WELL-PLANNED AND IMPLEMENTED MONITORING IS AN ESSENTIAL COMPONENT OF SUCCESSFUL DAM CONSTRUCTION AND OPERATION. DAM MONITORING IS SUBJECT TO NUMEROUS REGULATIONS AND IN MANY COUNTRIES IT IS REGULATED BY STRICT ADMINISTRATIVE STANDARDS.

The primary function of monitoring is to ensure the longevity and safety of a dam. Monitoring must enable the timely detection of any behavior that could deteriorate the dam, potentially result in its shutdown or failure, in order to implement corrective measures.

Monitoring also plays a fundamental role during construction. It enables the verification of design hypothesis and may affect the construction rate of certain works. Monitoring is particularly crucial during the initial filling of the dam reservoir.

References

- Alicura – Argentina
- Butgenbach – Belgium
- Albion Sands – Canada
- La Grande – James Bay – Canada
- Daniel Johnson (Manicouagan 5) – Canada
- R.H. Saunders G.S. – Canada
- Las Condes – Chile
- Ertan – China
- Sichuan – China
- San Carlos – Colombia
- Bath County Pumped Storage – USA
- Beaver Dam – USA
- Howard Hanson – USA
- Lock & Dam 26 (Melvin Price) – USA
- De Bimont – France
- Marchand – France
- Chamera – India
- Andekaleka – Madagascar
- Ait Hammou – Morocco
- De la Dumbea – New Caledonia
- La Fortuna – Panama
- Guri – Venezuela
INSTRUMENTATION: THE KEYSTONE OF MONITORING

Instrumentation is used to accurately quantify certain parameters of structural behavior over time and to monitor their rate of change.

SELECTION CRITERIA FOR INSTRUMENTATION

Three major criteria guide instrument selection:

- Reliability of the measurements obtained (accuracy, resolution, precision and drift)
- Instrument longevity, supported by numerous references
- Ease of readout automation, essential for efficient data collection and interpretation

Monitoring involves numerous steps including direct or remote visual inspection as well as topographical measuring and instrumentation. The scope of the monitoring methods employed depends on the potential risk associated with dam and site characteristics. Such characteristics include:

- Dam height and type
- Potential damage to people and structures located in flood zone
- Reservoir and spillway capacity
- Site seismicity
- Foundation weakness zones

TYPES OF MEASUREMENTS

The types of measurement to be carried out as well as instrument location must be selected according to the particular conditions of the foundation and of the dam itself.

DAM FOUNDATION

The following are the main points to verify:

FOUNDATION HYDRAULICS

- Relative impermeability between the foundations and reservoir perimeter
- Cutoff structure efficiency
- Efficiency of the downstream drainage networks

These behaviors can be monitored with the following instruments:

- Piezometers
- Flow meters

FOUNDATION DEFORMATION

Settlement and horizontal deformation behavior can be evaluated once measurements are complete. Particular attention must be paid to zones where significant differential settlement could lead to fissuring in the structure.

Instruments used:

- Borehole extensometers
- Settlement gauges
- Inclinometers

ARCH OR MULTIPLE-ARCH CONCRETE DAM

Objectives

- Measure stress condition and, in particular the absence of tension zones
- Verify the efficiency of impervious seals
- Monitor cracking and determine the causes

Measured Parameters

- Stress
- Temperature
- Deformation
- Fissuring
- Upfift
- Seepage flow

GRAVITY DAMS (STANDARD OR ROLLER COMPACTED CONCRETE)

Objectives

- Verify general stability of structure
- Verify the efficiency of impervious seals and drainage system
- Monitoring fissuring

Measured Parameters

- Fissuring
- Temperature
- Deformation
- Upfift
- Displacement
- Seepage flow
FOUNDATION STABILITY

Instruments used for monitoring potential shear zones:
- Jointmeters
- In-place inclinometers

MONITORING INSTRUMENTS FOR SPECIFIC APPLICATIONS

In addition to offering a complete line of monitoring instruments for new dams, Smartec designs and builds instrumentation equipment for existing dams and adapts these instruments to specific applications.

Older Dam

Many instruments are designed to be installed while a dam is under construction and cannot be incorporated into existing works.
This poses a problem mainly for concrete dams with fissuring problems. The instruments used include the following:

For Crack Opening Variations
- Single-point or triaxial surface-mount crackmeters, such as the RTF, which can be installed under water on the upstream side of the dam.
- BOF-EX borehole extensometer

Dam Stress Relief by Sawing

Dam-sawing techniques have been developed to solve the problem created by the swelling of old concrete due to the reaction between certain cements and aggregates.

Smartec has designed customized instrumentation based on the BOF-EX borehole extensometer and stress variations measurement to monitor stress release and internal deformations provoked by the saw-cut.

EARTHS & ROCKFILL DAM

Objectives
- Verify general stability of structure
- Ensure that infiltration does not cause piping or internal erosion

Measured Parameters
- Pore pressure within the core and core permeability
- Impermeability of core/foundation or membrane/foundation
- Total and differential dam deformation
- Filter zone efficiency

Improving Stability Or Heightening a Concrete Dam

Improving stability or heightening a concrete dam requires the installation of permanent high-capacity tieback anchors. To monitor these anchors, Smartec has designed high-capacity vibrating wire load cells.

TAILING DAMS

Tailing dams constructed with hydraulic fill are built near the equilibrium limit and require close monitoring. The main measurements required for dam stability analysis and slide prevention are pore pressure, settlement and lateral deformation.

Instruments used:
- Piezometers
- Settlement gauges
- Inclinometer probes and in-place inclinometers

AUTOMATED DATA ACQUISITION AND PROCESSING

The collection and analysis of large quantities of data, especially over long distances, requires centralized and automated measuring techniques. Results are more accurate and data can be processed more rapidly thus enabling efficient alarm systems to be implemented when predetermined thresholds are exceeded. It is practically impossible to consider the instrumentation of a major dam without automated data acquisition systems.

Smartec’s SENSLOG allows economical data logging and can be readily connected to multi-node networks for real-time monitoring. Data acquisition centers are easily user-configured through a high-level “soft” instrument control language.

This language supports full diversity in connected device types, measurement intervals, data conversion, statistical processing, and strategies for alarm control, and logging.
Smartec is the leading developer, manufacturer and supplier of innovative sensing technologies based on vibrating wire and fiber optic sensors for geotechnical and structural instrumentation.

We are featuring a complete line of conventional sensor-based solutions ranging from the ultra-robust traditional vibrating wire technology to state-of-the-art fiber-optic technology used for the measurement and monitoring of geotechnical projects and structural health monitoring (SHM) of critical assets such as: dams, tunnels, mines, buildings, bridges, nuclear power plants and many other structures too numerous to list.

Smartec offers a wide range of pressuremeters, rock dilatometers, laboratory and in-situ testing equipment for soil and rock.

Available Application Notes

- FO Leak Detection for Dams and Dikes
- Dam & Dike Instrumentation and Safety Monitoring
- Tunnel Instrumentation & Structural Health Monitoring
- Bridge Instrumentation & Structural Health Monitoring
- Building Instrumentation & Structural Health Monitoring
- Historical Monument Instrumentation
- Geotechnical and Structural Monitoring
- Nuclear Power Plant Instrumentation
- FO Movement Detection in Tunnels
- FO Leak Detection for Chemical Plants
- FO Leak Detection for Pipelines
- Storage Facility Instrumentation
- Cliff Instrumentation