LE BARRAGE FAIT PEAU NEUVE

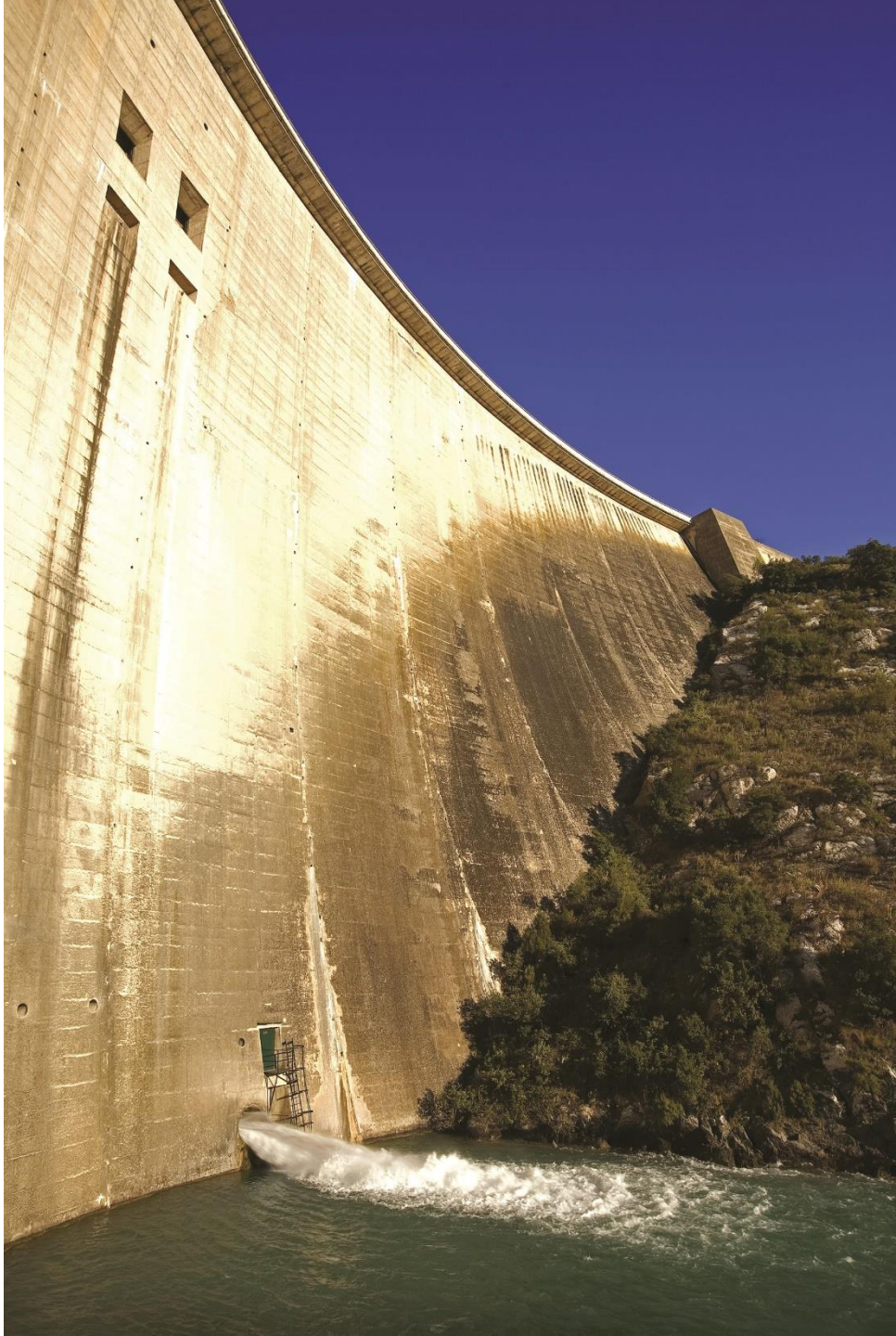
SCP Partager l'eau, construire l'avenir

TRACTEBEL ENGIE

COYNE ET BELLIER Ingénieurs Conseils

Bimont

BARRAGE RÉNOVÉ, PATRIMOINE PRÉSERVÉ



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1 Context

2 Preliminary studies

3 Numerical Modelling

4 Rehabilitation works

SCP Partager l'eau, construire l'avenir

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01

CONTEXT

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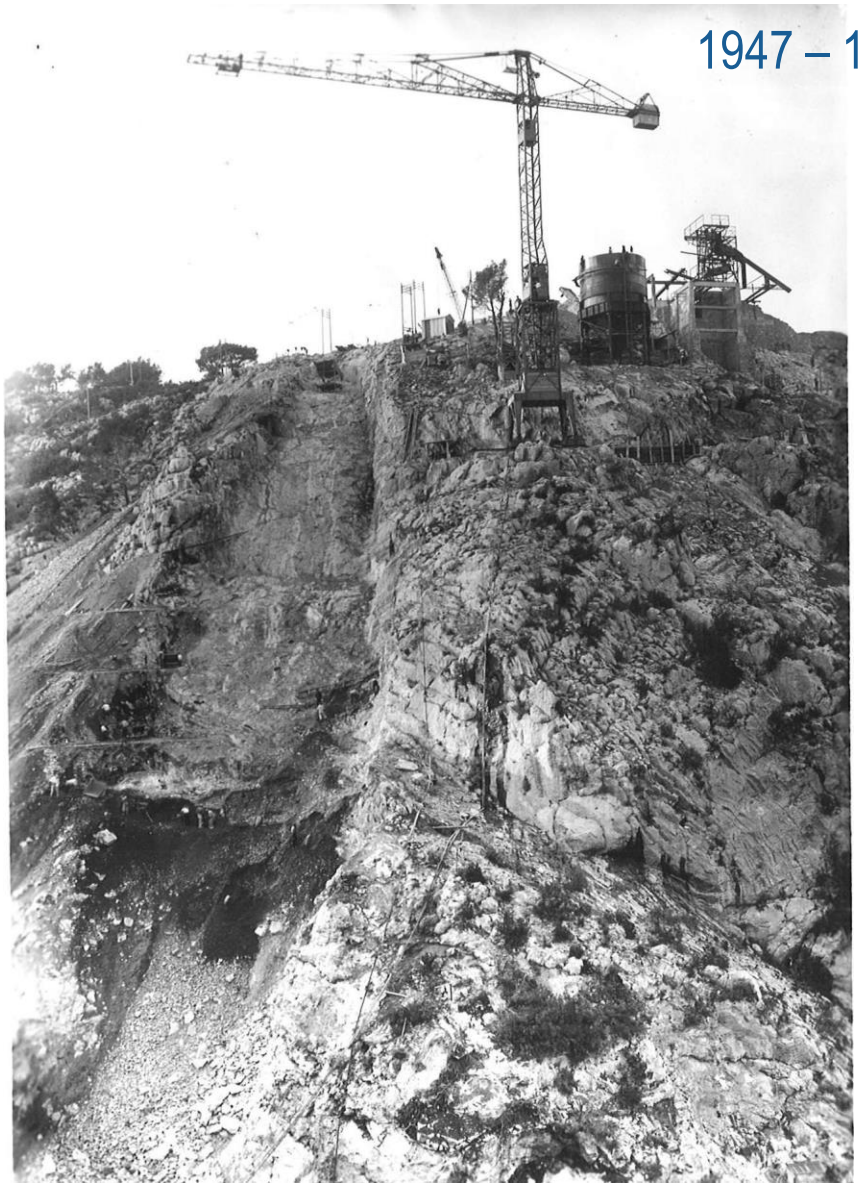
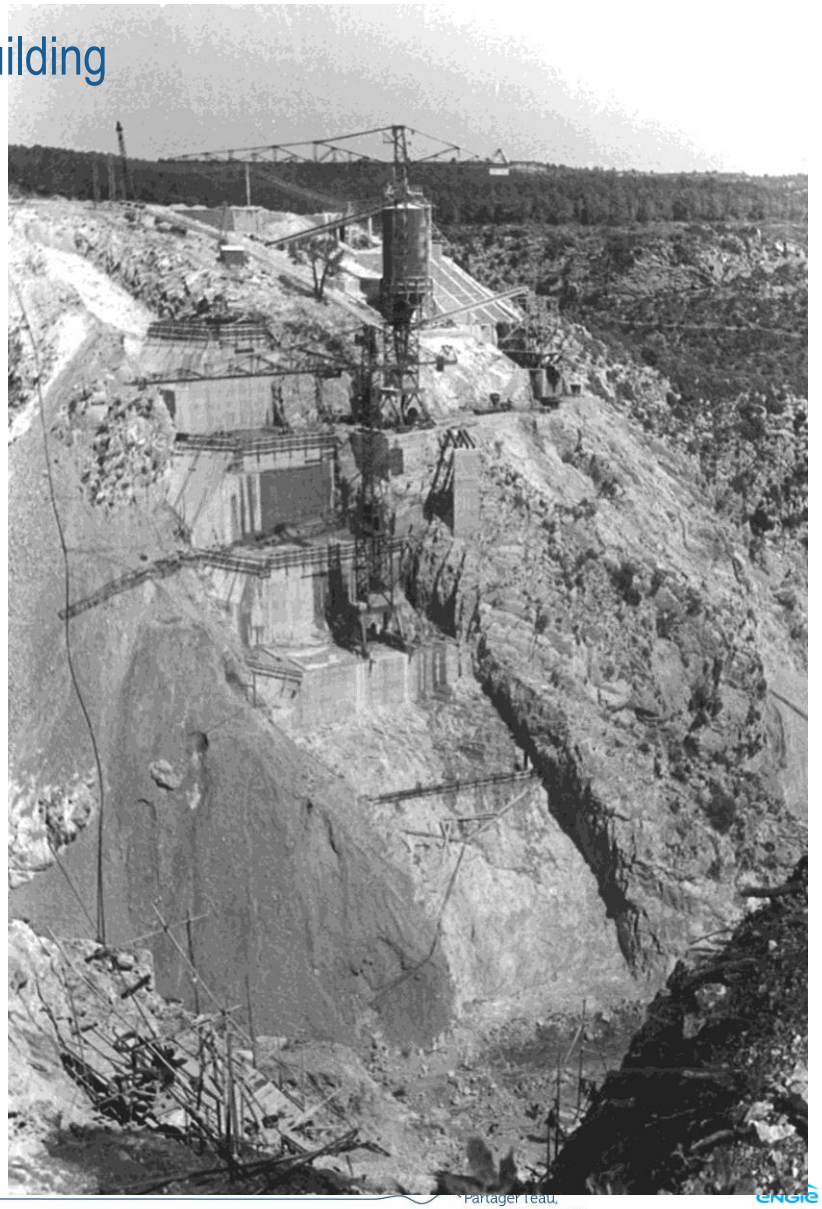
1947 – 1951 : Building





THE CRACKS

- 1963: The SCP takes possession of the bimont Dam
- Only 3 years after Malpasset disaster
- Numerous cracks observed on the second plot and on the right bank of the dam

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SCP
Partager l'eau, construire l'avenir

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ENGIE

- The geology was first suspected.

- Numerous fields of investigations:
  - Complementary geological studies
  - Gallery cutted into the rock foundation of the second cantilever
  - Additionnal monitoring instruments: 2 plumblines, fissurometers, Topographic survey
  - Mapping of the cracks network
  - Several numerical models

⇒ A geological cause of the damages was rejected

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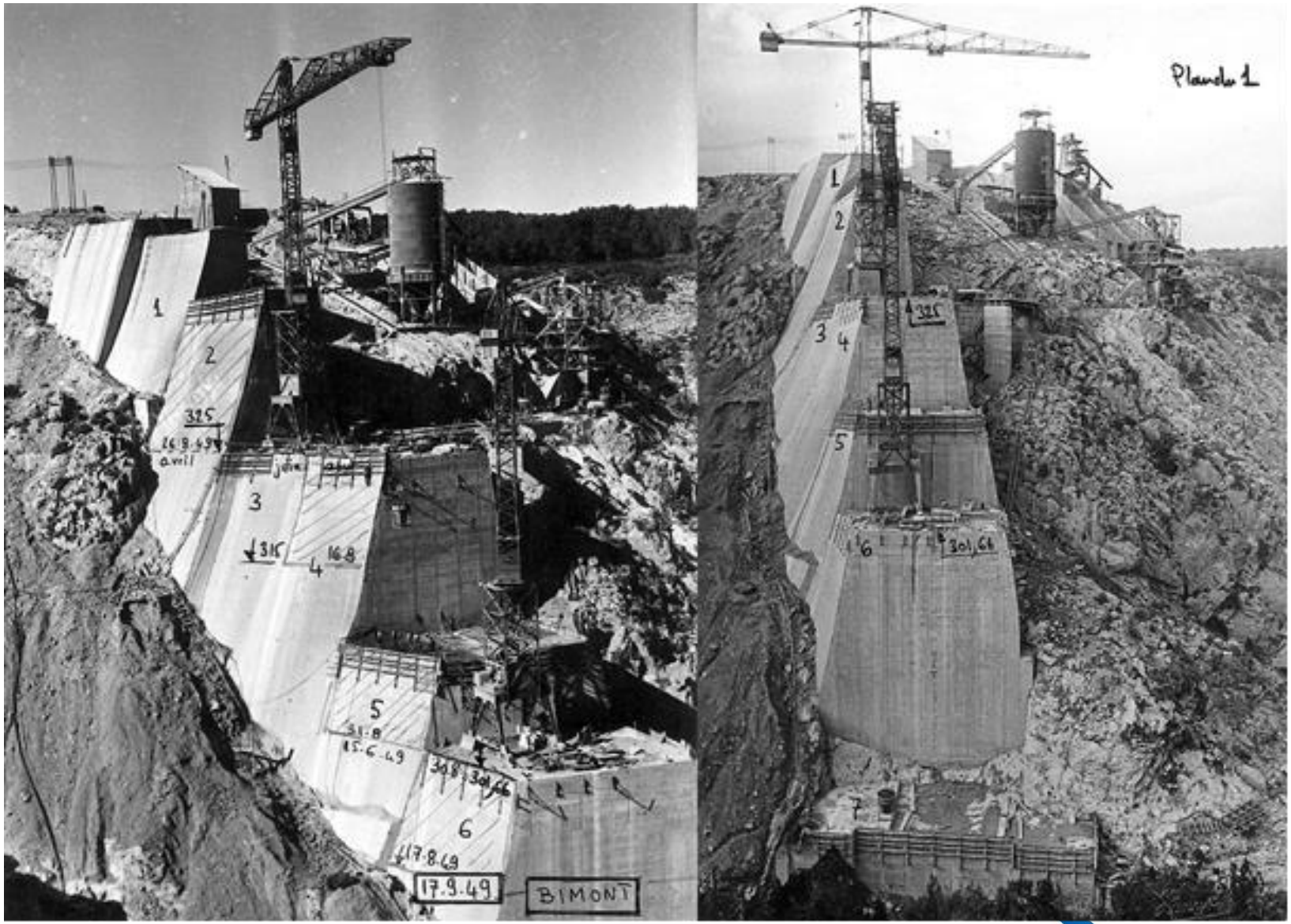
THE CRACKS



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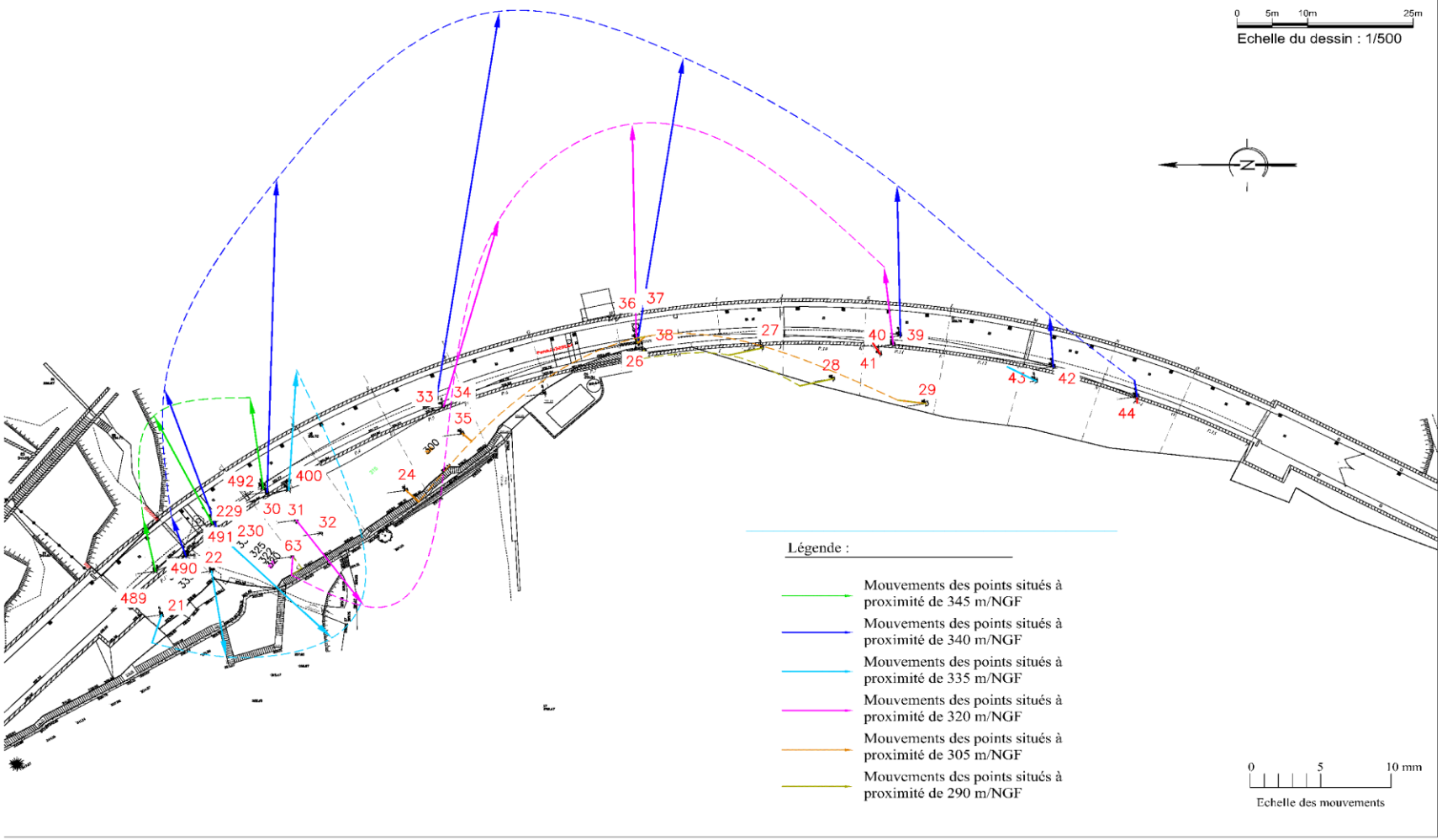
BARRAGE DE BIMONT

Représentation des mouvements radiaux et tangentiels au 17/09/2014 x2000



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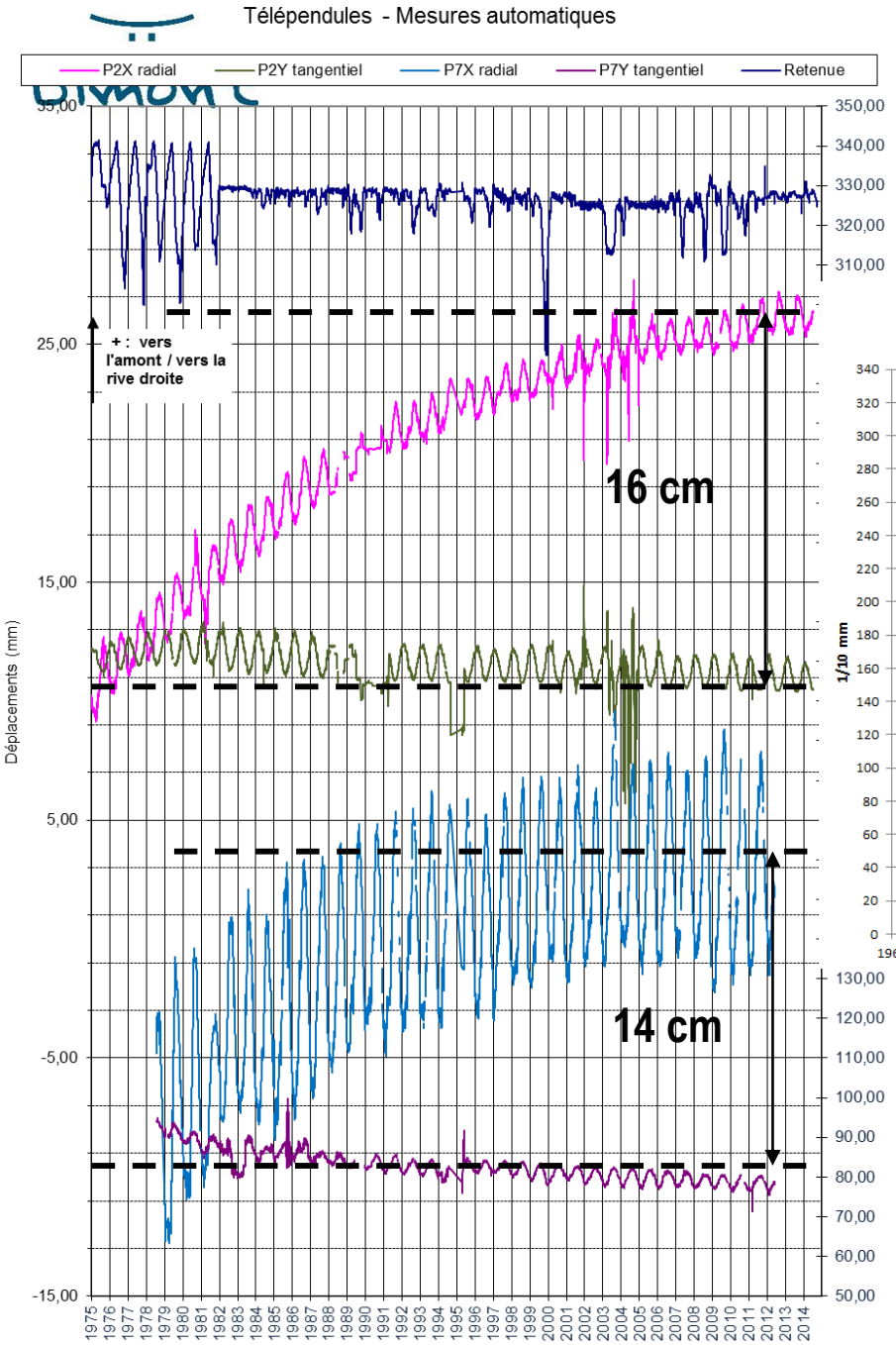
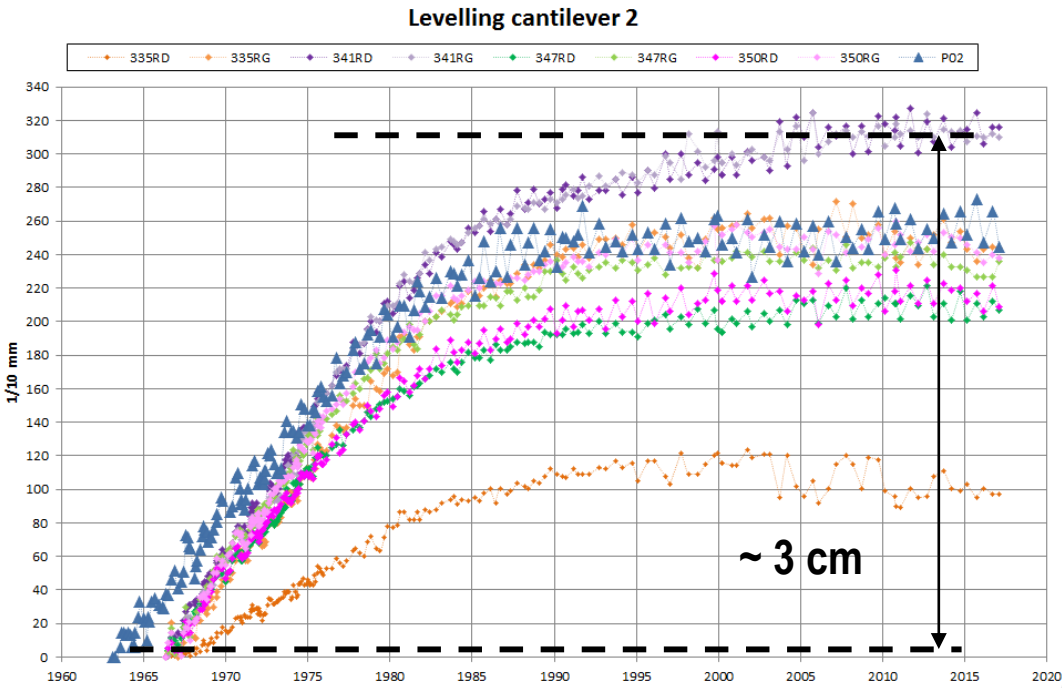
TRACTEBEL ENGIE





Partager l'eau, construire l'avenir

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02

PRELIMINARY STUDIES

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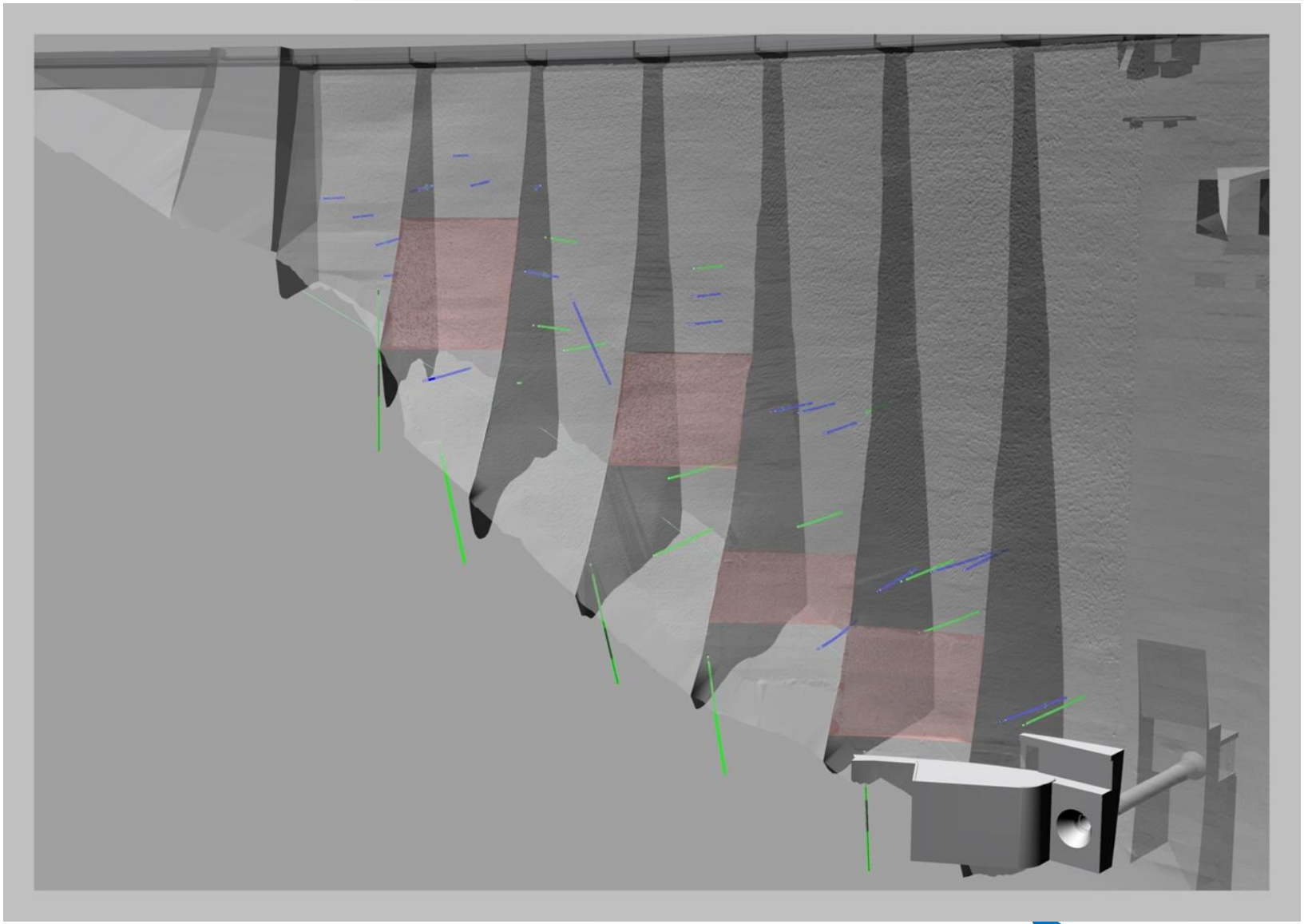
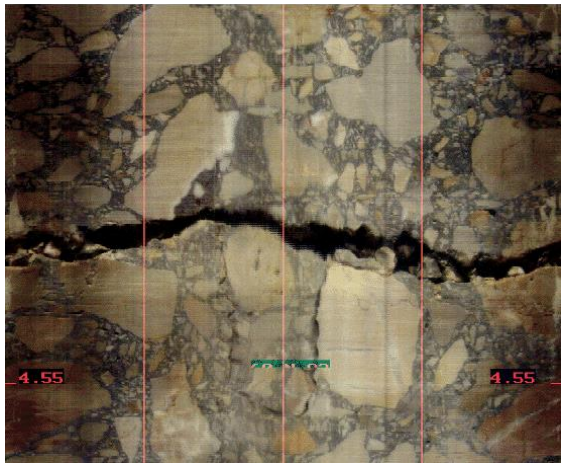
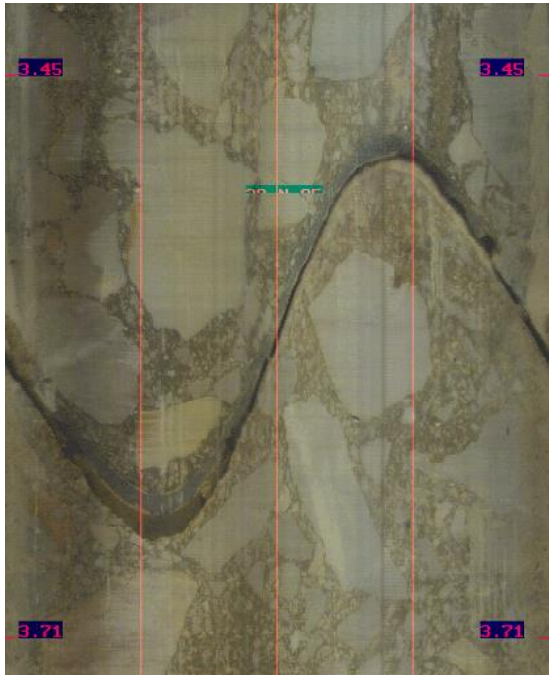
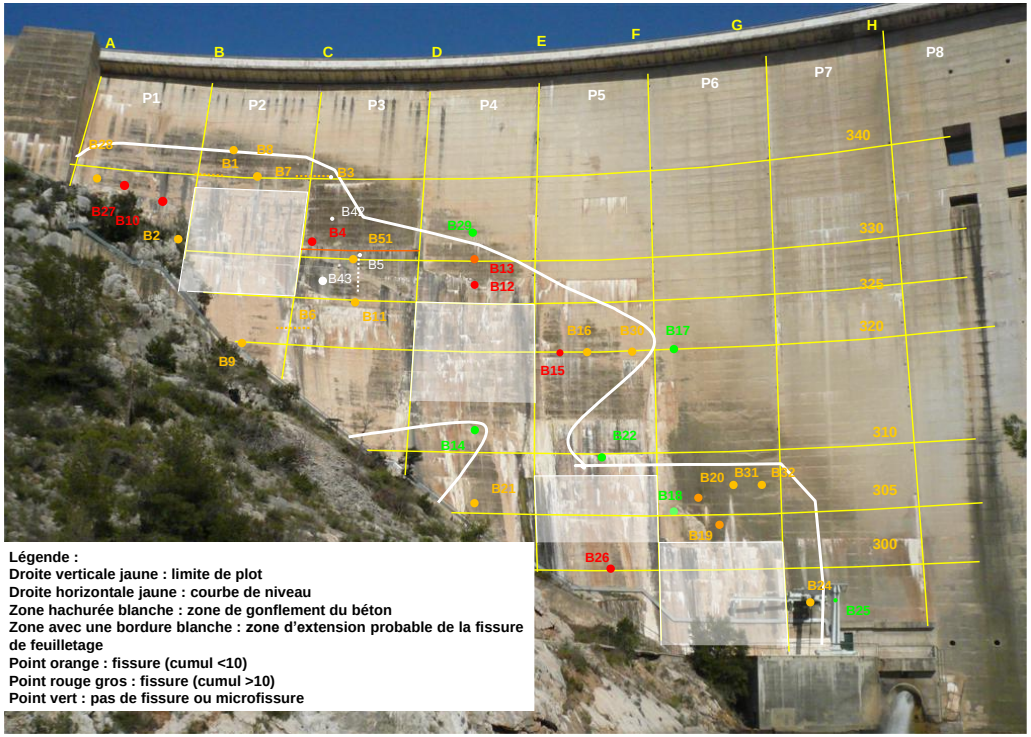






⇒ The investigations showed internal cracks into the seven cantilevers of the rights banks



Légende :
Droite verticale jaune : limite de plot
Droite horizontale jaune : courbe de niveau
Zone hachurée blanche : zone de gonflement du béton
Zone avec une bordure blanche : zone d'extension probable de la fissure de feuilletage
Point orange : fissure (cumul <10)
Point rouge gros : fissure (cumul >10)
Point vert : pas de fissure ou microfissure

Lmdc toulouse

Division Transfert de Technologie

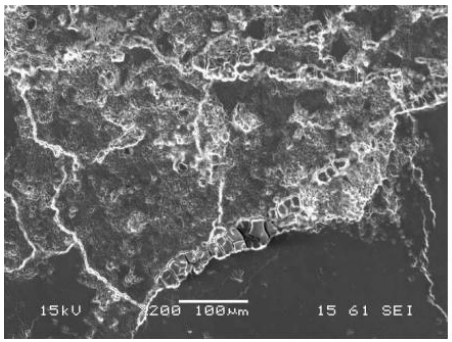
Laboratoire Matériaux et Durabilité des Constructions

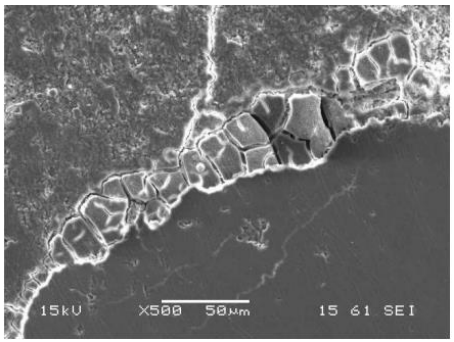
INSA/UPS - Génie Civil - 135 Avenue de Rangueil - 31077 Toulouse Cedex 04

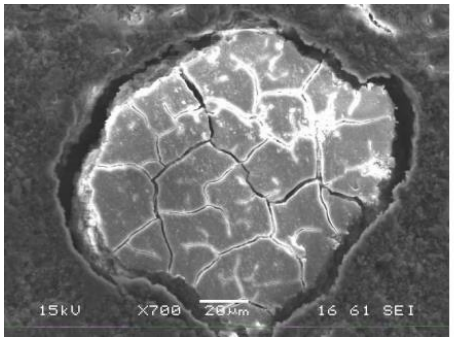
Tel : 05.61.55.60.08 Fax : 05.61.55.81.49 mail : lmdc-dtt@insa-toulouse.fr

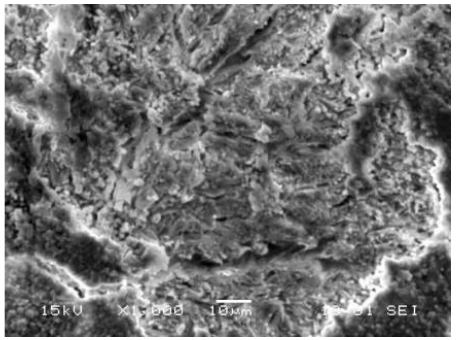
- Electron microscope, energy dispersive X-ray spectrometer

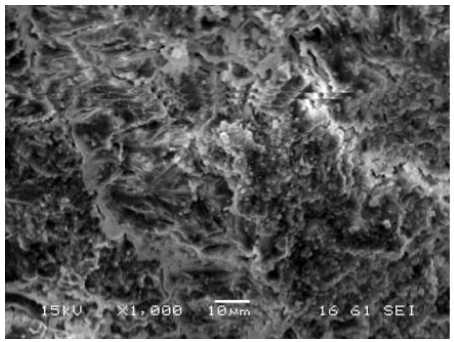
  ⇒ Presence of massive secondary ettringite resulting from an internal sulphate reaction.

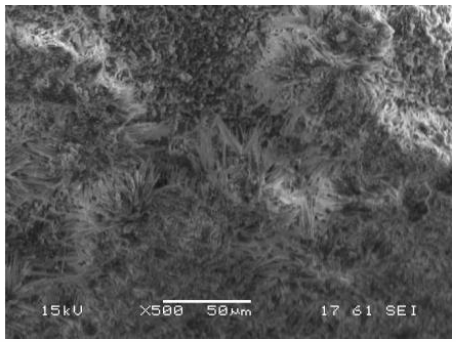












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- Test performed during 106 weeks to assess the residual expansion of concrete samples taken into sane concrete and swelling concrete.

S1		
1,70 a 1,90 m	3,50 a 3,70 m	5,00 a 5,20 m
60	98	171
S2		
1,40 a 1,60 m	3,60 a 3,80 m	4,80 a 4,95 m
72	88	94
S3		
1,65 a 1,85 m	3,50 a 3,70 m	5,10 a 5,30 m
54	84	82
S4		
1,65 a 1,85 m	3,25 a 3,45 m	4,70 a 4,90 m
306	129	155
B13		
1,50 a 1,70 m	3,50 a 3,70 m	5,15 a 5,35 m
35	25	31

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NUMERICAL MODELLING

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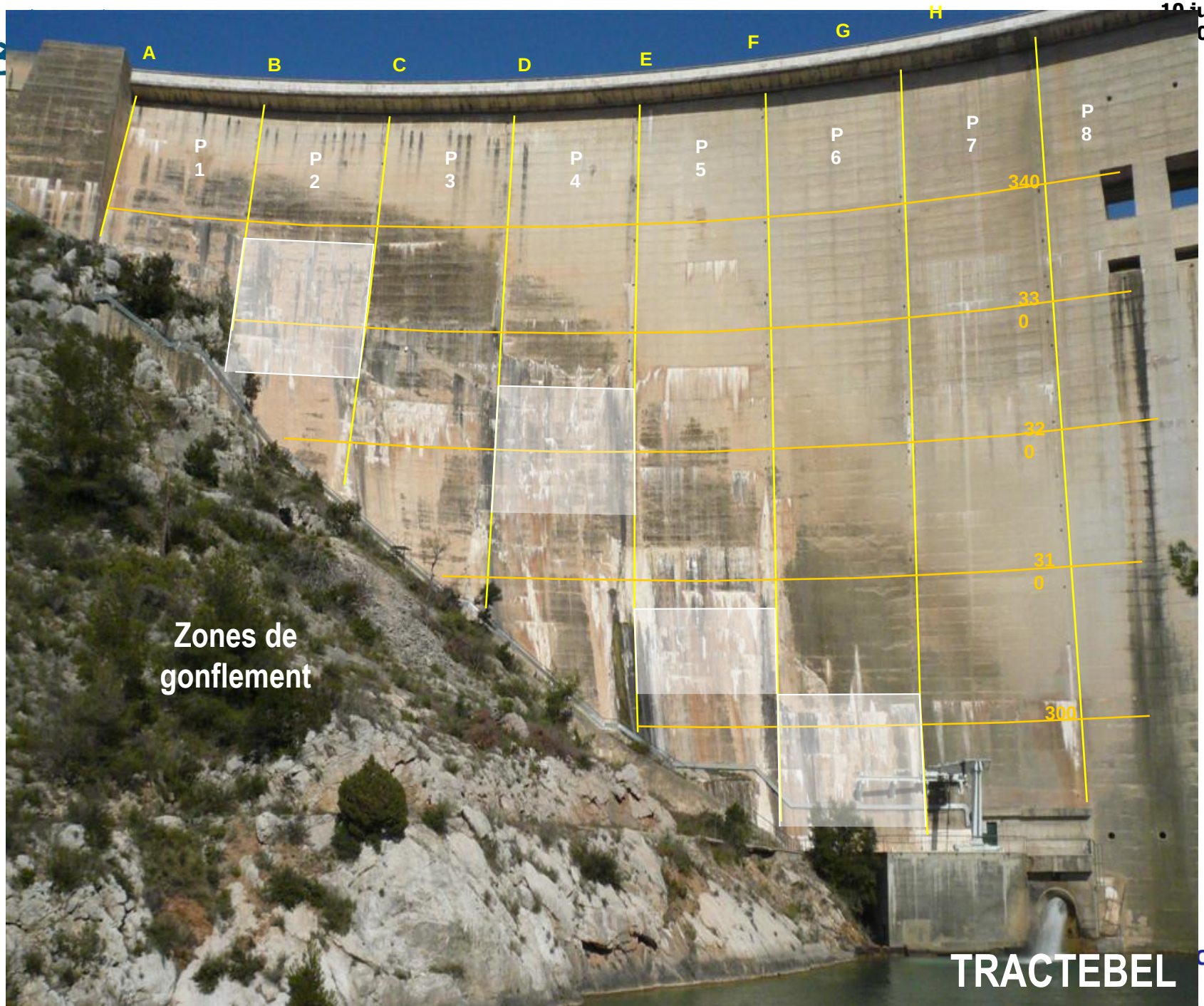
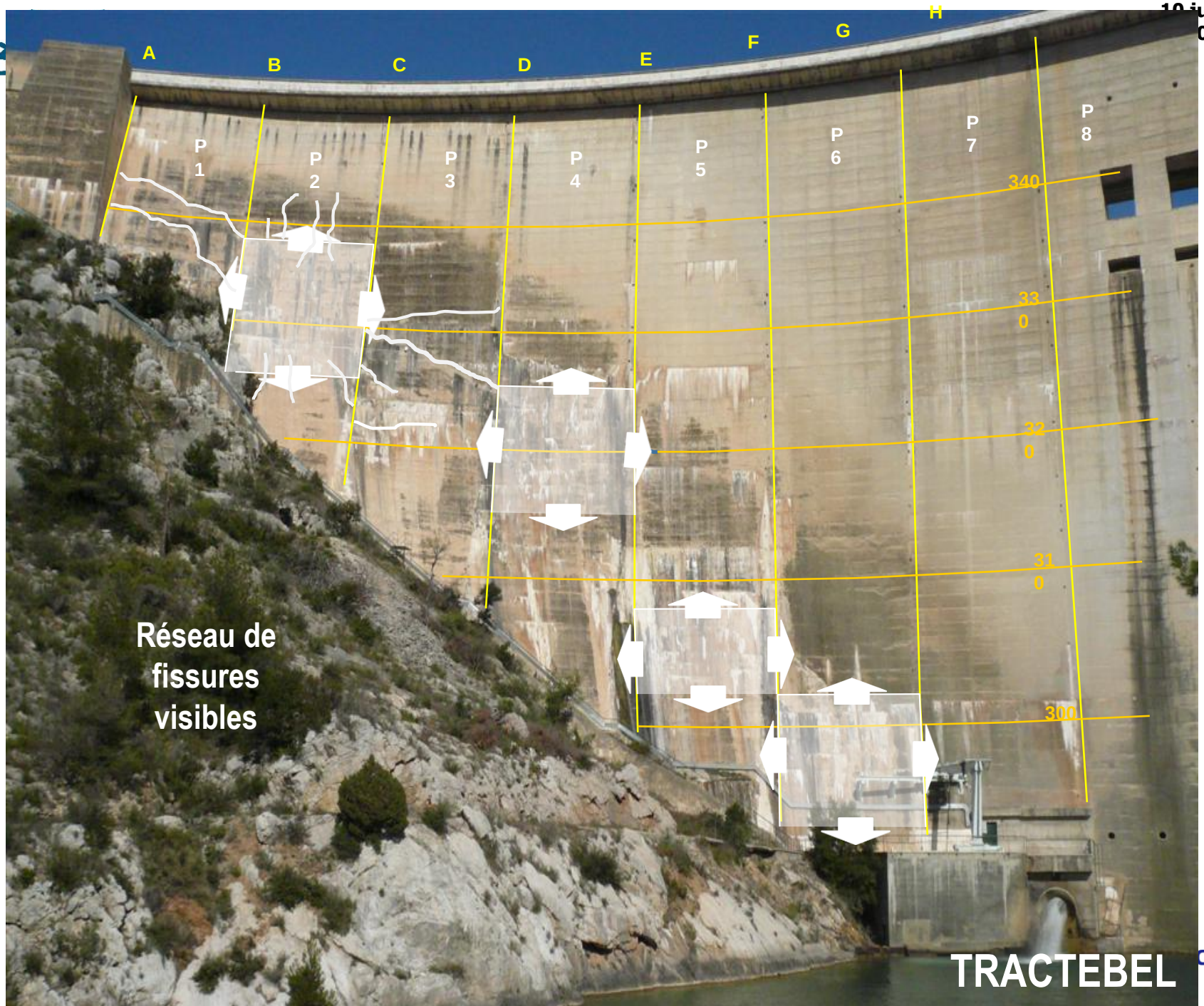

A
B
C
D
E
F
G
H
P 1
P 2
P 3
P 4
P 5
P 6
P 7
P 8
340
33 0
32 0
31 0
300
Zones de gonflement
TRACTEBEL


A
B
C
D
E
F
G
H
P 1
P 2
P 3
P 4
P 5
P 6
P 7
P 8
340
33 0
32 0
31 0
300
Zones de gonflement
TRACTEBEL


A
B
C
D
E
F
G
H
P 1
P 2
P 3
P 4
P 5
P 6
P 7
P 8
340
33 0
32 0
31 0
300
Réseau de fissures visibles
TRACTEBEL


A
B
C
D
E
F
G
H
P 1
P 2
P 3
P 4
P 5
P 6
P 7
P 8
340
33 0
32 0
31 0
300
Downstream View:
Swelling zones
Cracks
Open construction joints

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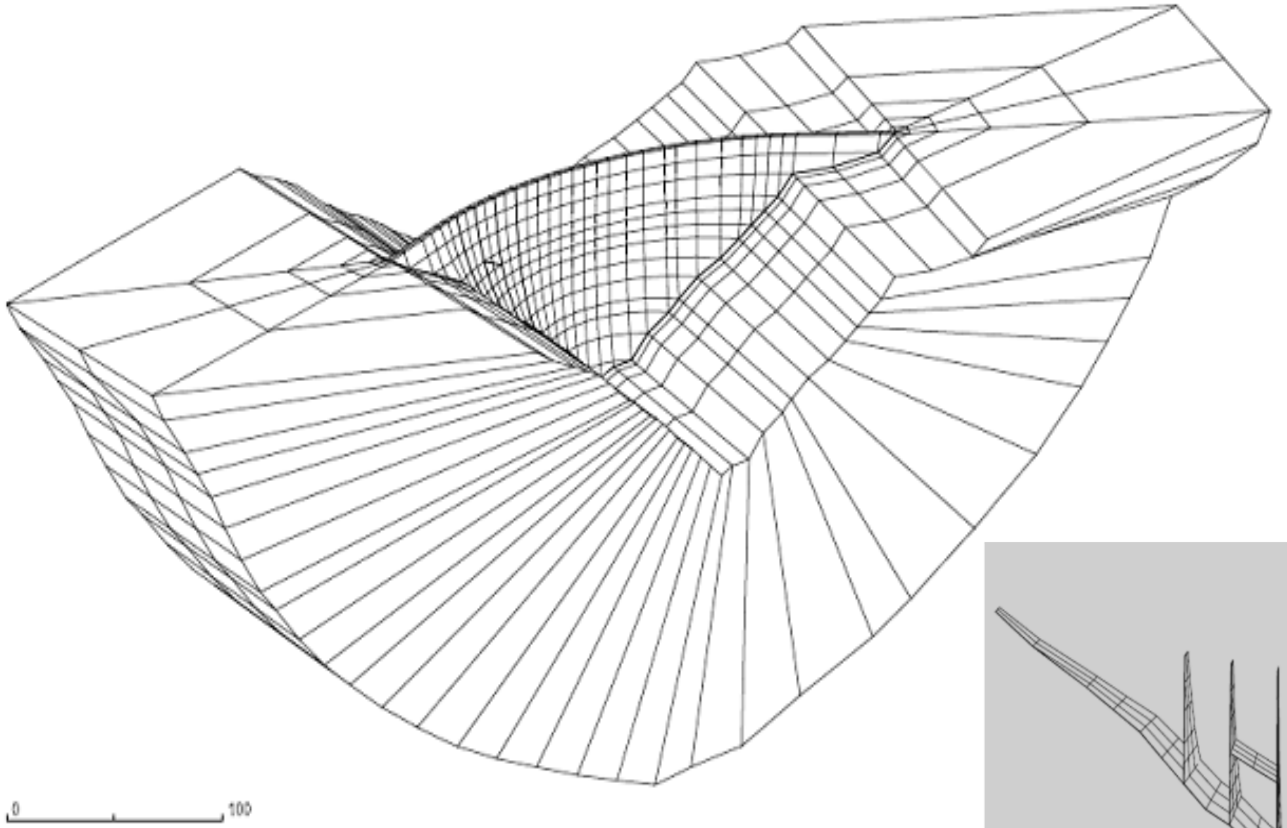
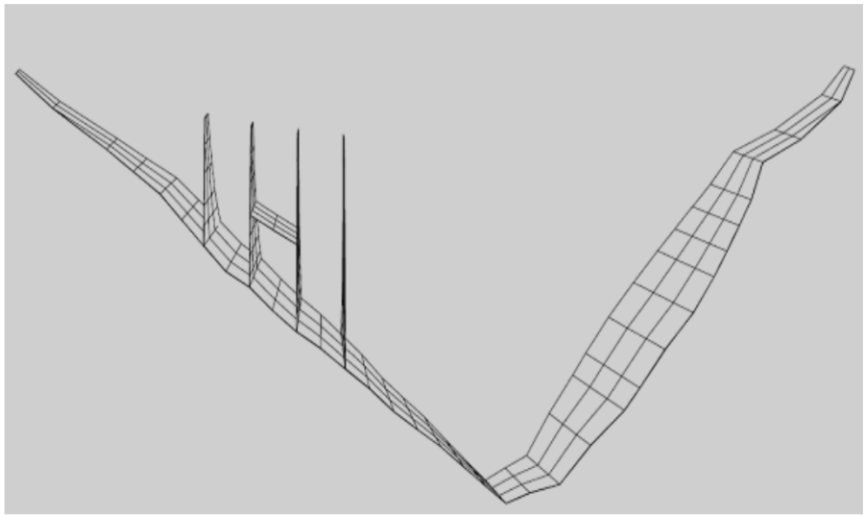
DAM AND FOUNDATION MESHES





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•Isotropic thermal equivalence

$$\lambda \times \Delta\theta = \varepsilon_g = \dot{\varepsilon}_g \times \Delta t$$

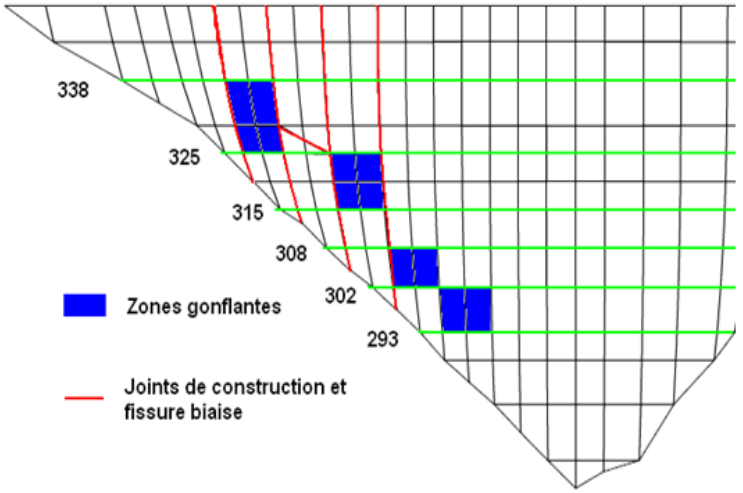
•SCAS model (Stress Controlled Anisotropic Swelling) :

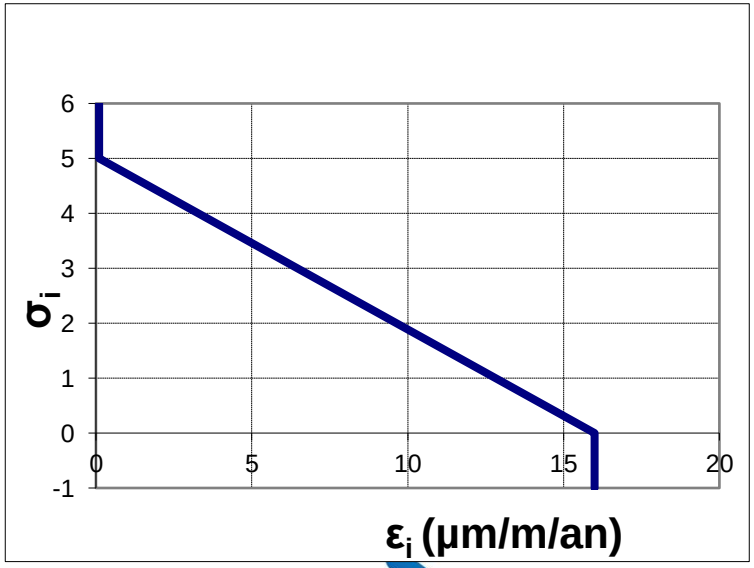
$\dot{\varepsilon}_g(i) = F(\sigma_i)$ **with** ***i=1, 2, 3***

$F(\sigma_i) = 0$ **If $\sigma_i \geq \sigma_L$ (high compression),**

$F(\sigma_i) = \dot{\varepsilon}_{gL}$ **if $\sigma_i \leq 0$ (tension),**

$F(\sigma_i) = \dot{\varepsilon}_{gL} \times \left(1 - \frac{\sigma_i}{\sigma_L}\right)$ **si $0 \leq \sigma_i \leq \sigma_L$**





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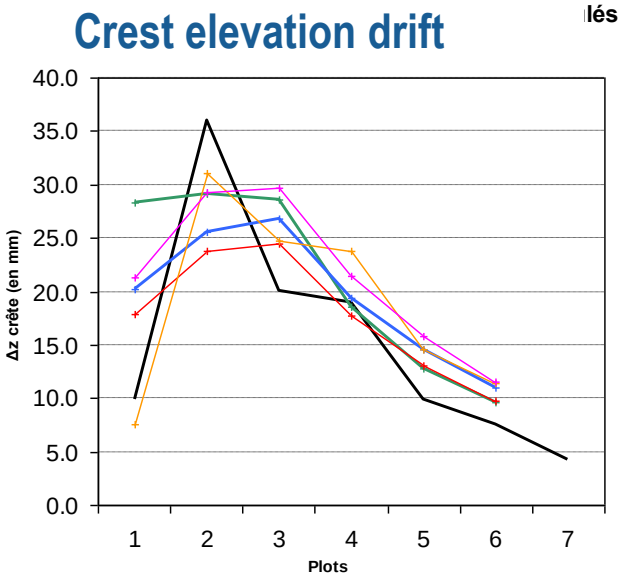
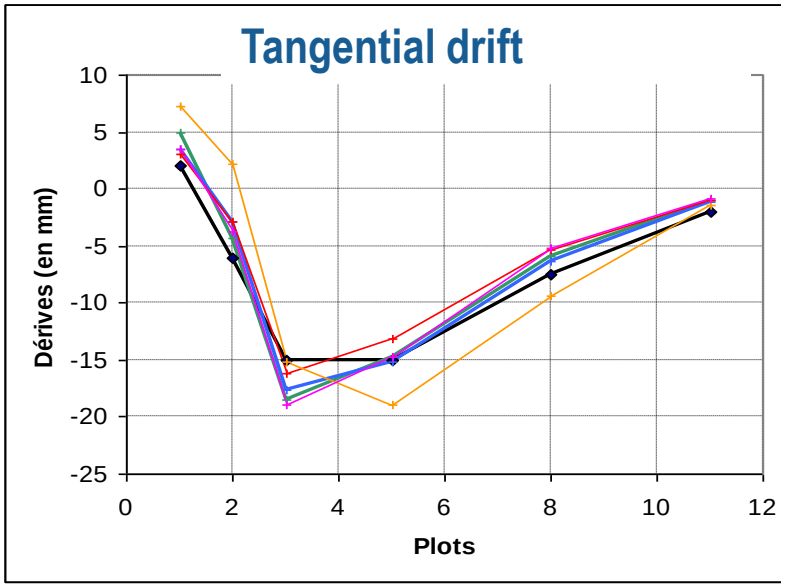
SWELLING MODELISATION

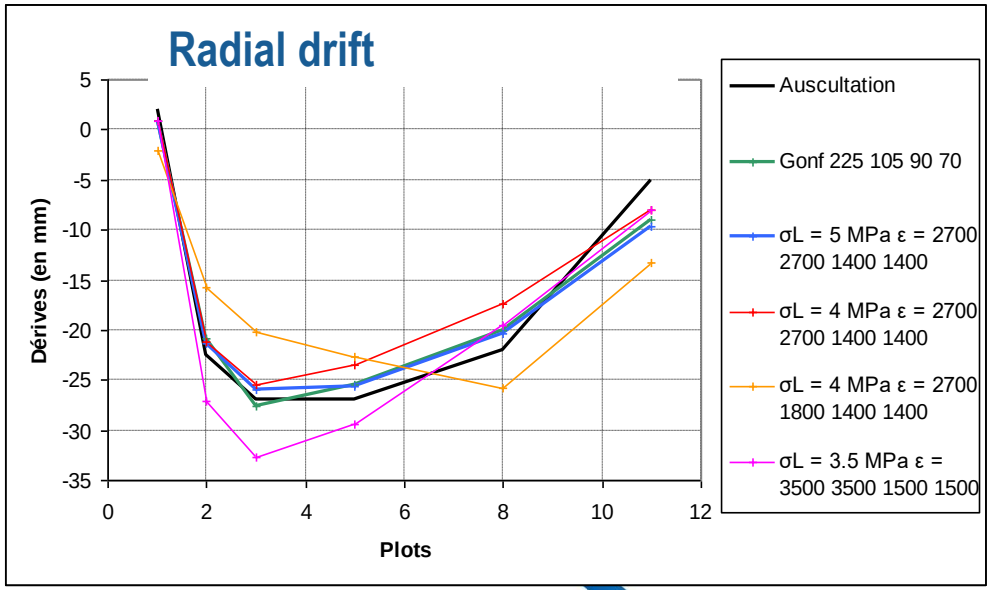
STRESS CONTROL ANISOTROPIC SWELLING LAW (SCAS) WITH

σ_L = 5 MPa, $\dot{\varepsilon}_{GL}$ = 90 10-6M/M/Y

ε_{GL} varying from 1,4 to 2,7 mm/m







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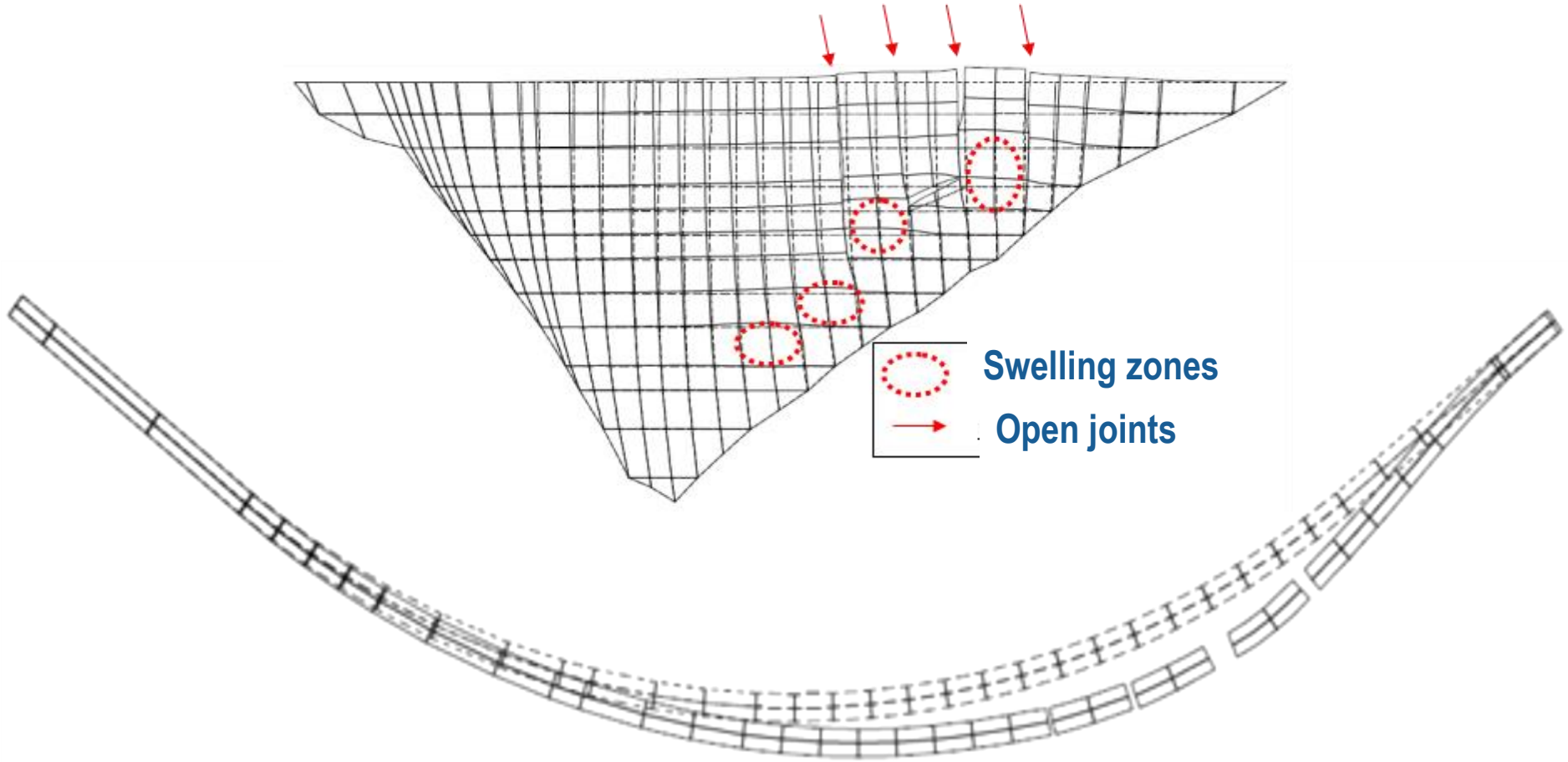
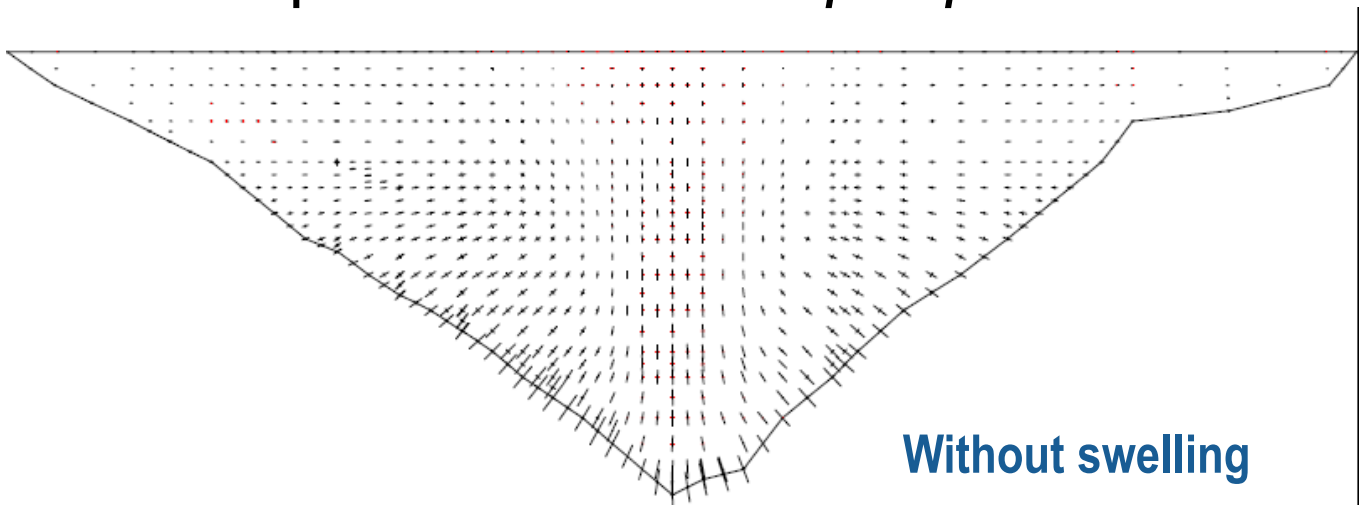
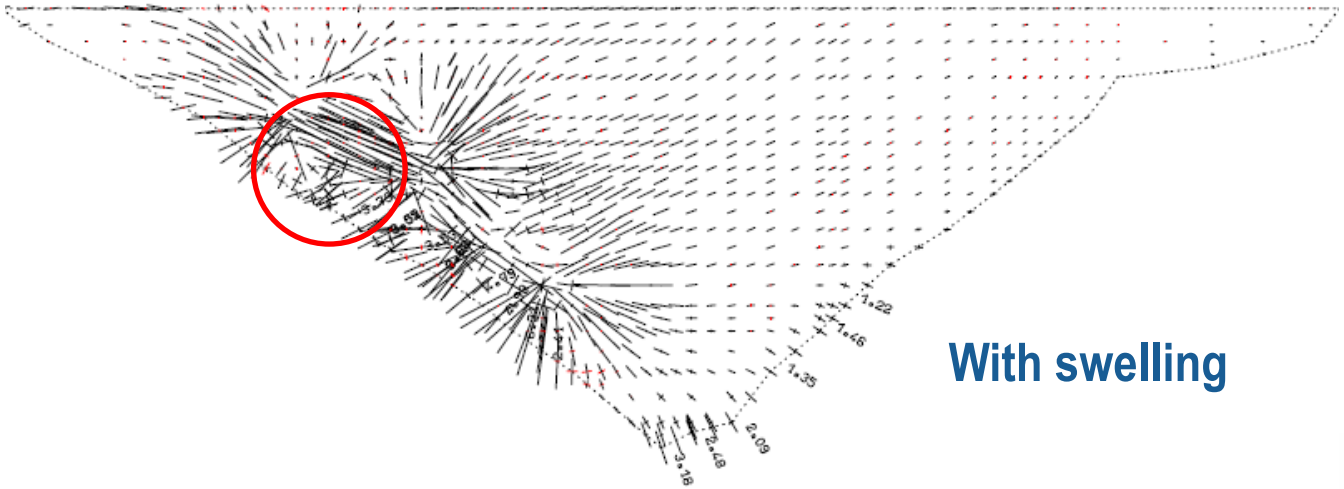
Deformations



Downstream face / *parement aval*
Principal stresses / *contraintes principales*

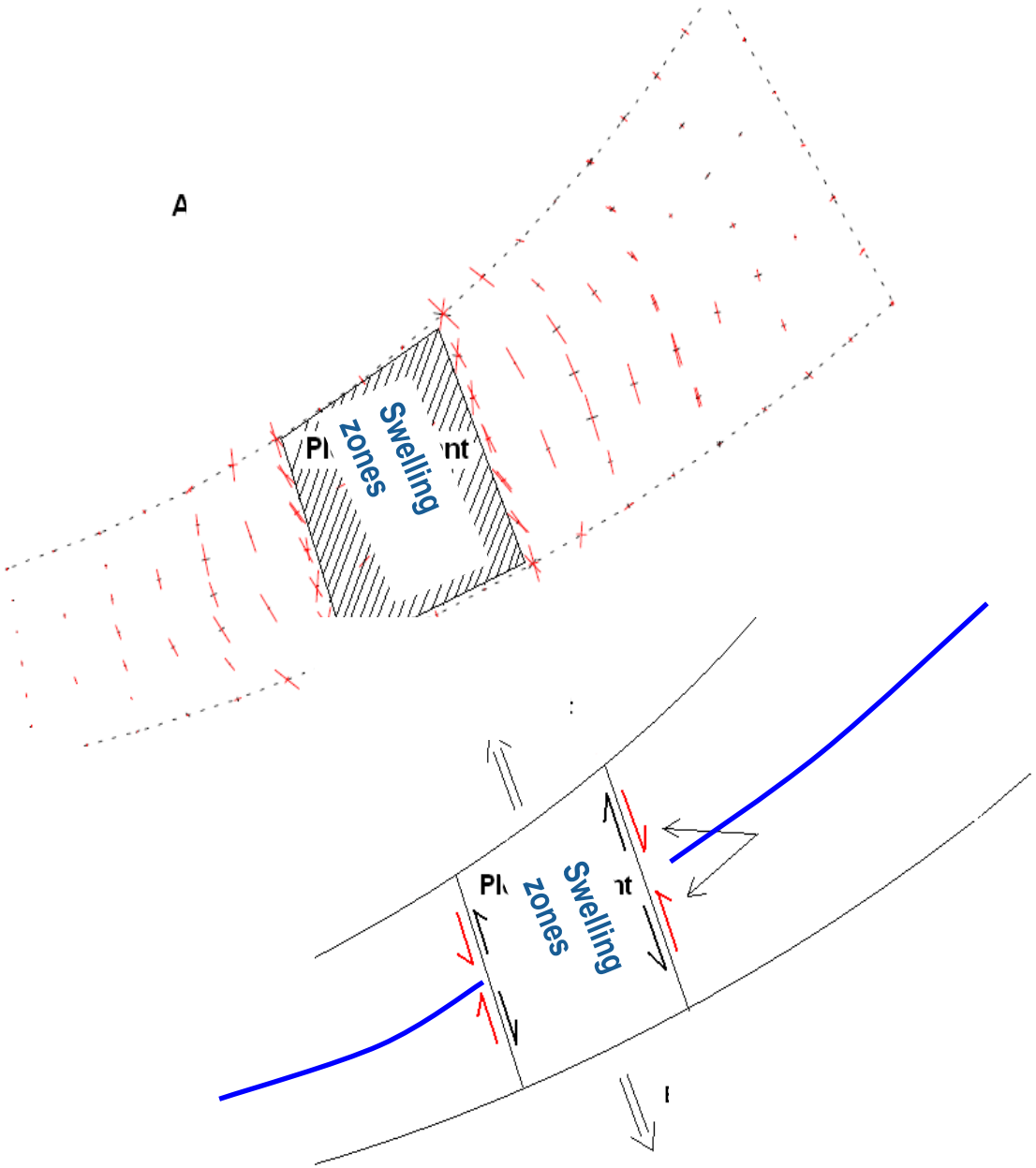


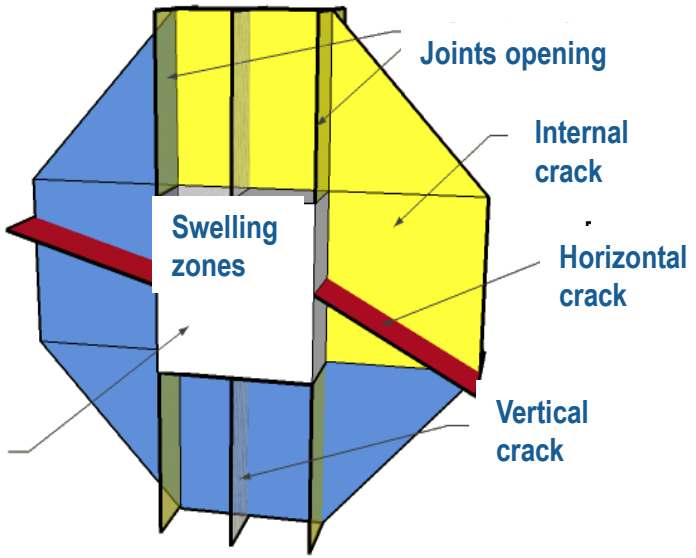
Without swelling



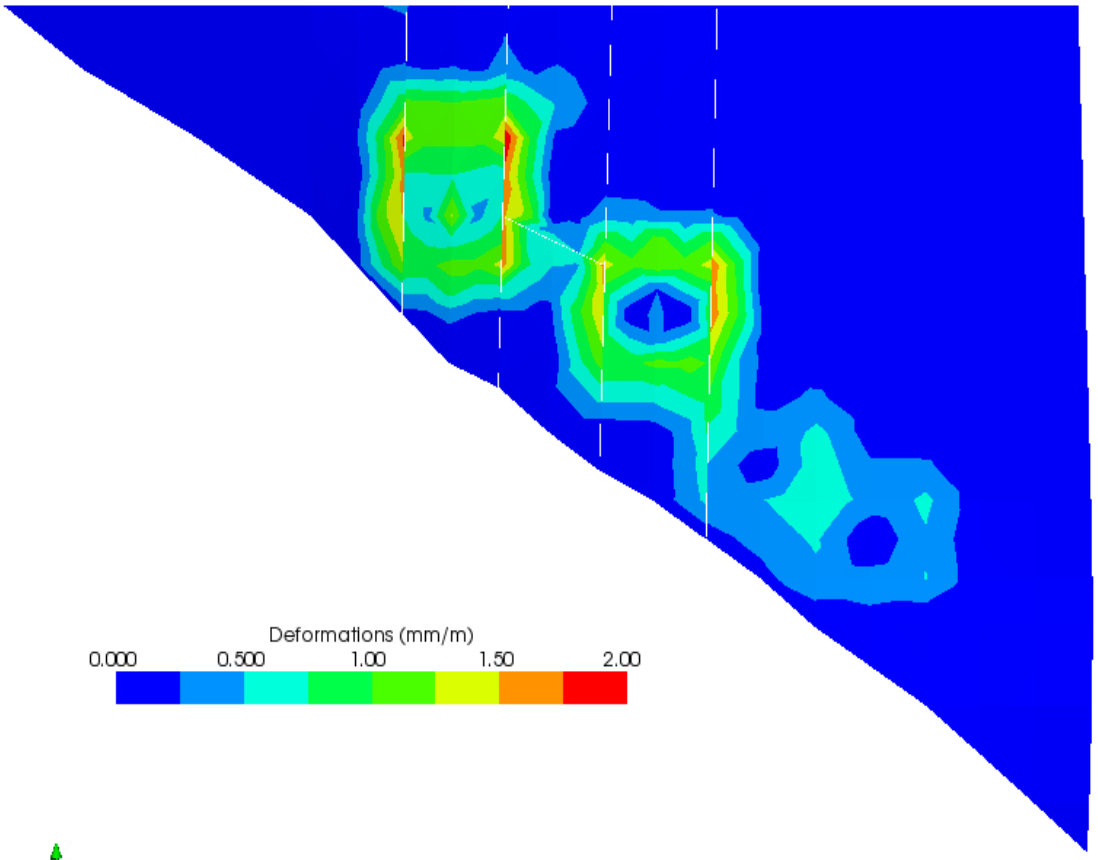
With swelling

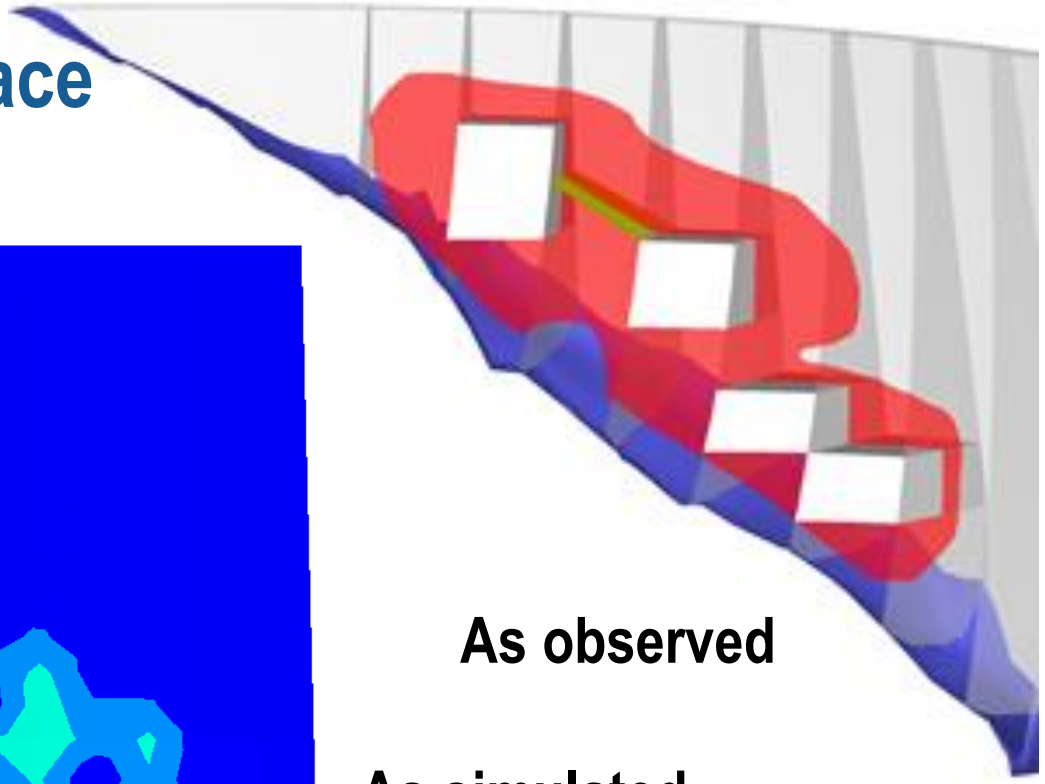
Interpretation





Internal cracking surface





As observed

As simulated

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REHABILITATION WORKS

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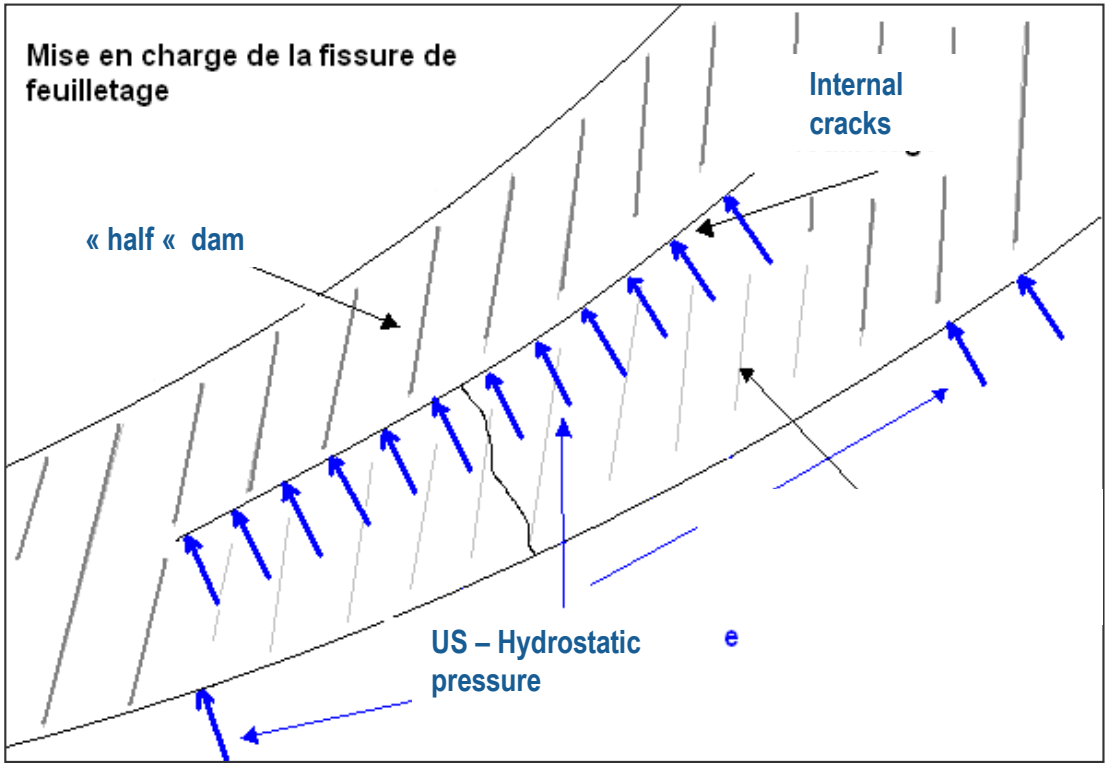
– Cracks grouting
– Construction joints grouting
– Upstream face watertightning
– RB thrust block reinforcement
– Drainage curtain

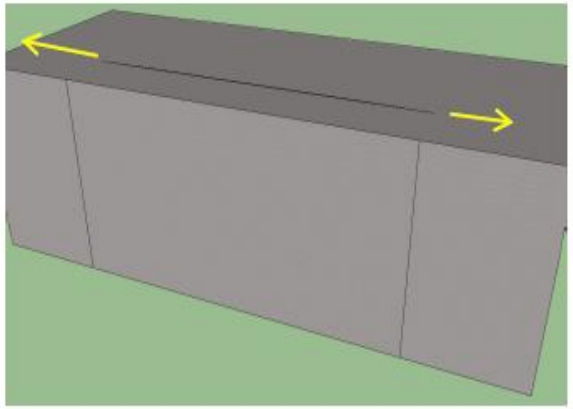
Cracks grouting: why ?

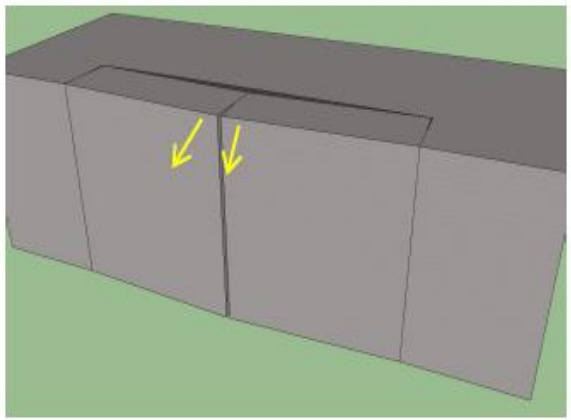
- Avoid application of pore pressure on internal cracks surface
- allow the arch stresses to be transmitted in the dam body



Cracks grouting

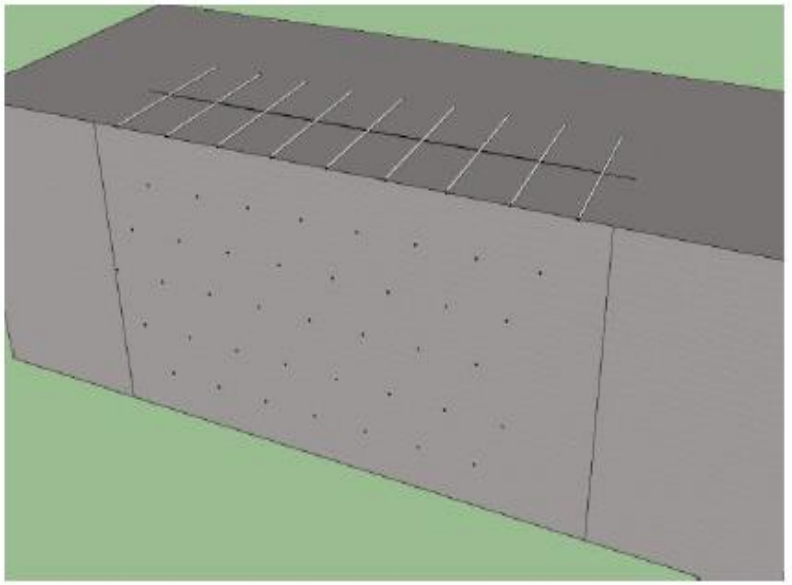
- Identified risks
  - Potential extension of cracks under grouting pressure
  - Possibility to eject the concrete part between the internal crack and dam faces due to grouting pressure
  -



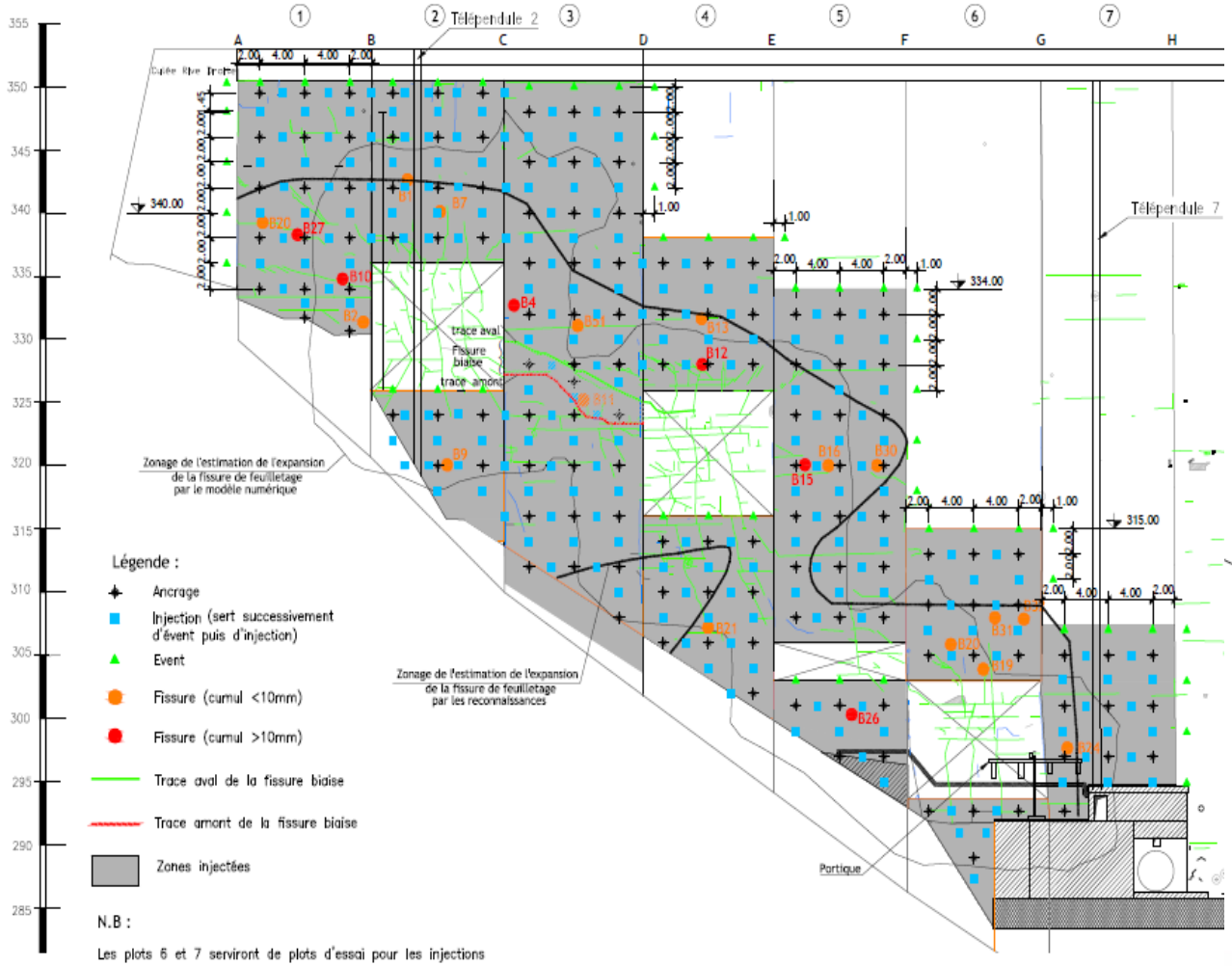


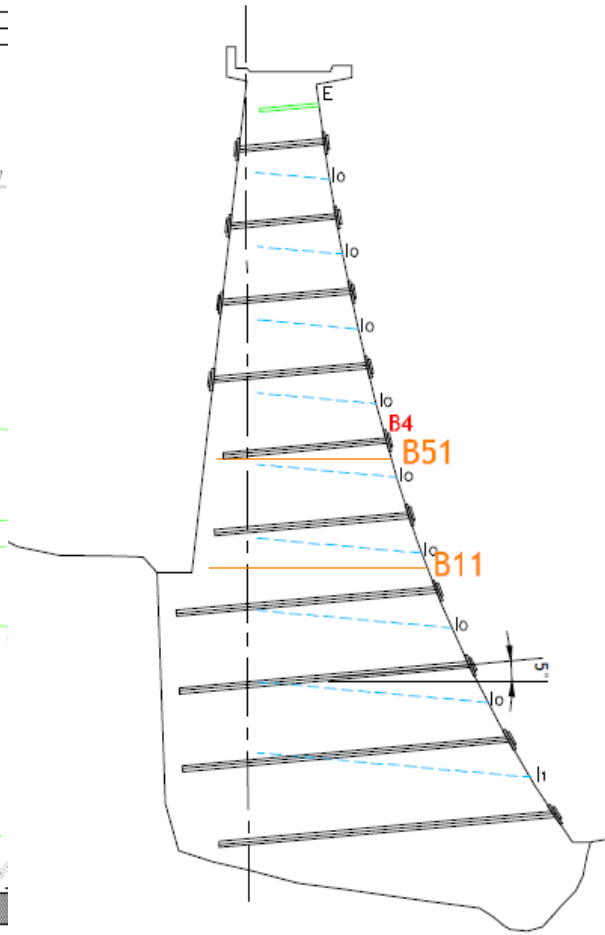
Cracks grouting

- Technical solutions
  - Temporary reinforcement with passive horizontal anchors
  - Systematic inspection of all drillings by camera
  - Cement grouting process bottom up
  - Grouting pressures carefully monitored en reduced surfaces (4 x 4 m)
  - Automatic topographic surveillance

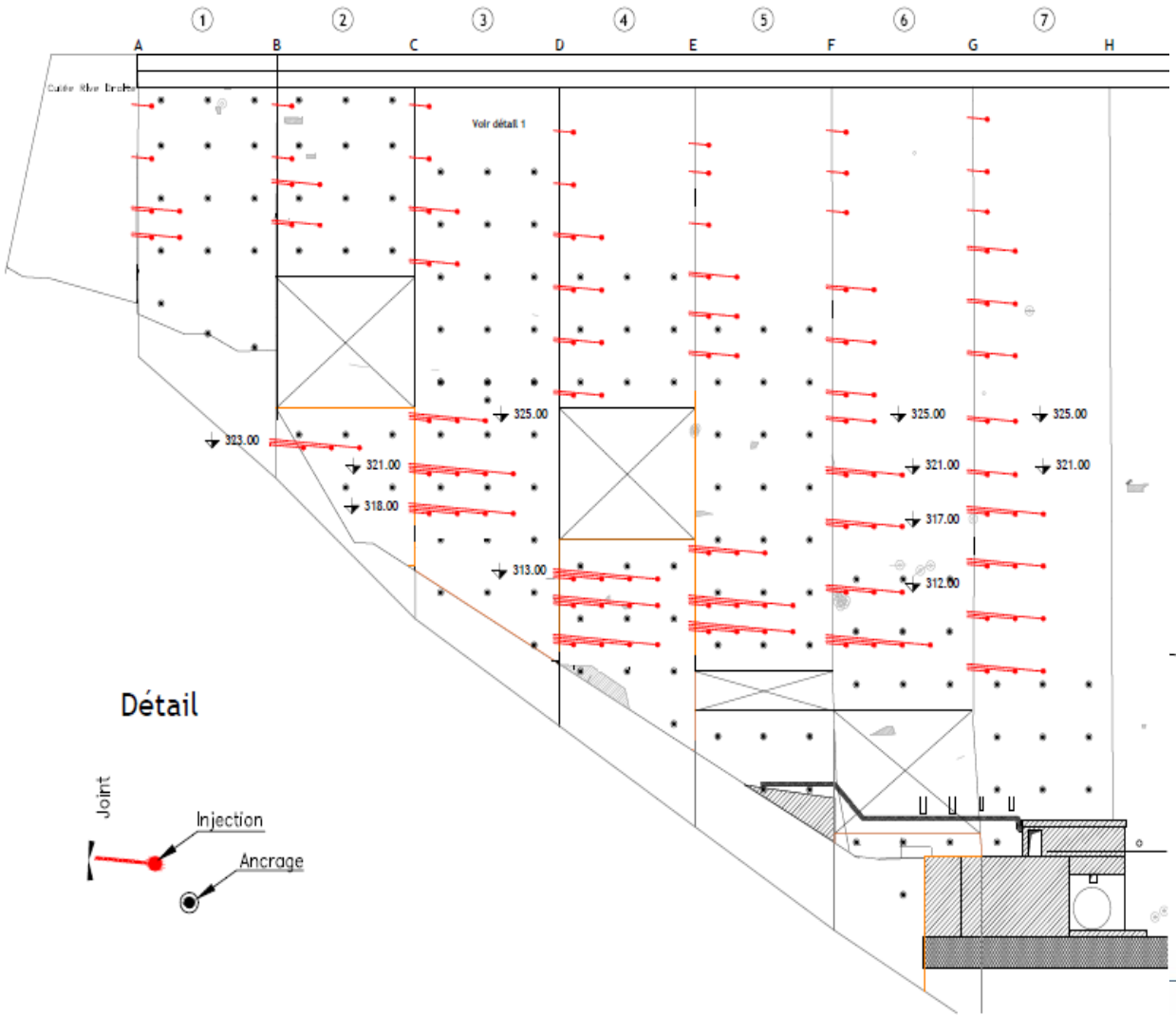


Cracks grouting : passive anchors implementation

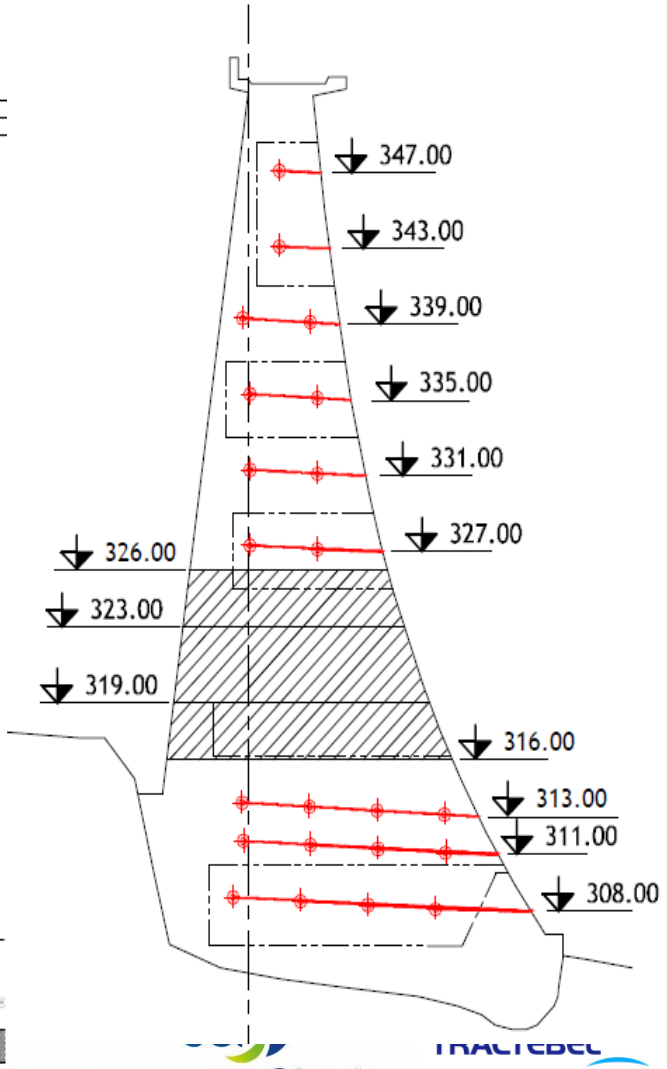




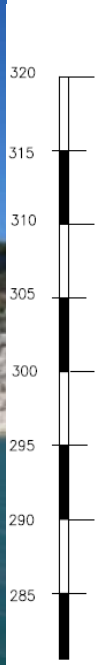
Construction joints grouting

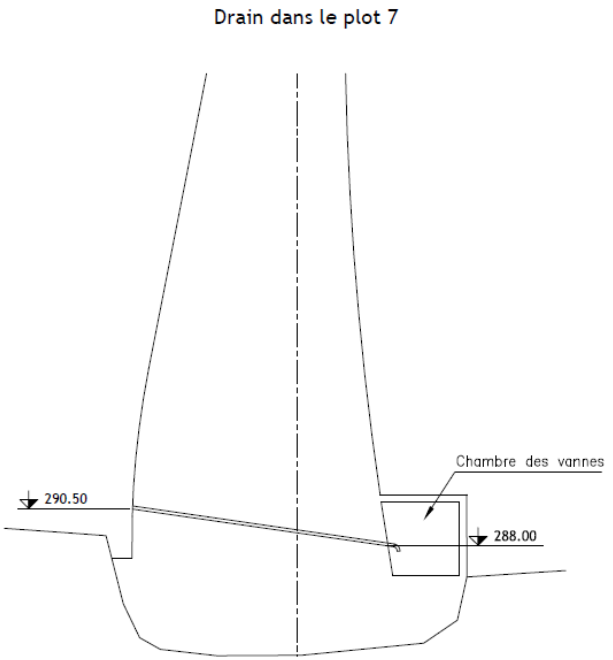


Coupe sur le joint D

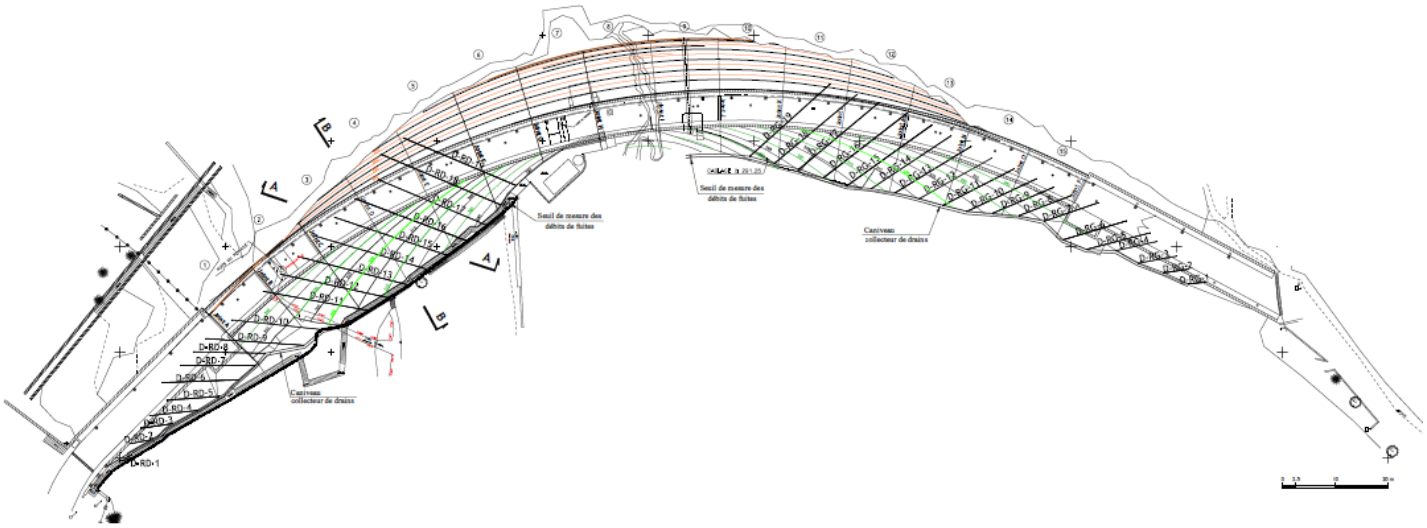


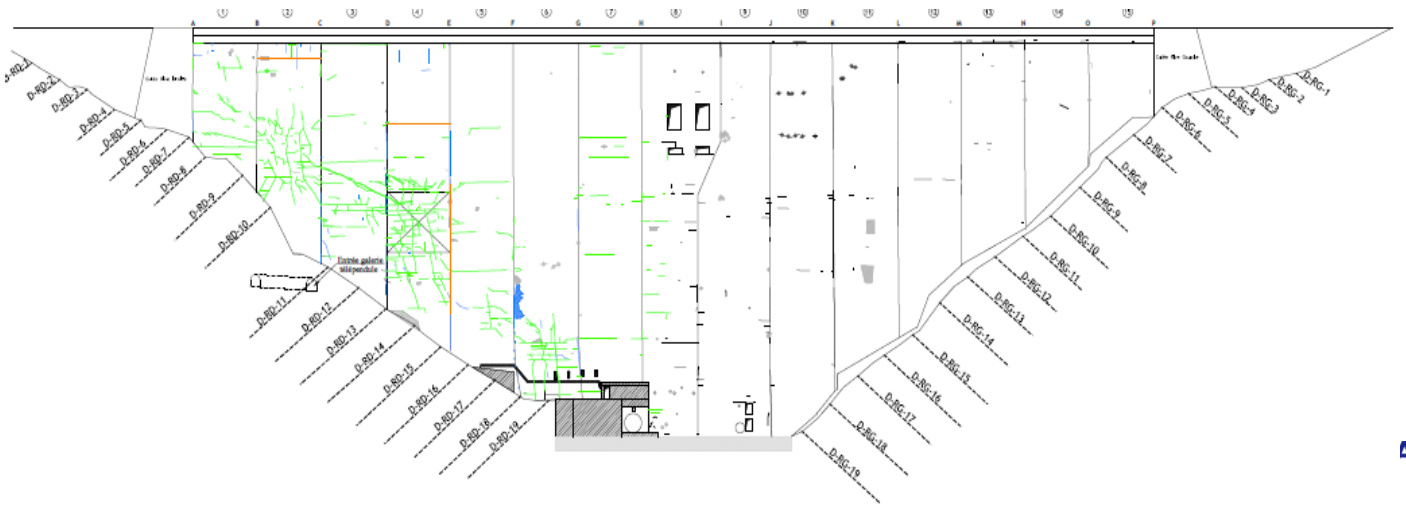
US face watertighting





Drainage curtain in the foundation





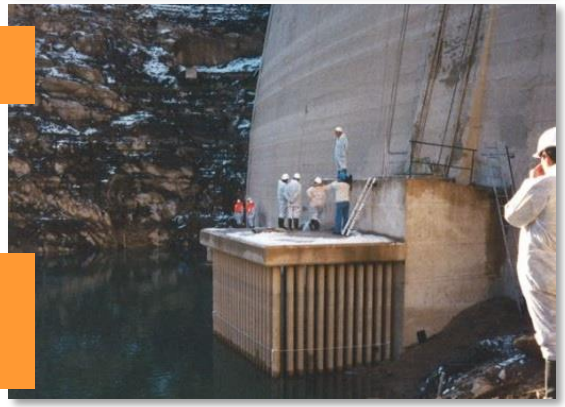
PLANNING

1 – Water by-pass implementation
Reinforcement of monitoring system

2016

2 – Reservoir emptying

2017

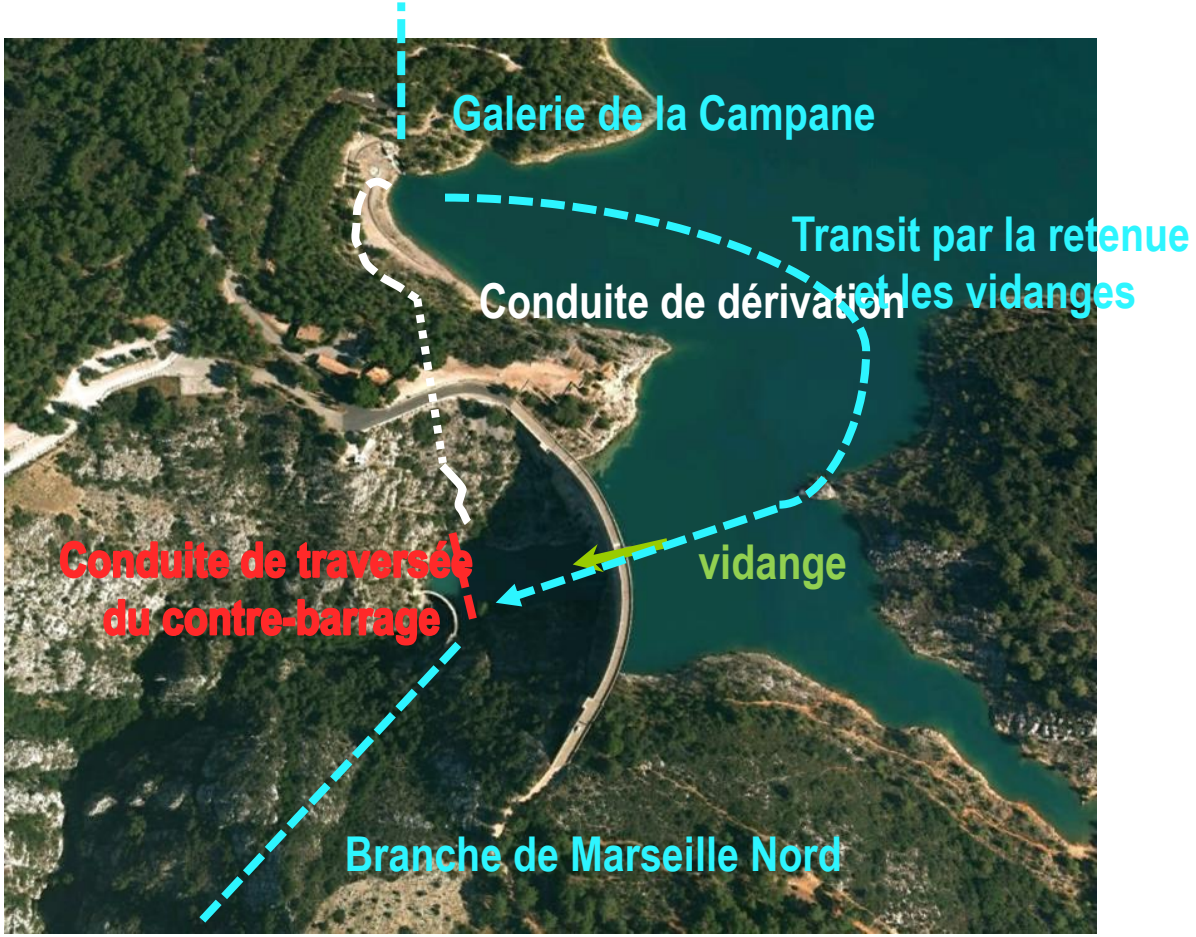


3 – Rehabilitation works

2017
2019

4 – Reservoir refilling

2019


Galerie de la Campane
Transit par la retenue
et les vidanges
Conduite de dérivation
Conduite de traversée
du contre-barrage
vidange
Branche de Marseille Nord

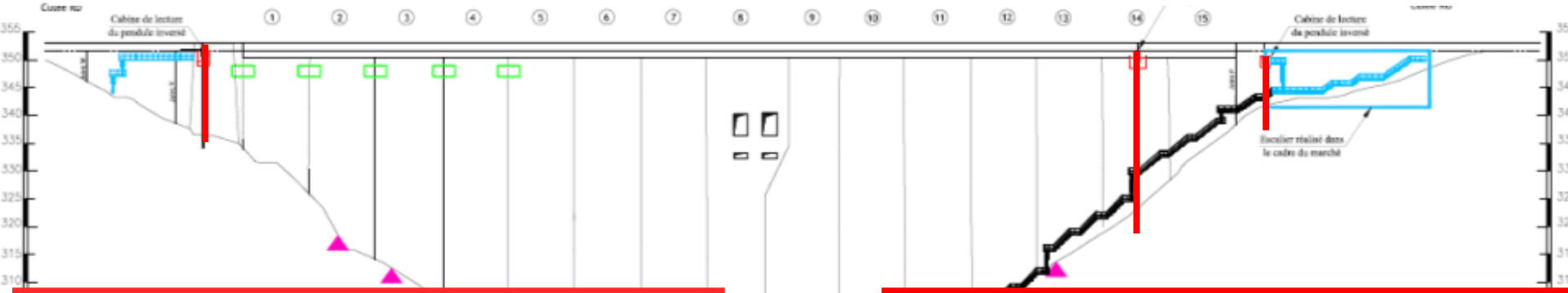
21/11/2017

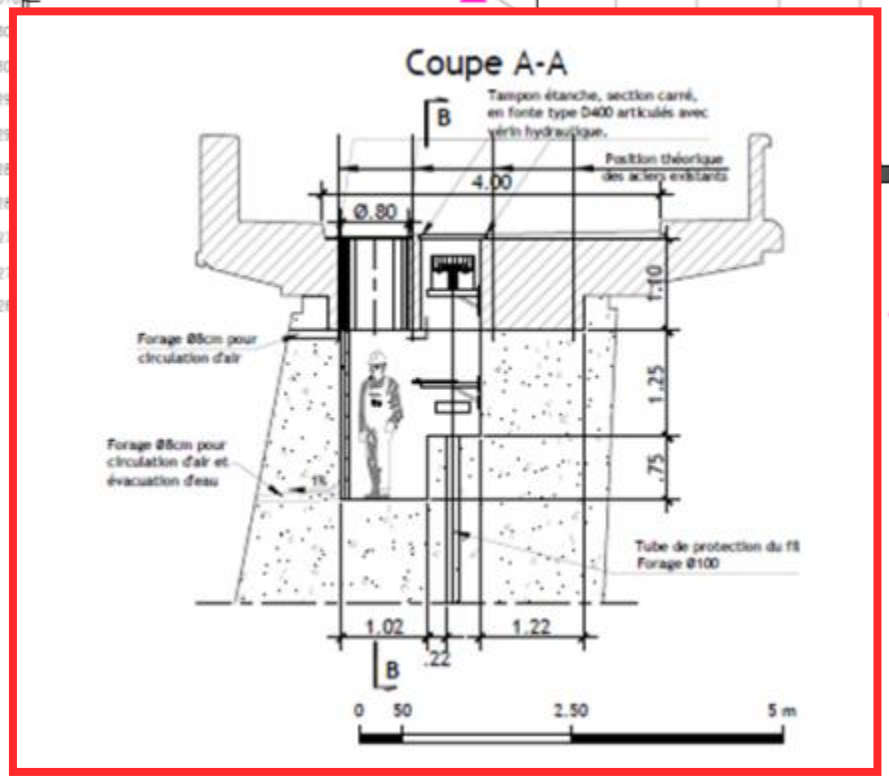
Bimont

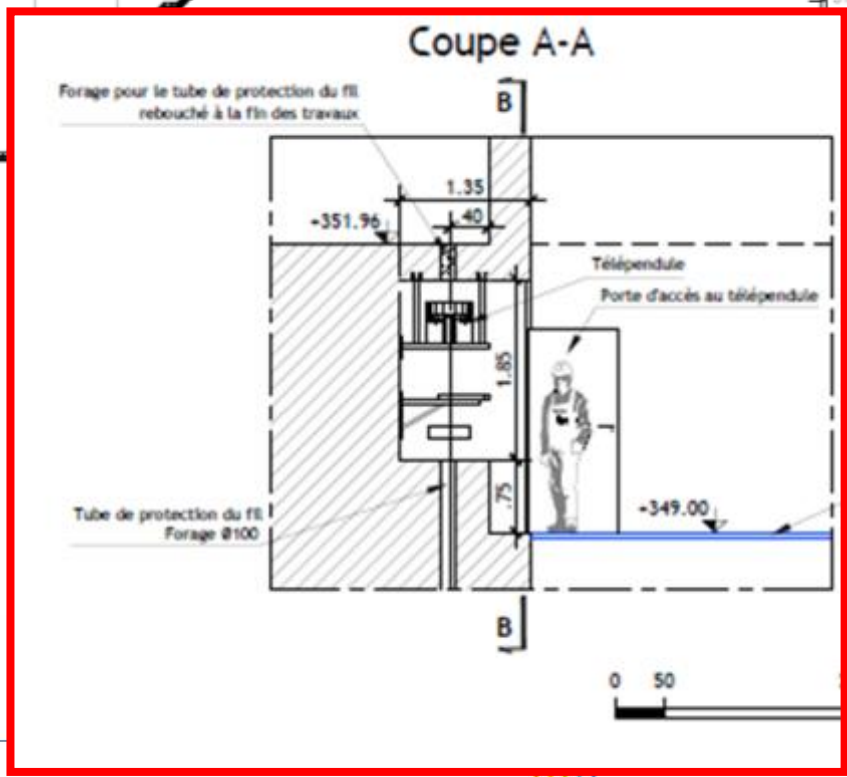
PHASE 1

LA RENOVATION DU DISPOSITIF D'AUSCULTATION

➡ **3 nouveaux télépendules, inversés**







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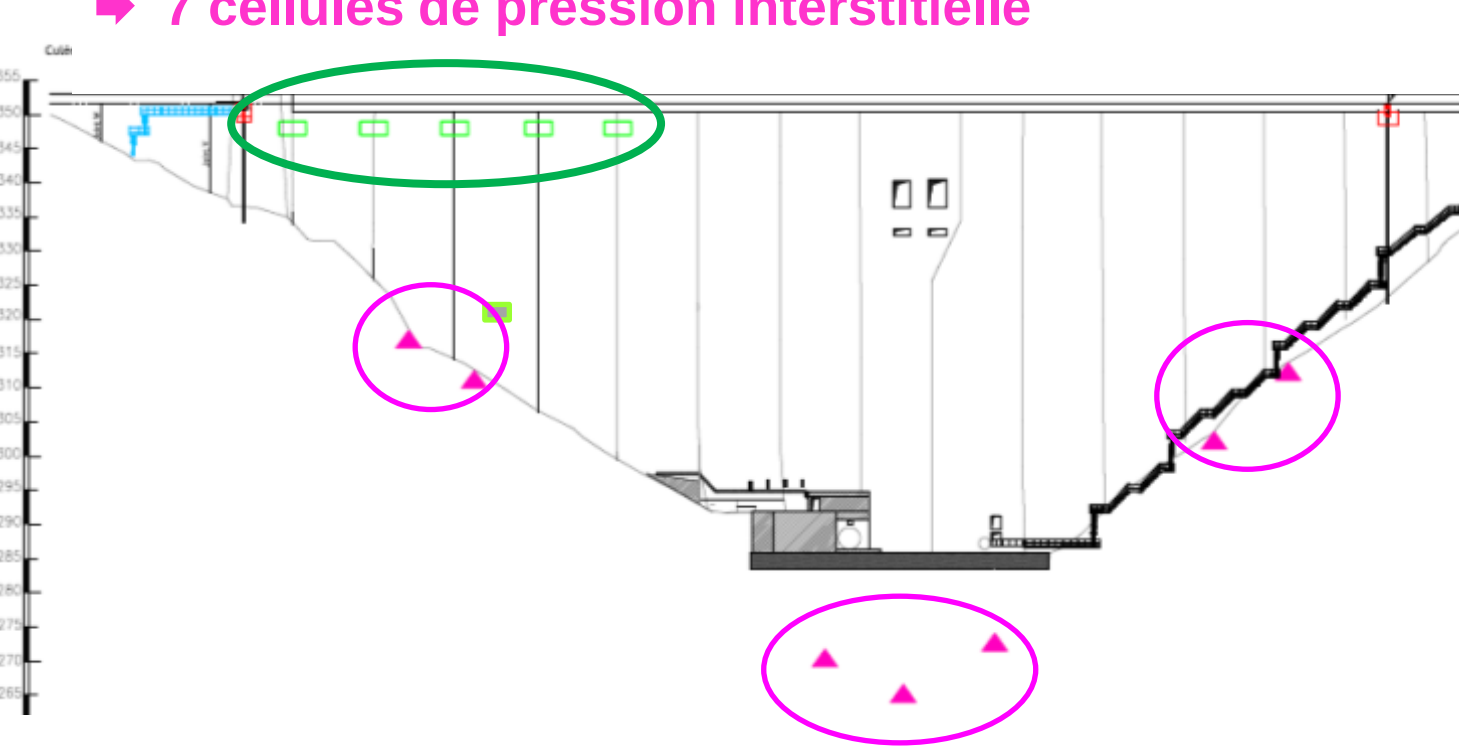
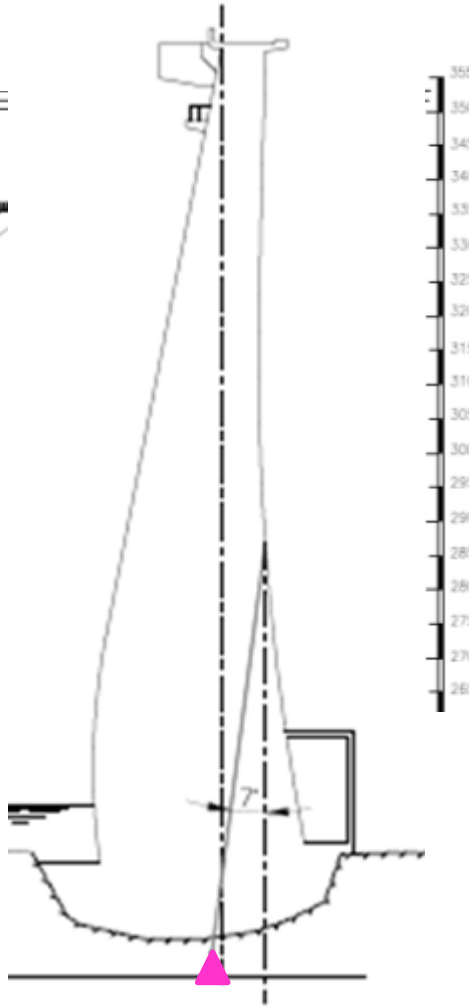
LA RENOVATION DU DISPOSITIF D'AUSCULTATION

- 5 téléfissuromètres
- 7 cellules de pression interstitielle





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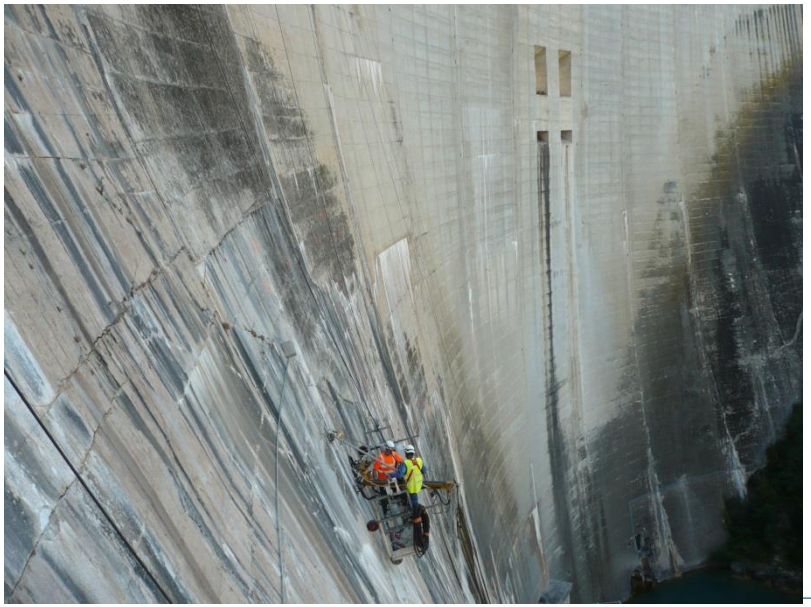
LA RENOVATION DU DISPOSITIF D'AUSCULTATION



SCP Partager l'eau, construire l'avenir

TRACTEBEL ENGIE

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SCP
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construire l'avenir

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