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PROTECTING WATER AND WASTEWATER STRUCTURES with crystalline self-healing concrete

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Concrete is the world's most widely used building material for the construction of water and wastewater systems. It's widely available, relatively low-cost, durable and easy to use. Yet, in spite of its many attributes, concrete is prone to deterioration due to its porous and permeable nature, which renders it susceptible to the ingress of liquids and gases. The diffusion or penetration of aggressive substances into concrete through the interconnected pores (e.g., capillary pores) and cracks causes material degradation and deterioration of the structure. Depending on their nature, diffusive substances can attack concrete or the steel reinforcement, jeopardizing the long-term integrity of critical drinking water or sewage systems.

Blocking the pores and healing the cracks enhances concrete's durability and extends a structure's service life. Traditional means for improving the durability of the concrete are through reduction of the water/cement ratio (W/C) and

increasing the moist curing time. More recently, partial replacement of the Portland cement with supplementary cementitious materials (SCMs), such as fly ash and ground granulated blast furnace slag (GGBFS), has become more popular for increasing the durability of concrete that is exposed to aggressive environments. However, it has been observed that these steps are often not enough by themselves to produce a durable or high performance concrete.

In particular, despite extensive efforts and attempts to increase the durability of concrete exposed to severe sewer environments, the problem still exists. Resolving deterioration issues motivated the development of permeability reducing admixtures that can considerably reduce moisture and chemical transfer into the concrete. Of note, these admixtures should not only reduce the permeability of the concrete, but also enhance resistance to chemical attack of the concrete.

Working inside the concrete

To ensure the long life and low permeability of concrete structures in water and wastewater systems, one

solution is the installation of spray-applied specialized coatings that act as a barrier between water and aggressive chemicals and the concrete structure. While these can be very effective, they are dependent on the integrity of the coating, which can puncture or tear and its adhesion to the surface, which inevitably will break down causing failure.

More recently, owners, engineers and contractors have turned to crystalline technology to make the concrete impervious to moisture. These permeability-reducing admixtures for concrete exposed to hydrostatic conditions (PRAHs) are considerably less costly and more convenient than external barrier/membrane solutions without the exposure disadvantages, such as tearing, puncturing or detachment.

After extensive testing and investigation, leading independent scientific laboratories and regulatory bodies, including the American Concrete Institute (ACI), agree. The ACI committee responsible for ACI 212.3R-10 (*Report on Chemical Admixtures for Concrete*) documented



Concrete deterioration
at wastewater treatment plant intake structure



Scanning Electron Microscope image
of crystalline formation in a concrete pore



Pine Creek WWTP, Calgary, AB



Seymour-Capilano Filtration Plant, North Vancouver, BC



Rosemont Reservoir, Montreal, QC

the applications and capabilities (durability, permeability and chemical resistance) of PRAH's. The report specifically spotlighted the uses and benefits of crystalline admixtures, which incorporate active ingredients that react with water and cement particles in the concrete to form calcium silicate hydrates and other precipitates in the existing micro-cracks and capillaries.

For example, Xypex technology, a crystalline waterproofing solution designed to reduce permeability of concrete, enhances the performance of concrete durability. This material is designed to react with the by-products of cement hydration in the capillary tracts and voids of concrete to produce a non-soluble crystalline structure that reduces concrete's natural porosity.

By effectively blocking the pores, capillary tracts and micro-cracks with a crystalline formation, liquid and gas diffusion is significantly reduced, thus protecting concrete structures against effects of acid and sulfate attack. In addition to visual evidence of the crystalline formation in the concrete voids through electron microscope images, independent tests confirm the ability of crystalline technology to significantly extend the service life of concrete structures. The result of this increased durability and longevity is less maintenance and repair work and dramatically improved sustainability.

Lifecycle crystalline benefits

Crystalline materials are available in powder form that can either be incorporated into a concrete mix for

new structures or mixed with water into a slurry consistency for brush or spray application on the surface of existing concrete structures. Crystalline waterproofing chemistry reacts with these materials to form small, mineral-based 'dendritic crystalline structures' that are insoluble in water. The formation of the crystals is a gradual process, requiring several days to several weeks for the crystals to reach maturity. As the crystals grow across the diameter of the concrete's pores, they form a microscopic, mesh-like barrier that plugs the pores and prevents the flow of liquids, even in extreme hydrostatic pressure.

Although crystal formation largely matures in two to three weeks, the process can continue as long as there is moisture in the concrete. The reaction effectively never runs out of lime, meaning that if water re-enters the concrete years later, the waterproofing chemicals automatically reactivate and new crystallization begins. 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 (16 mil) 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 both a micro and macro scale.

Since crystallization becomes an integral, permanent part of the concrete matrix, it cannot be punctured or damaged like a liner or surface coating; it withstands high

hydrostatic pressure from both the positive and negative side; and is not affected by humidity, ultraviolet light or oxygen levels. A crystalline technology such as Xypex-developed solution, is a modification of the concrete itself and hence is permanent and will not blister or fail.

In addition, the crystalline technology improves the concrete's resistance to freeze-thaw and protects reinforcing steel from corrosion. It self-heals and, when used as an admixture, can increase compressive strength and reduce shrinkage cracking. Crystalline waterproofing technology is non-toxic, contains no VOCs (volatile organic compounds), and is NSF-61 approved for potable water by NSF International, a widely accepted, independent source of public health and safety standards around the world.

One of the other advantages of crystalline waterproofing is that it can be introduced into new concrete as an admixture, a dry-shake product, or a surface-applied coating. It's also the waterproofing technology of choice on one of the largest potable water reservoirs in the world.

Because it interacts to strengthen and repair concrete, crystalline waterproofing improves the durability and performance of concrete structures while lowering maintenance costs and extending the lifespan of structures by protecting against the effects of water ingress and aggressive chemicals – thus delivering a sustainable lifecycle solution.



Crystalline concrete waterproofing in action

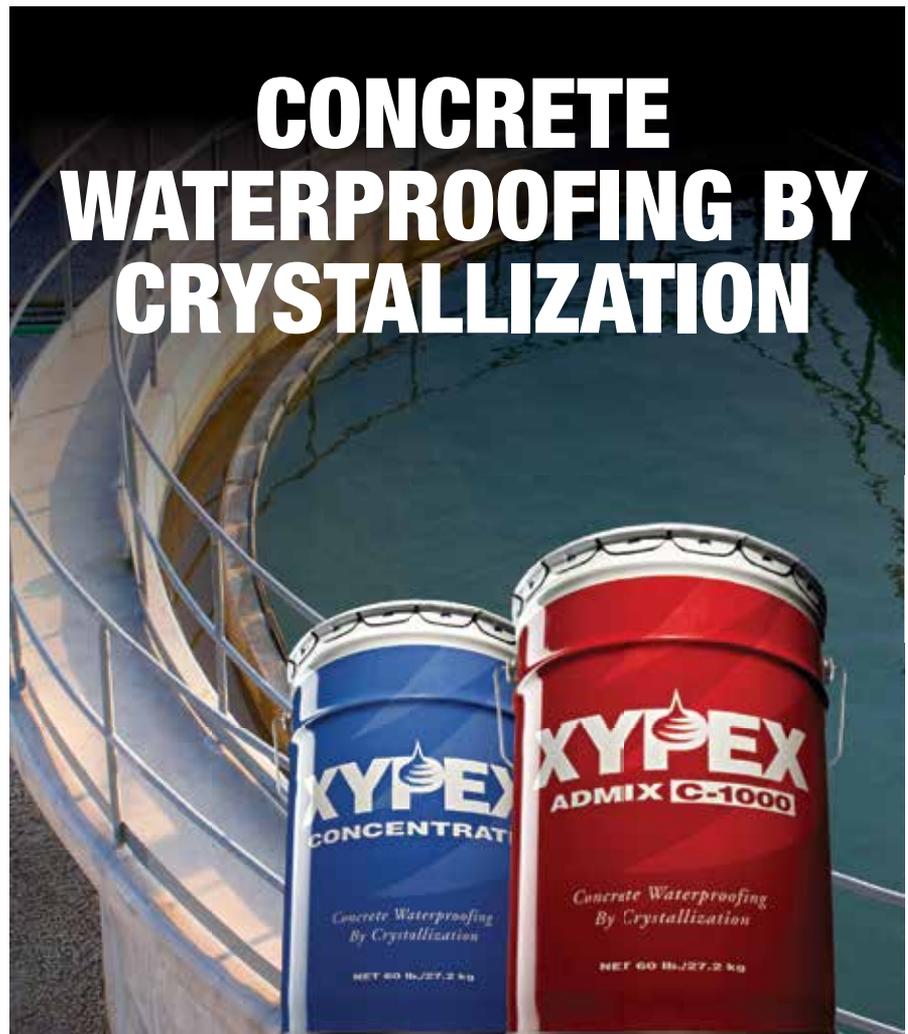
Crystalline waterproofing has been widely used in the construction and rehabilitation of water and wastewater structures around the world for more than 40 years. Some examples of projects completed using crystalline materials in western Canada are the Pine Creek Wastewater Treatment Plant in Calgary, which discharges treated effluent to the Bow River, an important natural and recreational resource and world-class fishery that has its source in the Rocky Mountains. During the construction of the facility, engineers, concerned about the aggressive nature of sewage, specified Xypex crystalline technology to waterproof, protect and enhance the durability of the primary and secondary clarifying tanks, the bio-reactor cells and more.

In Vancouver, crystalline waterproofing was extensively used for waterproofing and protection of concrete tanks at the Seymour-Capilano Filtration Plant, the largest of its kind in Canada, which includes the world's largest ultraviolet disinfection system and filters up to 1.8 billion litres of water per day and supplying up to 70% of the drinking water to Metro Vancouver.

Crystalline waterproofing was also used for the restoration of the Rosemont Reservoir, Montreal's largest underground water reservoir. Rosemont was built in the 1960s but decommissioned in 1978 because of changes to the city's drinking water supply system. However, Rosemont will be reactivated through a five-stage restoration program in 2016 as a way to substantially increase the city's potable water supply. The reservoir holds 250 million litres of water and is the equivalent size of four football fields by four football fields. Over 70,000 kg each of Xypex Concentrate and Modified were used to waterproof, protect and renovate the walls, ceiling and slab of this major project.

While self-healing concrete has been described in recent media reports as 'new,' crystalline technology has been used to waterproof, protect and repair concrete structures over the past 40 years in more than 70 countries. The necessity for the right method used to waterproof concrete is crucial to the

operation and longevity of any water or wastewater treatment system. Other solutions for concrete waterproofing have their advantages. None, however, can match the depth and breadth of benefits provided by crystalline technology for short- and long-term performance.



CONCRETE WATERPROOFING BY CRYSTALLIZATION

EXTEND THE SERVICE LIFE OF WATER TREATMENT STRUCTURES

Leaks, cracking, joint failure, chemical attack and surface deterioration are problems common to water treatment systems. Whether for new or rehabilitated structures, Xypex Crystalline Technology is a proven and permanent solution.

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