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EFFECT OF SILICA FUME ON PROPERTIES OF CONCRETE-A REVIEW

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ABSTRACT:- *The effect of silica fume in concrete improves both the mechanical and durability characteristics of the concrete. The paper aims to review the effect of silica fume on properties of concrete. The replacement of silica-fume as partial replacement of cement by weight at 0% (control mix), 5%, 10%, 15%, 20%, and 25%, with and without superplasticizer are studied. It emphasized the effect of silica fume on workability level and its maintenance of fresh concrete; strength development, strength optimization and elastic modulus of hardened concrete; and chemical and mechanical durability of mortar. The chemical and physical properties of silica fume shows that it is most reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable.*

Key Words: **Silica fume, Concrete, Pozzolan, Durability.**

1. INTRODUCTION

Silica fume, also known as micro silica is an amorphous (non-crystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production. It is extremely fine with particles size less than 1 micron and with an average diameter of about 0.1 microns, about 100 times smaller than average cement particles. Its behaviour is related to the high content of amorphous silica (> 90%). The reduction of high-purity quartz to silicon at temperatures up to 2,000°C produces SiO_2 vapours, which oxidizes and condense in the low temperature zone to tiny particles consisting of non-crystalline silica.

During the last three decades, great strides have been taken in improving the performance of concrete as a construction material. Particularly Silica Fume (SF) and fly ash individually or in combination are indispensable in production of high strength concrete for practical application. The use of silica fume as a pozzolana has increased worldwide attention over the recent years because when properly used it as certain percent, it can enhance various properties of concrete both in the fresh as well as in hardened states like cohesiveness, strength, permeability and durability. Silica fume concrete may be appropriate in places where high abrasion resistance and low permeability are of utmost importance or where very high cohesive mixes are required to avoid segregation and bleeding.

Fig: 1 Silica fume

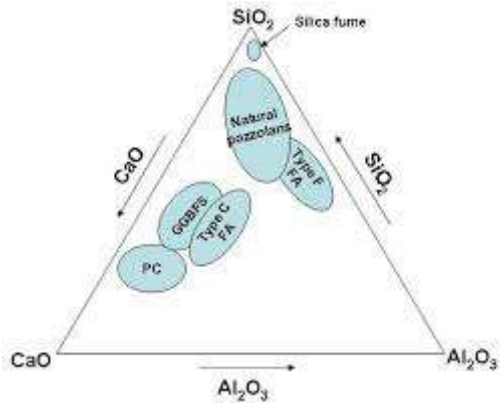

Fig: 2 Reaction of Silica fume

2. LITERATURE REVIEW

Prof. Vishal S. Ghutke, Prof. Pranita S.Bhandari [1] conducted a research on influence of silica fume on concrete by replacing 5%,10%,15%,20%of cement with silica fume and compared the strength of the concrete with the regular concrete and driven the result from the experiments. The research was based on code IS: 12269-1987(9). 53grade of concrete was considered for the study. The difference between the study was examined with water cement ratio of 0.5and 0.6.the result was taken from testing the concrete on 3 ,7 and 28days and compared the values. From the research it is studied that the optimum value of compressive strength can be achieved in 10% replacement of silica fume.

Hon. FICT, Dip M, Chartered MCIM, [2] conducted a research on effect of silica fume on the properties of concete.This paper focuses on the effects of silica fume on all the main properties of concrete in the fresh and hardened

state. The code of BS EN 13263 is used Silica fume for concrete. The percentage of addition should be <8% and should not exceed more than 12.5%. From the addition of silica fume High earlycompressive strength (in excess of 25N/mm2 at 24 hours) can be achieved. With proper concrete design, very high 28-day strengths can be produced, using normal ready-mixed concrete plants and in the USA and Asia 100–130N/mm2 concretes are used in tall buildings. Cementations contents are generally > 400 kg/m3 and w/c in the range 0.30 to 0.40.Hooton reports that the splitting-tensile strengths as a percentage of compressive strength of 10% silica fume concrete (w/c = 0.35) ranged from 8.5% to 8.9% at ages of 28 to 182 days, whereas similar concrete without silica fume ranged from 9.4% to 10.7%. Rather than the compressive and tensile strength addition between 10% to 15% addition of silica fume the concrete works great for protection to embedded steel (chlorides), protection to embedded steel (carbonation), sulfate resistance , resistance to acids,etc and much more.

Vikas Srivastava, Alvin Harison, P. K. Mehta, Atul, Rakesh Kumar,Assistant Professor, Civil Engg. [3] made research on effect of silica fume. Standard IS codes are used in this study. The research shows that the addition of silica fume reduces workability. However, in some cases it improves the workability. Silica fume inclusion increases the compressive strength of concrete significantly (6-57%). The increase depends upon the replacement level. The tensile and flexural strength of silica fume concrete is almost similar to the referral concrete. The addition of silica fume improves the bond strength of concrete. The modulus of elasticity of silica fume concrete is almost similar to the referral concrete.

Vikas Srivastava , Rakesh Kumar , V. C. Agarwal and P. K.[4] researched about the silica effect in workability and compressive strength of OPC concrete.The referral concrete M25 was made using 43 grade OPC (Birla) and the other mixes were prepared by replacing part of OPC with silica fume. The replacement levels were 5%, 10%, 15%, 20%, 25% and 30% (by weight).The properties of cement were determined in accordance with IS – 8112: 1989. The optimum replacement level of cement by silica fume is found to be 5% by weight. There is a significant improvement in the compressive strength of concrete using silica fume at both 7 and 28 days as compared to the referral concrete. The workability in case of silica fume concrete is marginally improved. Beyond optimum silica fume level the strength decreases but the workability increases.

H S Abdelgader and A S El-Baden [5] research is about the silica fume addition in 2 stage of concrete strength.Two-stage concrete (TSC) is an innovative concrete that does not require vibration for placing and compaction. TSC is a simple concept; it is made using the same basic constituents as traditional concrete: cement, coarse aggregate, sand and water as well as mineral and chemical admixtures. As its name suggests, it is produced through a two-stage process. Firstly washed coarse aggregate is placed into the formwork in-situ. Later a specifically designed self-compacting grout is introduced into the form from the lowest point under gravity pressure to fill the voids, cementing the aggregate into a monolith.Each mix twenty four standard cylinder samples of size (150mm□300mm) of concrete containing crushed aggregate were produced. The tested samples were made from combinations of w/c equal to: 0.45, 0.55 and 0.85, and three c/s of values: 0.5, 1 and 1.5. Silica fume was added at a dosage of 6% of weight of cement, while super plasticizer was added at a dosage of 2% of cement weight. Results indicated that both tensile and compressive strength of TSC can be statistically derived as a function of w/c and c/s with good correlation coefficients. The basic principle of traditional concrete, which says that an increase in water/cement ratio will lead to a reduction in compressive strength, was shown to hold true for TSC specimens tested. Using a combination of both silica fume and super plasticisers caused a significant increase in strength relative to control mixes.

M. H. Zhang ,S. Swaddiwudhipong,K. Y.J. Tay &C. T. Tam [6] researched about the effect of silica on cement hydration and temperature rise. With an initial temperature of 30□, adiabatic temperature rise of the concrete with 8% silica fume as cement replacement was similar to that of the control Portland cement concrete up to about 18 h. After 24 h, however, the temperature of the silica fume concrete was lower than that of the control concrete. Since the concrete with 8% silica fume had a higher 28-day compressive strength (72.5 MPa) than the control concrete without silica fume (59.2 MPa), the concrete with silica fume is likely to have a lower temperature rise as compared with the control concrete of equivalent 28-day strength by reducing cementations materials content with the same water content. The extent of heat evolution in the silica fume pastes was generally greater at lower temperatures of 20–50□, but less at 65□ than in the control paste. At the relatively high curing temperatures, the degree of cement hydration in the paste with silica fume was lower than that in the control cement paste at early ages. However, the pozzolanic reaction started even before 24 h after water was added.

Amudhavalli& Mathew [7] studied the Effect of silica fume on the strength and durability characteristics of concrete. The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by silica fume by 0, 5, 10,15and by 20%. a detailed experimental study in Compressive strength, split tensile strength, flexural strength at age of 7 and28 day was carried out.Results Shows that Silica fume in concrete has improved the performance of concrete in strength as well asin durability aspect.

Perumal& Sundararajan [8] observe the Effect of partial replacement of cement with silica fume on the strength and durability properties of high grade concrete. Strength and durability properties for M60, M70 and M11 0 grades of HPC trial mixes and to arrive at the maximum levels of replacement of cement with Silica fume, investigations were taken. The strength and durability

characteristics of these mixes are compared with the mixes without SF. Compressive strengths of 60 N/mm2, 70 N/mm2 and 110 N/mm2 at 28days were obtained by using 10 percent replacement of cement with SF. The results also show that the SF concretes possess superior durability properties.

Kumar & Dhaka [9] write a Review paper on partial replacement of cement with silica fume and its effects on concrete properties. 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 indicate that the use of silica fume in concrete has increased the strength and durability at all ages when compared to normal concrete.

Ghutke & Bhandari [10] examine the Influence of silica fume on concrete. Results showed that the silica fume is a good replacement of cement. The rate of strength gain in silica fume concrete is high. Workability of concrete decreases as increase with % of silica fume. The optimum value of compressive strength can be achieved in 10% replacement of silica fume. As strength of 15% replacement of cement by silica fume is more than normal concrete. The optimum silica fume replacement percentage varies from 10 % to 15 % replacement level.

Hanumesh, Varun & Harish (2015) observes the Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement. [11] Themain aim of this work is to study the mechanical properties of M20 grade control concrete and silica fume concrete with different percentages (5, 10, 15 and 20%) of silica fume as a partial replacement of cement. The result showed that The compressive strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is a decrease in compressive strength and The split tensile strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is a decrease in split tensile strength.The optimum percentage of replacement of cement by silica fume is 10% for M20 grade of concrete.

Shanmuga priya& Uma (2013) carried an Experimental Investigation on Silica Fume as a partial Replacement of Cement in High Performance Concrete. [12] The concrete used in this investigation was proportioned to target a mean strength of 60 MPa and designed as per A The water cement ratio (W/C) adopted was 0.32 and the Super Plasticizer used was CONPLAST SP 430.Specimens such as cubes, beams and cylinders were cast for various mix proportions and tested at the age of 7,14and 28 days CI 211.4R-08.The investigation revealed that the partial replacement of cement by silica fume will develop sufficient compressive strength, flexure strength and split tensile strength for construction purposes. The optimum dosage of silica fume found to be 7.5% (by weight), when used as partial replacement of ordinary Portland cement

Alok (2016) write a Research Paper on Partial Replacement of Cement in M-30 Concrete from Silica Fume and Fly Ash. [13] Replacement levels of OPC by Silica Fume were 0%, 2.5%, 5%and 7.5% where replacement levels of Ordinary Portland cement by Fly Ash were 0%, 5%, 10% and 15% by weight. 1% super-plasticizer was used in all the test specimens for better workability at lower water cement ratio and to identify the sharp effects of Silica Fume and Fly Ash on the properties of concrete. Water-cement ratio was kept 0.43 in all cases.43.1 N/mm2 was the maximum compressivestrength which was obtained at replacement levelof 7.5% by weight of SF and 20% by weight of FA with cement.6.47 N/mm2 was the maximum flexural strength which was obtained at replacement level of 7.5% by weight of SF and 20% by weight of FA with cement.2.573 N/mm^2 was the maximum split tensile strength which was obtained at replacement level of 7.5% by weight of SF and 20% by weight of FA with cement.

Jain &. Pawade (2015) studied the Characteristics of Silica Fume Concrete. [14] The physical properties of high strength silica fume concretes and their sensitivity to curing procedures were evaluated and compared with reference Portland cement concretes, having either the same concrete content as the silica fume concrete or the same water to cementations materials ratio. The experimental program comprised six levels of silica-fume contents (as partial replacement of cement by weight) at 0% (control mix), 5%, 10%, 15%, 20%, and 25%, with and without super plasticizer. It also included two mixes with15% silica fume added to cement in normal concrete. Durability of silica fumemortar was tested in chemical environments of sulphate compounds, ammonium nitrate, calcium chloride, and various kinds of acids.

Roy &Sil (2012) Studied the Effect of Partial Replacement of Cement by Silica Fume on Hardened Concrete. [15] From the study it has been observed that maximum compressive strength (both cube and cylinder) is noted for 10% replacement of cement with silica fume and the values are higher (by 19.6% and 16.82% respectively) than those of the normal concrete (for cube and cylinder) whereas split tensile strength and flexural strength of the SF concrete (3.61N/mm2 and 4.93N/mm2 respectively) are increased by about 38.58% and 21.13% respectively over those (2.6 N/mm2 and 4.07 N/mm2 respectively) of the normal concrete when 10% of cement is replaced by SF.

Amarkhail (2015) observed Effects of Silica Fume on Properties of High-Strength Concrete.[16] He found that up to 10% cement may be replaced by silica fume without harming the concrete workability. Concrete containing 10% silica fume replacement achieved the highest compressivestrength followed by 15% silica fume replacementwith a small difference. Concrete with 15% silica fume content achieved the highest flexural

strength.10% and 15% silica fume content as replacement of cement were found to be the optimum amount for significantly enhancement of compressive strength and flexural strength respectively.

Sasikumar&Tamilvanan (2016)Performed an Experimental Investigation on Properties of Silica Fumes as a Partial Replacement of Cement.[17] Mainparameter investigated in this study is M30 grade concrete with partial replacement of cement by silica fume 0%, 25%, 30%, 40% and 50%. The normal consistency increases about 40% when silica fume percentage increases from 0% to 25%. The optimum 7 and 28-day compressive strength has been obtained in the 25 % silica fume replacement level. Also the split tensile strength is high when using 25% silica fume replacement for cement.

Ajileye (2012)Cement replacement up to 10% with silica fume leads to increase in compressive strength for M30 grade of concrete. [18] From 15% there is a decrease in compressive strength for 3, 7, 14 and 28 days curing period. Compressive strength of M30 grade of concrete was increased from 16.15% to 29.24% and decrease from 23.98% to 20.22%.

Sharma &Seema (2012) examined the effect of partial replacement of cement with silica fume on compressive strength of concrete.[19] M20 grade of concrete with W/C ratio as 0.5 and percentage replacement was 0%,10%,20%. The optimum compressive strength is obtained at 20% cement replacement by a Silica Fume at all age levels (i.e. 24 hours,7& 28 days). The 28 days' compressive strength at 20% replacement was found to be 32.29 MPa with a slump value of 21 mm.

Pradhan and Dutta (2013) investigated the effects of silica fume on conventional concrete [20] The optimum compressive strength was obtained at20% cement replacement by silica fume at 24hours, 7days and 28 days. Higher compressive strength resembles that the concrete incorporated with silica fume was high strength concrete.

Srivastava (2012)worked out the workability of concrete on optimum replacement of silica fume by cement. Workability reduces with the addition of silica fume. [21] 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.

3. CONCLUSION

The review of various researchers were analysed and following conclusions were arrived.By adding 1.0% silica fume, there is large amount of increase in strength after 7, 14 and 28 days respectively. The Compressive strength tends to increase with increase percentages of silica fume in the mix and decreases after 10% replacement. The optimum strength of cube is gain at 10% replacement for all 7, 14 and 28 days respectively. Split tensile strength adding 0.5% silica fume in the mix, there is an increase in the strength of cube after 7 days as com pa red to concrete without replace men t. And after 14 days and 28 days there is enormous increase in strength as compared to the control mix. By adding 1.0% silica fume, there is large amount of increase in strength after 7, 14 and 28 days respectively.

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