TECHNICAL MEMORANDUM
GEMITE PRODUCTS INC.
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Resistance to Chloride Penetration using Adi-Con CSF(R) In Parking Garage & Bridge Deck Overlays

INTRODUCTION

Condensed silica fume (microsilica) is a by-product of the smelting process used to produce silicon metal and ferrosilicon alloys. The following are the main characteristics of the material:

- SiO_2 content from 85 to 98%
- Mean article size in the range 0.1 - 0.2 micron, hundred times smaller than cement particle
- Spherical shape with a number of agglomerates
- Amorphous particles
- It is an reactive pozzolan and a very effective filler

The practical use of this material as admixture to concrete goes to Norway and Sweden in the early 1970s. The Canadian use of CSF starts in the early 1980s. The chemical composition of this material, combined with a high surface area, results in a very effective pozzolanic reaction. This is the reaction between amorphous silicone dioxide and lime in the presence of water. If we re-write the hydration reaction of Portland cement in simplified terms as:

CS	+	H	------------->	CSH	+	LIME
calcium silicate		water		hydrated calcium silicate		

Then, the pozzolanic reaction can be described as:

LIME	+	S	+	H	------------->	CSH
		silicon dioxide		water		hydrated calcium silicate

The addition of CSF and its reaction with the lime generated by the hydration of cement results in the chemical transformation of highly reactive, soluble lime into a more chemically stable, water non-soluble hydrated calcium silicate. The combined effect of the above described pozzolanic and micro-filling effect results in:

- A considerable decrease in hydraulic permeability of concrete. The coefficient of hydraulic permeability of conventional concrete is between 10 <M^>-11 <D>and 10 <M^>-12 <D> m/s. CSF modification results in permeability as low 10<M^>-14<D>m/sec (1)
- Increase in chemical resistance
- Increase in compressive strength

The high surface area of CSF results in a higher water demand during mixing. Therefore the majority of commercial CSF admixtures combine the CSF with a variety of water reducing and other surface acting additives to prevent a loss of workability.

RESISTANCE TO CHLORIDE PERMEABILITY

Adi-Con CSF(R) modified concrete exhibits a very high resistance to chloride penetration. The virtual elimination of chloride penetration makes Adi-Con CSF(R) modified concrete highly suitable for construction and repair of parking structures, bridge decks, marine structures or in applications where damage due to corrosion of embedded steel can result.

Construction Technology Laboratories, Division of The Portland Cement Association conducted a 90 day chloride permeability test according to the Federal Highway Administration (FHWA) - Procedure 2.

This test measures the chloride permeability of hardened concrete by ponding 3% NaCl solution. The high strength concrete with CSF admixture, showed an average absorbed relative chloride content of 0.003% at 12.7 to 25.4 mm (1/2 to 1 in) depth, as compared to 0.028 % for the control mix. The absorbed chloride level of 0.003% was also less for concretes prepared with latex modifier. Results of rapid chloride penetration test for various types of concrete were also reported (3). This test is now known as AASHTO T-277, Rapid Test for Chloride Permeability of Concrete. The test classifies concrete in respect to chloride permeability as follows:

Permeability	Charge Passed	Type of Concrete
HIGH	4000	High w/c ratio, 0.6
MODERATE	2000-4000	Moderate w/c ratio, 0.4-0.5
LOW	1000-2000	"Iowa method" concrete, latex modified concrete,
VERY LOW	<1000	CSF modified concrete
NEGLIGIBLE	<<100	Polymer Impregnated Concrete, Polymer Concrete

The reported chloride permeability values in the Reference (3) were: control concrete 3,900 Coulombs, latex modified concrete 2080 Coulombs and the CSF modified concrete 300 Coulombs. For conventional repair mixes Gemite has measured values between 600 to 800 Coulombs. In some high silica fume content mixes, such as Spray-Con WS MS (manhole shotcrete), the values as low as 80 Coulombs were measured.

FINAL REMARKS

In comparing the CSF modified concrete and latex modified concrete, the resistance to chloride penetration is similar or better in CSF modified concrete. There is however, a considerable difference in the cost of the two concretes. The cost of latex modified concrete in the Metropolitan Toronto area is approximately $600 and this cost increases to $1,000 per cubic meter when ordering the latex modified concrete outside of the Metropolitan area. This is due to the fact, that specialized continuous mixing equipment is required for mixing the latex modified concrete. The cost of Adi-Con CSF (R) modified concrete was about $ 130 / m^3 (assuming cost of $80 / m^3 a conventional, high quality concrete. Adi-Con CSF(R) is added to the "ready mix" track at the site, and 8-15 min. of mixing is required to uniformly mix the admixture into concrete.

Precaution

The microsilica controls effectively sedimentation in concrete, which mans that the "bleeding" water (that slows down the water evaporation) is not present at the concrete surface. Consequently Adi-Con CSF modified concretes are more susceptible to plastic shrinkage cracking, and the surface evaporation retarder, Adi-Con SER, must be applied to the concrete surface immediately after screeding, or the surface must be fogged with water to prevent formation of plastic shrinkage induced cracking. The application of the Adi-Con SER must be done almost immediately, within 10-15 minutes after screeding. The Adi-Con SER also acts as a "lubricant" and speeds up the finishing (e.g. bull floating), of the concrete surface.

References

1. Maage, M. "Effect of microsilica on the durability of concrete structures," Report STF65 A84019, FCB/SINTEF; The Norwegian Institute of Technology, Trondheim, Norway; 1984.
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3. Christensen, D.W., Sorensen, E.V., and Radjy, F.F.,"Rockbond; a new microsilica concrete bridge deck overlay material", Proceedings Int. Bridge Conference, Pittsburgh, June 4-6 1984.

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