Effect of silica Fume on Compressive and Tensile Strength of Concrete

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Abstract

Effect of Silica Fume on compressive and tensile strength of concrete is proving to be a novel development. Concrete being a composite material packed with particle ranging from millimeters to nanometer, the addition of Silica Fume can improve its various performance features. A concrete with target characteristic compressive strength of 40 Mpa was designed for a 'very serve' exposure condition satisfying the durability requirements of IRC-112 and workability requirements of MoRTH. To know the effect of replacement of a different percentage of cement with Silica Fume on compressive and tensile strength of concrete. To find out the optimum quantity of cement to be replaced by Silica Fume in concrete for the safe and economic design.

Keywords: Silica Fume, Tensile Strength, Compressive, MoRTH, Optimum quantity.

Introduction

Concrete is building material which outperforms most of the construction materials in terms of strength and durability, requiring little or no maintenance. Worldwide it is the most commonly used materials, next to the water. Globally about 20 billion metric tons of concrete is being produced every year (Sakai, 2012). However, development and innovations are needed in the area of cement and concrete for making the material more economical, efficient as well as sustainable. Such as a concrete containing one or more mineral admixtures, which increases its strength, reduce porosity and modifies other properties in fresh as well as hardened state of concrete, due to its pozzolanic activity and filler ability is called High-Performance Concrete (HPC's).Use of pozzolans in the construction industry is not a recent development. The durability of many of the structures built 2000 years ago is due to their highly compacted microstructure resulting from the reaction of extremely fine non-crystalline admixtures like volcanic ash, tuffs, and potsherds (Lea, 1971). However, Portland cement invented by Joseph Aspdin in 1824 has replaced the earlier normal lime-pozzolanic mix as an efficient cementious binder has possessed high workability, faster setting, and hardening. Due to technological, economic and ecological considerations, large quantities of pozzolanic materials such as fly ash, micro silica, mineral admixture in concrete and such concrete came to be known as eco-concrete. Silica fume consists of Silica (94.3%), Alumina (0.09%), Ferrous oxide (0.10%), Lime (0.30%), and Magnesium (0.43). Some of the benefits of silica fume in concrete are higher ultimate strength, improved workability, reduced bleeding, reduced heat of hydration, reduced permeability, increased resistance to sulphate attack, and reduced shrinkage, increased durability. The use of pozzolanic materials in the cement and concrete industries has risen sharply during the last 50years. It is predicted that, in the future, a concrete mixture without pozzolanic material cannot be imagined. The characterization of materials used in the study and the mix design of concrete are presented. The experimental investigations for the identification of the optimum replacement level of cement with Silica Fume to achieve a target compressive strength, workability, durability criteria based on strength efficiency factor are presented. Also, the specimen preparation for evaluation of various structural properties has been discussed. A by-product of producing silicon metal of Ferro-silicon alloys in smelters using electric furnaces. It improves different properties of concrete in plastic as well as in hardens state. It also acts as a mineral admixture.

Objective of Present Study

- To know the effect of replacement of different percentage of cement with silica fume on compressive and tensile strength of concrete.
- To find out the optimum quantity of cement to be replaced by silica fume in concrete for the safe and economic design.

Tests Performed on Materials

i. Specific gravity of cement and silica fumes was determined using Le-Chateliers flask method. Specific gravity of fine and coarse aggregates was determined as per IS 2386-part 3. The test properties are as given below:

ii. Consistency and setting time of cement was determined using Vicat apparatus.

iii. Gradation of cement, sand, silica fume, fine and coarse aggregates was also carried .The grading of each material is shown in Table 2.

Table1. Test Result of specific gravity of materials

Materials	Cement	Silica fume	Fine aggregate	Course aggregate
Specific Gravity	3.00	2.21	2.36	2.69

Table2. Amount of material used and % of replacement

% Replacement	Mass of cement per cubic meter (kg)	Mass of silica fume per cubic meter (kg)	Fine aggregate amount (kg)	10 mm aggregate amount (kg)	20 mm aggregate amount (kg)
0	400	0	598.53	571.41	644.35
3	388	12	598.53	571.41	644.35
6	376	24	598.53	571.41	644.35
9	364	36	598.53	571.41	644.35
12	352	48	598.53	571.41	644.35
15	340	60	598.53	571.41	644.35
18	328	72	598.53	571.41	644.35

Variation in slump with replacement of silica fume: The variation in slump was determined as per procedure defined in IS 7320. The test results are shown in Figure 1.

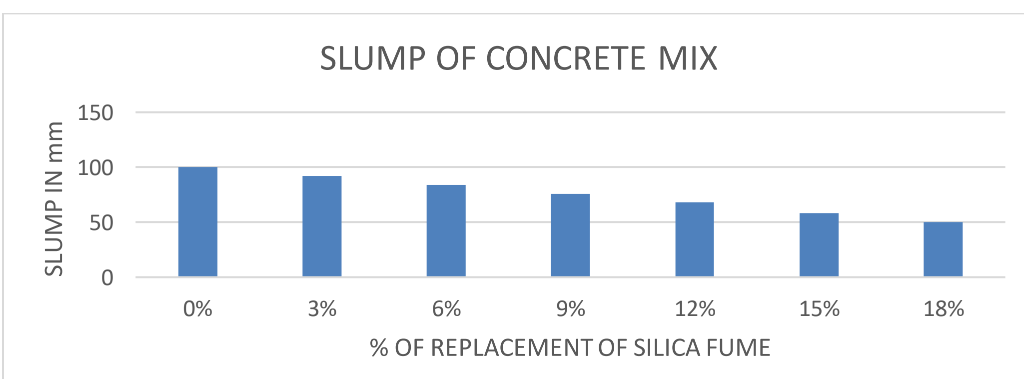

Figure1. Slump variation with replacement of Silica Fume

Compressive strength of concrete was determined at different interval of curing and the test results obtained are given in table-2 and figures-1.

Table3. Compressive strength of concrete determined at different ages of curing

% Replacement	7 days curing	28 days curing
0%	49	71
3%	61	85
6%	70	93
9%	67	90
12%	51	67
15%	50	69
18%	49	66

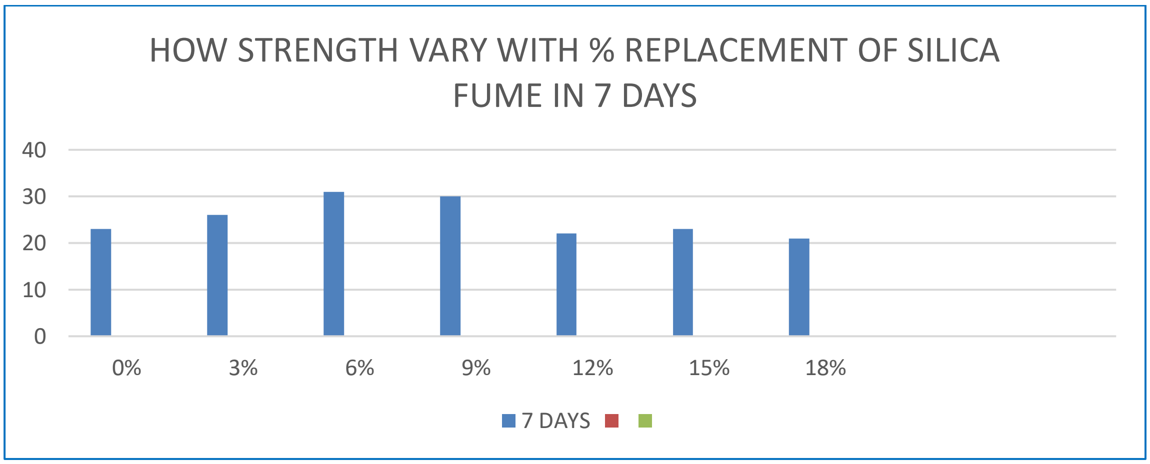

Figure2. Compressive strength result in 7days

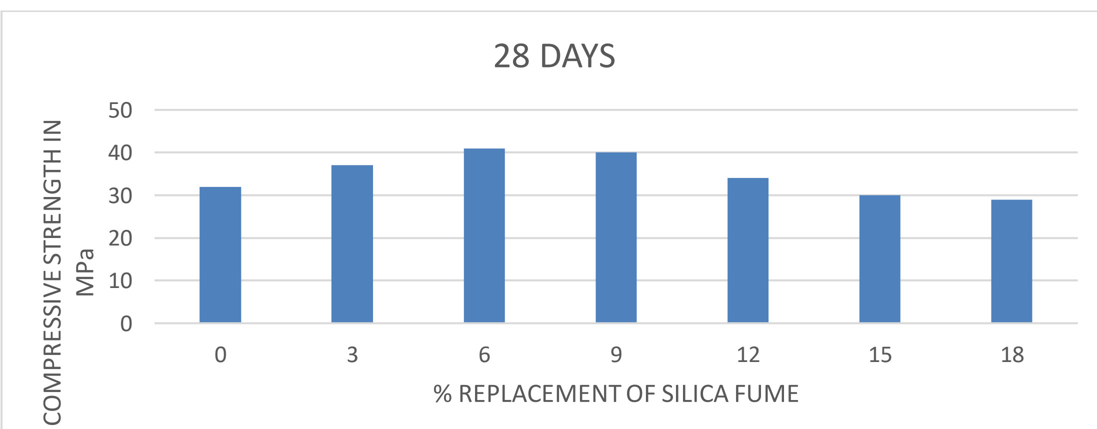

Figure3. Compressive strength result in 28 days

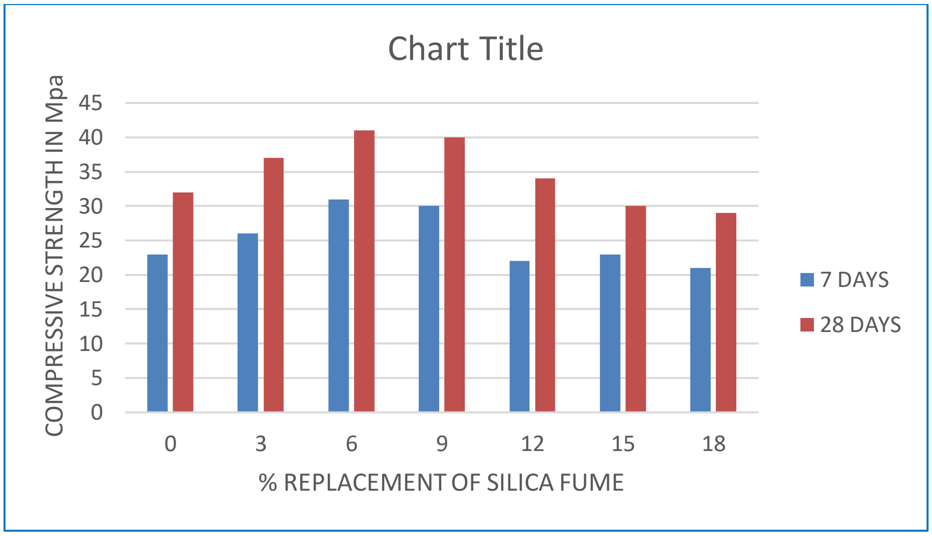

Figure4. Comparing Compressive Strength of 7 and 28 days

Table4. Tensile strength of concrete

No. of days	0%	3%	6%	9%	12%	15%
7	3.12	3.78	3.78	4.09	3.84	3.74
28	4.70	4.77	4.88	4.97	4.86	4.72

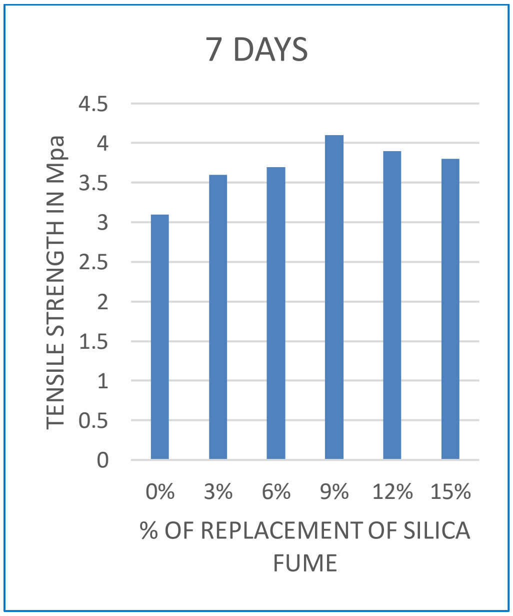

Figure5. Tensile strength results in 28 days.

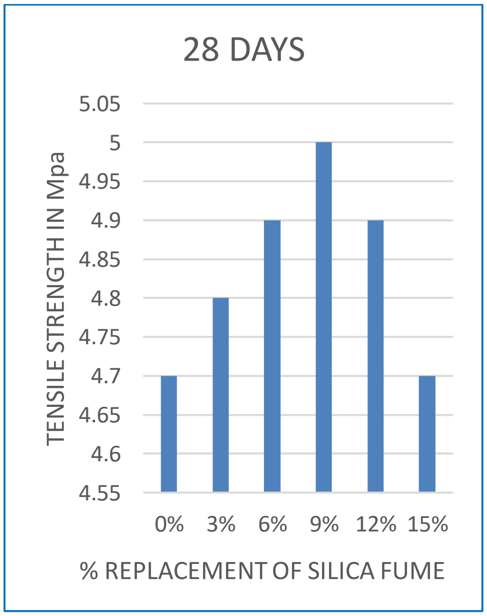

Figure6. Tensile strength results in 28 days

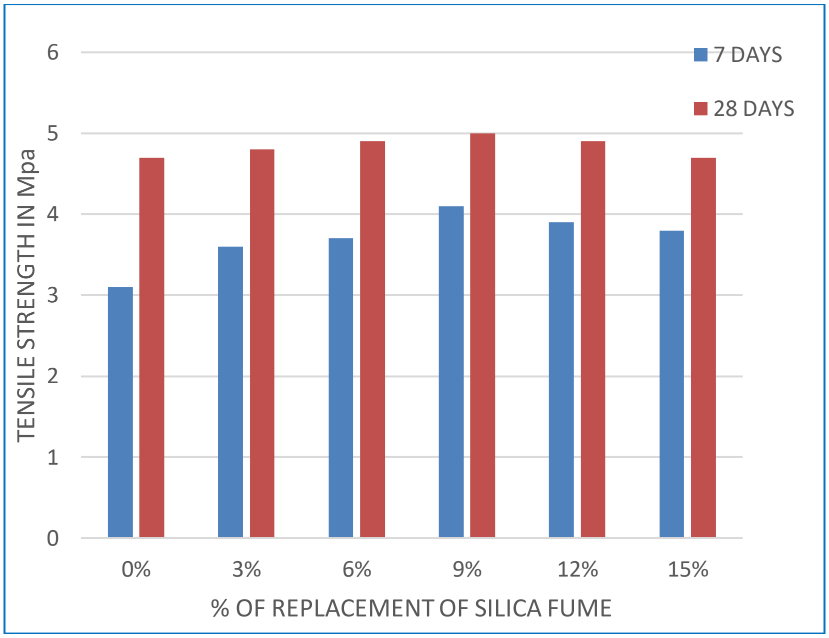

Figure7. Comparison of Tensile Strength in 7 and 28 days

Conclusion

The tensile strength of concrete first increases up to the replacement of 8% then decreases with increases in the percentage of replacement of silica fume. The optimum replacement level of both the materials was then determined based on specific requirements such as workability, strength, durability, as well as strength efficiency factor. 9% replacement with silica fume resulted in maximum compressive and tensile strength.

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