

# CONCRETE ENGINEERING

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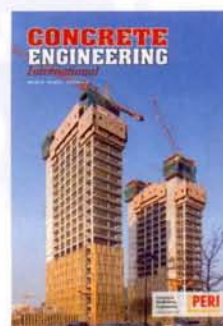
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Extension work at the European Court of Justice in Luxembourg is adding another 50,000m<sup>2</sup> of office space. PERI engineers developed a comprehensive customised formwork solution taking into account the high safety requirements along with the exact needs of the contractor. See page 12.

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# Crystalline waterproofing at hydro-electric power plant

**Work to repair 2km of the main concrete tunnel at a hydropower plant in Italy centred on crystalline waterproofing. The system provides a permanent seal against water ingress and chemical attack and becomes an integral part of the concrete.**

*Florian Klouda, ICS/Penetron International Ltd, East Setauket, USA*

**E**NEL is Italy's largest power and second-largest gas company, supplying electricity to more than 32 million customers in Europe, North and Latin America, with a generating capacity of 53,000MW. The company operates 46 thermal plants, 500 hydro facilities, 32 geothermal plants, 17 windfarms and four photovoltaic plants, with more than 1 million km of power lines in Italy and overseas.

ENEL's hydro-electric power station in Andonno (Cuneo), Italy is one of the com-

pany's most important power generation plants in the country. Some 2km of the plant's main concrete tunnel have recently been restored to guarantee its usability and to protect the structure, which has a total length of 11km between the canal bridges of Bousset and Raschia.

The repair and waterproofing works became necessary after cracks and water leakage had been discovered in the tunnel. Concrete is a porous material, as evaporating excess water in the hardening stage leaves behind a web of pores, capillaries and micro-cracks through which water can later enter the structure. Cracking can occur at all stages of its lifetime and have a number of causes including design, material and construction defects, damage to the structure due to overload, chemical spill, and fire but also – and in many cases – from deterioration of the structure due to freeze/thaw cycles, metal corrosion, chemical attacks and erosion. The latter

mainly occurs due to ingress of water into the pores and capillaries of the concrete that results in the corrosion of the steel reinforcement or in freeze/thaw cycles, which significantly weaken the structure.

## Waterproofing solution

On the project site in Andonno, high hydrostatic pressure had pushed water into the pores and capillaries of the concrete, resulting in the observed leakage. Finally, the solution to repairing the tunnel was found in a crystalline waterproofing system.

Crystalline waterproofing products can be applied to new and existing concrete structures either by brush/spray application (onto existing concrete), dry-shake (to freshly laid horizontal concrete slabs) or as an admixture at the time of batching (to new concrete). Therefore, the concrete surface needs to be clean, damp and to have an 'open-capillary system'.

When crystalline waterproofing products are applied to concrete, a chemical reaction causes these pores, capillaries and micro-cracks to be filled with insoluble crystals. Water is unable to pass through these crystal formations and as a result the concrete becomes waterproof.

Photos: ICS/Penetron International Ltd



*Figure 1: Tunnel surface after the cleaning operation and before the treatment.*



*Figure 2: Mixed powder of crystalline product ready to apply in the spray machine tank.*



*Figure 3: Spray-application of the slurry.*

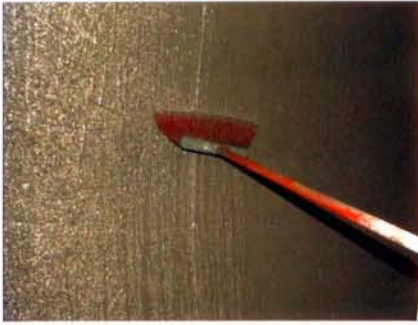


Figure 4 above: Brush distribution of excess material between the two coats.

Figure 5 right: Repaired horizontal cracks.



### Complex chemical reaction

The ability of crystalline waterproofing products to penetrate deep into the concrete structure, even when applied from the negative side (opposite the water pressure) and against high hydrostatic pressure, is the result of a complex chemical reaction involving osmosis, dry particle reactions and Brownian movement. Once inside the concrete the products' components react with water, calcium hydroxide and aluminium as well as various other metal oxides and salts

contained in the concrete moving through the capillaries. The crystalline formation that ensues as a result of this reaction prevents water from moving through but still allows air to pass, thus avoiding the build-up of vapour pressure inside the concrete. If new cracks appear throughout the life of the concrete, the crystals will form in these cracks as well, preventing water from finding new ways to penetrate. When there is no water inside the crack, the crystals lie dormant, but as soon as water reappears, the crystalline growth is resumed and resealing and permanent protection of the structure is achieved.

In order to waterproof the main tunnel of the Andonno hydro-electric power plant, all active leakage was stopped using resins before the crystalline waterproofing material was applied. All cracks larger than 0.4mm were cut out and chiselled back to a size of 30 x 30mm and were repaired with a crystalline-based mortar. Subsequently, the entire levelled concrete surface of the tunnel section to be repaired (24,000m<sup>2</sup>) was water-blasted under high pressure to open up the capillary system of the concrete and an additional two coats of crystalline waterproofing were spray-applied at a rate of 0.8kg/m<sup>2</sup> for each coat.

The installation of an integral capillary concrete waterproofing system offered several benefits to ENEL and the operation of the power plant, as it addressed the prob-

lems and further offered a long-term protection of the treated areas. With the cracks sealed by insoluble crystals the tunnel is now permanently sealed against water ingress and chemical attacks. The system was applied from the negative side (opposite the water pressure) and became an integral part of the concrete, which protects the tunnel against the high-hydrostatic pressure on this project site.

The fact that crystalline waterproofing systems constantly reactivate as soon as water in new cracks is present and thus self-heal cracks of up to 0.4mm, significantly lowers ENEL's future maintenance costs. The system helps to maintain the alkaline environment that is necessary to prevent steel reinforcement corrosion and thus the structure is further strengthened.

### Conclusion

Crystalline waterproofing systems are non-toxic and therefore are not detrimental to the water used in the plant. Similar projects around the world and in different climatic zones have already been successfully treated with crystalline waterproofing systems, offering total concrete protection to end users and infrastructure projects. Furthermore, this system offers an effective, economical alternative to traditional waterproofing methods such as membranes and cementitious coatings. ■



Figure 6: Repaired tunnel construction joints.



Figure 7: Crystalline waterproofed surface after one week of curing.



Figure 8: Treated tunnel wall after one week of curing.