DamPulse™

Integrated Distributed Sensing-Based Tailings Dam Monitoring Solution

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Solution overview

DamPulse - Tailings Dam Monitoring Solution

DamPulse™, the integrated fibre optic sensing-based tailings dam monitoring solution addresses issues of dam stability, public safety, and environmental protection.

Delivering ULTRA HD quality distributed temperature, strain, and acoustic measurements in real-time, the system offers early alerts of potential problems, minimizing the risk of dam failures.

Distributed fibre optic monitoring offers dense spatial and temporal profiling over large sub-surface volumes, long lengths, and at locations where conventional point sensing is not applicable or cost effective. The fibre optic cable, which is the sensing element, requires no power. A single cable can deliver temperature, strain, and acoustic data with a sub meter resolution along several kilometers.

Applications

- » Seepage detection
- » Condition monitoring
- » Seismic event detection
- » Slope deformation
- » Dam breach detection

DamPulse – Tailings Dam Monitoring Solution

Key benefits

Continuous, distributed sensing-based monitoring reveals even the smallest potential problems

Continuous, high-precision data acquisition allows trends to be identified, analysed over time and defects related to the performance captured at an early stage.

Immediate insight into the structural health of the asset

Distributed fibre-optic sensing is a key technology that can be applied to monitor critical parameters for dam safety and environmental performance. Performance criteria can be selected for actionable alerts.

Continuous monitoring and/or imaging on demand

Continuous monitoring provides alarms of anomalous changes in the subsurface by combining temperature, strain and acoustic interpretations of the data. DAS data provides tomographic images to highlight physical variations in the dam.

Early-warning alerts

Continuous and real-time processing of seepage flow, identification of stress locations and seismic activity enable a quick response, potentially saving lives.

The system also provides invaluable environmental benefits as it minimises the risk of catastrophes and tailings dam failures.

By providing early alerts, DamPulse delivers financial benefits, avoiding high expenditure on remedial works.

Fully automated, remote monitoring

The system enables dams to be run with optimal efficiency and unmanned operation. There is no requirement on the operator to provide additional data.

Surveillance of monitoring performance and quality check of cable

The system provides automatic warning of a cable break. The diagnostics allow the signal quality to be checked on demand.

Minimal maintenance

There are no maintenance costs associated with the fibre optic cable.

Small environmental footprint

The system has a low-power requirement.

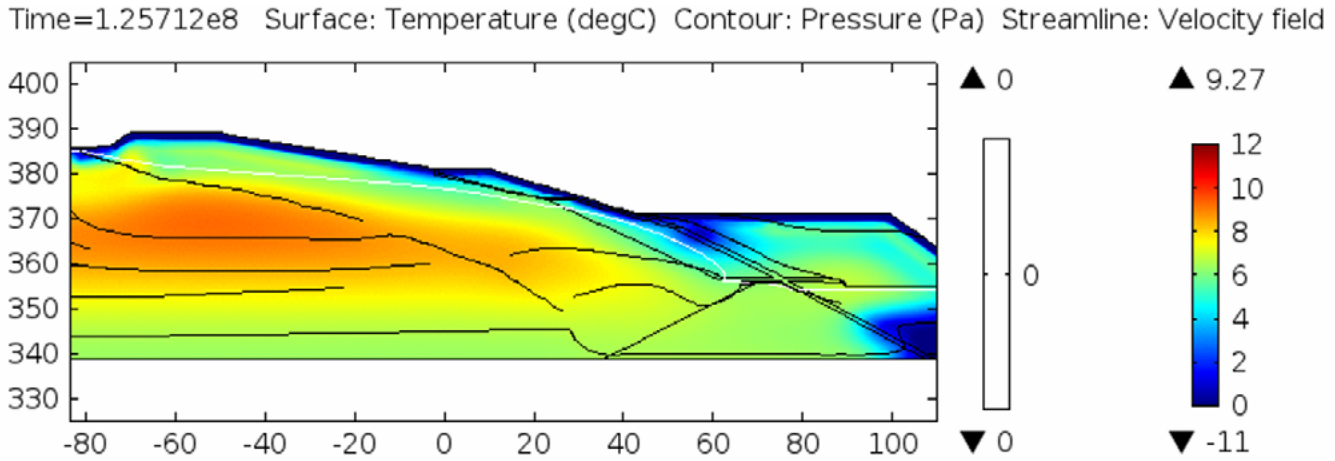
Seepage detection

By acquiring high-resolution Distributed Temperature Sensing (DTS) measurements, the system uses the natural seasonal temperature variations in the drainage system and reservoir to monitor changes in the seepage flow distribution. This allows the system to precisely locate sites of internal erosion as they develop.

The sensor is a typical telecom-type fibre optic cable and is installed permanently along the dam. High resolution temperature data, with fine spatial sampling, is continuously acquired using Silixa's ULTIMA DTS™ or XT-DTS™.

The DTS data is processed using the XSeepT™ application developed by Hydroresearch. This system has been deployed on over 70 embankment dams worldwide. XSeepT uses the high spatial resolution temperature data from Silixa's DTS units to calculate seepage rates and to detect small seepage flow changes in a dam structure. Any change in the seepage flow rates can be an indication of erosion, one of the most common causes of dam failure.

The monitoring system evaluates the data in real-time and provides the operator with information locally or via a cloud application. Both temperature and seepage information are offered. Seepage data can be calculated and evaluated for each section of the dam. XSeepT can export selected evaluated data to SCADA or ADAS and when sudden threshold changes are noticed alarm signal can be sent via 24V, E-mail or SMS.



Seepage detection

Case study

Seepage detection based dam monitoring in Boliden, Sweden

Click here to open the video in YouTube

Condition monitoring

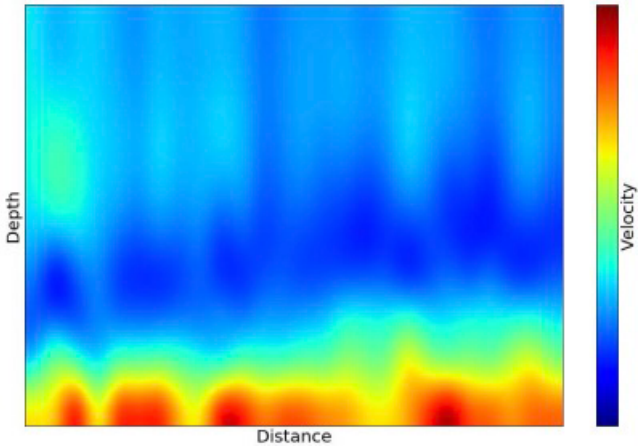
The system records acoustic data continuously or on demand to image the subsurface through advanced seismic techniques.

Variations in seismic velocity highlight any material changes in the dam to aid identification of internal erosion and increasing seepage rates at early stages.

Additional measurement techniques based on the same fibre-optic cable to map seepage below the drainage system are used to identify density changes in the dam and subsurface geology. These new monitoring techniques apply Distributed Acoustic Sensing (DAS) using both passive and active seismic methods.

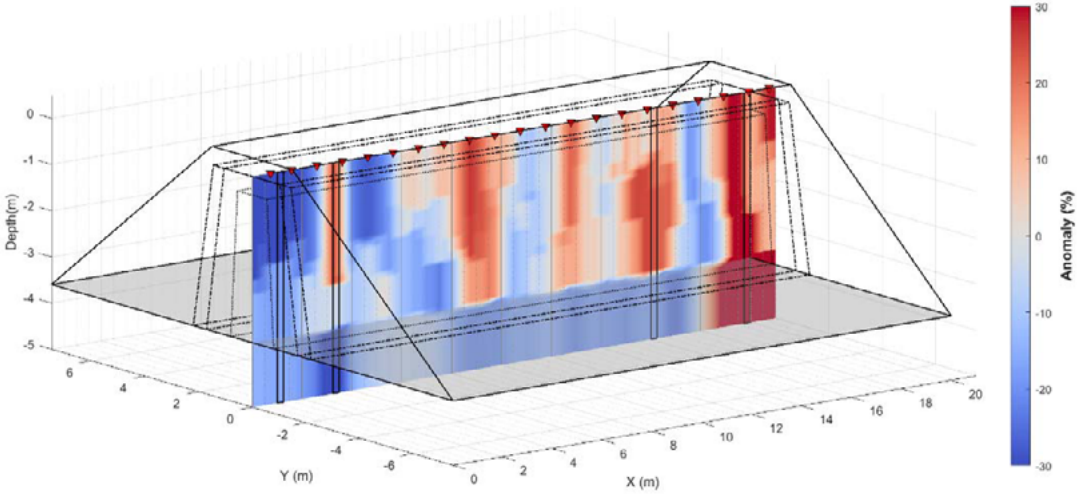
Seismic surveys can be active (use of external energy sources) or passive (analysis of natural noise or seismic events). Active seismic surveys can be used to image the subsurface, applying techniques such as multi-channel analysis of surface waves (MASW) and other tomographic methods.

A dam can be imaged with high precision by applying passive ambient noise interferometry (ANI). With this technique, recordings of background noise are used to reconstruct waves detected at different points along the cable as they propagate.



Left: Shear-wave seismic velocity profile determined using active MASW DAS survey.

Right: Seismic velocity anomalies in a dam imaged using ANI *(Johansson et al., Engergiforsk report 2021:732, ISBN 978–91-7673–732-3).*



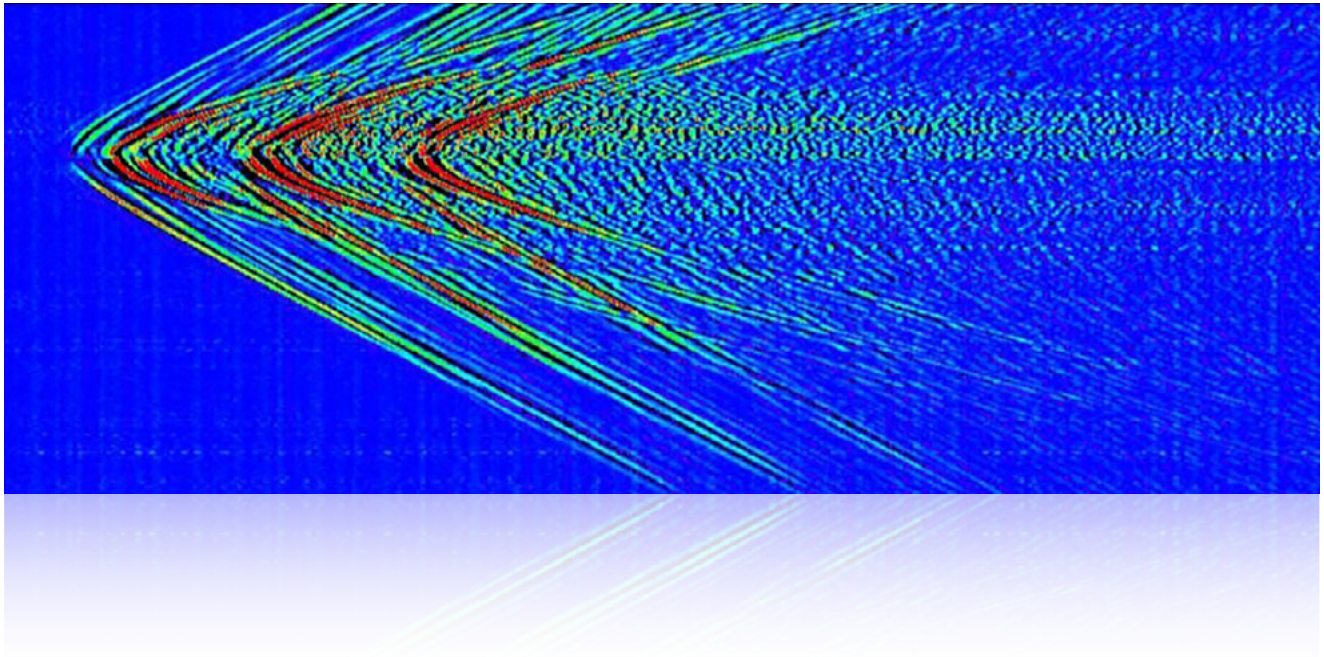
Seismic event detection

Through continuous and/or on-demand recording seismic activity due to movement in/below the dam can be monitored and assessed.

Small seismic events, termed microseismicity, caused by movement on fractures or faults, can also be detected using DAS technology.

DAS microseismic monitoring can be used to detect seismic movement in dams or induced seismicity in the area surrounding dams where seismic hazard is often an important safety consideration.

Below: Microseismic event detected with Silixa's intelligent Distributed Acoustic Sensor (iDAS™)



Slope deformation

Through continuous monitoring of strain and seismic activity, any movement, deformation or subsidence can be detected with high spatial resolution at early stages.

Distributed Strain Sensing

Using DSS, local movements can be detected at an early stage if the cable is well coupled to the soil and movement is effectively transferred to the cable. This provides useful and additional information to the survey points which are normally used to detect movements.

Temperature compensation is achieved in combination with DTS measurements.

A combination of dynamic and static strain changes offers a better understanding of potential structural changes and make early decision-making possible.

The system can detect strain changes (movement) in the dam and can therefore be used either as early-warning system with continuous monitoring, or as an investigation tool to measure deformation regularly.

Measured strain differences correspond to movement perpendicular to the cable. Local soil properties and water content influence the friction between the cable and the soil and change the length over which the movement will occur. However, the central point will be unaffected.

Dam Breach Detection

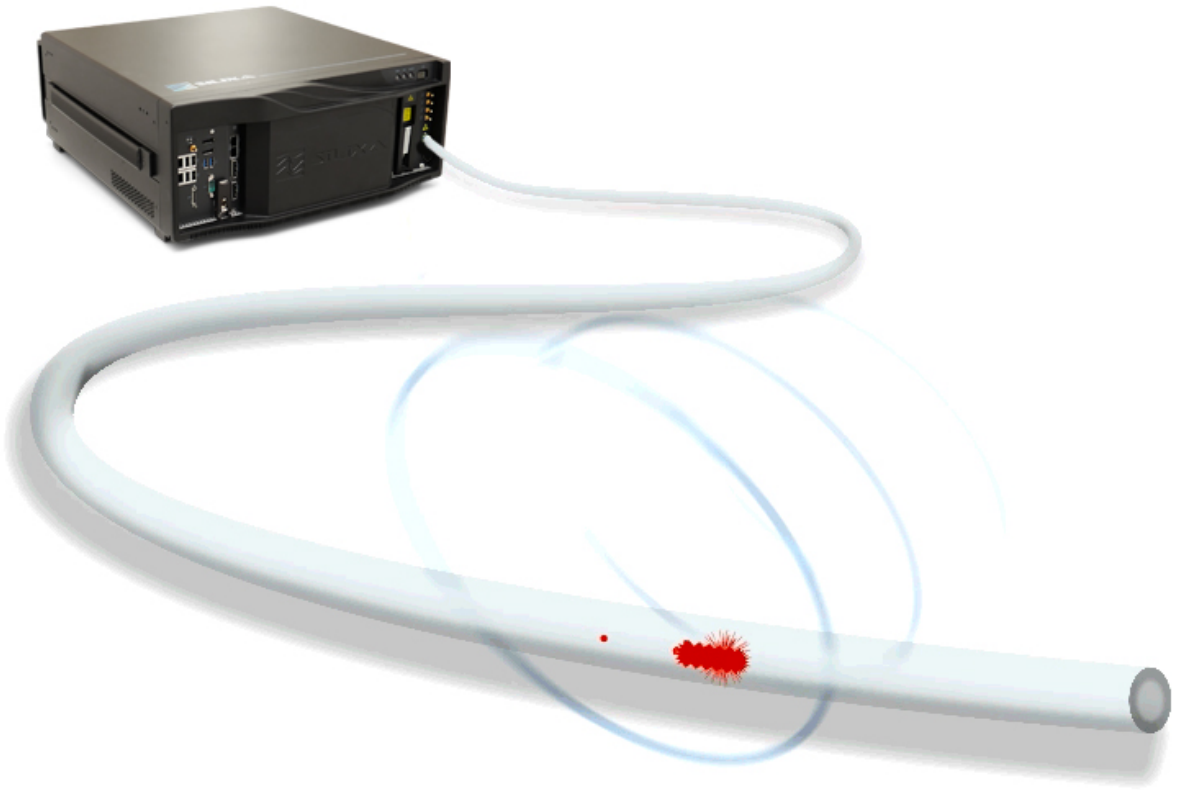
Dam breach verification provides alerts of the time and location of sudden failures in the embankment. The continuity of the sensing cable is checked continuously.

DAS, DSS and DTS are capable of detecting a fibre breach location in real time. Using purpose built software, it is also possible to analyze the signal losses along the full length of the cable. Temporal signal loss changes can then be detected before a full cable and associated dam breach will occur and an alarm enables rapid operator intervention.

Detection of signal losses is often used during installation to ensure a correct installation of the cable. This is recommended at all installations, if possible, to identify any damage on the fibre. Damages are mostly caused by local deformation around boulders or local movements (insufficient compaction) resulting in a small bending radius of the cable. In such cases the cable can carefully be exposed, and carefully stretched out and placed back in the trench and backfilled.

What is distributed sensing?

Distributed sensing is a technology that enables continuous, real-time measurements along the entire length of a fibre optic cable.



Unlike traditional sensors that rely on discrete sensors measuring at pre-determined points, distributed sensing does not rely upon manufactured sensors but utilises the optical fibre.

The optical fibre is the sensing element without any additional transducers in the optical path.

The interrogator operates according to a radar-style process: it sends a series of pulses into the fibre and records the return of the naturally occurring scattered signal against time. In doing this, the distributed sensor measures at all points along the fibre.

As the fibre is the sensor, it is also a cost-effective method that can be easily deployed even in the harshest and most unusual environments.

Distributed sensing is used for acquiring temperature, strain and acoustic data.

Distributed fibre optic monitoring offers high spatial and temporal profiling over large surfaces, long lengths and at locations where conventional point sensing is not applicable or cost effective.

About Silixa

Our mission: to provide actionable insight into assets and systems to incerase efficiency prevent loss, reduce operational costs and extend lifespans.

- Sustainability
- Social licence
- Tailings facility management
- Water management
- Safety
- Digitalisation

Our story

Silixa, an award-winning company, was set up in 2007 to develop and commercialise the next generation of optical fibre sensors. During the past decade we have become the global leading provider of fibre-powered data solutions that address the most critical measurement challenges in the Alternative Energy, Mining, Environmental & Earth Sciences, Infrastructure and Oil & Gas sectors.

With our heritage of cutting-edge innovation and technological leadership, we have been developing and manufacturing the world's best performing distributed acoustic, temperature and most recently strain sensing systems.

These leading-edge sensing technologies form the basis for a suite of our monitoring services directed towards the world's most demanding measurement challenges.

What we do

We offer dense array data sets of the highest fidelity. They enable operators to gain actionable insight into their assets and systems to increase efficiency, enhance safety, prevent loss and extend lifespans. We do so with a significantly reduced environmental footprint.

We offer a portfolio of proven distributed fibre optic sensing-based solutions. They enhance productivity, minimise risks and ensure sustainability by providing more reliable and cost-effective means of geophysical assessment as well as asset and process monitoring.

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2021

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