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SPECIAL SECTIONS

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PROTECTING CONCRETE WASTEWATER SYSTEMS AGAINST MICROBIAL INDUCED CORROSION

By **Dave Ross**

Many wastewater collection and treatment structures are in need of repair or replacement because they have lost structural integrity due to microbial induced corrosion (MIC) and other forms of physical and chemical attack. The breakdown of wastewater infrastructure allows increased infiltration of runoff and groundwater and allows the leakage of wastewater into the environment along deteriorated conveyance systems and via overflows at treatment facilities.

Microbial induced corrosion is a complex bacterial process involving sulfate-reducing bacteria that generate hydrogen sulfide (H_2S) gas in the waste flow of sewer systems. This gas is released from the wastewater flow in areas of increased turbulence such as manholes, lift stations and head works. It then dissolves in the moisture and slime layer coating the concrete walls of these structures and is metabolized by *Thiobacillus* bacteria into sulfuric acid. Different species of *Thiobacillus* produce progressively stronger sulfuric acid that eventually can destroy unprotected concrete.

Xypex Megamix II with Bio-San repair mortar combines crystalline waterproofing with bioactive mineral solids.

CONCRETE PROTECTION METHODS

With so much replacement and repair work on the books, owners and specifiers are challenged to find ways to prevent deterioration from reoccurring, and to protect against MIC using modern construction methods.

While there are many approaches to providing MIC protection, there are limitations for each that need to be considered. Solutions for the repair or prevention of MIC damage include repair mortars, corrosion-resistant coatings and inserts, cured-in-place pipe relining, antimicrobial concrete additives and waste stream chemical treatments.

ENHANCING CONCRETE DURABILITY

There are various ways to increase the resistance of concrete to acids and other forms of chemical attack. Diffusion or penetration of aggressive substances into concrete through interconnected capillary pores and cracks can lead to degradation and deterioration of the structure. Depending on the nature of the diffusive substances, they can attack concrete or its steel reinforcement. By blocking the pores and healing cracks, the mass-transfer rate into the concrete can be decreased, thereby enhancing the concrete's durability and the longevity of the structure's service life.

Traditional means for improving the durability of concrete are through reduction of the water/cement ratio and by increasing the moist curing time. Another way to increase concrete durability is through the partial replacement of Portland cement with supplementary cementitious materials such as fly ash, ground granulated blast furnace slag and silica fume.

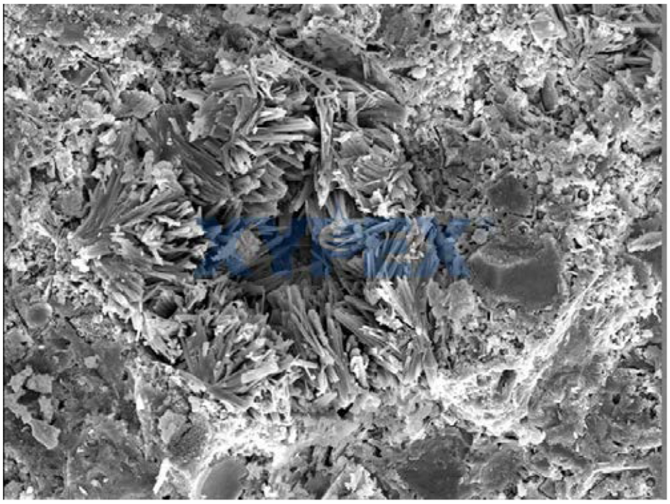
CRYSTALLINE WATERPROOFING

Another time proven method of increasing the durability of concrete structures is through the use of crystalline waterproofing technology. This technology can be used as an admixture to protect new concrete, as a cementitious coating for repairs, or as a protective preemptive treatment.

Crystalline waterproofing technology reduces permeability and increases durability of concrete by filling and plugging pores, capillaries and micro-cracks with a non-soluble, resistant crystalline formation. This form of waterproofing technology reacts with the byproducts of cement hydration to plug the pores, capillary tracts and micro-cracks with a crystalline formation. Infiltration and diffusion of liquids is significantly reduced, which protects concrete from the effects of acid, sulfate and chloride attack.

PROTECTING CAST-IN-PLACE CONCRETE

One private ski club is expanding its facilities with the construction of 13 new, larger cabins as well as a 43-unit employee village. Wastewater treatment for the expansion project will be provided by a municipal wastewater plant by means of a gravity sewer extension to the facility. It includes a 200 mm PVC collection line that will gravity feed to a 4.2 m



Crystalline formation completely fills concrete pores (left). Hydrostatic testing of the lift station was successful on first attempt (right).

high lift station buried below grade.

The design for the new sewer lift station includes protection from MIC via crystalline waterproofing technology from Xypex Chemical Corp. "When you are designing a lift station for sewage the key question is how can we do this so that it will hopefully last forever, particularly knowing that it will be cast-in-place concrete that will be subject to a hostile H_2S environment and varying pH levels," notes design engineer Paul Rutledge, of Sopris Engineering LLC.

The cast-in-place lift station required approximately 32 m^3 of ready-mix concrete. The concrete was treated with Xypex Bio-San C500 admixture, a powdered product that combines crystalline waterproofing with a mineral-based antimicrobial that kills the *Thiobacillus* group of bacteria species responsible for MIC. The antimicrobial component in Bio-San works indefinitely to destroy harmful bac-

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teria at the cellular level.

"Before we knew about concrete admixtures like Xypex," Rutledge continues, "we would have specified an epoxy or some other coating for a lift station or manhole where we needed extra protection. With Xypex waterproofing with antimicrobial, the protection becomes an inherent part of the structure. It not only heals cracks and stops leakage, it inhibits slime growth."

LONG-LASTING REPAIRS POSSIBLE

One city, with a population of about 8,000 residents, has a wastewater system composed of 90 km of collection lines ranging in size from 150 mm to 600 mm, three lift stations, one main pumping station and treatment lagoons.

The city completed a new main lift station in early 2011 to replace a preexisting lift station that had reached the end of its useful life. Unfortunately, the new lift station has experienced accelerated corrosion due to high levels of H_2S gas. MIC has eroded the interior of the lift station to the extent that up to 50 mm of concrete could be easily scraped off, particularly in the wet well.

According to project manager Adam Teunissen, of JVA, Inc., "the original structure is less than 10 years old, yet it is experiencing a very rapid corrosion rate. We have recommended that the surface damage within the lift station be repaired with Xypex Megamix II with Bio-San. It is a new repair mortar designed specifically for situations where MIC is involved. We also plan to reduce levels of H_2S gas in the system by introducing biocide at different points in the wastewater stream."

Part of the post-repair monitoring program will be to mount treated and untreated concrete cylinders inside the wet well area and check them periodically to measure the effectiveness of Megamix II with Bio-San.

Xypex Megamix II with Bio-San repair mortar combines crystalline waterproofing with bioactive mineral solids. The product can be used to resurface and waterproof deteriorated concrete, providing resistance to acids, sulfates and chlorides, as well as limit MIC development.

This will not be the first time that the product was evaluated in such a "hot" H_2S environment. In an independent study of the antimicrobial effect of Xypex Bio-San C500, the active ingredient was added at 1% by weight of Portland cement mortar and compared to untreated control samples.

Sample cylinders were suspended in a wastewater facility that was chosen due to elevated levels of H_2S (about 50 ppm) over a period of 10 years. Exposure trials showed that treated samples had nine times less concrete mass loss compared to the untreated control samples. Bacterial concentration on the treated samples was minimal, even after 10 years of exposure. ■

Dave Ross is with Xypex Chemical Corp. For more information, visit www.xypex.com

CASE STUDIES

The following are two examples of environmental projects that were successful as SR&ED claims.

Dewatering of an excavation. At a condo development in Toronto, wells were drilled, according to the technology standards, to the depth of the underground garage excavation. The wells encountered till deposits consisting of low permeable fine sand, sandy silt, silt and clay. The low permeability of these deposits was considered favourable for the excavation dewatering. However, when the excavation progressed, groundwater started to flow through the garage floor and tie back holes into the excavation.

The claimant hypothesized and further confirmed by drilling deeper boreholes and performing pumping tests that the source of the water was the deep aquifer in the sand formation located 10 m below the bottom of the excavation with high piezometric head values.

This artesian aquifer provided upward groundwater movement either through the overlying low permeable deposits or through artificial conduits such as tie backs.

Through pumping experiments, the claimant identified that effective dewatering of the excavation could be provided by three deep dewatering/depressurizing wells extended into the deep aquifer.

Remediation system for deeply positioned VOCs. At an urban environmental site, high concentrations of volatile organic compounds (VOCs) were identified in deeply positioned groundwater. The site geology featured 8 m – 14 m of silt, underlain by 5 m – 15 m of sand. Groundwater level at the site was located between 9 m – 11 m below the ground surface. The deep position of the contamination made traditional active remediation techniques unfeasible. The claimant came up with a concept of in situ bioremediation.

A series of bench-scale tests were performed to prove the concept and identify the optimal concentrations of the remedial agents.

The problem was that the site started with non-detect levels of specific micro-organisms, *Dehalococcoides*, which were supposed to destroy VOCs. To compensate for this deficiency, *Dehalococcoides* were injected into the deep subsurface, followed with sodium lactate to stimulate growth of the micro-organism population. This technology worked well for reducing concentrations of VOCs.

CONCLUSION

The SR&ED tax credit is an effective means of stimulating innovation in the environmental industry and well-organized engineers should not have trouble using it to support their businesses. ■

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