« Taking the pulse of the river »*

The CACOH is CNR's expertise centre in the field of measurements, monitoring and design of hydraulic structures.

It was founded in 1936 to survey and validate the hydraulic design of the whole Rhone River hydropower cascade and navigation waterway using small scale physical models.

This historic mission has been progressively enriched by merging essential competences in measurements, monitoring and diagnoses for guaranteeing a safe and optimized operation of the Rhone River hydropower developments. It currently reports to CNR's Coordination of Operations and Safety Department. In this framework, it is also responsible for establishing and disseminating technical references shared by all the actors of CNR involved in hydraulic measurements and structures monitoring.

This unique engineering centre brings together around 50 engineers, technicians and project managers. Its scope of expertise calls on a wide range of strategic skills to operate CNR's structures: metrology, hydrometry, hydrology, hydrography, topography, hydraulics, sedimentology, civil engineering, geotechnics, geomaterials, hydromechanics and electromechanical engineering.

An internationally acknowledged knowhow...

CNR's experience gained from the Rhone River provides CACOH with a unique expertise acknowledged by and shared in a large number of French and international institutions. Every year, CACOH's experts also participate in the leading international technical conferences in the field of hydraulic structures.

... regularly mobilized for the benefit of external projects

CACOH's experts are also involved in engineering projects commissioned by external clients based in France and abroad. They imagine and optimize structures based on reliable and cost-effective solutions gained from CNR experience in operation and maintenance (O&M) of the Rhone River cascade. This dual approach provides to our clients an unparalleled added value to meet their specific requirements.

** Erik Orsenna during a visit to Lyon on 9 February 2015*

THE CACOH IN FIGURES

- **80 years' experience**
- **50 experts and specialists**
- **12 areas of skills**

MAIN INSTITUTIONS IN WHICH CACOH IS INVOLVED

Association Francophone d'Hydrographie (AFHy), Doppler Hydrometry and Sediment Transport sections of the Société Hydrotechnique de France (SHF), Comité Français des Barrages et Réservoirs (CFBR), ICOLD (International Commission on Large Dams), EWGIE (European Working Group on Internal Erosion), PIANC (World Association for Waterborne Transport Infrastructure)...

CNR, CONCESSIONARY OF THE RHONE RIVER

FRANCE'S LEADING PRODUCER OF 100% RENEWABLE ENERGY

Founded in 1933, CNR was entrusted with the Rhone River concession by the government in 1934 to develop and operate it according to three missions in the public interest: hydroelectricity production, improving navigation, and providing water for irrigation and other agricultural uses.
A historic producer of hydroelectricity, over the last 10 years CNR has developed an energy mix based on hydro-, wind and solar power France's leading producer of renewable energy, CNR fully contributes to energy transition as a corporate laboratory of tomorrow's energies.

A UNIQUE MODEL OF DEVELOPMENT

Thanks to the nature of its activities and their mode of funding, CNR has been driven by the principles of sustainable development from the outset. Its development model, based on redistribution to the territories where the energy is produced, combines economic performance, social equity and environmental responsibility. This model has been strengthened still further since 2004, through the voluntary policy of Missions in the General Interest..

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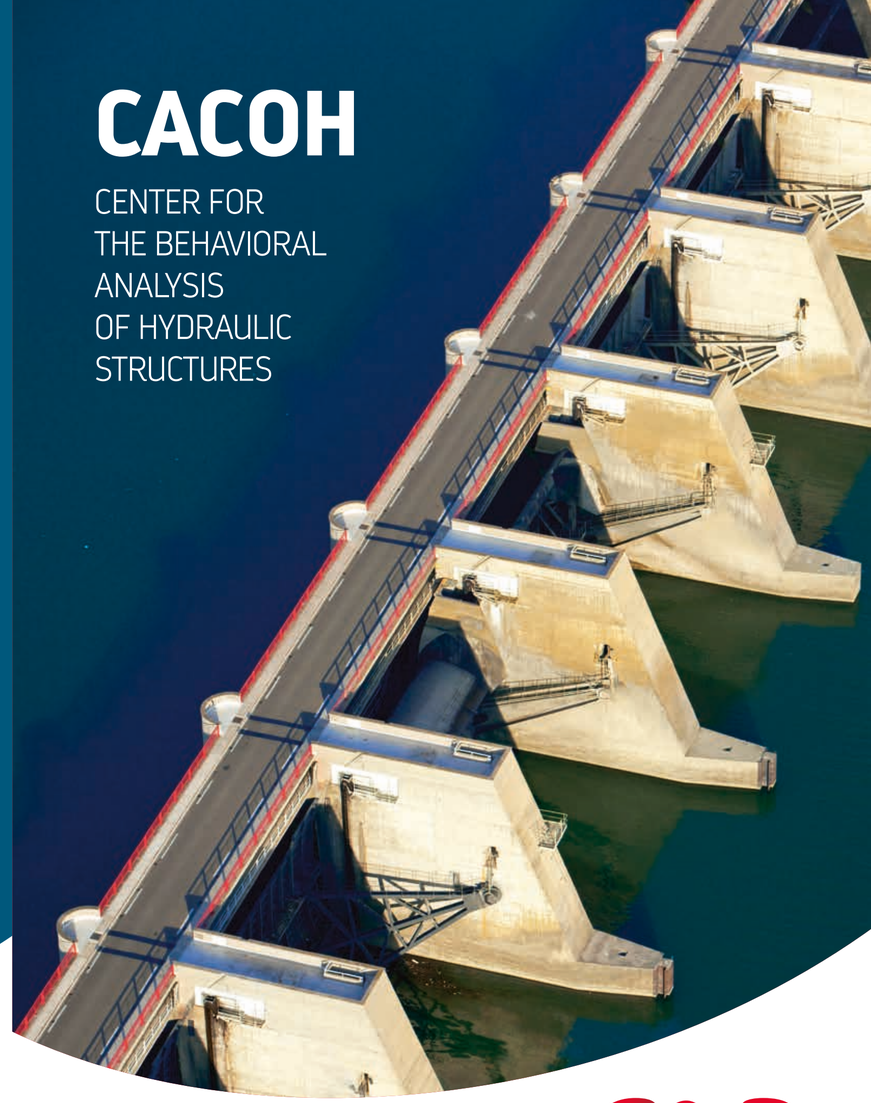
Energy is our future, so let's save it!

GRAPHISTA/04/2019

Energy is our future, so let's save it!

CACOH

CENTER FOR THE BEHAVIORAL ANALYSIS OF HYDRAULIC STRUCTURES



Innovating

for projects, operations and safety

CACOH adopts an approach of permanent innovation to satisfy CNR's requirements for hydraulic safety and its commitments in favour of energy transition and climate protection.

A vital element for ensuring the optimisation of CNR's industrial facilities, innovation lies at the heart of the measurement, monitoring and modelling activities performed by CACOH. These innovations result from the creativity of the operational teams and long-term collaborations with leading-edge clusters, specific institutions and different partners: suppliers, laboratories, engineering offices, research centres, etc. Our approach combines knowhow and innovation, by privileging experience sharing and integrating new technologies at the earliest stages of their maturity.

CNR INNOVATION IN FIGURES

- **40 communications annually** at national and international conferences
- **50 RID projects** in progress
- **10 PhD theses** in progress
- **40% of RID projects** carried out by CACOH teams

SSELECTION OF ONGOING RID ACTIONS

- **Experimental research on internal erosion mechanisms in earth dikes**
- **Feasibility study on reinforcement of earth dikes under permanent hydraulic head by bio-calcification**
- **Hydraulic structures monitoring by aerial (LiDAR, photogrammetry) and subaquatic surveys**
- **Flow velocity measurement by LSPIV, ultra-sound and radar**
- **Bedload and suspended load measurement using acoustic methods**

CENTER FOR THE BEHAVIORAL ANALYSIS OF HYDRAULIC STRUCTURES

FLOWS
- Measurement and monitoring of water and sediment fluxes
- Measures related to hydraulic performance
- Hydraulics and physical modelling laboratory
- Sediment management

STRUCTURES
- Bathymetric measurements and river bed monitoring
- Materials engineering
- Control and monitoring of civil engineering and hydro-electromechanical structures

Support for measures and expert tools

Measuring

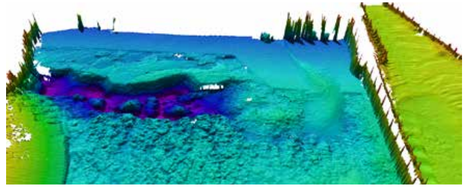
water discharges and sediment inflows

CACOH's hydrometry specialists are responsible for measuring water discharges and solid flows on the Rhone River and its tributaries. They monitor the evolution of inflows, evaluate the quality of the measures performed, and control the consistency of the data collected.

Thanks to the real-time supervision of a 220 gauging stations network, CACOH contributes to predicting the evolution of water inflows and thus optimising hydroelectricity production programmes. The challenge is to guarantee the supply of reliable, precise and consistent observations that are continuously available to support the operation of hydraulic structures from low water flows to flood conditions.

MEASURING AND IMPROVING PERFORMANCE

CACOH carries out analyses to evaluate the performance of the hydraulic systems operated by CNR: turbine units, locks, gates, etc. These analyses rely on advanced measurement techniques and are used to optimise the operation of structures while conforming to the initial design criteria.



Monitoring

the morphological evolutions of the Rhone and its tributaries

The activities of CACOH's hydrographic team consist in monitoring and analysing the evolution of the bed of the Rhone River due to the sediment supply of tributaries and to the specific dynamics of the river.

The first aim of those measurements is to verify that the depth of the navigation channel is sufficient for the boats to navigate in total safety. They are performed on each reach at regular intervals and after every significant flood. These field surveys are carried out using a multi-beam echo sounder installed on the «Frédéric Mistral» hydrographic vessel. A side scan sonar used for objects detection and river bottom classification is also part of the embedded equipment. Four smaller vessels equipped with single beam echo sounders complete those measurements in shallow water sections. Specific inspections are also carried out close to the submerged parts of the structures in order to fully inspect concrete facing.

CNR'S ASSETS IN FIGURES

- **19** dams
- **19** hydropower plants
- **22** small hydropower plants
- **400 km** of dikes
- **330 km** of wide gauge navigable waterway
- **14** wide gauge locks
- **32** pumping stations

EXAMPLES OF STANDARD TESTS DEVELOPED BY CNR:

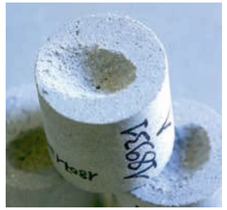
- **Impact resistance testing for materials subject to cobble impacts.**
- **Specific in-situ and lab tests to evaluate the quality and durability of rip-rap blocks exposed to freeze-thaw cycles.**
- **Abrasion test for qualifying the wear resistance of concretes subjected to rapid flows.**

Evaluating

the quality and ageing of structural materials

CACOH's materials engineering specialists carry out a large number of in-situ and lab tests for internal needs and at the request of external clients.

These tests conform to the national and international standards and their purpose is to control the quality and ageing of materials used to build hydraulic structures (ground, concretes and rock-fill). Some of these tests have been developed specifically by CNR and have become references for many clients.



Designing

projects using hydraulic physical scale models

The hydraulics and physical modelling laboratory is originally the core expertise of CACOH. Its mission is to design, optimise and validate technical solutions for solving complex hydraulic problems.

The CACOH hydraulic team designs and builds large- and small-scale models to simulate free surface and pressurized flows. It has also a cutting-edge expertise to provide cost-effective and practical solutions to sediment-related issues in rivers, torrents and reservoirs. Its experience in the hydraulic design and hydro-dynamic analysis of civil engineering structures is acknowledged internationally. In addition, the CACOH experts combine in a perfect synergy the respective advantages of state-of-the-art numerical and physical scale models to survey non-standard hydraulic structures.

MAIN APPLICATIONS

- **Dams, spillways**
- **Hydropower plants**
- **River and torrent developments**
- **Large woody debris and sediment traps**
- **Locks, canals**
- **Water intake, pumping stations**

Controlling

the behaviour of hydraulic structures

Controlling and monitoring civil engineering structures and hydro-electromechanical equipment are the essential pillars of CNR's safety management system.

For CACOH's experts, the approach consists in analysing the behaviour of structures by evaluating information obtained from visual inspections and monitoring data. These diagnostics allow detecting possible changes in the structures, determining their real state and interpreting subtle early-warning signs potentially precursors of instabilities and dysfunctions. This diagnostic capacity combined with the preventive maintenance programme of the structures allows CNR to guarantee the hydraulic safety of its installations.

Managing

the sediment dynamics of the river and reservoirs

The sustainable sediment management of the Rhone River and its tributaries is of vital concern to CNR in view to conciliate the different issues at stake and the uses supported by existing stakeholders.

This mission, ensured by the CACOH sediment experts, consists in particular to guarantee the safety of navigation and the passage of floods without aggravating the natural impacts of phenomena for the riverine people and properties. To achieve this objective, the hydrometric and hydrographic data collected by CNR's teams are essential inputs for building models used to establish diagnostics, define integrated management strategies combining different challenges, and determining the actions required in areas where deposits and erosions may cause problems.