EFFECT ON MECHANICAL PROPERTIES OF CONCRETE USING PARTIAL REPLACEMENT OF CEMENT BY GLASS POWDER AND FLY ASH

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Abstract : In the present study the effect of glass powder and fly ash with different proportions in concrete by partial replacement of cement has been studied. 04 different mixes were prepared, in which glass powder and fly ash at different proportions CM, (10GP+20FA), (15GP+15FA) and (20GP+10FA) were utilized in replacement of cement by weight. The strength properties (compressive strength and split tensile strength) were evaluated at 7 days and 28 days of curing. It has been observed that the average compressive strength values of the cubes at 7 and 28 days for the mix having (10GP + 20 FA) has reduced marginally when compared to the general mix without GP and FA, whereas, it has increased for other two mixes (15GP + 15 FA), (20GP + 10 FA).

IndexTerms **- Compressive Strength, Cement, Glass Powder, Fly Ash.**

I. INTRODUCTION

Concrete is used as the major material in construction industries. As the population of world is increasing rapidly, world faces the problem for habitation and waste by- product. As the waste is proportional to the population and there are restriction of natural resources used in concrete , the construction industry need some attention to use some alternative material whose physical properties are same as the conventional one.

Fly ash, also known as "pulverized fuel ash" in the United Kingdom, is a coal combustion product that is composed of the particulates (fine particles of burnt fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash. Depending upon the source and composition of the coal being burned, the components of fly ash vary considerably. Primarily, fly ash has substantial amounts of silicon dioxide (SiO_2), aluminium oxide (Al_2O_3) and calcium oxide (CaO).

Glass is amorphous material with high silica content, thus making it potentially pozzolanic when particle size is less than 75µm. Studies have shown that finely ground glass does not contribute to alkali – silica reaction. In the recent, various attempts and research have been made to use ground glass as a replacement in conventional ingredients in concrete production as a part of greenhouse management. A major concern regarding the use of glass in concrete is the chemical reaction that takes place between the silica – rich glass particle and the alkali in pore solution of concrete, which is called Alkali – Silicate reaction can be very detrimental to the stability of concrete, unless appropriate precautions are taken to minimize its effects. ASR can be prevented or reduced by adding mineral admixtures in the concrete mixture, common mineral admixtures used to minimize ASR are pulverized fuel ash (PFA), silica fume(SF) and metakolin (MK). A number of studies have proven the suppressing ability of these materials on ASR. A high amount of waste glass as aggregate is known to decrease the concrete unit weight. The use of finely divided glass powder as a cement replacement material has yielded positive results, Optimal dosage range of this glass powder is chosen based on cement paste studies.

II. RESEARCH METHODOLOGY

The aim of the experimental program is to compare the mechanical properties of concrete by partial replacement of fly ash and waste glass powder with varying percentages in concrete by weight of cement. The basic tests carried out on concrete samples are discussed in this paper, followed by a brief description about mix design and curing

III. EXPERIMENTAL DETAILS

Various physical test on cement, sand and aggregates are conducted in laboratory and their values are calculated after they are checked as per IS code recommended values. Physical tests on cement fineness, consistency, initial and final setting times,

soundness and compressive strength while for sand some basic tests are conducted such as sieve analysis, specific gravity. On the other hand aggregates test are also conducted like sieve analysis, impact test, crushing strength values and abrasion test. At the end the compressive tests and split tensile strength tests on concrete are done.

IV. MATERIAL USED

For the entire experimental program, following materials were used.

4.1 Cement

Ordinary Portland Cement O.P.C-43grade (Ultra tech Cement) was used as per IS:8112-1989, the test results on physical properties of cement obtained in the lab are as shown in table 1.

Table 1: Physical Properties of OPC

Test Conducted	Test Results	IS code values
Fineness of cement	3.5%	Less than 10%
Consistency	31.0%	26% to 32%
Initial Setting Time	62 mins	Minimum 30 mins
Final Setting Time	263 mins	Maximum 600 mins
Soundness	2 mm	Less than 10mm
Specific Gravity	3.15	-
Compressive Strength (MPa)		
7 days	35.80	33
28 days	45.77	43

4.2 Stone Aggregate

Locally available angular crushed stone aggregates of size 20 mm and down were used as coarse aggregates and River sand was used as fine aggregate in the concrete mixes. The physical properties of the test results on coarse and fine aggregates are as shown in table 2 and 3.

Table 2: Physical properties of Fine Aggregate.

S.No.	Characteristics	Test Results
1	Type	Natural sand
2	Specific Gravity	2.69
3	Fineness modulus	2.55
4	Grading Zone	Zone III

Table 3: Physical Properties of Coarse Aggregate

S.No.	Test Conducted	Test Results
1	Impact test	6.8 %
2	Crushing Strength test	20.3%
3	Los Angeles Abrasion Test	21%
4	Specific gravity (10mm)	2.68
5	Specific gravity (20mm)	2.65

4.3 Water

Water used in preparation of concrete for experimental work is tap water.

4.4 *Fly Ash*

The flyash used in the experimental work was procured from Bathinda Thermal Power Plant, which as per the plant was conforming to class F as per ASTM- C 618-93, which categorizes natural pozzolans and fly ash into the following three categories:- Class N Fly Ash, Class F Fly Ash and Class C Fly Ash.

Table **4** Requirements for Fly Ash and Natural Pozzolans for use as a Mineral Admixture in Portland Cement Concrete as per ASTM C 618-93

Requirement	Fly ash classifications		
	N	F	C
Chemical requirements			
SiO2+Al2O3+Fe2O3, min%	70	70	70
SO3, max%	4	5	5
Moisture content, max%	3	3	3
Loss on ignition, max%	10	6	6
Physical requirements			
Amount retained when wet sieved on 45mm sieve, max%	34	34	34
Pozzolanic activity index, with Portland cement at 28 days, min% of control	75	75	75
Pozzolanic activity index, with lime at 7 days, min (MPa)	5.5	5.5	---
Water requirement, max% of control	115	105	105
Autocalve expansion or contraction, max	0.8	0.8	0.8
Specific gravity	5	5	5
Percentage retained on 45 mm sieve	5	5	5

4.5 Waste Glass Powder

Waste glass was collected locally and grounded into powder form using ground miller machine to the size of 70 µm. The colour of the waste glass powder obtained was white. The main chemical composition of the glass powder was Silica, Lime, Alumina and sodium oxide.

V. METHODOLOGY

The design of concrete mix for a particular grade requires the economical selection of relative proportions of it ingredients such as cement, fine aggregates, coarse aggregates, water and admixtures, if any. Though, the characteristic compressive strength of the concrete is the main criterion, the concrete must also have the desired workability and durability.

5.1 Design of Concrete Mix

Mix design has been done as per IS code 10262- 2009**.** Steps followed for proportion of concrete mix are

1) Selection of ingredients –cement, supplementary cementing materials, aggregates, water and chemical admixture.

2) Quantities of all ingredients to meet an economical concrete.

3) Quality control.

5.2 Design Data

Grade Designation = M-30
Type of Cement = O.P.C-43grade
Brand of cement = Ultra tech Cement
Fine Aggregate = Zone-III

Specific Gravity Cement = 3.8

a. Fine Aggregates = 2.71
b. Coarse aggregates (10mm) = 2.68
c. Coarse aggregates (20mm) = 2.65

Minimum Cément content = 390kg/m^3
Maximum water cement ratio = 0.45

Table 5 Mix Proportion

Unit of Batch	Cement (kg)	Fine Aggregate (kg)	Coarse aggregates (Kg)		Water
			10mm	20mm	
Cubic meter	390	705.8	613.5	613.5	175.5

Ratios	1	1.8	1.573	1.573	0.45

5.3 Mix Composition

One concrete mix without (FA+GP) and three concrete mixes with different proportions of (FA+GP) were prepared in the lab as shown in table 6.

Table 6 Mix composition in all batches

MIX	GP (Replacement by weight of cement) %	FA (Replacement by weight of cement) %
CM	0	0
(10GP + 20FA)	10	20
(15GP + 15FA)	15	15
(20GP + 10FA)	20	10

VI. RESULTS

6.1 Compressive Strength

For the compressive strength test, 150x150x150 mm size cubes were cast and tested at age of 7 and 28 days for all the batches of mixes. Three cubes of each mix were tested after 7 days and 28 days of curing, the results of which are as shown in table 7.

Table 7 Compressive Strength Tested at the age of 7 days and 28 days

MIX	Average Compressive Strength (N/mm^2)	
	7 days	28 days
CM	25.142	41.565
(10GP + 20FA)	24.560	41.270
(15GP + 15FA)	27.468	42.146
(20GP + 10FA)	29.066	49.558

The replacement of glass powder and fly ash in concrete by weight of cement increases the compressive strength as compared to normal conventional concrete (CM). It has been observed that the compressive strength initially increases with addition of glass powder and fly ash in the mix in the proportion (20 GP + 10 FA) and (15GP + 15FA). However, the decrease in compressive strength has been observed when the proportion of glass powder and fly ash was increased to (10GP + 20FA).

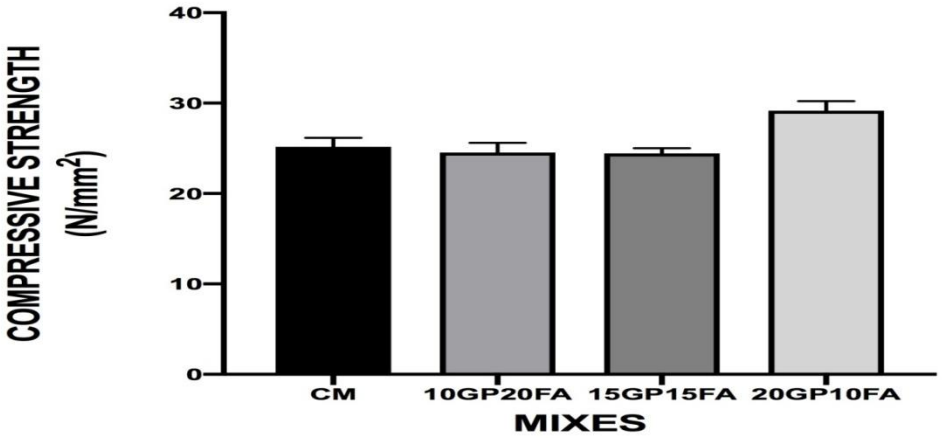

Fig. 1. Compressive Strength at the age of 7 days

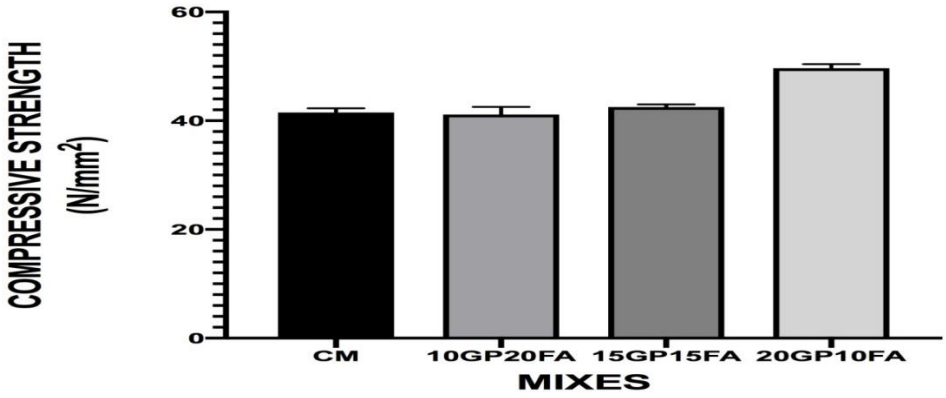

Fig. 2. Compressive Strength at the age of 28 days

6.2 Split Tensile Strength

Six cylinders of sized 150x300 mm were cast and three of each mix were tested for the spilt tensile strength after 7and 28days of curing, the test results of which are as shown in table 9

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Table 9 Split Tensile Strength Tested at the age of 7 days and 28 days

MIX	Split Tensile Strength(N/mm^2)	
	7 days	28 days
CM	2.313	2.775
10GP 20FA	2.035	2.845
15GP 15FA	2.451	2.868
20GP 10FA	2.450	2.910

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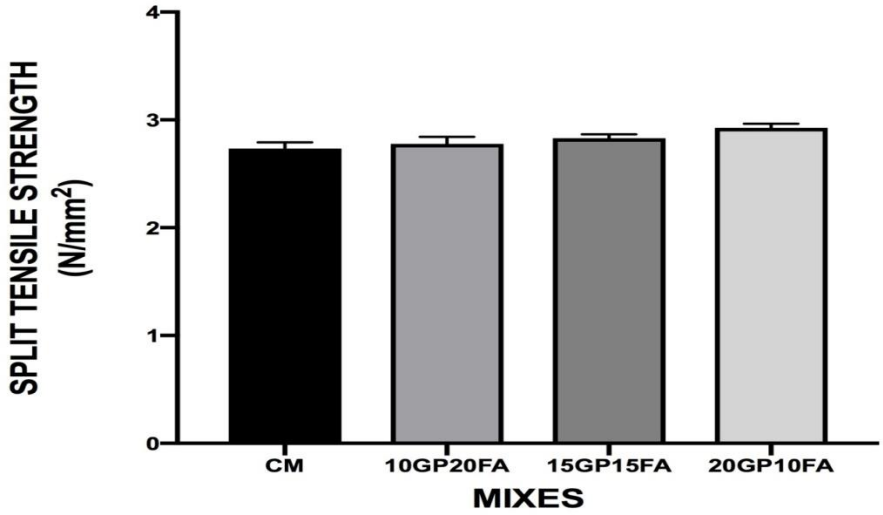
It has been observed that the split tensile strength for concrete having glass powder and fly ash at different proportions show increase in strength when compared to the normal conventional (CM).



xFig.3 Split Tensile Strength at the age of 7 days

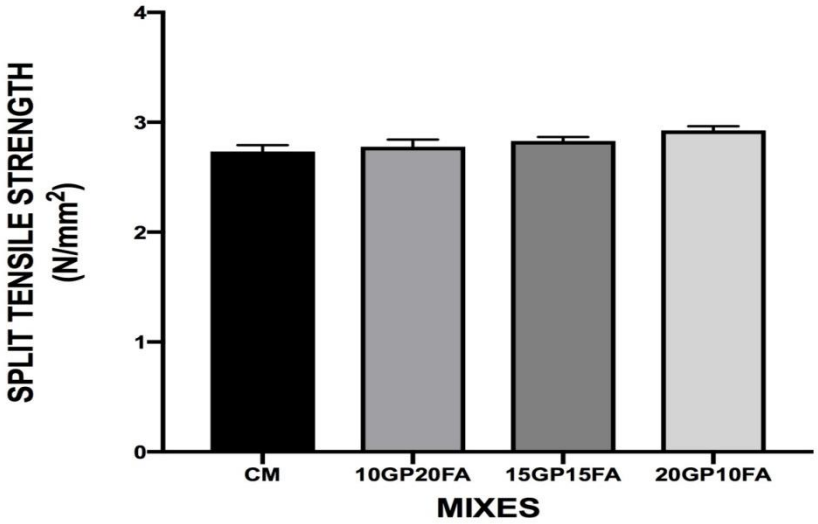


Fig.4 Split Tensile Strength at the age of 28 days

VII. CONCLUSION

Based on the limited experimental investigation , the following conclusions are drawn:.

1. Conventional concrete shows at 28 days compressive strength as 41.565 N/mm^2, split tensile strength of 2.775N/mm^2.
2. The compressive strength increases with addition of glass powder and fly ash in the mix in the proportion (20 GP + 10 FA) and (15GP + 15FA).
3. Decrease in compressive strength has been observed when the proportion of glass powder and fly ash was increased to (10GP + 20FA).
4. The optimum replacement of cement with a mixture of glass powder and fly ash has maximum compressive strength value at the 20% replacement.
5. The split tensile strength for concrete having glass powder and fly ash at different proportions show increase in strength when compared to the normal conventional (CM).

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