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Effect Of Silica Fume on the Properties of Concrete : A Review

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ABSTRACT

The main aim of this study focuses on the investigation of silica fume's performance in concrete for the improvement of various properties like compressive strength, durability in view with the rising demand of concrete at higher scale which leads to many environmental problems. So, to overcome those problems many recycling and reusing processes are practised at an experimental phrase and practical applications of concrete. Therefore, the idea was developed to partially replace cement with few percentages of its substitutes such as silica fume, fly ash et cetera. Silica fume, an industrial by-product is also known as micro-silica, an ultrafine powder collected as a by-product of silicon and ferrosilicon alloy production. The silica fume provides greater cohesiveness, less segregation and reduced bleeding in concrete. In this review, silica fume was partially replaced upto 25% by weight of cement in the production of concrete. This paper presents a detailed study on the performance of silica fume on various properties of concrete like compressive strength, split tensile strength and flexural strength at different ages of curing i.e. 7th and 28th day. The result in comparison indicates that the replacement level ranges between 10-20% increases strength and durability of concrete but the optimum percentage of replacing silica fume is not constant. Hence, there is a sudden decrease in strength if the cement is replaced more than 20%. Also by replacing the cement with silica fume, the better and reliable performance of concrete can be obtained along with the environmental suitability at economical level.

KEYWORDS

Silica fume, Compressive Strength, Split Tensile Strength, Flexural Strength, Pozzolanic

INTRODUCTION

Concrete is the dominant construction material widely used all over the world for infrastructure. It is basically known for its high strength and performance in almost every civil engineering work.Particular amount of water is added for concrete because excess water leads to bleeding of concrete and less water results in segregation. Materials used for the production of concrete are non-renewable.Unfortunately, production of concrete involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and global warming, hence it is inevitable either to search for another material or partly replace it by some other material [1]. Ordinary Portland Cement (OPC) is mostly used with silica fume all over the world. However, concrete has some deficiencies like low tensile strength, low ductility, large deformation et cetera. For high strength concrete, it is necessary to reduce cement ratio and which result in increase of cement content So Nowadays, many substances(steel fiber, silica fume, asbestos sheets, coal, fly ash et cetera) are used in the mixture to improve the physical properties of the wet or finished concrete so as to provide good tensile and compressive strength. Silica fume is one of the best ingredient used for partial replacement of cement in concrete. In the world of research, silica fume is found to be most suitable and commonly used replacement due to its good packaging nature. Silica fume is also known as Micro silica and it is very effective pozzolanic material composed of amorphous silica produced by electric arc furnaces as a by-product of the production of elemental silicon or ferrosilicon alloys and also consists of spherical particles [2]. The Process involves the reduction of high purity quartz (SiO_2) in electric furnace at temperatures in excess of $2,000^0$C. Silica fume consists mainly of microspheres of mean diameter about 0.15 microns, with a very specific surface area (15,000-25,000 m^2/kg) [3]. This is approximately 100 times smaller than the average size of cement particle. Because of its extreme fineness and high silica content in silica fume, there is decrease in

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unit weight of concrete and increase in its strength. The main physical effect of silica fume in concrete is that it acts as a filler and because of its fineness, silica fume fit into the space between the cement grains just as sand fill the space between particles of coarse aggregate or cement grains fill the space between the sand grains [2]. Replacement of cement by silica fume effects sound absorption, durability, ductility, strength, modulus elasticity,bonding strength, vibration damping capacity, abrasion resistance, air void content, shrinkage, creep rate, thermal conductivity, permeability, corrosion et cetera. Silica fume concrete is not completely impervious to all the aggressive chemicals, especially in the case of concentrated acid attack on the surface; however, research and field performance show that at a low workability/consistency, silica fume concrete can be used effectively to prevent significant damage by many types of chemical attack including sewage and silica fume concrete has been specified for use in sewer and outfall pipes in many countries [4]. When pozzolanic material comes in contact with the concrete, the silica particles react with calcium hydroxide which are released during hydration of cement and thus forms additional calcium silicate hydrate (C-S-H) which are further beneficial for mechanical properties of concrete. Use of silica fume is good for economy and environment as it is sustainable and have responsible nature.

LITERATURE REVIEW:

Mohammad Panjehpour (2011)stated that the thermal conductivity can be reduced by replacing cement by silica fume due to the reaction between silica fume and cement which acts as an obstacle against heat conduction. Also, shrinkage in cement paste is increased when silica fumes are used. Silica fume decreases bleeding and consumes more water due to its small particle size. It enhances the corrosion resistance and sound absorption ability. The strength properties increase by 30% depending upon the level of replacement.

Vikassrivastava (2012)stated that the silica fume improves the bond strength of concrete. Also, there is a drastic change in the workability, it dependsupon the level of replacement whether the workability increases or decreases. compressive strength of concrete significantly increases by 6 - 57 % when cement is replaced upto 10 - 25 %. The modulus of elasticity, tensile strength and flexural strength of silica fume resembles to the referral concrete.

N.K.Amudhavalli(2012) presented that when the silica fume percentage increases the consistency increases greatly. Increment in split tensile strength was observed when silica fume is replaced by 10% whereas the flexural strength is gained by 15% of replacement. Silica fume have more valuable effects on the flexural strength than the split tensile strength but when compared to other mix the loss in weight and compressive strength was found to be 2.23 % and 7.69 % when replaced by 10% of silica fume with cement in concrete.

Mr. Sabale (2014) stated that the replacement upto 10% increases the strength factors but beyond that limit, there is a sudden decrease in tensile strength, compressive strength and flexural strength found after 28 days of curing period. In addition, there is decrease in the workability as the level of replacement increases. The water consumption also increases due to its fine particle size. Silica fume gives excellent result on the properties of concrete.

Ghutke& Bhandari (2014) represented that the portal cement can be partially replaced by silica fume upto 10%. It is non-metallic and non- hazardous waste of industries which is suitable for mix and improvement of properties of concrete. The optimum replacement percentages can be used under Indian conditions. It has been observed that there is an increment in compressive strength of concrete when the silica fume is replaced by 10% and up to a certain extent. Further higher replacement also leads to lower the strength.

H.M.Somasekharaiah (2015)resulted that the optimum percentage is 1.25 % of composite fiber with silica fume's replacement upto 10% and it gives the best results for achieving maximum benefits. Moreover, the replacement of 20% of silica fumes and adding 1.25% composite fiber (steel and polypropylene) decreases the overall strength of concrete. As a result, 10% of silica fume can be taken as optimum dosage for partial replacement for giving the best results in case of strength for reinforced higher performance concrete. Other composite fibers without silica fume decreases settlement, plasticity, water permeability and shrinkage.

R.Radhika(2016) concluded that the compressive and tensile strength increases upto 20% by replacement of 5% of silica fume with cement in concrete. Both the strength increases due to its fine particle size and good packaging nature. The voids are also reduced when the silica fume are used in concrete. The optimum percentage of replacement is observed as 20% of silica fumes for its better results after 28 daysof curing period.

A.Sasikumar(2016)concluded that the normal consistency increases about 40% when silica fume's percentage is upto 25%. The peak compressive strength is obtained in 25% of silica fume replacement at different ages of curing i.e. 7 and 28 days. Moreover, the replacement of microsilica with cement increases the smoothness of concrete which results in decrease of void and shows its consistency. Silica fume isfiner than cement which is beneficial for economy too. Overall strength is greatly increases by 25% when silica fume is replaced by cement. In case of concrete it helps to reduce the impacts on environment due to cement production process.

CONCLUSION

The review of studies related to partial replacement of cement with silica fume reveals that there is a drastic change in all the properties of concrete like compressive strength, flexural strength, split tensile strength, workability et cetera. High performance concrete with silica fume can be effectively used in high rise building since high early strength is required with reduced construction period. From the above literature review it is observed that the optimum percentage of silica fume varies from 10% - 20% whereas the split tensile strength and compressive strength increases by 10% - 25% and the flexural strength is more effected by silica fume as increases upto 30% within 28 days of water curing period. Workability increases upto a certain limit of partial replacement and beyond the limit it decreases instantly.

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