Waterproofing the Montsouris Reservoir: Using Hydraulic Binders and Nonwoven Geotextiles to End Leaks

The drinking water reservoir of Montsouris (France), built in 1874, is one of oldest among the thirteen that supply Paris with water. Located on the southern edge of the city, it has a capacity of 7.2 million cubic feet of water with a semi-buried structure consisting of basins two across and two high that each have a total surface area of 182,000 square feet. The general foundation is built on stone-lined shafts forming the base for supports connected by stone arches, while the boundary consists of a sturdy wall 6.6 to 13 feet thick in a general U-shaped parallelepiped layout. The thin cover that encloses the basin can expand freely in the horizontal plane without generating stresses on the peripheral wall. This cover is supported solely by lines of interior posts spaced at thirteen to twenty foot intervals.

While these were the construction methods of the time, they are the cause of leakage problems that have plagued the reservoir since it entered service. As explained by Francis Maquennehan, one of the engineers at the French construction and public works firm Sagep, "the watertightness of the structure, achieved by burrstone brickwork, is ensured by the application of cement-enriched mortar about 4″ thick."

Short-Lived Facelifts

More than a century ago the reservoir cracked naturally when it was filled with water, under the fluctuations in load arising from daily use and under the strain of thermal shocks. "We have recorded temperatures varying from 32° to more than 68° F in the space of a single day," Maquennehan said.

Waterproofing carried out on the reservoir dates over many years as testified by the many sinkages filled with liquid coal-tar pitch or cement grout seen over the entire structure. Regular repairs over time demonstrated the unsuitability of these old repair techniques with leaks reappearing systematically several years after the treatment of cracks. This is a problem more modern techniques have not been able to stop. According to a recent report, "the diagnosis made at Montsouris on one of the upper basins at the beginning of the 1990s revealed a 13,120′ line of cracks, with a daily leakage rate estimated at 16,000 gallons."

"We have a very specific porous support that absorbs part of the repair products used, during polymerization," Maquennehan said. "This partial migration results in a modification to the composition of the mixture and, therefore, some physico-chemical characteristics of the final impermeable lining." This analysis explains in part the failure of various more recent solutions implemented over several years. Trials performed on the cement mortar waterproof layer of other reservoirs in Paris located in the Ménilmontant and Montmartre districts with polyurethane type products ended in failure with the rapid appearance of blistering. According to a engineer's report, "the phenomenon then continued with a general detachment of the lining in sections covering dozens of square feet in area."

After scouring the support to uncover a sound structural surface, a primer is applied that mineralizes the capillaries and microfissures, thus regaining cohesion in depth. ▲

Three layers of waterproofing product are sprayed on, the second layer being reinforced with a nonwoven geotextile. ▼

A Flexible Elastic Hydraulic Binder

Similar experiments carried out at Montsouris with epoxy resins also were shown to be ineffective, and this in spite of the care and precautions taken during their application. All of these products essentially were delicate, since they had been applied on dry supports at humidities of less than 85 percent and ambient temperatures greater than 50° F, a range of conditions that are practically impossible to achieve.

This led to the idea of changing to a new type of material that combines the advantages of elastic impermeable products while preserving the characteristics of hydraulic binders in order to enable them to be used in damp and cold environments and on porous supports. A program of research required a large amount of laboratory work and a battery of field tests. "This was because it was necessary to study and understand the mechanism of the reaction between the product and the support during application in order to be able to slightly modify its composition to adapt it to conditions of the site," Maquennehan said.

This resulted in System K, developed and manufactured by the French manufacturer Kristo, located in the Haute-Savoie region of southern France, which was then used on the reservoir. The work area related to the second upper basin covers 315,000 square feet of waterproofing that needed restoring, while the whole of the work was finished at the end of 2000.

In practice, the treatment consists of applying, after scouring the support to uncover a sound and solid structural surface, a primer based on the principle of silicic mineralization of concrete. "This strengthens and reinforces the substrate by means of crystallizing elements that mineralize the capillaries and microfissures, thus regaining cohesion in depth," said Jean Pierre Bron, general manager of Kristo.

Three layers of waterproofing product then are sprayed on. These consist of an impermeable compound based on hydraulic binders and resins in dispersion, the second layer being reinforced with a non-woven geotextile.

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