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SILICA FUME CONCRETE

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ABSTRACT

Proper introduction of silica fume in concrete improves both the mechanical as well as durability characteristics of the concrete. The long-term compressive strength of silica-fume concrete has been recently questioned by some researchers. This paper reports the results of compressive strength of silica fume. The effectiveness of silica-fume concrete in resisting damage caused by corrosion of embedded steel had investigated using an accelerated impressed voltage-testing setup. The physical properties of high strength silica fume concretes and their sensitivity to curing procedures were evaluated and compared with reference Portland cement concretes, having either the same concrete content as the silica fume concrete otherwise the same water to cementations materials ratio. The marked increase in the strength of the silica fume concrete over the two reference concretes, which was observed even at one day, was not accompanied by liberation of excessive heat. Moreover, the compressive strength results obtained on concrete cores taken after a 4-year period from an experimental column built with a very high-strength concrete also confirmed that tendency was not for strength loss in silica-fume concretes. . Since the beginning of its use in concrete in Canada, silica fume has been used as a cement replacement material in normal strength concrete so as to obtain a desired 28-day compressive strength. It is presently used in the produced form or in the form of blended cement. The two major cement producers in Canada are presently marketing what is called type silica-fume blended cement. Silica fume in concrete increases its impermeability, electrical resistivity, and tensile strength. These three fold improvements in concrete properties can enhance its resistance to corrosion-related damage. Addition of silica fume reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion.

Keywords: - Compressive Strength, Corrosion, Durability, Silica Fume.

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1.0 INTRODUCTION

1.1 General

Silica fume (micro-silica) had recognized as a pozzolanic admixture that is effective in enhancing the mechanical properties and improving the chemical durability of concrete. The use of silica fume is growing in various parts of the world to produce economical high strength and/or chemical-resistant concrete. Since the beginning of its use in concrete in Canada, silica fume has been used as a cement replacement material in normal strength concrete so as to obtain a desired 28-day compressive strength. It is presently used in the produced form or in the form of blended cement. The two major cement producers in Canada are presently marketing what is called type silica-fume blended cement.

1.2 Necessity

Silica fume in concrete increases its impermeability, electrical resistivity, and tensile strength. These three fold improvements in concrete properties can enhance its resistance to corrosion-related damage. Addition of silica fume reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion.

1.3 Background Of Silica Fume

Silica fume is a by-product from electric arc furnaces used in the manufacture of silicon metal of silicon alloys. The material, which contains more than 80% silica in the form of extremely fine particles (0.1 µm average diameter). When used to produce high-performance concrete, silica fume is typically 4-15% of the cement weight. The exact addition rate depends on the specific performance characteristic to be improved. Compared to the other ingredients in concrete, the amount of silica use is small.

For the silica fume to be effective, there are two issues that must be known:

• First, the agglomerations that make up the densified silica must be broken down.

• Second the silica fume must be distributed uniformly throughout the concrete.

2.0 REVIEW STUDY

2.1 Making Silica Fume Concrete In The Laboratory

1. Silica fume must always be added with the coarse aggregate and some of the Water. Never batch the silica fume alone or first into the mixer. Mix these materials for 11/2 minutes.
2. Add the Portland cement and any other cementitious material such as fly ash or Slag cement. Mix for an additional 11/2 minutes.
3. Add the fine aggregate and use the remaining water to wash in any chemical admixtures.
4. Mix for 5 minutes, rest for 3 minutes, and mix for 5 minutes. Actual time of mixing may vary, depending upon the characteristics of mixer. If full dispersion and efficient mixing has been accomplished, mix longer.

2.2 How Does Silica Fume Work In Concrete?

When silica fume is added to concrete, first of all it remains inert. Once Portland cement and water in the mix start reacting with each other (hydrating), primary chemical reactions produce two chemical compounds: Calcium Silicate Hydrate (CSH), which is the strength producing crystallization, and Calcium Hydroxide (CH), as a by-product also called free lime which is responsible for nothing much other than lining available pores within concrete as a filler or leaching out of inferior concrete. Pozzolanic reaction occurs between silica fume and the CH, producing additional CSH in many of the voids around hydrated cement particles. This additional CSH provides the concrete with not only improved compressive, flexural and bond- strength but also a more denser matrix, mostly in areas that would have remained as small voids subject to possible ingress of deleterious materials.

2.3 Properties Of Silica Fume

2.3.1 Physical Properties

Silica fume particles are extremely small, with more than 95% of the particles finer than 1 lm. It's typical physical properties are given in Table1 Silica fume colour is either premium white or grey.

Table 1. Typical physical properties of silica fume

Property	Value
Particle size (typical)	< 1 micro meter
Bulk density	200-250 kg/m^3
Slurry	1,320–1,440 kg/m^3
Densified	480–720 kg/m^3
Specific gravity	2.22
Surface area (BET)	13,000–30,000 m^2 /kg

2.3.2 Chemical Properties.

These are the chemical properties of **silica fume** .

Amorphous: This term simply means that silica fume is not a crystalline material. A crystalline material will not dissolve in concrete, which must occur before the material can react. Never forget that there is a crystalline material in concrete that is chemically similar to silica fume. That material is sand. While sand is essentially silicon dioxide (SiO_2), it does not react because of its crystalline nature.

Silicon dioxide (SiO_2): This is the reactive material in silica fume. Trace elements. There may be additional materials in the silica fume based on the metal being produced in the smelter from which the fume was recovered. Usually, these materials have no impact on the performance of silica fume in concrete. Standard specifications may put limits on some of the materials in this category.

2.4 Reaction Mechanism

Because of its extreme fineness and very high amorphous silicon dioxide content, silica fume is a very reactive pozzolonic material. As the Portland cement in concrete begins to react chemically, it releases calcium hydroxide. The silica fume reacts with the calcium hydroxide to form additional binder material called calcium silicate hydrate which is very similar to the calcium silicate hydrate formed from Portland cement. It is an additional binder that gives silica-fume concrete its improved properties. Mechanism of silica fume in concrete can be studied basically under three roles.

2.5. Disinfection And Reactions

2.5.1 Pore-Size Refinement and Matrix Densification:

The presence of silica fume in the Portland cement concrete is mix causes considerable reduction in the volume of large pores at all ages. It basically acts as filler due to its fineness and because of which it fits into spaces between grains in the same way that sand fills the spaces between particles of coarse aggregates and cement grains fill the spaces between fine aggregates grains.

2.5.2 Reaction with Free-Lime (From Hydration Of Cement):

CH crystals in Portland cement pastes are a source of weakness because cracks can easily propagate through or within these crystals without any significant resistance affecting the strength, durability and other properties of concrete. The Silica fume which is siliceous and aluminous material reacts with CH resulting reduction in CH content in addition to forming strength contributing cementitious products which in other words can be termed as ''Pozzolanic Reaction''.

2.6 Availability and Handling

Silica fume is available in two conditions: dry and wet. Dry silica can be provided as a produced or densified either with or without dry admixtures and can be stored in silos and hoppers. Silica Fume slurry with low or high

dosages of chemical admixtures are available. Slurred products are stored in tanks.

2.7 Silica Fume Efficiency

Silica fume efficiency [8] in concrete is not constant at all percentages of replacement. The overall efficiency factor of silica fume can be divided in two separate parts; ‘‘general efficiency’’ which is constant at all percentages of replacement and the ‘‘percentage efficiency factor’’ which varies with the replacement percentage. The activity of silica fume in concrete is obtained in terms of the amount of cement replaced through its ‘‘cementing efficiency factor’’ (K). The Efficiency factor for silica fume in concrete is defined as the number of parts of cement that may be replaced by one part of the silica fume, without changing the property being investigated generally the compressive strength.

K = (Ke) * Kp

K = Overall Efficiency Factor

Kp = Percentage Efficiency Factor (Kp) = 0.0015 pr2 - 0.3671 pr + 2.8502

Ke = General Efficiency Factor (Ke). It is taken as 3, It usually kept constant for all the percentages of replacement.

Pr = the percentage of silica fume in the total cementitious materials.

3. ADVANTAGES AND APPLICATIONS:

3.1 Advantages of Using Silica Fume

1. High early compressive strength
2. High tensile, flexural strength, and modulus of elasticity
3. Very low permeability to chloride and water intrusion
4. Enhanced durability
5. Increased toughness
6. Increased abrasion resistance on decks, floors, overlays.
7. Superior resistance to chemical attack from chlorides, acids, nitrates and sulphates and life cycle cost efficiencies
8. Higher bond strength
9. High electrical resistivity and low permeability

3.2 Applications of Silica Fume

1. High Performance Concrete (HPC) containing silica fume:- It is for highway bridges, parking decks, marine structures and bridge deck overlays which are subjected to constant deterioration caused by rebar corrosion current, abrasion and chemical attack. Silica fume will protect concrete against deicing salts, seawater, road traffic and freeze/thaw cycles. Rebar corrosion activity and concrete deterioration are virtually eliminated, which minimizes maintenance expense.

2. High-strength concrete enhanced with silica fume:- It provides architects as well as engineers with greater design flexibility. Traditionally used in high-rise buildings for the benefit of smaller columns (increasing the usable space) high strength concrete containing silica fume is often used in precast and prestressed girders allowing longer spans in structural bridge designs.

3. Silica-fume Shotcrete:- It delivers greater economy, greater time savings and also more efficient use of sprayed concrete. Silica fume produces superior shotcrete for use in rock stabilization; mine tunnel linings, and rehabilitation of deteriorating bridge and marine columns and piles. The Greater bonding strength assures outstanding performance of both wet as well as dry process shotcreting with less rebound loss and thicker applications with each pass of the shotcrete nozzle.

4. Repair Products:- The silica fume is used in a variety of cementitious repair products. The Mortars or grouts modified with silica fume is tailored to perform in many different applications—overhead and vertical mortars benefit from silica fume’s ability to increase surface adhesion. Silica fume significantly improves cohesiveness making it ideal for use in underwater grouts, decreases permeability in grouts used for post-tensioning applications and increases the resistance to aggressive chemical.

4.0 CONCLUSION

From the above study it is conclude that

1. The silica fume is a better replacement of cement.
2. The rate of strength gain in silica fume concrete is high.
3. The optimum value of compressive strength can be achieved with replacement of silica fume.
4. Workability of concrete decreases as increase with use of silica fume.

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