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Increasing the service life of concrete water and wastewater structures

By Les Faure

Concrete is the world's most widely used building material for a variety of applications, including wastewater treatment systems. This makes economic and environmental sense, as long as the concrete is protected from deterioration. Then, the wastewater treatment system, including concrete pipes and manholes, enjoys a longer service life.

Despite all the advantages concrete offers, its porous nature renders it permeable to liquids and gases. Consequently, it is susceptible to deterioration by water penetration and by acid produced by hydrogen sulphide gas (H_2S) in sewer pipes.

A time-tested waterproofing solution by Xypex® Chemical Corp., in Vancouver, for both new and existing concrete, is crystalline technology, which has been used in thousands of projects in more than 70 countries. Crystalline technology is permanent, easy to use and economical.

With crystalline technology, water is used in the capillary tracts as a diffusing medium to carry waterproofing chemicals into the concrete. These chemicals migrate through the waterways of the saturated pore network, where they react and grow insoluble, needle-like crystals that plug the pores. Within a few weeks of crystal growth, liquids can no longer pass through and the transmission of gases is restricted.

The effect is permanent. In fact, the technology self-seals new micro-cracks if and when they occur, even years after the original application.

Crystalline waterproofing can be easily introduced into new concrete as an admixture, a dry-shake product or a surface-applied coating. For existing (i.e., cured) concrete, surface-applied coatings are used. The technology is non-toxic, contains no volatile organic compounds (VOCs), and is NSF 61-approved for potable water by NSF International.

H_2S – the Achilles heel

The Achilles heel for concrete structures in sanitary sewers and wastewater treatment plants is H_2S gas, which not only causes a “rotten egg” odour, but also



Caption

results in chemical attack and corrosion. Control of H_2S is a major concern for managers of wastewater collection systems, especially in warm climates, or in systems with low velocity.

If a concrete sewer is only partially full, the damp surface above the water line is an open invitation to aerobic bacteria that oxidize the H_2S and produce sulphuric acid. This acid attacks the calcium hydroxide and calcium silicate hydrate in concrete. Corrosion is most severe at the crown of the pipe, where the acid collects. This leads to a weakening of the pipe and, if left unattended, can also cause a collapse. The key is low water permeability and keeping out bacteria that cause the problem.

The chemical formulations of crystalline waterproofing products are a manufacturer's trade secret, but, in all cases, these materials react with the byproducts of cement hydration such as calcium hydroxide, (lime), and other minerals within the cement matrix.

Growth of waterproofing crystals is a



gradual process, requiring two to three weeks to reach maturity. The result is the formation of a microscopic, mesh-like barrier as the crystals grow across the diameter of the concrete's pores, plugging them against the flow of liquids, and even against extreme hydrostatic pressure.

Although crystal formation largely matures in two to three weeks, the process can continue virtually as long as there is water in the concrete. Cessation usually occurs due to natural drying of the concrete. The reaction effectively never runs out of lime, meaning that, if water re-enters the concrete years later, it automatically reactivates the waterproofing chemicals, and new crystallization begins.

Testing for effectiveness

The effectiveness of crystalline waterproofing in the field is backed up by extensive independent laboratory testing for

permeability, crack-sealing and chemical resistance. Permeability testing in accordance with U.S. Army Corps of Engineers (ACE) CRD C-48-73, *Permeability of Concrete*, demonstrated that crystalline-treated concrete could withstand up to 123 m of head pressure, or 1.2 MPa (megapascals), which was the limit of the testing apparatus.

At the micro-level, shrinkage-cracking from drying potentially creates passageways for moisture infiltration. If they occur while crystals are still forming, micro-cracks up to 0.4 mm can be bridged. If they occur later and allow water infiltration, the water reactivates the waterproofing chemicals, making the concrete self-healing on a microscale.

Crystalline admixtures require no expertise or additional labour on the part of the contractor, as they are added to the ready-mix truck at the batch plant. Curing of the concrete is simultaneous with that of the waterproofing application. Dosage is generally in the range of 1–3% of cement content by weight. Concrete with crystalline waterproofing can achieve higher compressive strength than similar “standard” mixes. Results vary with the dosage.

The dry-shake method is installed on new slabs after the concrete reaches initial set. Powder is applied onto the wet surface and then trowelled in evenly.

Surface-applied coating is appropriate for new concrete and is the only method available for existing concrete. For new concrete, it is preferable to apply it as soon as forms are stripped. If the surface is dry, it must be re-wetted before application (to use water as the delivery system to introduce the crystalline chemicals into the concrete).

In Canada, crystalline waterproofing products have been used extensively in water and wastewater construction. Some recent examples are projects such as the \$430-million Pine Creek Wastewater Treatment Plant in Calgary, which can treat up to 100 megalitres of wastewater per day, and the Seymour-Capilano Water Filtration Plant in Metro Vancouver.

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