SENSITIVE INSPECTION AND MONITORING OF EMBANKMENT DAMS

Temperature Sounding Method • Drag forces caused by seeping water can significantly endanger the stability of dams. Changes in the flow condition within embankment dams usually occur over long time spans, and are often not visible at the surface. The onset of internal erosion can very rapidly compromise the stability of the dam and potentially lead to its failure. By detecting potential problem zones during the early stages, timely and carefully targeted repair works can be undertaken.

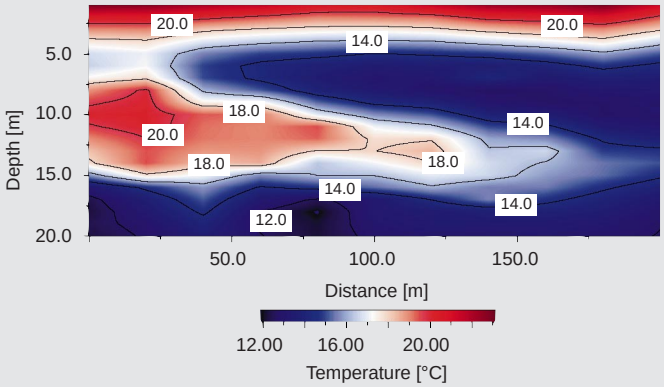
Both surface water temperatures and ground temperatures show seasonal variations. Due to the low thermal conductivity of soil and other construction materials, significant differences develop between the temperature of the reservoir water and the temperature distribution within the dam. The advective heat transport associated with reservoir water percolating into the dam through a leak in the sealing system, or through a zone of higher permeability, will lead to a distortion of the temperature distribution within the dam towards the reservoir water temperature. Seepage zones for sites within the Northern hemisphere are characterised by a positive anomaly in the temperature distribution during summer, and by a negative anomaly during winter periods.

Failure of an earthfill dam in Lesotho due to internal erosion

Using the ground temperature sounding technique developed by GTC (Pat. No. DE 41 27 646), temperatures in earthfill dams can be measured to depths in excess of 30 m, allowing seepage zones to be located.

More than 500 linear kilometres of dam, and many other types of hydraulic structures have now been investigated and monitored successfully using this thermometric technique. Many leaks and zones of increased permeability have been detected, and accurately located. In addition, zones of increased flow within the foundations of dams have been identified. The technique can also be used to undertake quality assurance investigations, following new construction or remedial work.

Further development of the GTC temperature sounding technique has allowed other parameters to be determined; these include degree of compaction, permeability and groundwater flow velocity.



Distribution of ground temperature along a vertical section parallel to the dam axis downstream of a slurry trench wall. The slurry trench wall reaches a depth of 13 m and extends horizontally over the whole diagram. The ground temperature measurements were taken during summer at a reservoir temperature of 22°C. Areas of increased temperature underneath a depth of 7 m were caused by leakage. The reservoir water passes through and underneath the slurry trench wall.

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Method Description · Many technical and environmental problems can be addressed using ground temperature sounding. Subsurface seepage often leads to temperature anomalies, since
the fluid often has a different temperature to the ground through which it flows. This seepage is inevitably related to an advective heat transfer, which will lead to the ground temperature approaching that of the fluid. This allows the fluid temperature to be used as a tracer, in order to detect and locate seepage. Temperature anomalies are difficult to detect near the surface, since climatic and anthropogenic factors dominate the temperatures within this zone. However, surface effects diminish rapidly with increasing depth; subsurface temperature measurements are therefore necessary to detect thermally distinct seepage.

GTC have developed a technique which allows the measurement of temperatures in soils and embankments to depths in excess of 30 m. A series of threaded, small diameter hollow pipes are driven into the ground to the required depth. A chain of temperature sensors is then inserted in the pipe via a cable. After a short time to allow temperatures to stabilise, the ground temperatures can then be measured at a series of depths. Following this measurement process, any temperature anomalies can be easily identified by graphical analysis, and can often be determined in the field. Both vertical and horizontal boundaries of seepage zones can be determined using this method.

Several years of experience with this measurement technique have shown that many problems can be solved with a reasonable technical and financial effort. E.g. the seepage monitoring at landfill sites, the inspection of tailings dams and waste water lagoons, the surveillance of fuel and gas tanks and pipeline systems.

Fields of Application

Leakage detection in embankment dams
Inspection of flood protection dikes
Seepage monitoring at cut-off walls
Quality control on injections
Surveillance of hydraulic works
Long term monitoring of hydraulic structures

References

HYDRO POWER COMPANIES
Alzwerke GmbH, Burghausen, D
CNR Companie Nationale du Rhône, Lyon, F
Degussa AG, Trostberg, D
EAM Energie AG Mitteldeutschland, Kassel, D
EdF Electricité de France
Chambery, Marseille, Mulhouse, St. Etienne, F
EnBW Energie Baden-Württemberg, Karlsruhe, D
e.on Wasserkraft GmbH, Landshut, D
ESB Electricity Supply Board, Dublin, IRL
Hidroelectrica S.A., Bucharest, RO
Industrielle Betriebe, Aarau, CH
LEW Lech Elektrizitätswerke AG, Augsburg, D
NOK Nordostschweizerische Kraftwerke AG,
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RADAG Rheinkraftwerk Albbruck-Dogern AG,
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RWE Energie AG, Essen, D
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