LEAKAGE DETECTION BY TEMPERATURE MEASUREMENTS

Slurry trenches / Trough excavation pits / Jet Grouting • In most cases, performing construction work below ground water level requires a dry excavation. For economic, structural and ecological reasons, it is usually necessary to isolate the pit hydraulically from it's surroundings. Therefore in most cases, the excavation is sealed artificially. The sealing system typically consists of vertical elements (walls), and in the absence of an impermeable embedment layer, a horizontal element as well. As the requirements for the sealing of excavations become more stringent, the importance of leakage detection work to allow quick remediation becomes ever more significant.

The vertical and horizontal sealing elements of deep excavations are typically formed from cement-based materials. During the curing of the cement, the release of heat from hydration leads to an increase in ground temperatures in the areas surrounding the sealing elements. A combination of low heat transport and high heat capacity in both the ground and building materials causes a low decay of the increased temperatures. However, if water flows from the ground into the excavation via a leak during dewatering, this will change the temperature profile in the ground around the affected area. The ground temperature therefore adjusts to the temperature of the inflowing water due to the advective heat transport of the flowing water. The cooled area extends to the area affected by leakage, and after some time to the close surroundings as well, though conductive heat transport. Temperature measurements in sealed excavation pits therefore enable the location of leaks in the sealing system.

At the completion of dewatering, no significant circulation occurs within the pit. The advective heat transport, linked to the leakage, will have stopped. From this point on, further temperature changes are only caused by heat conduction. The temperature front propagates in saturated and unsaturated materials at a velocity of approximately 10^{-6} to 10^{-7} m/s, equivalent to a few centimetres to a decimetre per day. Therefore, temperature anomalies in the ground will only fade very slowly, allowing the temperature profile in the vicinity of a leak to show clearly for a considerable time after dewatering (known as a memory effect). Leaks can therefore be detected even following dewatering of an excavation pit, although if the detection method is used during the initial stages of drawdown the measuring grid can be narrowed down in the vicinity of a leak, allowing a more accurate location to be made.

Leakage detection in a trough excavation pit in Berlin

GTC have developed a method (Patent No. DE 41 27 646) for making reliable and cost-effective ground temperature measurements, which allows in-situ measurements to be made to around 30m depth. To insert the temperature sensors, a hollow pipe with a nominal external diameter of 22mm is driven into the ground to the required depth. After driving, a sensor chain comprising several temperature sensors at 1m intervals is inserted in the pipe and ground temperatures are measured over a range of depths. The data obtained are used to compile temperature-depth profiles, as well as horizontal and vertical isothermal sections for the excavation pit. The measurements allow a distinction to be made between leaks in the vertical walls, and in the horizontal sealing elements if present.

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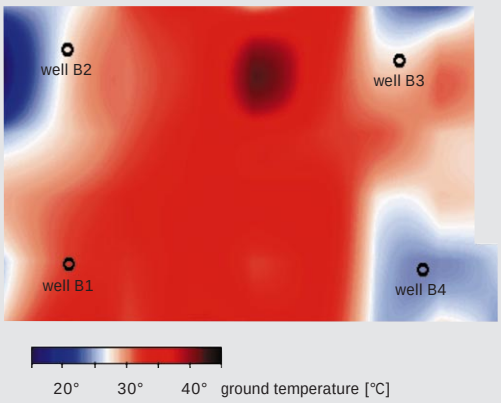
The temperature sounding method is applied successfully since 1991 for the localisation of leaks in ship canals and water retaining structures for hydro power. Worldwide more than 500 km of dams have been inspected so far. Since 1997 this method has been used in more than 100 impermeable excavation pits for leakage detection. These excavation pits were sealed by various elements. As horizontal waterproofing following elements were used: jet grouting, micro cement and gel injections. The vertical enclosures consisted of slurry trenches, bore pile walls and sheet pils. Based on the temperature measurements leaks could be detected exactly and pin pointed remedial work could be enabled.

The figure below shows exemplary the results of a thermal leakage detection in an excavation pit sealed with jet grouting and sheet piles. The horizontal isothermal section shows clearly that cold water is flowing into the pit in the area between the well B2 and the wall. Additional leaks are located in the surroundings of the wells B3 and B4. The cooling at these wells is less pronounced as the cooling at B2, meaning that the seepage flow at B3 and B4 is lower than the one at B2.

At excavation pits, where the vertical enclosure does not consist of cement based materials no temperature increase is developing compared with the surrounding ground material, since the respective hydration processes are missing. Therefore, the temperature sounding method can be applied only restricted. This kind of tasks are best solved with the help of the heat-pulse- as well as the frost-pulse-method. At both methods artificially caused temperature anomalies are used to detect seepage flows in the ground and thus, leaks can be detected as well.



The expansion in time and space of injection suspensions can be monitored as well with the help of the temperature sounding method. The temperature of the injection material serves as thermal tracer for the to be detected flow. The procedure has already been used successfully within the scope of a quality monitoring system for propagation surveys of gel and micro cement injections.

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