





Grugliasco, 29 Maggio 2018 | Luca Dellarole

# INTRODUZIONE AL PROGRAMMA SHALLOW

# Design Software Tool SHALLOW

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Use our software and design our systems for slope stabilization, debris flow barriers and for shallow landslides.  
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## Software

Only accurately dimensioned systems will provide reliable protection against natural hazards. That is why we utilize software that we have verified and calibrated through our 1:1 field tests. To dimension our systems we provide the following software:



### RUVOLUM®

Slope stabilization systems TECCO® SYSTEM³ and SPIDER®

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### SPIDER®

Rock protection systems with SPIDER®

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### DEBFLOW

Flexible ring net barriers against debris flows

Manual EN



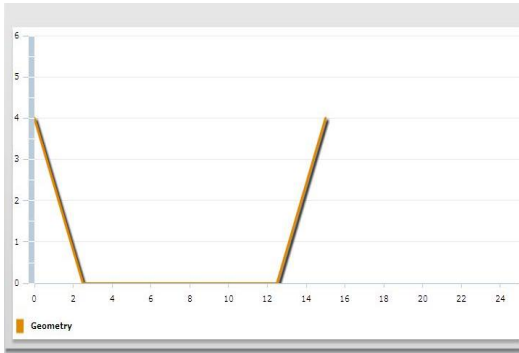
### SHALLOW

Flexible barriers against shallow landslides

# SHALLOW

# DIMENSIONAMENTO

## Geometria



## Struttura

# kiloPascal?

## Estensione



## Volume



## Shallow Online Tool

Tool is based on 1:1 field tests in Veltheim, Switzerland in collaboration with the Swiss Federal Institute for Forest, Snow and Landscape Research WSL  
All system components tested in 1:1 field tests and verified by numerical computer simulations.

Project:  Date:

Design parameters

System and proofs

Parametri per  
dimensionamento

Scelta barriera e  
verifiche



## Parametri per dimensionamento (Design parameters)

Design parameters

System and proofs

Simulazioni possibili,  
Load cases #1, #2, etc

Load case #1



### Starting volume and density of shallow landslide

Width of the starting volume

$b_0$  =  [m]

Total starting volume shallow landslide

$V$  =  [m<sup>3</sup>]

Density of shallow landslide material

$\rho$  =  [kg/m<sup>3</sup>]

Ampiezza della frana nella zona di innesco

Volume iniziale frana superficiale

Densità del materiale in frana

Design parameters

System and proofs

Load case #1



## Starting volume and density of shallow landslide

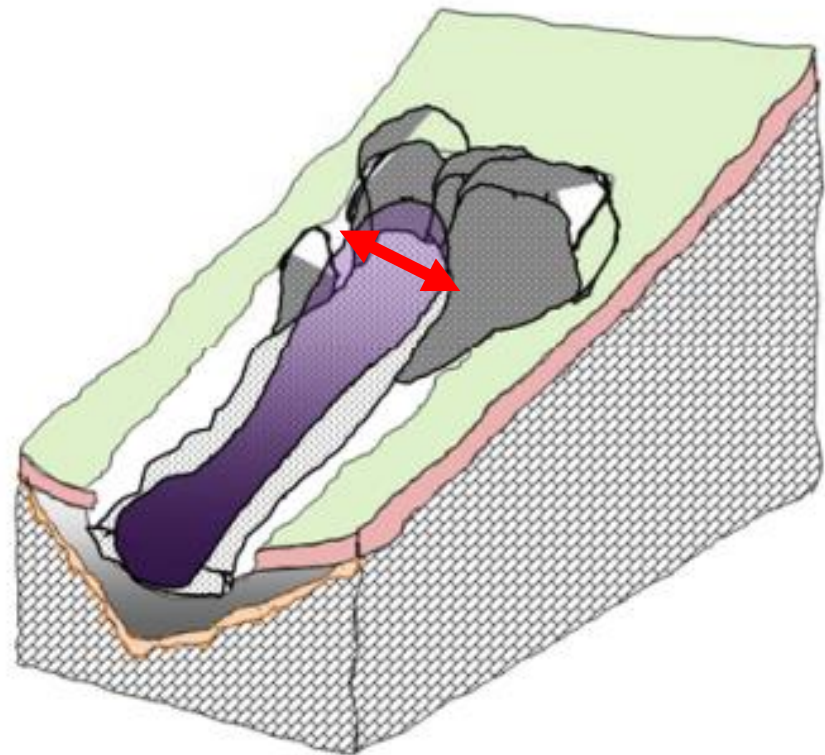
Width of the starting volume

$b_0$  =  [m]

Total starting volume shallow landslide

Density of shallow landslide material

Ampiezza della frana  
nella zona di innesco



Design parameters

System and proofs

## Starting volume and density of shallow landslide

Width of the starting volume

$b_0$

=



10

[m]

Total starting volume shallow landslide

$V$

=



150

[m<sup>3</sup>]

Density of shallow landslide material

$\rho$

=



2100

[kg/m<sup>3</sup>]

Load case #1



Volume iniziale frana  
superficiale



m<sup>3</sup> di materiale  
mobilizzabile

Design parameters

System and proofs

## Starting volume and density of shallow landslide

Width of the starting volume

$b_0$

=



10

[m]

Total starting volume shallow landslide

$V$

=



150

[m<sup>3</sup>]

Density of shallow landslide material

$\rho$

=



2100

[kg/m<sup>3</sup>]

Load case #1



Densità del materiale in frana  
[kg/m<sup>3</sup>]



# SOFTWARE SHALLOW

Fattore di sicurezza globale [1.0 – 1.5]

**Safety factor**

global safety factor

SF

=



1.2

# GEOMETRIA DEL VERSANTE

## Slope geometry

Distance from breakout zone to barrier location

$L_0$  = 80 [m]

Spreading angle of starting volume

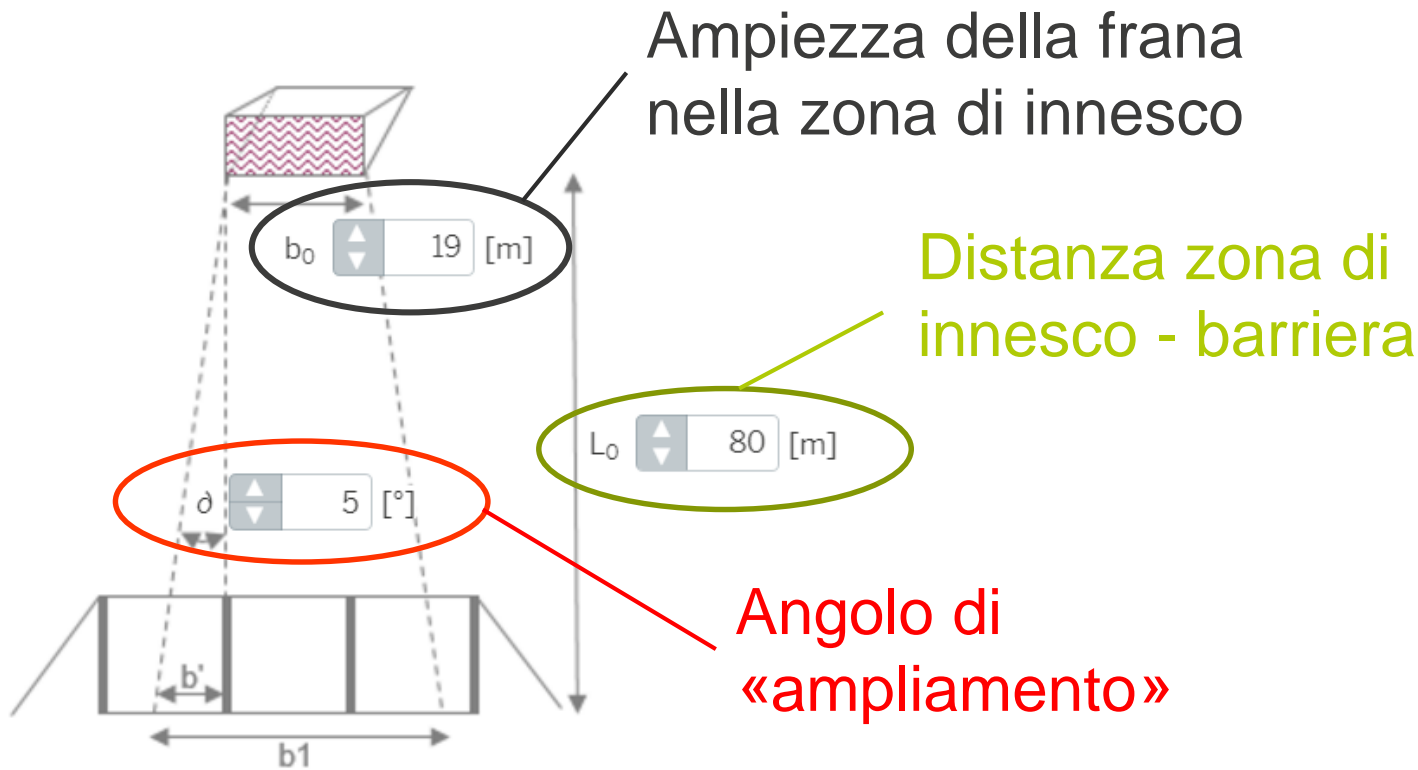
$\vartheta$  = 5 [°]

Additional width at impact section on each side of  $b_0$

$b'$  = 7 [m]

Width of shallow landslide at the impact point

$b_1$  = 33 [m]



# GEOMETRIA DEL VERSANTE

## Slope geometry

Distance from breakout zone to barrier location

$L_0$  = 80 [m]

Spreading angle of starting volume

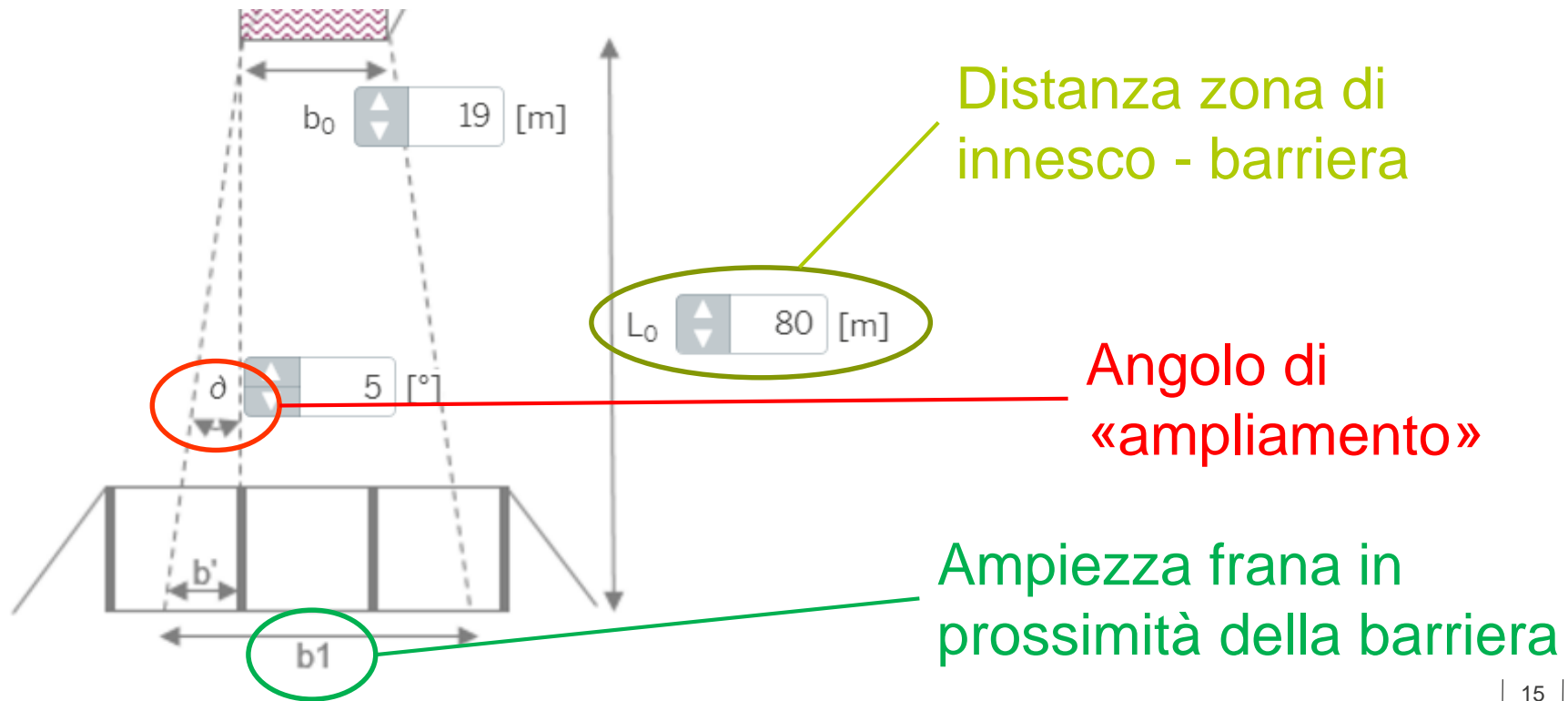
$\vartheta$  = 5 [°]

Additional width at impact section on each side of  $b_0$

$b'$  = 7 [m]

Width of shallow landslide at the impact point

$b_1$  = 33 [m]



# PORTATA DI PICCO E ALTEZZA DI FLUSSO

| Calculation of max. peak discharge and flow height at barrier location  |              |   |                          |
|---|--------------|---|--------------------------|
| Maximum speed of shallow landslide at impact section (chosen)           | v            | = | 6 [m/s]                  |
| Travel time of landslide front between starting zone and impact section | T            | = | 13.33 [s]                |
| Peak discharge (calculated)   | $Q_{p, rec}$ | = | 0.08 [m <sup>3</sup> /s] |
| Peak discharge (chosen)   | $Q_p$        | = | 48 [m <sup>3</sup> /s]   |
| Flow height (calculated)  | $h_{fl}$     | = | 0.24 [m]                 |

Velocità massima della frana superficiale [m/s]

Tempo di trasporto da punto di distacco a sezione di impatto

Portata di picco calcolata =  $Vol / T$

Portata di picco scelta

Altezza di flusso calcolata =  $Q_p / v / b_1$

(distribuzione omogenea del flusso su tutta la barriera)



# TIPOLOGIA BARRIERE E VERIFICHE

Design parameters

System and proofs

Load case #1

+

## Flexible, permeable debris flow protection system

System type / post distance

Type ▼ [GEOBRUGG SL 150 / 5 [m]

Maximum system height

$H_{0, \max}$  = 3.50 [m]

Maximum post distance

$d_{0, \max}$  = 5.00 [m]

Minimum barrier length (calculated and recommended)

$B_{\min, \text{calc}}$  = 35.00 [m]

Minimum barrier length (chosen)

$B_{\min, \text{ch}}$  = 54.00 [m]



SL 100 o SL 150?

Distanza montanti?

Design parameters

System and proofs

Load case #1

+

## Flexible, permeable debris flow protection system

System type / post distance

Type

▼ [GEOBRUGG SL 150 / 5 [m]

Maximum system height

$H_{0, \max}$

=

3.50

[m]

Maximum post distance

$d_{0, \max}$

=

5.00

[m]

Minimum barrier length (calculated and recommended)

$B_{\min, \text{calc}}$

=

35.00

[m]

Minimum barrier length (chosen)

$B_{\min}$

=

54

[m]

**Altezza del sistema standard –  $H_{0, \max}$**

Design parameters

System and proofs

Load case #1



## Flexible, permeable debris flow protection system

System type / post distance

Type

▼ [GEOBRUGG SL 150 / 5 [m]

Maximum system height

$H_{0, max}$

=

3.50

[m]

Maximum post distance

$d_{0, max}$

=

5.00

[m]

Minimum barrier length (calculated and recommended)

$B_{min, calc}$

=

35.00

[m]

Minimum barrier length (chosen)

$B_{min}$

=

54

[m]

**Interasse tra i montanti**

Design parameters

System and proofs

Load case #1

+

## Flexible, permeable debris flow protection system

System type / post distance

Type

▼ [GEOBRUGG SL 150 / 5 [m]

Maximum system height

$H_{0, \max}$

=

3.50

[m]

Maximum post distance

$d_{0, \max}$

=

5.00

[m]

Minimum barrier length (calculated and recommended)

$B_{\min, \text{calc}}$

=

35.00

[m]

Minimum barrier length (chosen)

$B_{\min}$

=

54

[m]

## Lunghezza minima barriera



| Proof of dynamic impact                              |              |  |
|--|--------------|--|
| Dynamic load coefficient                             | $C_w$ =      | 1  |
| Dynamic load pressure (according to 1:1 field tests) | $P_{dyn}$ =  | 18.35 [kN/m <sup>2</sup> h <sup>fl</sup> ] |
| Load capacity of barrier                             | $R_{dyn}$ =  | 28.64 [kN/m <sup>2</sup> h <sup>fl</sup> ] |
| Safety factor  | $SF_{dyn}$ = | 1.56                                       |
| Proof of dynamic impact                              | FULFILLED    |  |

Coefficiente di impatto dinamico [0.6 – 1.0] da sperimentazione in vera grandezza

Pressione dinamica massima, funzione del coefficiente dinamico  $c_w$ , della velocità e della densità

Resistenza massima della barriera

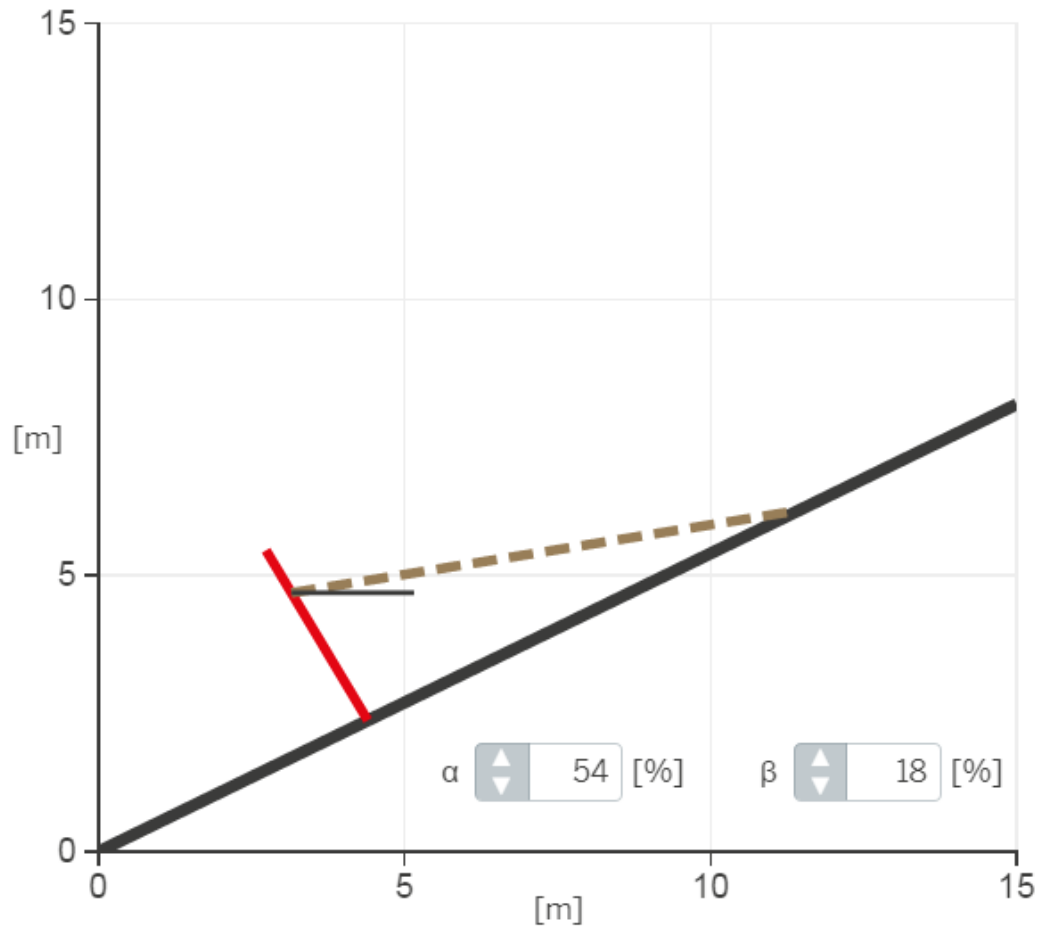
Fattore di sicurezza e verifica

# VERIFICA VOLUME TRATTENUTO

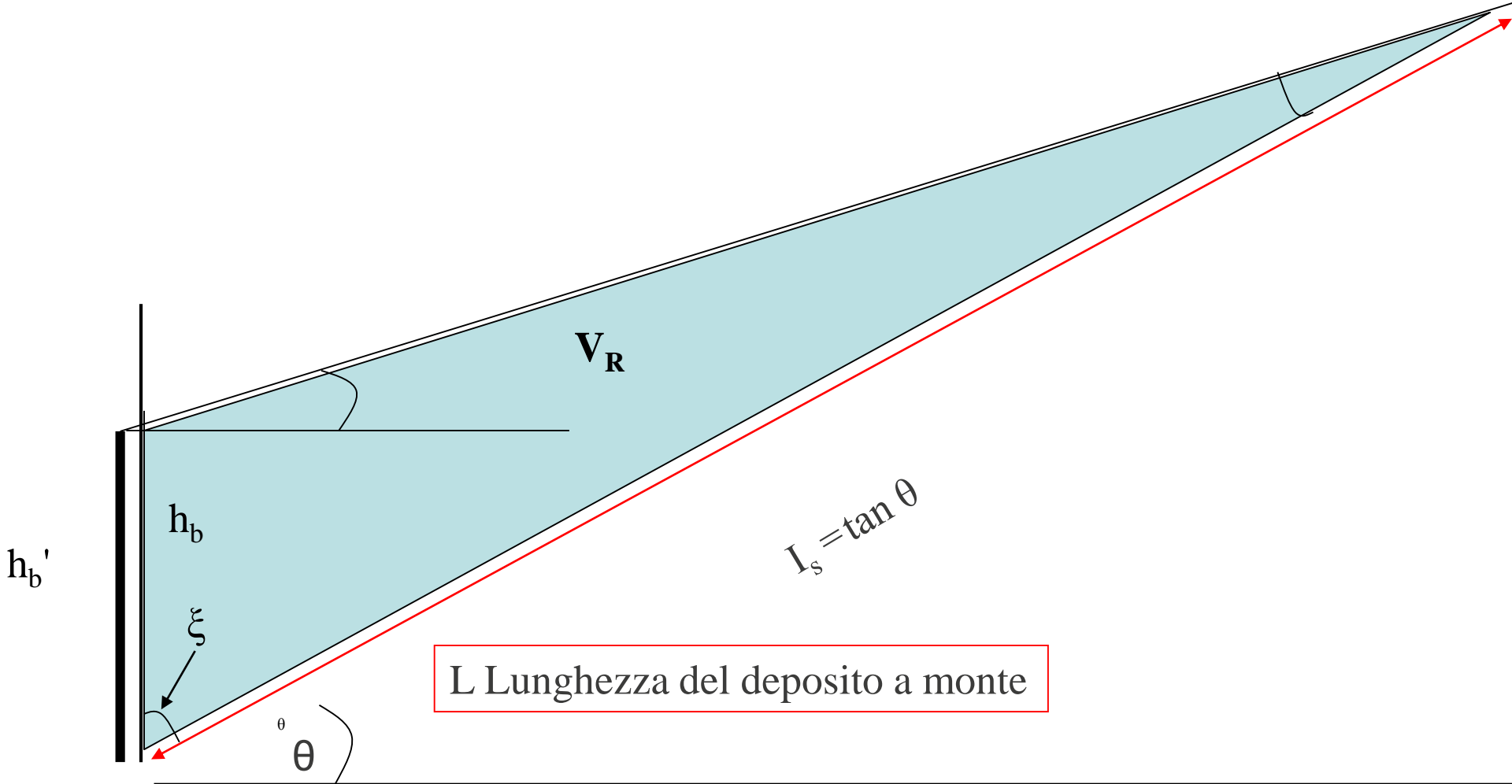
| Proof of retention volume                           |  |
|---|--|
| System height of the filled barrier                 | $H_1 = 2.63 \text{ [m]}$                             |
| Slope angle   | $\alpha = 54 \text{ [%]}$                            |
| Inclinazione versante [min. 50%, circa 26,5°]       | $28.37 \text{ [°]}$                                  |
| Inclination of retained material behind the barrier | $\beta = 18 \text{ [%]}$                             |
| Inclinazione volume depositato a monte [0° – 15°]   | $10.20 \text{ [°]}$                                  |
| Retention volume per linear meter                   | $V_{\text{ret}} = 10.50 \text{ [m}^3\text{/m]}$      |
| Total retention volume                              | $V_{\text{ret,total}} = 567.03 \text{ [m}^3\text{]}$ |
| Proof of retention volume                           | <b>FULFILLED</b>                                     |
| Overflow  | $= 0.00 \text{ [m}^3\text{]}$                        |

# VOLUME TRATTENUTO

Barrier and retained material behind barrier - Load case #1

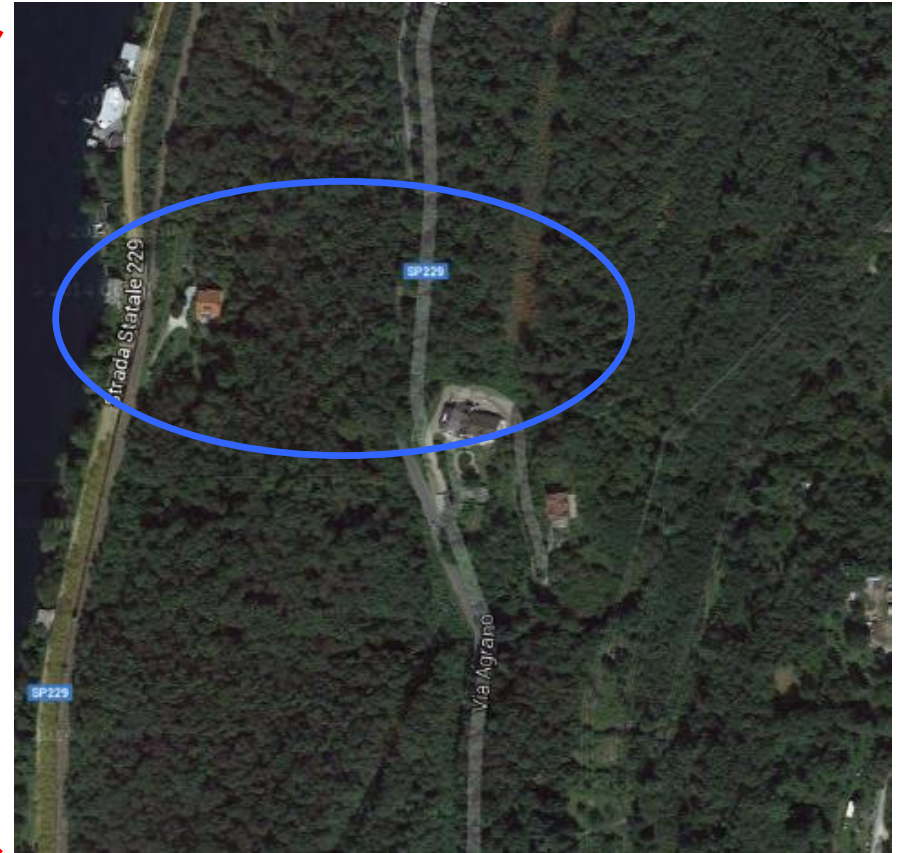
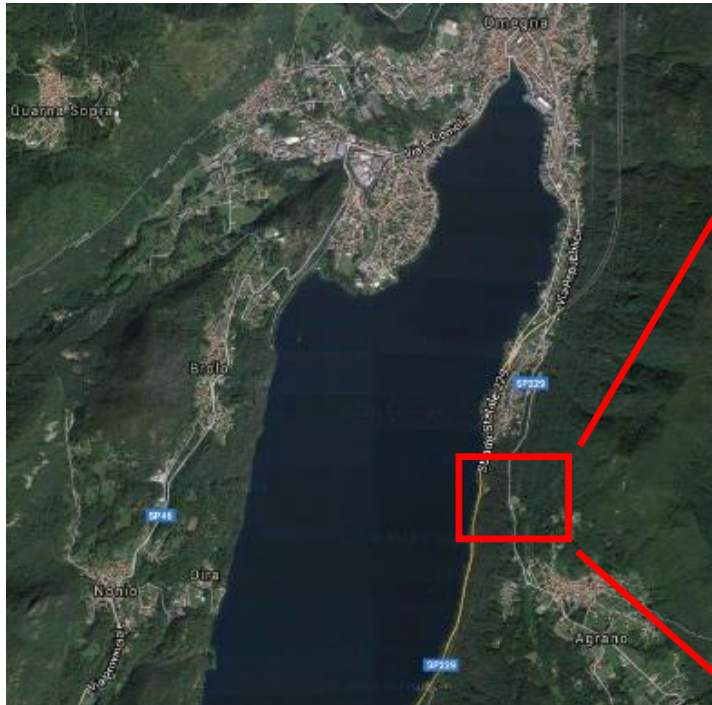


# VOLUME TRATTENUTO



$$V_r = 0.5 \cdot h_b \perp' \cdot L \cdot b_m + h_b \parallel' \cdot h_b \perp' \cdot b_m = 0.5 \cdot h_b'^2 \cdot b_m \cdot \sin(\xi) \left( \frac{\sin(\xi)}{\tan(\Theta - \Theta')} + \cos(\xi) \right)$$

# CASE HISTORY: OMEGNA (VCO)



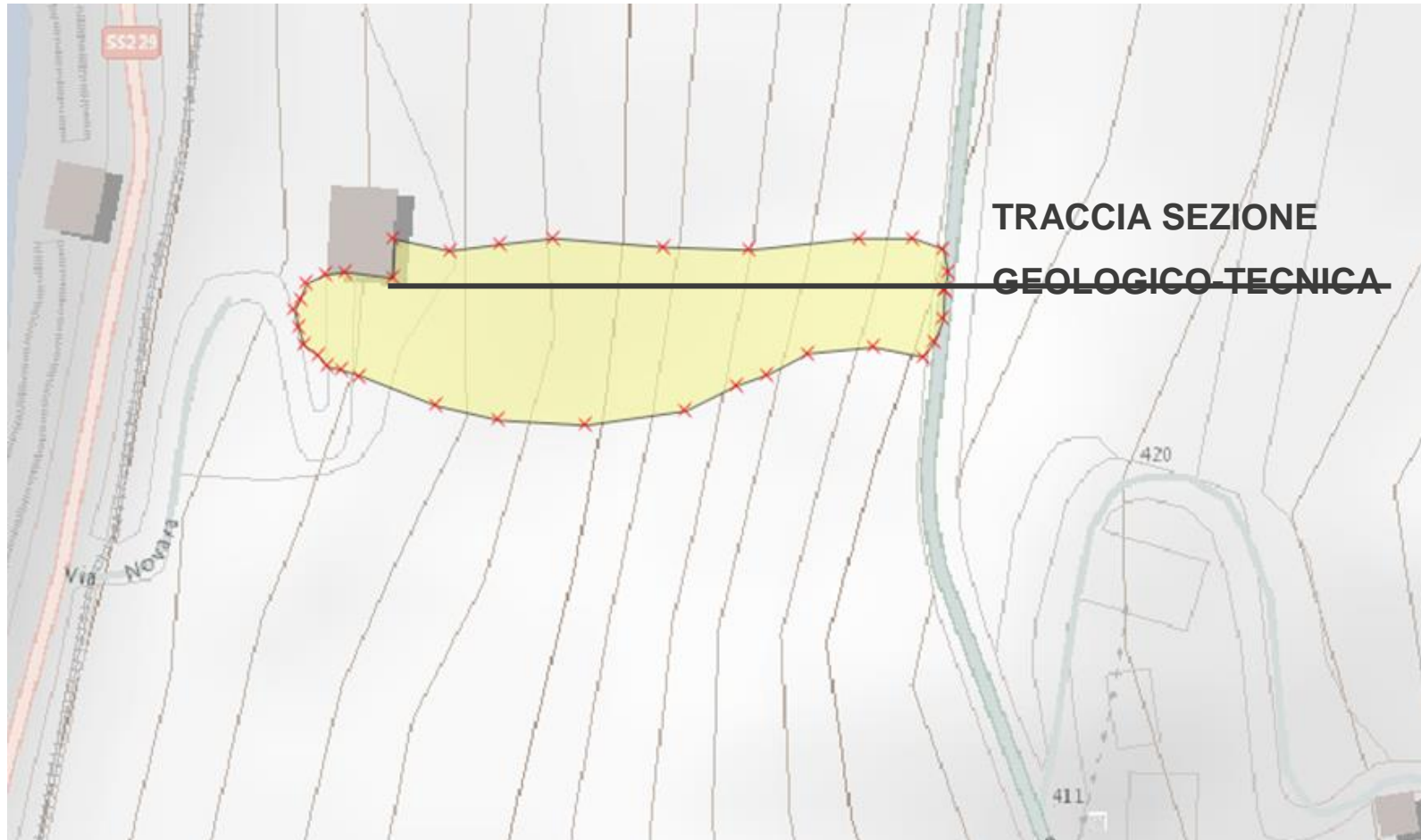



# LA FRANA DI BORCA S.P. 42 ARMENO- OMEGNA: COROGRAFIA EX-ANTE





# CASE HISTORY: OMEGNA (VCO)



0  40 m SCALA 1:1.600

# CASE HISTORY: OMEGNA (VCO)

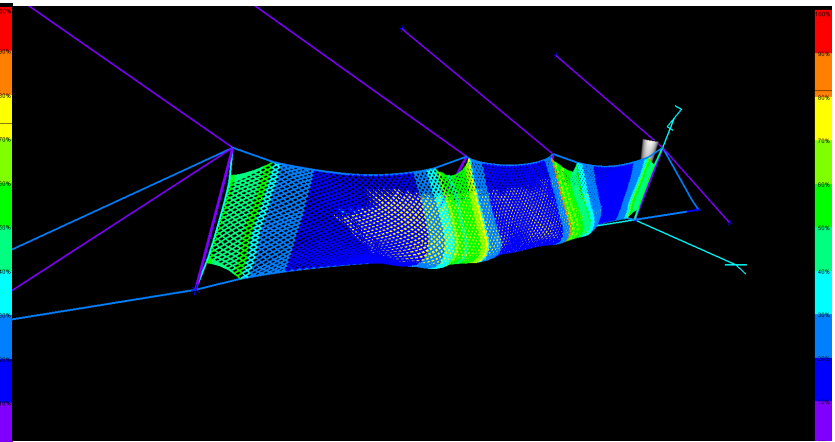
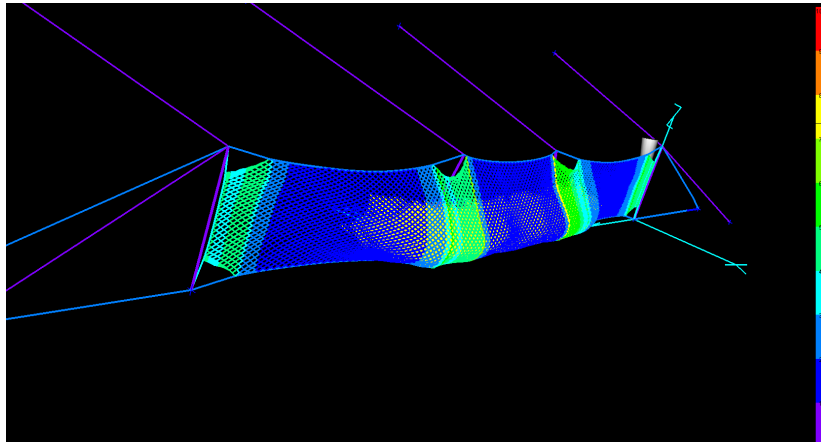
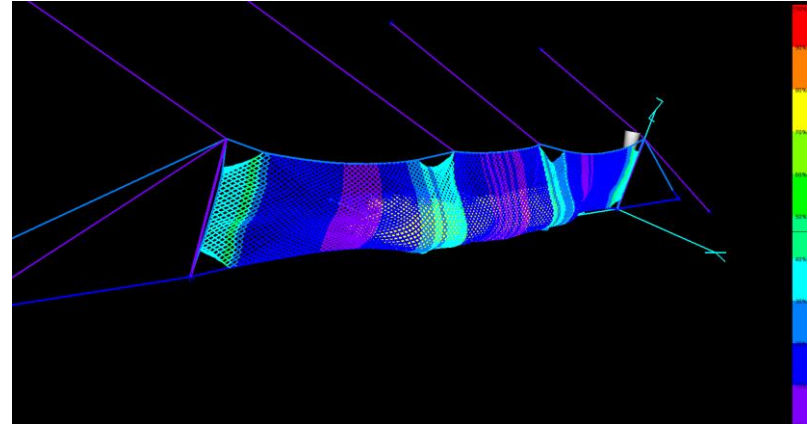
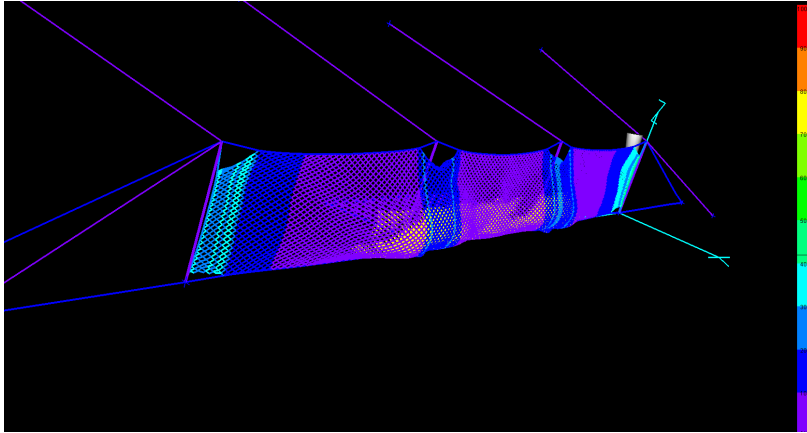




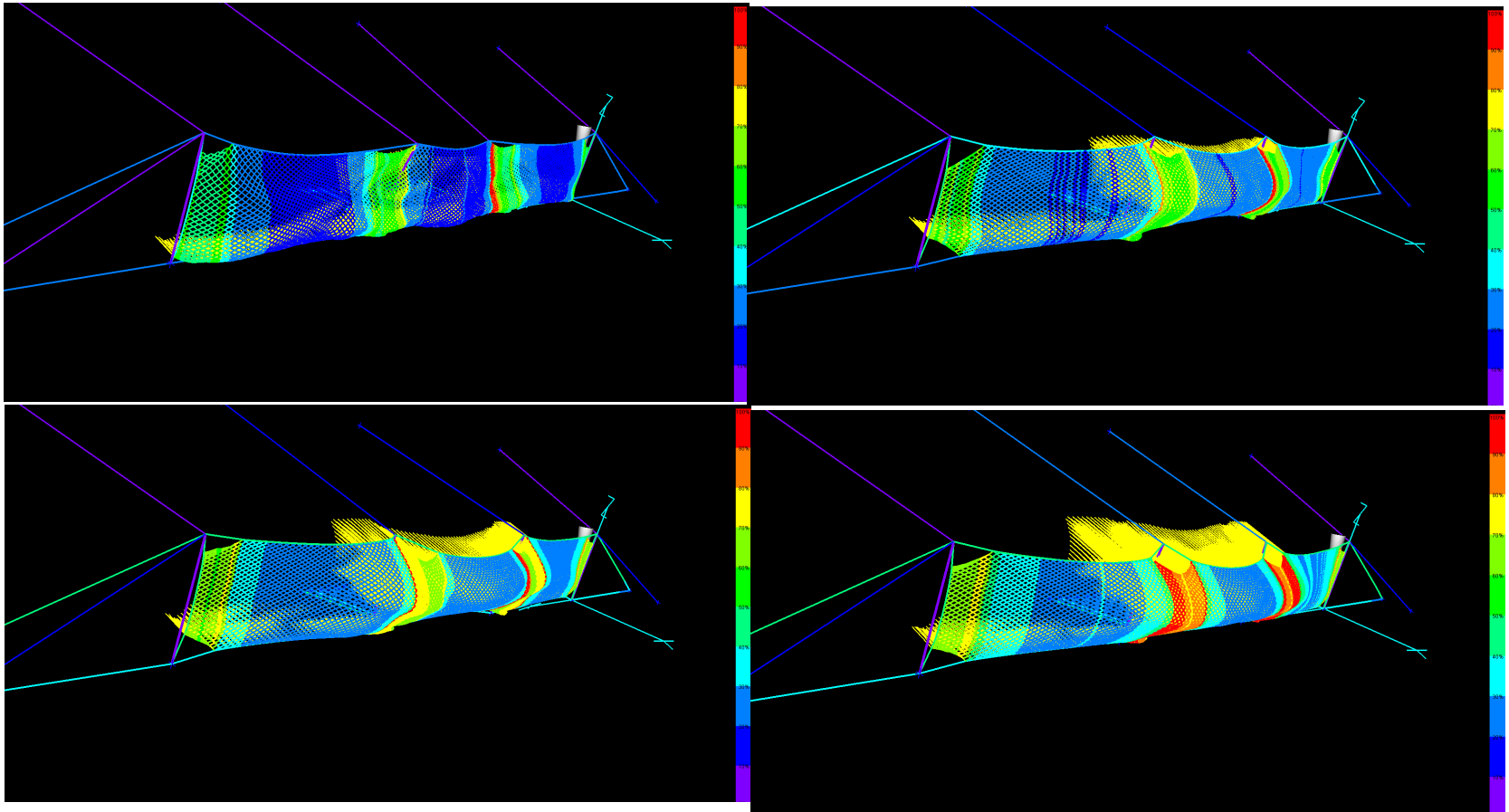
# CASE HISTORY: OMEGNA (VCO)



# CASE HISTORY: OMEGNA (VCO)



# CASE HISTORY: OMEGNA (VCO)





# INSTALLAZIONE

Installazione di una barriera a protezione della S.P. 299 e di una villetta privata

Tipologia di barriera:

SL-100, H=2,0 m, L=30 m





# CASE HISTORY: POTENZA



## **Vietri di Potenza – SL-100**

Lunghezza 40 m

Altezza **2,0 m**

Volume franato: ca 150 m<sup>3</sup>



# CASE HISTORY: SCALETTA ZANCLEA (ME)



**SL 150 H=3.5 m**

2 marzo 2011: a seguito di intense piogge, una frana superficiale ha impattato una delle barriere SL installate



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