JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

STUDY ON PROPERTIES OF HIGH STRENGTH CONCRETE USING SILICA FUME

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Abstract : Industrial waste by-products are becoming hazard to the environment which are needed to be reduced by using these products as a useful component in construction industry. Silica Fume is one of the by-products obtained from smelting process in Silicon and Ferrosilicon industry. It is an effective component to be used in concrete to improve the mechanical properties and reduce environmental impact causing because of its disposal directly into the environment. In this paper, study is carried out to determine the optimum percentage replacement of Silica Fume with cement to improve the mechanical properties of High-Strength Concrete. Utilizing Silica Fume in Ordinary Portland Cement shows early strength gaining properties. Satisfactory results are obtained by 10%-15% of silica fume replacement.

Keywords **– Silica Fume, Cement, High-Strength**

I. INTRODUCTION

For reducing environmental hazards causing from industrial byproducts, several practices are made in the construction industry. Using silica fume as partial replacement of cement is an optimum way of using the Silicon industry by-product and reduce wastage. Silica Fume is also known as micro-silica or condensed Silica Fume. It is a material resulting from reduction of quartz with coal in an electric arc furnace in the manufacture of Silicon or Ferrosilicon alloy. Chemical composition of silica fume contains more than 90% Silicon Dioxide. other constituents are Carbon, Sulphur and Oxide of aluminium, Iron, Calcium, Magnesium, Sodium and Potassium. The physical properties of Silica Fume are its diameter about 0.1micron to 0.2micron, its surface area is about 30000m^2/kg and density varies from 150 to 700kg/m^3.

Silica fume concrete results in improvement of mechanical properties of conventional concrete like Compressive strength, Flexure strength and Split-Tensile strength. The most important property of concrete is its Compressive strength which is to be focused in High-Strength concrete. The aim is to achieve the Compressive strength of 60-70MPa by replacing cement with silica fume in an optimum range. Study is carried out about improvement in compressive strength after 7, 14 & 28 days of mixing. Mix design of the concrete with partial replacement of cement by silica fume is studied and observations are done on their compressive strength. Finally, the percentage of cement replacement by silica fume is determined at which the concrete gains maximum compressive strength.

II. REVIEW OF ARTICLES

2.1 Debabrata Pradhan & D. Dutta (2013) studied the effects of Silica Fume in conventional concrete. Experiment is carried out to determine different compressive strength of concrete on partial replacement of silica fume with cement ranging from 0% to 20%. Strength is calculated on cube specimen after the age of 24 hours, 7 and 28 days. Ordinary Portland Cement of 43 grade is used in the mix and Silica Fume used is Elkem- micro silica 920 D. CONPLAST-SP 430 superplasticizer is used to balance the workability of concrete. After 28 days, highest compressive strength obtained is 57.40MPa on 100mm cubes for optimum replacement of silica fume as 20%.

2.2 Suresh Sankaranarayannan & Revathi Jagadesan (2016) studied on comparision of High-Performance Fly Ash Concrete using Nano Silica Fume on different mixes is carried out. The conclusion obtained from this study is that 1% Nano-silica fume as partial replacement of cement gives 140% improvement in the compressive strength of concrete at early age of 3 & 7 days. At 28 days, the improvement is about 62%.

2.3 Perumal & Sundararajan (2004) published on observing the effects of partial replacement of cement with silica fume on strength of High-Performance Concrete of grade M60, M70 & M110. The target compressive strength was achieved by using 10% replacement of cement with SF. They also conclude that SF improves the durability of concrete.

2.4 T Shanmugpriya & Dr. Uma (2013) published an experiment conducted on partial replacement of silica fume with cement to achieve high strength concrete. They aimed to design a mix proportion of concrete achieving mean strength of 60MPa after the curing period of 7,14 & 28 days. Materials used in mix proportion are 53 grade OPC having specific gravity 3.15, silica fume of grade 920D, superplasticizer CONPLAST SP-430 and w/b ratio adopted is 0.32. Result obtained is optimum replacement of 7.5% silica fume achieving the compressive strength of 65.33MPa.

2.5 A.R. Hariharan, A.S. Santhi & G. Mohan Ganesh (2011) studied on Strength Development of High Strength Concrete having Silica Fume and Fly Ash is carried out. Partial replacement of cement with Class C fly ash as 30%, 40% and 50% and Silica Fume by 6% and 10% weight of cement. Water binder ratio is constant as 0.4 and superplasticizer is used to maintain the slump(workability). Compressive strength was determined after various ages up to 90 days. The mix was prepared in three series that are CF series having cement with fly ash, CS series having cement with silica fume and CFS having all three cements, fly ash and silica fume. Optimum strength was observed in CS series having 6% silica fume after the age of 90 days as 61.2MPa. In CFS maximum strength for 40% FA and 6% SF shows 58.7 MPa.

2.6 Judita Gražulytė, Audrius Vaitkus, Ovidijus Šernas, Donatas Čygas (2020) carried an experimentation investigation on effect of silica fume on high strength concrete performance. Three same types of concrete mix with different amount of silica fume replacement 0%, 7% & 10% with constant w/b ratio 0.4 is used for specimen casting and testing. 360 kg/m^3 of cement is used for high strength concrete with air-entraining agent and superplasticizer to maintain workability. After 28 days of concrete mixing, the three specimens of SF0, SF7 and SF10 shows strength results as 43.9MPa, 60.4MPa and 58.8MPa respectively. Optimum strength is obtained at 7% replacement of silica fume with cement to enhance the performance of high-strength concrete.

2.7 Piotr Smarzewski (2019) studied on influence of silica fume on mechanical properties of high strength concrete. The mix was prepared by replacement of silica fume as 0%, 5%, 10%, 15%, 20% & 25% by weight of cement. w/b ratio used is 0.25. After 28 days age of concrete, test results show the highest compressive strength of about 110MPa for 20% and 25% of SF used in concrete mix.

2.8 Thallapaka Vishnu Vardhan Reddy, K. Rajasekhar and Seelanani Janardhana (2015) studied the performance of high strength concrete using nano silica and silica fume. The experiment was performed on concrete of grade M40 and M50. Silica fume replacement used are 5% and 10% and nano silica is used as 1.5% and 3%. Combined application of SF 5% + NS 1.5%, SF 10% + NS 1.5%& SF 5% + NS 3%, SF 10% + NS 3% is also performed. Out of all the designed mix, optimum strength for M40 grade concrete is 58MPa for 1.5% nano silica and 10% silica fume. Whereas maximum strength for M50 grade concrete is obtained as 59.2MPa for 5% silica fume concrete after an age of 28 days.

2.9 VF Yogendran, BW Langan, MH Haque & MA Ward (1987) studied the efficiency of silica fume in influencing the strength of High-Strength concrete at different w/c ratio and dosages of silica fume. Target mean strength was 50-70MPa for which the optimum replacement of cement with silica fume in silica fume is 15%. The result shows that for cement content of 500kg/m^3 and w/c ratio of 0.28, increase in strength of concrete was not possible using silica fume.

2.10 Poornima Patil & Kushal Kapali A (2018) conducted a detailed experimental study on workability & compressive strength at the age of 7 & 28 days for both mix using superplasticizer and silica fume. Experiment was performed for mix design of concrete M55 grade by replacing 10%, 15% and 20% cement by silica fume. Results of the experiment shows the compressive strength obtained for the mixes are about 58.40MPa, 61.30MPa and 57.90MPa respectively after 28 days of mixing. The maximum strength is obtained for the optimum percentage replacement of 15% of cement by silica fume.

III. RESULTS AND DISCUSSION

The review of articles shows that partial replacement of cement by silica fume helps in improvement of compressive strength in High-Performance Concrete. The comparision of various experiment results is shown in the following table.

Table 1. Comparision of various test results

Sr. No	Cement Content (Kg/m^3)	% Replacement of cement by Silica Fume	W/C Ratio	Compressive Strength obtained (N/mm^2)
1	450	20%	0.5	57.40
2	745	20%	0.25	110.00
3	552	7.5%	0.32	65.33
4	450	6%	0.4	61.22
5	360	7%	0.4	60.40
6	500	15%	0.28	70.00
7	413	15%	0.23	61.30

IV. CONCLUSION

By studying the comparision of various test results mentioned in table 1, the conclusion obtained is that for High-Performance Concrete, cement content required is about 500kg/m^3 and w/c ratio is 0.25-0.3. Optimum percentage replacement is about 7% to 15% for obtaining high compressive strength. Silica Fume helps in reducing the cost compared to conventional concrete.

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