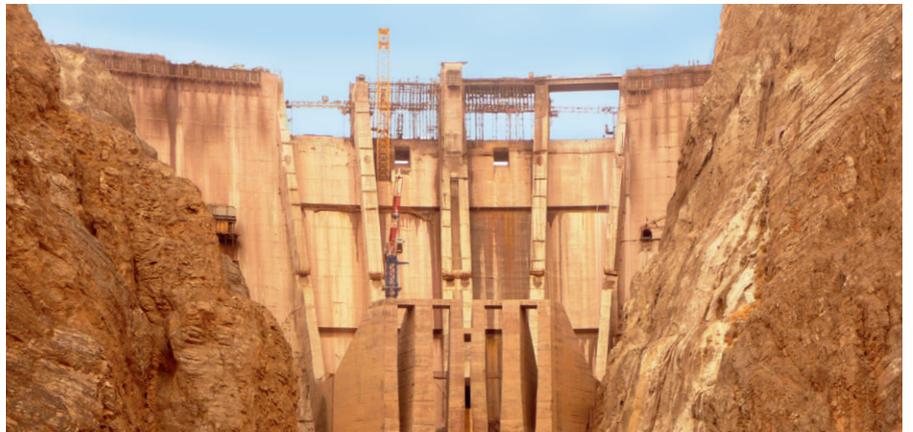


# GEOTECHNICAL ENGINEERING AND DAMS

*Shaping our world*



# Consultancy for Geotechnical Works in Hydropower and Water Resources Projects

## General Remarks

Geological and geotechnical challenges are often very demanding when planning hydraulic structures.

Hydropower, water supply and irrigation projects require a detailed geotechnical investigation as a basis for the design.

During planning and execution of the works, constant update of the parameters by geotechnical specialists is essential. The adopted design inevitably depends on the specific project requirements and actual in-situ conditions.

## All Project Phases

The focus of Tractebel in the field of geotechnical engineering includes all design phases, supervision and monitoring during construction of

all kinds of structures in rock and soil, such as caverns, tunnels, slopes, dykes, construction pits, dams and foundation sealing.

This includes the evaluation of the optimum location and orientation of the structures by designing individually tailored geotechnical investigation campaigns.

The scope of works covers all investigation and testing programmes necessary to determine the key characteristic parameters for underground structures, dams and foundations as well as for obtaining construction materials such as natural fill or concrete aggregate materials. An evaluation of the site-specific seismic hazard completes the scope.

## Pool of Experts

Tractebel's substantial and long-term experience guarantees that the geotechnical work in all planning phases, i.e. investigation, review, planning, tendering, construction supervision and commissioning can be provided by an in-house pool of specialists.

They can act as project managers, prepare expert reports, or can be integrated within design or construction supervision teams. The utilisation of a wide range of state-of-the-art specialised software is ensured.

The geotechnical staff of Tractebel stays in close contact with suppliers and developers of proprietary software products in order to secure further developments and updates of the software packages.

## Services for Geotechnical Engineering



# Geology / Geotechnics / Underground and Rock Engineering

## Geological Investigations

- Establishing geological basics from regional and detailed mappings, aerial photo interpretation, survey of stratigraphy, lithology, petrography, discontinuity systems and tectonics of the site
- Evaluation of seismic activity and seismic hazard assessment
- Borehole and surface geophysics for a continuous survey of the site characteristics in collaboration with specialised companies
- Identification of material sources and testing of their suitability as dam fill materials or concrete aggregates

## Geotechnical Engineering and Hydrogeology

- Design and tendering of geotechnical investigation campaigns. Execution, supervision and evaluation of

in-situ and laboratory testing also in cooperation with specialised companies

- Rock mass rating and soil classification, estimation of excavation and support classes. Determination of key characteristic soil and rock parameters as base for static and dynamic analyses
- Engineering judgement of groundwater conditions and their impact on structures. Design of groundwater barriers such as cut-off walls, grout curtains and groundwater handling in drains, wells or open channels
- Foundation design

## Design and Analyses of Structures in Rock

- Design, analyses and support determination for all stages for slopes, tunnels, caverns, shafts, etc.

- Determination of excavation sequences and techniques, blasting methods, handling of water, specialised construction methods and support measures

## Monitoring

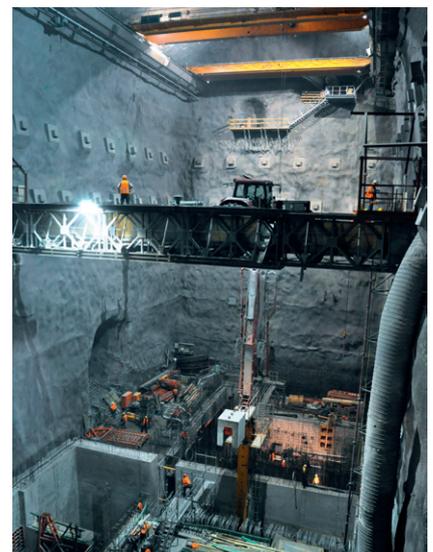
- Design of instrumentation systems and monitoring programs. Evaluation and interpretation of monitoring data during construction and operation of the structure
- Vibration measurements to monitor impact by blasting
- Geological and geotechnical mapping during construction and 'as-built' documentation
- Back analyses of structures and comparison of monitoring data versus best estimate. Adaptation of support measures according to encountered conditions and monitored behaviour if so required.



Specimen preparation for large-scale triaxial testing (Goldisthal, Germany)



Rock excavation & foundation preparation for a surface powerhouse (Nam Theun II, Lao PDR)



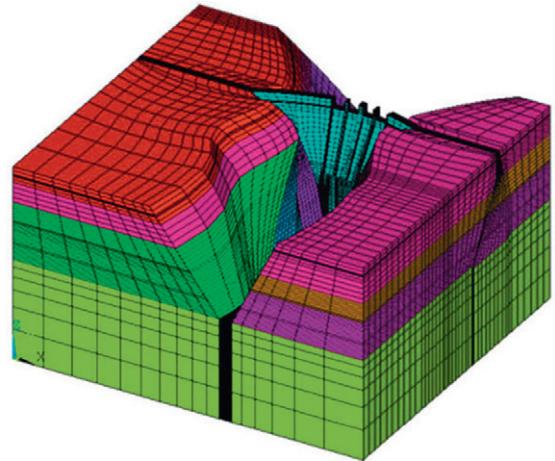
Excavated powerhouse cavern (Vianden, Luxemburg)

# Dam Engineering

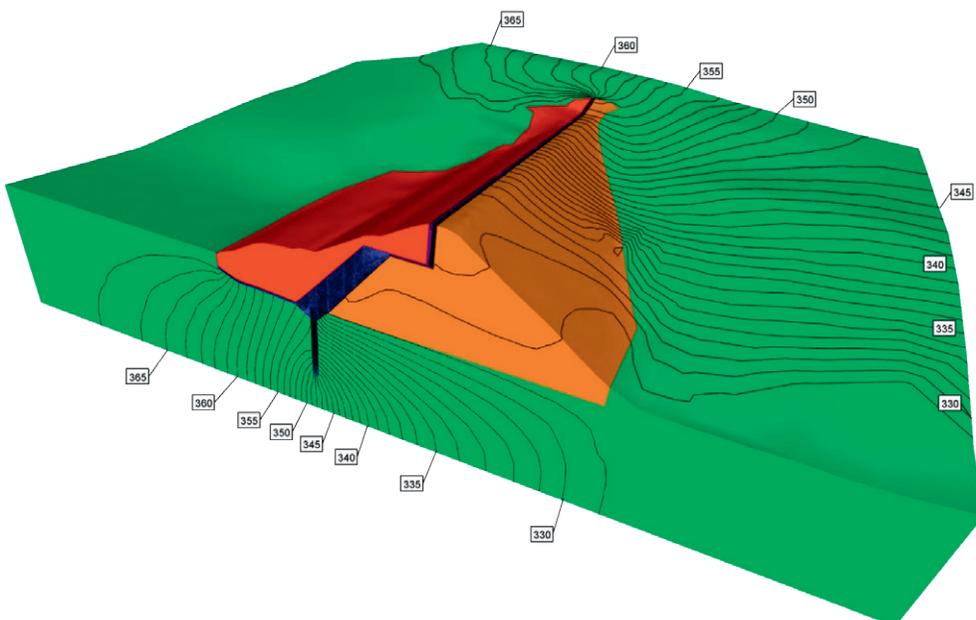
## Rockfill and Concrete Dams

- All design phases for dams and appurtenant structures, including feasibility studies, tender design and tendering, construction design, and commissioning. Dam site and type evaluation. Layout development
- Analyses of dams, e.g. stability analysis, 2D and 3D FEM modelling, thermal impact, consolidation and seepage analyses
- Design of construction pits, including support structures, grouting/sealing, groundwater lowering and water handling measures
- Managing and planning of investigation campaigns, design and site supervision of dams and their foundations and abutments including impermeable barriers and drainage systems

3D FEM modelling of arched RCC dam



- Field compaction tests and triaxial tests on rockfill
- Site supervision and quality control
- Mix designs for conventional concrete and RCC
- Specification and evaluation of laboratory tests and full-scale trials using the final construction equipment
- Thermal studies for concrete dams
- 3D dynamic time history analysis of dams
- Evaluation of the hazard of suffusion, internal erosion, liquefaction of dam and/or foundation material



Groundwater flow modelling



## Special Topics



*Pendulum in a concrete arch dam*

### Safety Assessment and Emergency Action Plan

- Development of a dam safety programme and maintenance & operation manual
- Performing dam safety review and field safety investigations
- Preparation of an emergency action plan (EAP), including the related structural and hydraulic field analysis
- Establishing annual dam safety reports

### Rehabilitation and Upgrade

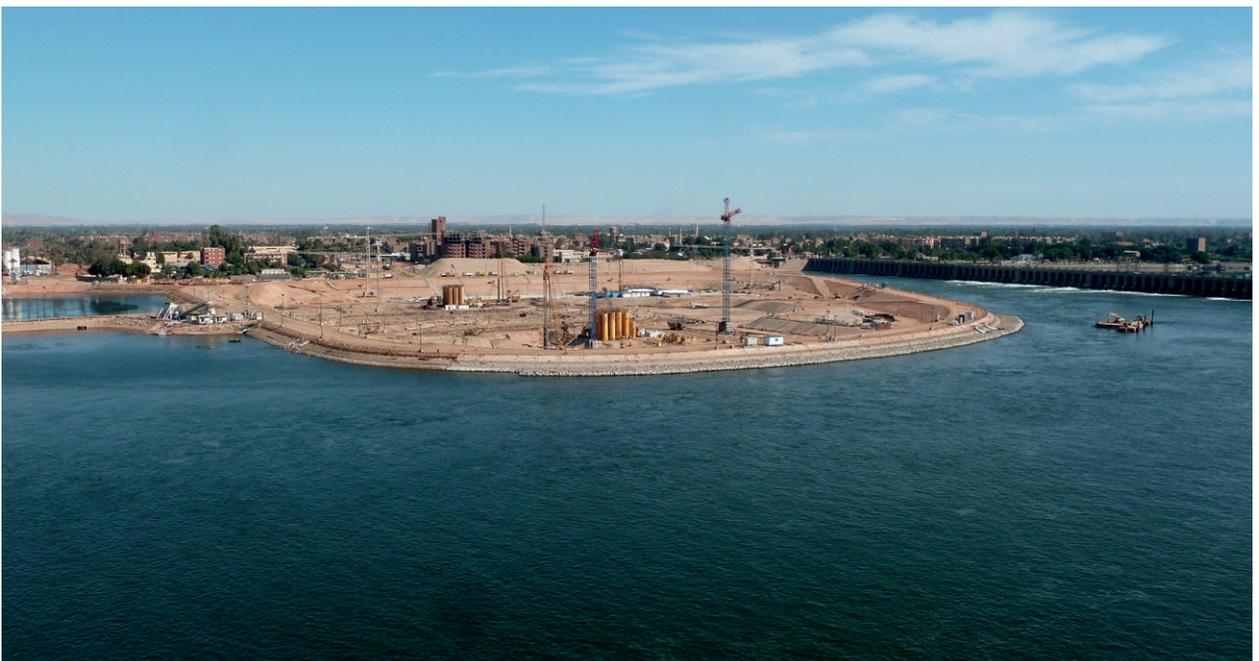
- Recording existing conditions, damage assessment, development of rehabilitation concepts, design and supervision of rehabilitation and/or upgrade works for existing dams, powerhouse foundations and appurtenant structures, tunnels, etc.

### Environmental Investigations

- Determination of environmental influences of dams and reservoirs
- Geotechnical input to environmental impact studies

### Consultancy to Contractors and Financiers

- Preparation of expert reports, risk evaluation, cost estimates, support to project management. Advice on all geotechnical aspects of the works including technical aspects of claims
- Support for preparation of proposals and detailed construction design
- Construction supervision
- Damage and loss analysis
- Due Diligence consultancy



*Assiut Barrage construction pit (Assiut, Egypt)*



# We are Tractebel

Tractebel provides a full range of engineering and advisory services throughout the life cycle of its clients' projects, including design and project management. As one of the world's leading engineering and advisory companies and with more than 150 years of experience, it's our mission to actively shape the world of tomorrow. With about 5,000 experts and presence in more than 70 countries, we are able to offer our customers multidisciplinary solutions in energy, water and urban.

Since December 2014, Tractebel Engineering GmbH (former Lahmeyer International) belongs to Tractebel and thus is part of the international ENGIE group headquartered in Paris. Tractebel (Brussels, Belgium) and Tractebel Engineering GmbH (Bad Vilbel near Frankfurt, Germany) cooperate on numerous international projects as one company.

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