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AN EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF CEMENT BY SILICA FUME AND GGBS WITH ADDITION OF POLYPROPYLENE FIBERS

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Abstract - *The production of cement involves emission of large amount of carbon dioxide into the atmosphere, a main contributor for greenhouse effect and global warming. This paper presents a partial replacement of cement by Silica fume and Ground Granulated Blast Furnace (GGBS). M40 grade of concrete is used in the study and mix design was carried out according to the guidelines of IS 10262. Silica fume replaces cement in the ratio of 5%, 10% and 15% along with GGBS in the ratio of 20 %, 30 % & 40 % respectively for every differential variation of silica fume.1% Polypropylene fiber is added for arresting micro cracks in concrete. The mechanical characteristics of the casted specimens are analysed by assessing the compressive, split tensile and flexural strength of the concrete is carried out. The strength parameters are better for the concrete with higher silica fume and lesser GGBS mix*.

Key Words: **Silica Fume (SF), Ground Granulated Blast Furnace Slag (GGBS), (Pfiber) polypropylene fiber, Compressive strength, Workability, Flexural strength.**

1. INTRODUCTION

Concrete is that the most generally used man-made construction material. it's obtained by mixing cement, water, aggregates and admixtures (if needed), in required proportions. The mixture when placed in forms and allowed to cure, hardens into rock – mass referred to as concrete. The strength, durability and other characteristics of concrete depends upon the properties of its ingredients, on the proportions of mix, the tactic of compaction and other controls during placing, compacting and curing. The very fat growth in industrialization has resulted in tons and plenty of by-product or waste materials, which may be used as GGBS (ground granulated furnace slag), silica fume. The utilization of those by-products not only helps to utilize these waste materials but also enhances the properties of concrete in fresh and hardened states. Perhaps the foremost successful Supply Chain Management (SCM) is silica fume and GGBS because it improves both strength and sturdiness of concrete to such extent that modern design rules involve addition of silica fume and GGBS for design of high strength concrete.

1.1 OBJECTIVE

The objective of the present research work is to find out the different properties of silica fume and GGBS. To reduce the utilization of cement by partial replacement of silica fume and GGBS. To enhance the best environmental alternate for cement.

1.2 MATERIAL AND METHODOLOGY

1.2.1 CEMENT

Ordinary Portland Cement (53 grade) conforming to IS: 12269 -1987 and with the specific gravity 3.23 was used for casting all the specimens. Tests conducted on cement are fineness of cement by sieve analysis (using 90 µ sieve), specific gravity using Le-chatlier's apparatus, initial setting time and final setting time using vicat apparatus.

Table-1 properties of cement

Sl.No	TESTS	RESULTS
1	Specific Gravity	3.23
2	Initial Setting Time	37
3	Final Setting Time	535
4	Consistency test	29.5
5	Fineness test	4.93

1.2.2 SILICA FUME

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Cement is partially replaced by silica fume by 5%, 10%, 15%. Tests conducted on silica fume are fineness of silica fume by sieve analysis and specific gravity using Le-chatlier's apparatus.

1.2.3 Ground Granulated Blast-Furnace Slag

Ground Granulated Blast-Furnace Slag is obtained by quenching molten iron slag from a blast furnace in water or stream, to produce a glassy, granular product that is then dried and ground into a fine powder. Cement is partially replaced by GGBS by 20%, 30%, 40%. Tests conducted on GGBS are fineness of GGBS by sieve analysis and specific gravity using Le-chatlier's apparatus.

1.2.4 Fine Aggregate

M-Sand is a substitute of river sand for concrete construction. Sand passing through IS 4.75 mm sieve and as per IS: 383-1970 was used for all the specimens. Test conducted on fine aggregate are specific gravity using pycnometer, fineness modulus by sieve analysis.

1.2.5 Coarse Aggregate

Crushed granite aggregate with specific gravity of 2.6 and passing through 20 mm sieve and retained on 12.5 mm sieve and as given in IS: 383 - 1970 is used for all the specimens.

1.2.6 Water

Casting and curing of specimens were done with the potable water as per IS 456:2000. The test results are compiled as

Table-2 water test

S.NO	WATER	pH VALUE
1.	Sample 1	7
2.	Sample 2	7
3.	Sample 3	7

1.2.7 Polypropylene Fiber

Polypropylene fiber a synthetic formed from a polypropylene melt. It is generally superior to polyamide fibers in elasticity and resiliency, but it has lower wear resistance. It displays good heat-insulating properties and is highly resistant to acids, alkalies and organic solvents. This even reduce the early plastic shrinkage cracking by enhancing the tensile capacity of fresh concrete to resist the tensile stresses caused by typical volume changes. 1% of Polypropylene fibers are used in the concrete.

1.3 MIX PROPORTIONS

The concrete mix design is a process of selecting suitable ingredients and determine their relative proportions with an object of producing the concrete of certain minimum strength and durability as economical as possible. The mix design was proposed by using IS 10262:2009. Concrete cubes of size 150mm x 150mm x 150mm were cast in cube mould using the design mix of (1 : 1.9 : 3.2)with w/c ratio of 0.45. the cylindrical specimen of 300mm height and 150mm radius and prism of 700mm X 150mm x 150mm were casted for testing. Ten mixes were used i.e. **M0 -** Conventional mix, **M1 -** SF- 5 %, GGBS- 20 %, Pfiber- 1 %, **M2** - SF- 5 %, GGBS- 30 %, Pfiber- 1 %, **M3** - SF- 5 %, GGBS- 40 %, Pfiber- 1 %, **M4** - SF- 10 %, GGBS- 20 %, Pfiber- 1 %, **M5** - SF- 10 %, GGBS- 30 %, Pfiber- 1 %, **M6** - SF- 10 %, GGBS- 40 %, Pfiber- 1 %, **M7** - SF- 15 %, GGBS- 20 %, Pfiber- 1 %, **M8** - SF- 15 %, GGBS- 30 %, Pfiber- 1 %, **M9** - SF- 15 %, GGBS- 40 %, Pfiber- 1 %.

Table-3 mix proportions

PROPORTION	WATER (lit/m^3)	CEMENT (kg/ m^3)	FINE AGGREGATE (kg/ m^3)	COARSE AGGREGATE (kg/ m^3)
By volume (m^3)	0.40	1	1.9	3.2
By weight(kg)	191	478.9	695.82	1126.6

Table-3.1 – mix proportions

PROPORTION	WATER (lit/ m^3)	CEMENT PROPORTION			FINE AGGREGATE (g)	COARSE AGGREGATE (g)	POLYPROPYLENE FIBRE%
		CEMENT (1000 g)	SILICA FUME(g)	GGBS (g)			
M0	0.40	1000	0	0	1900	3200	0
M1	0.40	750	50	200	1900	3200	1
M2	0.40	650	50	300	1900	3200	1
M3	0.40	550	50	400	1900	3200	1
M4	0.40	700	10	200	1900	3200	1
M5	0.40	600	10	300	1900	3200	1
M6	0.40	500	10	400	1900	3200	1
M7	0.40	650	15	200	1900	3200	1
M8	0.40	550	15	300	1900	3200	1
M9	0.40	450	15	400	1900	3200	1

1.4 TEST ON SPECIMENS

Testing of specimens plays an important role in controlling the quality and quantity of concrete. All the specimens cast were subjected to testing to study the effect of partial replacement of silica fume and GGBS with respect to cement on strength properties are studied with

- Compressive strength test,
- Split tensile strength test,
- Flexural strength test.

1.4.1 COMPRESSIVE STRENGTH TEST

The compressive strength test was carried out on 150mm x 150mm x 150mm cubes as specified by IS 516-1959(1989). The results of the compressive strength of conventional and partial replacement of cement by silica fume and GGBS with addition of polypropylene fiber concrete at 3 days, 7 days and 28 days for M40 grade concrete are tabulated.

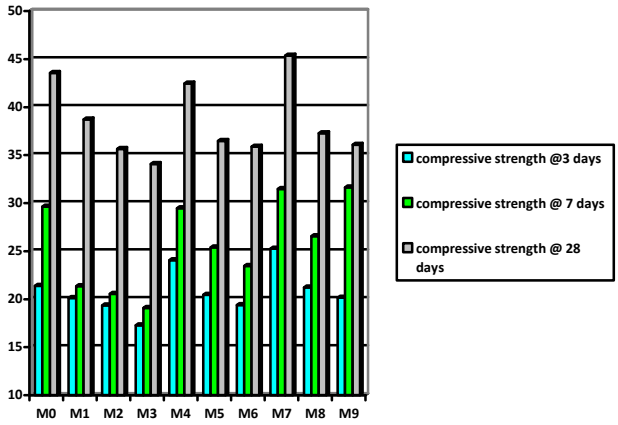

Chart-1 compressive strength

Table-4 Compressive strength			
Mix proportions	**Compressive Strength @ 3 days (N/mm²)**	**Compressive strength @ 7 days(N/mm²)**	**Compressive strength @ 28 days (N/mm²)**
M0	21.39	29.62	43.56
M1	23.12	31.34	41.72
M2	21.34	30.56	40.63
M3	20.28	29.09	35.18
M4	24.07	35.48	43.45
M5	22.45	33.39	41.49
M6	21.37	28.74	37.89
M7	25.25	37.43	45.36
M8	21.23	36.56	42.27
M9	20.14	31.65	39.08

1.4.2 SPLIT TENSILE STRENGTH TEST

The split tensile strength test was carried out on cylindrical specimens of 150mm diameter and 300 mm length. The results of the split tensile strength of conventional and partial replacement of cement by silica fume and GGBS with addition of polypropylene fiber concrete at 7 days and 28 days for M40 grade concrete are tabulated.

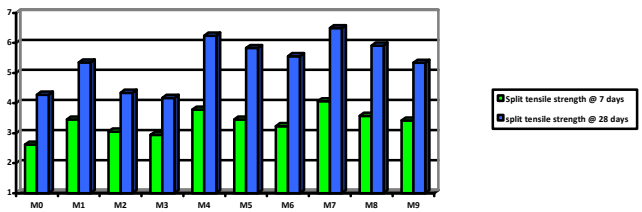

Chart-2 split tensile

Table-6 flexural strength	
Mix proportions	**Flexural strength of @ 28days (N/mm²)**
M0	7.4
M1	7.9
M2	6.56
M3	5.6
M4	8.2
M5	6.6
M6	5.83
M7	9.4
M8	6.9
M9	6.23

1.4.3 FLEXURAL STRENGTH TEST

The flexural strength test was carried out on prism specimens of 700mm length, 150 mm breadth and 150 mm height. The results of the flexural strength of conventional and partial replacement of cement by silica fume and GGBS with addition of polypropylene fiber concrete at 28 days for M40 grade concrete are tabulated.

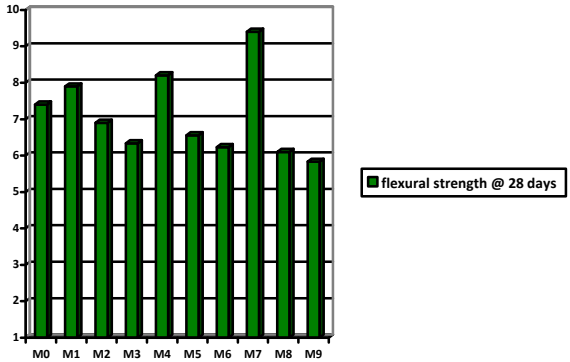

Chart-3 flexural strength

Table-5 split tensile		
Mix proportions	**Split tensile strength @ 7 days (N/mm²)**	**Split tensile strength @ 28 days (N/mm²)**
M0	2.62	4.28
M1	3.45	5.35
M2	3.05	4.34
M3	2.96	4.17
M4	3.78	6.24
M5	3.45	5.83
M6	3.23	5.56
M7	4.06	6.49
M8	3.57	5.91
M9	3.42	5.74

1.5. CONCLUSIONS

The present work experimentally investigated the partial replacement of cement by Silica fume and Ground granulated blast furnace slag with addition of polypropylene fiber. Concrete properties (compressive strength and water absorption) were analyzed on the basis of the results from the present study, following conclusions are drawn.

Based on the test carried out on the five mixtures the following conclusion has been made:

The fineness and high-water absorption properties of the silica fume and GGBS reduce the workability of the concrete, and the workability of the concrete also decreases with an increase in the silica fume and GGBS substitution rate.

Due to the addition of polypropylene fibers into concrete, the plastic shrinkage cracks of concrete at the early age reduced.

High strength, high durability as well as pore reducing capacity in the structures due to the addition of silica fume and GGBS compared to control mix.

From the results obtained it is suggested that silica fume 15 % and GGBS with a substitution rate up to 20% can be used effectively as a partial replacement of cement in good concrete production without affecting the concrete standards

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