

World Tunnelling

Latin & Central America

The region's first immersed tunnels

Drill & blast

Pressing ahead on Europe's longest high-speed rail network

Waterproofing

The benefits of crystalline technology



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SYSTEMS

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REFUGEE CHAMBERS

8 PERSONENHET
PERSON UNIT

AFTER HANDBA BEF'LE
ROTATE HANDLE SLOWLY

Improving tunnel performance

Crystalline technology can prevent costly leaks, saving tunnel operators billions of dollars

Near right: a coat of Xypex concentrate was applied to this 40cm-thick cast-in-place concrete tunnel structure in Colombia

Far right: crystalline waterproofing reduces lifecycle maintenance costs on the Queensway Interchange in Singapore

The cost to repair the Delaware Aqueduct Rondout West Branch Tunnel in New York City, which currently leaks 15-35 million gallons of water per day, is well over US\$1 billion. Problems of this magnitude clearly demonstrate the need for an effective answer to water egress.

Research has found that crystalline waterproofing technology, applied during concrete batching or on the surface after concrete placement, can be just as effective as conventional solutions for impermeability at considerably lower cost, with longer lifecycle advantages and without the typical installation challenges and skilled labour requirements associated with membranes and liquid coatings.

INSIDE TUNNEL CONSTRUCTION

The most common problem in tunnels is cracks in the concrete walls and slabs caused by drying shrinkage, thermal cracking, strain and settlement. Mix components, such as high cement content or high-silica fume replacement used in high-strength concrete, can also create cracking problems.

Difficult construction conditions and the quality of workmanship are also primary factors in defective cold and construction joints and issues relating to poor consolidation.

Water ingress into tunnels can compromise the integrity of the structure, result in increased maintenance costs and create unsafe conditions for vehicles. In geographic locations that are subjected to very cold conditions, the water can freeze and damage tunnel systems.

For example, the Tunnel de Chamoise near the Nantua viaduct in France experienced a problem with icicles forming due to seepage in the ventilation shafts. When the icicles became too heavy or melted in the spring, the



ice would fall down the shaft and damage the fans that provide ventilation in the tunnel.

WATERPROOFING ALTERNATIVES

Properly installed preformed sheet membranes, such as HDPE or PVC, are 100% impermeable, have good crack bridging and mechanical strength and exhibit low-temperature resistance.

However, at the point of connection, water can breach the membrane and flow along the lining until it finds the next faulty joint. When a membrane is breached, the pressurised water may flow along the tunnel liner until it emerges through a concrete joint or crack some distance away from the point of penetration. Even if the joint or crack is repaired, the pressurised water will then continue to flow along the concrete lining until reaching the next faulty area.

Much like preformed sheet membranes, sprayed membranes or liquid coatings such as EVA (ethylene vinyl acetate), epoxy or MMA (methyl methacrylate) are impermeable. They do not require anchoring, are less expensive and faster to install than sheet membranes, although they do require some surface preparation and curing time.

Bentonite systems contain an expansive clay material, which is manufactured into either a panel or bonded geotextile liner. Bentonite membranes and panels have self-healing capabilities. They do not require any special tools like a spray system but are



labour-intensive. The system needs to be constantly under compression, otherwise it could lift away from the concrete surface. After installation, repairs are impossible and replacement after failure requires excavation.

INTEGRAL WATERPROOFING

Crystalline waterproofing products – made of Portland cement, very fine treated silica sand and proprietary chemicals – react with the by-products of cement hydration such as calcium hydroxide – commonly called ‘freelime’ – and other mineral salts within the cement matrix to form mineral-based ‘dendritic crystalline structures’ that are insoluble in water.

The formation of the crystals in concrete pores, cracks and other voids is a gradual process, requiring several days to a couple of 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 blocks the flow of liquids, even under extreme hydrostatic pressure.

Engineers selected crystalline technology as the waterproofing system for the upgrade of the Queensway Interchange in Singapore because of its enduring catalytic reactivity that significantly reduces the need for future concrete maintenance.

In this case, Xypex Admix C-Series was used in the reinforced concrete walls in the construction of the depressed ►

“As the crystals grow across, they form a microscopic, mesh-like barrier that blocks the flow of liquids, even under extreme hydrostatic pressure”

The 15km Santo Domingo Metro Tunnel in the Dominican Republic has been waterproofed

Crews replaced a failed membrane with crystalline waterproofing to repair cracks and stop all leakage on the 50-year-old Nikko-Kensei Road Tunnel

carriageways. A brush-on application of Xypex Concentrate was applied to the diaphragm walls, while wall-to-wall construction joints were treated with the Xypex Concentrate Dry-Pac system.

Crystalline waterproofing was also selected for the \$30.7 million, 1,000ft Bremerton Tunnel, which connects downtown Bremerton, Washington, with the city's ferry terminal. With the surge in ferry traffic and growth of the city's downtown core, the cut-and-cover tunnel was built to increase safety and alleviate traffic congestion above ground.

Traditional waterproofing membrane systems were deemed unsuitable for this project since the tunnel was to be built on a high water table, and its entire length needed waterproofing. Considerable rebar work was needed on the floor, which raised the risk of damage to a membrane. In addition, the ceiling would be covered with a 10ft-deep backfill, rendering a



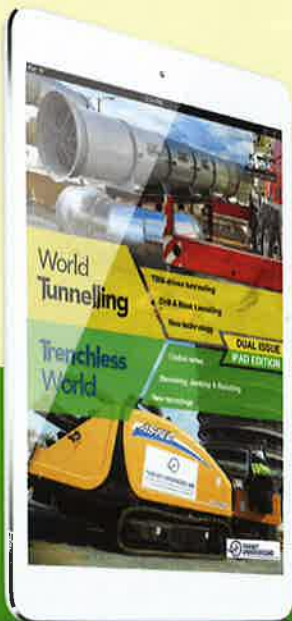
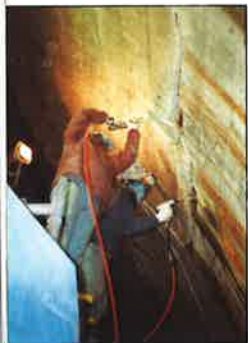
membrane impractical to repair.

The Japan Proton Accelerator Research Complex (J-PARC), a high-intensity proton accelerator, is a 3.5km circular tunnel encased in concrete up to 5m thick. Because of the sensitivity of this synchrotron and the radioactive processes involved, protecting it from outside moisture and chemical elements was vital. The site of the complex has a high water table and is adjacent to the ocean – presenting contamination challenges that could affect the accelerator's sensitive functions.

In two coats, 60t of Xypex Concentrate was spray-applied to the exterior walls and roof slab, covering a total area of 50,000m².

The 1.6km-long Domain Tunnel in Melbourne, Australia, comprises 460m of cut-and-cover tunnel at the west end, 680m of bored tunnel and 500m of cut-and-cover, which includes a shallow river crossing. Roadheaders were used to dig the bored section of tunnel, while at the eastern end the 170m final section of cut-and-cover was built under the Yarra River, using a cofferdam approach.

The tunnel carries three 3.5m-wide traffic lanes with 0.5m-wide shoulders and has two cross tunnels to the Domain Tunnel. The road level is up to 40m deep, and has a gradient of 2%. Xypex Admix C-1000NF was used to waterproof the concrete pavement and lining walls. Yarra Crossing Stage 2 of the same tunnel, which was cut-and-cover construction, used Xypex Concentrate and Xypex Modified coatings on the wall segments. Xypex DS1 Concentrate was used on the horizontal surfaces of the concrete pavement and roof segments.▼



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ELIMINATE WATER PENETRATION



Inadequate waterproofing, cracking and joint failure in tunnels subjected to hydrostatic pressure are major problems that result in leaking and concrete deterioration. Whether for new or rehabilitated tunnels, Xypex Crystalline Technology is a most effective and permanent solution. In all types of tunnel construction, Drill and Blast, NATM, TBM, Immersed Tube and Cut and Cover, Xypex has proven to cost effectively prevent water infiltration even under extreme hydrostatic pressure.

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