

# Safe Dams to Serve for a Better World

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Dean – Faculty of Civil Engineering

ICOLD - Vice President – Europe; ATCOLD - President





# Dams for a better world



# Content of Presentation

Austrian Dam Commission

Development of Austrian National Committee on Large Dams  
Regulations

Academic Education – Dam Safety

Context of ICOLD

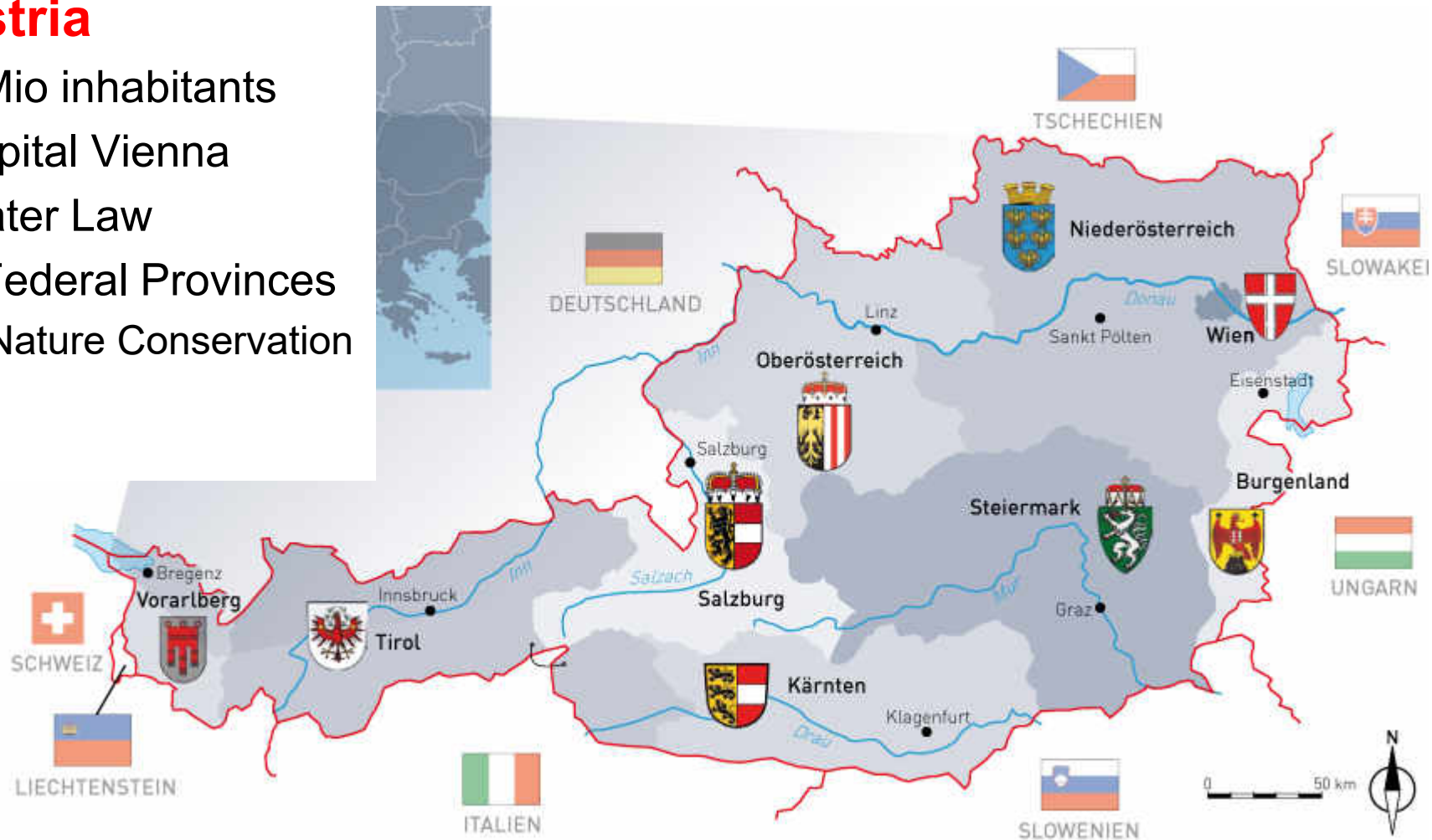
National Committee's  
Technical Committee's



# Austria Overview

## Austria

- 9 Mio inhabitants
- Capital Vienna
- Water Law
- 9 Federal Provinces
  - Nature Conservation



# Role of Dams

- Hydropower
- Flood Mitigation / Irrigation
- Reservoirs – Snow Production
- Navigation
- Recreation
- Improving flow conditions during dry conditions



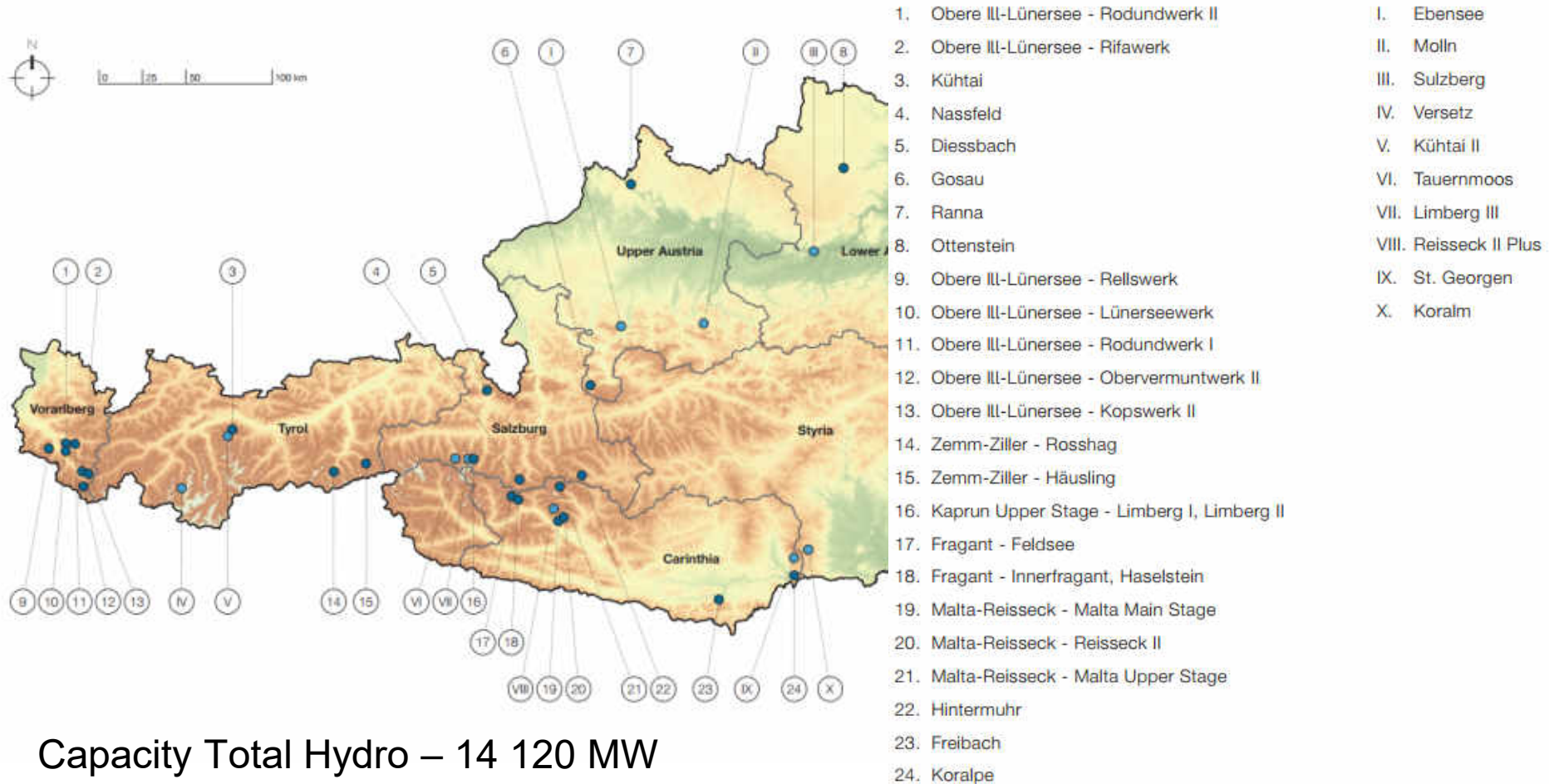
Ti



## Kaprun – Limberg / Mooserboden



# High Head Pumped Storage Schemes



Capacity Total Hydro – 14 120 MW

High Head Power Plants / Pumping – 9400 MW / 5200MW





# Dam Safety – Large Dams

## The Start

- **1916 a flood mitigation reservoir embankment dam failed during heavy rainfall**  
caused a lot of victims and economic loss



# Dam Safety – Large Dams

## The Start



# Dam Safety – Large Dams

## The beginning

- **1916 a flood mitigation reservoir embankment dam failed during heavy rainfall**  
caused a lot of victims and economic loss
- **1918 “Austrian Dam Commission” (ACD) was founded**  
to avoid such disasters in the future

This commission is a panel of experts of all fields of Dam Engineering.  
**Must be consulted by authorities in cases of new dam projects,**  
dam height > 15m or reservoir capacity > 500.000m<sup>3</sup>.



# Number of large dams

## Austria

- **About 150 dam projects have been examined by the commission**  
embankment dams with different sealing concepts  
all types of concrete dams
- **85 dams for energy production (up to 200m)**
- **42 dams for snowmaking (up to 40m)**
- **23 dams for flood mitigation (up to 40m)**

## Salzburg

- **19 dams for energy production (up to 112m)**
- **20 dams for snowmaking (up to 40m)**
- **2 dams for flood mitigation (up to 18m)**



# Dam Inspection - organization

## The beginning

1959 failure of the Malpasset Dam (France)  
1963 failure of the reservoir slopes of Vajont (Italy)  
**both failures caused numerous victims**

### Austria

- **After these causalities the Subcommittee for Dam Inspection was established.**  
To do periodical sound inspections of all Large Dams in Austria

### Salzburg Province Supervisor

- **since 1970 - dams for energy production**
- **since 2013 – dams for snowmaking reservoirs**



# State of the Art

## Austrian Dam Commission elaborate specific guidelines

Guideline  
stability evaluation concrete  
dams



Guideline  
stability evaluation  
embankment dams



Guideline  
flood estimation safe flood  
control



Guideline  
control centers  
supervising  
remote controlling

# State of the Art Small dams

## Austrian Dam Commission (ACD)

Requirements on Dam Safety Engineers and Dam Surveillance



**Mindestanforderungen  
an den Stauanlagenverantwortlichen  
von „Kleinen Stauanlagen“**  
FASSUNG 12/2009



**HANDBUCH**  
Betrieb und Überwachung von „kleinen Stauanlagen“ mit  
länger dauernden Staabelastungen  
FASSUNG 12/2009



# State of the Art Snowmaking reservoirs

Federal provinces and the ACD elaborate special guidelines



Part 1: New reservoirs



Part 2: Existing reservoirs







ATCOLD

Österreichisches Nationalkomitee für Talsperren

Seit 80 Jahren im Dienste der Talsperrensicherheit

# 06. Juni 2013

80+ Jahre - Staubeckenkommission Mitglied der ICOLD

50+ Jahre - Österreichisches Nationalkomitee für Talsperren

Sichere Talsperren - Sichere Infrastruktur



# Historical Development

1919 – Setup of Austrian Dam Commission

Assessment of large dam

Initiating Event

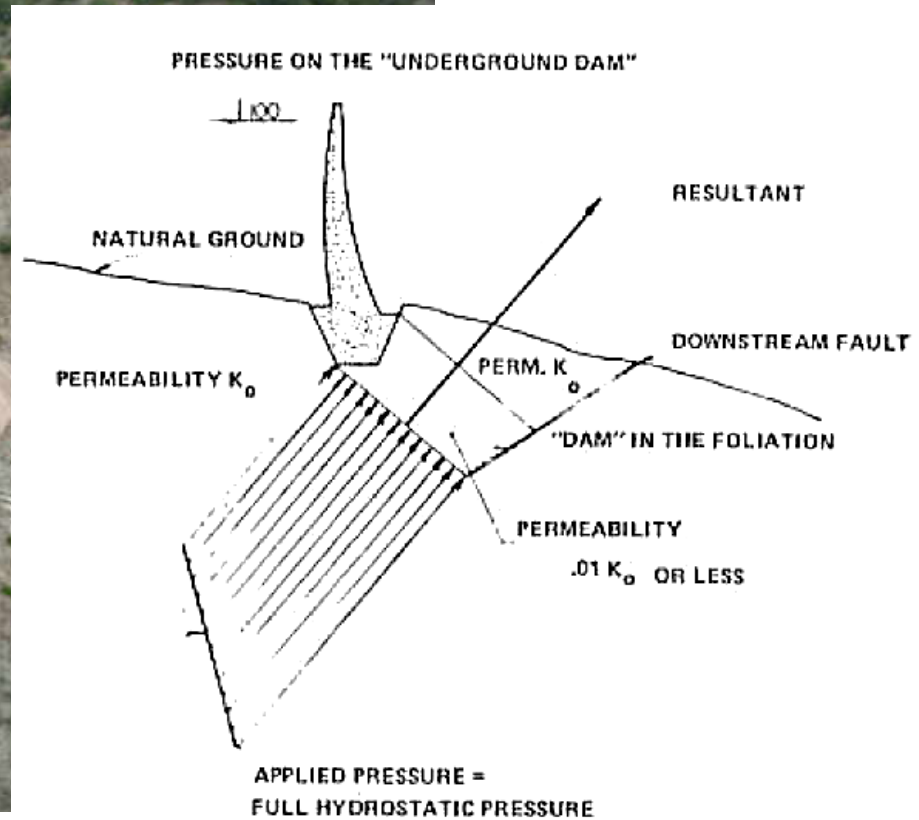
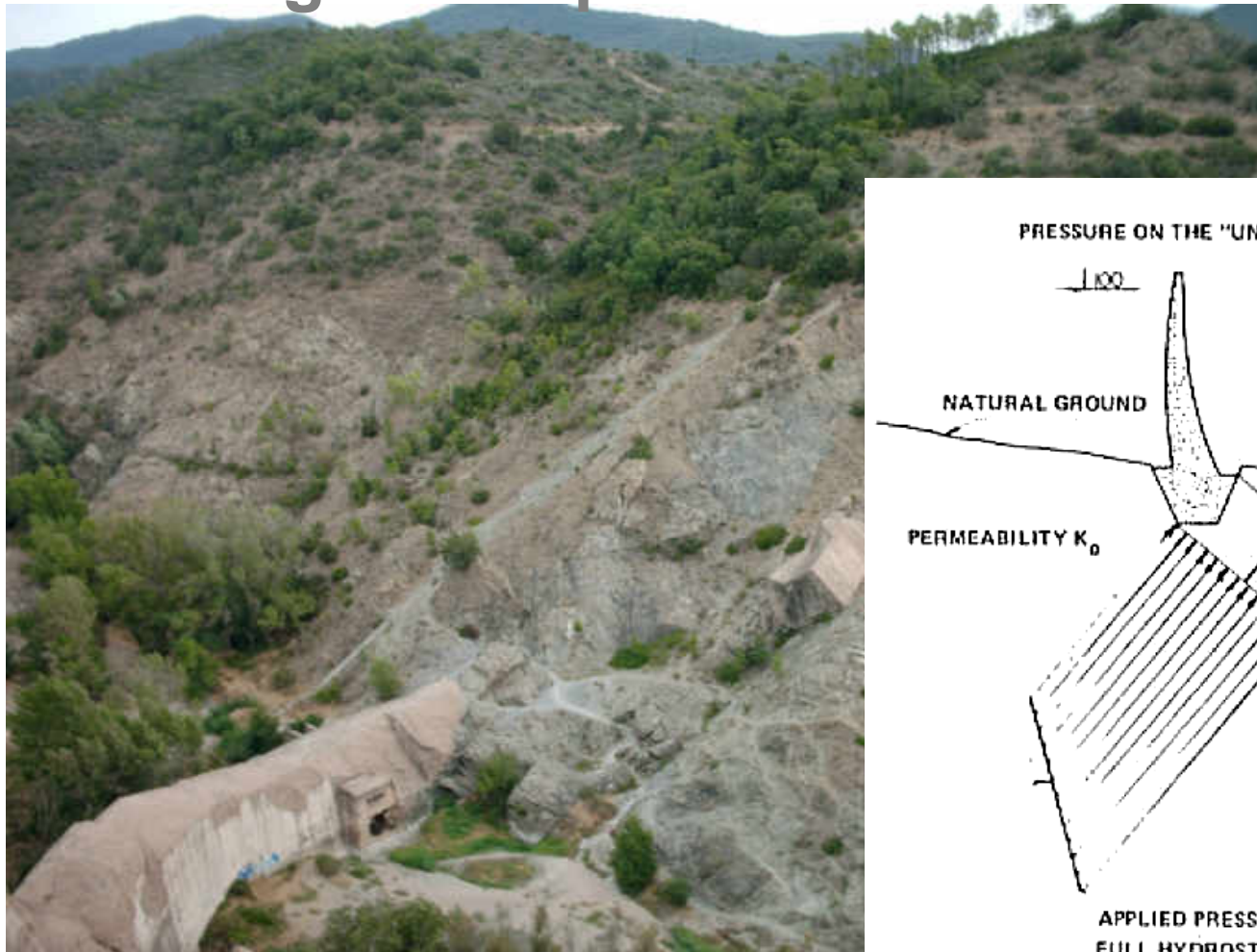
Failure Flood Retention Reservoir “Weisse Desse”

1928 – Founding - International Commission on Large Dams - ICOLD

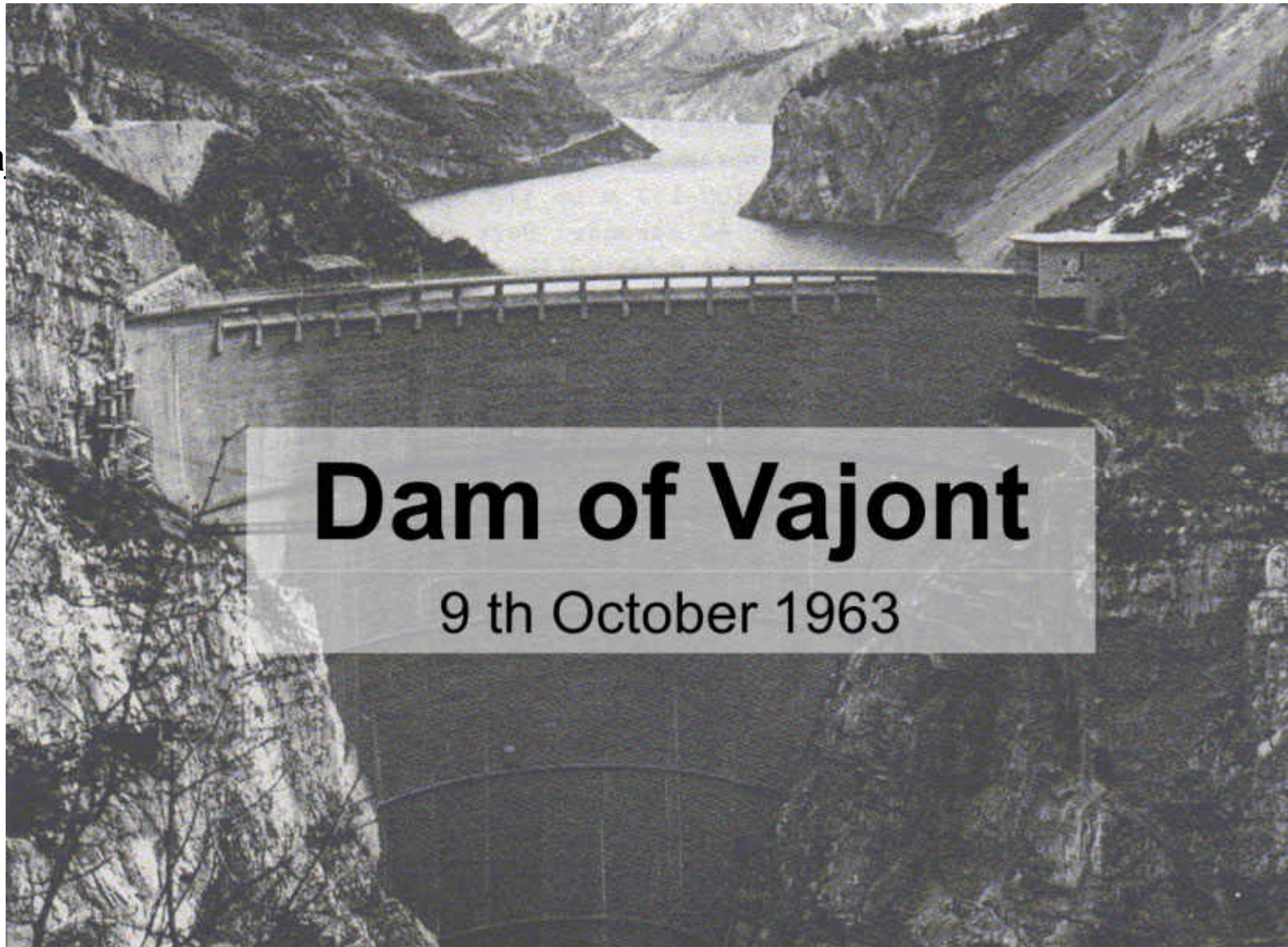
1931 – First General Assembly Meeting of ICOLD –  
with 13 National Committees, including Austria –  
represented by a committee of Austrian Dam Commission



# Arch Dam Malpasset - 2. Dezember 1959 Initiating developments in Rock Mechanics



Va



# Dam of Vajont

9 th October 1963





**The Vajont reservoir.**

**Before...**



**... and after**

# Time Line Development of ATCOLD

## Interaction of Foundation – Water - Dam

Soil- and Rock mechanics – Hydrology and Hydraulic – Structural Mechanics

1962 – Foundation of Austrian National Committee on Large Dams

Representing Austria in ICOLD

Focusing on and representing of issues for Dams

Knowledge transfer and research for Dams

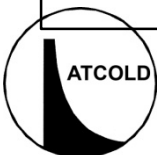
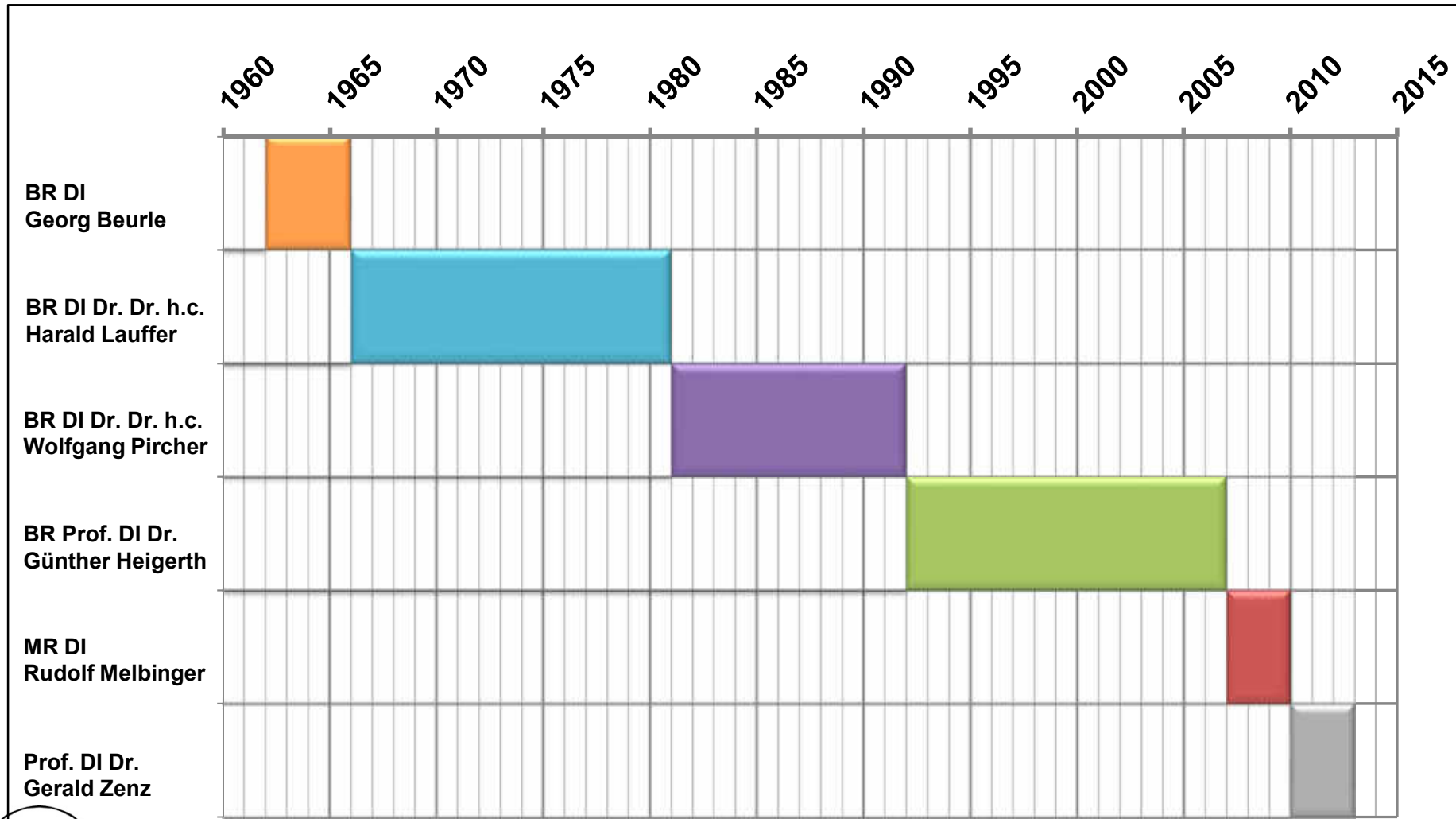
Education about dam design and operation

1962 – Foundation of Austrian Society of Geomechanis (later ISRM)

Headquarter in Salzburg



# Austrian National Committee on Dams 1962 - 2013



# Commemorate of Hermann Grengg's plaque Graz University of Technology









## Die Talsperren Österreichs - Heft 34



**Autor:** Prof. Walter Schober

**Titel:** Embankment Dams, Research and development, construction and operation





## Die Talsperren Österreichs - Heft 35



**Autor:** Dipl.Ing. Dr.techn. Richard Widmann

**Titel:** Arch Dams, Experiences-Problems-Developments





# Graz University of Technology



ATCOLD

Austrian Committee on Dams

Dam Engineering

## History

- 1811** The *Joanneum* is founded by the Archduke Johann.
- 1864** The Styrian Government makes it an institution of higher education called "*Technische Hochschule*".
- 1874** The k.k. *Technische Hochschule* is taken over by the state.
- 1901** The *Technische Hochschule* is granted the right to award doctorates.
- 1955** University Organisation Act 1955 (HOG '55).  
The *Technische Hochschule* is divided into three faculties.
- 1975** University Organisation Act 1975 (UOG '75).  
Divided into five faculties.  
Renamed into *Graz University of Technology, Erzherzog-Johann-University*.
- 1993** University Organisation Act 1993 (UOG '93).
- 1996** The adoption of UOG '93 is completed.
- 2002** University Act 2002 (UG '02).
- 2004** The UG '02 comes into effect.  
*Graz University of Technology* is divided into seven faculties and 104 institutes.  
Becomes a legal entity in public law.  
The University is headed by the Rectorate, the Senate and the University Council..



## The 7 faculties of the Graz University of Technology

- Architecture
- **Civil Engineering**
- Mechanical Engineering and Economic Sciences
- Electrical and Information Engineering
- Technical Mathematics and Technical Physics
- Technical Chemistry, Chemical & Process Engineering and Biotechnology
- Computer Science



**TU AUSTRIA**  
Austrian Universities of Technology



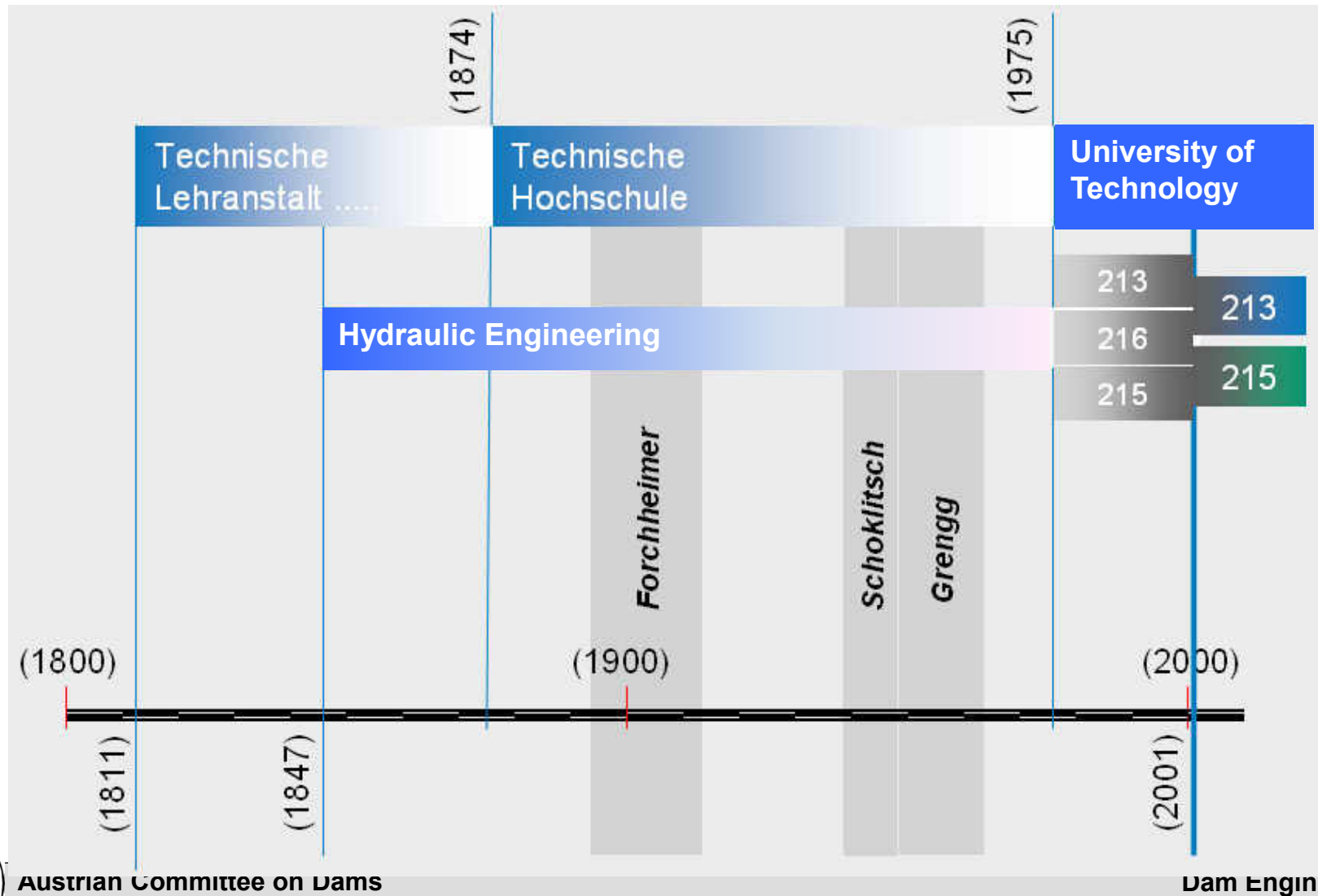
10 Jahre  
Universitätsautonomie

Zentrale Erfolge der drei technischen  
Universitäten Österreichs

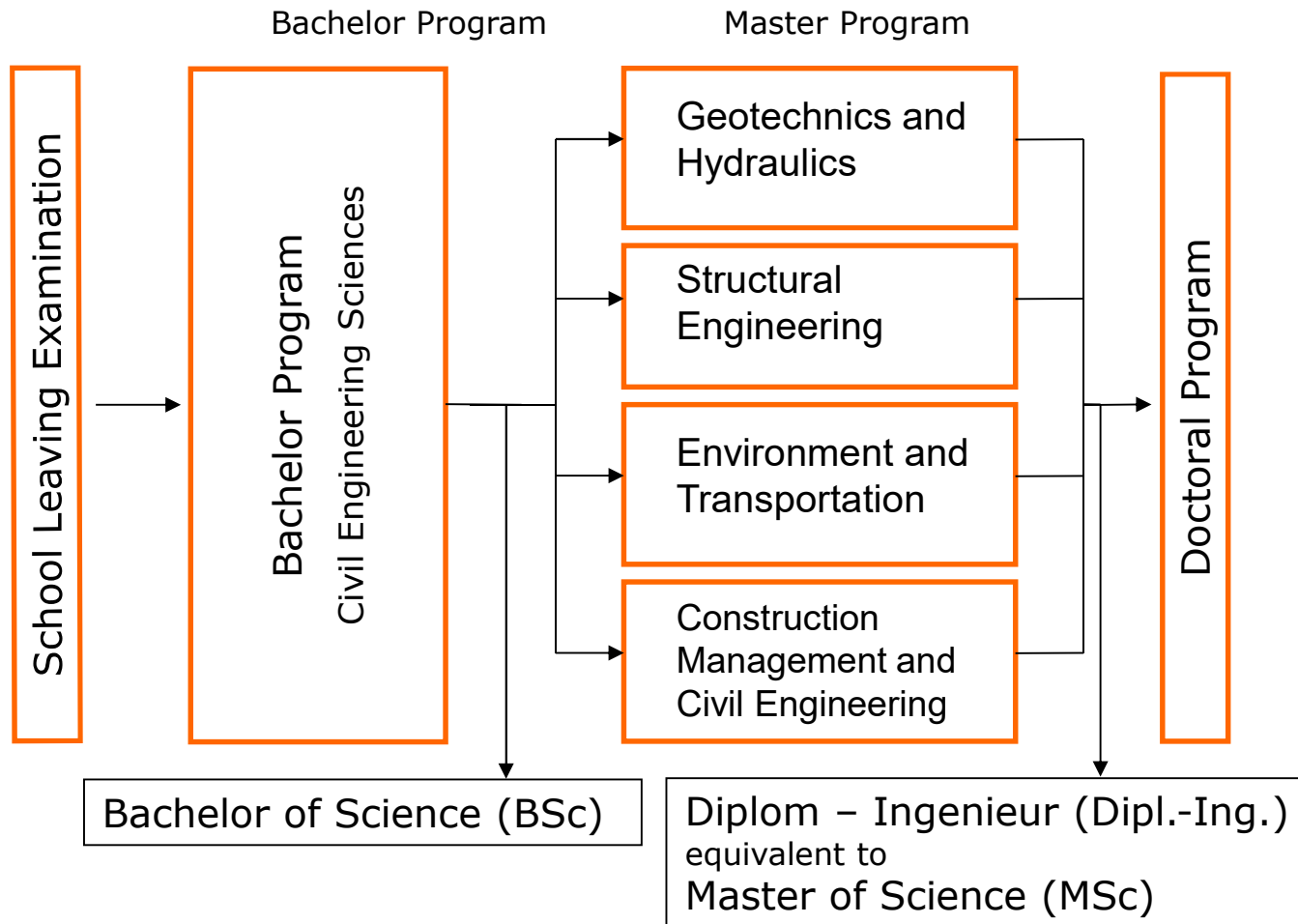




# Structure of hydraulic engineering



# Education – is our Success



# Geotechnical & Hydraulic Engineering

## Admission Requirements & Application Information

Students worldwide are invited to apply for admission to the Master of Science program in Geotechnical & Hydraulic Engineering. English proficiency and an earned bachelor degree in Civil Engineering (compatible with European standards) are required.

For detailed information regarding application and admissions requirements, tuition, fees and related topics, please visit the TU Graz website:

[www.tugraz.at](http://www.tugraz.at)  
 >Academics>Registration Office

Curriculum Details and Syllabus: [www.bau.tugraz.at](http://www.bau.tugraz.at)

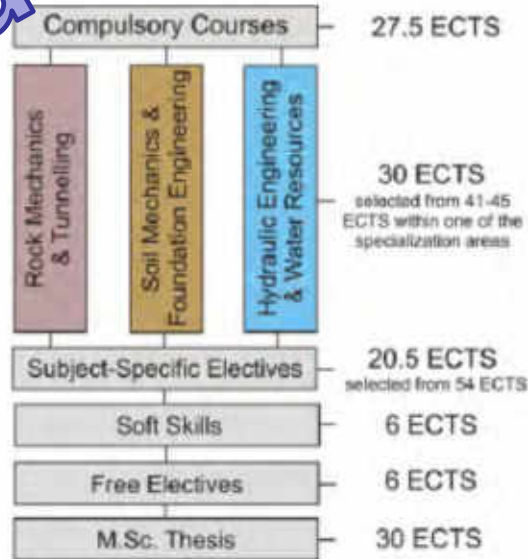


## Participating Institutes

The Master of Science program in Geotechnical & Hydraulic Engineering is offered through the auspices of several institutes of the Faculty of Civil Engineering and the Institute of Engineering Geology and Measurement Systems. For subject-specific information pertaining to the core participating institutes please visit the following websites:

- Rock Mechanics & Tunneling
- Soil Mechanics & Foundations
- Hydraulic Engineering & Water Resources

A total of 60 European Credit Transfer and Accumulation System (ECTS) units comprise the M.Sc. program. The academic degree granted is the Dipl.-Ing. (equivalent to the M.Sc.).



TU  
Graz

Graz University of Technology  
Faculty of Civil Engineering

**TU GRAZ  
MASTER'S  
PROGRAM**

**Master of Science in  
Geotechnical & Hydraulic Engineering**





ICOLD 2018  
26<sup>th</sup> Congress  
86<sup>th</sup> Annual Meeting  
1 - 7 JULY, VIENNA



CIGB 2018  
26<sup>ème</sup> Congrès  
86<sup>ème</sup> Réunion Annuelle  
1 - 7 JUILLET, VIENNE

Picture copyright: VERBUND

**Session Mo-TW3**

**A-COMPUTATIONAL ASPECTS OF ANALYSIS AND DESIGN OF DAMS**  
**B-SEISMIC ASPECTS OF DAM DESIGN**

Chair TC A: Guido MAZZA, Chair TC B: Martin WIELAND





**ICOLD**  
International  
Commission on  
Large Dams

**15<sup>th</sup> International Benchmark  
Workshop on Numerical Analysis  
of Dams**

**9<sup>th</sup> - 11<sup>th</sup> September 2019  
Milano, Italy**

**Topics**

- Theme A:** Seismic analysis of Pine Flat concrete dam. *Formulators: USBR; University of Boulder (USA). KTH (Sweden). RSE (Italy)*
- Theme B:** Seismic analyses of Menta Embankment dam. *Formulators: Cassino and Southern Lazio University; Perugia University; So.Ri.Cal. SpA (Italy)*
- Theme C:** Coupled hydromechanical analysis of the pre-failure and the failure behaviour of a levee on soft subsoil. *Formulators: Politecnico di Milano (Italy). Delft University of Technology; STOWA (The Netherlands)*
- Open Theme:** Papers related to numerical modelling of dams and/or appurtenant structures

- 1991 Bergamo, Italy
- 1992 Bergamo, Italy
- 1994 Paris, France
- 1996 Madrid, Spain

**1999 Denver, United States**

- 2001 Salzburg, Austria
- 2003 Bucharest, Romania

**2005 Wuhan, China**

**2007 St. Petersburg, Russia**

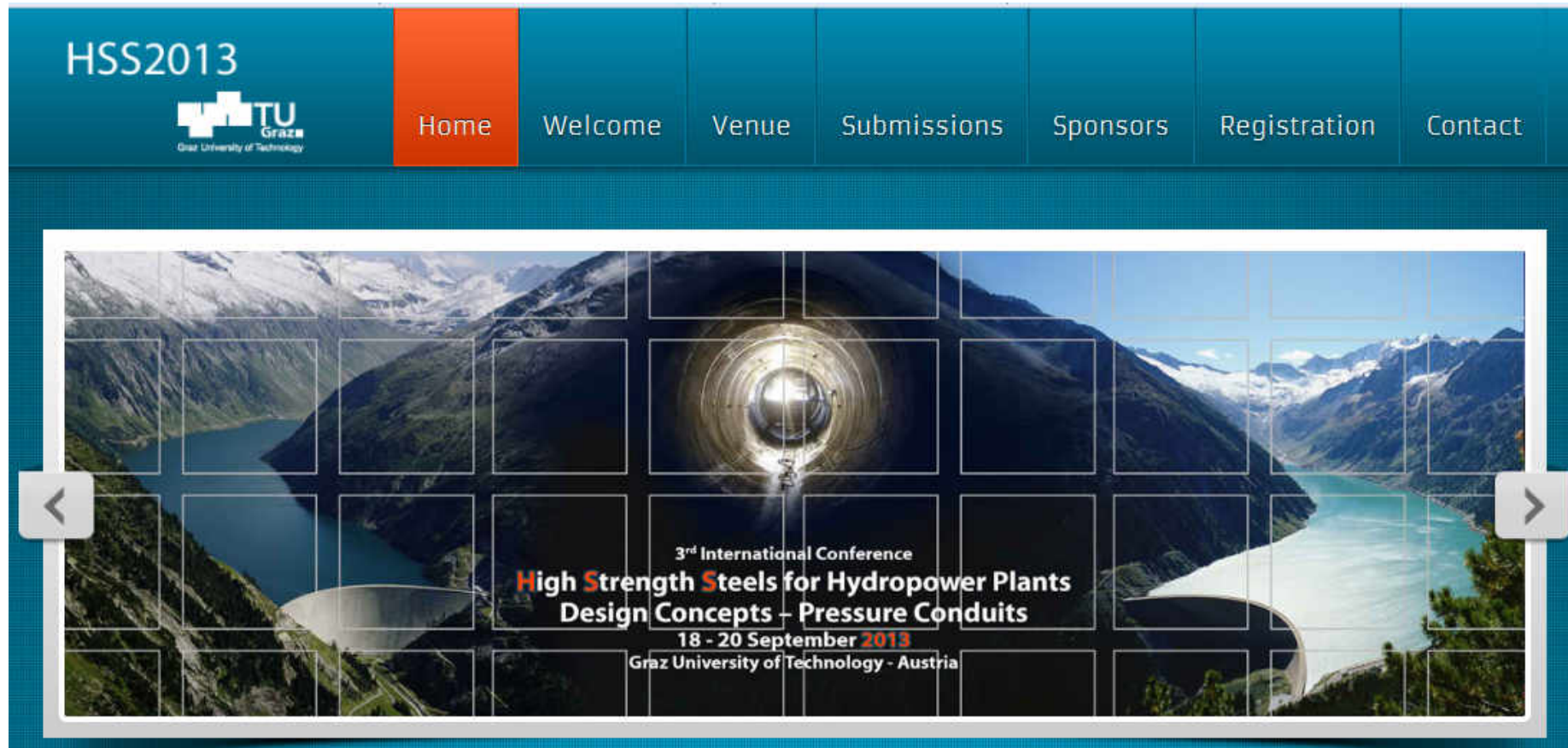
- 2009 Paris, France
- 2011 Valencia, Spain
- 2013 Graz, Austria
- 2015 Lausanne, Swiss
- 2017 Stockholm, Sweden
- 2019 Milano, Italy

 **POLITECNICO MILANO 1863** CONFERENCE HOME ABOUT SEARCH TEAM VENU



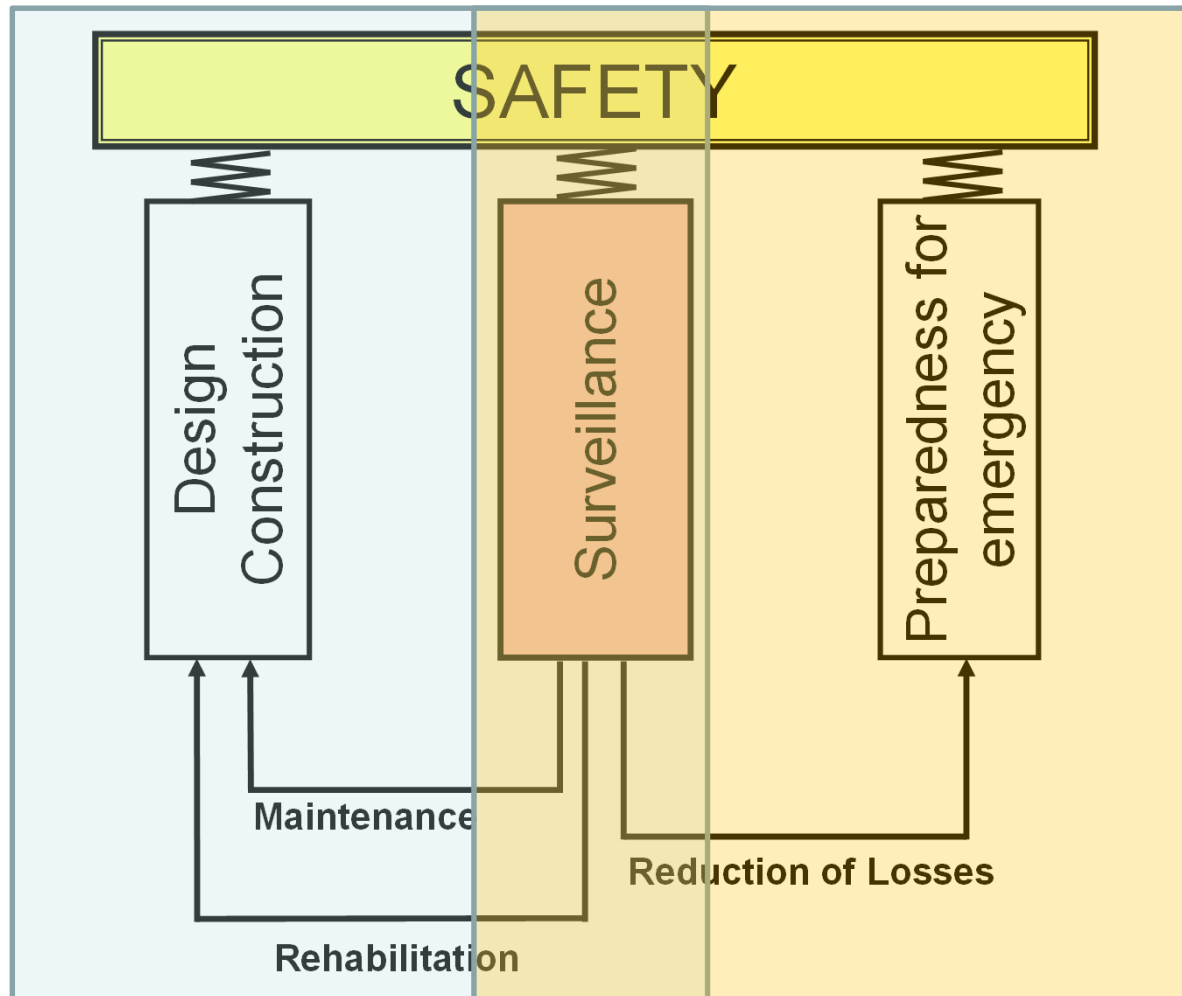
**ICOLD-BW 9<sup>th</sup>-11<sup>th</sup> September 2019 MILANO**

**Numerical analysis of dams**



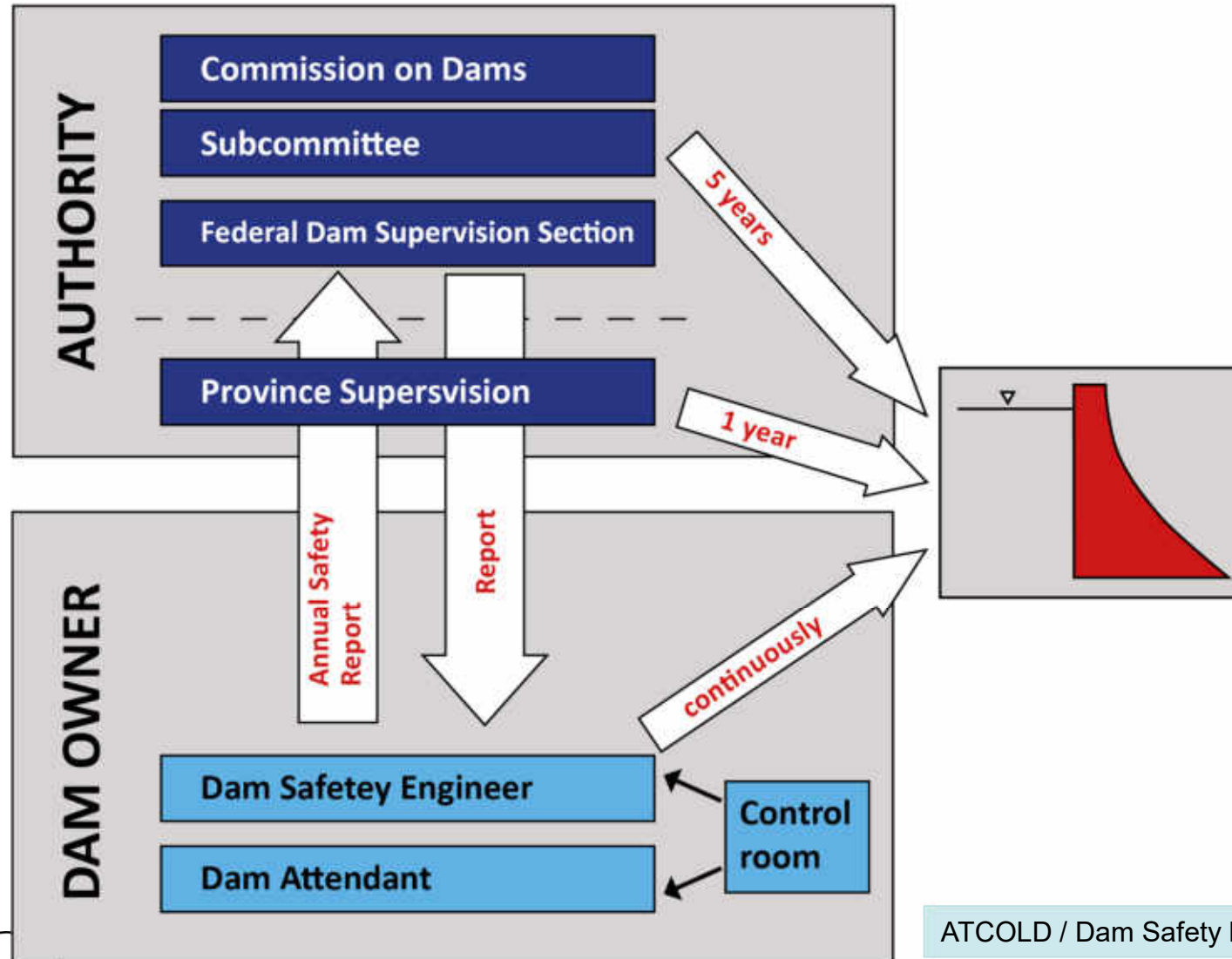
Dam Engineering is multidisciplinary –  
Needs highly specialized knowledge – **Needs Research**



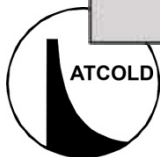


ATCOLD / Dam Safety Expert Seminar / Melbinger

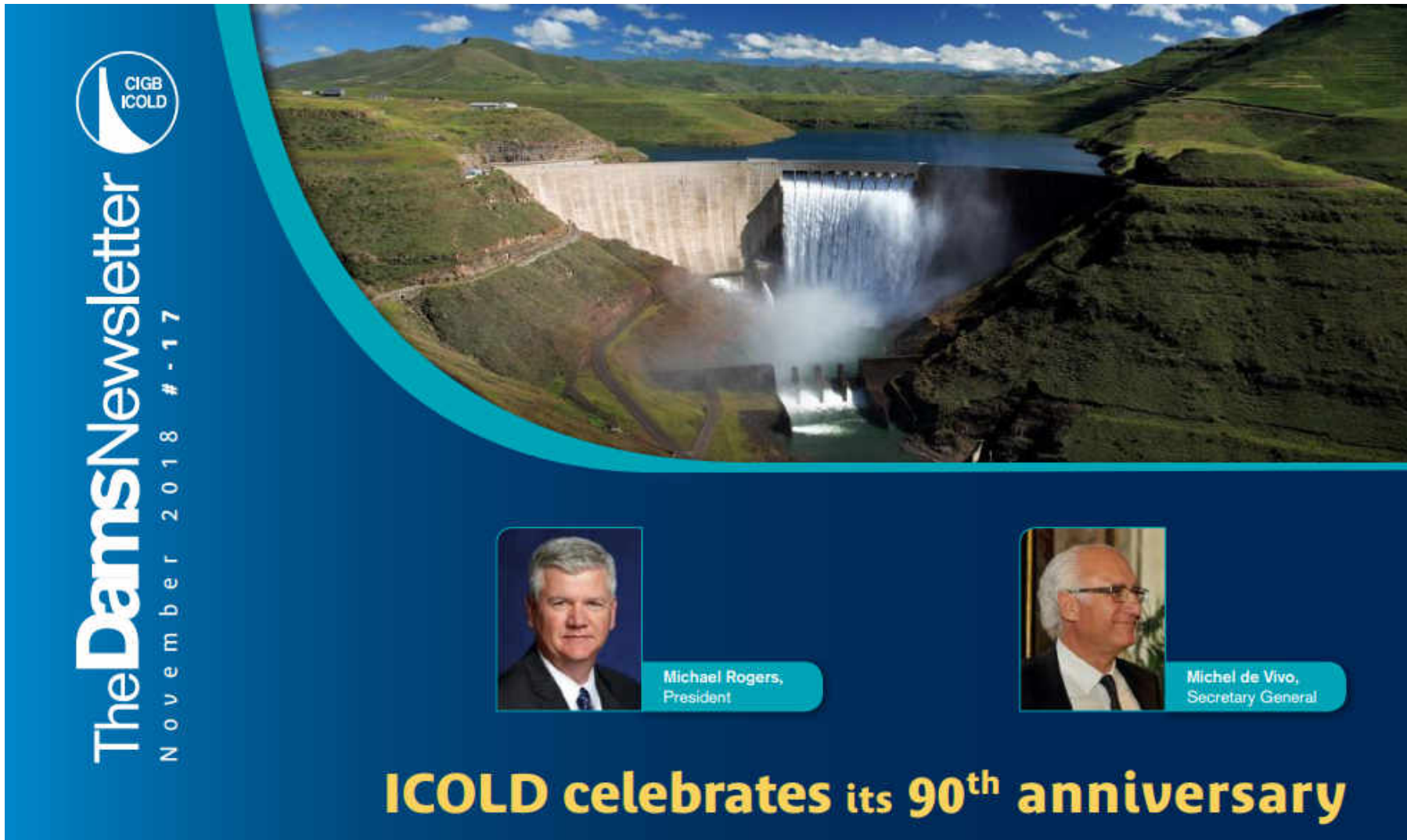
# MULTI-LEVEL PRINCIPLE





ATCOLD / Dam Safety Expert Seminar / Melbinger








  
**The Dams Newsletter**  
November 2018 # - 17

  
Michael Rogers,  
President

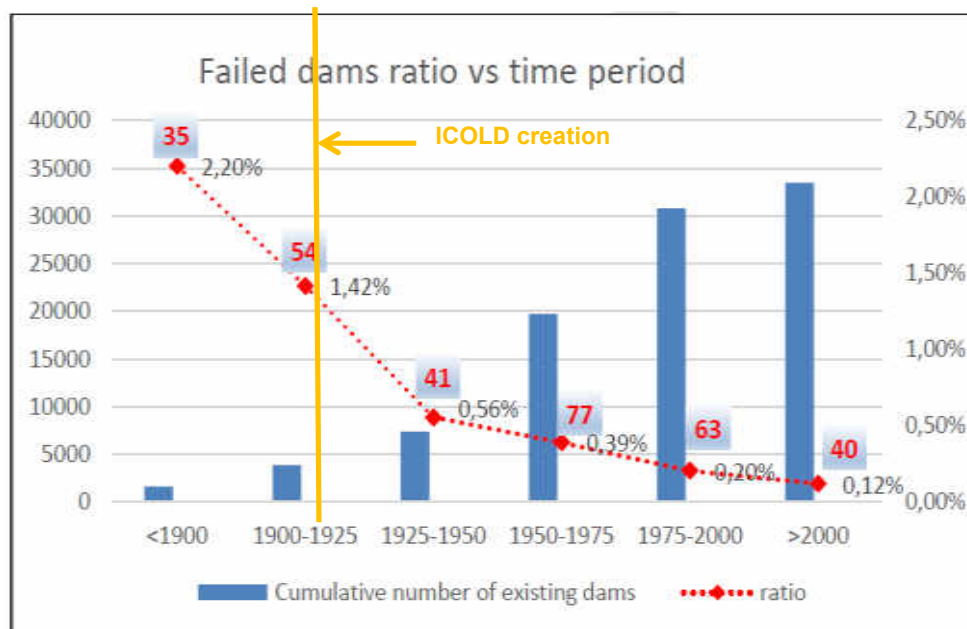
  
Michel de Vivo,  
Secretary General

**ICOLD celebrates its 90<sup>th</sup> anniversary**



## Dam Safety - Core value for ICOLD

ICOLD played a key role in the **very strong improvement of dam safety**



Source : ICOLD Dam Safety Committee -  
Michel Lino

Failure rate

- Before 1925 > 1,4%
- Now 0,12%

ICOLD Technical Committees: bulletins and congress

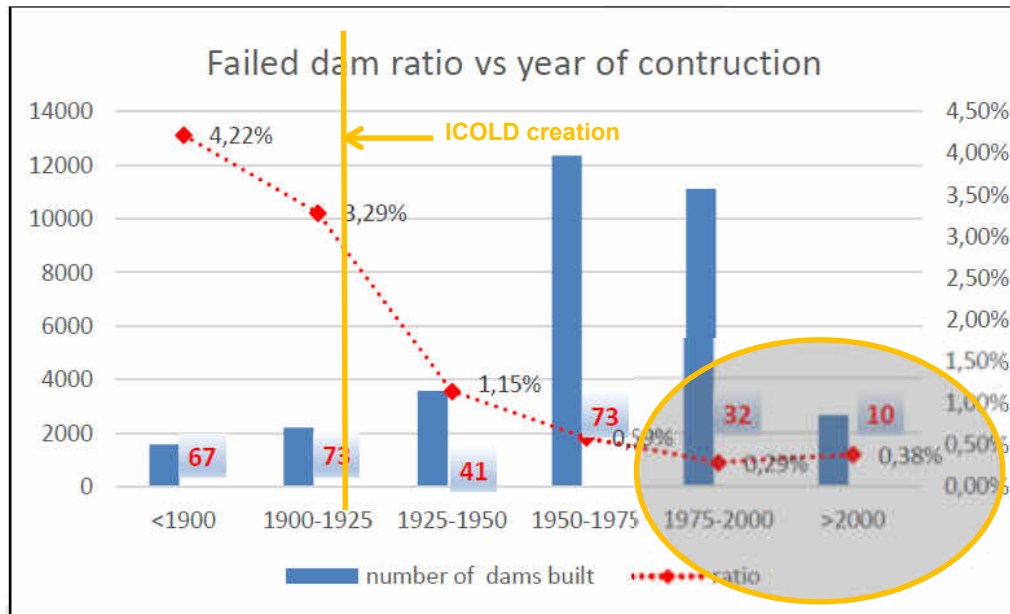
Also, major advances in dam science and technology in the last 50 years





# Dam Safety - Core value for ICOLD

However, **strong efforts still necessary**



### Failure rate

- 1900-1925 3,29%
- 1975-2000 0,29%
- 2000-2018 **0,38%**

?  
Stagnation in dam safety progress?

Source : ICOLD Dam Safety Committee - Michel Lino



# Dam Safety

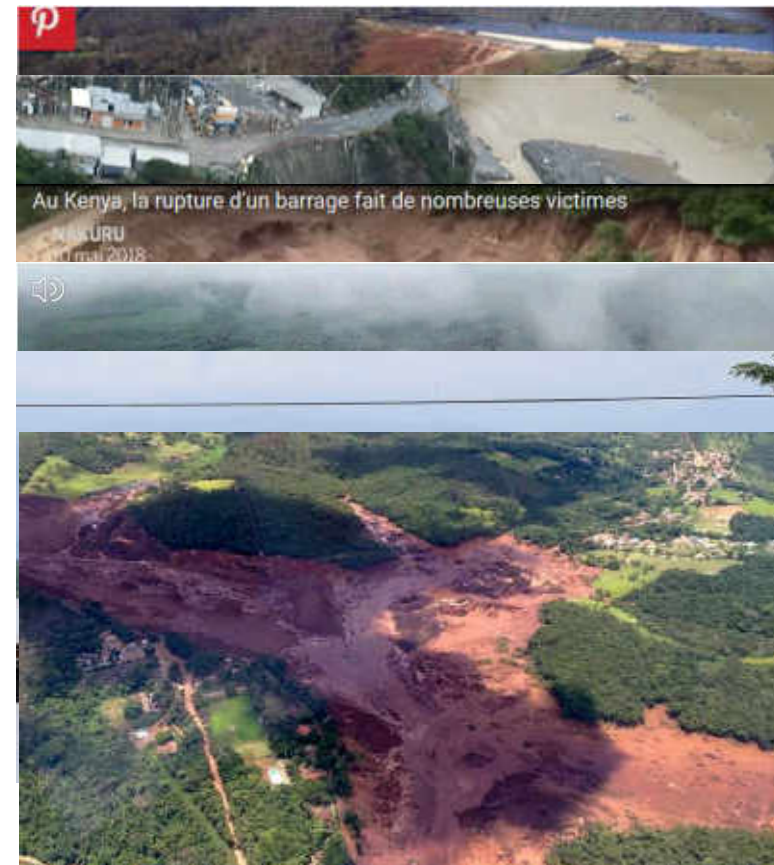
VP Michel Lino

## 2017-2019 : a bad series

- Feb 2017 : Oroville (USA)
- May 2018 : Ituango (Colombia)
- May 2018 : Patel (Kenya)
- June 2018 : Xe Namnoy (Laos)
- Aug 2018 : Swar Shaum (Myanmar)
- Jan 2019 : Brunadinho (Brazil)



world hydropower  
congress



# Dam Safety



## AN EVOLVING CONTEXT FOR DAM SAFETY

- Ageing of existing infrastructure
- Many dams are under construction
- New dam sites are more and more difficult
- Increasing implication of the private sector
- Climate change impact

ICOLD is preparing a **WORLD DECLARATION ON DAM SAFETY**





## World Declaration on Dam Safety

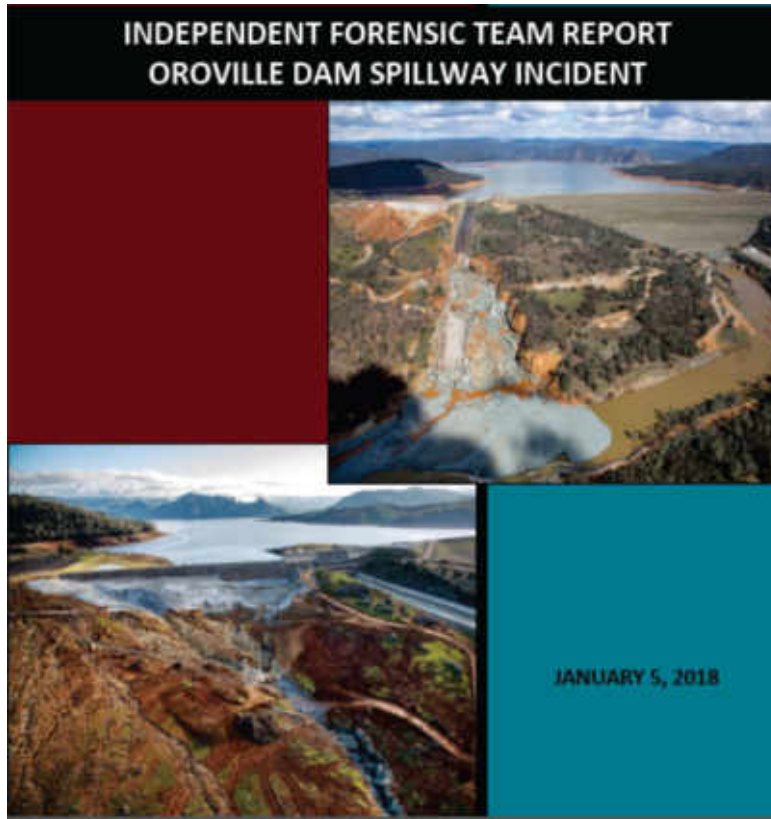
Throughout history, the construction, operation and maintenance of dams and their storage **reservoirs have provided significant benefits to humankind**. Storage of water behind dams regulates natural streamflow, allowing for benefits resulting from increased water availability, renewable energy production and reduction of adverse impacts caused by nature's extremes of flooding and drought.

In our fragile world, growing population is causing a steady increase in demand for water, food, energy and minerals to meet basic needs as well as rising standards of living. At the same time, water storage **represents additional risks to downstream communities, property and the environment, including the potential for dam failure**, possibly resulting in an uncontrolled release of stored water.

The Dams Engineering community has a **profound ethical responsibility** to carry out its professional duties so that dams, reservoirs and levees are designed, constructed and operated in the most effective and sustainable way, while also ensuring that both new and existing dams are safe during their entire lifespan and after decommissioning.



## Significance of Multilevel Principle



Owner and Operator

Structure for Surveillance

Know How and Technical Experience

Structured Education

Bureaucracy

Authority

Competence

Independence

Problems known since 1970

## Oroville Session – ICOLDAustria2018

**E**nsure safe management in companies a strong „top-down“ safety structure

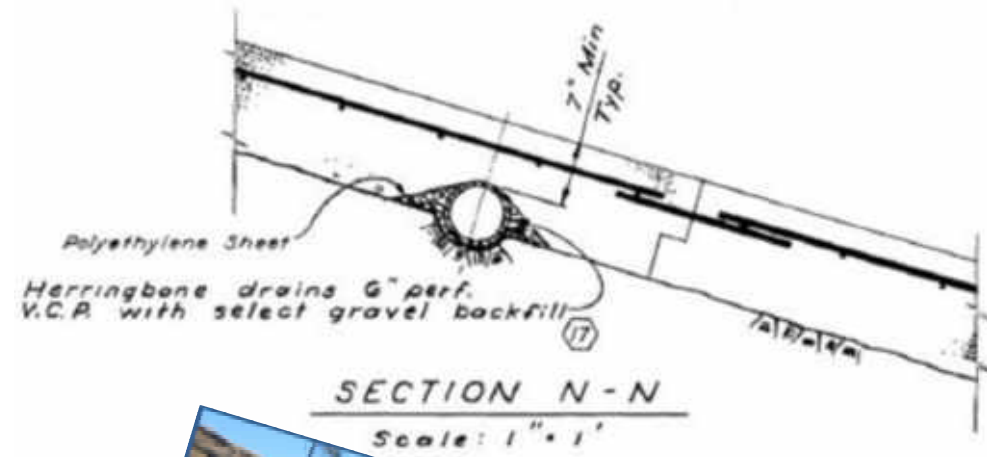
**E**xecutive personnel charged with entire responsibility of dam safety

**P**eriodic comprehensive reviews – e.g. five years inspections

**A**ppurtenant structures must be given attention (spillway, outlet works ..)

**P**otential failure mode analysis (PFMA) – must be addressed

**C**ompliance with regulatory requirements is not enough





## Oroville – The Owners Responsibility

Dam Safety Culture was immature – too reliant on regulators and the regulatory process

- **overconfident and complacent** regarding civil structures, together with cost pressure resulted in inadequate priority for dam safety

- **insular organization**; inhibiting access to industry knowledge and developing technical expertise

- ability has been limited by **bureaucratic constraints**



<https://www.enr.com/videos?bctid=5671167289001>

## Oroville – Emergency Spillway



Emergency installations must be operable under all circumstances  
-- otherwise ...

## Feijao Tailings Dam



June 2018

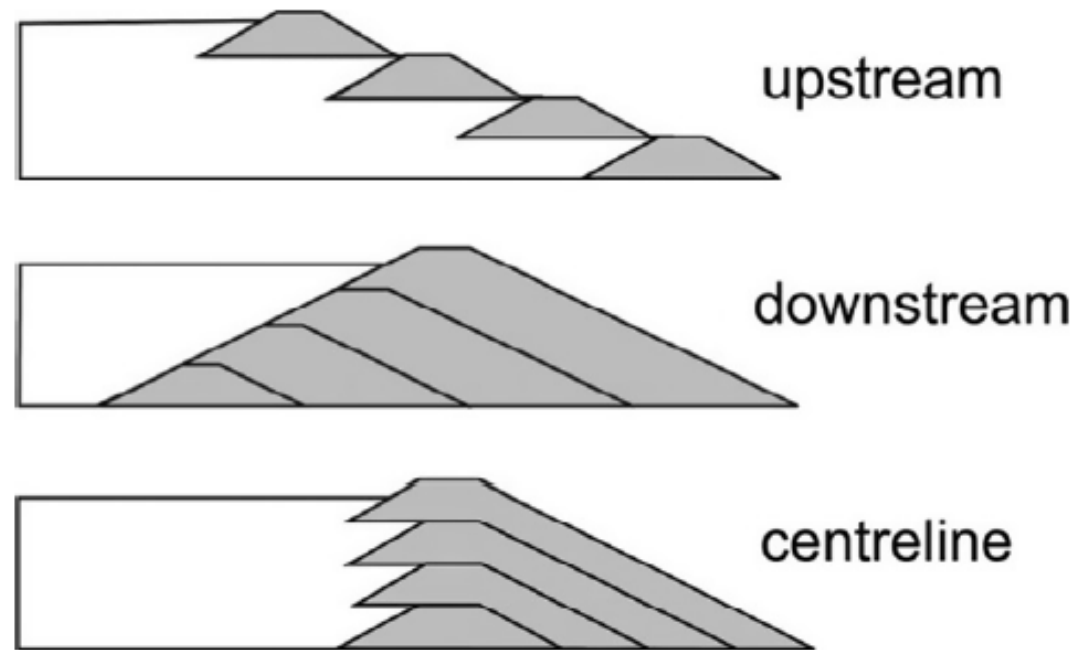
„Dam I“  
Height ~ 90m  
Crest length ~ 700m  
Reservoir Volume ~  $12.7 \cdot 10^6 \text{ m}^3$

Feijao Tailings Dam

Dams deserve careful engineering

Dependent on thread associated

Permanent safety assessed



General schematics of tailing dam constructions (Kossoff et al. 2014)

Upstream construction method, using the “sub-aerial” method (ICOLD 1996)

## Leftovers of “Dam I” at right abutment



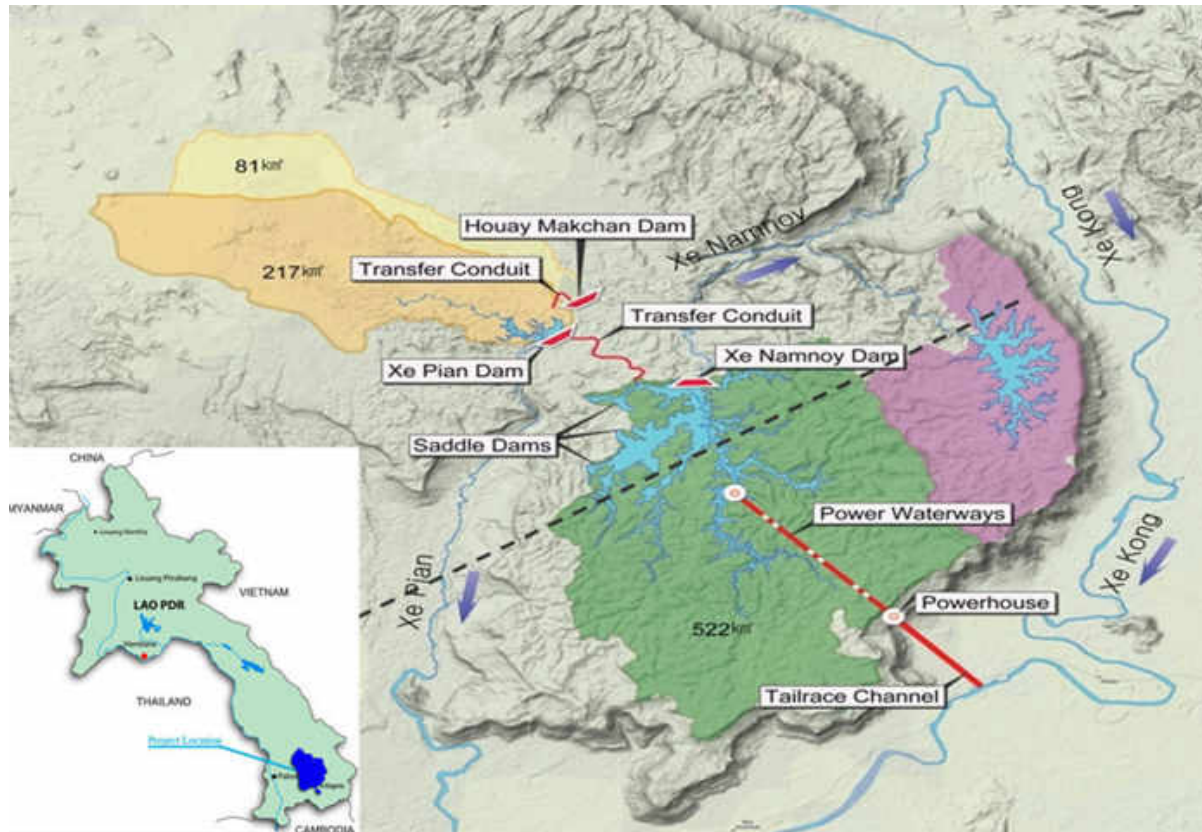
Source: Reuters / Washington Alves

Until 2015 used to depose tailings - Several years in consolidation



Source: Reuters / Washington Alves

## Xepian-Xe Nam Noy – Incident Laos – 2018



Impounding

Diversion

Design

Source: <http://www.pnpclaos.com/index.php/en/project/maps>; at 26.11.2018

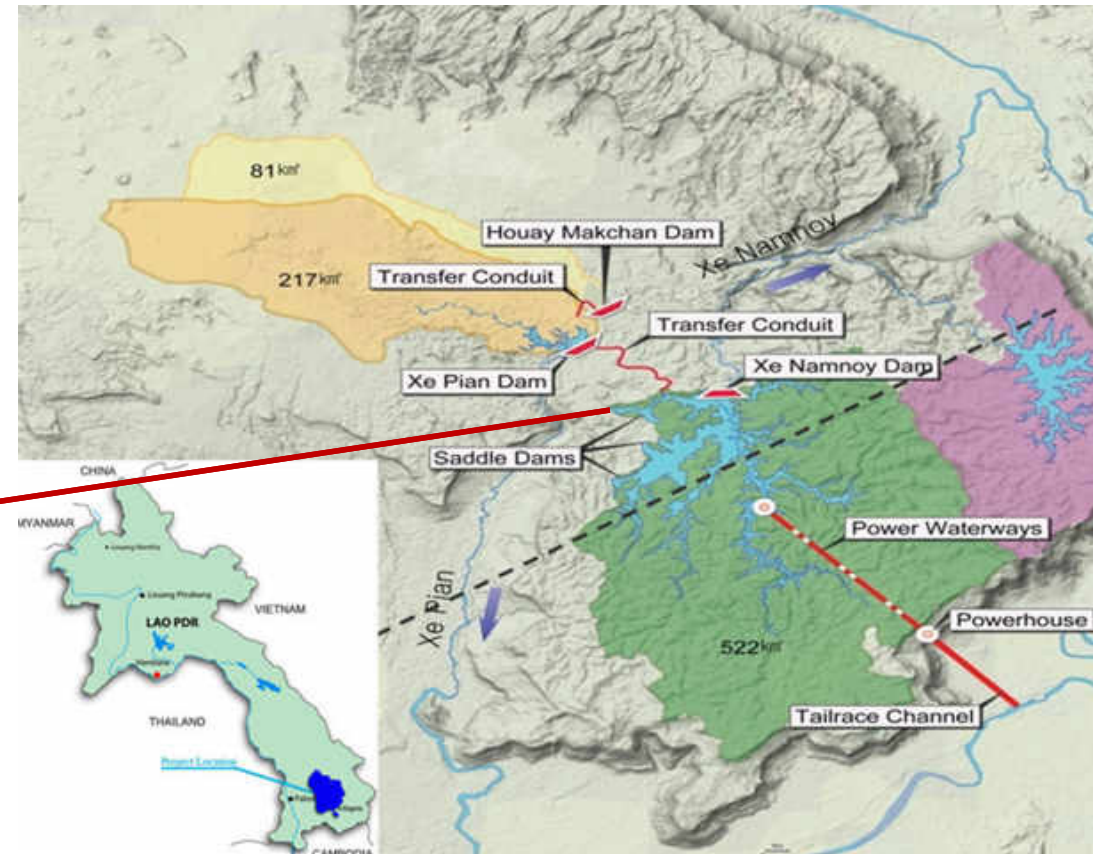
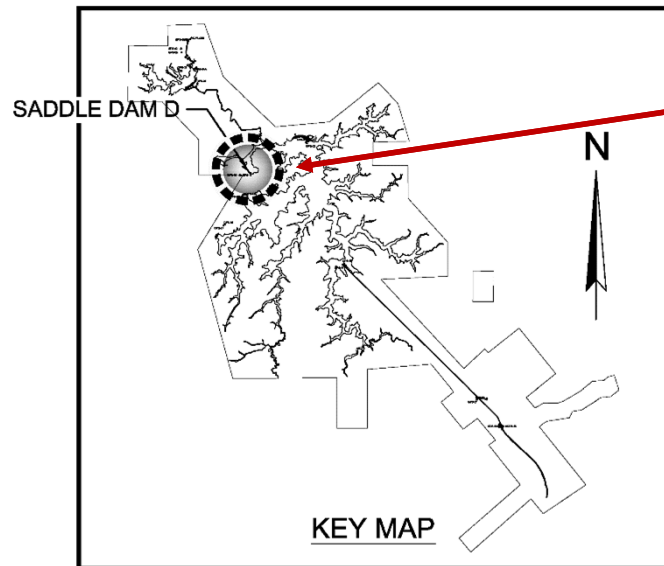
# Xepian-Xe Nam Noy – Incident Laos – 2018 – Impounding - Diversion

## Saddle Dam D

Max.dam height 16m

Crest length 770m

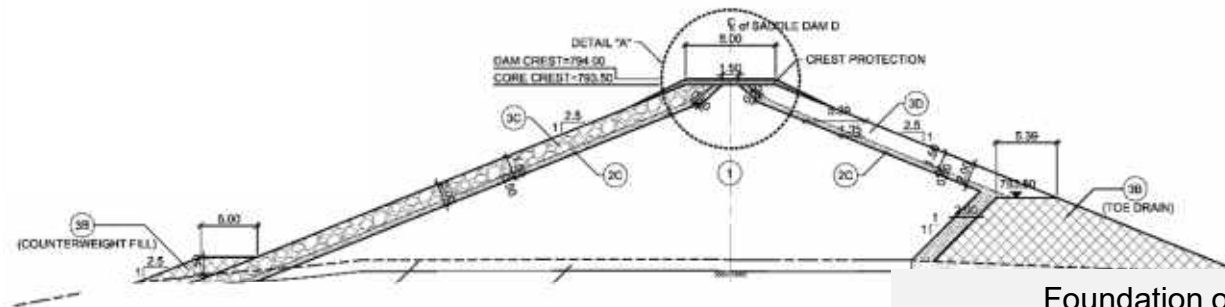
Crest width 8m



Source: <http://treasuresoflaos.blogspot.com/2018/07/xepian-xe-nam-noy-dam-in-laos-collapsed.html>; at 26.11.2018



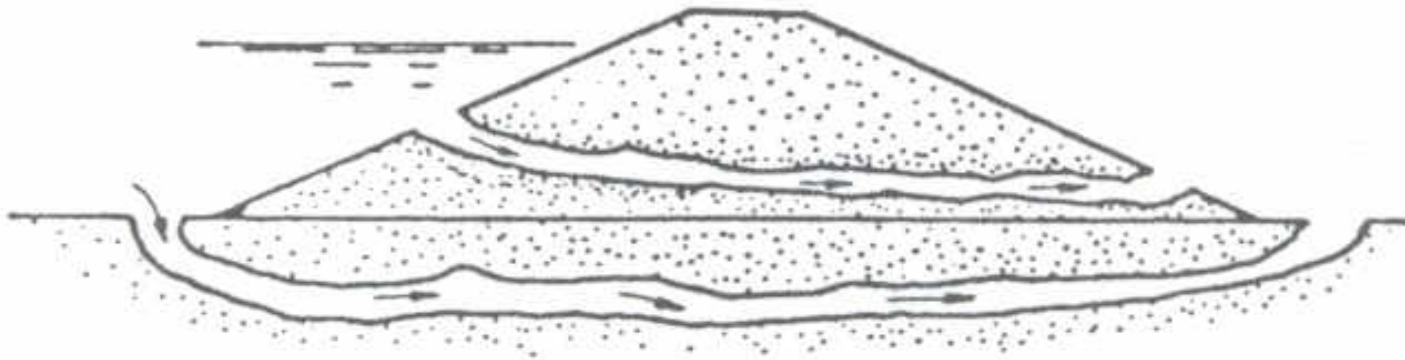
# Xepian-Xe Nam Noy – Incident Laos – 2018 – Impounding - Diversion



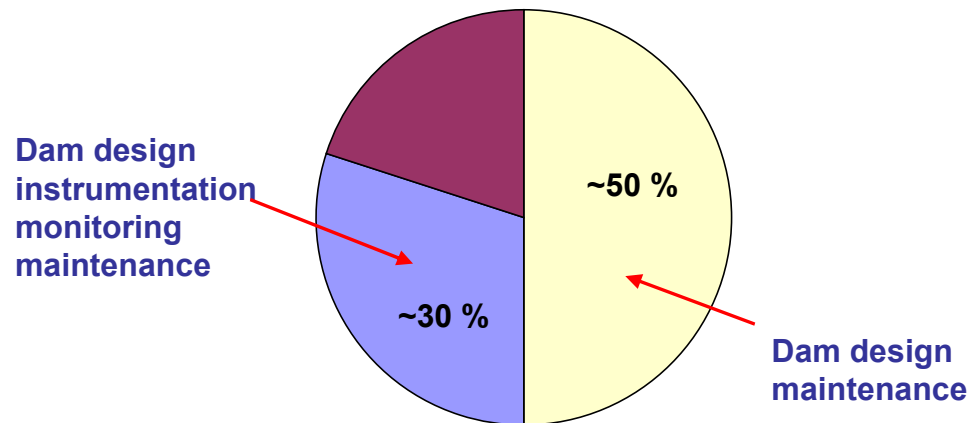
Foundation on subsoil  
Grouting - Consolidation



# Dam Failure due to Piping



## Small dams $\leq 15$ m

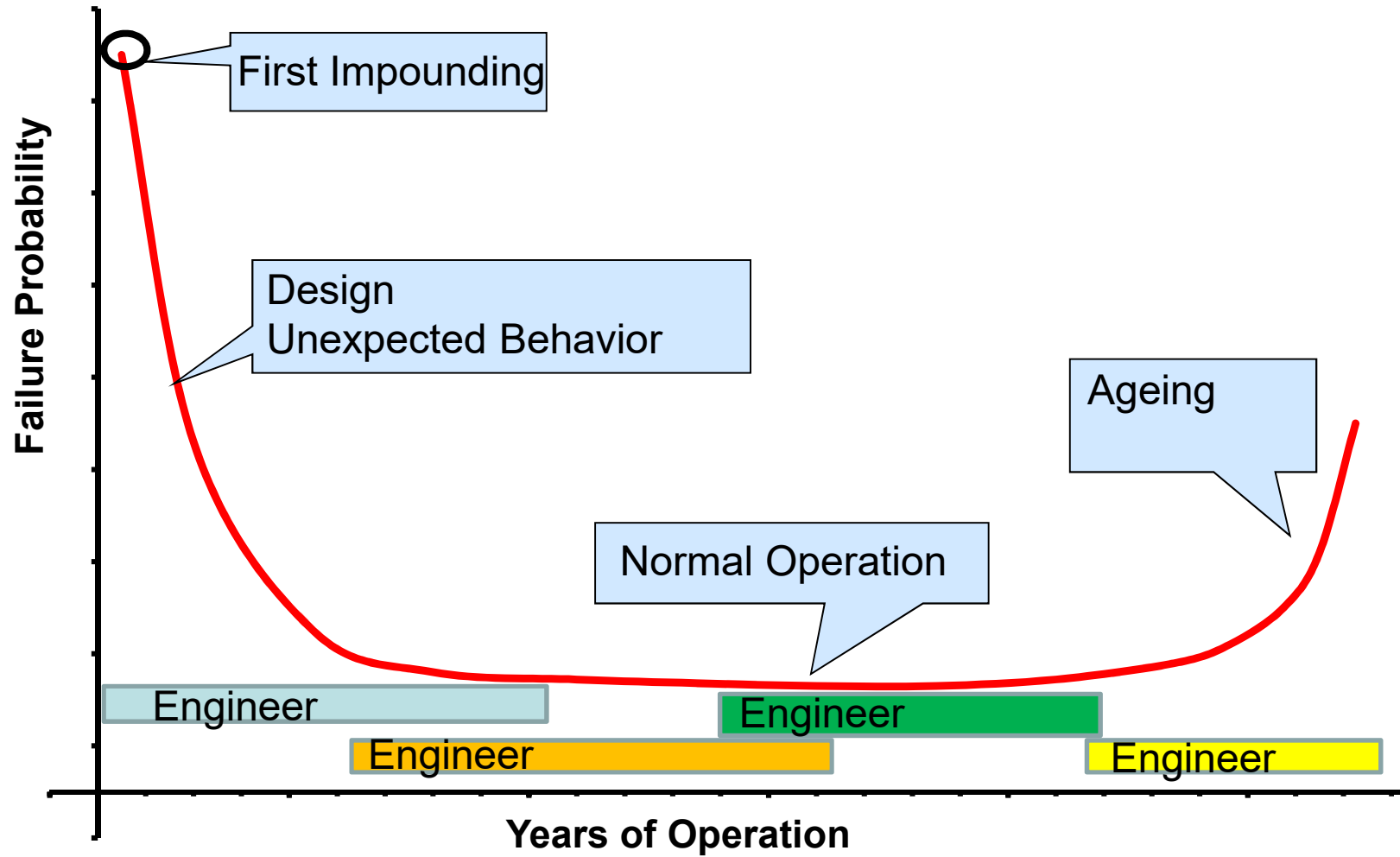


Matter of evidence  
ICOLD data base

Design  
Piping Foundation

- Legend:
- Overtopping
  - Piping
  - Other cases, stability

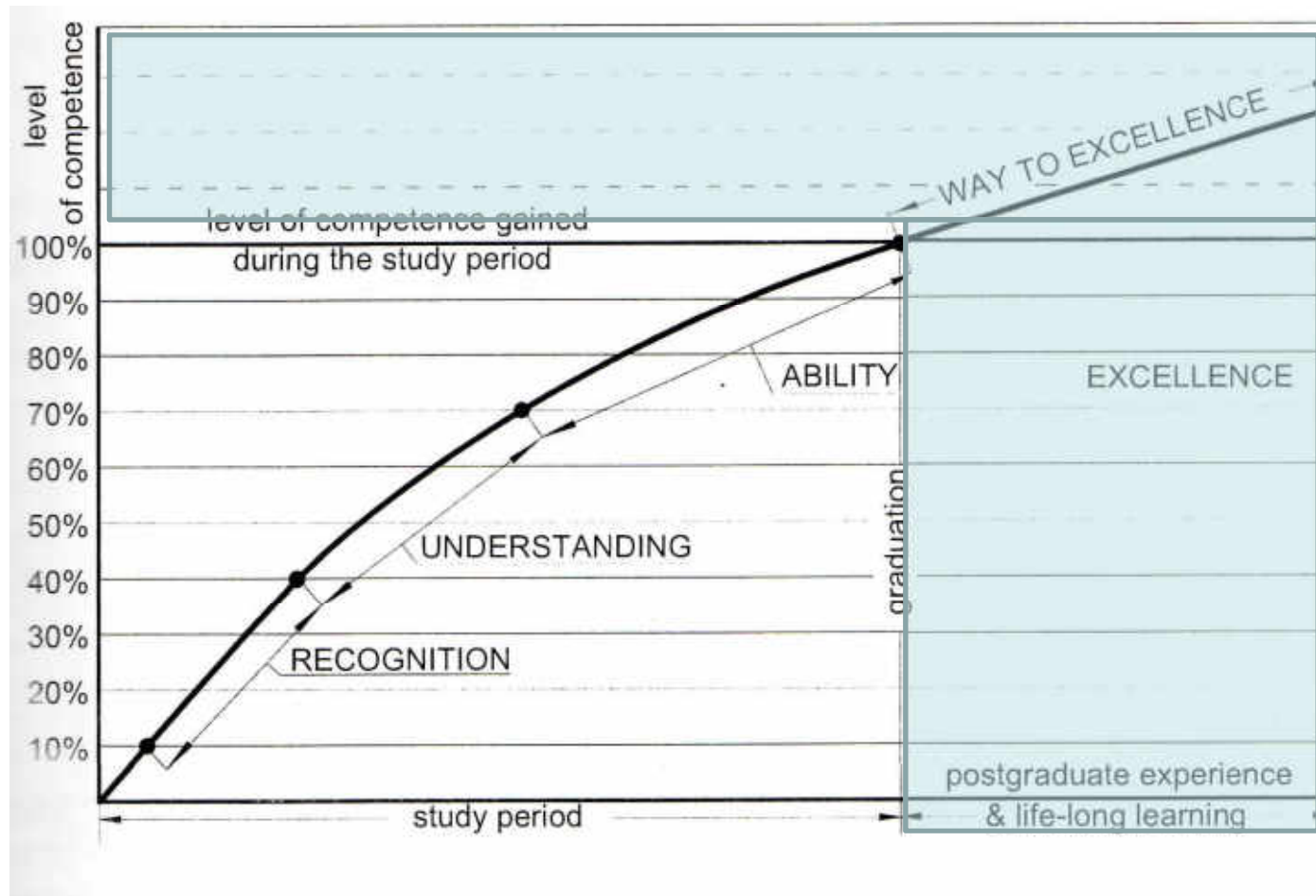




ATCOLD / Dam Safety Expert Seminar / Melbinger



# Life Long Learning



Source: European Civil Engineering Education and Training EUCET – Program Sixth Volume





Austrian  
National  
Committee  
on Large  
Dams

2<sup>nd</sup>

# Experts Seminar

KAPRUN, Province of Salzburg  
AUSTRIA

## Dam Surveillance Practice





Austrian National Committee on Large Dams

# Experts Seminar

KAPRUN, Province of Salzburg  
AUSTRIA

## Dam Surveillance Practice

Introduction	Site visit (together)	Introduction for site visit	Workshop
Lectures	Exercises (in groups)	Site visit (together)	Lecture
Lunch	Lunch at site	Lunch at site	Lunch
Lectures	Site visit (together)	Exercises (in groups)	Lecture
Introduction for site visit	Preparation for workshop	Preparation for workshop	Final discussion
	Supper		Farewell
	Workshop	Candlelight dinner	

Theory

On Site

Workshop - Discussion



## Fill Dam – Specific Topics – Drainage / Spillway / Debris Management



Capacity of Spillway  
Flood Events  
Climate Change

Source: Verbund Hydro Power

## Fill Dam – Relief Wells and Vegetation - downstream

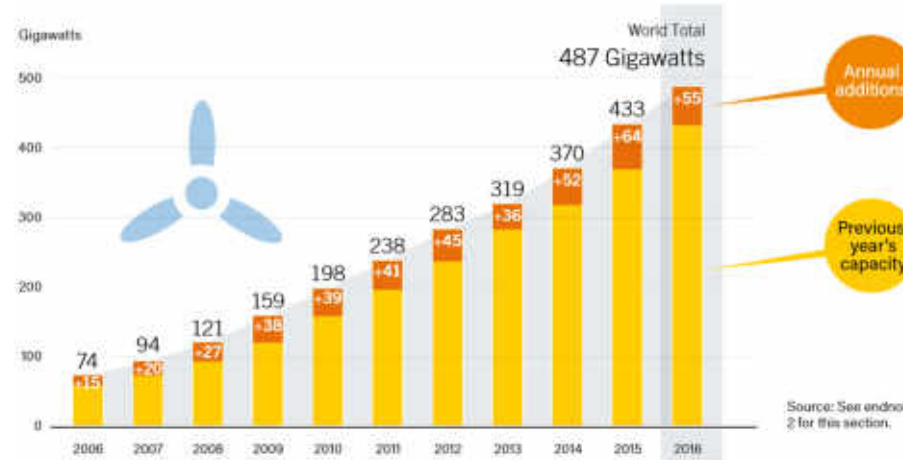




## Concrete Dams – Bottom Outlet Testing



# Sustainable Hydro - Renewable - PV – Wind - Hydro

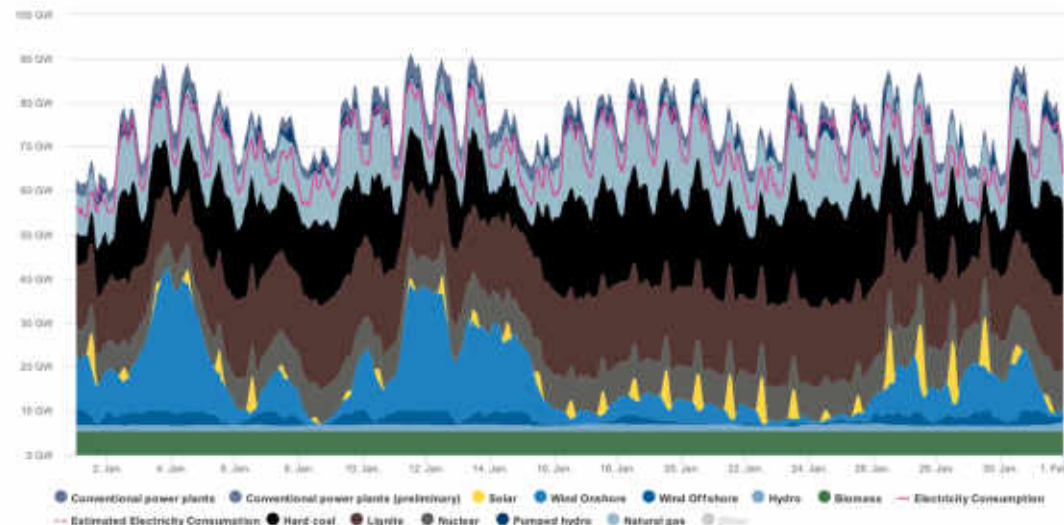


## Electricity Production / Consumption, Germany Jan 2017

High Volatility

Flexibility

Storage Capacity



# Sustainable Hydro – Our Future



Reservoir Mooserboden

## High Head Pumped Storage Schemes

## Run-of-River Plants



Reservoir Birecik



## **ACTION PLAN ON CAPACITY BUILDING**

[Ad-Hoc Committee on Capacity Building \(CBC\)](#)

December 2016

## **AD HOC COMMITTEE ON CAPACITY BUILDING IN DAM ENGINEERING**

(2009 – 2017)

**Chairman:** Adama NOMBRE

**Vice Chairman:** Dr ALI NOORZAD

**Secretary:** Eng FEMI SONUGA

**Members**

KHALID EL GHOMARI

EL GHISSASSI ABDERRAHIM

HAMIDOU KEBE

HASAN BASRI YUKSEL

Dr. XU ZEIPING,

LARS HAMMAR,

SERGEY YURIEV

KEVIN WALL



ICOLD – Young Engineers Forum

Inaugurated – **ICOLD Congress in Brasilia 2009**

Attract - Younger Engineers  
Knowledge Transfer

First Inaugural Meeting of **YEF**

**ICOLD Annual Meeting in Lucerne 2011**

Mentoring the Younger Generation





**Create Network** – encourage attendance to ICOLD meetings  
Provide opportunity for **knowledge transfer** to next generation  
Provide platform for Young Engineers to exchange  
Inspire Young Engineers to be active in National Committees



**D**o be  
**A**ware of  
**M**ultiple benefits &  
**S**ustainable effects

