Experimental Investigation on Mechanical and Durable Properties of Glass Fibre by Partial Replacement of cement with Flyash and Silicafume

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Abstract— GFRC has many advantages such as light weight material, steel reinforcement corrosion free and structural deterioration free. So due to these reason the researches all over the world are attempting to develop high performance concrete with the use of glass fiber as well as mineral admixture. The combination of fly ash, alkaline liquids, fine, coarse aggregate and glass fiber resulted in the product called as glass fiber reinforced concrete. In the present investigation glass fiber at different percentages like 0.1%, 0.2% and 0.3% to the volume of concrete were used. And cement was partially replacement by fly ash and silica fume. A 15% of both silica fume and fly ash were used throughout the experiment work. The results of these parameters were compared to those of standard M30 grade concrete. For 0.2% of glass fiber addition with 15% of fly ash and 15% silica fume as cement replacement the maximum strength obtained for both compressive test and split tensile strength test. The specimens were tested for 3, 7, 28, 56 and 90 days. The water absorption test was conducted and the tests were noted. The result specifies that the specimens have an absorption less than 15%.

Key words: GFRC, Light Weight, Silica Fume, Fly Ash, Glass Fibers

I. Introduction

Concrete is the most widely used construction material after water in the world and the performance of Glass Fiber Reinforced concrete. The study revealed that the use of glass fiber in concrete not only improves the properties of concrete and a small cost cutting but also provide outlet to dispose glass as environmental waste from industry. it could be revealed that the flexural strength of the beam with 1.5% glass fiber shows almost 30% increase in strength. The reduction in slump observed with the increase in glass fiber content [1]. The study had revealed that the increase in compressive strength, flexural strength, split tensile strength for M20, M30 and M40 grade concrete at 3,7 and 28 days observed to be 20% to 30% and 25% to 30% and 25% to 30% respectively after the addition of glass fibers as compared to plain concrete. [2]. The alkali resistant glass fibers were used to find workability, resistance of concrete due to acids, sulphate and rapid chloride permeability test of M30, M40 and M50 grade of glass fiber reinforced concrete and ordinary concrete. The durability of concrete was increased by adding alkali resistant glass fibers in the concrete. The experimental study showed that the addition of glass fibers in concrete gives a reduction in bleeding. The addition of glass fibers had shown improvement in the resistance of concrete to the attacks of acids [3]. alkali resistance Glass Fibres to study the effect on compressive, split tensile and flexural strength on M20, M40 and M60 grades of concrete for addition of 0.03% of glass fibre. The percentage increase of compressive strength of various grades of glass fibre concrete mixes compared with 28 days compressive strength is observed from 10 to 20%. The percentage increase of flexural and split tensile strength of various grades of glass fibre concrete mixes compared with 28 days is observed from 10 to 20%[4]. The study conducted on Fiber Reinforced Concrete with alkali resistant glass fibers containing 0% and 25% by weight of cement 12 mm cut length, compared the result.[5]. the effect of using the alkali resistance glass fibres on compressive, split tensile and flexural strength on M20, M30, M40 and M50 grades of concrete. The mechanical properties of glass fibre reinforced polyester polymer concrete were evaluated. The author observed that the modulus of rupture concrete containing 20 percent polyester and about 79 per cent fine silica aggregate is about 20 Mpa. The addition of about 1.5 per cent chopped glass fibres (by weight) to the material increase the modulus of rupture by about 20 per cent and the fracture toughness by about 55 per cent. [6]. 'the use of fibres in the tensile zone of reinforced concrete beams to control cracking and improve durability', the use of Simcon for repair and reinforced concrete beams and columns to satisfy seismic requirements and the use of Simcon as a jacket in reinforced concrete columns, also o improve seismic resistance. [7]. A comparison steel fibre reinforced concrete and plain concrete showed significant improvement in the strengths of hybrid fibre reinforced concrete due to the inclusion of both fibres and silica fume.Bantia et al (1997) studied the performance of E-glass and AR-Glass fibre reinforced composites with the cementitous matrices. The results were compared with those of ordinary Portland cement composites. It was shown that by adjusting the composition of matrix, there is a potential for developing highly durable fibre cement composites, even with E-glass, which is probably the most sensitive to corrosion of the man-made high strength fibres. [8]. the use of glass fibres with structural concrete. CEM-FILL anticrack high depression, alkali resistance glass fibre 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. [9]. A theoretical and experimental study on mechanical properties and flexural strength of fly ash-geo polymer concrete using young's modulus, Poisson's ratio stress-strain relation and indirect tensile strength with four-point loading and as FEM and concluded after the results there were approximate values by comparing both the theoretical and experimental study [10].

II. EXPERIMENTAL STUDY

As our aim to develop the strength of concrete by using different materials as an addition to concrete mix to get more strength than plain concrete. And also many other aspects to fulfill like durability and less porosity. Now a day's one of the great applications in various structural fields are glass fibers, which is getting popularity because of its positive effect on various properties of concrete.

A. Materials

- Cement-Ordinary Portland Cement (OPC)
- Mineral admixtures
  - Fly ash
  - Silica fume
- Fine aggregate
- Coarse aggregate
- Water
- Glass fibers

B. Mix proportion:

The proportions of materials required for geo polymer concrete has been designed based on Rangan's method [11]. The proportions for geo polymer concrete is as shown in Table 1.

S.NO	Name of The Compound	Conversion Formulae	% present in Cement
1	Tri-Calcium Silicate (3Cao.SiO_2)	4.07(Cao)-7.60(siO_2)-6.72 (Al_2O_3)-1.43 (Fe_2O_3)-2.85(SO_3)	51.49
2	Di-calcium Silicate (2Cao.SiO_2)	2.87 (SiO_2)-0.754 (3 Cao.SiO_2)	23.37
3	Tri-calcium aluminates(3CaO.Al_2O_3)	2.65 (Al_2O_3)-1.69 (Fe_2O_3)	9.31
4	Tetra-calcium alumina ferrite (4CaO.Al_2O_3.Fe_2O_3)	3.04 (Fe_2O_3)	11.70

Table 1:

C. Normal consistency:

The normal consistency of cement sample prepared with different replacements of Fly ash (10% and 15%) is compared with ordinary cement. Both the initial and final setting time of cement sample is prepared with different replacements of Fly ash (10% and 15%) are compared with ordinary cement. If the difference is less than 30 minutes, the change is to be considered as insignificant and it is more than 30 minutes, the change is considered as significant and the standard consistency as shown in Table 2.

S.NO	Mix proportion	Standard consistency (%)
1	100%OPC+0% FA	32
2	90%OPC+10% FA	33
3	85%OPC+15% FA	33.5

Table 2:

D. Initial and Final setting time:

The result of initial and final setting time for different replacement percentages of cement with Fly ash. Initial setting time result shows very slight increase in initial setting time of cement for different dosages 0%, 10% and 15% of Fly ash in ordinary Portland cement. Final setting time result shows very slight decrease in final setting time of cement for different dosages 0%, 10% and 15% of Fly ash in ordinary Portland cement as shown in Table 3 and figure 1.

S.NO	MIX PROPORTION	INITIAL SETTING TIME (MINUTES)	FINAL SETTING TIME (MINUTES)
1	100%OPC+0% FA	40	340
2	90%OPC+10% FA	60	320
3	85%OPC +15% FA	65	270

Table 3:

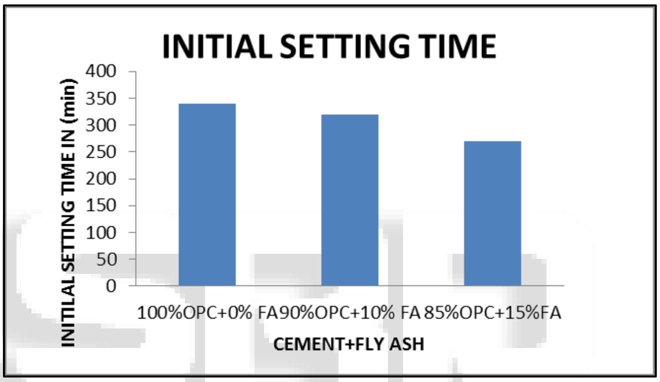

Fig. 1: Initial setting time for different replacements

E. Flyash:

Fly ash is used as supplementary materials (SCM) in the production of Portland cement concrete. As supplementary cementitious material, when use in Portland cement, contributes to the properties of hardened concrete through hydraulic or pozzolanic activity, or both. The potential for using fly ash as supplementary cementitious material in concrete has been known almost since of the last century. The last 50 years has seen the use of fly ash in concrete grow dramatically with close to 15 million tons used in concrete. Historically, fly ash has been used in concrete at levels ranging from 15% to 25% by mass of the cementitious material component. The dosage levels of fly ash used in concrete is shown in table3 below will be used to represent low, moderate, high and very high levels of fly ash.

Level of fly ash % by mass of total cementitious material	Classifications
<15	Low
15-30	Moderate
30-50	High
>50	Very high

Table 4:

F. Silica fume:

Silica fume is a by-product or said fumes collected from the production of Ferro Alloys especially for the silicon metal or

Ferro Silicon which can be purified, processed according to the final purpose and applications. The process involves the reduction of high purity quartz in electric arc furnace at temperature in exceed of 2000 degree centigrade. The silica fume is a very fine powder consisting mainly of spherical particles or microspheres of mean diameter about 0.15 microns with a very high specific surface area.

G. *Fine aggregates Grading:*

Advantage of natural sand is that the particles are cubical or rounded with smooth surface structure texture. The grading of natural F.A. is not always ideal. It depends on place to place. Being cubical, rounded and smooth textured it gives good workability. So far, crushed sand has not been used much in India for the reason that ordinary crushed sand is flaky, badly graded rough textured and hence they result in production of harsh concrete for the given design parameters. We have been also not using super plasticizer widely in our concreting to improve the workability of harsh mix. For the last about 4-5 years the old methods of manufacturing ordinary crushed sand have been replaced modern crushers specially design for producing, cubical, comparatively smooth textured, well graded sand, good enough to replace natural sand as shown in figure

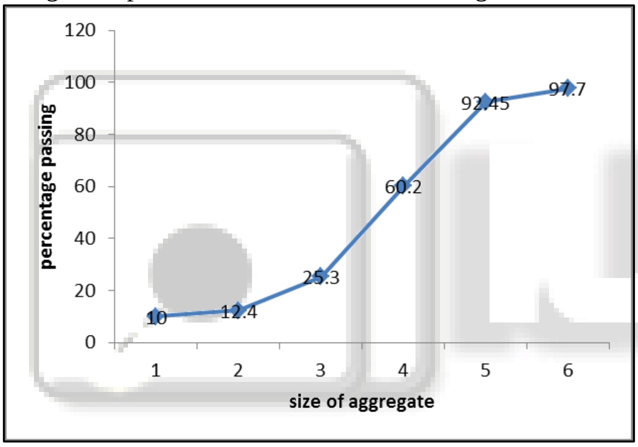

Fig. 2: Finess modulus of Fine aggregates

H. *Bulking of Sand:*

The below graph clearly shows that the bulking of sand was maximum at 5% of percentage of water added by weight of sand. The bulking of sand at 1%, 2%, 3% and 4% are 14.28, 21.14, 24, 30.28 respectively

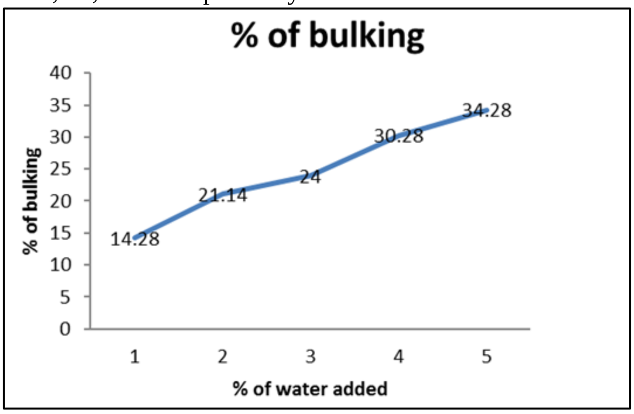

Fig. 3:

I. *Coarse aggregates Grading:*

The shape of aggregates is an important characteristic sine it affects the workability of concrete. It is difficult to really measure the shape of irregular body like concrete aggregate which are divided from various rocks. Not only the characteristics of the parent rock, but also the type of crusher used will influence the shape of aggregates, e.g., the rocks available rounded, irregular, angular or flaky.

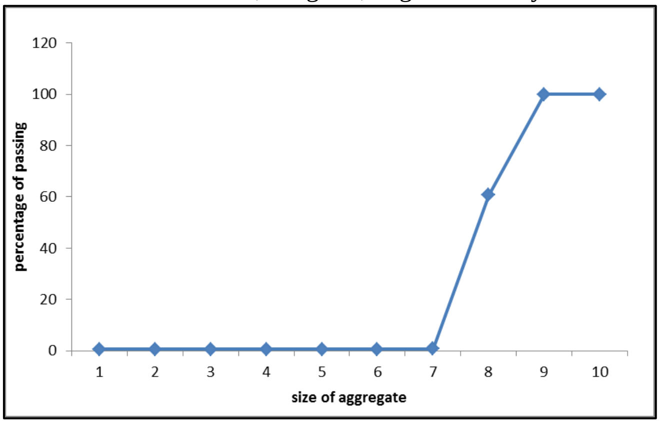

Fig. 4:

III. RESULTS & DISCUSSION

The results of present investigation are shown in both tabulated and graphical forms. For every experiment the results are shown in tabular form and also in graphical views. At each phase the results are obtained based on the literature and as well as result obtained. The significance of results is assessed with reference to the standards specified by the relevant IS code.

The tests are done for cubes and cylinders for 3, 7, 28, 56 and 90 days and the results are shown in graphical view and tabulations below. By the results the calculations shows the increase in compressive strength, and split tensile strength results.

This result shows the addition of glass fibers and fly ash to concrete and this makes the utilization of glass fibers and fly ash used in concrete at certain intervals to attain maximum strength.

A. *Compressive Strength Results:*

The compressive strength results shows the different replacement of fly ash 15% and silica fume 15% with 0.1%, 0.2%, and 0.3% of glass fibers to the volume of concrete and these compressive strength test are done for 3, 7, 28, 56, and 90 days. The cubes were tested for different proportions and an average of three test sample are taken for testing to get accurate results. At the room temperature, the cubes were cured in curing tank. And the compressive strength results are shown in below figure.

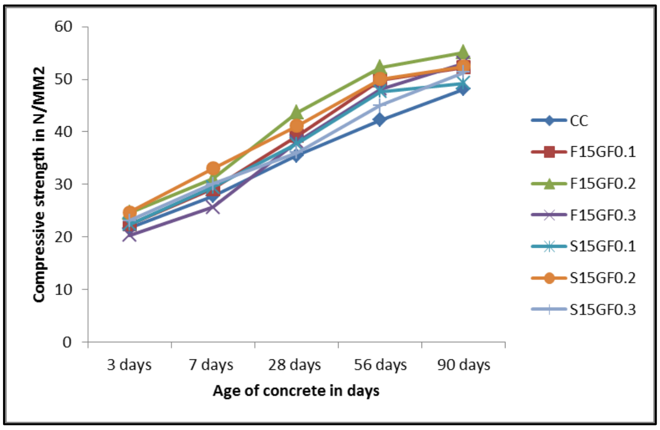

Fig. 5: compressive strength comparison for all proportion of concrete with 0.1%, 0.2%, and 0.3% of glass fibers as admixture

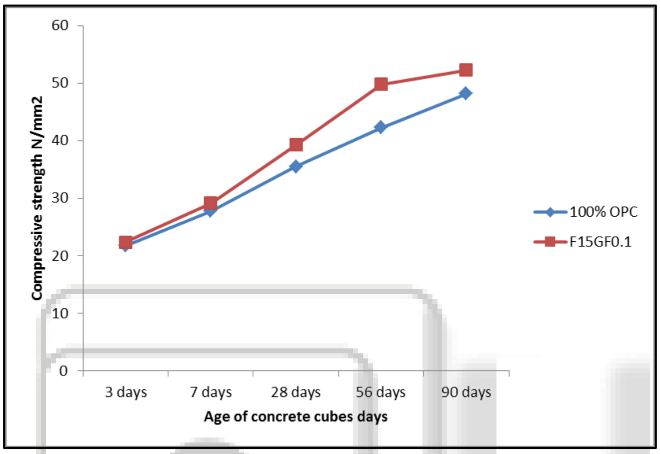

Fig. 6: Compressive strength comparison of controlled concrete with 15% fly ash replace with cement and 0.1% of glass fibers by volume of concrete

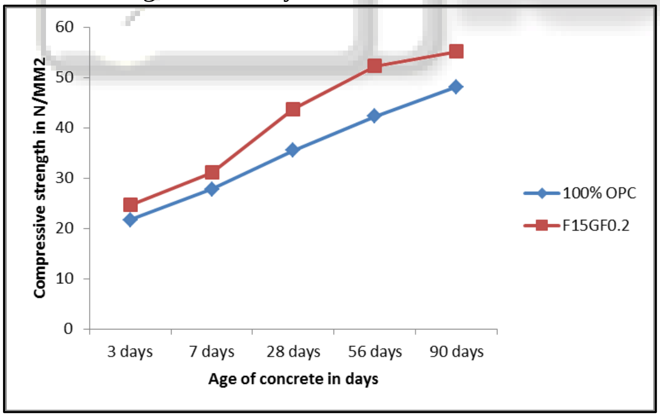

Fig. 7: Compressive strength comparison of controlled concrete with 15% fly ash replace with cement and 0.2% of glass fibers by volume of concrete

B. Split Tensile Strength:

The split tensile strength test at 28 days for various percentages of silica fume and flyash

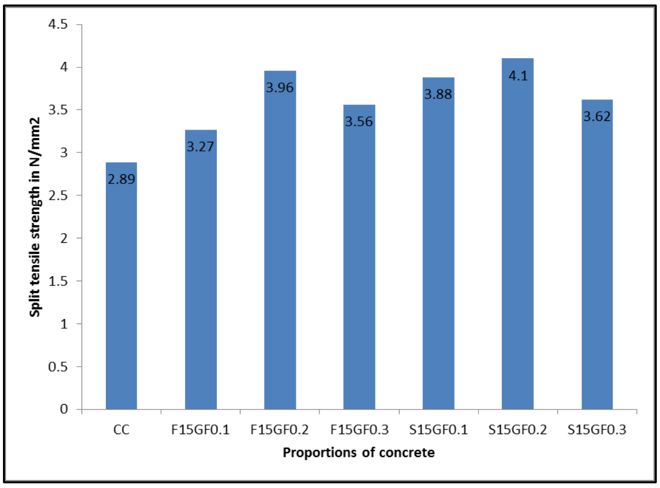

Fig. 8: Tensile strength at 28 days for various percentages of Silica Fume and Fly Ash

From above graphs it has been seen that, the comparison of split tensile strength results of concrete for various replacements of silica fume and fly ash with 0.1%, 0.2%, and 0.3% glass fibers as admixture. At 0.2% glass fibers for fly ash and 0.2% glass fibers for silica fume gives maximum 28 days split strength as 4.1 N/mm2.

IV. CONCLUSIONS

The major objective of this investigation is to use glass fibers in concrete based on present experimental investigation the following conclusion drawn

- 0.2% glass fiber volume can be taken as the optimum dosage, which can be used for giving maximum possible compressive strength at any stage for glass fibers used in concrete.
- 15% of fly ash and 15% of silica fume can be taken as the optimum dosage which can be used as partial replacement to cement for giving maximum compressive strength.
- The % increase in compressive strength at 28 days of 0.2% fiber volume with 15% of fly ash and 15% of silica fume.
- The compressive strength of glass fiber concrete more than 15% of fly ash and silica fume the results are as the lower side.
- The percentage increase in split tensile strength at 28 days of 0.2% fiber volume with 15% of fly ash and silica fume concrete.
- The addition of silica fume and fly ash as replacement to cement, its normal consistency and initial setting time increases with increase in percentage and final setting time decreases with increase percentage.
- In this experimental investigation glass fibers cannot use more than 0.2%volume with replacement of fly ash and silica fume not more than 15%.

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