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Experimental investigation on glass fibre concrete with partial replacement of cement by fly ash

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Abstract: **Fly ash has been used as a mineral admixture in cement and concrete. Using it provides several advantages, such as improved strength and workability properties, and environmental benefits related to the disposal of waste materials and to reduced carbon dioxide emissions. Alkali Resistant glass fibres are used as additional reinforcement of concrete. Glass fibres acted as good crack arrester and increases split and flexural strength not increase in compressive strength. M30 grade of concrete is used for this study. The main objective of this work is to study the suitability of the fly ash as a mineral admixture for cement replacement and additional reinforcement of glass fibres in concrete. Fly ash as partial replacement of cement and glass fibres are used as additional reinforcement, which satisfies the various structural properties of concrete like compressive, split and flexural strength. From the entire study it is concluded that mix M3 (10%FA+0.15%GF) is the best combination among all mixes, which gives maximum, tensile strength, (10% FA + 0.15% GF) shows better flexure strength and mix M3 (5% FA + 0.10% GF) is shows good compressive strength at 28 days over normal concrete. There is no increased compressive strength at 7 days and split tensile strength in fly ash mixes.**

Keywords: Fly Ash (FA), Alkali Resistance Glass Fibre (GF), Workability, Compressive Strength, Split Tensile Strength, Flexural Strength.

1. INTRODUCTION

Generally Sustainable development and produce a greener concrete material in the construction industry requires the utilization of industrial and agricultural waste materials. Now a day, for a number of reasons, the concrete construction industry is not sustainable. Mainly, it requires very large amount of virgin materials which can again require for next generations. Secondly, the main binding material in concrete is Portland cement, in the production of Portland cement produces huge amount of Carbon dioxides, this is a main reason to green house gas effects, emissions of carbon dioxides in manufacturing of Portland cements are causing global warming and climate change. Then another important criteria is, so many concrete structures suffer from durability problems which may waste the natural resources. So, implementing a solution to use a industrial and agricultural waste products for partial replacement of the port land cement, It seems to be suitable solution for sustainable development for present and future days. Recycling and reuse of waste materials contribute to energy savings in cement manufacturing, natural resources protection, and to protection of the environment from green house gas effect from minimises the emissions of carbon dioxide. Then other reasons are, the proper utilization of other certain components which are potentially pozzolanic reactivity can significantly improves the certain properties of concrete. One of the most important and suitable resource of mineral admixture among the industrial waste material is fly ash, as it is available in large quantities and it relatively contains a huge amount of silica.

Fibre reinforced concrete is a mixture of mainly port land cement, fine aggregate, coarse aggregate, water and addition of fibres. Fibre reinforced concrete is relatively new material, in fibre reinforced concrete, small length of fibres are dispersed randomly throughout the mix. The variety number of natural and artificial types of fibres is available in market the artificial fibres are mainly glass fibre, steel fibres, recrons and organic polymers etc. When the fibres are present in concrete mixes it will acts as crack arresters and improves the tensile and flexural strength of fibres. Compared to the normal concrete mixes means, concrete having only cement, fine aggregate, coarse aggregate and water, fibre reinforced concrete increases the strength in terms of flexure and tensile strength.

2. OBJECTIVES

The main objectives of this experimental investigation are as follows.

- To study the various properties of fly ash used as mineral admixture for partial cement replacement and glass fibre is used as additional reinforcement.
- To study the workability properties of concrete when cement is partially replaced with fly ash and increase the percentage of glass fibres in concrete.
- To study the various mechanical properties of concrete such as compressive, split tensile and flexural properties of the study.

3. MATERIAL DESCRIPTION

The materials used in the projects are cement, Fine aggregate, Coarse aggregate, Fly ash, Glass fibre are detailed below:

A. Cement

Cement is the essential ingredient to bind all other materials to form workable concrete. The Ordinary Portland Cement of 53 grades was used in this experimentation conforming to IS: 12269:1987 is used in this experimental project.

Table No 1:Physical properties on cement

PROPERTY	CEMENT
Specific gravity	3.15
Fineness	6%
Normal consistency	33
Initial setting time	36 minutes

B. Fine Aggregate

Natural river sand conforming to zone II of IS 383-1970 was used as fine aggregate. Table 2 shows the test results of basic properties of fine aggregates.

Table No 2:Basic Properties of Fine Aggregates

PROPERTY	FINE AGGREGATE
Specific gravity	2.66
Water absorption	0.3%

C. Coarse Aggregate

Natural crushed stone with 20mm down size was used as coarse aggregate. Table 3 shows the test results of basic properties of coarse aggregates.

Table No 3:Basic Properties of coarse Aggregates

PROPERTY	COARSE AGGREGATE
Specific gravity	2.75
Water absorption	0.5%

D. Glass fibre

In this experiment, alkali resistant glass fibres, 12mm long, specific gravity value of 2.68 was used.

E. Fly ash

Fly ash is obtained from a product of coal. Fly ash containing low calcium having color of whitish grey, specific gravity of 2.16, was used.

F. Water

Ordinary portable water was used in this investigation both for mixing and curing.

4. DESIGN MIX

As per IS 10292-2000 designed by M30 grade of concrete and water cement ratio 0.45.

Table No 4:Mixing of Concrete

MATERIALS	QUANTITY	MIX RATIO
Cement(kg/m3)	380	1
FA(kg/m3)	791.42	2.08
CA(kg/m3)	1129.8	3.07
Water(lits)	171	0.45

Casting and Curing of test Specimens

Hand mixing was done during the entire process of casting of specimens. Initially the dry mix constituents of the mix namely cement, fine aggregate and coarse aggregate was mixed for two minutes in the mixer and then the water and mixing continued for another 2 minutes. The total mixing time was kept at 4 minutes until a homogeneous mixture was obtained. Compaction was achieved by means of Tamping rod.

Fig No 1: Mixing of concrete

5. EXPERIMENTAL RESULTS

Fresh concrete:

The fresh concrete properties slump test is conducted. The slump value of concrete was 73mm.

Hardened concrete:

The hardened concrete specimen properties are checked by compressive strength, split tensile strength and flexural strength.

Compressive strength:

For every percentage of replacement 30 cubes have been casted. Among them, 10 cubes were tested on the 7th and the other 20 cubes were tested

on the 28th day. Totally 30 cubes were casted and 7th day and 28th day testing has been completed. Compressive test of concrete is carried out on specimens like cube by compression testing machine.

$f_c = (P/A)$ N/mm^2

Where,

P = Load at which the specimen fails in Newton(N)

A = Area over which the load is applied in mm

f_c = Compressive Stress in N/mm^2

Table No 5: Compressive Strength Results

MIX	Glass Fibre in %	Fly ash in %	Compressive strength(N/mm^2) at 7days	28 days
M1	-	-	16.25	32.86
M2	0.05	5	15.75	32.55
M3	0.05	10	15.67	32.43
M4	0.05	15	15.48	32.38
M5	0.10	5	15.70	33.01
M6	0.10	10	15.73	32.49
M7	0.10	15	15.55	32.24
M8	0.15	5	15.70	32.95
M9	0.15	10	15.78	32.69
M10	0.15	15	15.65	32.20

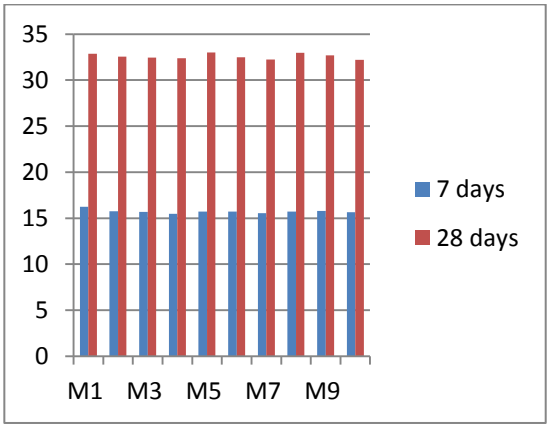

Fig No 2: Analysis of compressive strength

Fig No 3: Testing of cube

Split tensile Strength

For every percentage of replacement cylinders have been casted. Among them, 10 cylinders were tested on the 7th and the other 20 cylinders were tested on the 28th day. Totally 30 cylinders were casted and 7th day and 28th day testing has been completed. Split tensile Strength test of concrete is carried out on specimens like cylinders by compression testing machine. The Split tensile strength of the specimen was calculated by using the formula

$f_t = (2P/\Pi dl)$ N/mm^2

Where,

P = Maximum load in N applied to the specimen

d = Measured length in cm of the specimen

l = Measured diameter in cm of the specimen

f_t= Tensile strength N/mm^2

Table No 6: Split Tensile Test Results

MIX	Glass Fibre in %	Fly ash in %	Split tensile strength(N/mm^2) at 7days	28 days
M1	-	-	4.10	6.25
M2	0.05	5	3.82	6.13
M3	0.05	10	3.65	5.95
M4	0.05	15	3.52	5.89
M5	0.10	5	3.85	6.23
M6	0.10	10	3.70	6.49
M7	0.10	15	3.58	6.25
M8	0.15	5	3.89	6.42
M9	0.15	10	3.75	6.43
M10	0.15	15	3.64	6.35

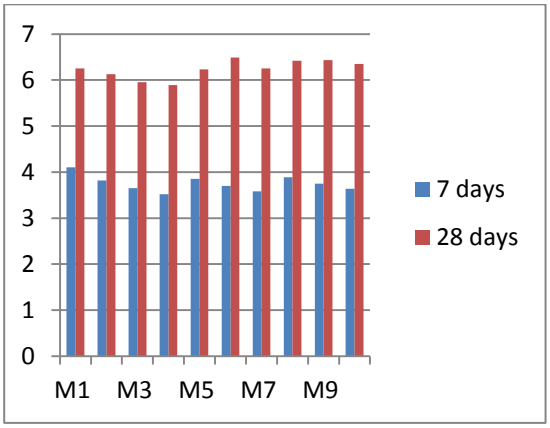

Fig No 4: Analysis of split tensile strength

Fig No 5: Testing of cylinder

Flexural Strength Test

For every percentage of replacement 30 beams have been casted. The 20 beams were tested on the 28th day**.** Totally 30 prisms were casted and 7th day and 28th day testing has been completed. Flexural strength is the one of the measure of the tensile strength of concrete. The flexural strength of the specimen was calculated by using the formula

$F_b = (Pl/bd^2)$ N/mm^2

Where,

P = Load at which specimen fails in (N)

l = Effective span in mm

b = Breadth of the specimen in mm

d = Depth of the specimen in mm

Table No 7: Flexural Strength Test Results

MIX	Glass Fibre in %	Fly ash in %	Flexural strength(N/mm^2) at 7days	28 days
M1	-	-	4.50	6.54
M2	0.05	5	4.20	6.20
M3	0.05	10	4.00	6.56
M4	0.05	15	3.80	6.45
M5	0.10	5	4.25	6.68
M6	0.10	10	4.37	6.76
M7	0.10	15	4.20	6.49
M8	0.15	5	4.32	6.76
M9	0.15	10	4.23	7.00
M10	0.15	15	3.95	6.54

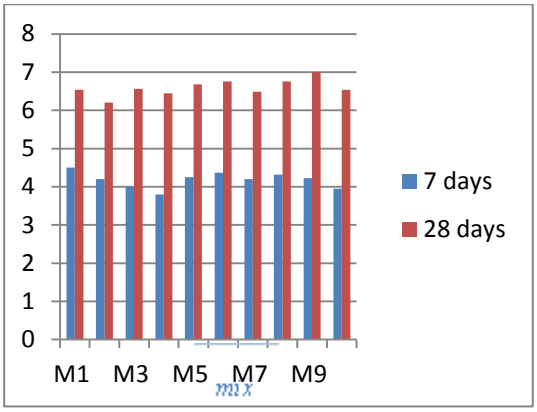

Figure no 6: Analysis of Flexural Strength

Fig No 7: Testing of prism

6. CONCLUSION

Based on experiments and test results on fresh & hardened concrete the following conclusions are drawn

- Fly ash content increased in the concrete mix workability of concrete is also increased and FA+GF combination mixes reduces the workability of mixes compared to the fly ash concrete mixes.
- The rate of gain in strength of fly ash concrete specimens is observed to be higher than the corresponding conventional concrete at 14 and 28 days.
- In 7 days strength there is no increased in compressive strength than control mix.
- Fly ash concrete having various cement replacement level up to 15% exhibited satisfactory results for both compressive, flexural and tensile strength.
- 10% FA and 0.15% GF combination gives good flexural strength than corresponding control mix and fly ash concrete mixes.
- 10% FA and 0.10% GF combination gives good tensile strength than corresponding control mix and fly ash concrete mixes.
- Use of fly ash reduces the amount of cement content as well as heat of hydration in a concrete mix. Thus, the

construction work with fly ash concrete becomes environmentally safe and also economical.

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