FOCUS ON *Rehabilitation of 6 dams in Macedonia*

The monitoring instrumentation in these six dams is, to a large extent, the same as originally installed more than 40 years ago and, due to careful maintenance most of the instruments were still in good condition. However, some components have become outdated, so ELEM designed a project for the rehabilitation of the dam monitoring instrumentation selecting Sisgeo as the main partner.
At the same time, a comprehensive program for the automation of the monitoring instruments and transmission of the monitoring data to a Central Control Center for all dams under ELEM's responsibility was initiated.

Underwater installation of sensors in Mavrovo Dam

Sisgeo has been involved in the rehabilitation and automation of the monitoring instrumentation of six hydropower plants in the Republic of Macedonia, owned and operated by ELEM- JSC Macedonian Power Plants, with a total installed capacity of 528 MW. The hydropower assets include the five clay-core of Mavrovo, Spilje, Globocica, Tikves and Kozjak as well as Sveta Petka arch dam.

Systems Installed:

Device for Measuring Pump Operation Time
Measurement of Pore and Total Pressure Cells
High Voltage Protection System
Data Transmission and Processing

Thanks to the dedicated work of ELEM's dam engineers and Sisgeo instruments, the safety level of these six dams in Macedonia has increased that level of safety even further.

Name	Type	Year	Height (m)	Crest length (m)	Dam volume (103 m3)	Reservoir volume (103 m3)
Mavrovo	TE	1952	54	210	777	357
Spilje	ER/TE	1969	101	330	2699	520
Globocica	ER/TE	1965	83	196	998	58
Tikves	ER/TE	1968	104	338	2722	475
Kozjak	ER/TE	2004	114	300	3340	550
Sv. Petka	VA	2012	69	118	27	9

Salient features of the dams belonging to JSC Macedonian Power Plants (Courtesy of ELEM)

Ituango hydroelectric project, Colombia

Ouldjet Mellegue dam, Algeria

Ermenek dam - Turkey

REFERENCE *PROJECTS*

Europe

Karanjukar dam - Iceland
Petka dam - Macedonia
Ravedis dam - Italy
Brama Peruća dam - Croatia
Czorsztyn dam - Poland
Val Clarea basin - Italy
Foz Tua dam - Portugal
Evinos dam - Greece
Konsko dam - Macedonia
Mavrovo dam - Macedonia
Globocica dam - Macedonia
Spilje dam - Macedonia
Ilarionas dam - Greece
Dabar HPP - Serbia
Valsamiotis dam - Greece

Asia & Oceania

Rogun dam - Tajikistan
Snowy 2.0 HP - Australia
Nurek dam - Tajikistan
Andijan dam - Uzbekistan
Hisorak dam - Uzbekistan
Kotri dam - Pakistan
Uma Oya project - Sri Lanka
Zhinvali HP - Georgia
Akhangaran reservoir - Uzbekistan
Salman-E-Farsi dam - Iran
Reis-Ali Delvari dam - Iran
Vedi dam - Armenia
RID Ministry dam rehab - Thailand
Nam Ngiep 1 HP - Laos
Polrood dam - Iran
Roodbar Lorestan dam - Iran
Ust-Kamenogorsk HP - Kazakhstan
Eyvashan dam - Iran
Geghi dam - Armenia
Namrood dam - Iran

Middle East

Ermenek dam - Turkey
Wadi Dayqah dam - Oman
Yusufeli HP - Turkey
Wala dam - Jordan
Qanouna dam - Saudi Arabia
Kufranja dam - Jordan
Wadi Ithwad dam - Saudi Arabia
Mujib dam - Jordan
Atasu dam - Turkey
Al Wehdah dam - Jordan
Arada dam - Saudi Arabia
Yesildere dam - Turkey

Africa

Koysha HP - Ethiopia
Ouldjet Mellegue dam - Algeria
Cahora Basa HP - Mozambique
Neckartal dam - Namibia
Metolong dam - Lesotho
Beni Slimane dam - Algeria
Songloulou dam - Cameroon
Kerrada dam - Algeria
Zarema May Day dam - Ethiopia
Kef Edir dam - Algeria
Capanda dam - Angola
Mauane dam - Algeria
Mkukurumdzi dam - Kenya
INGA HP - Congo

America

Ituango HP - Colombia
Sogamoso HP - Colombia
Santa Maria dam - Mexico
El Quimbo HP - Colombia
Mazar HP - Ecuador
Cerro del Aguila HP - Perù
Central Fabricio Ojeda HP - Venezuela
Las Tortolas dam - Chile
Ojo de Agua dam - Honduras

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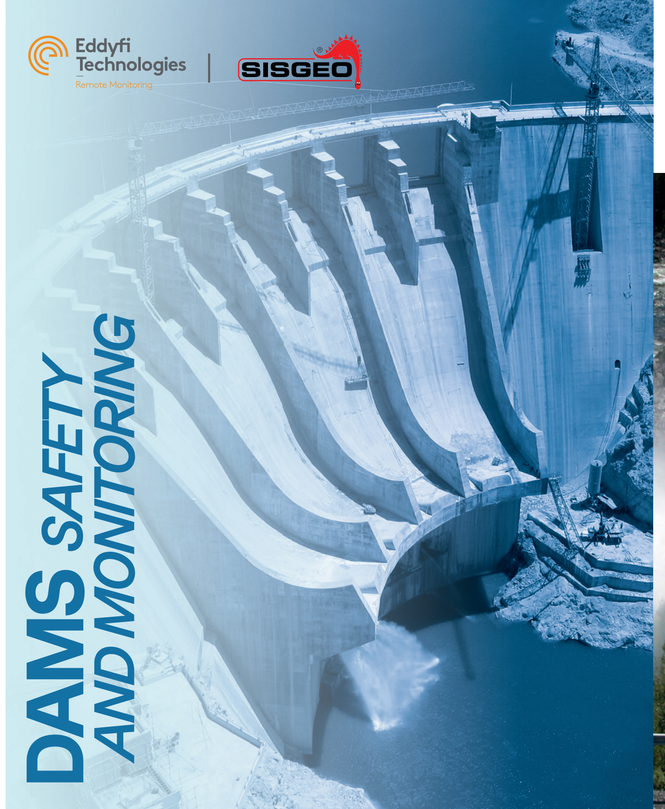
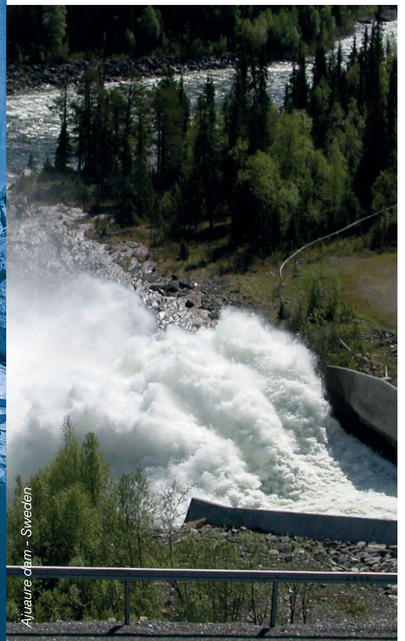
DAMS *SAFETY AND MONITORING*



DAMS *SAFETY AND MONITORING*

Planning a performance monitoring program is an essential component of successful dam construction and operation.
Dam monitoring is recommended to ensure the safety of a dam and to control its trend.



Ajaure dam - Sweden

Monitoring *purposes*

To evaluate the initial conditions at dam site

Safety during construction stages

Dam stability during initial filling and discharge of the reservoir

Long-term monitoring of the dam performances during operation

Main dams *types*

Concrete gravity dam

Concrete arch dam

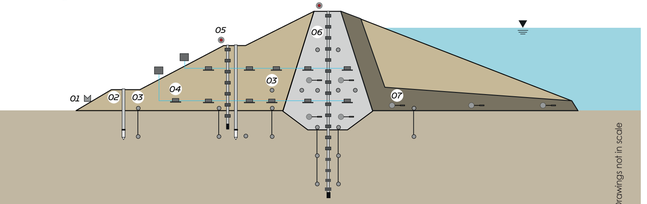
RCC dam

Clay-core dam

Rock-fill dam

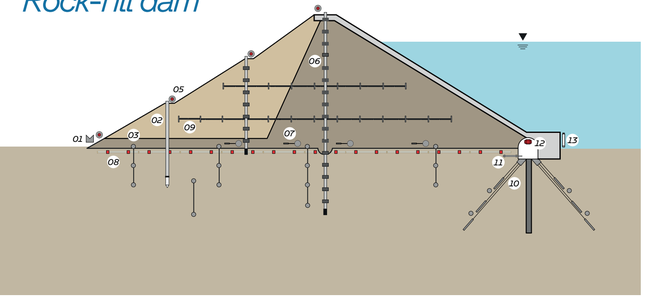
DAMS SAFETY AND MONITORING_EN_08_09/2025

EMBANKMENT DAM
MONITORING SYSTEM
Clay-core dam



Drawings not in scale

Rock-fill dam



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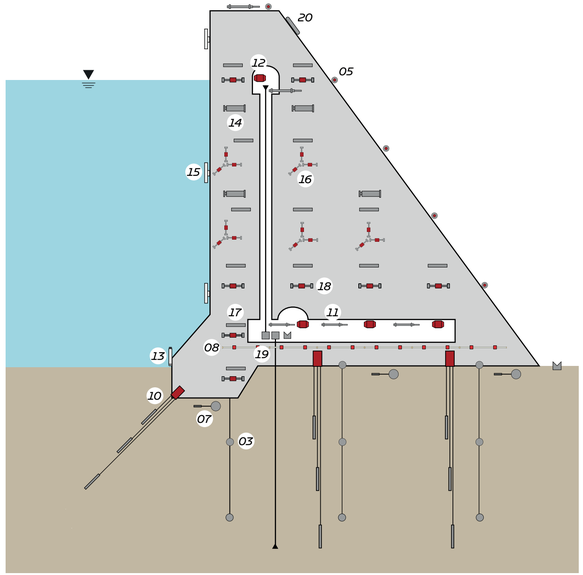
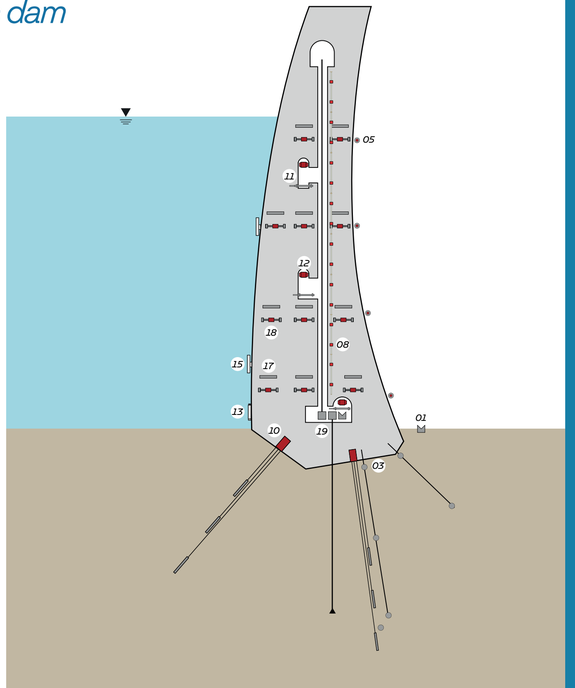
CONCRETE DAM
MONITORING SYSTEM
Gravity dam



CONCRETE DAM
MONITORING SYSTEM
Arch dam



INSTRUMENTS

01 Weirs (flow meters)	Seepage flow
02 Casagrande piezometers	Water table level in boreholes
03 Piezometers	Pore water and uplift pressure
04 LLS Liquid Level Gauges	Settlement within the dam embankment
05 Geodetic survey points	Surface structural displacements
06 Inclino-settlement columns	Horizontal displacements and settlements
07 Earth pressure cells	Total pressure between dam body and foundations or within the embankment
08 LT-Inclibus array	Dam body displacements, foundation settlements
09 Embankment extensometers	Horizontaldisplacements within the embankment
10 MPBX extensometers	Multi-points foundation settlements in boreholes

INSTRUMENTS

11 Jointmeters	Surface displacement of exhisting cracks or structural joints
12 Tiltmeters	Local inclinations (horizontal displacement) of the structure
13 Relative pressure transducers	Water table level in standpipes
14 Embedment jointmeters	Structural joints displacements
15 Submersible tiltmeters	Local inclinations of the structure also in underwater conditions
16 3D Rosette strain gauges	3-D stress and strains within concrete mass
17 Embedded thermometers or thermistor strings	Evaluation of thermal curve during concrete mass curing
18 Concrete embedded strain-gauges	Strains within concrete mass
19 Direct and inverted pendulums	Horizontal displacements of concrete dam body

READOUT AND DATALOGGER

MIND redout

OMNIAlog multichannel datalogger

Wireless system

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