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The Effect on Concrete by Partial Replacement of Cement by Silica Fume: A Review

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Abstract – *This research review represents the collection of data from various previous studies done on the compressive strength, flexural strength, tensile strength testing of concrete incorporating silica fume by optimum replacement of cement. Portland cement is now days partially replaced by silica fume, a by-product from silicon alloy factories. From various studies Silica fume is a non-metallic and non hazardous material having very large surface area which is suitable for concrete mix. This review paper is a good source for understanding the effect on optimum replacement of cement by silica fume.*

Keywords– *compressive strength, optimum replacement, flexural strength, tensile strength.*

1. INTRODUCTION

Cement is becoming a scarce resource all over the world because of its increasing demands day by day. The construction activities have increased in almost all the developing countries of the world. There always has been great effort in improving the quality and standards of the properties of concrete as a construction material. Traditionally fly ash and silica fume or the combination of both is added to concrete as a pozzolana material to enhance the properties of concrete. The use of silica fume as a pozzolana material has increased in recent years because when mixed in certain proportions it enhances the properties of both fresh and hard concrete like durability, strength, permeability and compressive strength, flexural strength and tensile strength. Silica fume is a very fine noncrystalline material produced in electric arc furnace as a by-product of silicon or alloy factories containing silica. Silica fume has been known to us with different names such as micro silica, silica dust, and condensed silica fume. Silica fume has a property that it behaves as a pozzolana as well as cementious material. When the fine pozzolana silica fume particles are added to the paste, a heat of hydration is observed resulting in the formation of pozzolanic material and calcium hydroxide. Due to large surface area silica fume gets densed packed in the paste of cement and aggregate reducing the wall effect in the transition zone between the paste and aggregate. Concrete having optimum percentage of siica fume shows increase in strength and durability of concrete.

Physical and chemical properties of silica fume

The physical properties of silica fume are as follows-

- Diameter of silica fume is 0.1 micron to 0.2 micron
- Surface area is in the range of 20,000-30,000 m^2/kg.
- Density varies from 150 to 700 kg/m^3

The chemical properties of silica fume are as follows:-

- Silica fume contains more than 90% of silicon dioxide (SiO_2).
- Other constituents are carbon, sulphur, and oxides of aluminium, iron calcium, magnesium, sodium and potassium.

The use of silica fume in concrete mix has engineering potential and economic advantage. The use of silica fume will not effect the weight of concrete. Silica fume will produce a much less permeable and high strength concrete. This paper will provide a review of silica fume and its effect on hard and fresh concrete.

2. Literature review

Abdulaziz A. Bubshait et. al. [1] investigated that the advantages of using micro silica can be considerable as it reduces thermal cracking caused by the heat of cement hydration and can improve durability to attack by sulphate and acidic water, giving increase in performance of concrete. The optimum replacement of cement by silica fume gave high durability, permeability, high compressive strength.

Faseyemi Victor Ajileye [2] concluded cement replacement up to 10% with silica fume leads to increase in compressive strength for C30 grade of concrete. From 15% there is a decrease in compressive strength for 3, 7, 14 and 28 days curing period. It was observed that the compressive strength of C30 grade of concrete was increased from 16.15% to 29.24% and decrease from 23.98% to 20.22%. The

maximum replacement level of silica fume was 10% for C30 grade of concrete.

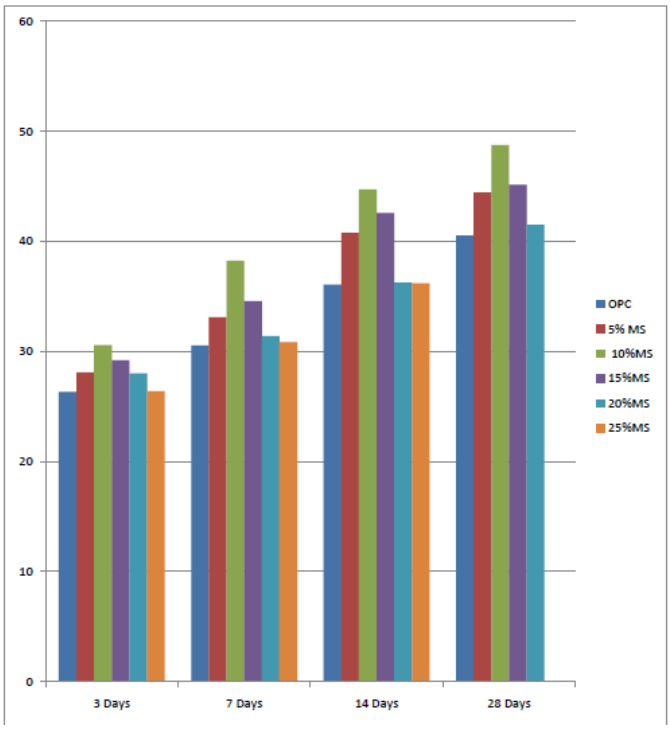

Figure 1: Relationship between compressive strength of varying MS replacement levels

N.K. Amudhavalli and jeena Mathew [3] this research concluded that with increase in fineness of cement consistency increases. Silica fume is having greater fineness than cement and greater surface area so the consistency increases greatly, when silica fume percentage increases. The normal consistency increases about 40% when silica fume percentage increases. The normal consistency increases about 40% when silica fume percentage increases from 0% to 20%. The 7 and 28 days compressive strength and flexural strength was obtained in the range of 10% to 15% silica fume replacement level. Increase in split tensile strength beyond 10% silica fume replacement was almost unsatisfactory whereas increase in flexural tensile strength occurred up to 15% replacement. Silica fume to have a more satisfactory effect on the flexural strength as compared to tensile strength. When the mix was compared to another mix the weight loss and compressive strength percentage was found to be reduced by 2.23 and 7.69 respectively when cement was replaced by 10% of silica fume.

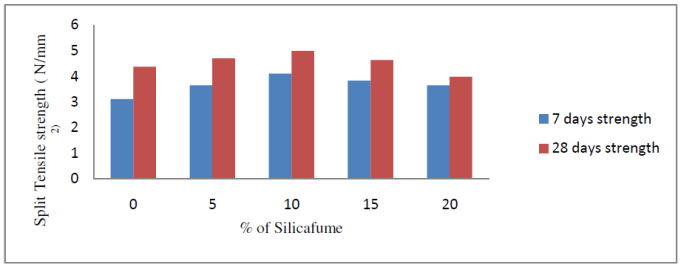

Figure 2: 7 days, 28 days split tensile strength test result with optimum SF replacement

Des King [4] investigated the impact of silica fume in concrete under various properties such as workability, permeability, durability, bleeding, heat of hydration, sensitivity to curing, acid resistance, tensile strength, flexural strength etc. He concluded that the 28th days strength of concrete with silica fume gives a higher strength of compressive strength as compared to any other material such as fly ash , GGBS etc. With addition of silica fume early high compressive strength can be achieved, further a very high strength can be achieved after 28 days with proper concrete mix design method.

Vikas Srivastava et. al. [5] worked out the workability of concrete on optimum replacement of silica fume by cement. Their research concluded that the workability reduces with the addition of silica fume. However in some cases improved workability was observed. With the addition and variation of replacement levels of silica fume the compressive strength significantly increased by (6-57%). There was no change observed in the tensile and flexural strength of the concrete as compared to the conventional concrete.

Debabrata Pradhan and D. Dutta [6] investigated the effects of silica fume on conventional concrete, concluded the optimum compressive strength was obtained at 20% cement replacement by silica fume at 24 hours, 7days and 28 days. Higher compressive strength resembles that the concrete incorporated with silica fume was high strength concrete.

Alaa M. Rashad et. al. [7] in his investigation the compressive strength and abrasion resistance of PC concrete, HVFA concrete and HVFA concrete blends with SF and slag was studied . He concluded that abrasion resistance was highly influenced irrespective of pozzoloan material. Both compressive strength and abrasion resistance decreased with the incorporation of 70 % FA compared to F70, especially at early age. The reduction rate decreased as curing time progressed. The replacement of 20 % SF gave good compressive strength and abrasion resistance and came in the second place, incorporation of 10 % SF came in the third place and incorporation of 10 % of equally combination of SF and slag (i.e. 5 % SF and 5 % slag) came in the fourth place.

Vishal S. Ghutke et. al. [8], concluded from their result that silica fume was a better replacement of cement. The strength of concrete gained in silica fume was high as compared to the concrete of only cement. They performed various tests by varying the water-cement ratio from 0.5 to 0.6 and analyzed their results which concluded -As the water-cement ratio increases the strength of concrete decreases. The target value of compressive strength can be achieved at 10% replacement of silica fume. The strength of 15% replacement of cement by silica fume was greater than the normal concrete. Therefore the optimum silica fume replacement percentage varies from 10% to 15%. Compressive strength decreases when the cement replacement was above 15% silica fume.

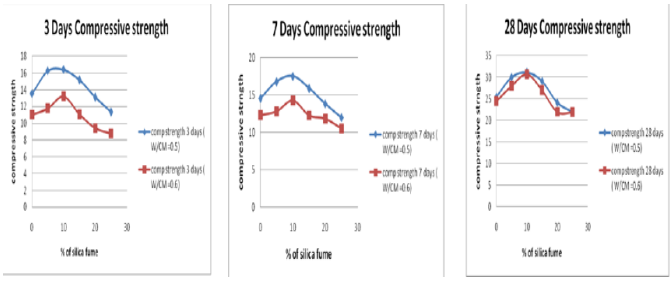

Figure 3: 3 days, 7 days, 28 days compressive strength result

3. CONCLUSIONS

This review paper concludes that:-

- That with increase in workability the compressive strength decreases.
- The optimum replacement of cement with silica fume 5% to 15% leads to increase in compressive strength whereas the percentage replacement of 20% leads to decrease in compressive strength.
- Variation of w/c ratio has an impact on compressive strength of concrete. With the increase in w/c ratio the compressive strength decreases and vice versa.
- Addition of silica fume in proper proportion improves durability attack by acidic waters and improving concrete conditions.
- Silica fume having high fineness leads to high normal consistency.
- Silica fume gives a higher strength of compressive strength as compared to any other material such as fly ash, GGBS.

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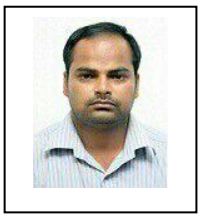

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