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Experimental Investigation on Partial Replacement of Cement by Fly Ash with Addition of Glass Fiber Reinforcement in M-35 Concrete

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Abstract: *Concrete is the widely used construction material in civil engineering field. The demand and cost of cement is increasing day to day, so experts are looking for supplementary materials with the main objective of reducing solid waste disposal problem, by using waste as supplementary by maintaining the same properties or by enhancing the properties, by using selected materials. Fly ash which is a solid waste generated from thermal power station is used in partial replacement of cement in various proportions which is environmental friendly and also different fibers are also used to increase tensile strength and reduce cracks in the concrete. Concrete is the most vital material in the modern construction. Which has been in practice from olden days but concrete suffers from low tensile strength, limited ductility and little resistance to cracking. To overcome these weaknesses a new variety of concrete is desired. Therefore here is an experimental study proposing changes to the conventional concrete to increase fire resistance, increase crack resistance, increase ductility and flexural strength by partial replacement of fly ash to the cement and introducing fibers in the preparation of the concrete. In this study, fly ash in different volume fraction with 6%, 12%, 18% and 24% replacement of cement have been to study the effect on compressive strength, split tensile strength, of concrete and compared it to the conventional concrete. For each mix standard sizes of cubes, cylinders and as per Indian Standards were cast and tested for compressive strength and split tensile strength at age of 7 &28days.*

Keywords: Glass fiber, Concrete, Fly ash, Compressive Strength, Tensile Strength.

1. INTRODUCTION

Fly ash is by-product obtained from the thermal power plants obtained from combustion of coal. Generally fly ash has higher impact on the environment because of presence of heavy metals like mercury, cadmium, boron. Fly ash being a byproduct was been used in landfilling as solution for solid waste disposal purpose where in which these heavy metals leach through this landfills and effect the health of the surrounding population. But India is only country whose 70% of population depends on thermal power which means higher coal consumption resulting in higher fly ash production which should properly disposed.

Concrete is probably the most widely used man-made construction material in the world. Also, any type and shape of the component of the structural member can be fabricated when the concrete is green either in a factory or at the place of casting. We also replace the cement with fly ash to obtain a concrete with less cost and good property. Fly ash is a finely divided powder thrown out as a waste material at the thermal power plants obtained from coal burning process to produce electricity. The use of fly ash a part replacement of cement in mortar and concrete at the construction site has been made all over the world including India and is well known. Since a huge quantity of cement is used in concrete in mass concrete construction and the cost of fly ash is negligible as compared to that of the cement, the use of fly ash concrete brings about a substantial saving in cement consumption and overall construction cost. Fly ash concrete may be used in general RCC structures including high strength concrete without any risk of steel corrosion. Researchers have proved that concrete with approved quality fly ash does not induces corrosion of reinforcing steel even in marine and industrial aggressive environments. With proper mix design the 7 and 28-days strength of fly ash concrete may be equal or even more than plain concrete.

We all are aware of the fact that concrete is weak in tension and strong in compression in order to compensate the tension in the concrete we use either reinforcement or fibers in concrete it is hard to reinforce very thin members so we use fibers to reinforce thin members. Fiber is a small piece of reinforcing material possessing some characteristic property. Fiber is often described with a parameter called "aspect ratio". Generally aspect ratio of fiber ranges from 30 to 150. Glass fibers are also used in conjunction of cement in order to reduce alkaline effects; it also enhances the tensile strength of concrete to 1020N/sq.mm to 4080n/sq.mm

The objective of this study:

- The unit cost of concrete can be reduced by partial replacement of cement with fly ash.
- To obtain the properties of ingredients of concrete including fly ash and glass fiber.
- To compare the various strength parameters of concrete and flyash based concrete when we use glass fibers in it.
- To determine effective quantity of flyash use in concrete mix as a replacement of cement when admixture like glass fibers use in it.

2. METHODOLOGY

The procedure is taken with precision in this study. All the material required was collected and their various properties (i.e. mechanical, chemical, physical etc.) were studied from different tile sources, in detail. After that M35 Grade of the concrete mix was design as per IS 456-2000. In this paper, glass fiber in different volume fraction with 1%, 1.5%, 3% and 5% replacement of cement by fly ash has been used to study the effect on compressive strength, split tensile strength and flexural strength. The result was recorded at age of 7 & 28 days.

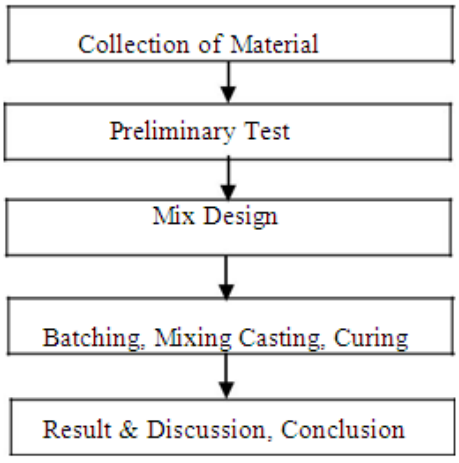

FIG 1: Experimental methodology

3. MATERIALS

CEMENT: Ordinary Portland cement of 43 Grade was preferably used referring to IS-8112:1989 of BIS. The grade manifests the compression strength (mpa) of the concrete that will attain after 28 days of setting. The cement having specific gravity value of 2.82, Soundness of 1 mm and normal consistency 33% was used.

Fly ash: Fly ash containing low calcium having color of whitish grey, specific gravity of 2.16, fineness of 315 m2/kg, moisture content of 0.17% was used as replacement for cement. The fly ash will be obtained from Rajiv Gandhi Super Thermal Power Project which is located between Khedar in Hisar, Haryana. To get the optimal replacement of the cement material, the particles of fly ash was passed through 90 micron sieve throughout the experimental works.

Glass fiber: In this experiment, alkali resistant glass fibers, 12mm long, having the tensile strength as 1700 MPA, specific gravity value of 2.68, modulus of elasticity as 72 GPA, having an aspect ratio of 857.1 and filament diameter of 14 micrometers was used.

Fine Aggregate: The fine aggregates utilized were easily accessible from the local market. Fine aggregate can be classified as those particles which roughly pass the 4.75mm IS sieve and significantly retains on the 75micron sieve. Fine Aggregates having specific gravity value of 2.79, fineness modulus as 2.51 was used.

Coarse Aggregate: The aggregates passing through 40mm sieve and retain at 4.75mm sieve was used as coarse aggregate. In this experiment, natural aggregates that are available locally, formed out of the rock disintegrated naturally, which was deposited by various agents. The two sizes of coarse aggregates were used, 10 mm & 20mm, having the specific gravity as 2.90 with the fineness modulus of 6.59.

4. CASTING & CURING

In this study, to achieve a target compressive strength of 35 MPa. Fly ash was used to replace ordinary Portland cement at varying percentage of 0%, 6%, 12%, 18% and 24% of cement. The Glass fibers of 0%, 2%, 4%, 6% and 8% by weight of cement were used.

S.NO.	MIX CODE	FLY ASH %	GLASS FIBER %
1	Mix 0	0%	0%
2	Mix 1	6%	1%
3	Mix 2	12%	1.5%
4	Mix 3	18%	3%
5	Mix 4	24%	5%

Table 1: Concrete Proportion

5. RESULT AND DISCUSSION

The compressive strength, flexible strength & split tensile strength of concrete specimens was tested at 7 & 28 days .The values of compressive strength of mixes at 28 days are shown below in the Table.

Table 2: Value of Compressive strength for 7 & 28 days

Sr. No.	% of Fly ash	Compressive Strength at 7 Days	Compressive Strength at 28 days
M0	0	24.74	39.47
M1	6	25.26	40.96
M2	12	25.84	42.59
M3	18	26.59	43.63
M4	24	25.11	41.48

Table 3: Value of split tensile strength for 7 & 28 days

Sr. No.	% of Fly ash	Split Tensile Strength at 7 Days	Split Tensile Strength at 28 days
M0	0	1.80	3.22
M1	6	1.89	3.42
M2	12	2.15	3.57
M3	18	2.22	3.7
M4	24	2.02	3.47

Table 4: Value of Flexural strength for 7 & 28 days

Sr. No.	% of Fly ash	Flexural Strength at 7 Days	Flexural Strength at 28 days
M0	0	3.42	4.70
M1	6	3.56	4.74
M2	12	3.7	4.83
M3	18	3.81	4.90
M4	24	3.64	4.72

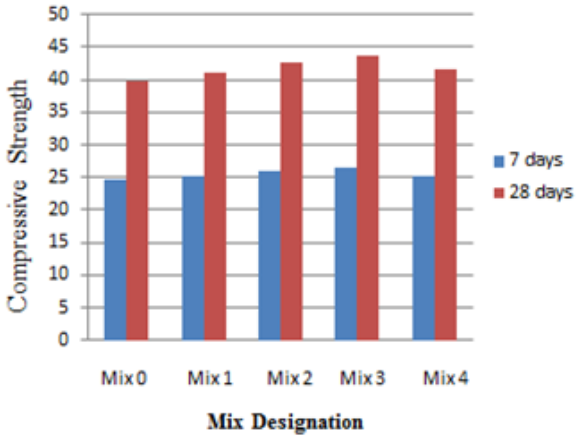

Fig.2: Graph comparing compressive strength for 7 and 28 days

5.1 COMPRESSIVE BEHAVIOUR OF SPECIMENS

The maximum compressive strength value is obtained when 18% of cement replaced with fly ash along with 3% of glass fiber.

Compressive strength values gradually increase with the percentage of fly ash increases. The compressive strength is decreased when 24% fly ash used with 5% glass fiber. It can be seen from the above tables and figures the addition of waste glass fiber also increases compressive strength value of concrete so that the compressive strength not reduced as the fly ash amount is decreased in different proportions Both at the curing age of 7 days and 28 days. The percentage increase in strength of concrete at 28 Days after adding 1, 1.5 & 3 percentage glass Fiber is 3.64%, 7.33% and 9.54% respectively.

Fig: 3 COMPRESSION STRENGTH TESTING MACHINE

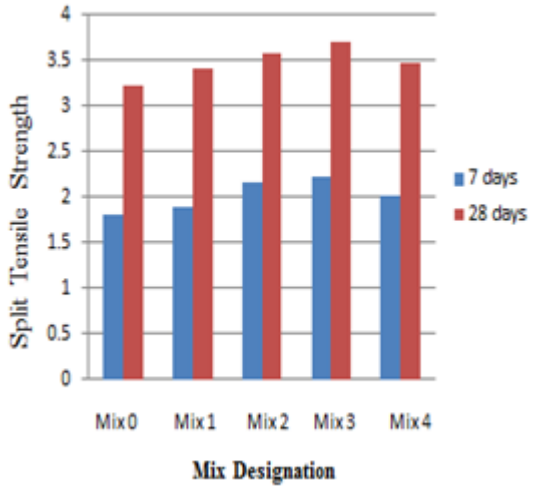

Fig.No. 4: Graph Split Tensile strength for 7 and 28 days

5.2 SPLIT TENSILE STRENGTH BEHAVIOUR OF SPECIMENS

Split tensile strength of concrete decrease with an increase in fly ash content. The maximum split tensile strength value is obtained when 18% cement replaces with fly ash along with 3% glass fiber.

It can be seen from the above tables and figures the addition of glass fiber increase in tensile strength of concrete both at the curing age of 7 days and 28 days. The percentage increase in strength of concrete at 28 days after adding 1, 1.5 and 3 percentage glass fiber is 5.85%, 9.81% and 12.98% respectively. The tensile strength decrease after adding 24% fly ash with 5% glass fiber.

Fig: 5 TEST SET UP FOR SPLIT TENSILE STRENGTH

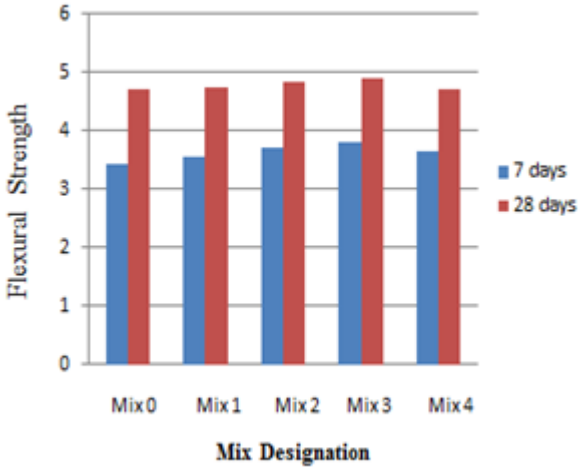

Fig.No. 6: Graph Flexural strength for 7 and 28 days

5.3 FLEXURAL STRENGTH BEHAVIOUR OF SPECIMENS

Flexural strength of concrete increase gradually with the percentage of glass fiber. And it decreases with an increase in fly ash content. The maximum flexural strength value is obtained when 18 % cement replaces with fly ash along with 3 % glass fiber. It can be seen from the above tables and figures that the flexural strength of concrete mixes containing glass fiber are higher than the flexural strength of the control mix. The percentage increase in flexural strength of concrete at 28 days after adding 1, 1.5 and 3 percentage of waste glass fiber is .85%, 2.7% and 4.09% respectively.

The split tensile strength is decreased with 24% fly ash used with 5% glass fiber.

Fig:7 Flexural Strength Testing.

6. CONCLUSIONS

In this paper, I made an attempt to study the properties of glass fiber reinforced concrete with partial replacement of fly ash with cement. The maximum compressive strength value for 28 days is obtained when 18% cement replaced with fly ash along with 3% glass fiber. Compressive Strength decreases with the increase of fly ash after 24% replacement. However, 24% replacement of cement with fly ash along with 5% glass fiber showed a decrease in the compressive strength by increasing fiber percentage. The maximum split tensile strength value for 28 days is obtained when 18% cement replaced with fly ash along with 3% glass fiber. Due to further addition of glass fiber split tensile strength decreased with increase the fly ash value. So that we can say that the strength of concrete increase at a certain limits if we use fly ash as a replacement of cement in concrete. This makes the concrete economical & also solves the dumping of waste fly ash in open land area.

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