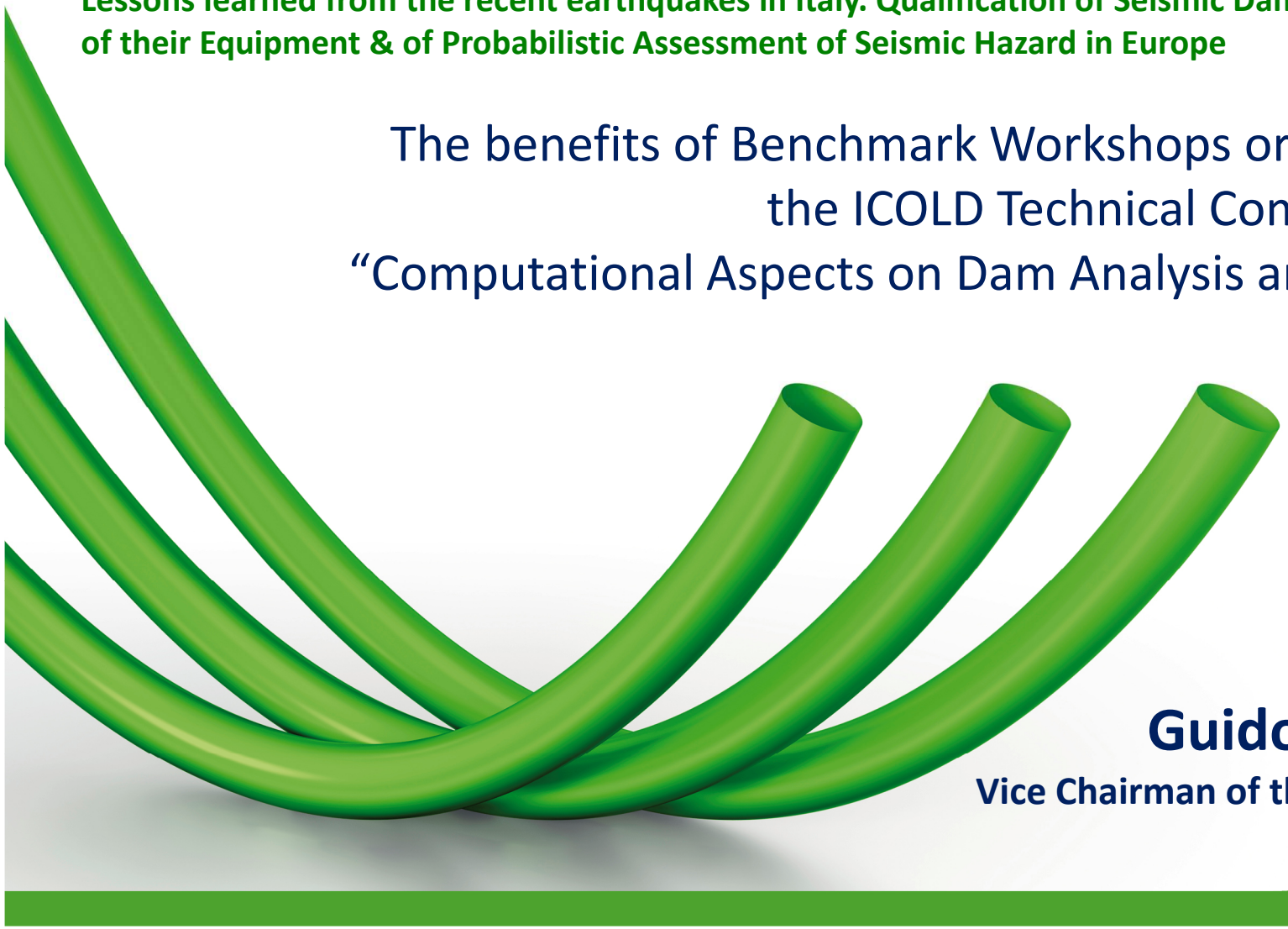
2nd "Dams & Seisms" EWG Workshop
6th – 7th February 2017 Rome

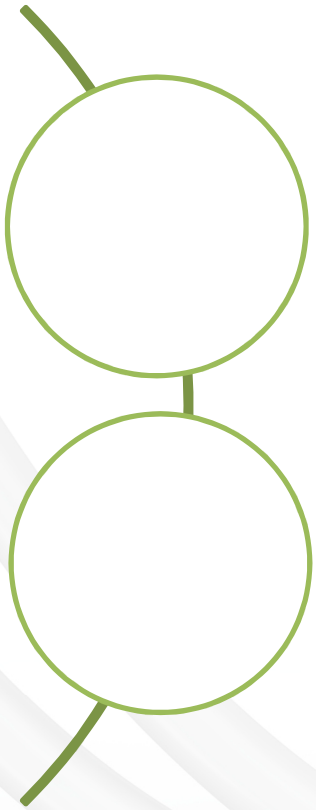
WORKSHOP:
Lessons learned from the recent earthquakes in Italy. Qualification of Seismic Dams Analyses and of their Equipment & of Probabilistic Assessment of Seismic Hazard in Europe

The benefits of Benchmark Workshops organized by the ICOLD Technical Committee on "Computational Aspects on Dam Analysis and Design"



Guido MAZZA'
Vice Chairman of the Committee

CONTENT



Some comments on the development of the numerical modelling process

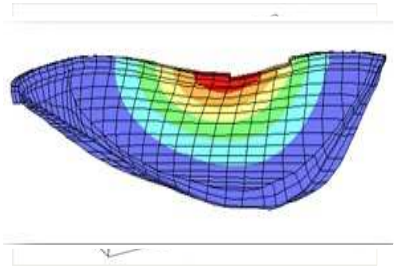
The activities of ICOLD Technical Committee on “Computational Aspects of Dam Analysis and Design”

Some comments on the development of the numerical modeling process

Numerical modelling represents nowadays a **key tool for dam engineers** to perform efficiently **numerical analyses in design making process** as well as in the **safety reassessment and rehabilitation** of existing dams.

However, the **application of numerical models** in the dam engineering field has suffered for many years a **gap between specialists of numerical modelling and dam engineers**.

Some comments on the development of the numerical modeling process

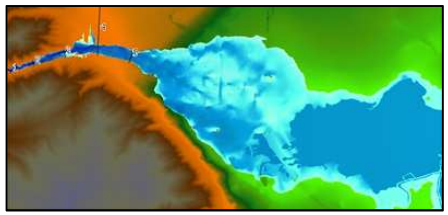


To cover such a gap it is noteworthy mentioning the contribution given by ICOLD ***Committee on Computational Aspects of Dam Analysis and Design*** to the diffusion of knowledge in the field of numerical modelling.

The Committee was appointed by ICOLD as an ***ad hoc Technical Committee*** in 1988 and as a ***permanent*** one during the 2005 ICOLD Annual Meeting.

The activities of ICOLD Technical Committee on Computational Aspects of Dam Analysis and Design

Technical Bulletins

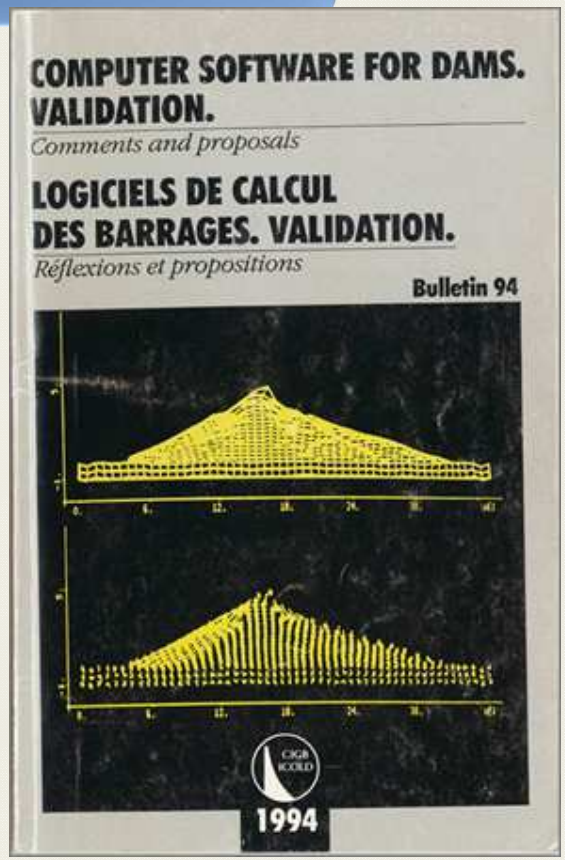


Benchmark-Workshops

Bulletin N. 94 (1994)
Computer Software for Dams. Validation

Validation

The process which ensures and certifies that a given software implemented into a computer program used by dam engineers is adequate for performing a definite task in a correct way



Bulletin N. 122 (2001)
Computational Procedures for Dam Engineering

Reliability and Applicability

Critical review of the reliability level and applicability of presently available numerical models and computer programs to represent correctly the various phenomena affecting the dam behavior during the different life stages

Bulletin N.155 (2013)
Guidelines for use of numerical models in dam engineering

Guidelines

A support to dam engineers to choose the more suitable computational strategies to cope with engineering problems considering potentialities and possible shortcomings of the available numerical models

Benchmark - Workshops

• Bergamo (Italy)	1991/1992
• Paris (France)	1994/2009
• Madrid (Spain)	1996
• Denver (USA)	1999
• Salzburg (Austria)	2001
• Bucarest (Romania)	2003
• Wuhan (China)	2005
• Saint Petersburg (Russia)	2007
• Valencia (Spain)	2011
• Graz (Austria)	2013
• Lausanne (Switzerland)	2015







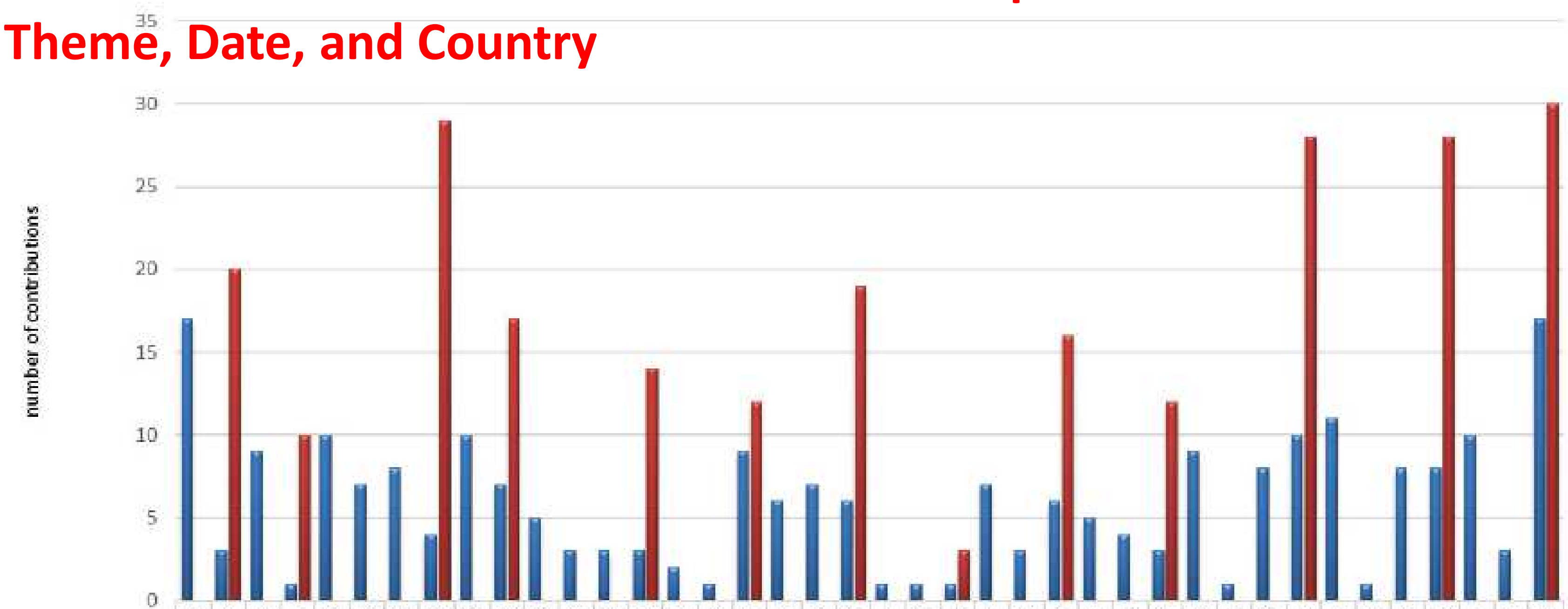




Benchmark - Workshops

RSE Ricerca Sistema Energetico

Benchmark Contributors Status 1991 – 2015 per Theme, Date, and Country



	1991 IT 1		1993 IT 2		1995 FR 3				1997 ES 4		1999 US 5			
	A	B	A	B	A1	A2	B1	B2	A1	A2	A1	A2	B1	B2
Contributions	17	3	9	1	10	7	8	4	10	7	5	3	3	3
Totals		20		10				29		17				14

	2001 AT 6			2003 RO 7			2005 CN 8			2007 RU 9			2009 FR 10		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Contributions	2	1	9	6	7	6	1	1	1	7	3	6	5	4	3
Totals			12			19			3			16			12

	2011 ES 11				2013 AT 12				2015 CH 13		
	A	B	C	D	A	B	C	D	A	B	C
Contributions	9	1	8	10	11	1	8	8	10	3	17
Totals				28				28			30

Benchmark - Workshops

Bergamo (Italy), 1991

The linear-elastic computation of a double curvature arch dam (Talvacchia) with its foundation under self-weight, hydrostatic load, thermal load

The seismic response of an embankment dam (El Infiernillo) under conditions of both low and medium levels of seismic loadings

Bergamo (Italy), 1992

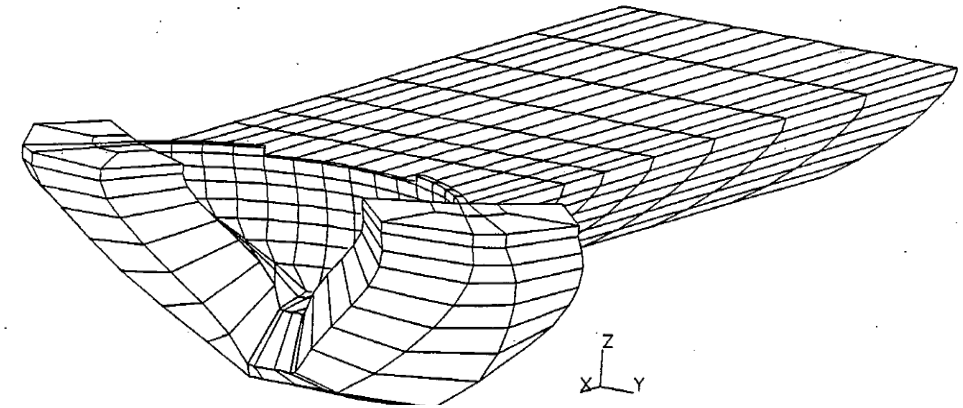
Seismic analysis of the Talvacchia dam

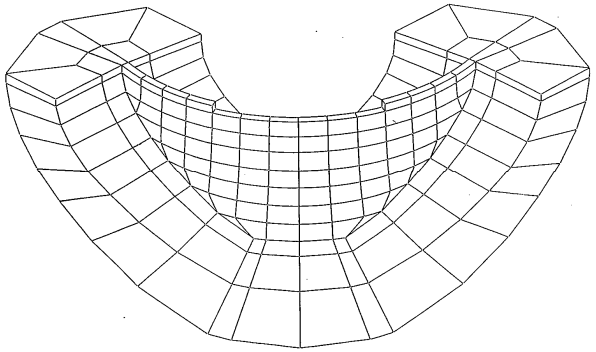
Static analysis and dynamic response of El Infiernillo embankment dam

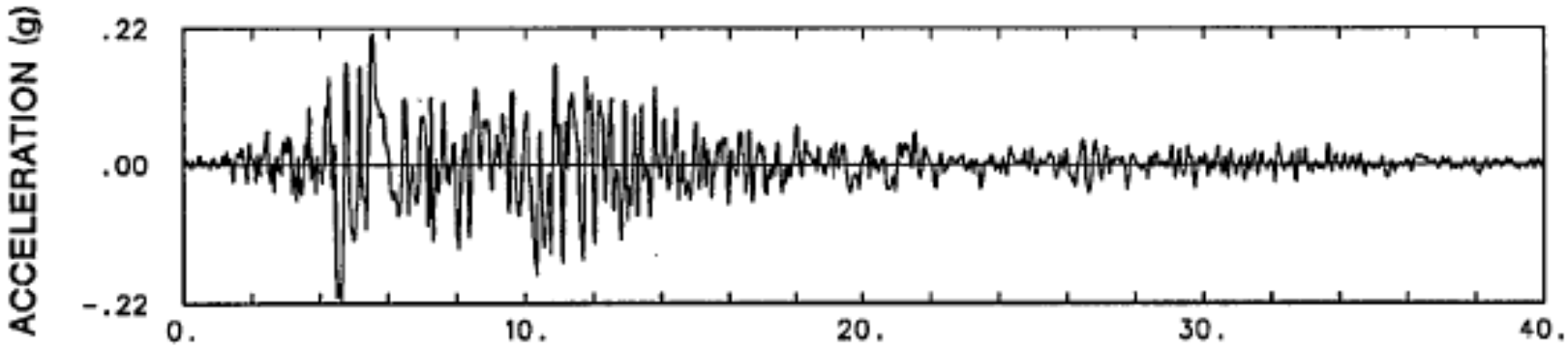
Paris, Gennevilliers (France), 1994

- Non-linear analysis of joint behaviour under thermal and hydrostatic loads for an arch dam
- Evaluation of critical uniform temperature decrease for a cracked buttress dam (2D analysis)
- Evaluation of pore pressure and settlements of an embankment dam under static loadings
- **Dynamic analysis of an embankment dam under a strong earthquake (El Infiernillo Dam)**

Static analysis and dynamic response of Talvacchia Dam





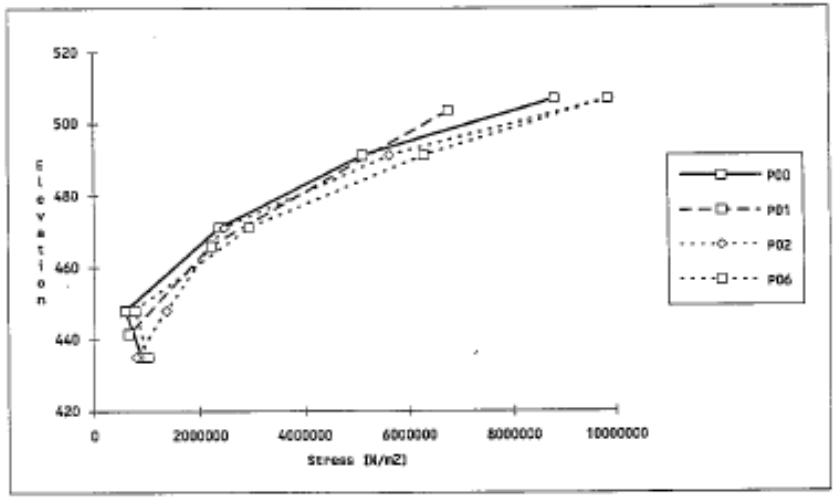


Talvacchia Dam: comparison of results. Some examples

FLEXIBLE FOUNDATION AND INCOMPRESSIBLE FLUID

MAX ABS PRINCIPAL STRESSES P1 AND THEIR TIME OF OCCURRENCE

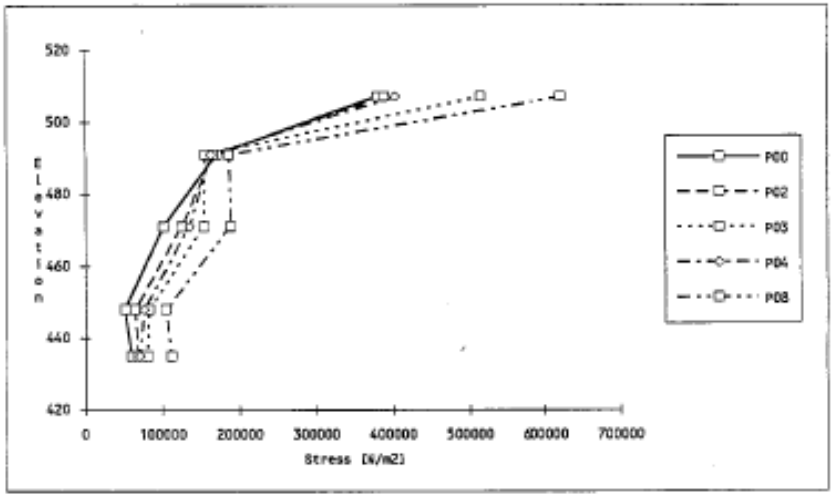
CENTRAL CANTILEVER



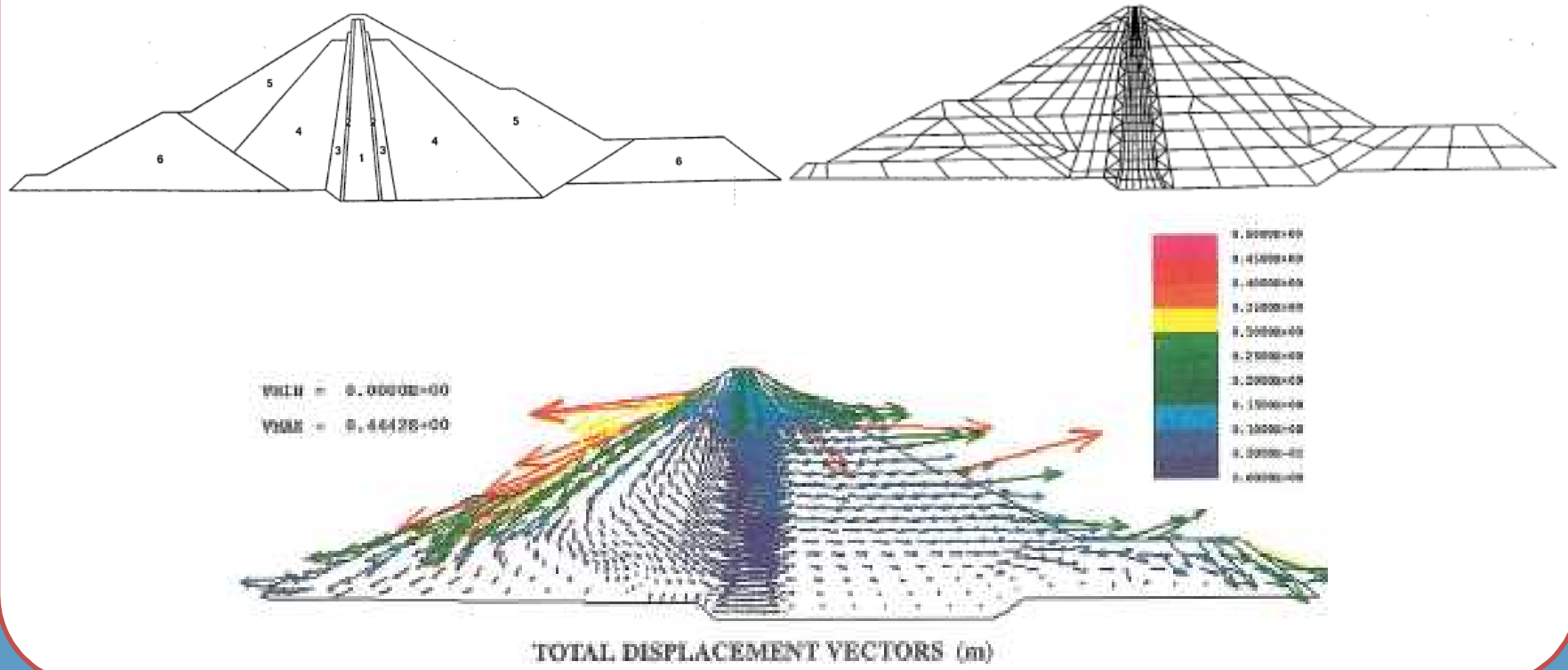
RIGID FOUNDATION AND COMPRESSIBLE FLUID

MAX ABS PRINCIPAL STRESSES P1 AND THEIR TIME OF OCCURRENCE

CENTRAL CANTILEVER



El Infiernillo Dam: linear equivalent, uncoupled and coupled linear and non linear analysis



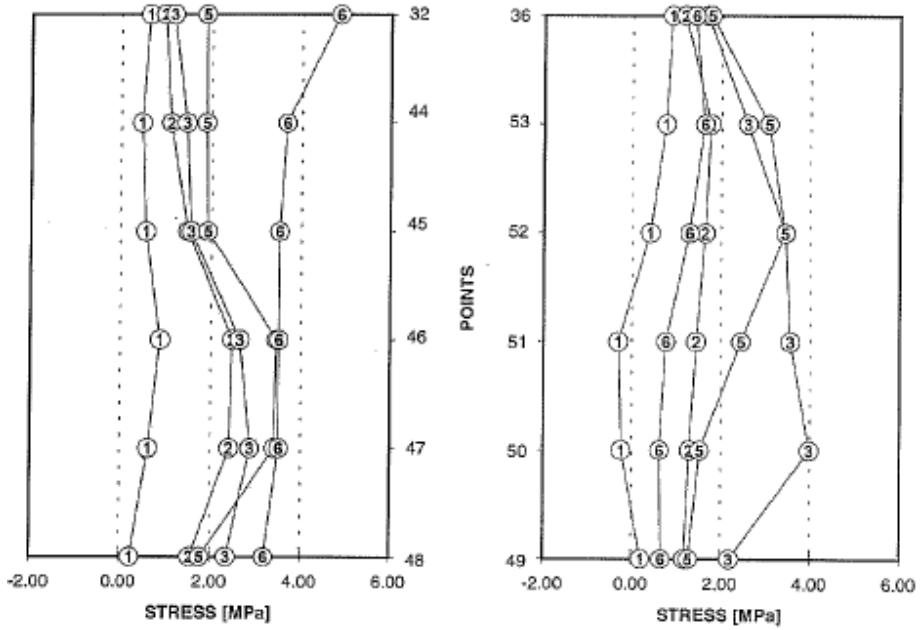
Madrid (Spain), 1996

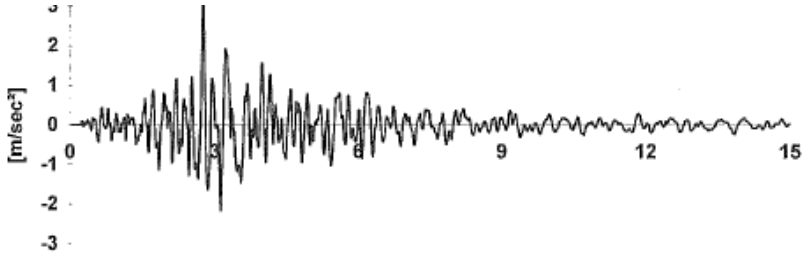
- **Earthquake response of an arch dam including the non-linear effects of contraction joint opening**
- Evaluation of stress intensity factor K1 along the tip of the crack in a buttress dam under thermal gradient effects (3D analysis)
- 2D steady-state and transient unconfined seepage analysis for different typologies of earthfill dams
- Effect of large foundation settlement on an embankment dam

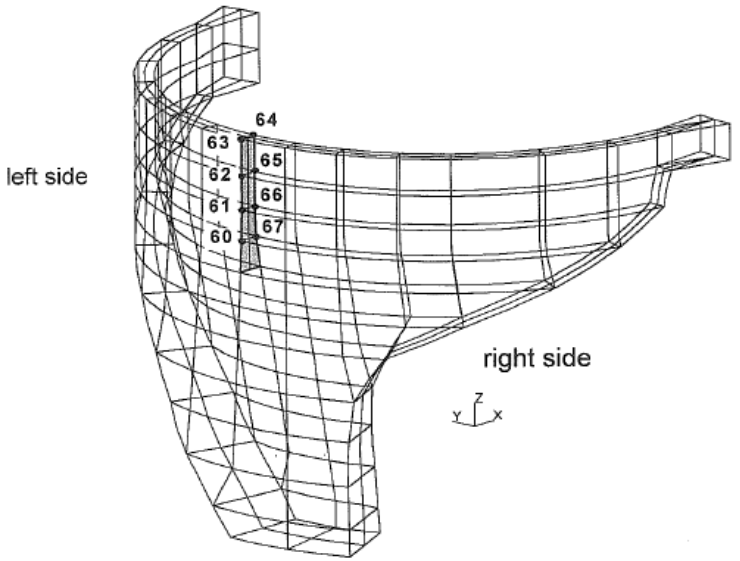
Benchmark - Workshops

Case 4 : model with joint and water
Maximum principal stresses and their time of occurence
Component P1

Central cantilever







Benchmark - Workshops

Denver, Colorado (USA), 1999

- Uplift pressure and stress analysis of an arch dam and foundation
- Imminent failure flood level evaluation for a gravity dam with interface rock/concrete and varying uplift pressure distributions
- Evaluation of the global factor of safety against failure of an embankment dam
- First filling of a rockfill dam: a case study

Salzburg (Austria), 2001

- Evaluation of AAR (alkali-aggregate reaction) effects on the structural behaviour of an arch dam
- Prediction of upstream face deflection of a CFRD (concrete faced rockfill dam) during its first impounding
- Interpretation of measurement results for the radial crest displacements of Schlegeis arch dam

Benchmark - Workshops

Bucharest (Romania), 2003

- Evaluation of ultimate strength of gravity dams with curved shape against sliding
- Thermal analysis of RCC (rolled compacted concrete) gravity dam
- Seepage through an earthfill dam-foundation system and piezometric level variation

Wuhan (China), 2005

- Evaluation of alkali-aggregate reaction effects on the behaviour of an Italian hollow gravity dam
- Temperature field simulation and crack analysis of a RCC arch dam
- Evaluation of the behaviour and safety of a rockfill dam

Benchmark - Workshops

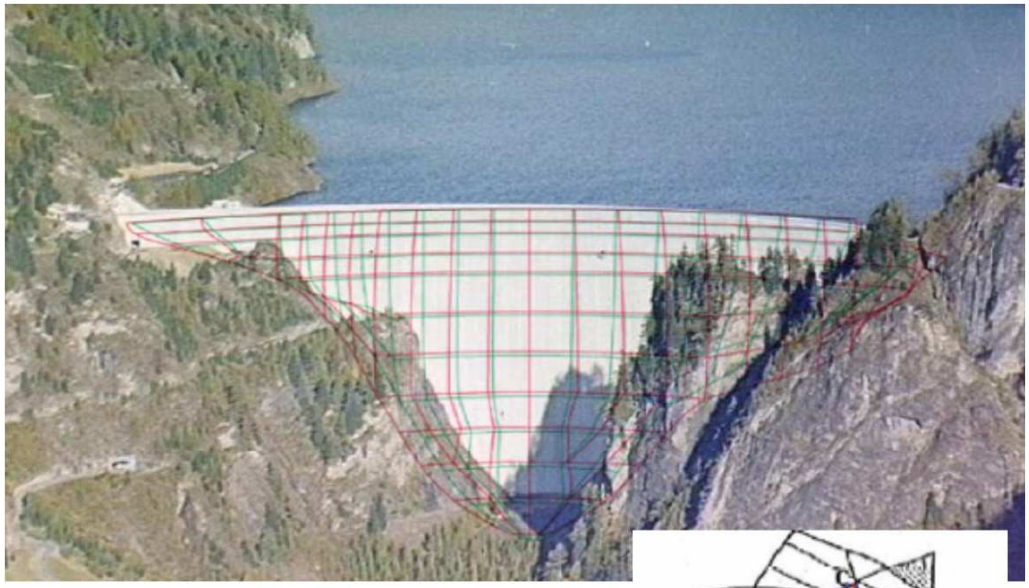
St. Petersburg (Russia), 2007

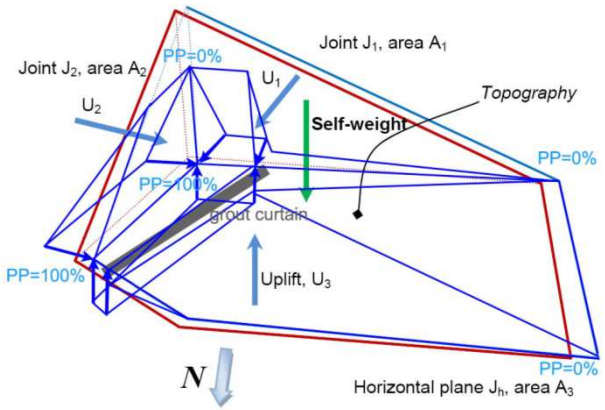
- Analysis of the elastic behavior of an arch-gravity dam
- Stress-strain state of high rock-fill dam with a central earth core under large amplitude of operation upstream water level variations
- Advanced numerical modelling for dams

Paris (France), 2009

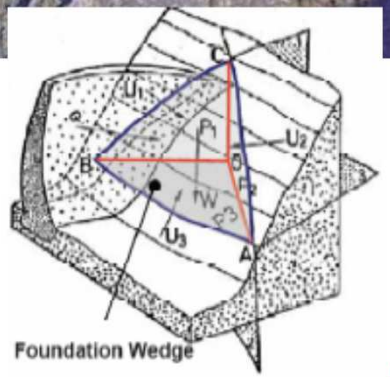
- Initial strain and stress development in a thin arch dam considering realistic construction sequence
- Analysis of a concrete faced rockfill dam including concrete face loading and deformation
- **Stability of a dam abutment including seismic loading**

Benchmark - Workshops





Luzzone Dam: wedge stability uplift assumptions



Benchmark - Workshops

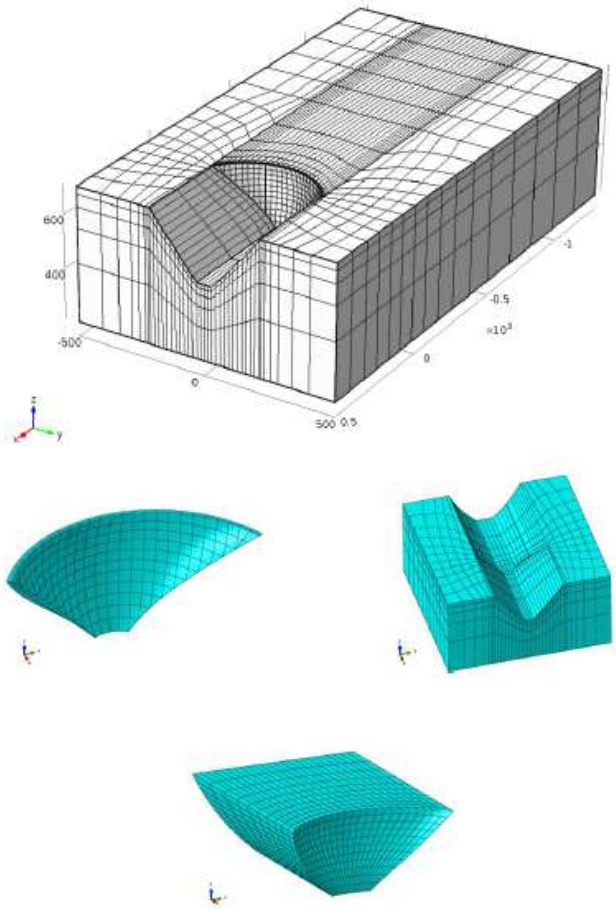
Valencia (Spain), 2011

- Effect of concrete swelling
- Overtopping and seepage evolution
- Probability of failure and safety coefficient

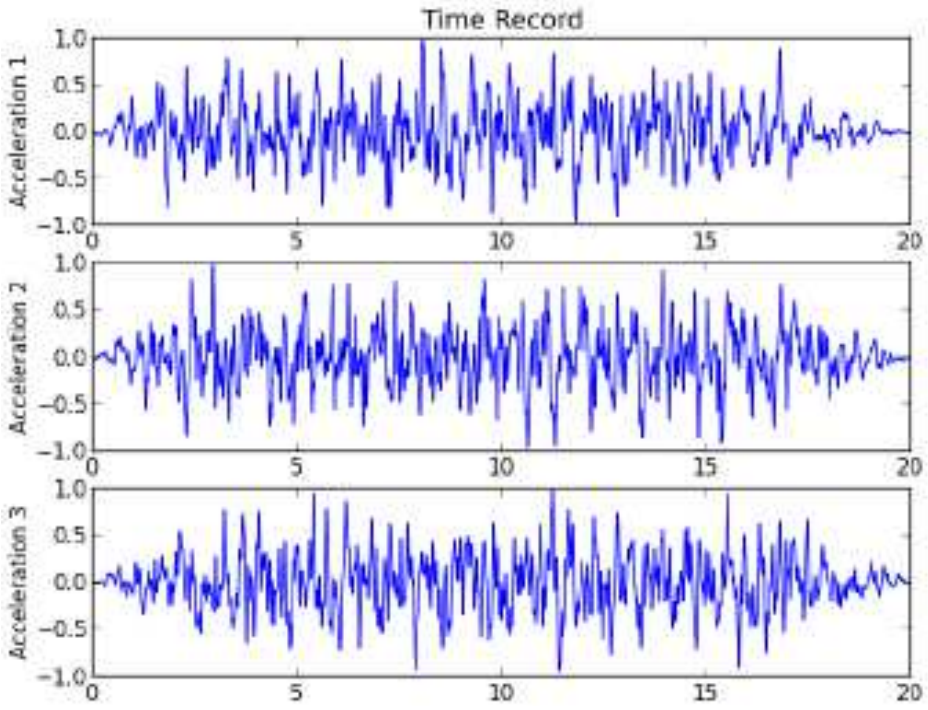
Graz (Austria), 2013

- **Fluid Structure Interaction Arch Dam - Reservoir at seismic loading**
- Long Term Behaviour of Rockfill Dams
- Computational challenges in consequence estimation for Risk Assessment

Benchmark - Workshops

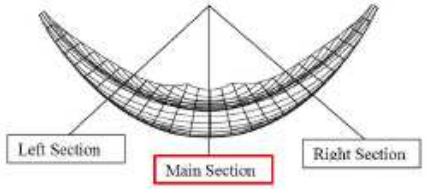


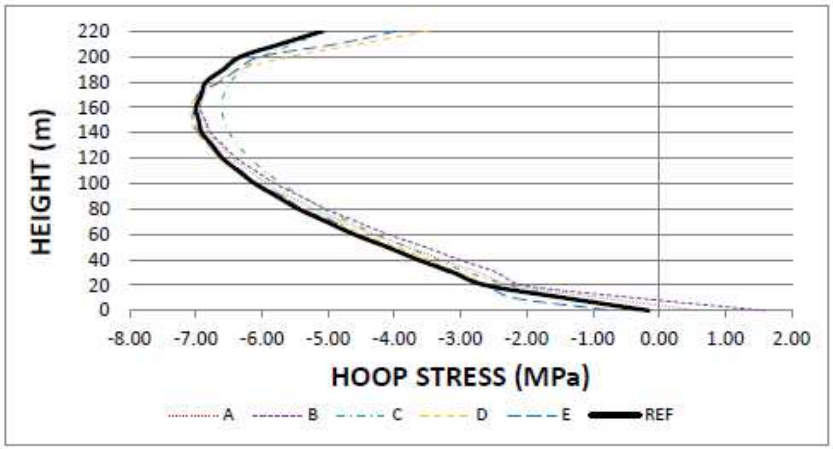
Idealized dam-foundation-reservoir system: static and seismic analysis



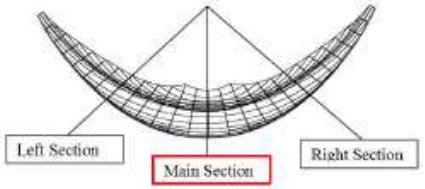
Benchmark - Workshops

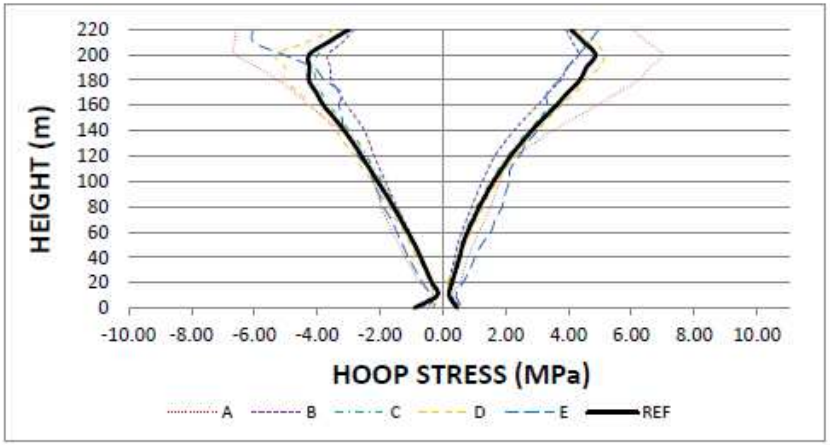
Hoop Stresses (Only Static Load) – Main Section – Upstream





Hoop Stresses (Only Dynamic Load) – Main Section – Upstream



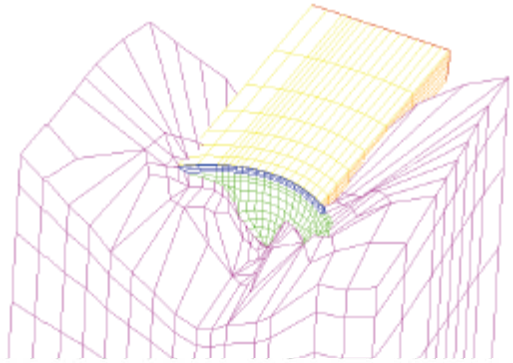


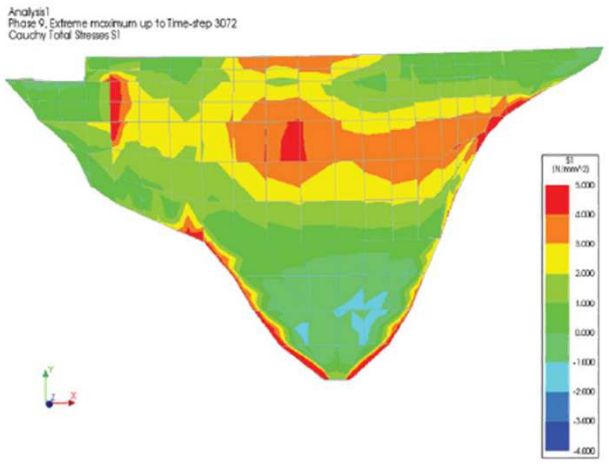
Benchmark - Workshops

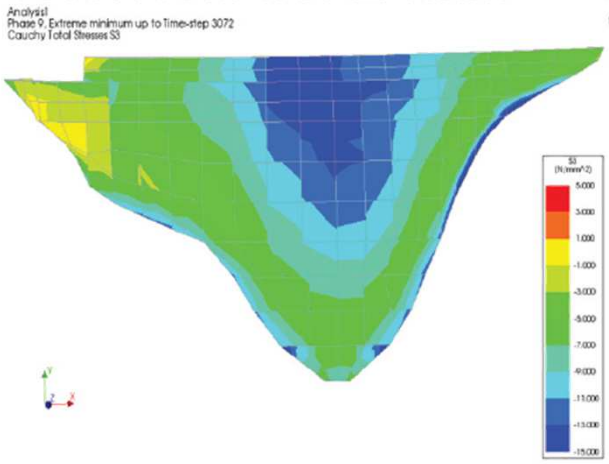
Lausanne (Switzerland), 2013

- **Seismic Safety Assessment of the Luzzone Arch Dam**
- Probability of failure of an embankment dam due to slope instability and overtopping
- Open Theme on Seismic/Dynamic analysis, Risk Assessment, Safety Assessment

Benchmark - Workshops







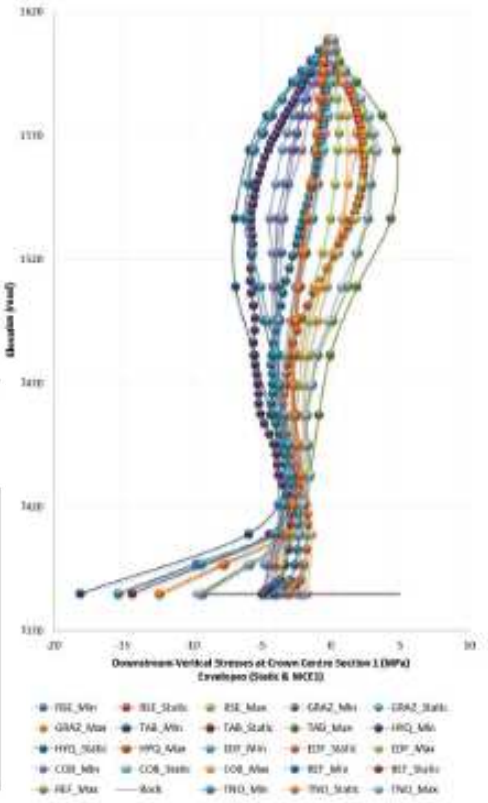


Figure 9 Maximum (Left) and minimum (Right) upstream principal stress (MPa) envelopes for MCE 1

14th Benchmark Workshop
Stockholm 6th – 8th September, 2017

Theme A: Cracking of a concrete arch dam due to seasonal temperature variations

Theme B: Static and seismic analysis of an arch-gravity dam

Theme C: Embankment dam behaviour – prediction of arching and cracking potential

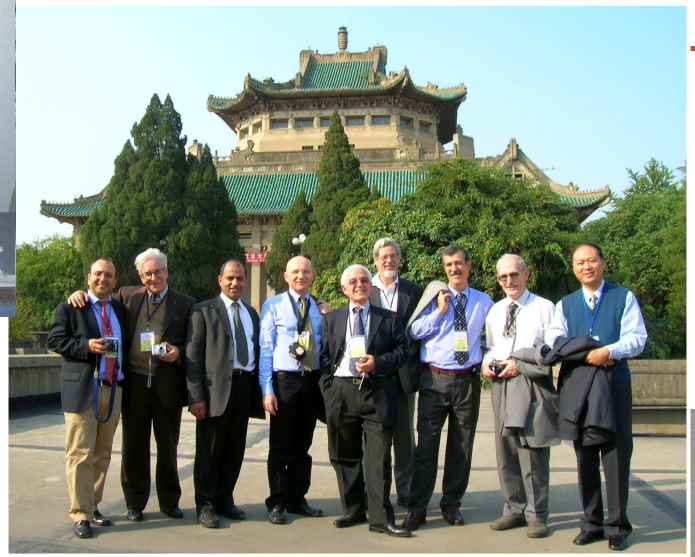
Theme D: Risk Analysis – assessment of reliability for concrete dams

Theme E: Open Themes

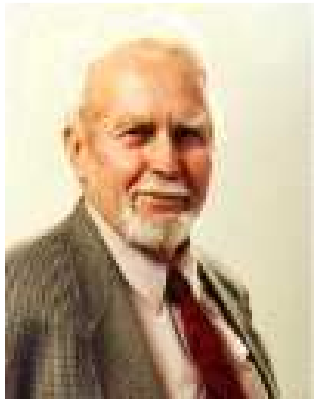
Concluding remarks

During its long-term mission, the Committee has changed continuously its membership.
Hence, it is not possible here to make a list of all experts who have contributed to its activity.
However, appreciation and gratitude have to be expressed to the former Chairmen and Vice-Chairmen who have given great boost to the conceiving and development of the Committee life.

Concluding remarks



- Olgierd Zienkiewicz
- Michele Fanelli
- Gabriella Giuseppetti
- Alain Carrère
- Ignacio Escuder Bueno



84th ICOLD ANNUAL MEETING

15th – 20th May 2016 Johannesburg, South Africa

WORKSHOP:

Lessons learned from the recent earthquakes in Italy. Qualification of Seismic Dams Analyses and of their Equipment & of Probabilistic Assessment of Seismic Hazard in Europe

The benefits of Benchmark Workshops organized by the ICOLD Technical Committee on "Computational Aspects on Dam Analysis and Design"