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Optimize Properties of Concrete with Silica Fume

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***Abstract*- This paper shows the results of an experimental work on concrete containing different parts of silica fume. Silica fume is a by-product of the silicon and ferrosilicon alloy production the main aim of this work is to find the optimum quantity of silica fume to reinstate cement in order to get better properties of hardened concrete. To accomplish the purpose, workability, compressive strength, flexure strength, split tensile of concrete containing silica fume were find after 7, 14 and 28 days of curing. Furthermore, judgment between normal concrete and modified concrete containing 5%, 10% and 15% of silica fume was studied. The water/binder ratio was kept constant at 0.45 throughout the mixing process. The outcomes of this investigation indicate that compressive strength and flexural strength gives the highest improvement of 10% and 15% silica fume replacement respectively. This paper can be a useful basis of information for other researchers to understand the profit and bad effects of silica fume and have a summary of its optimum percentage when dealing with concrete.**

***Keywords*: Micro-Silica, By-Product, Ordinary Portland cement (OPC), Eco-Friendly, Compressive strength, Split tensile strength, Flexural Strength**

I. INTRODUCTION

Silica fume is mineral admixture tranquil of very fine solid smooth spheres of silicon dioxide (SiO2).Most silica fume particles are less than 1microns (0.00004 inch) in diameter, generally 50 to 100 times finer than average cement or fly ash particles. Normally called condensed silica fume, silica fume is a byproduct of the industrial manufacture of ferrosilicon and metallic silicon in high temperature electric arc furnaces. The ferrosilicon or silicon product is drawn off as a liquid from the bottom of the furnace. Steam rising from the 2000-degree-C furnace bed is oxidized and as it cools condenses into particles which are trapped in huge cloth bags. Dealing out the condensed fume to remove impurities and control particle size yields silica fume. Indian production of silica fumes is likely to be about 300,000 tons per year, with world production near 1.1million tons. Recently silica fume has been used in India as an admixture in concrete. But in Scandinavia where abundant hydroelectric power favors electric arc furnaces and much of the worlds silicon alloy is processed use of silica fume goes back at least 15 years. When silica fume is added to concrete, at the start it remains static. Once hydration starts, primary chemical reactions produce two chemical compounds: Calcium Silicate Hydrate (CSH), which is the strength producing crystallization, and Calcium Hydroxide (CH), a result causes creation of free lime which is responsible for nothing much other than lining available pores within concrete as filler or leaching out of inferior concrete. Pozzolanic reaction occurs between silica fume and the CH, producing additional CSH in many of the voids around hydrated cement particles. This supplementary CSH provides the concrete with not only increased the compressive, flexural and bond- strength but also a much denser mould, mostly in field that would have remained as small voids subject to possible entrance of harmful materials.

PHYSICAL PROPERTIES OF SILICA FUME (11)

Particle size (typical): < 1 μm, Bulk density: (as-produced): 130 to 430 kg/m^3, (densified): 480 to 720 kg/m^3, Specific gravity: 2.2, Specific surface: 15,000 to 30,000 m^2 /kg.

II. METHODOLOGY

***A.* Resources**: 53 grad of OPC cement, Zone II sand, 20 mm downgraded aggregate, commercial Silica Fume Grade 920-D (specific surface = 21.4, bulk density = 620 Kg/m^3) have been used for various composites. Designed Mix Proportion has been used as (normal concrete) 1: 2.14: 2.65 for M25 grade concrete with the following ingredients:

a) Cement = 380.9 Kg/m^3, b) Sand = 817.34 Kg/ m^3 c) Well graded aggregate (20mm size) = 1012.032 Kg/m^3

d) Coarse aggregate / Fine aggregate ratio was 1.23 and water cement ratio was 0.43 for all mixes.

***B* .Sample Preparation**: High workable concrete is obtained by mixing cement, FA, CA with silica fume in concrete mixer. The workability is measured by using slump cone, compaction factor & Vee bee consistometer. The concrete has been placed in 150 mm cube, 150mm diameter & 300mm high cylinder and 100mm X100mm X500mm beam moulds and vibrated with standard vibrator. The three specimens for each curing days & testing were cast in laboratory under standard curing method. The compressive, split tensile, & flexure test were conducted on casted specimen & results are studied.

III. TEST RESULTS AND DISCUSSIONS

(A) Test on fresh concrete: After concrete mixing the concrete is test for workability by using different methods such as Slump Cone Method, Compaction Factor Method & VeeBee Consistometer Test. The results are shown below in form of table & graph.

(1) Workability by Slump Cone Method: The results of slump test as follows. Figure shows Graph of Slump Vs % Silica Fume

% SF	Slump (mm)
0	70
5	64
10	50
15	35

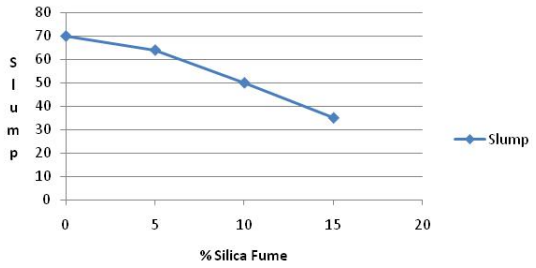

Figure 1. Slump(mm) Vs % SF

(2) Workability by Compaction Factor (CF) Method: The results of CF test as follows. Figure shows Graph of CF Vs % Silica Fume

% SF	CF
0	0.78
5	0.76
10	0.73
15	0.72

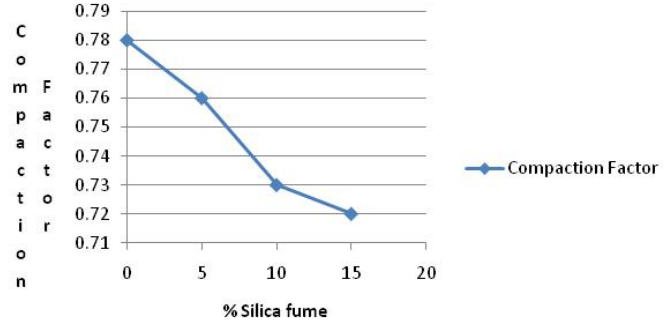

Figure 2 Compaction Factor Vs % SF

(3) Workability by Vee Bee Consistometer Method: The results of Vee bee consistometer test as follows. Figure shows Graph of Vee Bee time Vs % Silica Fume

% SF	VeeBee Time(sec)
0	6
5	7
10	8
15	9

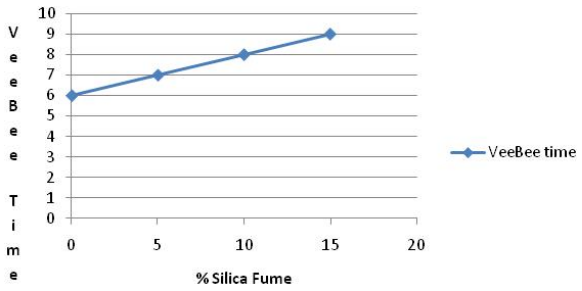

Figure 3 Vee Bee Time(sec) Vs % SF

(B) Test on Harden concrete: The casted specimen was tested for 7days, 14 days & 28 days curing for the compressive test, split tensile test, flexure test.

(1) **Compression test:** Average compression strength is calculated for respected curing days. The figure shows graph of compressive strength Vs % Silica fume

% SF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)	% Increase in Strength
0	17.76	23.301	25.89	0.00
5	18.81	26.127	29.03	12.13
10	20.09	29.601	32.89	27.04
15	22.67	31.284	34.76	34.26

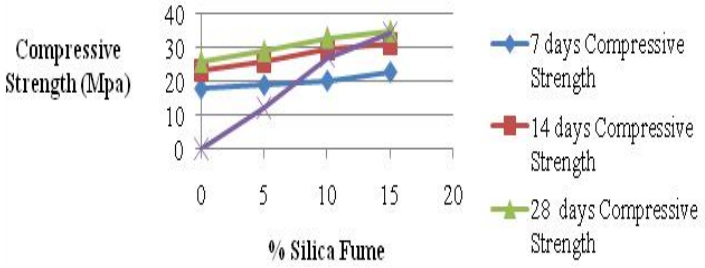

Figure 4 Compressive Strength(MPa) Vs % SF

(2) Split tensile test: Average Split tensile strength is calculated for respected curing days. The figure shows graph of Split tensile strength Vs % Silica fume

% SF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)	% Increase in Strength
0	1.87	1.98	2.56	0.0
5	1.9	2.02	2.86	11.7
10	1.98	2.1	2.9	13.3
15	2.01	2.13	2.98	16.4

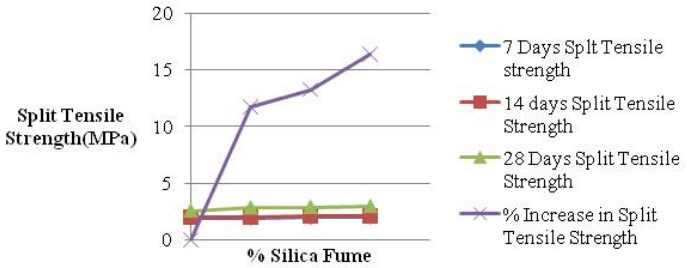

Figure 5 Split Tensile Strength (Mpa) Vs % SF

(3) Flexure test: Average flexure strength is calculated for respected curing days. The figure shows graph of Split tensile strength Vs % Silica fume

% SF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)	% Increase in Strength
0	2.32	3.21	3.56	0.0
5	2.45	3.39	3.77	5.9
10	2.61	3.61	4.01	12.8
15	2.68	3.71	4.13	15.9

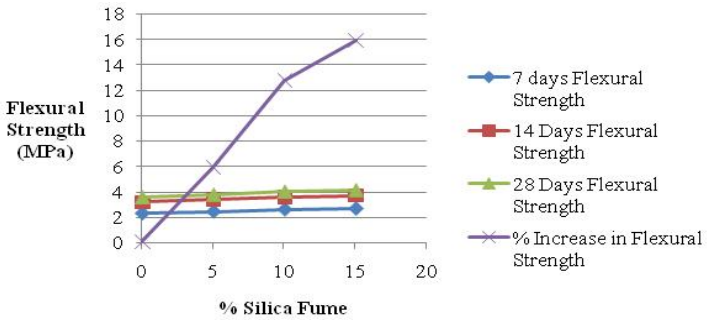

Figure 6 Flexural Strength (Mpa) Vs % SF

IV. CONCLUSION

- With the experimental studies conducted on concrete with silica fume the following conclusions can be drawn:
- Compressive strength, Split tensile strength & Flexural Strength are directly proportional to consider percentage replacement of cement by silica fume.
- Percentage change in compressive strength, Split tensile strength & Flexural strength for 15% replacement of cement with silica fume gives optimum results.
- Workability is inversely proportional to the % of silica fume.
- The use of chemical admixture is necessary for increasing workability of concrete with silica fume
- As the increase in w/c ratio with silica fume strength of concrete decreases.

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