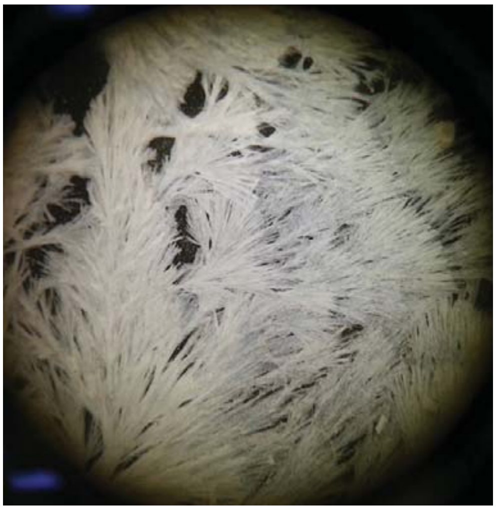
How crystalline waterproofing admixtures combat corrosion



Concrete structures are typically designed for a lifespan of 50–125 years. To keep these structures in service, a significant amount of infrastructure budget is reactively put towards repairs, rather than investment in new construction. The largest contributing factor for the high cost of repairs and for infrastructure not meeting its service life expectancy is corrosion of reinforcement found in concrete. ***Alireza Biparva*** *of* ***Kryton International*** *reports.*

Water movement through the concrete allows waterborne chlorides to penetrate reinforcing steel and causes corrosion, resulting in expansive pressure and cracking. Once cracking has started, water movement increases and the rate of deterioration increases leading to a drastically shortened lifespan.

The problem is that concrete on its own is not waterproof. Concrete is filled with interconnected capillary pores that allow the concrete to 'breathe', but also allow water to pass through.

Due to concrete's high pH level, it is typically good at protecting reinforcement. The steel reinforcing bars are passivated by an iron oxide film that protects the steel. However, the passive layer can break down over time due to atmospheric carbon dioxide, which through carbonation, lowers the pH of the concrete until the passive layer becomes unstable. The passive layer can also be rapidly broken down by aggressive chemicals such as chloride brought in by water. Once the passive layer is compromised, reinforced steel will begin to corrode if there is moisture and oxygen present at the surface of the steel.

Mitigating water ingress through the

Above: Krystol crystalline technology.

Left: Krystol Internal Membrane (KIM) added to concrete provides water-resistance.

(Photos: Kryton International Inc.)

KIM admixture is added to ready-mixed concrete truck at time of batching.

concrete over its lifespan is critical to the overall integrity, durability and sustainability of new construction.

Traditional solutions

Traditionally, protecting concrete from water has been accomplished with a membrane of some kind. Typically, membranes are applied to the surface of the concrete either as a liquid coating or as flexible sheets that are joined together but are easily compromised by a puncture or separated seam.

In structures where membranes are not allowed, concrete is currently designed to enhance durability. By using the optimum cement content and type to yield a dense and relatively unabsorbent concrete, and placing more concrete cover over the reinforcement, it slows the rate at which water can penetrate through to the reinforcement.

New solutions

Waterproofing admixtures are products added to the concrete during mixing to make the concrete water-resistant by blocking the passage of water through capillary pores and cracks. These waterproofing admixtures are commonly referred to as permeability-reducing admixtures (PRAs). PRAs are broken down into two categories based on performance: permeability-reducing admixtures for hydrostatic conditions (PRAH) and those for non-hydrostatic conditions (PRAN).

A PRAN is intended for applications that are not subject to hydrostatic water pressure and are sometimes called damp-proofing admixtures. Most PRANs contain water-repellent chemicals that shed water and reduce water absorption into the concrete. They will not withstand high hydrostatic pressure and are better suited to applications such as concrete exposed to damp soil or rain.

PRAHs are intended for use in concrete to reduce concrete permeability and the penetration of water under pressure. They are effective at stopping water and able to withstand high hydrostatic pressure, and can self-seal micro-cracks. Thus, PRAHs are suitable for building tanks, watertight structures such as deep basements (including deep excavations), water containment structures, tunnels and dams.

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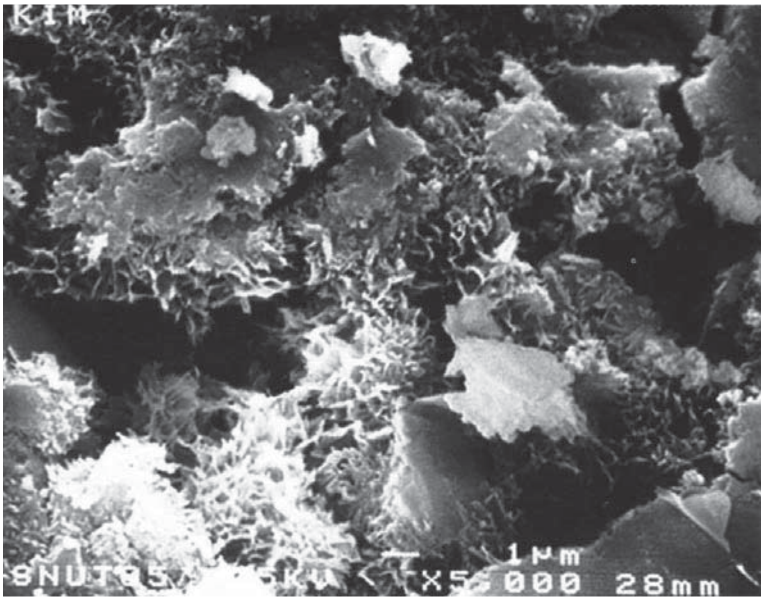
The waterproofing benefits of PRAHs are also being realised in reducing corrosion and adding longevity to reinforced concrete.

PRAHs leverage crystalline technology to combat corrosion. Crystalline waterproofing admixtures react with water and unhydrated cement particles to form insoluble needle-shaped crystals that fill capillary pores and micro-cracks in the concrete and block the pathways for water and waterborne contaminants.

The most unique and effective long-term feature of certain crystalline technology is the ability to 'self-seal'. When water enters, new crystals form and grow, blocking and filling any cracks that form due to drying shrinkage, seismic activity, etc. Crystalline technology may help to reduce the long-term maintenance and repair costs and extend the life of a concrete structure.



SEM magnification of Krystol treated concrete.

Testing crystalline technology

A joint study[1] between the author and Risha Gupta from the University of Victoria demonstrated that the incorporation of certain crystalline technology not only reduces the permeability of concrete but it is also able to self-seal to keep a structure watertight and prevent ingress of waterborne contaminants.

For this study, the authors developed a test method for replicating and analysing real-life conditions of the self-sealing process and to investigate the effects of waterproofing crystalline admixtures on the self-sealing properties.

Self-sealing is a unique phenomenon that allows concrete to retain its high durability. The rate of water reduction and self-sealing is not constant. The addition of certain crystalline technology waterproofing admixtures enhances the concrete's natural ability to self-seal, thereby greatly improving the durability of concrete structures.

Also, a long-term corrosion study[2] funded by the Hawaii Department of Transportation was conducted by the University of Hawaii to evaluate the durability of 22 reinforced concrete specimens, all containing various pozzolans and chemical admixtures. Test panels were exposed to a marine environment in the tidal zone in Honolulu harbour from 2002 to 2012. Panels were monitored for half-cell potential, chloride concentrations, cracking and visible signs of corrosion.

The overall conclusion of these studies is that certain crystalline waterproofing admixtures significantly outperformed other permeability-reducing admixtures and corrosion inhibitors. The result is a structure with increased durability, a longer lifespan and lower maintenance costs over the structure's service life, which could allow structures to meet their service requirements. ■

References:

1. BIPARVA, A. and GUPTA, R. *Advancements in evaluation of the self-sealing properties of permeability reducing admixtures*. Available at: *http://blog.kryton.com/2017/03/advancements-in-the-evaluation-of-self-sealing-properties-2*, 2017.
2. ROPERT, J., and ROBERTSON, I.N. *Performance of corrosion inhibiting admixtures in Hawaiian concrete in a marine environment*. Research Report UHM/CEE/12-04, University of Hawaii at Manoa, Honolulu, Hawaii, 2012, available at: *www.cee.hawaii.edu*.