PARTIAL REPLACEMENT OF CEMENT WITH SILICA FUME AND ITS EFFECTS ON CONCRETE PROPERTIES

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ABSTRACT: The aim of this study is to evaluate the performance of Silica Fume an industrial by product as a admixture in concrete keeping in view the increasing market demand of cement which compel production of cement at large scale resulting in environmental problem and depletion of natural resources on one hand and rising prices on the other hand. To overcome these problem ideas developed 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 of silica fume and its effects on concrete properties has been studies by adopting M-35 concrete mix in this dissertation. The main parameter investigated in this study M-35 concrete mix with partial replacement by silica fume with varying 0, 5, 9, 12 and 15% by weight of cement The paper presents a detailed experimental study on compressive strength, flexural strength and split tensile strength for 7 days and 28 days respectively. The results of experimental investigation indicates that the use of silica fume in concrete has increased the strength and durability at all age when compared to normal concrete. Hence the use of Silica Fume leads to reduction in cement quantity for construction purpose and its use should be promoted for better performance as well as for environmental sustainability.

KEYWORDS:-Silica Fume, Compressive Strength, Split tensile Strength, flexural Strength

I. INTRODUCTION

Concrete is a mix of ingredient of cement, fine aggregate, coarse aggregate & water. It can be molded into any shape in plastic stage. The relative quantity of ingredient control the property on concrete in wet stage as well as in hardened stage. Before two or three decades ago, the production of concrete for construction of building with OPC with the ease of availability of ingredient of concrete irrespective of quality was in practice without considering the future of concrete structure. Now with the passage of time in the modern era investigation since last two to three decades made by the Engineers & scientists keeping in view the structural stability of structure which needs quality concrete with improved strength, durability & other characteristics of concrete. The demand of these characteristics derive 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. Cement concrete is most construction material today. We can say that we are living in the era of concrete. Concrete is prepared by mixing cement, aggregates & water. 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. 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 save 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. A number of studies are going on in India as well as abroad to study the impact of use of these pozzolanic materials as cement replacements and the results are encouraging. Addition of silica fume to concrete has many advantages like high strength, durability and reduction in cement production. The optimum silica fume replacement percentage for obtaining maximum 28- days strength of concrete ranged from 5 to 15%. Cement replacement up to 12% with silica fume leads to increase in compressive strength, for M35 grade of concrete. 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.

Material Used:

Cement

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

Table : Properties of Cement

Sr. No	Property	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 cm2/gm
6	Soundness of cement	1.0 mm

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 below:

Table : Properties of Fine Aggregate

Sr. No	Property	Result
1	Bulk density	1625 kg /M 3
2	Specific Gravity	2.67
3	Fineness Modulus	3.20
4	Water absorption	1.15

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

Table : Properties of Coarse Aggregate

Sr. No	Property	Result
1	Bulk density	1525 kg /M 3
2	Specific gravity	2.89
3	Fineness Modulus	3.67
4	water absorption	0.46%

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

Silica Fume
Silica fume is a by product of Ambuja Cement Limited & brought from counto microfine product limited, corporate office velho building 2nd floor opp. municipal garden Panaji (Goa).

Table: Physical & Chemical Properties of Silica Fume

Sr. No	Physical Properties	Range/Result
1	Bulk density	750-850 Kg/m3
2	Surface Area	20000 m2/kg
3	Particle Shape	Irregular
4	Particle size	N/A
	d50	<7 micron
	d95	<20 micron
5	Specific gravity	2.90
6	Chemical Properties	Result
7	SIO 2	30-36%
8	Al 2 O3	18 - 25%
9	Fe 2 O3	.08-3%
10	Ca O	30-34 %
11	SO 3	0.1 -0.4 %

II. EXPERIMENTAL INVESTIGATION PROCEDURE

Mix Proportion:-

Table : Silica Fume Concrete Mix

Mix	Percentage of Silica Fume	Water Ltr	Cement Kg	Coarse Aggregate (20 mm Size) Kg.	Coarse Aggregate (10 mm Size) Kg.	Fine Aggregate Kg	Micro Silica Kg
MX0	0	14.10	34.662	36.501	64.998	52.799	0
MX1	5	4.10	32.929	36.501	64.998	52.799	1.733
MX2	9	4.10	31.543	36.501	64.998	52.799	3.119
MX3	12	4.10	30.503	36.501	64.998	52.799	4.159

Casting of Specimen:-
1. 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.
2. Casting of Specimen: The following mould for casting the specimen were used

- The specimen of standard cubes of (150 mmx 150 mmx 150 mm) was used to determine the compressive strength.
- The specimen of standard cylinders of (300 mmx 100 mm) were used to determine split tensile strength.
- The specimen of standard prisms of (150mmx150mmx700mm) 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 material were mixed by hand mixing. The concrete was filled in different layer and each layer was compacted. The specimens were demoulded after 24 hours cured in water for 7 & 28 days. Thus tested for its compressive, split tensile and flexural strength as per Indian standard.

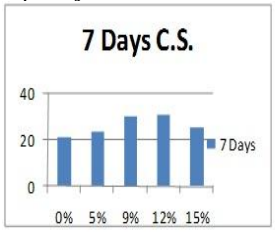
III. TEST RESULT AND DISCUSSIONS

Result of fresh and hardened concrete with partial replacement of Silca Fume are discussed in comparison with those of normal concrete:

Table: Result of compressive, split tensile and Flexural strength

Mix	Percentage of Silica Fume added	Compressive Strength (N/mm2)		Split tensile Strength (N/mm2)		Flexural Strength (N/mm2)	
		7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
MX0	0	21.62	39.18	2.94	4.22	1.56	2.68
MX1	5	23.62	43.10	3.44	5.41	1.96	3.01
MX2	9	29.84	44.69	3.55	5.54	2.60	3.65
MX3	12	30.95	46.14	2.61	4.45	2.67	3.77
MX4	15	25.55	41.33	2.28	4.04	1.78	3.37

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:-



Compressive Strength 7 days **Compressive Strength 28 days**

The compressive strength as shown in above parameter upto 30.95 N/mm2 & 46.14 N/mm .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%The optimum silica fume replacement for obtaining maximum 28 day strength varies form 5% to 12% 5% replacement of silica fume.

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. The results are shown below

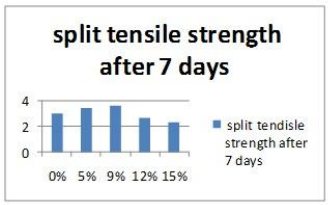
Flexural Strength 7 days

Flexural Strength 28 days

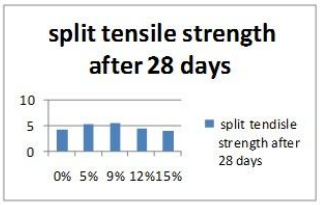
Flexural Strength at the age of 28 days silica fume concrete continuously increase with respect of controlled concrete and reached maximum value of 5 to 12 % replacement of silica fume. The partial replacement 12% Silica fume is found to be suitable optimum. Thus at the age of 28 days with the partial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

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



Split Tensile Strength 7 days



Split Tensile Strength 28 days

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. The partial replacement of silica fume indicates 31% greater split tensile strength as compared normal concrete.

IV. CONCLUSION

High performance concrete produced by partial replacement of cement with silica fume in this study. The achievement of the present study obtained with the replacement of cement by 5%,9%,12% and 15% silica fume The Compressive strength split tensile strength and the flexural strength test were observed for the mixes at the age of 7 days and 28 days. Thus high performance concrete obtained by replacement of cement up to 12% silica fume leads to increase in compressive strength, and the flexural strength of concrete. The compressive strength mainly depend 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 17.76%, split tensile strength 20.74% and the flexural strength is 40.67%at the age of 28 days by replacing partial replacement of cement with silica fume. The optimum percentage of partial replacement of cement with silica fume is 12% for compressive and flexural strength and 9% for split tensile strength of concrete.

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