Seepage detection in dams

A fibre-optic sensing based automated seepage monitoring and evaluating system has been developed by HydroResearch in Sweden to help ensure dam safety, utilising instrumentation developed by Silixa

Above: **The Höljes Dam monitoring project was carried out for Fortum by HydroResearch utilising Silixa's ULTIMA DTS**

Below: **Installation work at Höljes dam**

TEMPERATURE MEASUREMENTS HAVE BEEN found to be one of the most sensitive methods to detect internal erosion due to their ability to monitor seepage flow. Utilising distributed measurements gives a heightened level of sensitivity and an unprecedented level of spatial coverage along dams and dykes.

Seepage detection based on distributed temperature sensing uses the natural seasonal temperature variations that occur in the reservoir to monitor and quantify the seepage flow. The temperature difference between the reservoir and downstream side of the dam indicates areas of increased seepage.

XSeepT™, a fibre-optic sensing based automated seepage monitoring and evaluating system, developed by Hydroresearch in Sweden, represents a clear break-through in dam safety, says the company. Utilising the highest quality instrumentation, ULTIMA™ DTS, developed by Silixa Ltd., XSeepT delivers previously unobtainable insights into dam condition by detecting even the smallest seepage changes within a dam.

Fibre optic cable installations have increased significantly since 1998. To date, almost 100 hydro power and tailings dams have been instrumented with fibre optic cables in Sweden alone.

The objective of fibre optic sensing-based dam seepage monitoring is to provide complementary information to conventional seepage measurements by identifying the abnormal seepage locations. The detailed information, given every meter all along a dam, has been found to be especially useful on extended dams such as long tailings dams.

There are numerous Installation possibilities when new dams are constructed, allowing the cable to be installed at critical locations. There is substantial potential for this technology to be applied more widely.

Left: **Cable installation at the dam**

Below: **A typical example of seepage flow analysis**

Case study: Höljes embankment dam, Sweden

A distributed temperature based seepage monitoring system needed to be installed in an earth filled embankment dam at Höljes, Sweden. As this is an older dam improved monitoring was required to bring it up to today's standards but due to the condition of the dam foundations and high downstream water level, installation of a traditional leak detection system was not possible.

HydroResearch proposed to the dam owner, Fortum, that high accuracy temperature measurements be made using Silixa's ULTIMA-DTS to interrogate optical fibre cable installed in standpipes in the downstream part of the dam. Four standpipes were installed on the two upper terraces of the dam and eleven along the dam toe. All standpipes were drilled through the downstream fill, the permeable soil layers in the old river bed and approximately 1m into the bedrock. Measurements were made with a fine spatial sampling (0.12m) allowing abnormal water flow to be observed with high resolution in the vertical direction. Using such a technique generates large data sets and to enable effective data collection, HydroResearch's proprietary web based software (XSeepT™) was deployed.

It was established early on that the level of water flow through the dam is low. The seasonal variations were in line with those expected but that significant differences of temperature existed throughout the standpipes indicating differences in water flow. Data continues to be collected.

Discussion

The Höljes project builds on work carried out by HydroResearch at Bergeforsen, Sweden, where measurements have been made since 2005. Additionally fibre optic cables have in recent years been installed in standpipes in the Mica and WAC Bennet dams in Canada, also in cooperation with HydroResearch.

Such detailed insights into dam condition are only made possible by utilising the highest quality instrumentation to provide the precise temperature measurements necessary to detect small changes within the dam. Silixa's range of DTS products, ULTIMA DTS and XT-DTS, have been designed to enable the early detection of any increase in flow.

A typical example of seepage flow analysis is shown on the graph below, with seepage flow rates passing through the dam analysed in space and time. The temperature is measured with the fibre optic cable installed along the dam.

The upper graph can plot either seepage flow or temperature on the Y axis and measured length or section on the X axis. The user can choose one of the predefined seepage zones and select start and stop date. Each coloured curve represents a specific measurement, sorted by time. The five dates are evenly spread between the selected start and stop date. ●

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