Rehabilitation and reconstruction of large water reservoirs in the Grand-Duchy of Luxembourg.

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Summary
The „Syndicat des Eaux du Sud“, located near Koerich in the southern part of the country and created in 1908 has for mission the drinking water distribution to its member towns (15 millions m^3 / year). Besides the catchments and sources, pumping stations and 220 km of pipes, the water reservoirs, located at "Rebierg", constitute the essential elements of the infrastructure of the S.E.S. drinking water distribution system.
This presentation describes the history of the construction of the first tanks in 1908, the recent construction of a new reservoir as well as the rehabilitation of a reservoir built in the mid-sixties. The construction techniques and the used materials as well as local treatments of water(disinfection) to guarantee an optimal hygiene of the water in the network up to the final consumers are exposed.
The current total capacity of the reservoirs is 32,000 m^3.

Résumé
Le Syndicat des Eaux du Sud, situé près de Koerich dans le sud du pays et créé en 1908, a comme mission la distribution d’eau potable à ses communes-membres (15 Mio m^3/an). A côté des captages-sources, stations de pompage et 220 km de conduites, les réservoirs d’eau situées au “Rebierg” constituent les éléments essentiels de l’infrastructure d’approvisionnement en eau potable.
Cette présentation décrit l’historique de la construction du premier réservoir en 1908, la construction récente d’un nouveau réservoir ainsi que la réhabilitation du réservoir construit en 1965. Les techniques de construction, les matériaux utilisés ainsi que le traitement local des eaux (désinfection, déférisation) afin de garantir une hygiène optimale de l’eau dans le réseau jusqu’au consommateur final sont exposés.
La capacité totale actuelle des réservoirs est de 32.000 m^3.

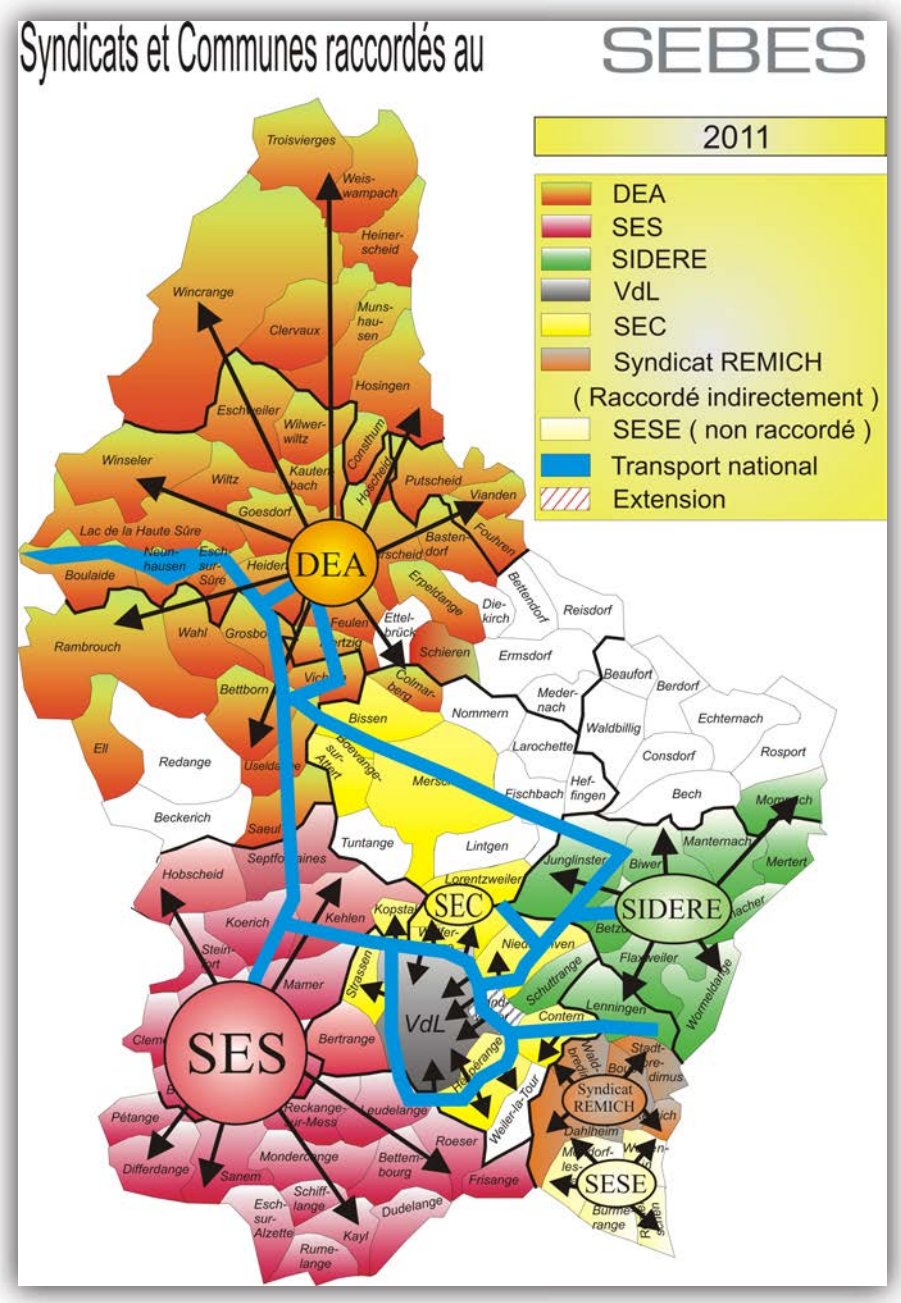
Zusammenfassung
Das “Syndicat des Eaux du Sud”, in der Nähe von Koerich im Süden des Landes und gegründet im Jahr 1908, hat zum Ziel die Verteilung von Trinkwasser an seine Mitgliedsgemeinden (15 Mio. m^3 / Jahr). Neben den Trinkwasserquellen, Pumpstationen und 220 km Rohrleitungen, sind die grossen Wasserbehälter, die sich

auf “Reberg” befinden, das Herzstück der Infrastruktur zur Verteilung von Trinkwasser.
Diese Präsentation beschreibt die Entwicklung vom Bau des ersten Behälters in 1908, über die Inbetriebnahme eines neuen Behälters im Jahr 2006 bis zur kürzlich abgeschlossenen Sanierung eines Behälters aus den 60er Jahren.
Die Bautechniken, Materialien sowie lokale Behandlung des Wassers (Desinfektion, Enteisenung), um eine optimale Wasserhygiene im Netzwerk bis zum Endverbraucher zu gewährleisten, werden beschrieben.
Die aktuelle Gesamtkapazität der Behälter beträgt 32.000 m^3

The "Rebierg" water reservoir in 2014

Introduction

In Luxembourg, the drinking water consumption has averaged around 120,000 m3 per day. This amount is provided for two-thirds by groundwater and one third by the treatment of surface water.Groundwater is captured by about 300 springs and wells fed mainly by water from the sandstone aquifers of Luxembourg. Drinking water from surface water is produced at the dam of Esch-s-Sûre located in the north of the country.
The water collected and treated, is distributed through reservoirs and pumping stations to the final consumers. The number of distribution facilities is estimated at 500.



The distribution network for drinking water in the G-D of Luxembourg

The 'Syndicat des Eaux du Sud (SES)'

On 8 June 1908, the municipalities in the south of Luxembourg decided to join forces as an inter-municipal syndicate, which was to supply drinking water to the affiliated municipalities. The task of the SES was, and still is, to provide its affiliated municipalities and industries with clean drinking water.
Sixty-five spring catchments in all, which draw their water from the Luxembourg Sandstone geological formation, supply spring water to the two pumping stations in Koerich and Dondelingen, from where it is pumped to the main reservoir on the "Rebierg", the highest point in the area supplied by the SES.
The SES is supplying around 40% of the population of Luxembourg with drinking water. The 22 municipalities that get their drinking water from the SES need about 15,000,000 m^3 of water a year, 20% of this water going to industry. The daily delivery varies from 35.000 to 55.000 m3/day. The SES water distribution network has a length of 220 km in total.

Catchment area and pipe network

History

When conceiving the SES network in the beginning of the 20's century, it was planned to build the main reservoir at one of the highest points in the southern part of Luxembourg, at "Rebierg" near the village of Hivange. This site is situated 8 km from the main pumping station in Koerich (where 2/3 of the spring catchments are collected) and 12 km from the second pumping station in Dondelange, which started operation in 1930 only. The Rebierg site is situated at an altitude of 400 meters (AMSL), 140 meters above the location of the SES in Koerich.
The first reservoir with a capacity of 1000 m3 was commissioned in 1911. In 1927 a second reservoir with a volume of 3000 m3 started operation.
The third reservoir, which is still in operation today, has a volume of 15.000 m3 and was connected in 1966.
In 1969 started feeding by surface water, provided by the damn and treatment facilities in the northern part of the country, near Esch-s-Sûre.
Important works started again at the "Rebierg" site in 1997, with the demolition of the ancient tanks from 1911 and 1927, and the construction of a new ground reservoir with a capacity of 15.000 m3 and a water tower of 2000 m3 (altitude: 424 m).
These basins are in operation since end of 2006.
In 2007 started rehabilitation works of the basin build in the 1930's. These have been concluded in 2014
Other works include the disinfection with chlorbioxyde and the drilling of 2 deep wells (depth: 290 m) in order to guarantee water delivery during summer peaks. These wells with a capacity of 3600 m3/ d are in operation since 2007.

The first water tower at the "Rebierg" site

Construction and rehabilitation of the "new" reservoir (1997 - 2007)

Why rehabilitate a new reservoir? Mainly because theory or planning by engineers does not always meet reality on site.
The shape of the new reservoir, especially of the water tower, was very ambitious, in order to get the best integration in the natural surrounding. Insufficient on-site work planning by the contractor as well as bad weather conditions (heavy rainfall during concrete installation) lead to a very poor concrete quality of the outer walls of the reservoir. Also the formwork was not able to resist to the pressure of the concrete and resulted in an irregular surface.

Rebierg reservoir construction

The first proposition was to demolish the whole structure and start reconstruction! Instead of this it was decided to improve the surfaces by covering them with shotcrete. Nonetheless he first test filling showed numerous leaks that could not be accepted.
Even after injection of the numerous cracks many leaks remained, and, after a second injection of the remaining cracks, it was decided to cover the whole interior walls of the reservoirs with an impermeable membrane.
The product that was applied was a flexible waterproof and waterproofing system made of hydraulic binders and synthetic resins in dispersion. It is prepared as a paste by mixing two components, the powder which is a complex mixture of cements, aggregates and additives, and a synthetic resin in water dispersion. Once applied it is supposed to make a perfectly flexible adhesive waterproof coating to the surface.

Unfortunately soon numerous blisters appeared, especially on the soil of the reservoir. On the affected surfaces the membrane was removed by sandblasting, and replaced by another cement membrane including a synthetic resin. Unfortunately another, much more severe problem appeared, just days before the tanks should be filled with water and go at last into operation. In fact the membranes had started developing mycoses ("Aspergillus"), especially on the bottom of the walls. A new expert concluded that this was due to insufficient mixture of the membrane material before application.

Mycoses on the internal coating

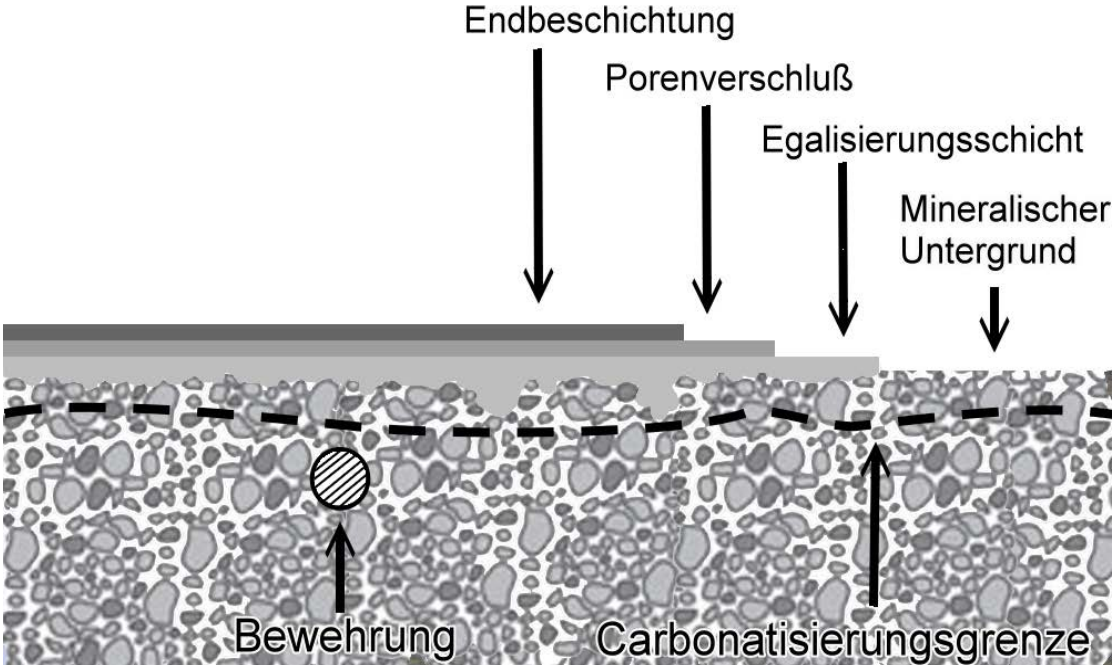
This then lead to parts with elevated organic materials, that could not be embedded into the hydraulic matrix, resulting in the formation of mycoses.
In order not to endanger the health of consumers the whole of the recently applied coating had to be removed again with dry sand blasting. Removal by sand blasting is preferred versus hydraulic demolition as it results in a smoother concrete surface, thus reducing the quantity of materials to be applied afterwards. Also we avoided in this way introducing additional mycoses into the walls and problems with treating the contaminated water.

Following the negative experiences with cement linings, the question of alternatives had to be raised. Epoxy resin coatings came into focus, one reason being the protection of the concrete against the potentially aggressive water resulting from the mixture of waters from different origins (ground- and surface waters).
Epoxy resin systems are high quality materials that are used for various applications. In drinking water supply, epoxy resins are used for their smooth, non porous and easy to clean surfaces combined with a high level of protection against various

substrates.
Presupposition for the usability in drinking water is the toxicological hygienic and technical suitability. The toxicological requirements are described in Germany by the "Guideline Coating" of the UBA. For the microbiological safety of the coating systems, a test in accordance with DVGW W 270 is required.
As conventional solvents are rarely used, problems arising from solvent retention are eliminated. The resulting higher viscosity of the coatings requires application by hot spraying or the use of heaters. By a double manual application the concrete and sandblasted surface is leveled and pores are closed before the top coat is applied by hot spraying. The resulting surface is smooth, non-porous and chemically inert, so that the cleaning costs are minimal and no substances can penetrate. Also the thin layers of the epoxy resin coatings avoid important additional static loads. The principle is the hermetic seal of the substrate, so that the concrete is beyond the influence of water and other substances.

Removal of waterproof membrane by sandblasting

The works should be executed by companies which are well acquainted with the materials and the special requirements of processing in drinking water systems and also have sufficient experience. In Germany, these systems have recently been integrated in the DVGW rules within worksheets W 300 (Drinking water reservoirs) and W 316 (Qualification requirements for specialized companies for the design, construction, repair and improvement of drinking water reservoirs).
While epoxy coatings will lead to higher energy costs for heating and drying, they will reduce the amount of waste compared to shotcrete membranes.
As the application of the new epoxy coating could be completed successfully, the reservoir was put into service in 2007, nearly ten years after the start of the works.



Basic structure of the epoxy coating system

Water flow in the new (left) and old (right) reservoirs

Rehabilitation of the "old" reservoir

As this reservoir was in operation since 1966, first plans proposed demolition and reconstruction. Finally it was decided to proceed to rehabilitation of the existing building. First the exterior bituminous sealing had to be replaced, as it presented numerous leaks. At the same time the aeration tubes over the water surface were removed and a central aeration and filtration unit was installed

Also some internal structural modifications had to be accomplished. Thus the two tanks of the old reservoir were connected by canals, so that water flow coming in would be separated equally between the new and the old reservoir.

The cement cover of the interior walls had lost strength, and it was decided to remove it by sand blasting and replace it with the same epoxy coating that was used in the new reservoir. Rehabilitation works had been finished in 2014.

Conclusions

New construction as well as rehabilitation of existing water reservoirs may offer unpleasant surprises due to insufficient planning and inadequate use of materials. Especially internal waterproof membranes can be very tricky and the installation of the right products is primordial. Special care should also be given to later maintenance, like easy cleaning, as well as to optimum hygienic conditions. Water reservoirs are important investments and the heart of every water distribution system.