FOCUS ON: REHABILITATION OF 6 DAMS IN MACEDONIA

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 embankment dams with clay core of Mavrovo, Spilje, Globocica, Tikves and Kozjak as well as Sveta Petka arch dam.

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 However, some components have become outdated, so ELEM established a project for the rehabilitation of the dam monitoring instrumentation selecting Sisgeo as the main partner.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 auscultation center for all dams under ELEM's responsibility was initiated.

Systems Installed:
1. Device for Measuring Pump Operation Time
2. Measurement of Pore and Total Pressure Cells
3. High Voltage Protection System
4. 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.

Underwater installation of sensors in Mavrovo Dam

Location map of the dams belonging to JSC Macedonian Power Plants (Courtesy of ELEM)

Name	Type	Year	Height (m)	Crest length (m)	Dam volume (10^3 m^3)	Reservoir volume (10^3 m^3)
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)

Sisgeo data and display

REFERENCE PROJECTS

- Vedi dam, Armenia
- Songloulou dam, Cameroun
- Asopos dam, Greece
- Wala dam, Jordan
- Dabar HPP, Serbia
- Casanuova dam, Italy
- Kokkinolakkas dam, Greece
- Cerro del Aguila hydroelectric project, Perù
- Ituango hydroelectric project, Colombia
- Asterios dam, Greece
- Cahora Bassa hydropower project, Mozambique
- Nam Ngiep 1 hydropower project, Laos
- Dam in Ikaria Island, Greece
- Azad dam, Iran
- Karatzas dam, Greece
- Rogun dam, Tajikistan
- Nurek Dam, Tajikistan
- Neckartal dam, Namibia
- Metsovitiko dam, Greece
- Ouldjet Mellegue dam, Algeria
- Metolong dam, Lesotho
- Racibórz hydroproject, Poland
- Nohob dam, Iran
- Shahri Koor dam, Iran
- Castel Giubileo dam, Italy
- Darkas dam, Greece
- Polrood dam, Iran
- INGA hydroelectric project, Congo
- Beni Slimane dam, Algeria
- Kufranja dam, Jordan
- Qanouna dam, Saudi Arabia
- El Quimbo project, Colombia
- Draa Diss dam, Algeria
- Kerrada dam, Algeria
- Sarney dam, Iran
- Narekvari dam, Georgia
- Avsar dam, Turkey
- Grncarevo dam, Serbia
- Zarqa-Ma'een and Lajjoun dam, Jordan
- El Tornillito hydroelectric project, Honduras
- El Cajon hydroelectric project, Honduras
- UMA OYA multitipurpose project, Sri Lanka
- Cheraghveys dam, Iran
- Kef Eddir dam, Algeria
- Aposelemi dam, Greece
- Evinos dam, Greece
- Galmadareh dam, Iran
- Yaba dam, Saudi Arabia
- Borinquen dam, Panama
- Zemborzyce dam, Poland
- Abha dam, Kindgdom of Saudi Arabia
- Nai Gaj dam, Pakistan
- Zarema May Day dam, Ethiopia
- Ojo del Agua project, Honduras
- Mahouane dam, Algeria
- Chahchahe dam, Iran
- Hozian dam, Iran
- Eyvashan dam, Iran
- Wadi Itwad dam, Kingdom of Saudi Arabia
- Maraba dam, Kingdom of Saudi Arabia
- Mkukurumdzi dam, Kenya
- Matala dam, Angola
- Booysendal Tailings dam, South Africa
- Tablachaca dam, Peru
- Avsa Hadimi dam, Turkey
- Valsamiotis dam, Greece
- Roodbar Lorestan dam, Iran
- Sogamoso hydroelectric project, Colombia
- Foz Tua dam, Portugal
- Akalin dam, Turkey
- Tetha dam,Kenya
- Ayvali dam, Turkey
- Gheshlag dam, Iran
- Central Hydroelectrica Angostura, Chile
- Akbas & Gokceler dam, Turkey
- Haliller Waterfill, Turkey
- Triantafullia dam, Greece
- Vardnili dam, Georgia
- Mavrovo dam, Macedonia
- Tikves dam, Macedonia
- Globocica dam, Macedonia
- Spilje dam, Macedonia
- Petka dam, Macedonia
- Kozjak dam, Macedonia
- Haygher dam, Iran
- Zhinvali dam, Georgia
- Ahsuba dam, Kingdom of Saudi Arabia
- Namrood dam, Iran
- Dayqah dam project, Oman
- RCC and saddle dams, Oman
- Kotri dam, Pakistan
- Herjab dam, Saudi Arabia
- Boguchanskaya hydroelectric project, Russia
- Nam Ken dam, Thailand
- Nacala dam, South Africa
- Ardahan dam, Turkey
- Nam Louk dam, Thailand
- ULU JELAY hydroelectric project, Malaysia
- NG dam, Laos
- Beyyurdu dam, Turkey

IN **30 YEARS** MORE THAN
500 INSTRUMENTED DAMS

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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

_ DAMS SAFETY AND MONITORING

Ajaure dam - Swaden

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 trends.

THE MONITORING PURPOSES

- To evaluate the initial conditions at dam site
- The safety during construction stages
- The safety during initial filling and frawdown, including basin
- Long-term monitoring of dam stucture
- To monitor the performances during dam life

MAIN DAMS TYPES

- **Concrete gravity dam**
- **Concrete arch dam**
- **Embankment clay-core dam**
- **Embankment rock-fill dam**
- **RCC dam**

GEOTECHNICAL
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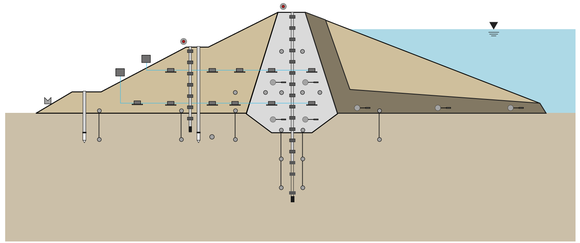
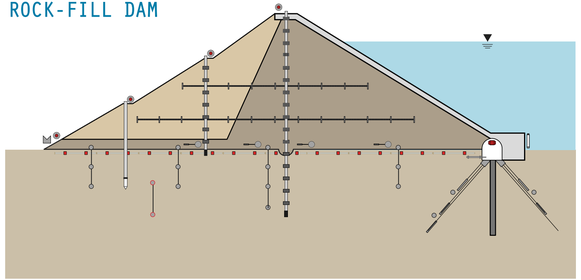
DAMS SAFETY AND MONITORING_EN_06_09/2022

EMBANKMENT DAM MONITORING SYSTEM

CLAY CORE DAM



ROCK-FILL DAM



-Drawings not in scale-

DAMS SAFETY AND MONITORING

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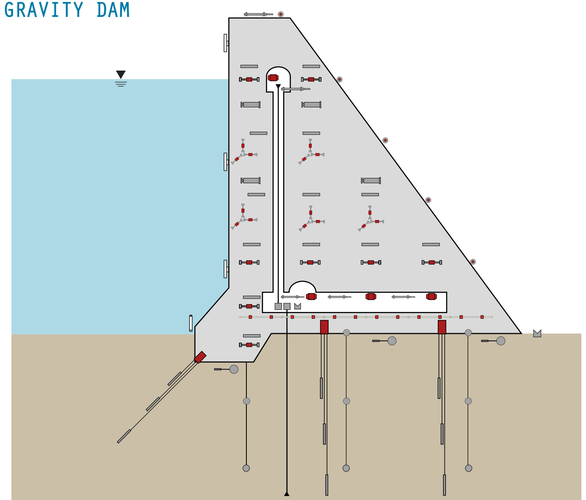
CONCRETE DAM MONITORING SYSTEM

GRAVITY DAM



READING SOLUTIONS AND DATA COLLECTION

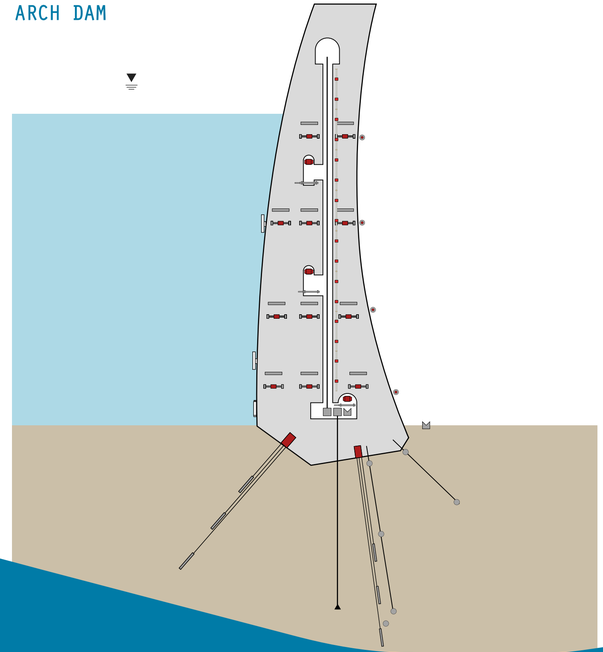
The readout units and dataloggers are an essential part of the monitoring system.
The readouts are needed during the installation procedures, in order to check any instruments before and after their installation, or when an automatic monitoring solution is not required. **MIND readout** is the new portable multichannel readout unit able to read and store data from both digital and analogue instruments, via its MIND 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 sensor types and gauges supporting vibrating wire, MEMS and digital sensors, and all major geotechnical instruments.

Sisgeo can also offer a dedicated service for data/measurement management from automatic and manual monitoring systems called A.I.D.A. (powered by FIELD).
The electric signals of the instruments are captured by the Data Acquisition Units, sent to a Server and later imported to a dedicated Database, where they are divided by project, instruments and measurements. Data are then converted into engineering units, validated, processed and represented in charts and table format.

CONCRETE DAM MONITORING SYSTEM

ARCH DAM



INSTRUMENTS	PURPOSES
Direct and inverted pendulums	Monitoring of the dam horizontal displacements
Concrete embedded strain-gauges	Monitoring of strains within concrete mass
Embedded thermometers or thermistor strings	Evaluation of thermal curve during concrete mass curing
3D Rosette strain gauges	3-D monitoring of strains within concrete mass
Weirs (flow meters)	Evaluation of water seepages
Tiltmeters	Local inclinations (horizontal displacement) of the structure
Jointmeters	Surface monitoring of exhisting cracks or structural joints
Piezometers	Pore water pressure monitoring
Geodetic survey points	Topographic control of structural displacements
LT-Inclibus	To verify dam body displacements or foundation settlements (redundancy)

INSTRUMENTS	PURPOSES
Submersible tiltmeters	Local inclinations of the structure also in underwater conditions
Relative pressure transducers	Monitoring of water table level in standpipes and in the basin
Earth pressure cells	Total pressure between dam body and foundations or within the embankment
Embedment jointmeters	Monitoring of structural joints within concrete structures
LLS Liquid Level Gauges	Settlement monitoring within the embankment
Casagrande piezometers	Pore water pressure monitoring
Inclino-settlement columns	Monitoring of horizontal and vertical embankment displacements
Embankment extensometers	Monitoring of horizontal displacements within the embankment
MPBX extensometers	Monitoring of settlements and displacements at different depths

REDOUT AND DATALOGGERS
MIND readout
OMNIAlog multichannel datalogger
WR Log wireless system

DISCOVER ALL THE PRODUCTS

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DAMS SAFETY AND MONITORING

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