

Civitanova Marche, 29 Marzo 2018 | Ing. Luca Dellarole,
Ufficio Tecnico Geobrugg Italia

Reti in acciaio per la prevenzione di frane in roccia e di versante: la progettazione di riferimento e i criteri di posa



Problematiche della fase progettuale

Geobrugg cosa propone per affrontare tali situazioni?

Tipologie dei sistemi e software per la verifica

Aspetti per la progettazione

Aspetti per la posa in opera

ENTITÀ DEL DANNO



ENTITÀ DEL DANNO?



ENTITÀ DEL DANNO?



ENTITÀ DEL DANNO



**Disponibilità economica
del committente?**



**Tempo per la
progettazione / realizzazione?**



DATI DI PARTENZA



SISTEMA ADATTO PER IL PROBLEMA?





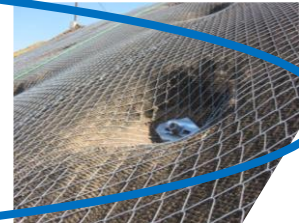
TIPI DI RIVESTIMENTO

In accordo alla Norma EN 14490 (2010)

Hard facing



Flexible facing



Soft facing



SISTEMA TECCO®

1 Rete in filo d'acciaio ad alta resistenza + connessioni



2 Piastre cuspidate TECCO®



3 Ancoraggi



SEMPLICI ELEMENTI CHE DEVONO LAVORARE BENE INSIEME

Reti TECCO® in filo d'acciaio ad alta resistenza



MAGLIA ROMBOIDALE

Sistema TECCO: 4 tipologie di reti



130 mm

65 mm

45 mm

RESISTENZE E DIAMETRI

Sistema TECCO: 4 tipologie di reti



250 kN/m

4 mm

85 kN/m

2 mm

CLASSI DI RESISTENZA

Norma UNI EN 10223-3:

Fili e prodotti trafilati di acciaio per recinzioni e reti.



$f_t \geq 350-500 \text{ N/mm}^2$

vs

Norma UNI EN 10264-1:

Filo d'acciaio e relativi prodotti. Filo d'acciaio per funi.



$f_t \geq 1180 - 2080 \text{ N/mm}^2$

Un filo da 3 mm di diametro

Reti in acciaio standard

$f_t \geq 500 \text{ N/mm}^2$

5 arrampicatori



Reti GEOBRUGG

$f_t \geq 1770 \text{ N/mm}^2$

18 arrampicatori





4 tipi di rete

TECCO® G45/2
TECCO® G65/3
TECCO® G65/4
SPIDER S3-130



3 tipi di piastre

P25/34
P33/40 + P33/50
P66/50



1 clip di
connessione

T3



BARRE PIENE E CAVE

Barre piene

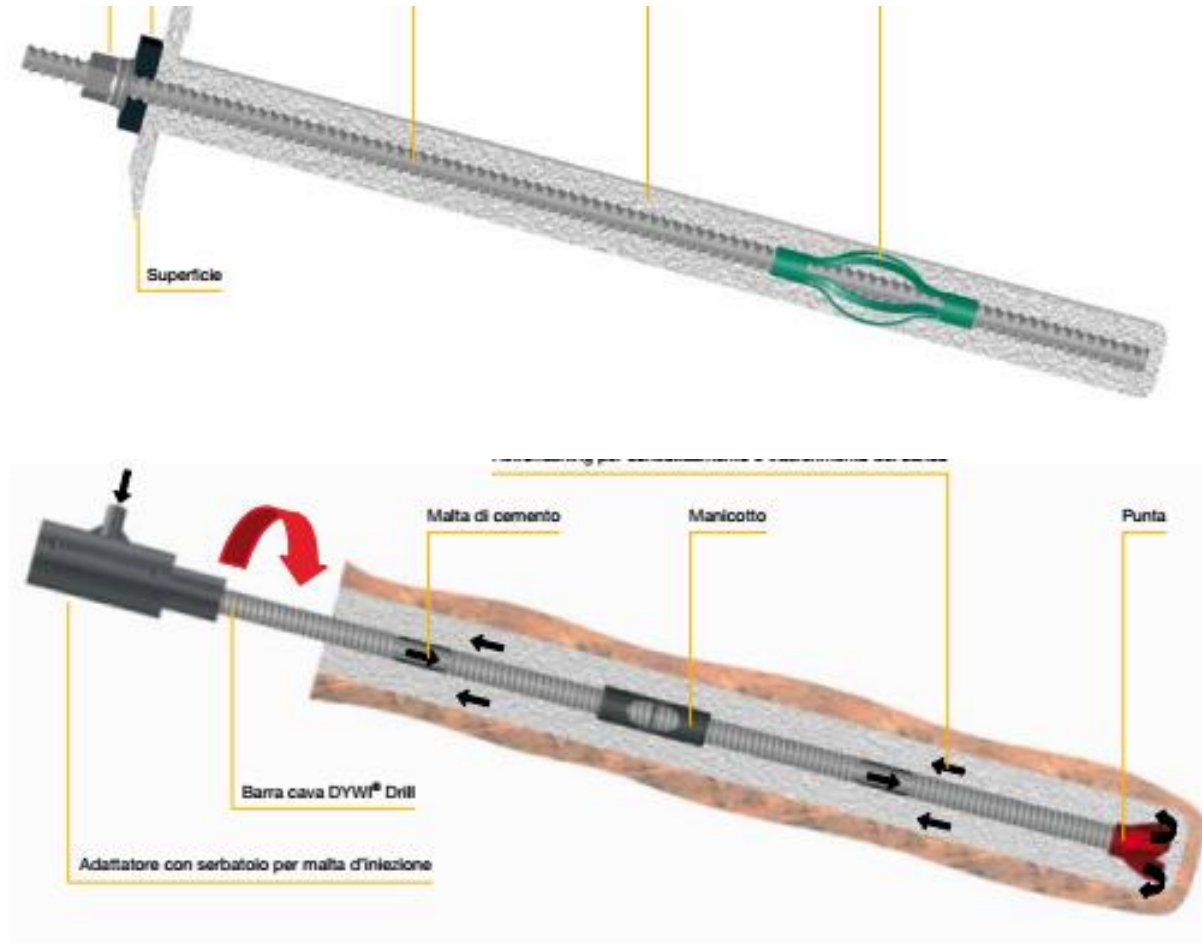


Barre cave,
autoperforanti



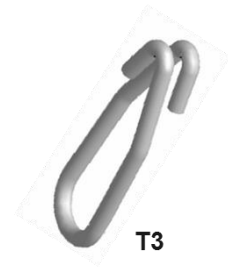
Barre con diametro variabile tra i 24 mm e i 32 (40) mm

BARRE PIENE E CAVE



Diametri di perforazione standard:
32 / 40 mm e i 110 mm.

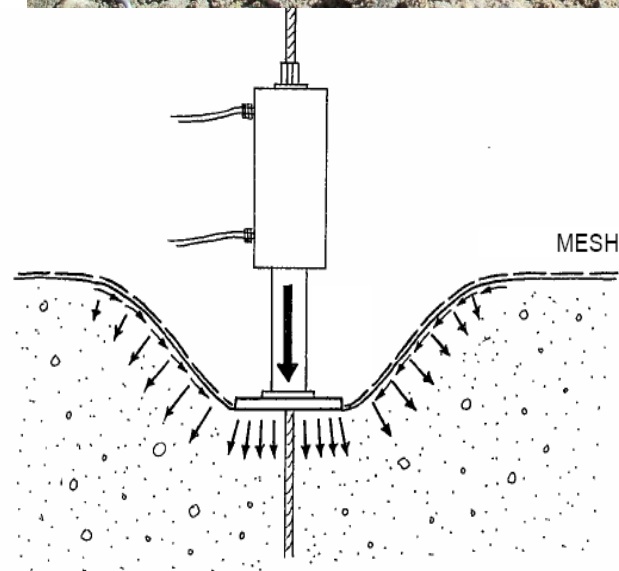
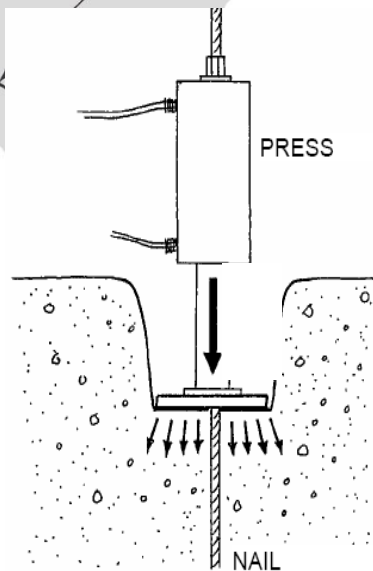
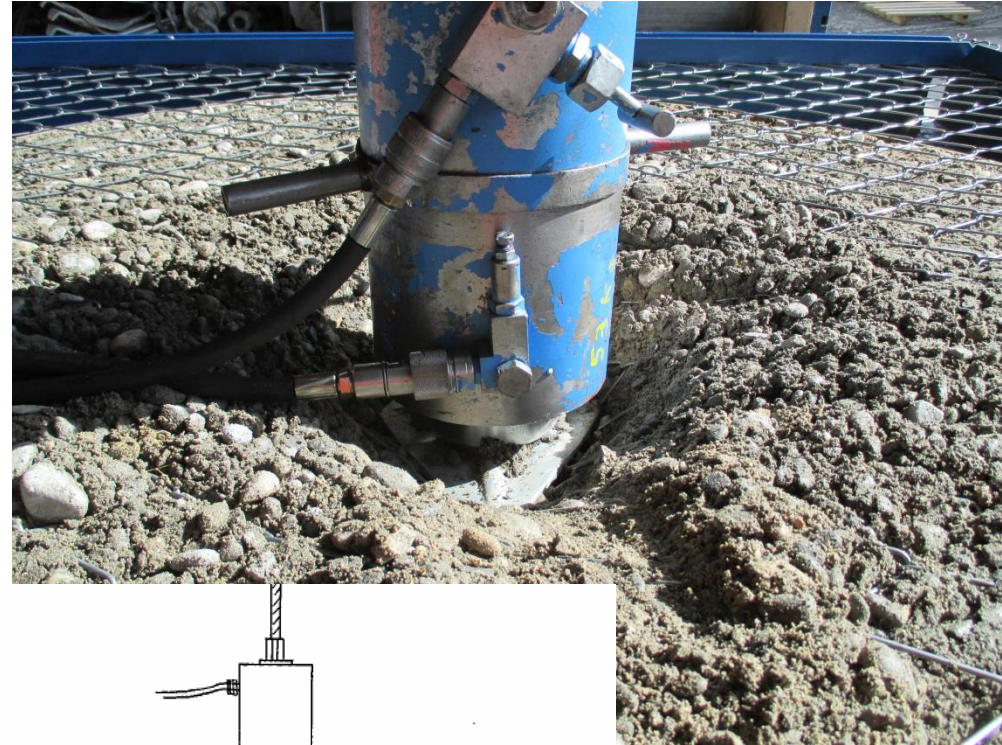
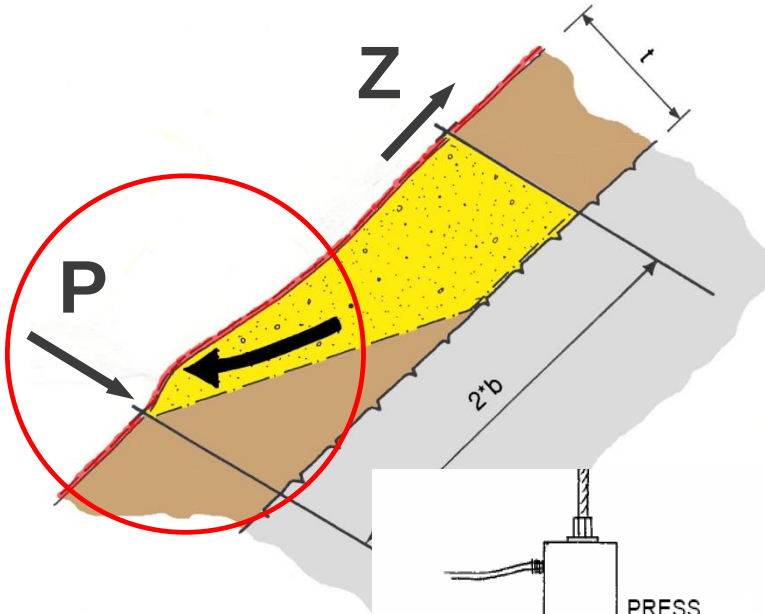
Come caratterizziamo i componenti?



PROVE DI LABORATORIO

Resistenza contro la rottura al bordo superiore della piastra

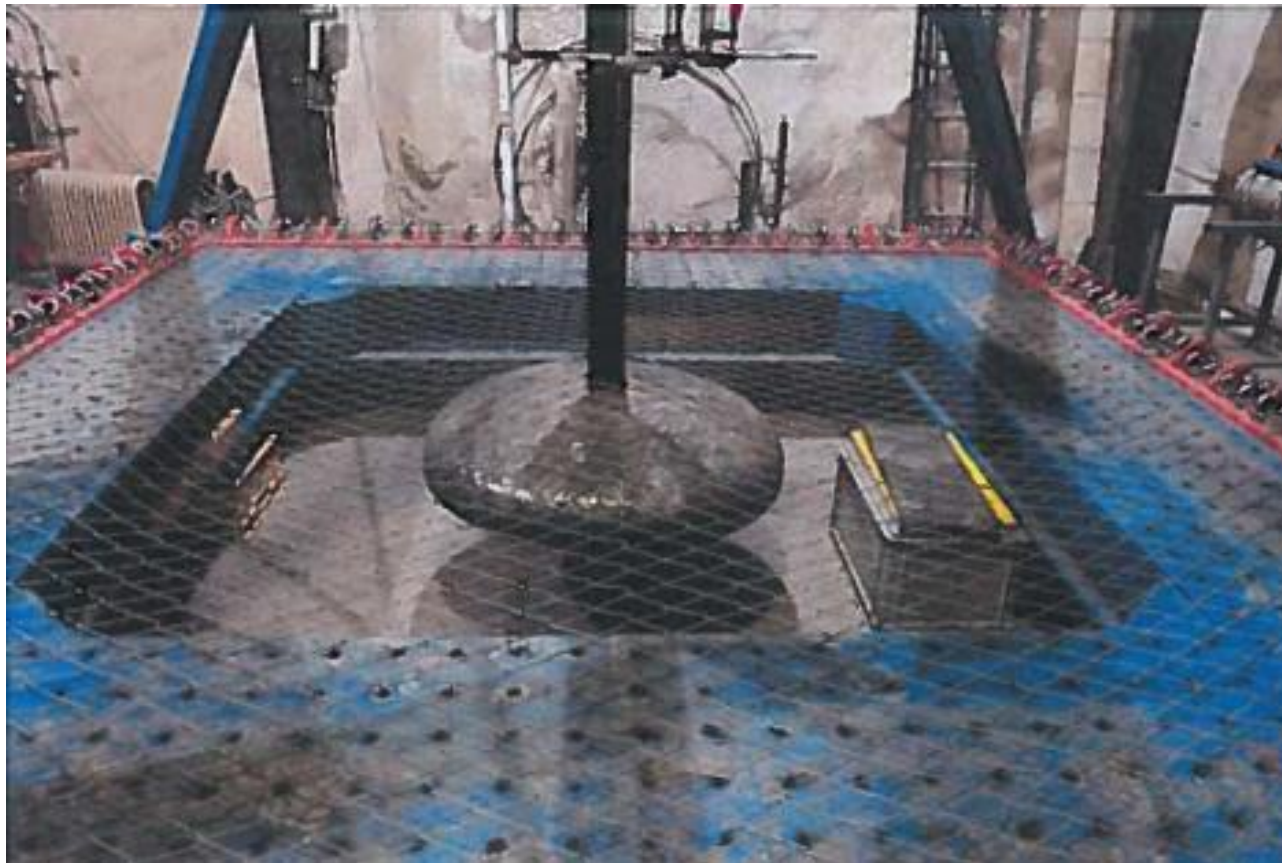
...come base per RUVOLUM®



TEST AL PUNZONAMENTO

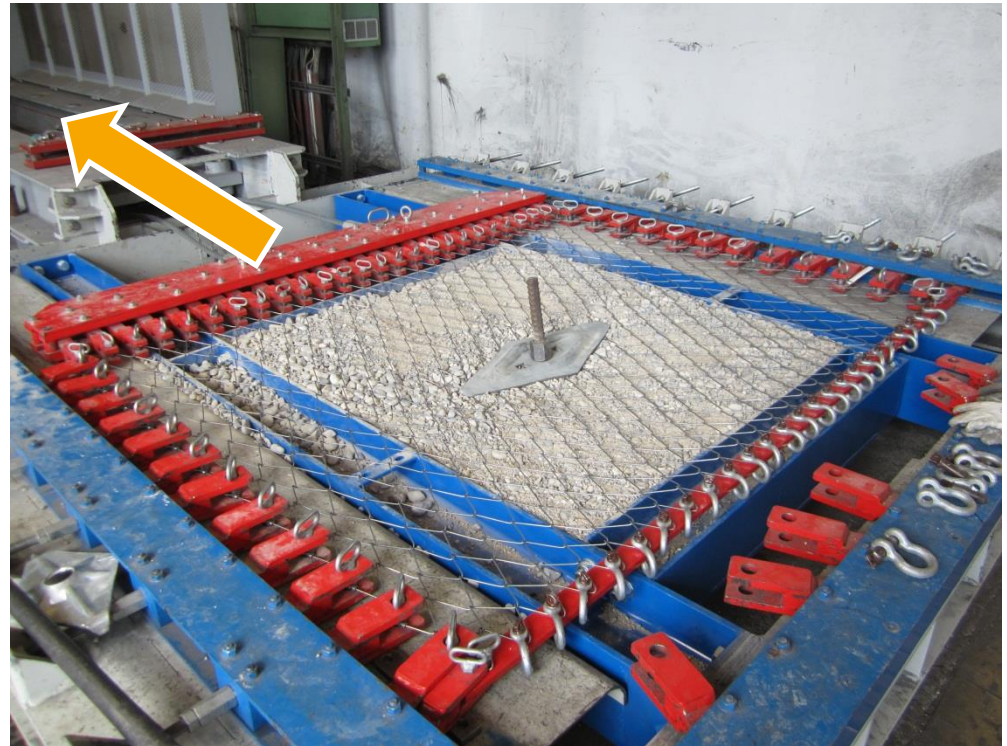
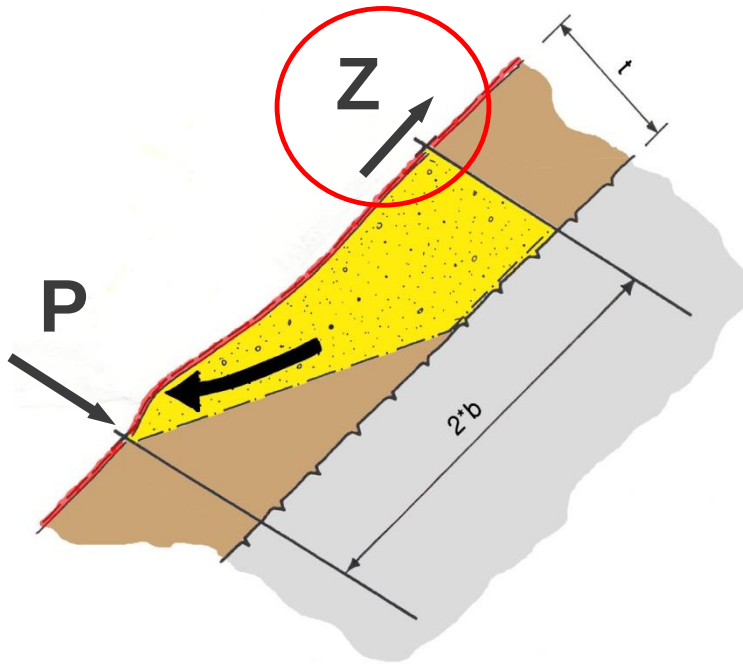
Test del cupolone: norma UNI 11437

«Prove su reti per rivestimento di versanti»



PROVE DI LABORATORIO

Resistenza alla trazione parallelamente al pendio
... come base per RUVOLUM®



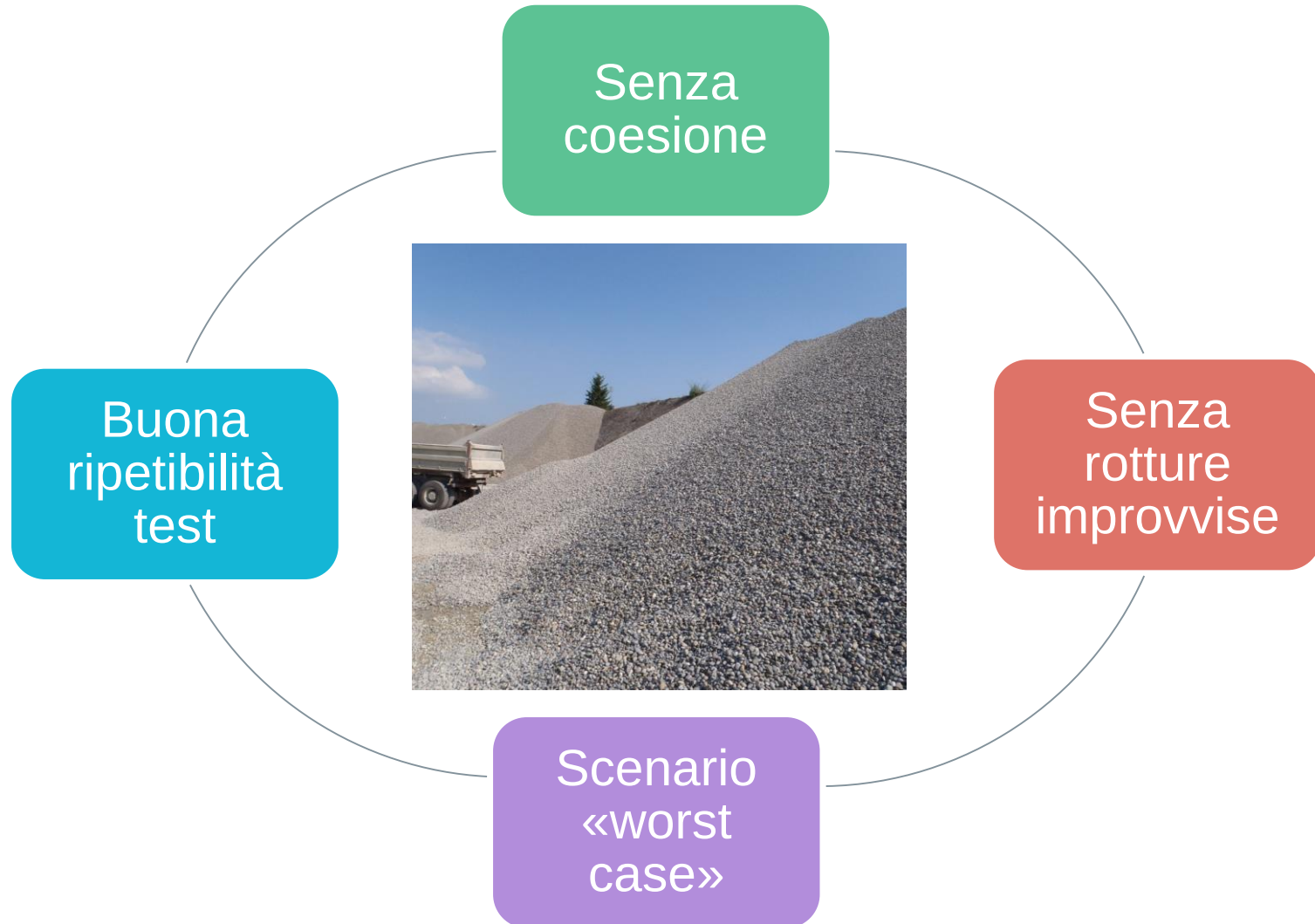
PROVE DI LABORATORIO



PROVE DI PERFORMANCE



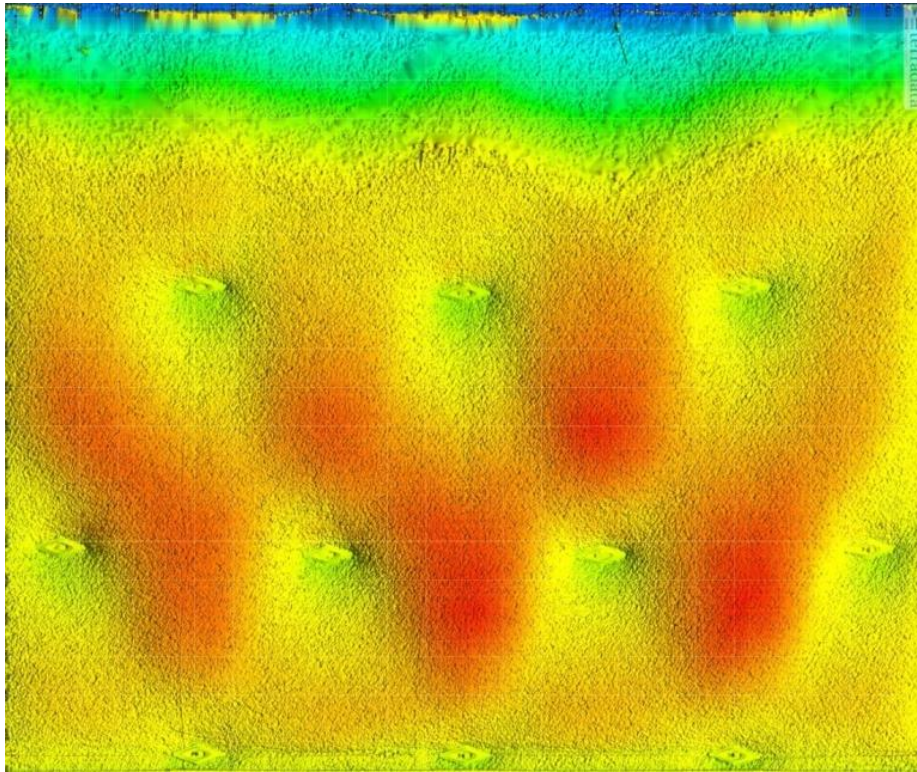
Caratteristiche materiale: Ghiaia lavata 16/32 mm



RUVOLUM® VERIFICATO CON TEST IN GRANDE SCALE

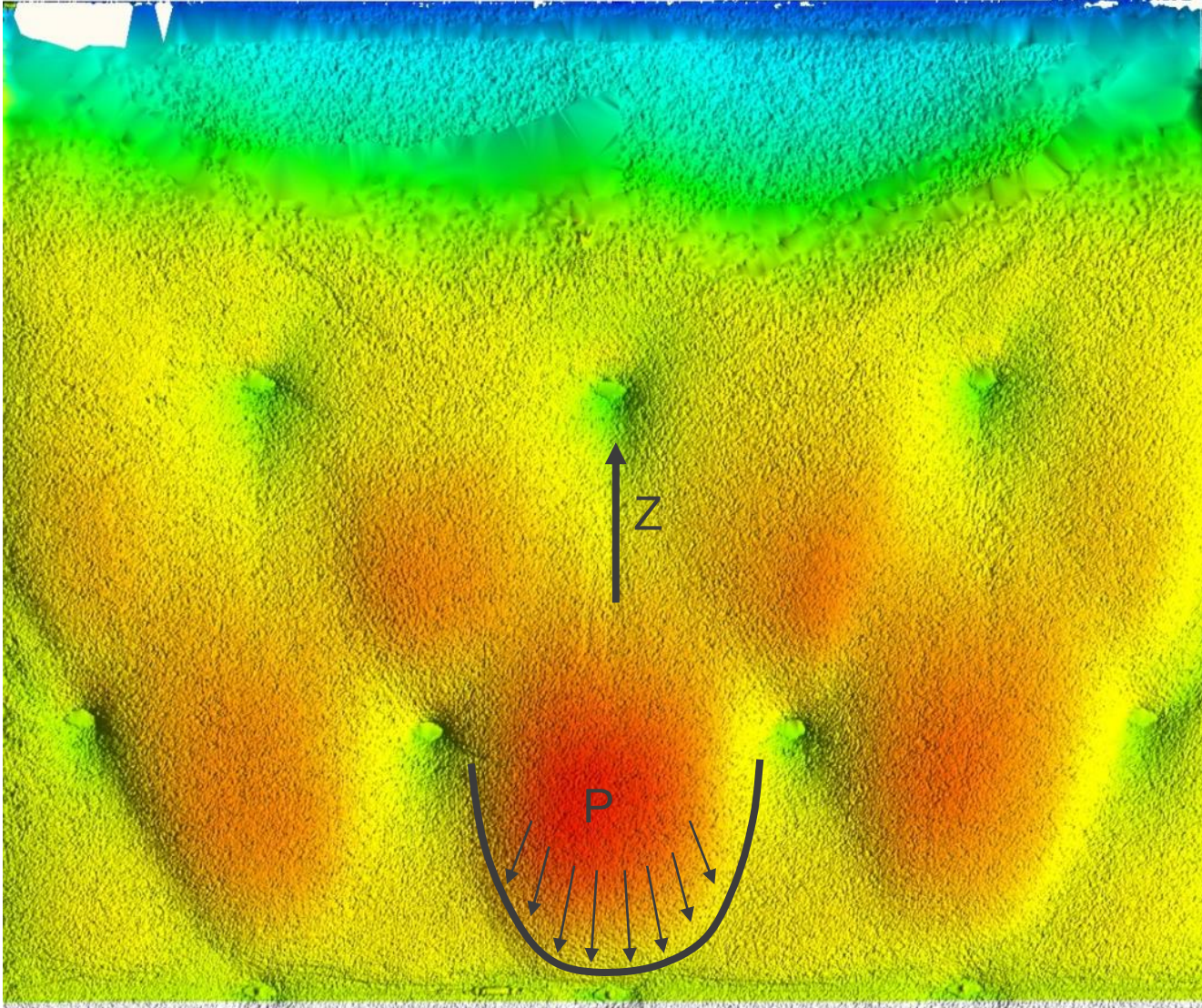
ANALISI DI MECCANISMI DI SCIVOLAMENTO REALI

Test #12, 19.06.2013

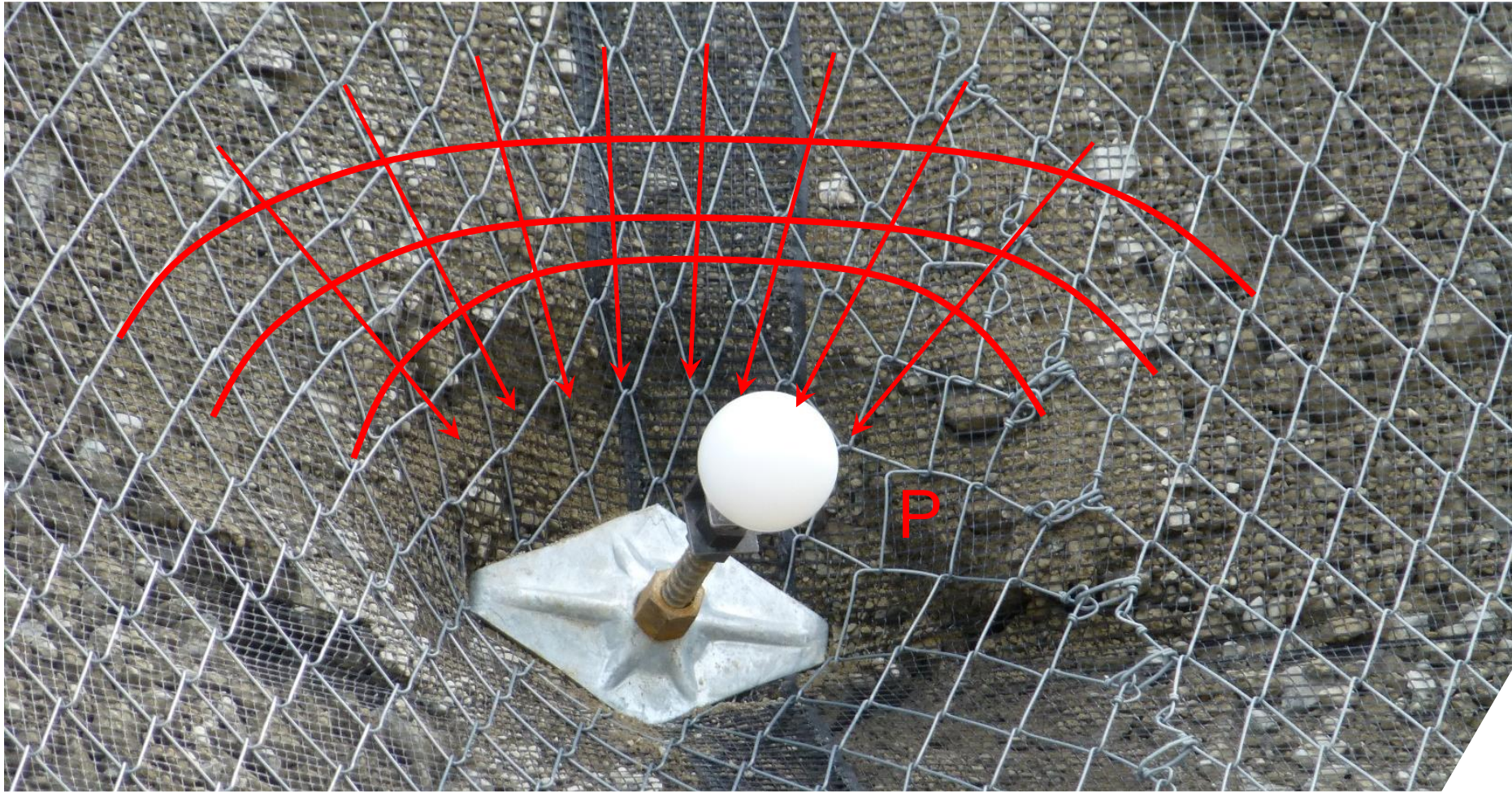


- ▶ TECCO G65/4 + P66
- ▶ $a = b = 3.5 \text{ m}$
- ▶ Ghiaia di fiume
- ▶ Fuso 16...32 mm
- ▶ $\alpha = 60^\circ$

ANALISI DI MECCANISMI DI SCIVOLAMENTO REALI



PUNZONAMENTO



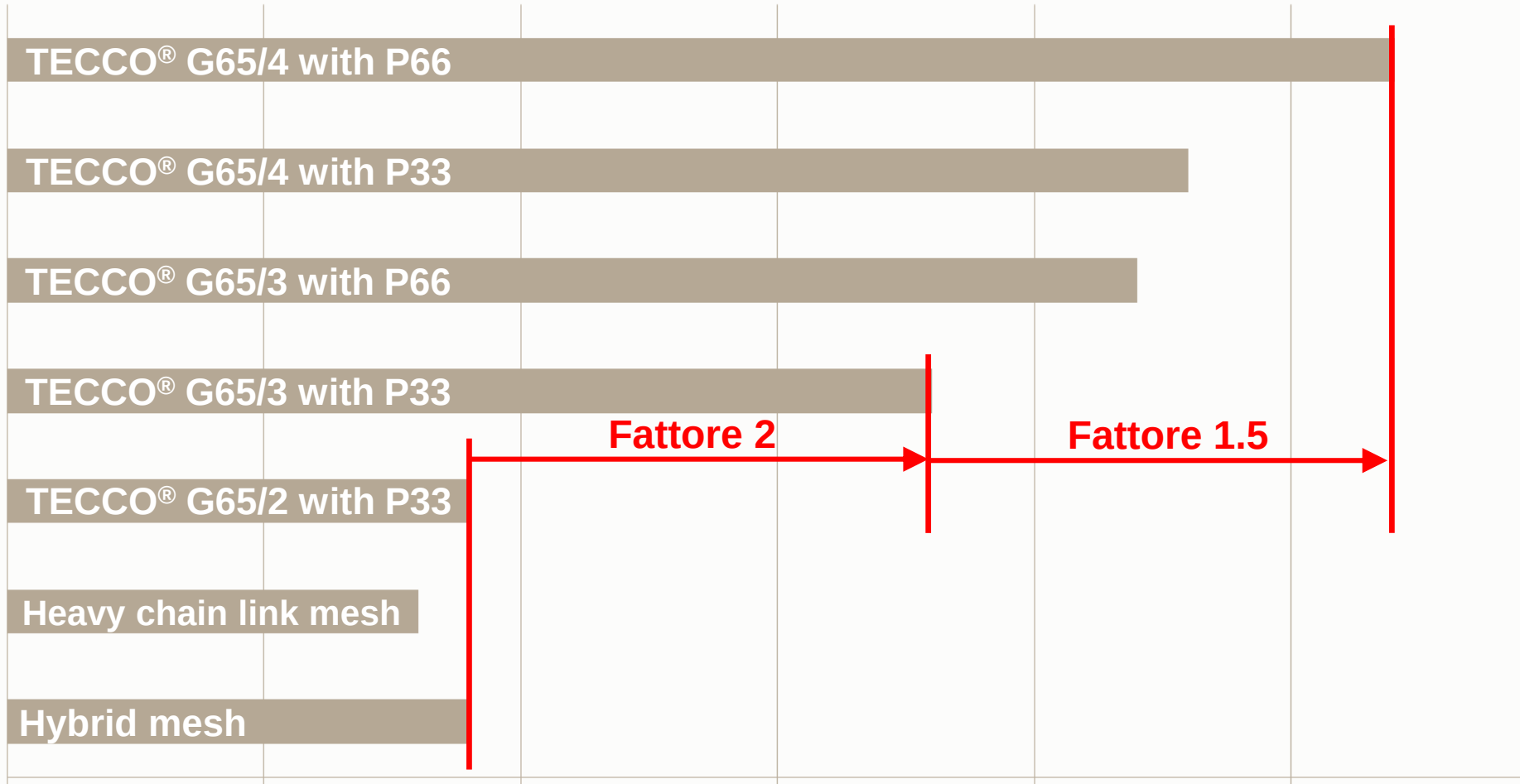
PUNZONAMENTO



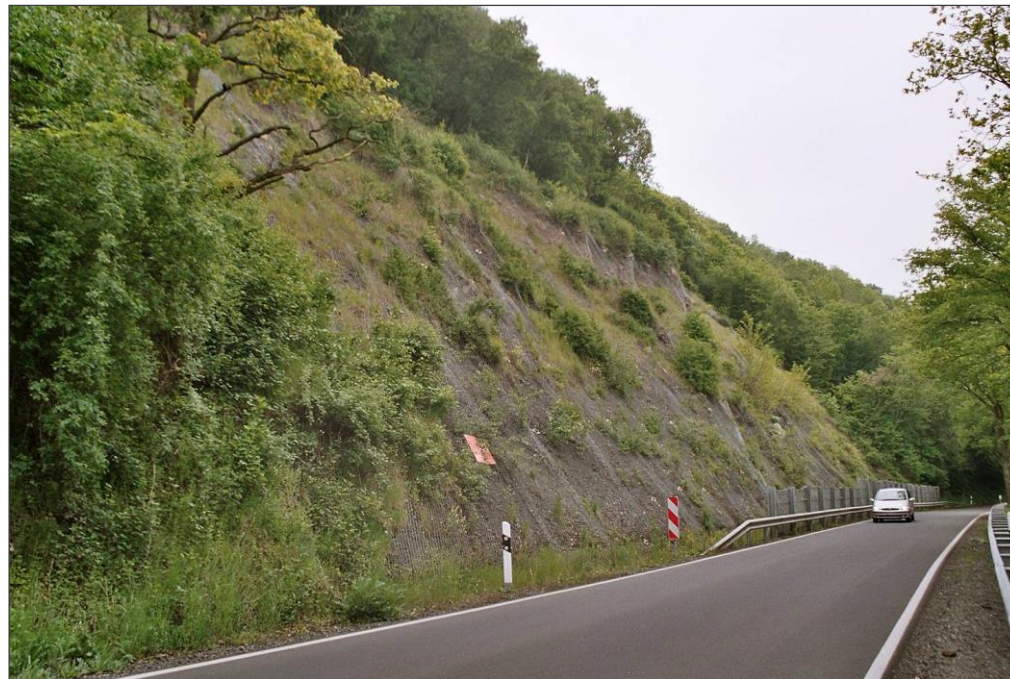
ROTTURA SEMPRE IN
CORRISPONDENZA
DELLA PIASTRA

ANALISI DELLE DIFFERENTI PERFORMANCES

Stabilized angle on design level [°]



ADATTABILE



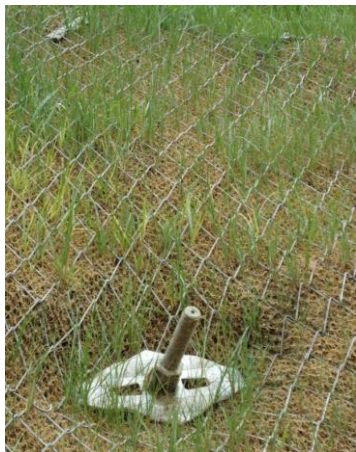


ADATTABILE



TECCO GREEN G65/3

TECCO® GREEN
G65/3



Rete TECCO G65/3 +
stuoia tridimensionale in
polipropilene

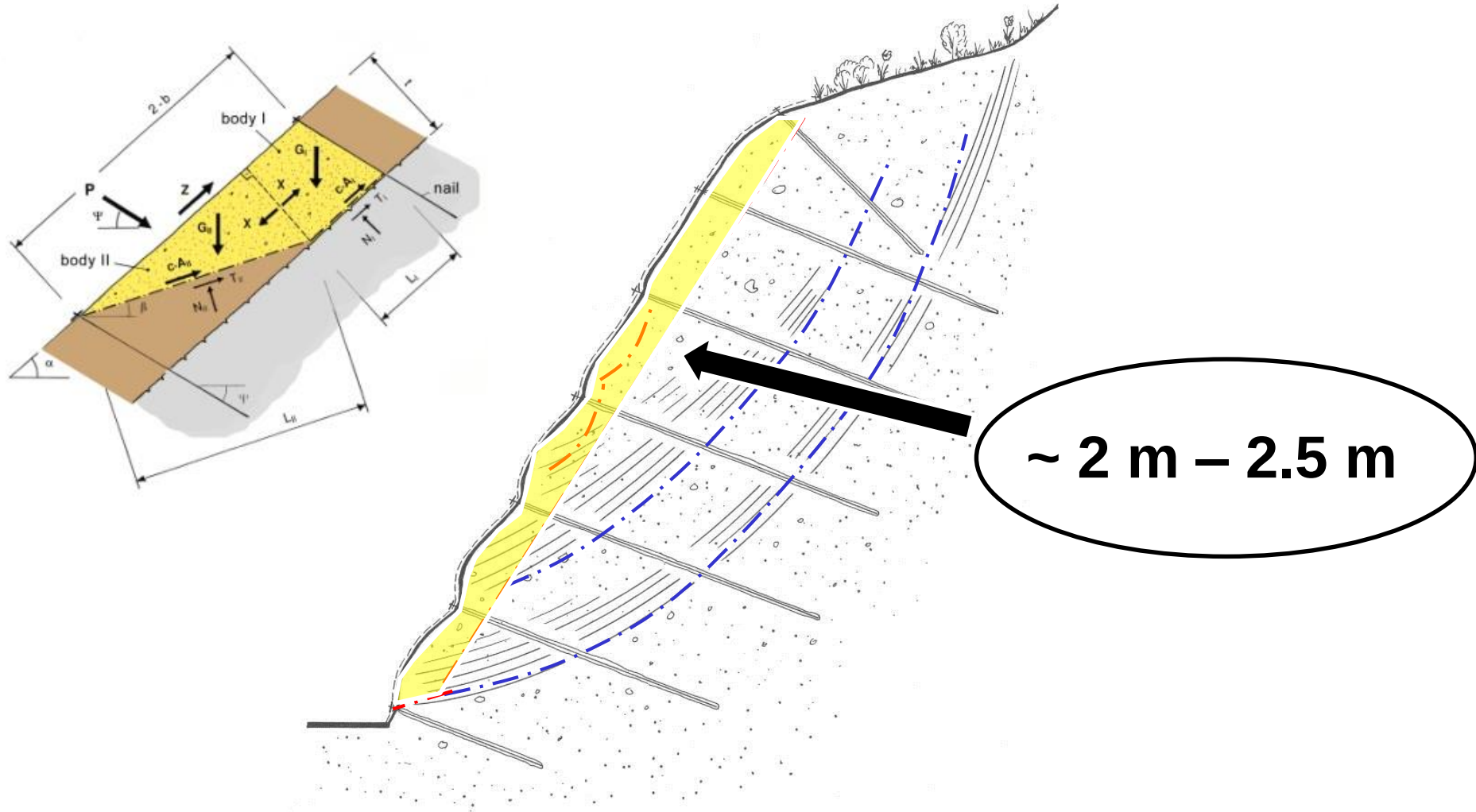
ADATTABILE



ADATTABILE



INSTABILITÀ SUPERFICIALE



Fino a che profondità??

VERIFICA TRAMITE SOFTWARE RUVOLUM

SOFTWARE RUVOLUM

Ruvolum® - The program to dimension the slope stabilization system TECCO®/ SPIDER®

Ruvolum Online Tool, Version 2014

Save

Load

Print

Full screen

Units

EN

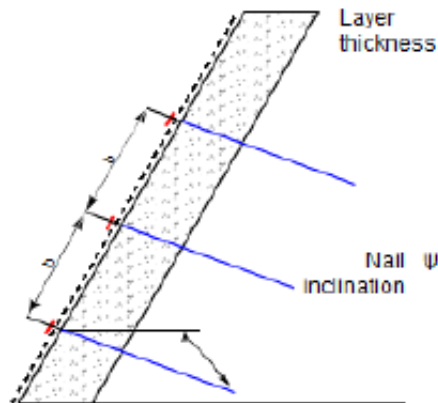


Project No. 12345-12345

Project Name Prova Sicilia

Date, Author Gennaio 2014 - G. Guasti

Cross-section:



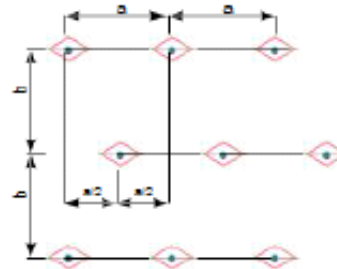
Layer thickness

$t = 1.00$ m

Nail inclination $\psi = 20.0$ degrees

Slope inclination $\alpha = 60.0$ degrees

View nail arrangement:



Mesh and spike plate type

TECCO® G65/3 + P33

About nailing

Variation a = b

Nail distance horizontal $a = 2.70$ m

Nail distance in line of slope $b = 2.70$ m

GEWI D = 28 mm

with rusting away

Dimensioning quantities

$\Phi_0 = 26.6$ degrees

$c_0 = 0.0$ kN/m²

$\gamma_s = 20.0$ kN/m³

Control:

Proofs of the mesh OK (0.73)

Proofs of the nails OK (0.95)

Load cases

Defaults

Safety factors

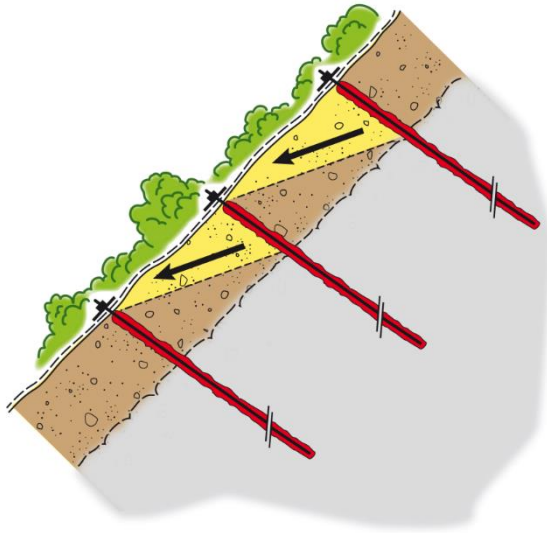
Nail types

Elements of the system

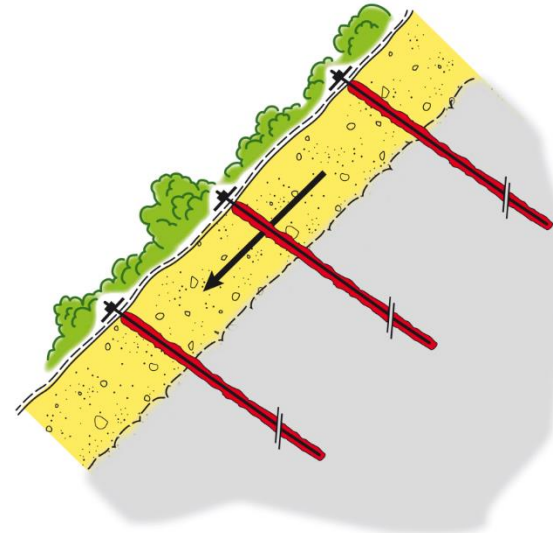
Proof of bearing safety

Analisi di tipo attritivo-coesivo alla Mohr Coulomb

1. La verifica di instabilità locali tra i singoli ancoraggi



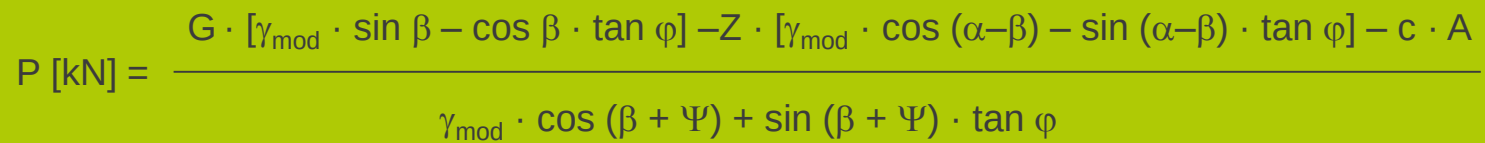
2. La verifica di instabilità di versante sul modello del pendio indefinito



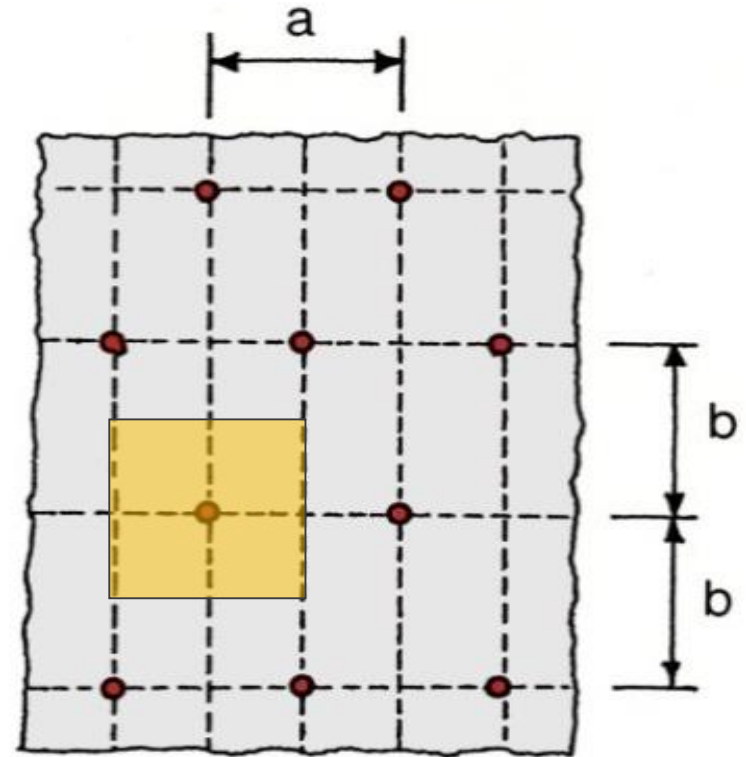
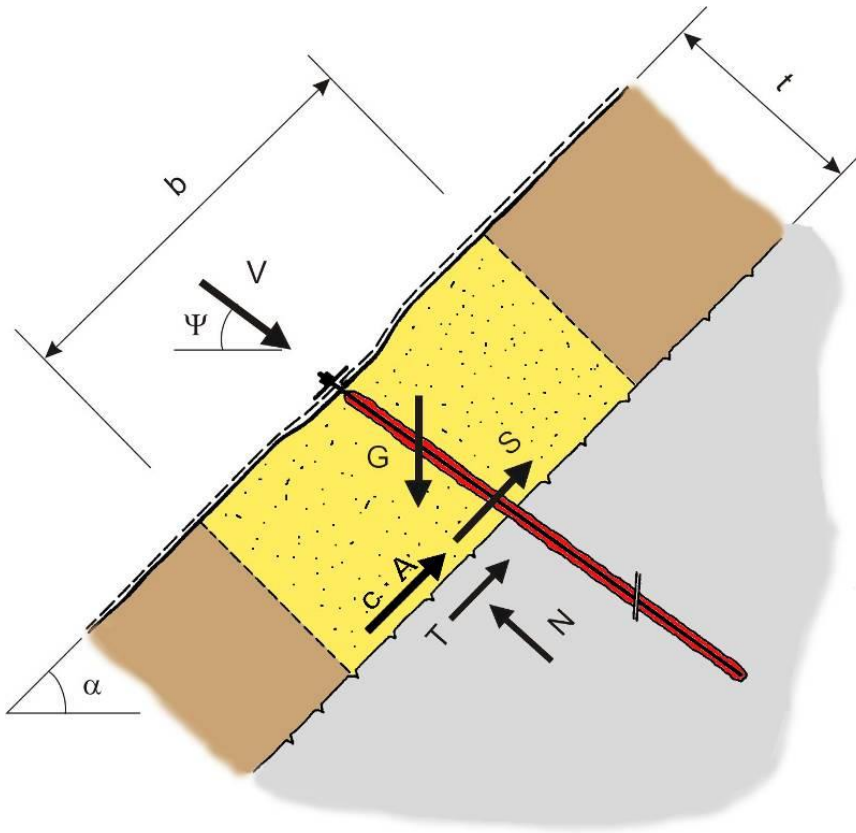
Secondo quanto definito da NTC e relativi fattori di sicurezza

GEOBRUGG®
BRUGG

Safety is our nature



MODELLO CONCETTUALE



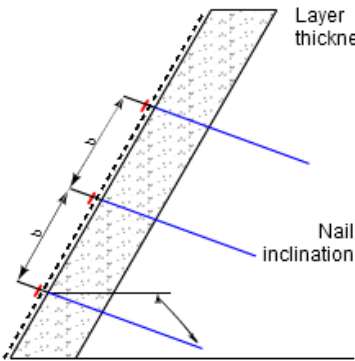
IL MODELLO DI CALCOLO RUVOLUM

Ruvolum® - The program to dimension the slope stabilization system TECCO®/ SPIDER®

Ruvolum Online Tool, Version 2014

Save Load Print Full screen Units EN

Project No. 2013001
Project Name Winterthur
Date, Author 04.11.2013, D. Flum
Cross-section:



Layer thickness
Nail inclination
Slope inclination $\alpha = 60.0$ degrees

Mesh and spike plate type

TECCO® G65/3 + P33

TECCO® G65/2 + P33
TECCO® G65/3 + P33
TECCO® G65/3 + P66
TECCO® G65/4 + P33
TECCO® G65/4 + P66
SPIDER® S3 - 130 + P33

Mesh and spike plate type
TECCO® G65/3 + P33

About nailing
Variation a = b
Nail distance horizontal a = 2.70 m
Nail distance in line of slope b = 2.70 m
GEWI D = 28 mm
with rusting away

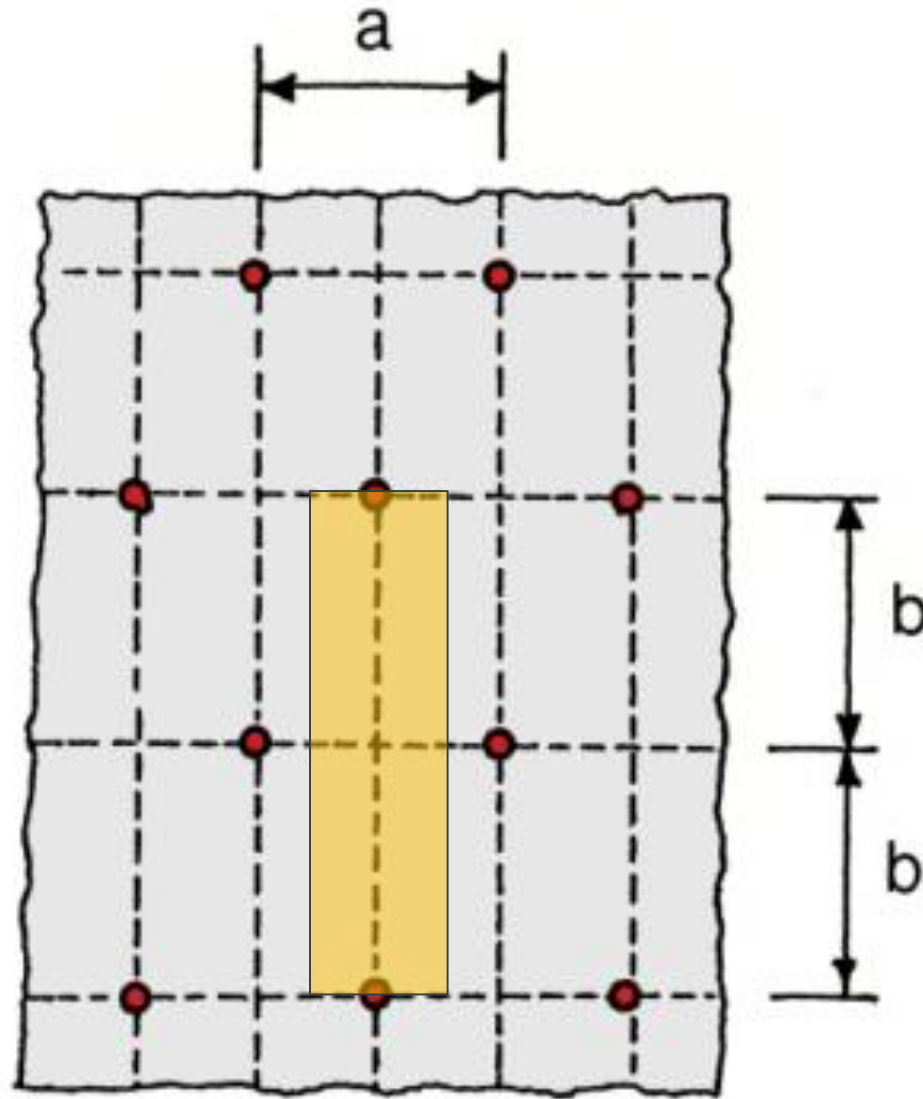
Dimensioning quantities
 $\Phi_d = 26.6$ degrees
 $c_d = 0.0$ kN/m²
 $\gamma_d = 20.0$ kN/m³

Control:
Proofs of the mesh OK
Proofs of the nails OK

Friction angle ground (characteristic value) $\Phi_k = 32.0$ degrees
Volume weight ground (characteristic value) $\gamma_k = 20.0$ kN/m³

Load cases Defaults Safety factors Nail types Elements of the system Proof of bearing safety

IL MODELLO DI CALCOLO RUVOLUM



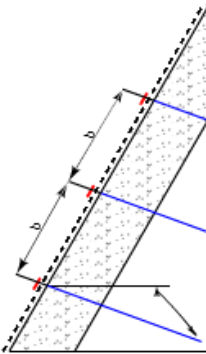
IL MODELLO DI CALCOLO RUVOLUM

Ruvolum® - The program to dimension the slope stabilization system TECCO®/ SPIDER®

Ruvolum Online Tool, Version 2014

Save Load Print Full screen Units EN

Project No. 20130
Project Name Winter
Date, Author 04.11.2
Cross-section:



Slope inclin

GEWI D = 28 mm
GEWI D = 25 mm
GEWI D = 28 mm
GEWI D = 32 mm
GEWI D = 40 mm
TITAN 30/11
TITAN 40/16

Friction angle ground (characteristic value) $\Phi_k = 32.0$ degrees
Volume weight ground (characteristic value) $\gamma_k = 20.0$ kN/m³

Mesh and spike plate type
TECCO® G65/3 + P33

About nailing
Variation a = b
Nail distance horizontal a = 2.70 m
Nail distance in line of slope b = 2.70 m
GEWI D = 28 mm
with rusting away

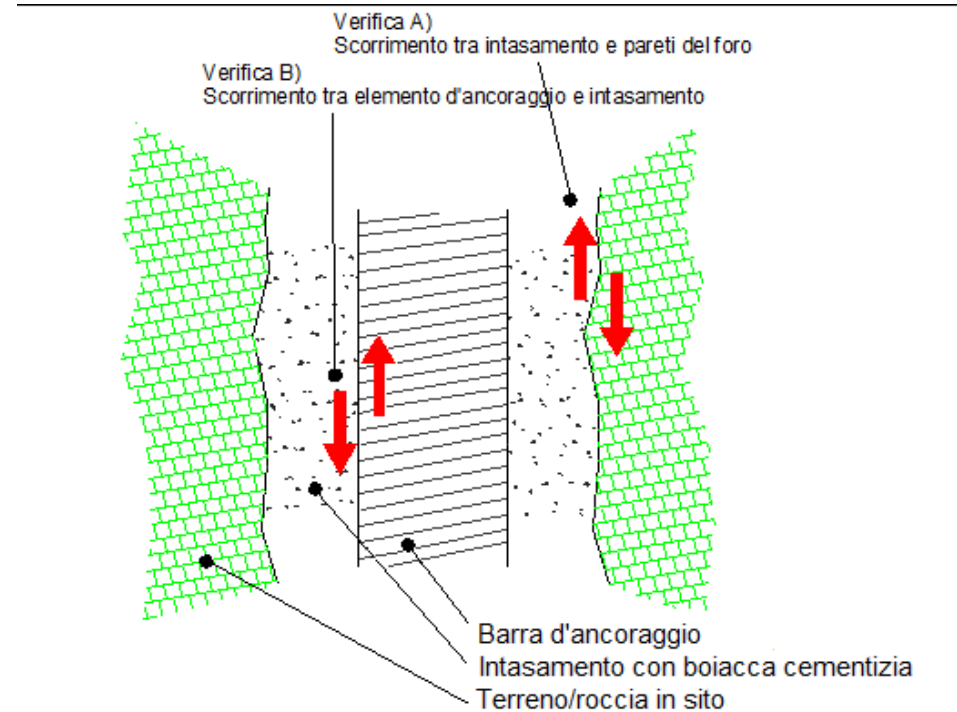
Dimensioning quantities
 $\Phi_d = 26.6$ degrees
 $c_d = 0.0$ kN/m²
 $\gamma_d = 20.0$ kN/m³

Control:
Proofs of the mesh OK
Proofs of the nails OK

Load cases Defaults Safety factors Nail types Elements of the system Proof of bearing safety

Calcolo lunghezza ancoraggi

- Verifica sezione acciaio
- Verifica interfaccia acciaio-malta
- Verifica interfaccia malta-substrato



Verifiche con approccio 2 (A1+M1+R3) NTC - cap.
Fondazioni su pali.

LUNGHEZZA ANCORAGGI

Verifica sfilamenti

γ_R fattore parziale
ancoraggi (rif.
Tecniche)

La lunghezza
ancoraggio

Ds diametro
perforazione



determinazione
substrato

Definizione di
progetto

Definizione
auto-malta

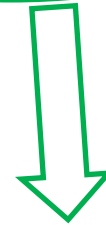
Capitolato:

$3 \times 3;$



Interasse ancoraggi

$L = 3 \text{ m}$

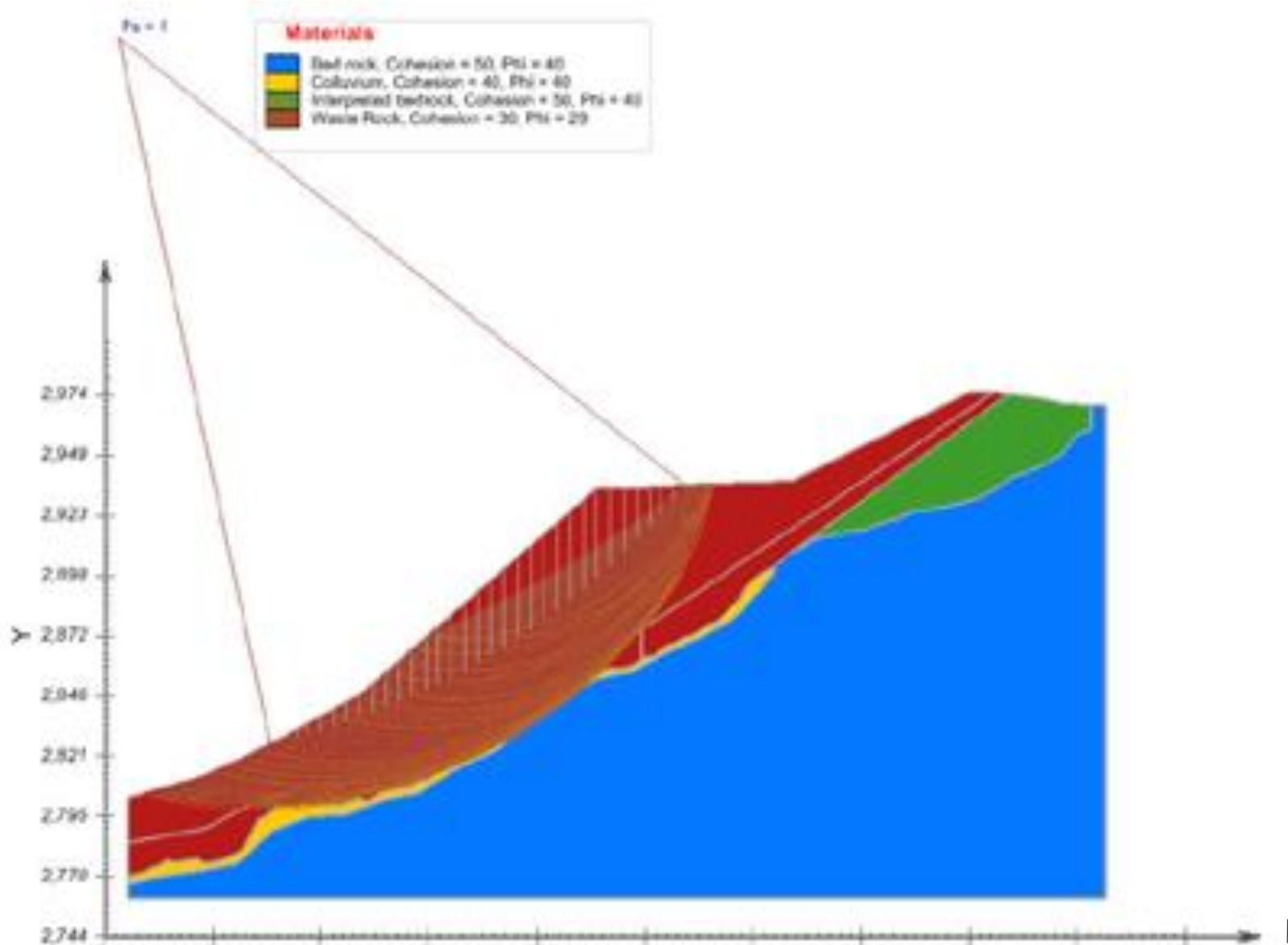


Lunghezza ancoraggi

PROGETTAZIONE

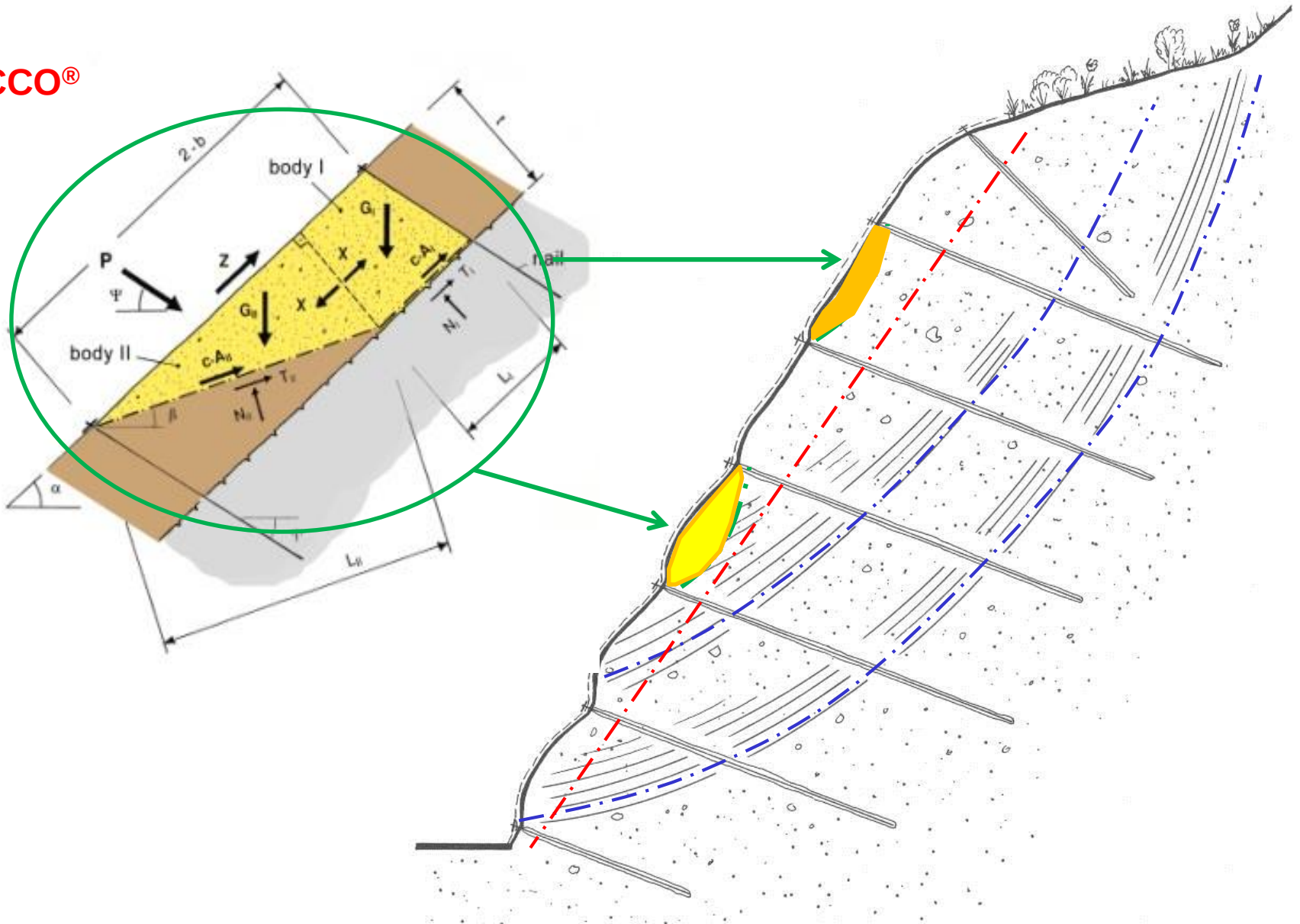


INSTABILITÀ SUPERFICIALI E PROFONDE



INSTABILITÀ SUPERFICIALI E PROFONDE

TECCO®



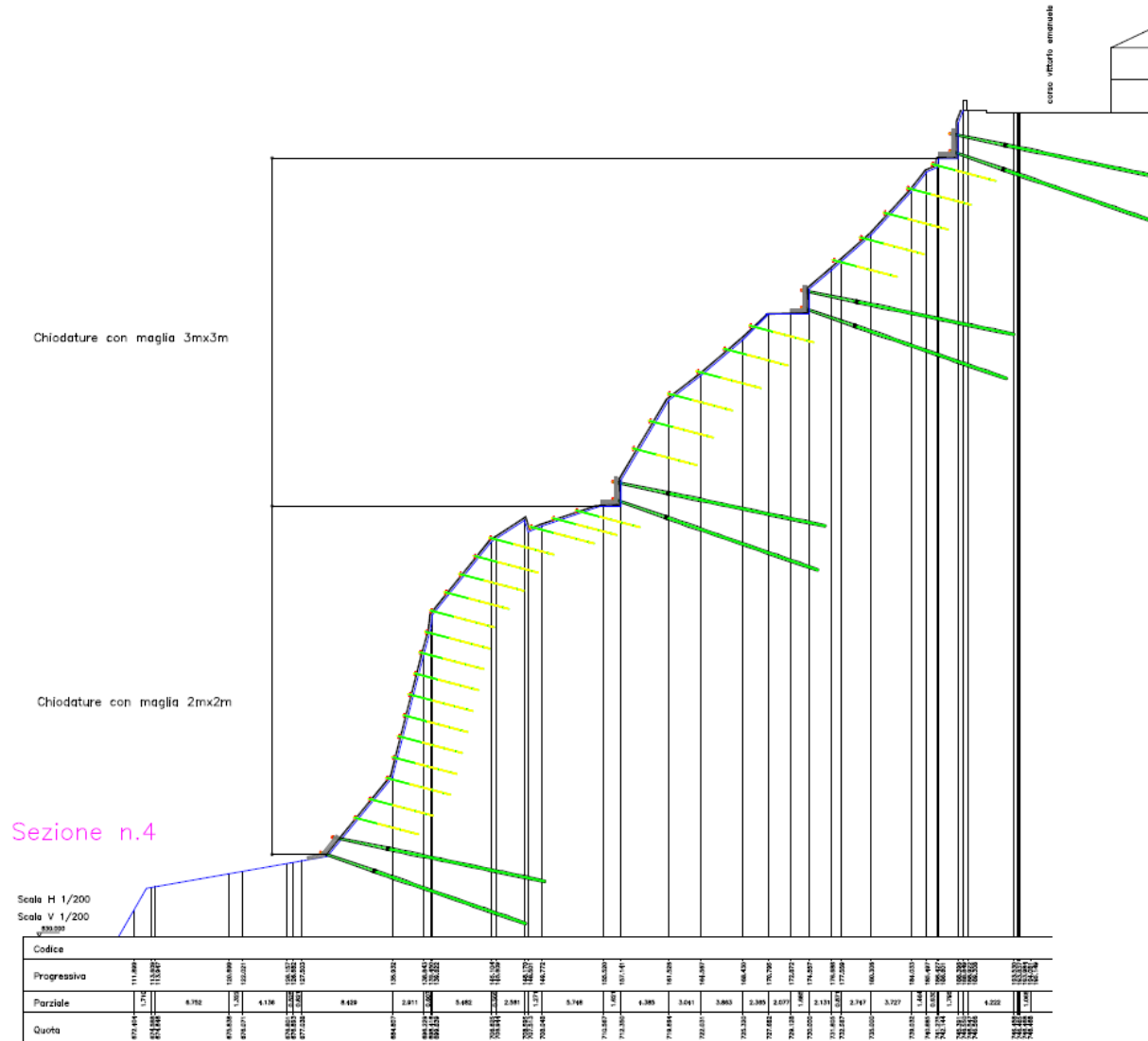
GEOBRUGG®
BRUGG

Safety is our nature

Safety is our nature



INSTABILITÀ SUPERFICIALI E PROFONDE



INSTABILITÀ SUPERFICIALI E PROFONDE



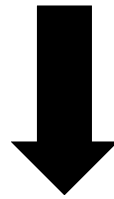
INSTABILITÀ SUPERFICIALI E PROFONDE







Che ulteriore aspetto dovete considerare?



CORROSIONE AMBIENTALE!



CLASSI AMBIENTALI

Corrosivity category	Mass loss per unit surface/thickness loss (after first year of exposure)				Examples of typical environments (informative only)	
	Low-carbon steel		Zinc		Exterior	Interior
	Mass loss g/m ²	Thickness loss mm	Mass loss g/m ²	Thickness loss µm		
C1 very low	≤ 10	≤ 1,3	≤ 0,7	≤ 0,1	—	Heated buildings with clean atmospheres, e.g. offices, shops, schools, hotels.
C2 low	> 10 to 200	> 1,3 to 25	> 0,7 to 5	> 0,1 to 0,7	Atmospheres with low level of pollution. Mostly rural areas.	Unheated buildings where condensation may occur, e.g. depots, sports halls.
C3 medium	> 200 to 400	> 25 to 50	> 5 to 15	> 0,7 to 2,1	Urban and industrial atmospheres, moderate sulfur dioxide pollution. Coastal areas with low salinity.	Production rooms with high humidity and some air pollution, e.g. food-processing plants, laundries, breweries, dairies.
C4 high	> 400 to 650	> 50 to 80	> 15 to 30	> 2,1 to 4,2	Industrial areas and coastal areas with moderate salinity.	Chemical plants, swimming pools, coastal ship- and boatyards.
C5 very high	> 650 to 1500	> 80 to 200	> 30 to 60	> 4,2 to 8,4	Industrial areas with high humidity and aggressive atmosphere	Buildings or areas with almost permanent condensation and with
maximum 60 g/ m ² /year => 5 years => 300 g/ m ²						
CX extreme	> 1500 to 5500	> 200 to 700	> 60 to 180	> 8,4 to 25	Offshore areas with high salinity and industrial areas with extreme humidity and aggressive atmosphere and subtropical and tropical atmospheres.	Industrial areas with extreme humidity and aggressive atmosphere

CATEGORIE AMBIENTALI

Category	Corrosivity
C1	Very low
C2	Low
C3	Medium
C4	High
C5	Very high
CX	Extreme

Corrosion Class
Impact

C1
Very low

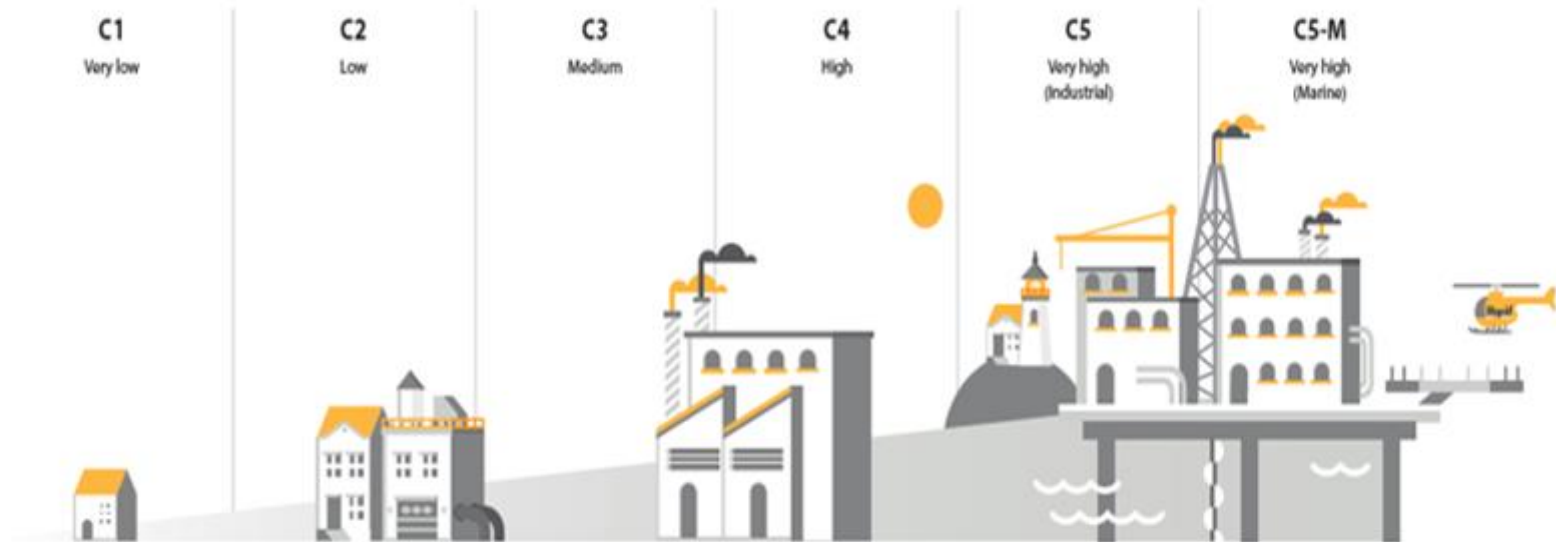
C2
Low

C3
Medium

C4
High

C5
Very high
(Industrial)

C5-M
Very high
(Marine)



Blygold Coating Formula

Country side

Urban & small industrial

Heavy industrial

Coastal & offshore

REALTÀ?



TIPI DI ACCIAIO

TIPO DI ACCIAIO / RIVESTIMENTO	CLASSE AMBIENTALE
Supercoating CLASSE B	C1 e C2
Supercoating CLASSE A	C3 e C4
ACCIAIO INOSSIDABILE	C4, C5, CX

Classe A > Classe B

255 g/m² vs 150 g/m²

Rivestimento:

95% Zn + 5% Al



PROTEZIONE CORROSIONE



Protezione INOX:



+ 10 – 30 %

**Protezione
Classe A / B:**



+ 100 %

SOPRALLUOGHI



FASI DI INSTALLAZIONE



FASI DI INSTALLAZIONE



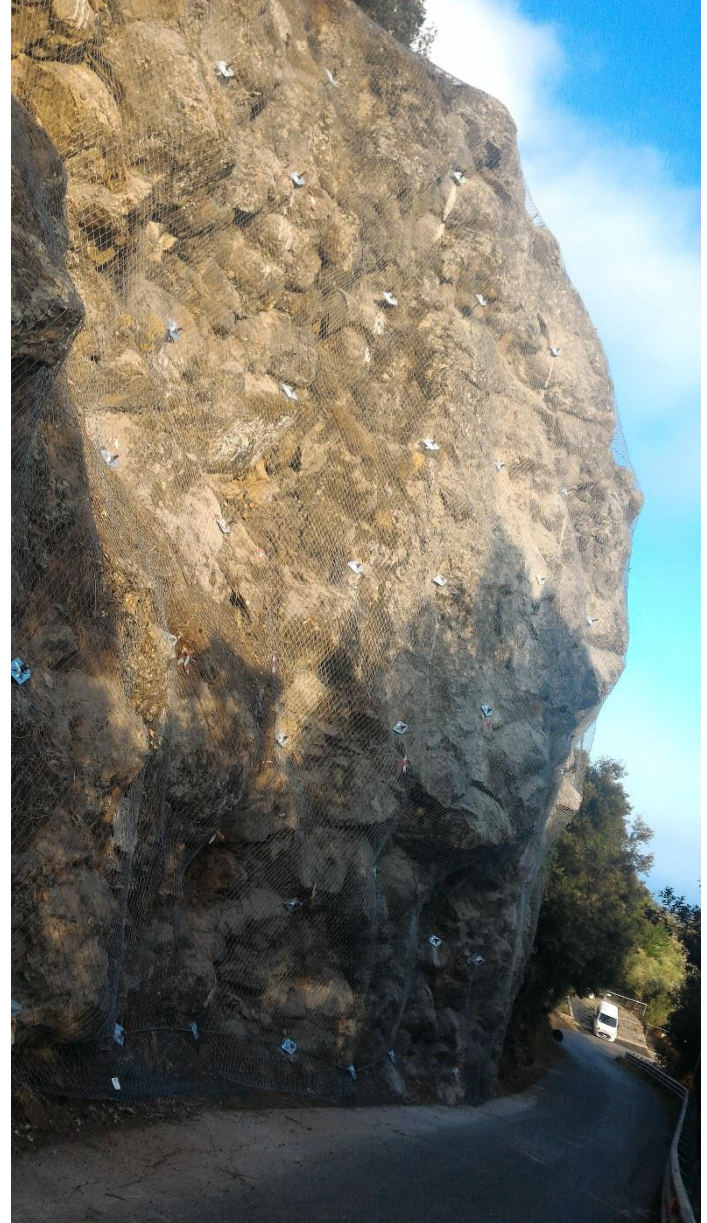
Slitta per perforazioni



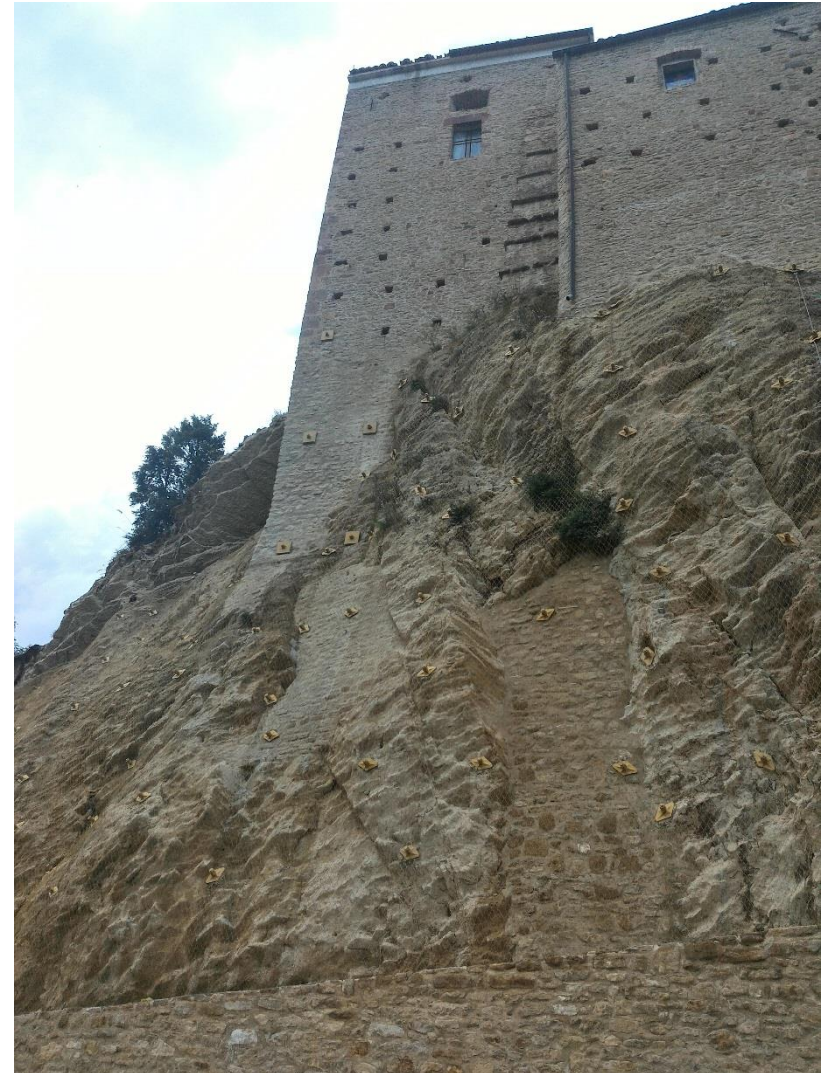
FASI DI INSTALLAZIONE



ALCUNE APPLICAZIONI

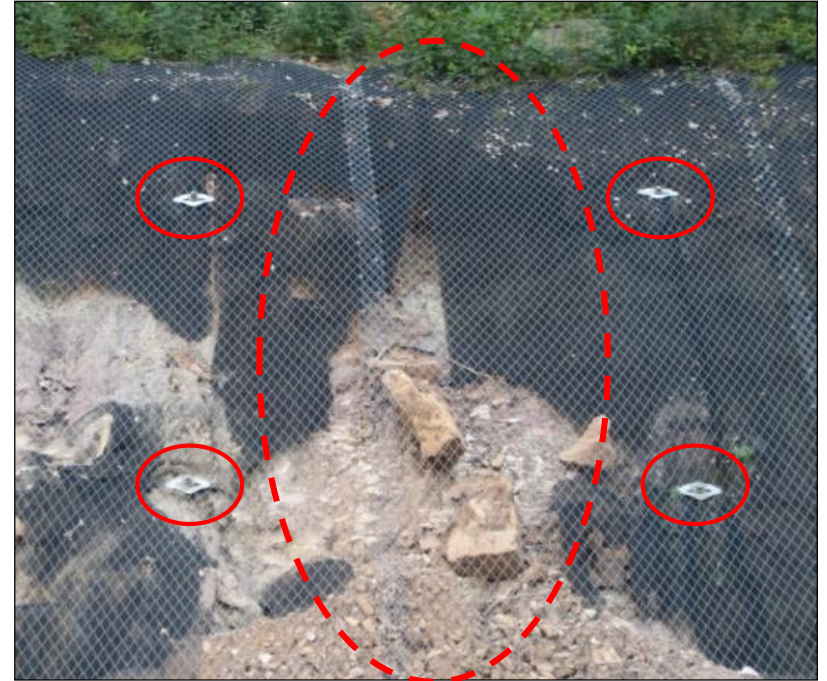
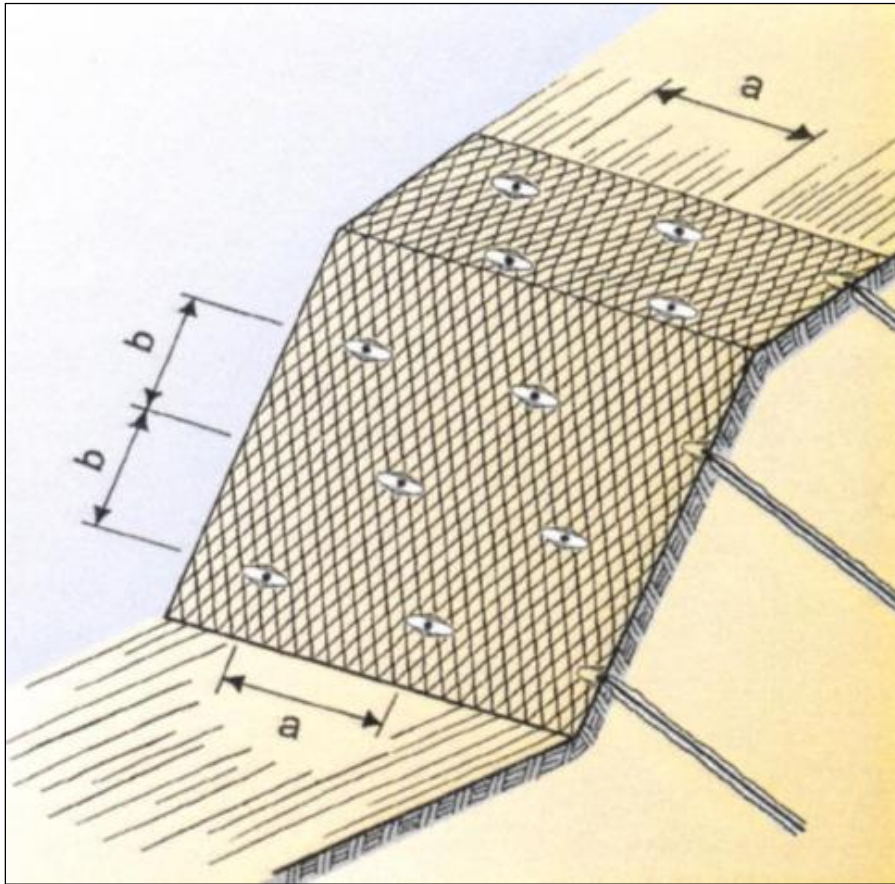


ALCUNE APPLICAZIONI



LA CORRETTA POSA IN OPERA

E' importante traslare le file di ancoraggi di un semi-interasse orizzontale!



Da evitare!!

LA CORRETTA POSA IN OPERA

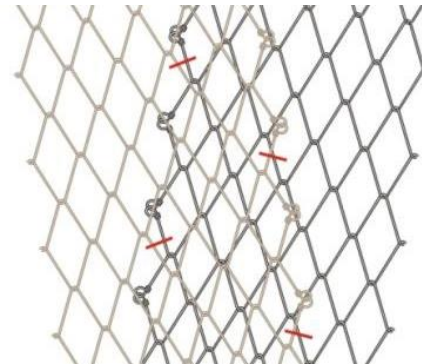
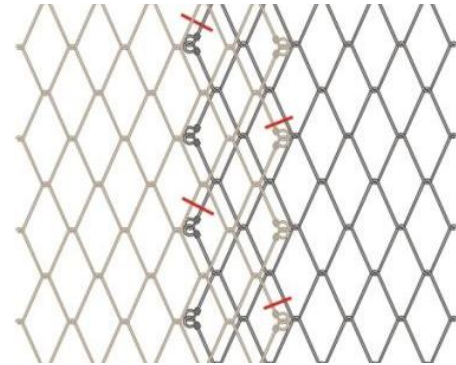
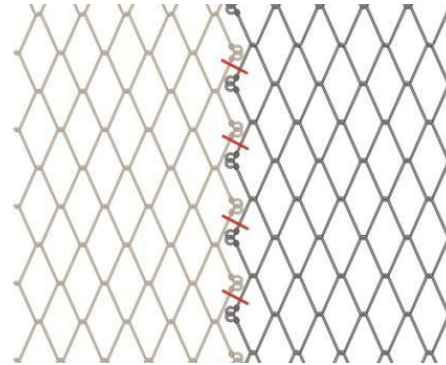
Messa in tensione della rete



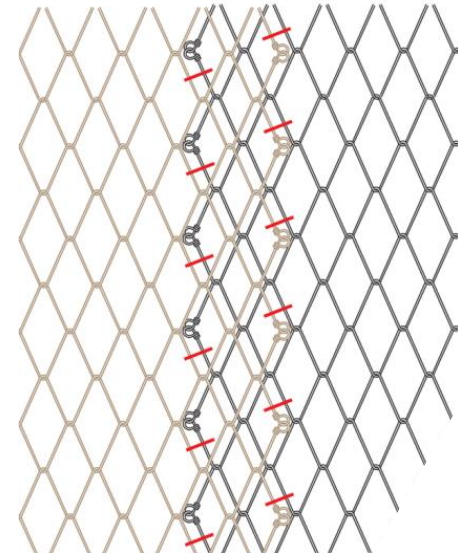
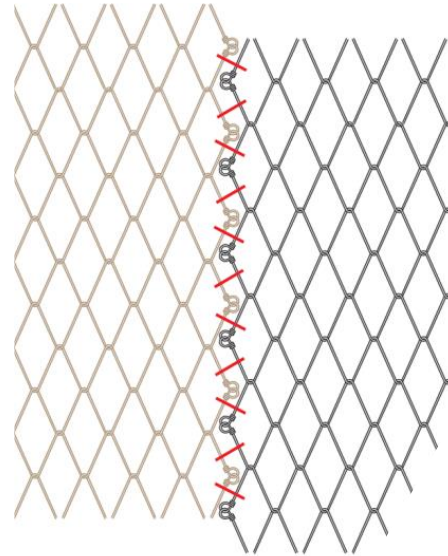
LA CORRETTA POSA IN OPERA



E' importante curare la giunzione tra i teli!
TECCO® G65/2 e G65/3: 1 clip per maglia



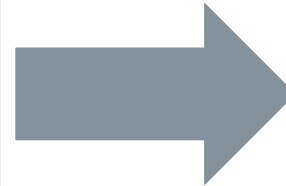
E' importante curare la giunzione tra i teli!
TECCO® G65/4 : 2 clip per maglia



PROTOCOLLO DI VERIFICA

CHECKLIST

☒	_____
☒	_____
☒	_____
☒	_____
☒	_____
☒	_____
☐	_____



Verifica corretto
montaggio

DOMANDE E APPROFONDIMENTI?

