

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 Itwad dam - Saudi Arabia
 Mujib dam - Jordan
 Atasu dam - Turkey
 Al Wehdah dam - Jordan
 Arada dam - Saudi Arabia
 Yesildere dam - Turkey

Africa

Koysya 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 - Peru
 Central Fabricio Ojeda HP - Venezuela
 Las Tortolas dam - Chile
 Ojo de Agua dam - Honduras



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.

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



Ajuare dam - Sweden

DAMS SAFETY AND MONITORING - EN - LOT_10/2023

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.

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	1949	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)



Underwater installation of sensors in Mavrovo Dam

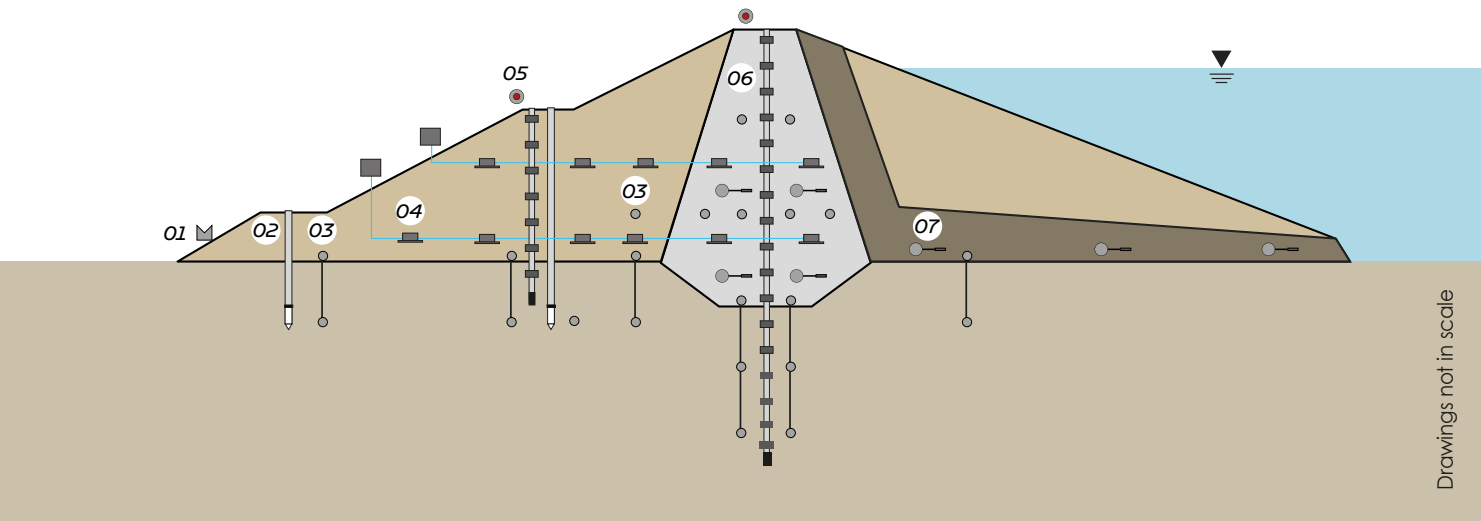
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SISGEO HEADQUARTER
 Via F. Serpero 4/F1 - 20060 Masate (MI) - Italy
 Tel. +39-02.95.76.41.30
 info@sisgeo.com

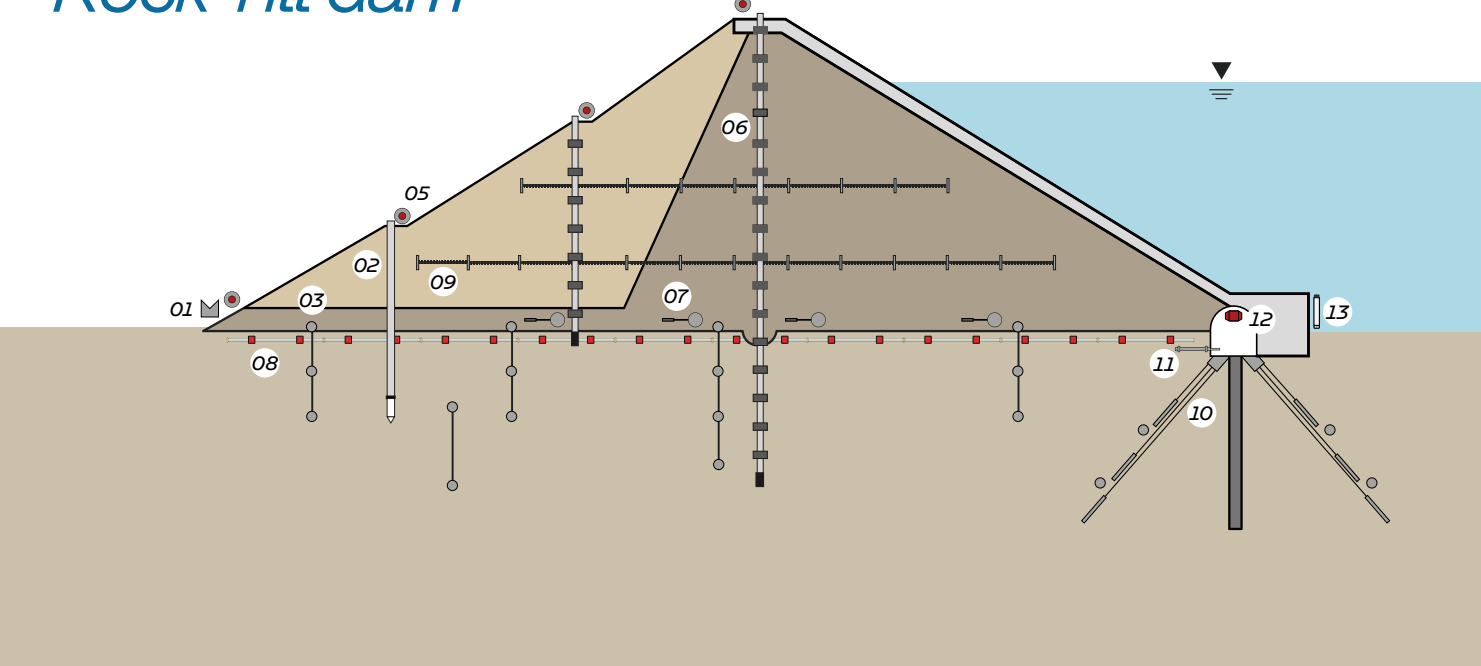
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EMBANKMENT DAM MONITORING SYSTEM

Clay-core dam

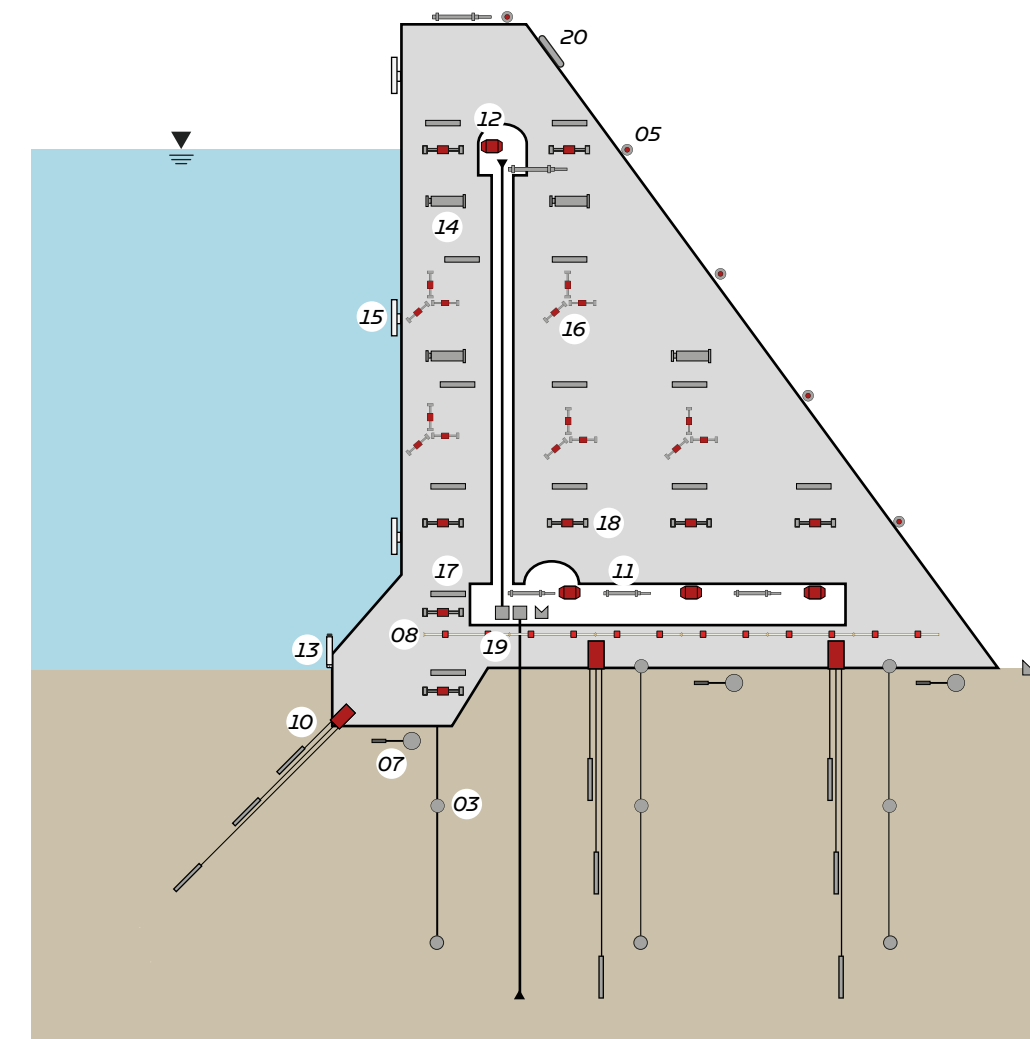


Rock-fill dam



CONCRETE DAM MONITORING SYSTEM

Gravity dam



Reading solutions and data collection

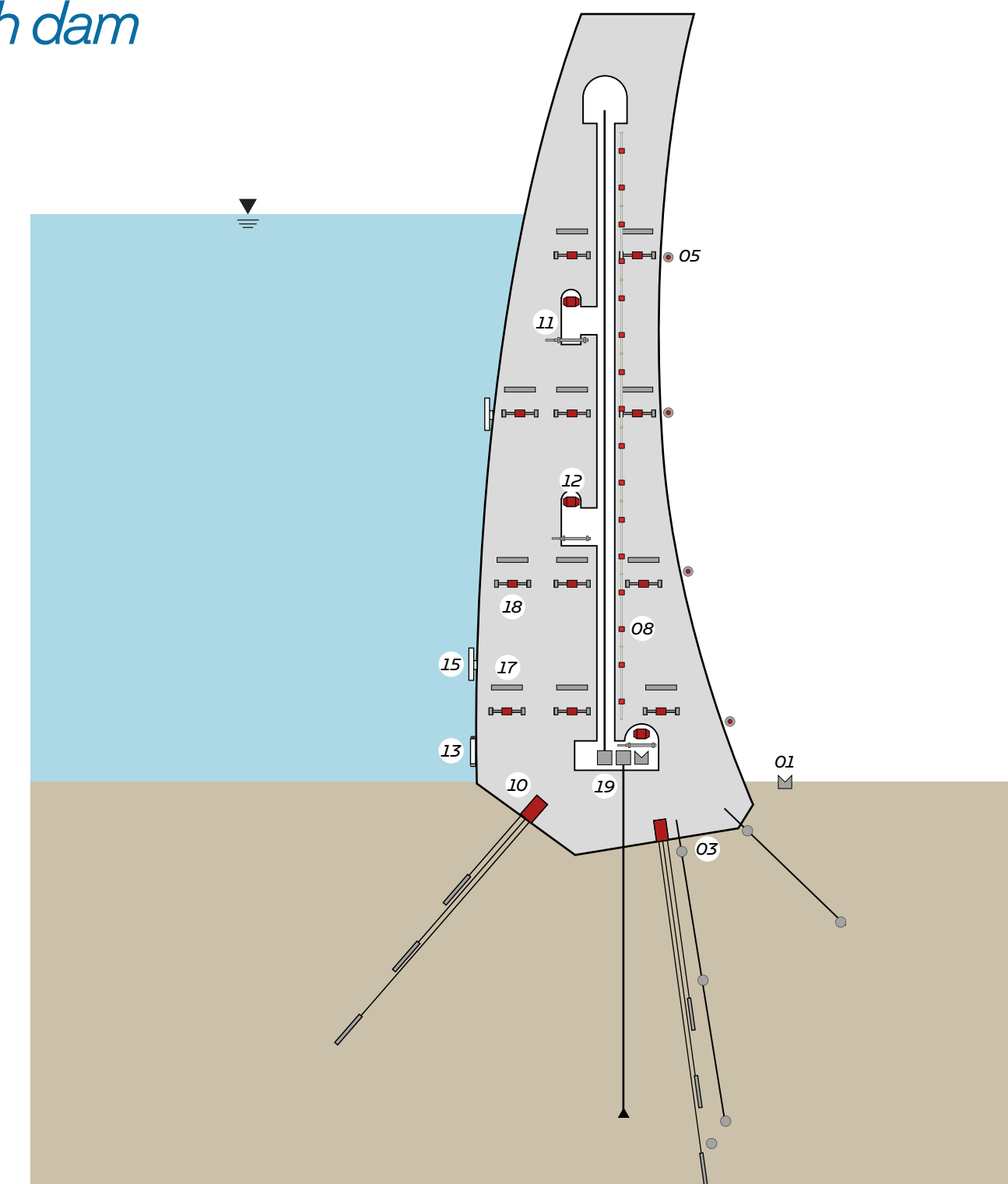
The readout units and dataloggers are an essential part of the monitoring system. The readouts are needed during the installation procedures, in order to check any instruments before and after their installation, or when an automatic monitoring solution is not required. MIND readout is the new portable multichannel readout unit able to read and store data from both digital and analogue instruments, via the dedicated app.

Dataloggers and wireless solutions are ideal for the automatic and remote monitoring in any geotechnical conditions. OMNIAlog and WRLog dataloggers offer precise measurement and reliable data acquisition from various technologies widely applied in the geotechnical field, such as: vibrating wire, MEMS and resistive and digital sensors. Sisgeo also offers a dedicated service, named AIDA IoT (powered by Field Srl), for data/measurement management from automatic and manual monitoring systems.

The electric signals of the instruments are acquired by wired and wireless dataloggers, sent to a server and later imported to a dedicated database, where they are divided by project, instruments and measurements. Data, converted into engineering units, are validated, processed and represented in charts and table format.

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 Horizontal displacements within the embankment
- 10 MPBX extensometers Multi-points foundation settlements in boreholes

READOUT AND DATALOGGER

- MIND readout
- OMNIAlog multichannel datalogger
- WR Log wireless system

INSTRUMENTS

- 11 Jointmeters Surface displacement of existing 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

STRUCTURAL HEALTH MONITORING SYSTEM

- 20 Ad-Signum solution Predictive analysis of the behaviour of concrete structures, real time alerts

