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DIPARTIMENTO DI SCIENZE DELLA TERRA
A. DESIO

Parametrization of a dry retaining wall on a terraced slope in Valtellina (Northern Italy) and stability analysis

(*Corrado Camera*, *Tiziana Apuani*, *Marco Masetti*)

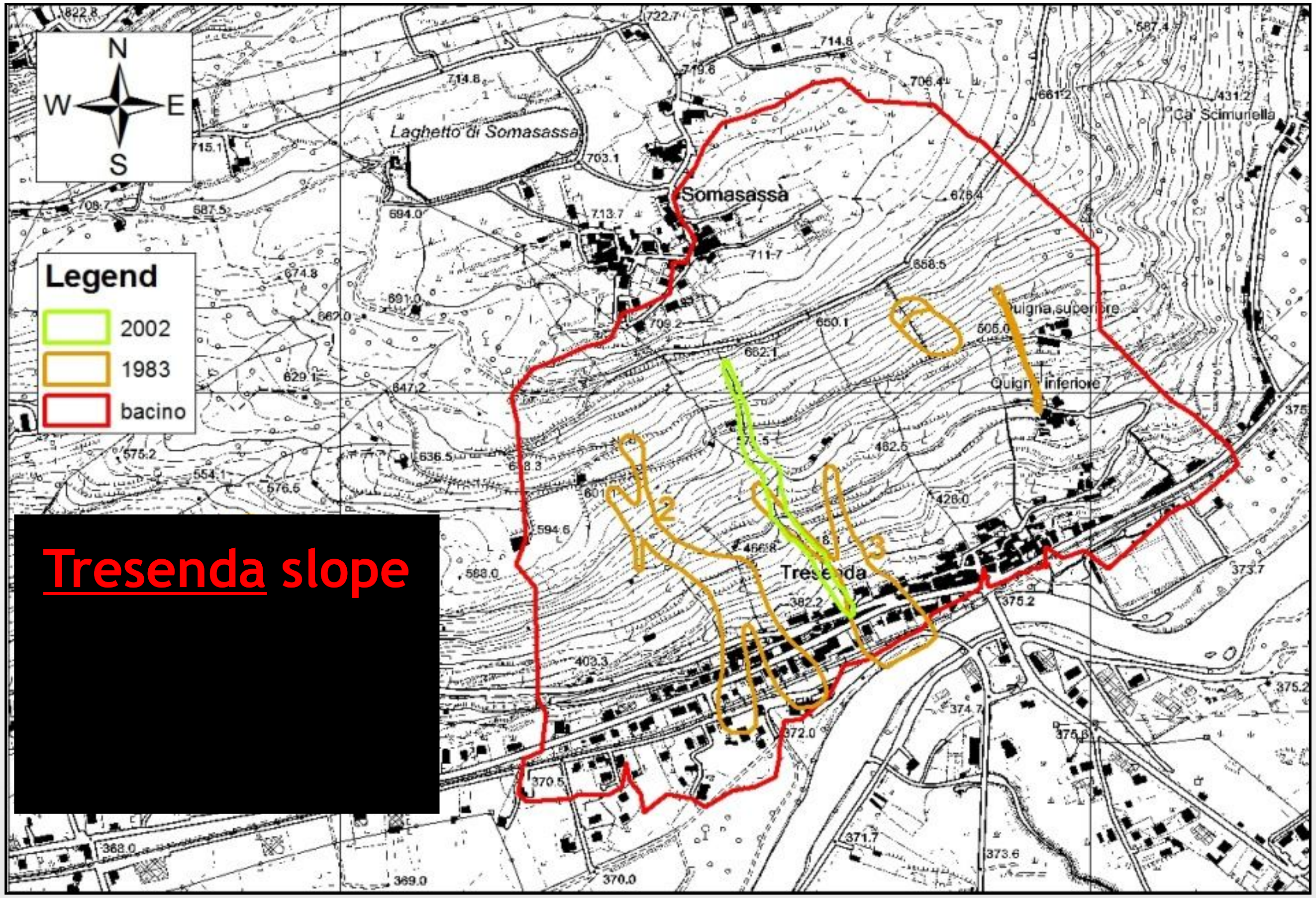
8th International Symposium FMGM – Berlin, 12-16 September 2011

Study Area

Geographical and Historical Setting

1983: 3 soil slips/debris flows. Casualties and damages.

2002: 1 soil slip/debris flow. Damages.



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Study Area

Geographical and Historical Setting

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Study Area

Geographical and Historical Setting

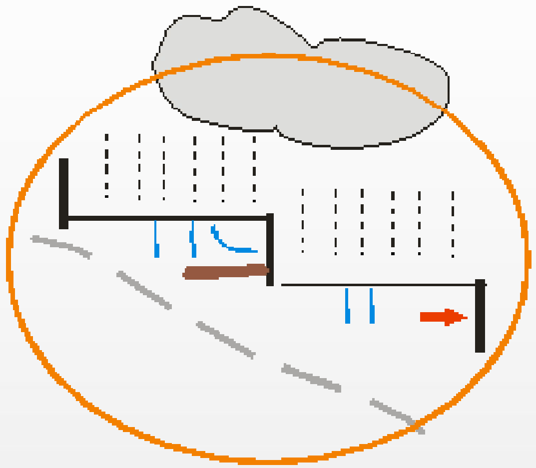
Targets

Triggering of superficial landslides:

- ✓ **Why?** → rainfalls, antecedent water content, soil and walls properties, etc.
  Single terrace scale. Single rainfall event.

- ✓ **Where and When?** → spatial and temporal variability.
  Slope scale. Rainfall temporal series.

- ✓ **How do they evolve?** → reology, topography.
  Slope scale. Post triggering.



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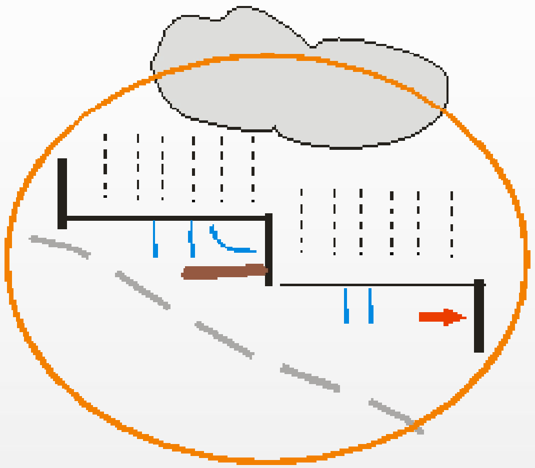

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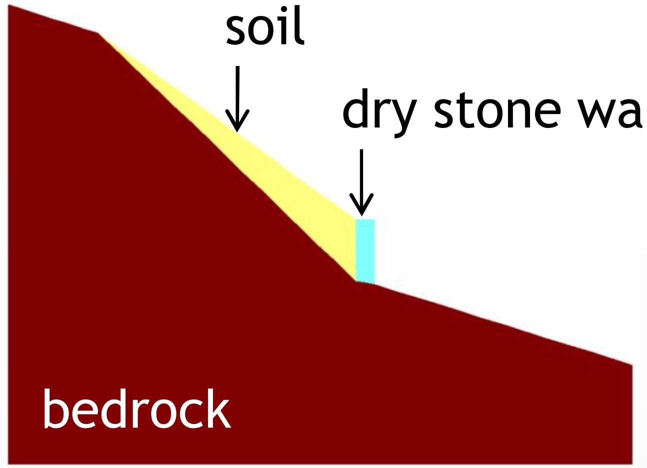
Methods: Hydrogeological and Stability Model

Parameterization

Hydrogeological parameters:

k_s → saturated hydraulic conductivity
SWRC → water content vs. water potential
k function → k vs. water content



for:

SOIL

k_s: field and laboratory data.

SWRC and k function: empirical methods from grain curve.

WALL

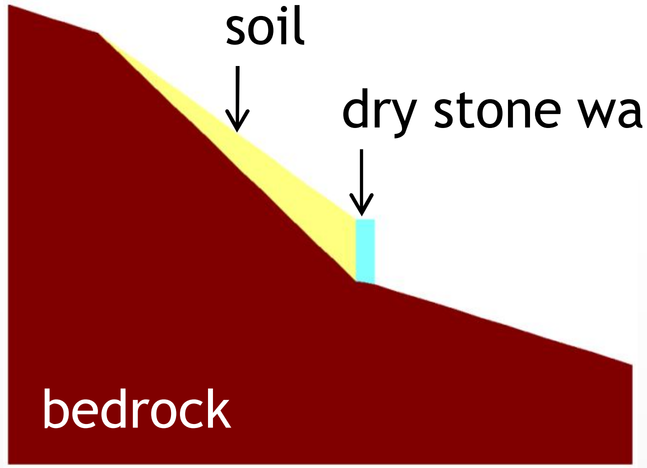
Derived by soil characteristics and depending on the wall's state of maintenance.

BEDROCK

Impermeable respect to wall and soil.

Methods: Hydrogeological and Stability Model

Parameterization



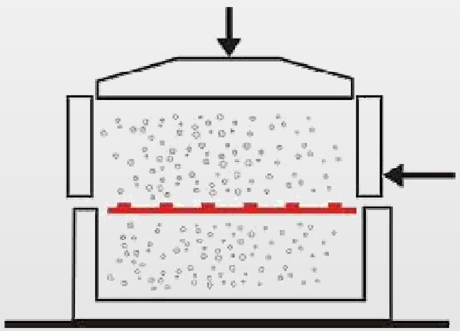
Geotechnical parameters:

Cohesion, **friction angle**, **bulk density**, **deformation modulus**.

for:

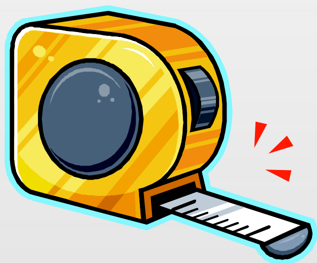
SOIL

Laboratory and field measurements.



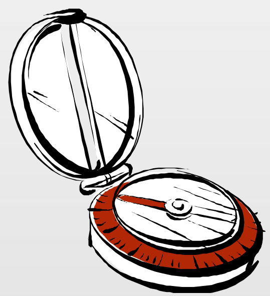
WALL

Geomechanical survey.



BEDROCK

Geomechanical survey.



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The dry stone wall is assimilated to a **rock mass**.

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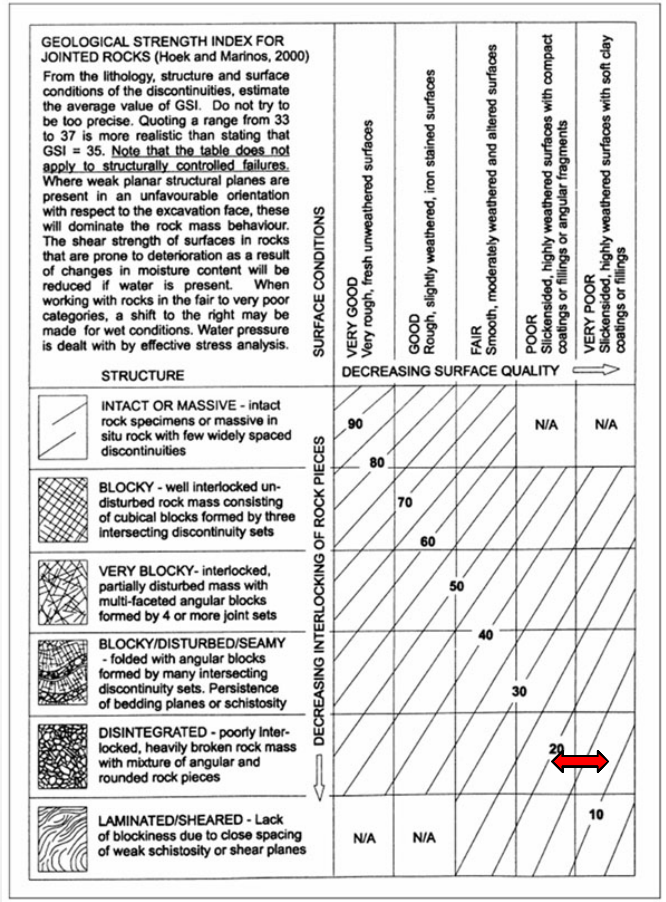
Methods: Hydrogeological and Stability Model

Parameterization

GSI



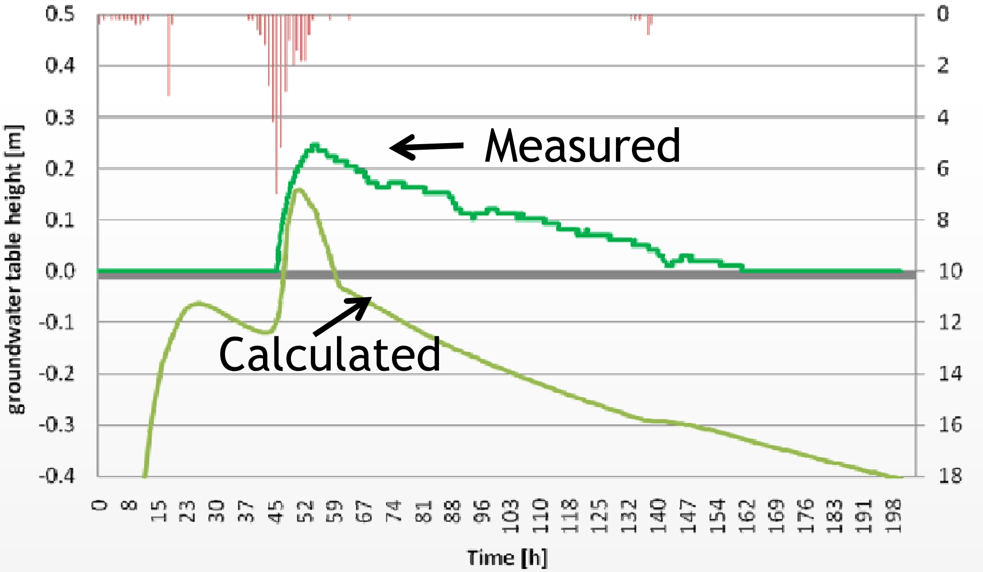
Hoek & Brown criterion → equivalent Mohr-Coulomb c and ϕ

GSI	σ_{ci} [MPa]	E_m [MPa]	c [kPa]	ϕ [deg]
10 - 20	20 - 50	450 - 1250	25 - 40	45 - 55

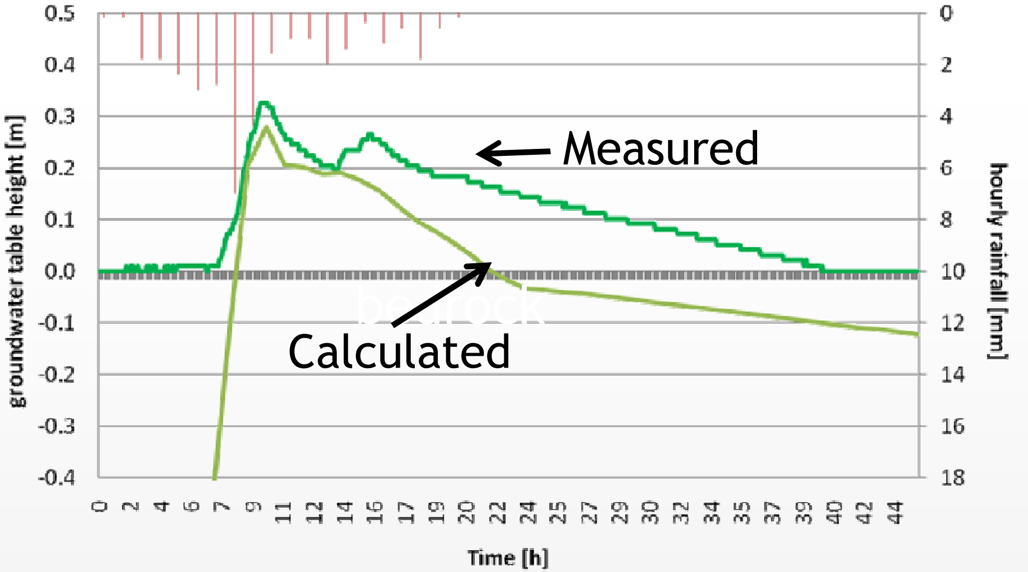
Methods: Hydrogeological and Stability Model

Calibration and Validation – Hydrogeological part

CALIBRATION



VALIDATION



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Methods: Hydrogeological and Stability Model

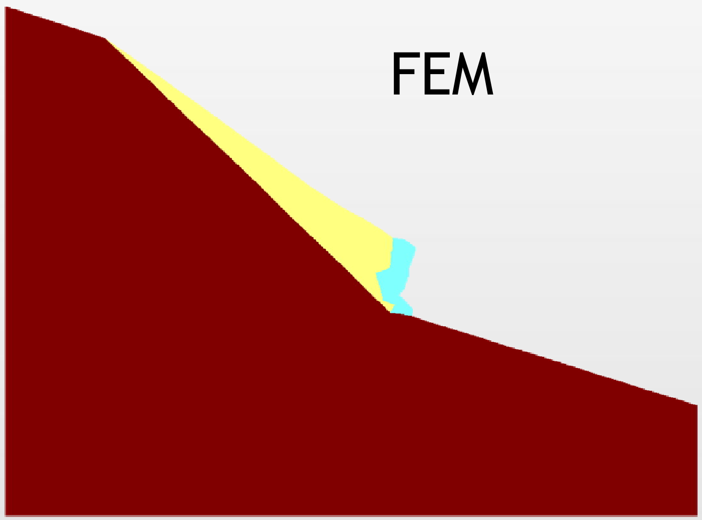
Calibration and Validation – Stability part

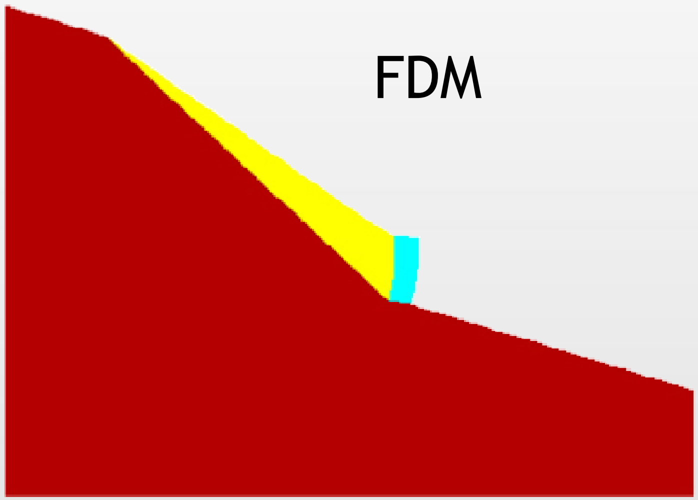
Three real rainfall events:

- similar duration
- similar total cumulated rainfall
- different antecedent water content

Two stable
One failure

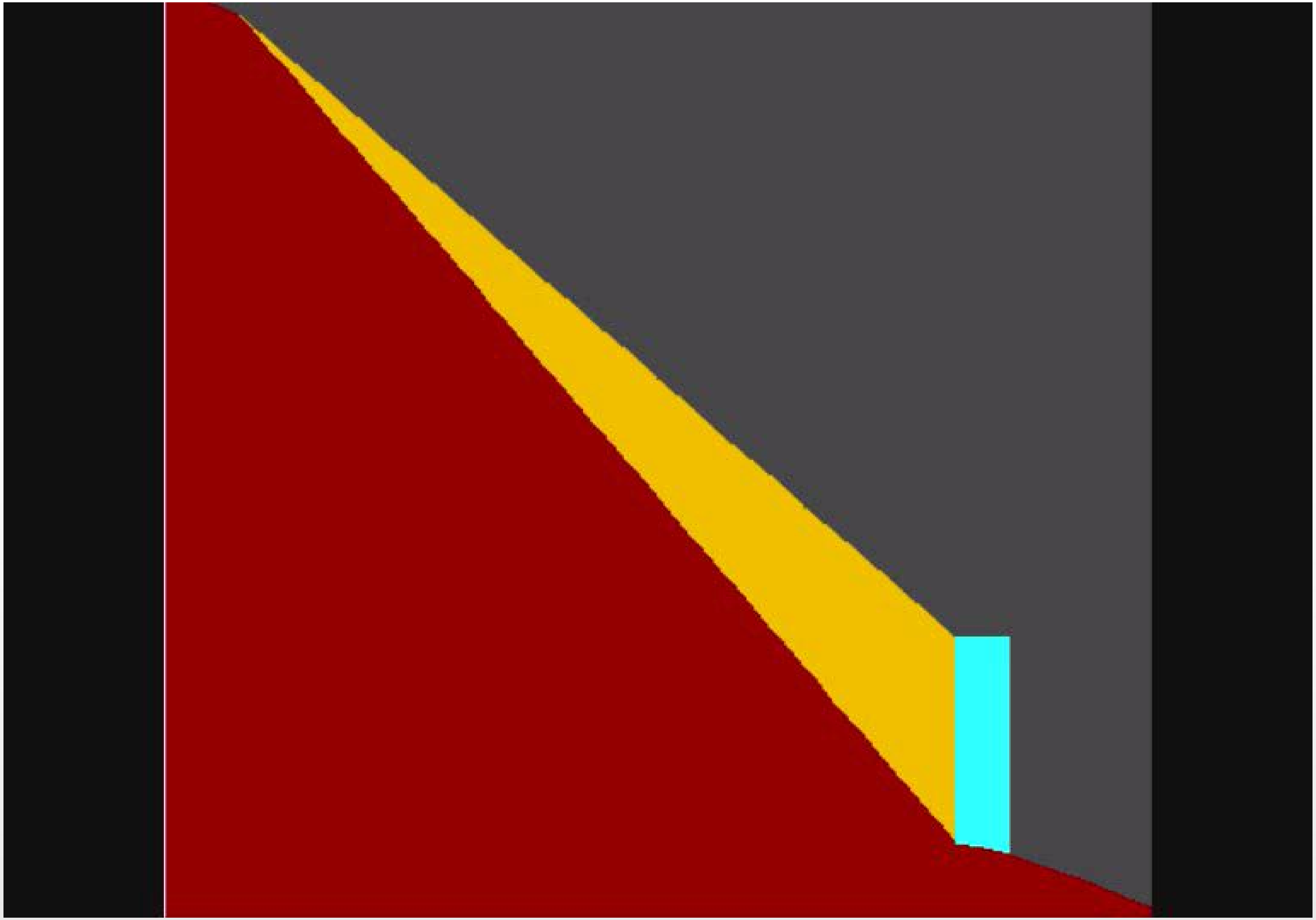
Finite Elements Method			Finite Differences Method		
E [Mpa]	c [kPa]	ϕ [deg]	E [Mpa]	c [kPa]	ϕ [deg]
250	120	55	250	15	55





Methods, Hydrogeological-Stability Model

Calibration and Validation – Stability part



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Methods: Hydrogeological and Stability Model

Use of the model and results

ID	Return period	Wall maintenance	Initial water content	Results FEM	Results FDM
1	10 years	Good	dry	stable	stable
2	10 years	Good	almost saturated	stable	stable
3	10 years	Bad	dry	stable	stable
4	10 years	Bad	almost saturated	stable	stable
5	50 years	Good	dry	stable	stable
6	50 years	Good	almost saturated	stable	stable
7	50 years	Bad	dry	stable	stable
8	50 years	Bad	almost saturated	stable	unstable
9	100 years	Good	dry	stable	stable
10	100 years	Good	almost saturated	unstable	stable
11	100 years	Bad	dry	stable	stable
12	100 years	Bad	almost saturated	unstable	unstable

Methods: Hydrogeological and Stability Model

Use of the model and results

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9	100 years	Good	dry	stable	stable
10	100 years	Good	almost saturated	unstable	stable
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1) For dry initial conditions the system is always stable.

Methods: Hydrogeological and Stability Model

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1) For dry initial conditions the system is always stable.
2) FEM-FDM models are coherent for the worst scenario.

Methods: Hydrogeological and Stability Model

Use of the model and results

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9	100 years	Good	dry	stable	stable
10	100 years	Good	almost saturated	**unstable**	**stable**
11	100 years	Bad	dry	stable	stable
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1) For dry initial conditions the system is always stable.
2) FEM-FDM models are coherent for the worst scenario.
3) Two cases are not in agreement.

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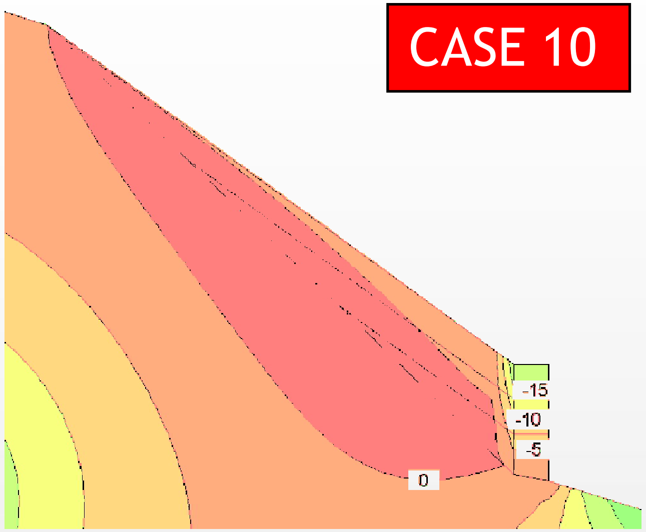
Methods: Hydrogeological and Stability Model

Use of the model and results

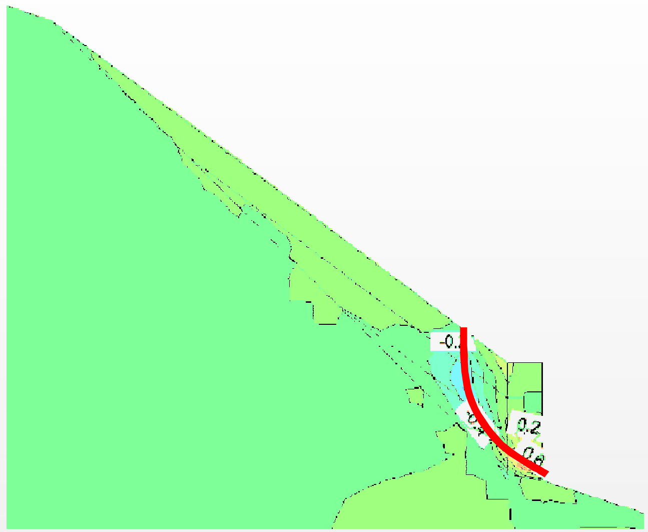
ID	Return period	Wall maintenance	Initial water content	Results FEM
10	100 years	Good	almost saturated	**unstable**
12	100 years	Bad	almost saturated	unstable

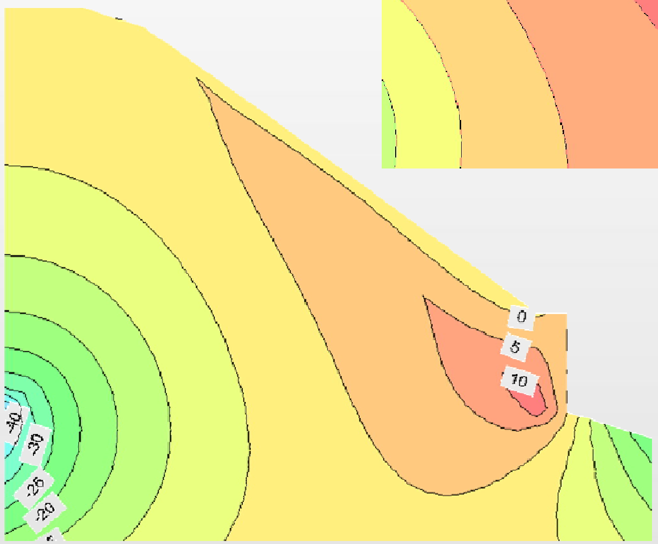
CASE 10

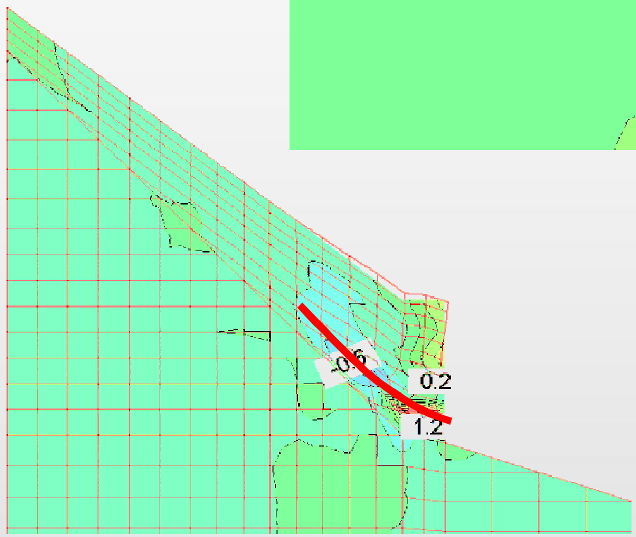
Pore water pressure



XY shear strain







CASE 12

Conclusions

- ✓ Importance of **field and laboratory characterization**.

HYDROGEOLOGICAL MODEL

Differences in the behaviour of differently maintained walls.

STABILITY MODEL

Validation of the GSI procedure.

Definition of scenarios.

- ✓ **Extreme rainfalls events** combined with **antecedent rainfalls** are crucial factors for stability.
- ✓ **Walls conditions** and **water table geometry** complicate the reaction of the system.


Thanks for you attention