EXPERIMENTAL STUDY ON CONCRETE PROPERTIES AND PARTIAL REPLACEMENT OF CEMENT WITH SILICA FUME

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Abstract

The research paper is to assess the recital of Silica Fume an industrialized by the product as a admixture in concrete maintenance in analysis the growing market order of cement which need manufacture of cement at huge scale resulting in environmental crisis and exhaustion of ordinary resources on one hand and increasing prices on the other supply. To defeat these crisis ideas industrial to investigate the use of industrial by product waste. The silica fume industrial by product found to be an attractive cementations material which is by product of smelting process in the silicon and ferrosilicon industry. The partial replacement or alternate of silica fume and its effects on concrete properties using M-35 concrete mix has been studied in this paper. The most important parameter accessed in M-35 concrete mix with partial replacement by silica fume with varying 0%, 5%, 9%, 12% and 15% by weight of cement. The experimental work has been investigated on compressive strength, split tensile strength and flexural strength for 7 days and 28 days respectively. The result revealed that the use of silica fume in concrete has been improved the durability and strength as compared to ordinary concrete. Hence the utilize of Silica Fume shows to decrease in cement quantity for manufacture use and it should be advanced for better performance and green environmental aspects.

Keyword: Compressive Strength, Flexural Strength, Silica Fume, Split Tensile Strength

1.INTRODUCTION

Concrete is usually as a mixture of cement, fine aggregate (sand), coarse aggregate (Jelly) and potable water. Today, Cement concrete is always used to the construction areas and can be created into several shapes in plastic phase [1,2]. The relative size of constituent controls the properties on concrete in wet stage and in hardened stage. Before two or three decades ago, the production of concrete for construction of building with ordinary Portland cement with the ease of accessibility of ingredient of concrete irrespective of quality was in practice without considering the future of concrete structure [2]. Now with the passage of time in the modern era investigation since last two to three decades made by the Engineers and scientists keeping in view the structural stability of structure which needs quality concrete with improved strength, durability and other characteristics of concrete [3]. The demand of these characteristics derives the search for supplementary cementitious materials. Search for any suitable material in partial replacement of cement which is universally sustainable development and lowest possible environmental impact [4,5]. It is easy to make concrete but actually concrete is complex material. It is site made material and a such its quality, properties and performance can vary to great extent due to use of natural material except cement. In the fast development of infrastructure in the country use of high strength & high performance cement (HPC) is now in common practice [6]. In the journey of research Silica Fume, fly ash, ground granulated blast furnaces slag etc are found suitable and most commonly used cementations materials in partial replacement of cement. Substantially use of industrial by products saves

the cost and energy in addition to meet out the requirement of environmental awareness.

Silica Fume pozzolanic materials is found most suitable industrial product as to be used in concrete as partial replacement of cement [7]. Researchers are going to study the impact of use of these pozzolanic materials as cement replacements in India /other countries and the results are hopeful. Addition of silica fume to concrete has many advantages such as high strength, durability and reduction in the production of cement. The finest silica fumes replacement proportion for obtaining maximum 28 days concrete strength varies from 5 to 15%. Cement replacement up to 12% with silica fume leads to increase in compressive strength, for M35 grade of concrete [8]. When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C – S – H), which improve durability and the mechanical properties of concrete.

2. MATERIALS AND METHODOLOGY

2.1. Cement

Ordinary Portland Cement of 43 grade confirming to IS 4031-1988 was used in the present study. The various properties of cement are shown in the Table 1.

Table 1. Properties of Cement (Is 4031-1988) [9]

Sl. No	Properties of cement	Result
1	Normal Consistency	33 %
2	Initial Setting Time	42 mins
3	Specific Gravity	9.99
4	Fineness of cement	5%
5	Specific Area	3250 cm^2/gm
6	Soundness of cement	1.0 mm

2.2. Fine Aggregate

Natural river sand locally available confirming to IS 383-1987 was used of grading zone II. The properties of fine aggregate are shown in Table 2.

Table 2. Properties of Fine Aggregate (Sand) as per IS 383- 1987 [10,11]

Sl. No	Property of fine aggregate	Result
1	Bulk density	1625 kg /m^3
2	Specific Gravity	2.67
3	Fineness Modulus	3.20
4	Water absorption	1.15

2.3. Coarse Aggregate

Coarse aggregate of size 10mm & 20 mm of crushed stone locally available confirming to IS 383-1987 was used (Table3)

Table 3. Properties of Coarse Aggregate (Jelly) as IS 383-1987 [10,11]

Sl. No	Property of Coarse Aggregate	Result
1	Bulk density	1525 kg /m^3
2	Specific gravity	2.89
3	Fineness Modulus	3.67
4	water absorption	0.46%

2.4. Water

The potable water used in this study was free of alkalis, acids, salts, organic materials & other impurities.

2.5. Silica Fume

Silica fume is a byproduct of Astrra Chemicals, 11, Moores Rd, Thousand Lights West, Thousand Lights, Chennai, Tamil Nadu. (Table 4).

Sl. No	Physical Properties	Range/Result
1	Bulk density	750-850 Kg/m^3
2	Surface Area	20000 m^2/kg
3	Particle Shape	Irregular
	Particle size	N/A
4	D50	<7 micron
	D95	<20 micron
5	Specific gravity	2.90
6	Chemical Properties	Result
7	SIO_2	30-36%
8	Al_2O_3	18 - 25%
9	Fe_2O_3	0.08-3%
10	CaO	30-34 %
11	SO_3	0.1 -0.4 %

3.EXPERIMENTAL INVESTIGATION PROCEDURE

3.1.Mix Proportion

Table 5. Silica Fume Concrete Mix

Mix	% of Silica fume	Water in Litre	Cement in Kg	20 mm size Coarse Aggregate in Kg	10 mm size Coarse Aggregate in Kg	Fine Aggregate in Kg	Micro Silica in Kg
Mix 0	0	14.1	34.7	36.5	65	53	0
Mix 1	5	4.1	33.0	36.5	65	53	1.7

Mix 2	9	4.1	31.5	36.5	65	53	3.1
Mix 3	12	4.1	30.5	36.5	65	53	4.1
Mix 4	15	4.1	28.5	36.5	65	53	5.2

3.2. Casting of Specimen

Mix Proportion: Mix proportioning by weight was used in concrete mix design in this experiment was designed as per table for given in IS 10262. (Table5)

Casting of Specimen: The following mould for casting the specimen were used [12]

The specimen of standard cubes of (150 mm x 150 mm x 150 mm) was used to determine the compressive strength.

- The specimens of standard cylinders of (300 mm x 100 mm) were used to determine split tensile strength.
- The specimens of standard prisms of (150 mm x150 mm x700 mm) were used to determine the flexural strength.
- Total 30 Cubes, 30 cylinders & 30 prisms were casted for the strength parameters. The constituents were waved and the materials were mixed by hand mixing. The concrete was filled in different layer and each layer was compacted. The specimens were remolded after 24 hours cured in water for 7 & 28 days. Thus tested for its compressive, split tensile and flexural strength as per Indian standard.

4. RESULT AND DISCUSSIONS

The results revealed that the fresh and hardened concrete with partial replacement of Silica fume as compared with normal concrete (Table6).

Table 6. Result of Compressive, Split Tensile and Flexural Strength for 7 and 28 Days

Mix	% of Silica fume added	Compressive strength in N/mm²		Split tensile strength in N/mm²		Flexural strength in N/mm²	
		7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
Mix 0	0	21.6	40.2	3.1	4.2	1.6	2.7
Mix 1	5	23.6	43.1	3.4	5.4	2.1	3.0
Mix 2	9	30.1	45.2	3.5	5.5	2.7	3.7
Mix 3	12	31.2	46.1	2.7	4.5	2.8	3.8
Mix 4	15	25.5	41.3	2.3	4.1	1.8	3.4

4.1. Compressive Strength

The test was carried out conforming to IS 516-1959 to obtain compressive strength at the age of 7 and 28 days. The cubes were tested using Compression Testing Machine (CTM) of capacity 2000 KN. The results are shown below:

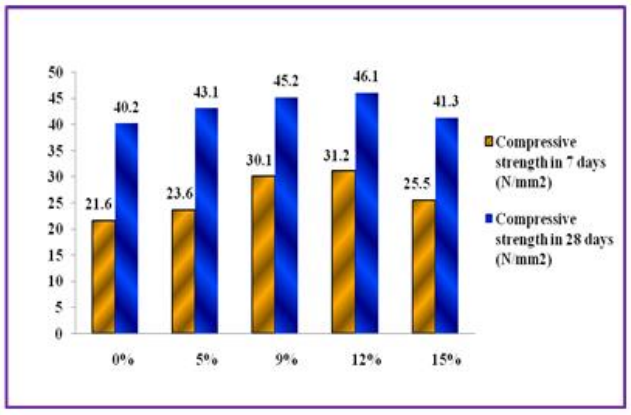

Figure1 Compressive Strength of Concrete with Silica Fume

The compressive strength as shown increased the values up to 31.20 N/mm2 and 46.10 N/mm2 at 7 and 28 days. There is a significant improvement in the compressive strength of concrete. The compressive strength with partial replacement of cement by silica fume increased 12 % and then decreased. The optimum silica fume was 12% replacement for obtaining maximum 28 day strength varies from 5% to 12% replacement of silica fume as shown in Fig.1.

4.2. Split Tensile Strength of Concrete

The test was carried out conforming to IS 516-1959 to obtain Split Tensile Strength of Concrete strength at the age of 7 and 28 days. The cylinders were tested using Compression testing machine (CTM) of capacity 1000 KN. The results are shown below

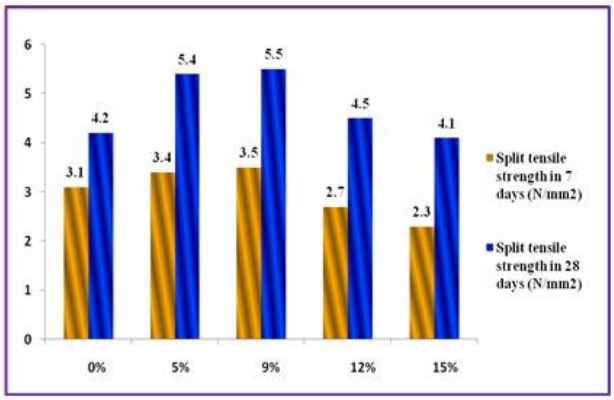

Figure 2 Split tensile strength of concrete with silica fume

Split Tensile Strength of Concrete increases with the increase of percentage of silica fume as shown above parameter. The partial replacement 9% Silica fume is found to be suitable optimum. Thus, at the age of 28 days with the partial replacement of high performance concrete obtained as shown in Fig.2. The partial replacement of silica fume indicates 31% greater split tensile strength as compared normal concrete.

4.3. Flexural Strength of Concrete

The test was carried out conforming to IS 516-1959 to obtain Flexural Strength of Concrete strength at the age of 7 and 28 days. The beams were tested using Flexural Testing machine (FTM) of capacity 1000 KN.

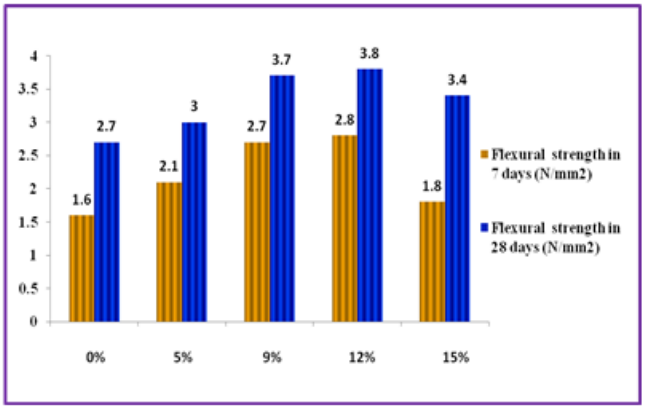

Figure 3 Flexural strength of concrete with silica fume

The results are shown below flexural Strength at the age of 28 days silica fume concrete continuously increase with respect of controlled concrete and reached maximum value of 5 to 12 % replacement of silica fume. The partial replacement 12% Silica fume is found to be suitable optimum. Thus at the age of 28 days with the partial replacement of Silica fume high performance concrete is obtained as shown in Fig.3. The partial replacement of silica fume indicates 41% greater Flexural strength as compared to normal concrete.

5. CONCLUSION

- The study revealed that high performance concrete produced by partial replacement of cement with silica fume.

- The present study achieved with the replacement of cement by 5%, 9%, 12% and 15% silica fume.
- Three tests were carried out such as compressive strength, split tensile strength and the flexural strength test at the age of 7 days and 28 days.
- Hence, high performance concrete achieved by replacement of cement up to 12% silica fume leads to rise (increased) in compressive strength and the flexural strength of concrete.
- The compressive strength mainly depends on percentage of silica fume. High performance concrete with silica fume can be effectively used in high rise building since high early strength is required with the reduced construction period.
- The percentage of increase in compressive strength is 18.02 %, split tensile strength 21.4 % and the flexural strength is 41.5% at the age of 28 days by replacing partial replacement of cement with silica fume.
- Finally, the optimum percentages of partial replacement of cement with silica fume such as compressive strength-12% and flexural strength and split tensile strength of concrete - 9%.

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