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Effect of Micro Silica on The Strength of Concrete with Ordinary Portland Cement

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Abstract

Concrete is the most important engineering material and the addition of some other materials may change the properties of concrete. With increase in trend towards the wider use of concrete for prestressed concrete and high rise buildings there is a growing demand of concrete with higher compressive strength. Mineral additions which are also known as mineral admixtures have been used with cements for many years. There are two tpes of materials crystalline and non crystalline. Micro silica or silica fume is very fine non crystalline material. Silica fume is produced in electric arc furnace as a by product of the production of elemental silicons or alloys containing silicon. IT is usually a gray coloured powder somewhat similar to portland or some fly ashes silica fume is generally categorized as a supplymentry cementitious material. Silica fume or micro silica was initially vied as cement rplacement material and in some area it is usually used as replaced by much smaller quantity of silica fume micro silica may be used as pozzolanic admixtures. Admixture is defined as a material other than cement water and aggregate that is used as ingredient of concrete and is added to the batch immediately before or during mixing. Pozzolanic admixtures are siliceous or aluminous material which is themselves posses little or no cementitious value but will in finely divided form and in the presence of water chemically react with calcium hydroxide liberated on hydration at ordinary temperature to form compounds possessing cementitious properties. In our experiment we are using micro silica as a artificial pozzolans. We are adding 0%, 5%, 10%, 15% by wt of cement in concrete.

Keywords: Silica fume, cement, composite, physical properties concrete properties.

Introduction

Concrete is a most widely used building material which is a mixture of cement, sand, coarse aggregate and water. It can be used for construction of multistory buildings, dams, road pavement, tanks, offshore structures, canal lining. The process of selecting suitable ingredients of concrete and determining their relative amount with the objective of producing a concrete of the required strength durability and workability as economically as possible is termed the concrete mix design. The compressive strength of hardened concrete is generally considered to be an index of its other properties depends upon many factors e.g. quality and quantity of cement water and aggregates batching and mixing placing compaction and curing. The cost of concrete made up of the cost of materials plant and labour the variation in the cost of material arise from the fact that the cement is several times costly than the aggregates thus the aim is to produce a mix as possible from the technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete and to evolution of high heat of hydration is mass concrete which may cause cracking. The actual cost of concrete is related to cost of materialsrequired for producing a minimum mean strength called characteristic strength that is specified by designer of the structures. This depends on the quality control measures but there is no doubt that quality control adds to the cost of concrete. The extent of quality control is often an economical compromise and depends on the size and type of job nowadays engineers and scientists are trying to increase the strength of concrete by adding the some other cheap and waste material as a partial replacement of cement or as a admixture fly ash, micro silica, steel slag etc are the few examples of these types of materials. These materials are generally byproducts from other industries for example fly ash is a waste product from power plants and silica fume is a byproduct resulting from reduction of high purity quartz with coal or coke and wood chips in an electric arc furnace during production of silicon metal or ferrosilicon alloys. Nowadays whole world is facing a major problem of environmental pollution these materials fly ash micro silica, steel slag may become a major pollution materials.

Material and Methods

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 and consists of spherical particles with an average particle diameter of 150 nm[1]. The main field of application is as pozzolanic material for high performance concrete. Silica fume is an ultrafine airborne material with spherical particles less than 1 µm in diameter, the average being about 0.1 µm. This makes it approximately 100 times smaller than the average cement particle. The unit weight, or bulk density, of silica fume depends on the metal from which it is produced. Its unit weight usually varies from 130 to 430 kg/m³. The specific gravity of silica fume is generally in the range of 2.20 to 2.5. In order to measure the specific surface area of silica fume a specialized test called the "BET method" or nitrogen adsorption method must be used. Based on this test the specific surface of silica fume typically ranges from 15,000 to 30,000 m³/kg.

Mechanism: Silica fume improves concrete through two mechanisms:

Pozzolonic effect: When water is added to cement, hydration occurs forming two products, as shown below:

OPC + H2O →CSH (Calcium silicate hydrate) + Ca(OH)2.

In thepresence of SF, the silicon dioxide from the ORISIL SF will react with the calcium hydroxide to produce more aggregate binding CSH as follows:
$Ca(OH)_2 + SiO_2 \rightarrow H_2O + CSH$.

The reaction reduces the amount of calcium hydroxide in the concrete. The weaker calcium hydroxide does not contribute to strength. When combined with carbon dioxide, it forms a soluble salt, which will leach through the concrete causing efflorescence, a familiar architectural problem. Concrete is also more vulnerable to sulphate attack, chemical attack and adverse alkali-aggregate reactions when high amounts of calcium hydroxide is present in concrete[2].

Micro filler effect: Silica Fume is an extremely fine material, with an average diameter 100 times finer than cement. At a typical dosage of 8% by weight of cement, approximately 100,000 particles for each grain of cement will fill the water spaces in fresh concrete. This eliminates bleed and the weak transition zone between aggregate and paste found in normal concrete. This micro filler effect greatly reduces permeability and improves paste-to aggregate bond in SF concrete compared to conventional concrete[3]. The silica fume reacts rapidly providing high early strength and durability. The efficiency of silica fume is 3-5 times that of OPC and consequently concrete performance can be improved drastically[4].

Cement: Cement is made by heating limestone (calcium carbonate) with small quantities of other materials (such as clay) to 1450°C in a kiln, in a process known as calcination, where by a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which is then blended with the other materials that have been included in the mix. The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum into a powder to make 'ordinary portland cement', the most commonly used type of cement (often referred to as OPC)[2]. Portland cement is a basic ingredient of concrete, mortar and most non-specialty grout. The most common use for portland cement is in the production of concrete. Concrete is a composite material consisting of aggregate (gravel and sand), cement, and water. As a construction material, concrete can be cast in almost any shape desired, and once hardened, can become a structural (load bearing) element. Portland cement may be grey or white. pozzolanic cement is a blend of OPC and another compound usually fly ash ordinary portland cement (OPC) has a property of hydraulic setting, binding and hardening when mixed with water. Some materials undergo hydraulic setting when combined with water in presence of cements, but not by itself. These are called pozzolanic materials. In other words, pozzolanic material + water do not set. Pozzolanic material + water + cement sets. Examples of pozzolanic materials are fly ash, blast furnace slag, brick powder (surkhi), rice husk ash etc. Commercial cement formed by mixing proportions of OPC and any pozzolaanic material, is called pozzolanic portland cement PPC. PPC can be made as good, durable and strong as OPC with proper mixing ratio. It is generally slow setting and sulphate resistant. Moreover, it is environment friendly serving to recycle waste products such as fly ash and slag. i. OPC – Ordinary ortland cement, ii. OPC is obtained by adding raw materials like calcareous materials and argillaceous materials, iii. PPC - portland pozzolona cement, iv. PPC is obtained by adding pozzolonic materials like flyash, pumicites, volcanic ashes, shales, tuffs, etc.

Experimental Details: The following materials were used for experiment, ordinary portland cement conforming to IS 456-2000 graded fine aggregates local clean river sand.

Graded coarse aggregates: locally available well graded aggregates of normal size greater than 4.75 mm and less than 10mm having a fineness modulus of 2.72.

Table-1
The basic components of cement

SiO_2	17-25 %
Al_2O_3	4-8%
Fe_2O_3	0.5-0.6 %
CaO	61-63 %
MgO	0.1-4.0 %
SO_3	1.3-3.0 %
$Na_2 + K_2O$	0.4-1.3 %
Cl	0.01-0.1%
IR	0.6-1.75 %

Results and Discussion

150x150x150 mm concrete cubes were cast using 1:1.5:3 mix proportion with w/c ratio of 0.50 Specimen with ordinary portland cement and ordinary portland cement with various silica fume level 0%, 5%, 10%, 15% were cast[5]. During moulding the cubes were mechanically vibrated after moulding the concrete blocks were demoulded and subjected to curing in water for 7days, 14days 28days. The specimen were tested for compressive strength using a compression testing machine of 200 KN capacity[6]. Compressive strength in N/m^2

Table-2
Compressive Strength test results in N/mm²

Mix Description	Plain	5 SF	10 SF	15 SF	20 SF
% adding of silica fume	0 %	5 %	10%	15 %	20%
7 Days	23.2	28.4	32.1	33.2	32.1
14 Days	28.7	30.5	34.4	37.4	36.3
28 Days	34.7	43.8	45.7	48.3	45.5

Conclusion

Silica fume increases the strength of concrete more 25%. Silica fume is much cheaper then cement therefore it very important form economical point of view. Silica fume is a material which may be a reason of Air Pollution this is a byproduct of some Industries use of microsilica with concrete decrease the air pollution. Silica fume also decrease the voids in concrete. Addition of silica fume reduces capillary[7]. Absorption and porosity because fine particles of silica fume reacts with lime present in cement.

Figure-1
Testing of concrete cube in testing machine

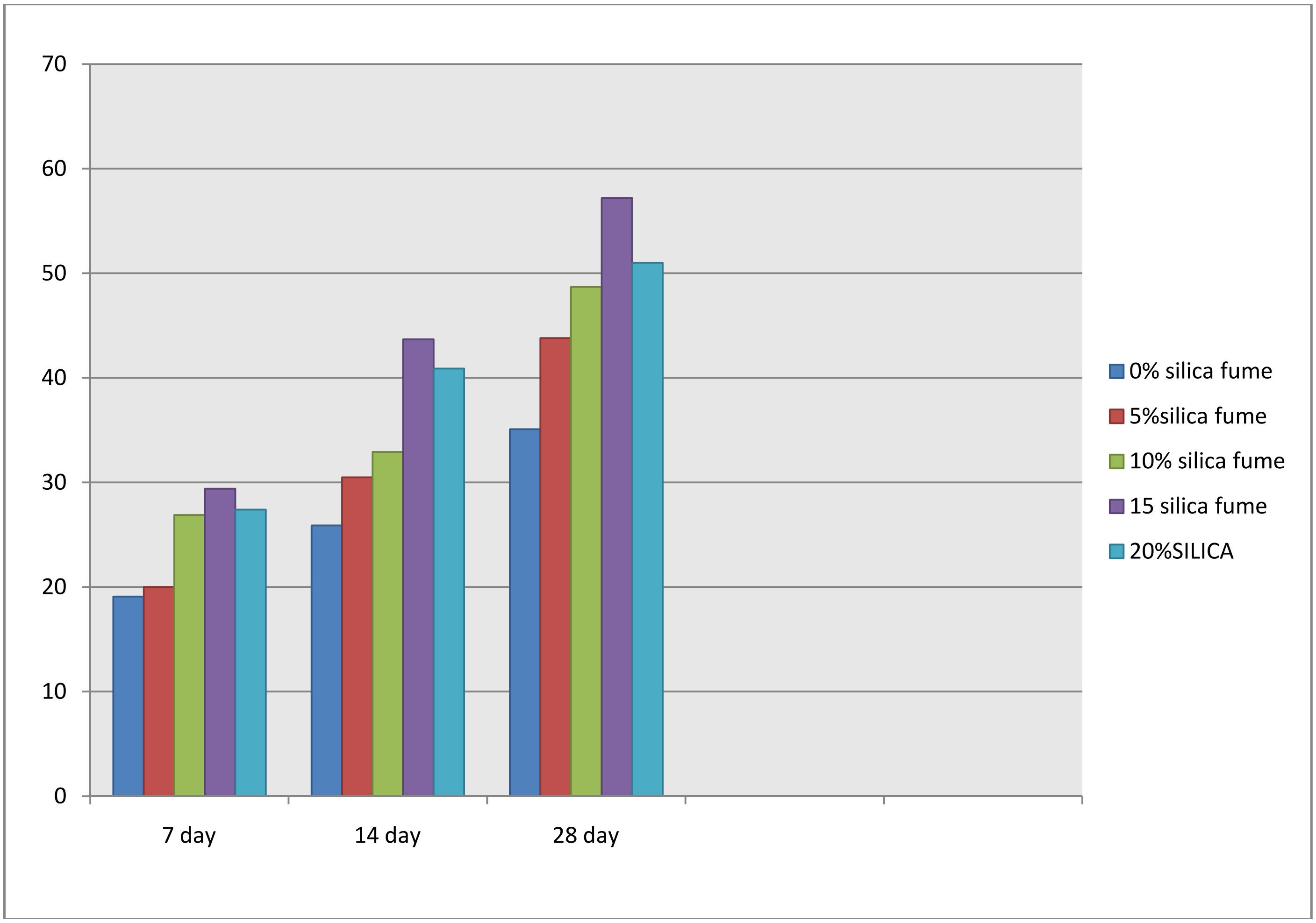

Figure-2
Change in strength of concrte while using Silica with OPC

References

1. Silica fume manual by Oriental Trexim Pvt. Ltd. **(2003)**
2. Shetty M.S., Concrete Technology, S. Chand and Company Pvt Ltd. New Delhi, India **(1999)**
3. Ha-Won Song, Seung-Woo Pack, Sang-Hyeok Nam, Jong-Chul Jang and Velu Saraswathy, Estimation of the permeability of silica fume cement concrete, *Construction and building material*, **24,** 315-321 **(2010)**
4. Abdullah A. Almusallam, Hamoud Beshr, Mohammed Maslehuddin and Omar S.B. Al-Amoudi, Effect of silica fume on the mechanical properties of low quality coarse aggregate concrete, *Cement and Concrete Composites*, **26,** 891–900 **(2004)**
5. IS 456-2000 Plain and reinforced concrete code of practice **(2000)**
6. Krishna M.V., Rao P., Kumar Ratish and Khan Azhar M., A study on the influence of curing on the strength of a standard grade concrete mix, *Architecture and Civil Engineering,* **8(1),** 23–34 **(2010)**
7. Bhanjaa S. and Sengupta B., Influence of silica fume on the tensile strength of concrete, *Cement and Concrete Research*, **35,** 743–747 **(2005)**
8. IS 10262 -2009 Indian Standard recommended guide lines for concrete mix design **(2009)**
9. IS 383-1970 code for properties of aggregates **(1970)**
10. ACI report 234R-96 **(2000)**