and they found that glass fiber helps concrete to increase compressive strength until indicated limit. A limit exists to a particular percentage from glass fiber mixed with concrete because increasing it effects on the bond of materials as is seen in the result. For 1.5% of cementitious weight gained best results are obtained as compared to other results. Air entrainment affects tensile strength to compressive strength ratio because the presence of air lowers the compressive strength of concrete more than the tensile strength particularly in the case of rich and strong mixes. By using 20 mm coarse aggregates more air entraining is increased in the concrete.

3. MATERIALS USED

3.1 CEMENT:

Ordinary Portland cement of 43 grade 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 specification of IS 12269-1987. The specific gravity was 3.15.

3.2 FINE AGGREGATE

The fine aggregates obtained from river bed of Koel clean from all sorts of organic impurities was used in the experiment. The fine aggregate was passing through 4.75 mm sieve and had a specific gravity of 2.67. The grading zone was zone II as per Indian Standard specifications.

3.3 COARSE AGGREGATE:

Coarse aggregate is another fundamental raw material which gives strength, hardness and increases the volume of the concrete. In my present work, coarse aggregate of size 20 mm and angular crushed shape is chosen. The density is 2723 kg/m3, the specific gravity 2.72 and the crushed strength 158 to 220 MPa.

3.5 ADMIXTURE

A chemical admixture "Super plasticizer confirming to IS 9013" is used in our work.

3.6 GLASS FIBER

The glass fibers used are of Cem-FIL Anti-Crack HD with modulus of elasticity 72 GPa, filament diameter 14 micron, specific gravity 2.68, length 12mm and having aspect ratio of 857.1. The number of fibers per kg is 212 million fibers. Fig 3.2 shows the bunch of glass fibers to be used for experimental analysis.

Fig. 1: Alkali resistant Glass Fiber

3.7 WATER

Normal tap water is used for the present work in the preparation of concrete.

4. RESULTS & DISCUSSIONS

4.1 Compressive Strength Results:

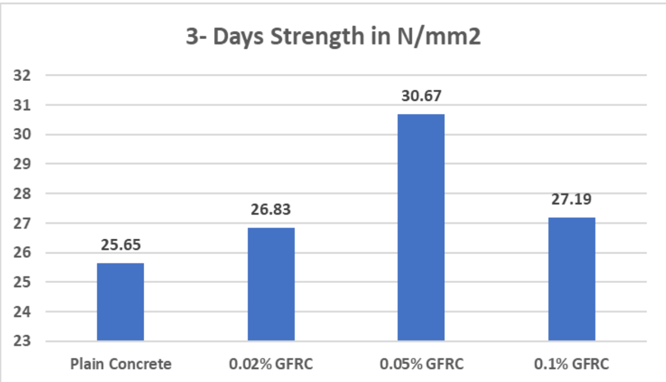

Chart -1: 3 days Compressive strength of plain cement concrete and GFRC with varying percentages of glass fiber

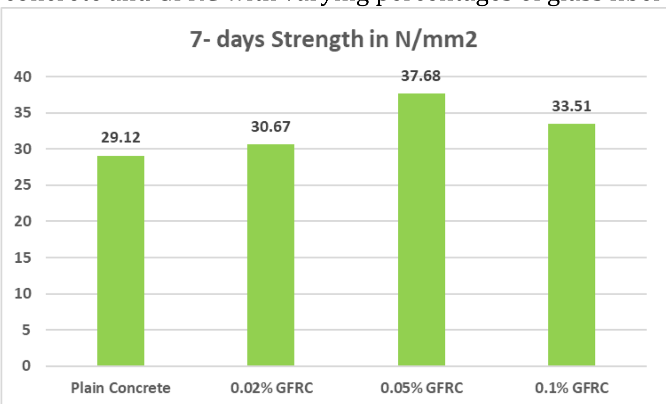

Chart -2: 7 days Compressive strength of plain cement concrete and GFRC with varying percentages of glass fiber

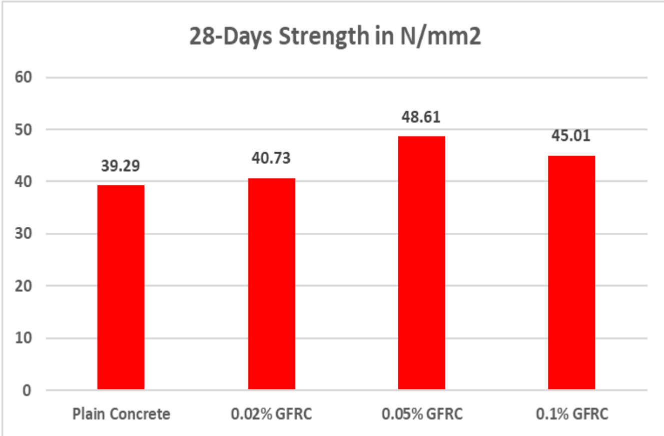

Chart -3: 28 days Compressive strength of plain cement concrete and GFRC with varying percentages of glass fiber

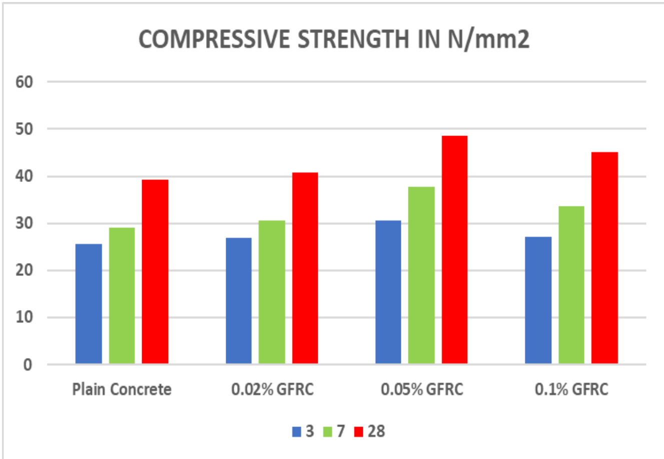

Chart -4: Compressive strength of plain cement concrete and GFRC with varying percentages of glass fiber at 3, 7 & 28 days curing period

Discussions:

The bar chart represents the compressive strength of concrete with various percentage of glass fiber at the age of 3, 7 and 28 days. From this chart it is observed that the compressive strength of concrete increases with the addition of glass fiber with age up to 0.5% by the volume of concrete. At 0.1% of glass fiber the compressive strength of concrete decreases in comparison with 0.05% of glass fiber reinforcement.

4.2 Split Tensile Strength Results:

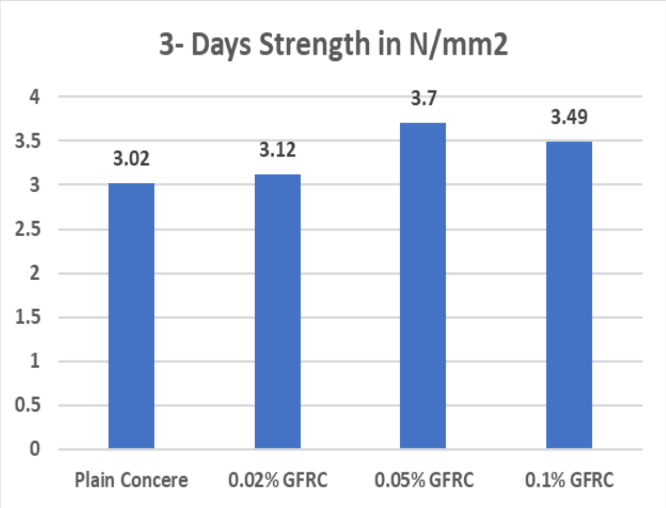

Chart -5: 3 days split tensile strength of plain cement concrete and GFRC with varying percentages of glass fiber.

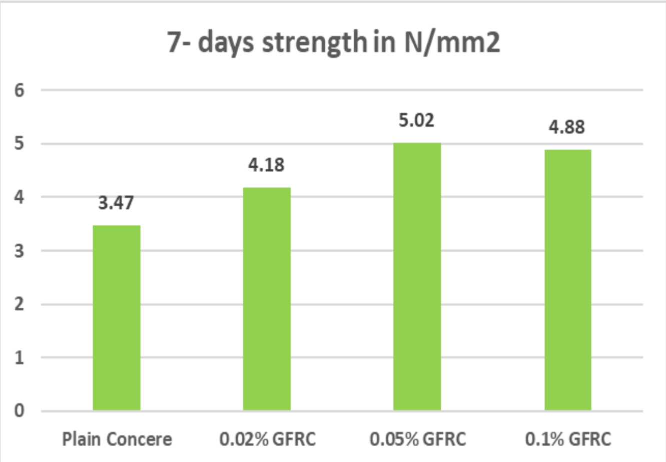

Chart -6: 7 days split tensile strength of plain cement concrete and GFRC with varying percentages of glass fiber.

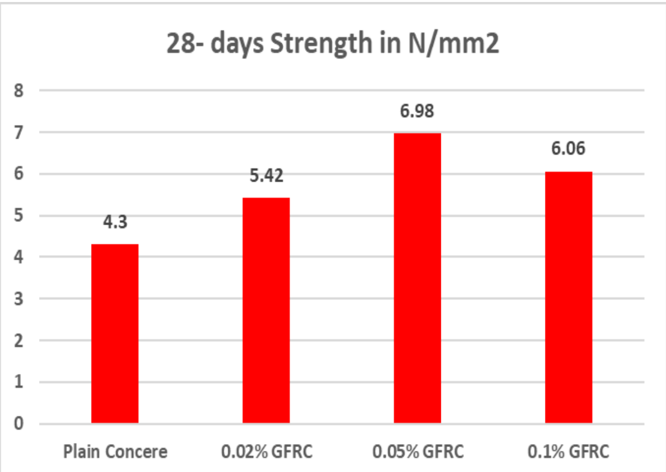

Chart -7: 28 days split tensile strength of plain cement concrete and GFRC with varying percentages of glass fiber

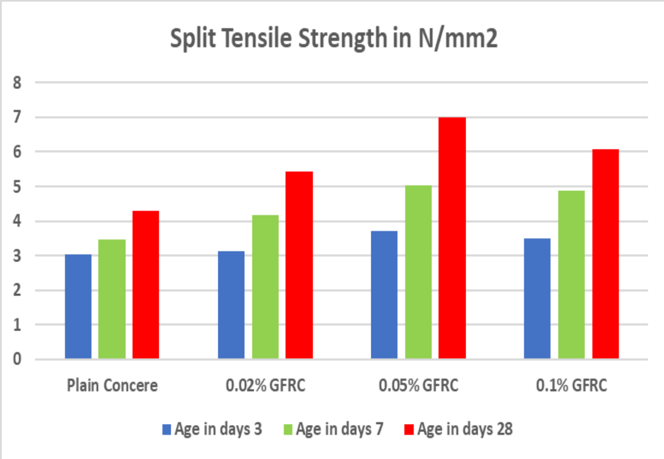

Chart -8: Split tensile strength of plain cement concrete and GFRC with varying percentages of glass fiber at 3, 7 & 28 days curing period.

Discussions:

The bar chart above represents the split tensile strength of concrete with various percentage of glass fiber at the age of 3, 7 and 28 days. From this chart it is observed that the split tensile strength of concrete increases with the addition of glass fiber with age up to 0.05% by volume of concrete. At 0.1% of glass fiber, the split tensile strength of concrete decreases in comparison with 0.05% of glass fiber reinforced concrete.

4.3 Flexural Strength Results:

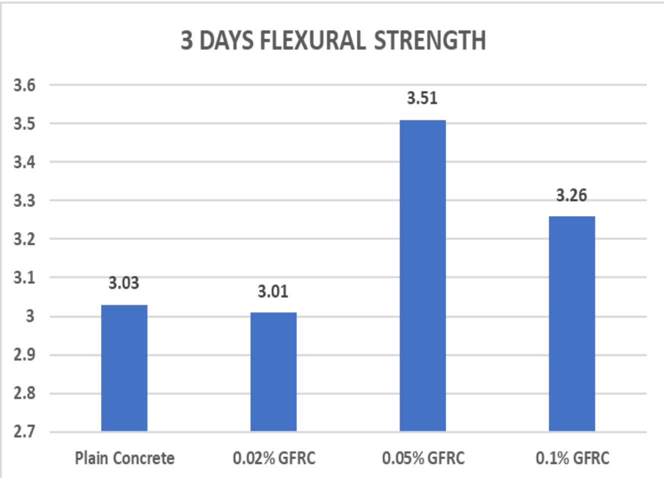

Chart -9: 3 days flexural strength of plain cement concrete and GFRC with varying percentages of glass fiber.

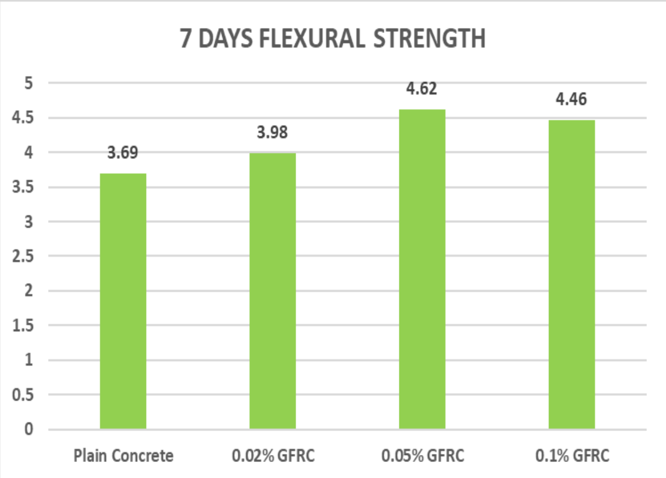

Chart -10: 7 days flexural strength of plain cement concrete and GFRC with varying percentages of glass fiber.

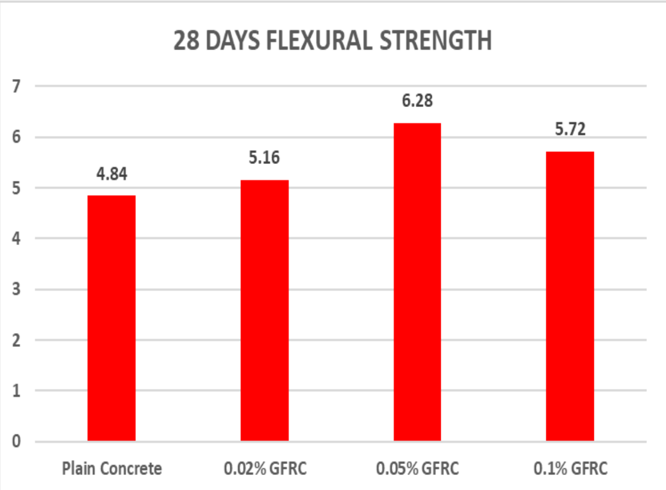

Chart -11: 28 days flexural strength of plain cement concrete and GFRC with varying percentages of glass fiber.

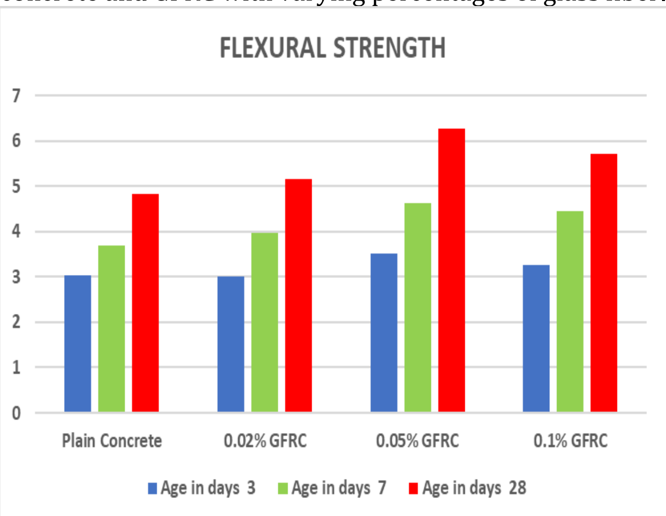

Chart -12: Flexural strength of plain cement concrete and GFRC with varying percentages of glass fiber at 3, 7 & 28 days curing period.

Discussions:

The bar chart above represents the flexural strength of concrete with various percentage of glass fiber at the age of 3, 7 and 28 days. From this chart it is observed that the flexural strength of concrete increases with the addition of glass fiber with age up to 0.05% by volume of concrete. At 0.1% of glass fiber, the flexural strength of concrete decreases in comparison with 0.05% of glass fiber reinforced concrete.

5. CONCLUSIONS

Based on the present experimental investigation conducted and the analysis of test results, the following conclusions are found out:

1. Higher percentage of glass fiber of 1 % affects the workability of concrete and may require the use of super plasticisers to maintain the desired workability. For a design mix of M30 with water cement ratio of 0.41, thew workability of concrete is only marginally affected even with a total fiber content of 0.1% by volume. Glass fiber having an aspect ratio of nearly 857 can be satisfactorily mixed along with the concrete to increase the strength and other characteristics.
2. The compressive strength of 'Cemfil Anti crack HD' fiber reinforced concrete is found to be maximum at 0.5% of fiber by volume of concrete at 28 days.
3. The compressive strength with 0.05% of glass fiber by volume of concrete is found to be maximum and there is an increase of 19.17 % at 28 days compared to plain concrete. With a total pf 0.1% glass fiber by volume the increase of compressive strength at 28 days is 12.7 % compared to plain concrete.
4. The split tensile strength of fiber reinforced concrete is found to be maximum at 0.05% of fiber by volume of concrete at 28 days.
5. The split tensile strength with 0.05% of glass fiber is found to be maximum and there is an increase of 39.39% at 28 days compared to plain concrete. With a total of 0.1% glass fiber by volume the increase of split tensile strength at 28 days is 29.04 % compared to plain concrete.
6. The Flexural strength of fiber reinforced concrete is also found to be maximum at 0.05% of fiber by volume of concrete at 28 days.
7. The flexural strength with 0.05% of glass fiber is found to be maximum and there is an increase of 22.93% at 28 days compared to plain concrete. With a total of 0.1% glass fiber by volume, the increase of flexural strength at 28 days is 15.38% compared to plain concrete.
8. The ductility characteristics have improved with the addition of glass fiber. The failure was gradual compared to that of brittle failure of plain concrete.
9. Cracks can be controlled by introducing glass fibers. Cracks have occurred and propagated gradually till the final failure. This phenomenon is true with all the

percentage of glass fiber, Glass fiber also helps in controlling the shrinkage cracks. Compared to metallic fibers like steel, alkali resistant glass fiber gives corrosion free concrete.

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