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A REVIEW FOR CHARACTERIZATION OF SILICA FUME AND ITS EFFECTS ON CONCRETE PROPERTIES

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Abstract: The key area of interest of present era is about the preservation of environment and sustainable development in each and every sector of engineering. Since advent of civilization various types of cementitous materials have been used for construction practices. The arrival of Ordinary Portland cement (OPC) changed the construction activities completely. However, because of several drawbacks associated with properties of cement and manufactured building materials using OPC as well as the cost factor attempts one mode to utilize other materials for economical constructions and improved mortar and concrete characteristics. Also, several waste materials are generated in huge quantities by different industrial activities. Now attempts were made to utilize these waste materials or industrial byproducts in construction activities to solve the environmental pollution problems, and safer and economical construction. Colloidal Silica fume is one such industrial by product which is being used and experimented upon to obtain a stronger and durable concrete. It is one of the pozzolonas having very large surface area which results in better and uniform utilization of calcium hydroxide released during hydration of OPC. Also, because of its very fine size it act as filler material between the cement gell grains. This paper presents a review of silica fume utilization in concrete production and its effect on the concrete.

Keywords: Silica fume, cement, Composite, concrete properties

INTRODUCTION

Concrete is one of the most important and widely used man-made construction materials. In fact concrete is a composite construction material, composed of cement (commonly Portland cement), coarse aggregate made of gravels or crushed rocks, fine aggregate (sand), and water. Sometimes admixtures are added to give concrete some special characteristics as required. Concrete is an incredibly useful and flexible building material without which modern architecture and construction would not be possible. It can be easily poured into forms and moulds to create different shapes; it quickly hardens to become a durable stone-like material. It is used in buildings, foundations, bridges, footings, roads and many other applications. Most normal concrete structures deteriorate rapidly especially when they face some challenging environments; consequently, they require costly repairs before their expected service life is reached to end. In order for a concrete to be good, it must meet two criteria, i.e. concrete has to be satisfactory both in its fresh and hardened state. Concrete in its fresh state must be consistent and cohesive, In other words, consistency of the mix should be such that it can be compacted easily without excessive effort, and also the mix should be cohesive enough so as not to produce segregation with a consequent lack of homogeneity of the finished product. The significant requirements from a concrete in its hardened state are satisfactory compressive strength and adequate durability.
Since this research work mainly focuses on the effects of silica fume on the properties of high-strength concrete; therefore it is important to know more about high-strength concrete and silica fume.

A. HIGH-STRENGTH CONCRETE (HSC)

It is a type of high performance concrete (HPC), generally with a specified compressive strength of (40 MPa) or greater. Its production requires more research and attention to quality control than conventional concrete. There are several reasons for using HSC in construction industry, among them requirement for durability and strength of structures, construction of high-rise buildings and long-span bridges, early age serviceability are mentionable.

B. SILICA FUME

Silica fume is also referred to as micro silica or condensed silica fume, but the term silica fume has become generally accepted. It is a by-product of the manufacture of silicon and ferrosilicon alloys from high-purity quartz and coal in a submerged-arc electric furnace.

Silica fume is a kind of mineral admixture which gives special characteristics to concrete such as; reduced permeability, improved reinforcement corrosion protection, enhanced resistance against sulfate and chemicals attack, improved mechanical performances, and increased tensile and flexural strengths and last but not the least enhanced Compressive strength of concrete. Silica fume has been widely used in all over the world, where high strength and durable concrete is required.

LITERATURE REVIEW

S. Bhanja studied the Influence of silica fume on the concrete The present paper is directed towards developing a better understanding on the isolated contribution of silica fume on the tensile strengths of high-performance concrete (HPC). Extensive experimentation was carried out over water–binder ratios ranging from 0.26 to 0.42 and silica fume–binder ratios from 0.0 to 0.3. For all the mixes, compressive, flexural and split tensile strengths were determined at 28 days. The compressive, as well as the tensile, strengths increased with silica fume incorporation, and the results indicate that the optimum replacement percentage is not a constant one but depends on the water–cementitious material (w/cm) ratio of the mix. Compared with split tensile strengths, flexural strengths have exhibited greater improvements. Based on the test results, relationships between the 28-day flexural and split tensile strengths with the compressive strength of silica fume concrete have been developed using statistical methods.

Arun Borsaikia studied on the effect of silica fume on some properties of concrete. In the present paper, experimental results on workability, compressive strength and permeability of concrete with various mixture proportions have been presented to study the effect of silica fume on concrete mixes. It has been found that micro silica increases the workability of the fresh concrete upto a certain limit of micro silica addition (upto 20%) as cement replacement. Compressive strength was also increased on addition of micro silica. The Ultrasonic Pulse Velocity results showed that during initial compression the UPV was increased slightly but on further increasing the compressive load the UPV was decreased. When the load was about 75-80 percent of ultimate strength, an abrupt reduction in UPV was observed. It has been found from the study that addition of micro silica (upto 20%) in concrete reduces the permeability by 35%-50%.

N.K. Amudhavalli and jeena Mathew 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.

Des King 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. 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 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. 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.

Abdulaziz A. Bubshait et. al. 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 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.

HISTORY OF SILICA FUME IN CONCRETE

The first testing of silica fume in Portland-cement-based concretes was carried out in 1952. The biggest drawback to exploring the properties of silica fume was a lack of material with which to experiment. Early research used an expensive additive called fumed silica, an amorphous form of silica made by combustion of silicon tetrachloride in a hydrogen-oxygen flame. Silica fume on the other hand, is a very fine pozzolanic, amorphous material, a by-product of the production of elemental silicon or ferrosilicon alloys in electric arc furnaces. Before the late 1960s in Europe and the mid-1970s in the United States, silica fumes were simply vented into the atmosphere. With the implementation of tougher environmental laws during the mid-1970s, silicon smelters began to collect the silica fume and search for its applications. The early work done in Norway received most of the attention, since it had shown that Portland cement-based-concretes containing silica fumes had very high strengths and low porosities. Since then the research and development of silica fume made it one of the world's most valuable and versatile admixtures for concrete and cementitous products.

CONCLUSION

For achievement of higher strength and workability in pervious concrete, it is not possible to get higher strength with conventional concrete mix. Modification is necessary in design. With use of silica fume, it can be possible to increment in strength of pervious concrete.

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