Seepage and Movement Monitoring in Dams Using Fiber Optics

HydroResearch

sensornet

HydroResearch

Sentinel DTS - The Most Advanced DTS System Available Today

Sensornet has developed the Sentinel DTS range of systems which have the most advanced performance and are the most reliable distributed temperature sensing systems available on the market today. The Sentinel DTS system is available in different models covering a range up to 30km long with a single channel. Combined with a temperature resolution of 0.01ºC at every meter interval, the Sentinel DTS offers a very effective tool for seepage monitoring along dams and dykes.

Sensor Fibre and Cable

In the Sensornet distributed detection system, the fibre is the sensor. Sensornet has developed rigorous quality assurance systems to verify the effectiveness of the fibres that are packaged into detector cables. Special cables for dam applications have been tested in research projects carried out together with HydroResearch.

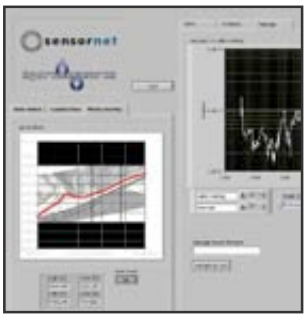
Distributed Strain Sensing Systems

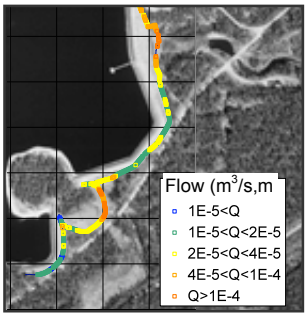
Sensornet has developed a unique capability to measure both temperature and strain along a fibre. The Distributed Strain Sensor can be used with specially designed strain measuring optical fibre cable for movement and subsidence monitoring along dams and dykes. The system has a range of up to 24km with 1^{o}C and 20μm and it is currently offered as a service.

Services and Software

These products are a result of more than 10 years of research and several pilot installations. Our products are all designed, developed and tested for the use in dams. Based on our experience of our products and their application in dam monitoring we offer unique and qualified services including:

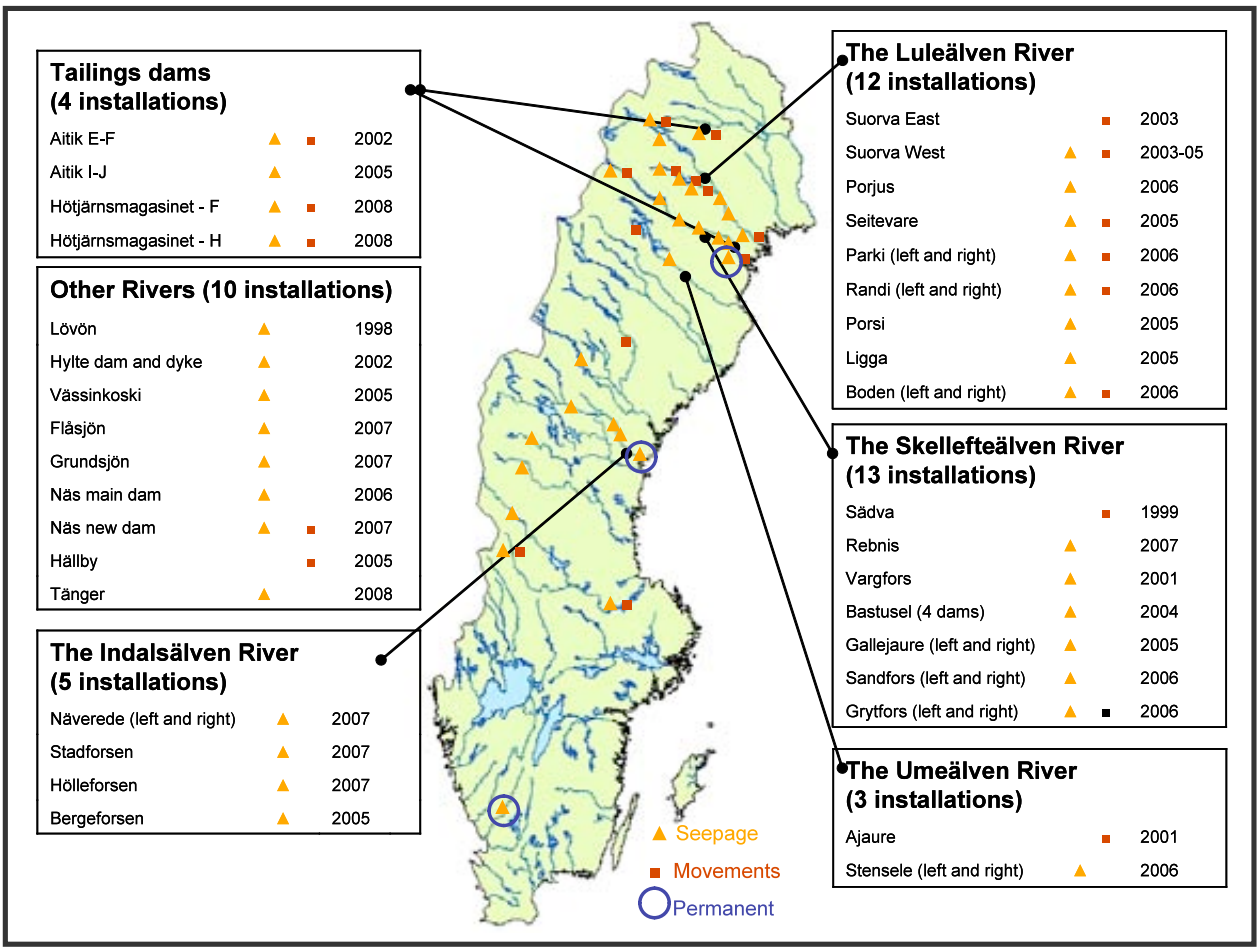
- Design of cable layout (based on pre-calculations and sensitivity analyses), and instructions for the installation of the cable;
- Final installations and system set-up for single measurements or monitoring;
- Evaluation of data;
- Software for evaluation and data visualisation;
- Site dependent software for automatic monitoring/evaluation and alarm settings, and
- Training and technology transfer.



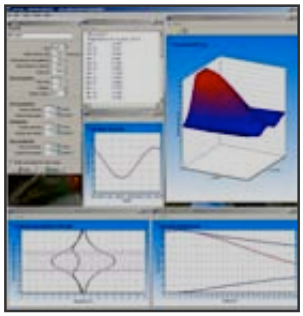


Installations in Sweden

To date, HydroResearch and Sensornet have been involved at installations for monitoring of seepage and/or movements in almost 50 dams, dykes and tailing dams at 31 different dam sites in Sweden for all the major hydro power companies. Different installation techniques have been developed depending on the dam's monitoring requirements. These include embedding of the fibre inside the dam (at new constructions), in the crest during raising of a dam, within new toe berms at upgrading work, just downstream of the dam toe, or vertically in standpipes. This technology is being recognised as the most effective way to detect seepage flow changes with high sensitivity along the entire dam. Permanent monitoring system are installed at Bergeforsen, Hylte and Hötjärnsmagasinet.



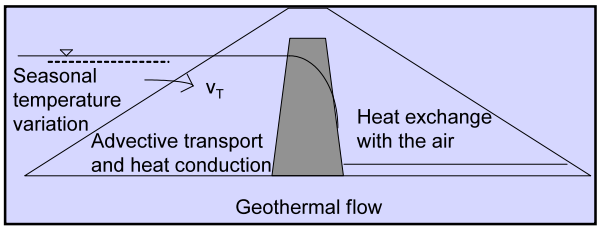


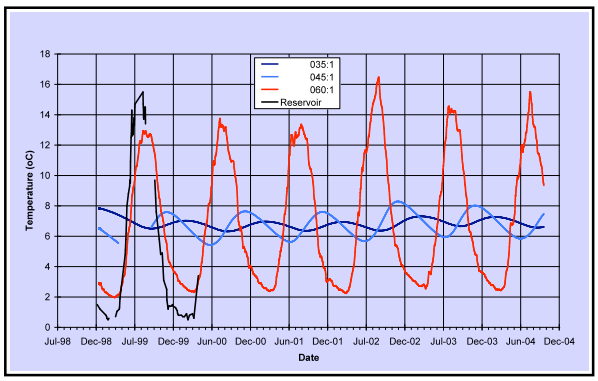



Seepage Monitoring and Internal Erosion Detection Using Temperature

Temperature measurements for seepage monitoring is gaining rapid acceptance in order to investigate the seepage flow in embankment dams. This method has been used successfully especially in Sweden, where HydroResearch has introduced and improved the required method including the evaluation procedure. Temperature measurements have successfully been used in more than 30 Swedish dams since 1987, both for limited monitoring/investigations and for long-term monitoring. The method is now recommended in the Swedish Guidelines for dam monitoring. One of the key tools for the measurement of temperature is the introduction of fibre optic distributed temperature measurements that started in 1998.

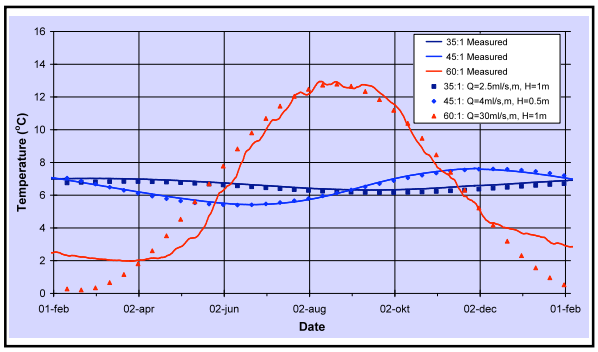
The seepage monitoring method uses the natural seasonal temperature variations that occur in all surface water (such as lakes, reservoirs and rivers). The seepage flow causes a seasonal temperature variation inside the dam. This seasonal temperature variation can be measured in the dam and used to evaluate the seepage flow through the dam. Temperature measurements can detect seepage flow changes, i.e. internal erosion.



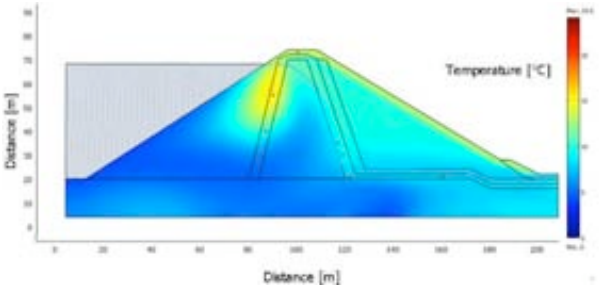


The fundamentals for the methods are:

- Seasonal temperature variation in the water creates seasonal temperature variation inside the dam.
- Larger seasonal temperature variations and shorter time lag between the temperature in the water and inside the dam indicate higher seepage.
- Increasing seepage causes increased annual temperature variation, and shorter time lag between the temperature in the water and inside the dam



Generally, a constant temperature will be a sign of a small seepage, while large seasonal variations may be sign of significant seepage. At increasing seepage flows the temperature in the dam will be changed, and the seasonal variation will increase. This variation is dependent on seepage flow, the seasonal variation at the inflow boundary, and the distance from the boundary to the measuring point.



Evaluation can made by FEM simulations of the temperature field, or by using DamTemp software, which often provides a more efficient way of seepage evaluation, appropriate for most dam applications.