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Use of Micro-silica as Additive to Concrete-state of Art

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Abstract

Concrete is the most important engineering material in construction industry because of its inherent strength properties. However, the addition of some other materials may change the properties of concrete. With increase in trend towards the wider use of concrete for pre-stressed concrete and high rise buildings there is a growing demand of concrete with higher compressive strength. Micro-silica, also called as silica fumes is produced in electric arc furnace as a byproduct of the production of elemental silicons or alloys containing silicon. It consists primarily of very fine smooth spherical silicon oxide particles with an extremely high surface area. Micro-silica particles are 100 times smaller than the average cement particle. Its handling and disposal is a point of concern because of the environment concerns. Silica fume is usually categorized as a supplementary cementitious material. These materials exhibit pozzolanic properties, cementitious properties and a combination of both properties. Due to these properties, it can affect the concrete behavior in many ways. The paper highlights the important physical and chemical properties of micro-silica and its contribution in improving the qualities of concrete.

Keywords: silica fumes, pozzolanic, cementitions, improving, concrete.

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 and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete. Silica fume is an ultrafine airborne material with spherical particles.

Micro-silica in concrete contributes to strength and durability two ways:

As a pozzolanic material, micro-silica provides a more uniform distribution and a greater volume of hydration products. As a filler, micro-silica decreases the average size of pores in the cement paste. Micro- silica effectiveness as a pozzolanic material and as a filler depends largely on its composition and particle size which in turn depend on the design of the furnace and the composition of the raw materials with which the furnace is charged.

2. Physical and Chemical Composition

Table 1: Micro-silica's chemical and physical typical composition.

	Unit	Micro-silica
SiO2	%	**90 – 98**
CaO	%	**0.2 - 0.7**
Al2O3	%	**0.4 - 0.9**
Fe_2O_3	%	**1 – 2**
Other	%	**2 – 3**
S.G	Kg/m^3	**2200**
Bulk density	Kg/m^3	**550 – 650**
Surface area	m2/kg	**20,000**

Due to its unique chemical and physical properties, micro-silica has become a versatile mineral admixture for a multitude of applications.

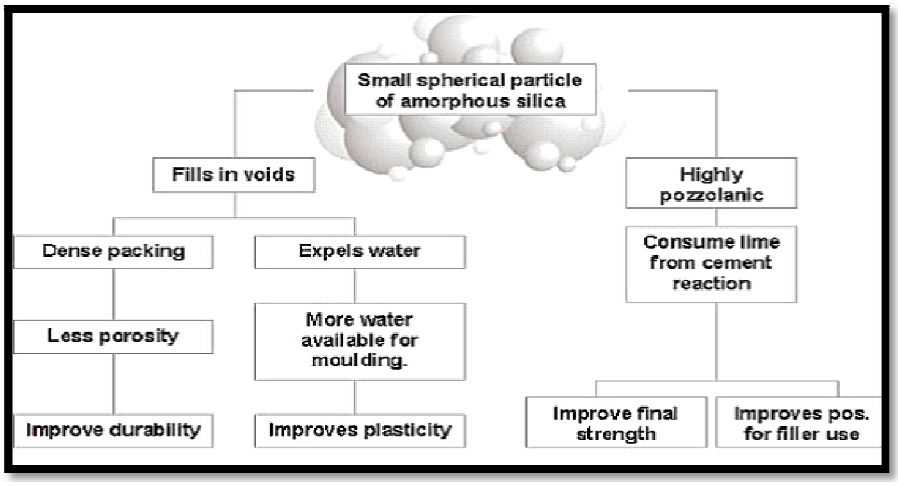

Figure 1: The basic effects of micro-silica in e.g. concrete are illustrated.

3. Working of Micro-Silica in Concrete

Micro-silica improves concrete through two mechanisms:-

3.1 Pozzolanic effect

When water is added to OPC (ordinary Portland cement), hydration occur forming two products, as shown below:

$\longrightarrow$ OPC + H_2O CSH (Calcium silicate hydrate) + Ca $(OH)_2$

In the presence of micro-silica, the silicon dioxide from the micro-silica will react with the calcium hydroxide to produce more aggregate binding CSH as follows:-

$\longrightarrow$ Ca $(OH)_2$ + SiO_2 +H_2O CSH

The reaction reduces the amount of calcium hydroxide in the concrete. The weaker calcium hydroxide does not contribute to strength. When combine 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.

3.2 Micro-filler effect

Micro-silica 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 will greatly reduce permeability and improve the paste-to-aggregate bond of silica fume concrete compared to conventional concrete. The silica react rapidly providing high early age strength and durability. The efficiency of micro-silica is 3-5 times that of OPC and consequently vastly improved concrete performance can be obtained.

4. Silica Fume Applications in Concrete

Because of the pozzolanic and micro-filler effect of micro-silica, its use in concrete can improve many of its properties opening up a wide range of applications including:-

4.1 Corrosion Resistance

The reduced permeability of micro-silica provides protection against intrusion of chloride ions thereby increasing the time taken for the chloride ions to reach the steel bar and initiate corrosion. In addition, micro-silica concrete has much higher electrical resistivity compared to OPC concrete thus slowing down the corrosion rate. The combined effect generally increased structures life by 5 –10 times.

4.2 Sulphate Resistance

Micro-silica concrete has a low penetrability and high chemical resistance that provides a higher degree of protection against sulphates than low C_3A sulphate resisting cements or other cementitious binder systems.

4.3 Heat Reduction

By replacing cement with Micro-silica and observing the efficiency factor of Micro-silica, a lower maximum temperature rise and temperature differential will take place for concrete with the same strength. It performs better than slag and fly-ash blends in thick sections. It is also the most effective way of achieving low heat without sacrificing early age strength.

4.4 Silica Fume Waterproof Concrete

Because of its low permeability, micro-silica can be use as an integral water-proofer for below ground structures where some dampness is acceptable, eg Car parks.

4.5 High Strength Concrete

Micro-silica in conjunction with super-plasticizers is used to produce very high strength concrete (70 – 120 MPa). It is also much easier to pump micro-silica concrete up the high rise buildings during construction.

4.6 Abrasion Resistance

Micro-silica concrete has very high abrasion resistance. In floor and pavement construction it's use saves money and time and improves operational efficiencies for the facility operator. It also improves the hydraulic abrasion-erosion resistance of concrete thus making it suitable for use in dam spillways.

4.7 Chemical Resistance

Micro-silica concrete is widely used in industrial structures exposed to an array of chemicals aggressive. In the alimentary industry the exposure comes from fat acids and other acids, detergents, etc. In the chemical industry there is exposure from mineral acids, phosphates, nitrates, petrochemicals, etc. Micro-silica concrete is therefore invaluable in the industrial and agricultural sectors.

5. Conclusion

Silica fume is a material which may be a reason of Air Pollution this is a byproduct of some Industries use of micro-silica with concrete decrease the air pollution. Silica fume also decrease the voids in concrete. Addition of silica fume reduces capillary. Absorption and porosity because fine particles of silica fume reacts with lime present in cement.

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