Slope Stabilization with High Tensile Wire Mesh

Geohazards In Transportation In The Appalachian Region Conference

Asheville, North Carolina

Frank Amend, PE
Geobrugg North America, LLC.
Rocky Mount, North Carolina

Overview

- Introduction
- The TECCO® System
- Elements of the system
- Dimensioning concept
- Installation / Durability
- Sample Projects

Slope failure above foot wall

Slope failure above unsuccesfull barrier

Conventional solutions

Unsuccessful slope stabilization

Unsuccessful shotcrete facing

Unsuccessful, approx. 10 years old shotcrete facing, replaced by a green solution with wire mesh cover.

Unsuccessful Geogrid

Failure of soft Geogrid facing due to:

- Creeping effects
- Cutting of grid at sharp edges
- Overload

Replacement of old flexible solution

In case of high static stress:

Replacing the standard mesh or shotcrete by TECCO®

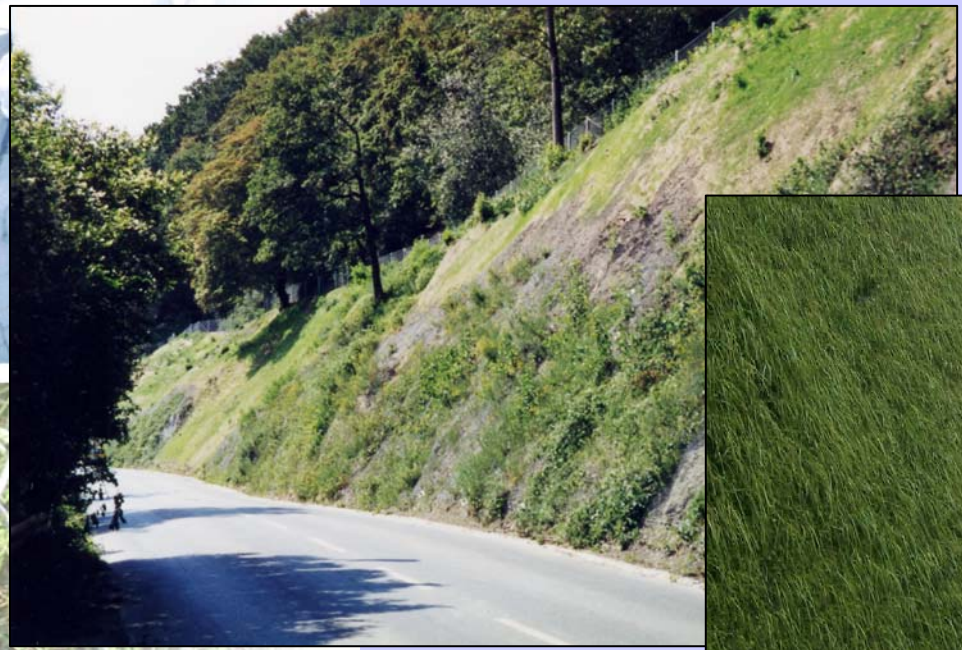
Advantages of TECCO®

- Combination of traditional rock/soil nailing with tensioned high performance wire mesh providing stability in the surface layer
- Active slope stabilization and rockfall prevention
- Alternative To Conventional Methods With Shotcrete, Geogrid, Retaining Structures
- Solving problems when standard mesh is inappropriate

The TECCO® System

The TECCO® system can be applied at rock, weathered rock and loose soils

Brot-Dessous – Rochfort, Switzerland



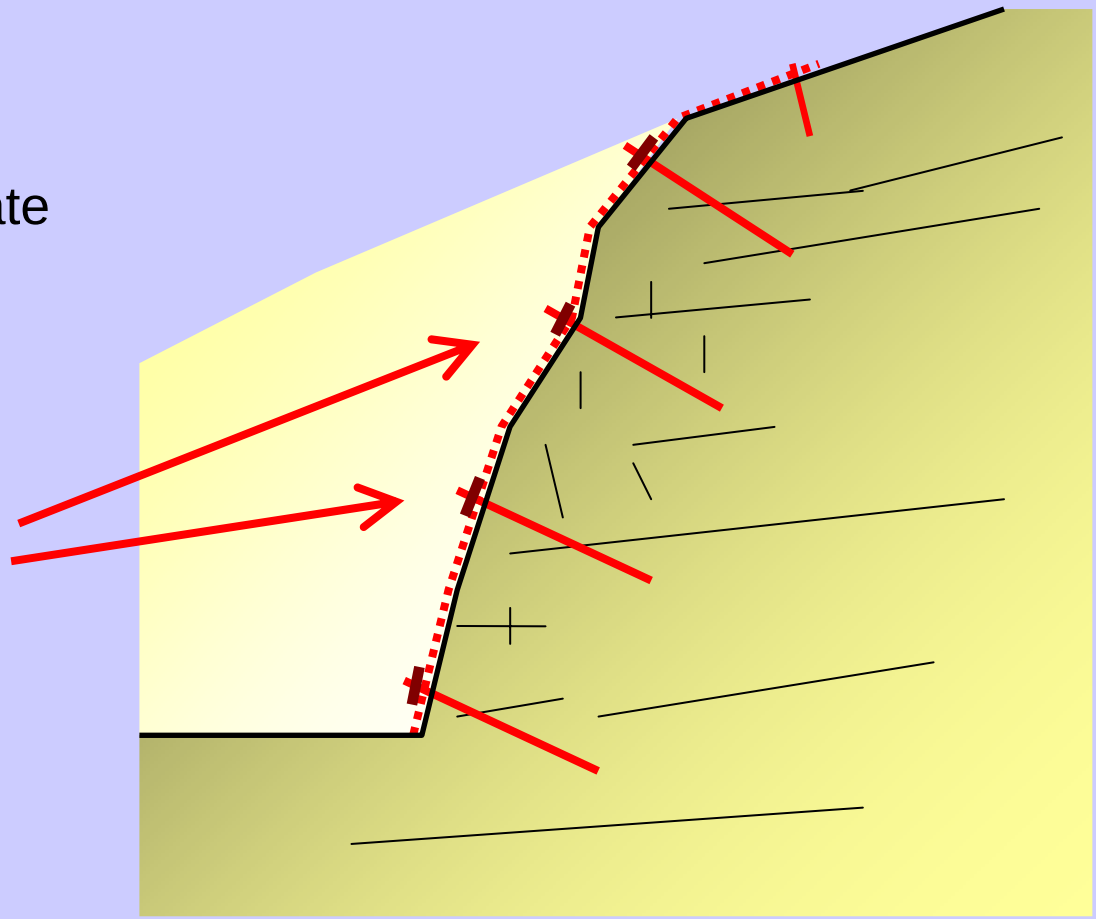
Mühlheim, Germany

Hundwil, Appenzell

Overview TECCO® Components

The Main Components:

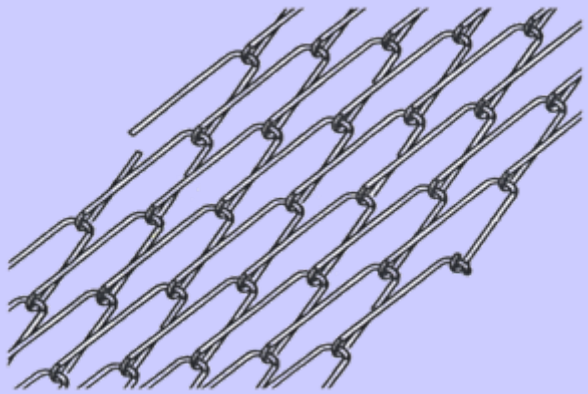
- Rock or soil nail
- TECCO® mesh
- System spike plate



TECCO Components: Mesh

Characteristics of the TECCO® Mesh

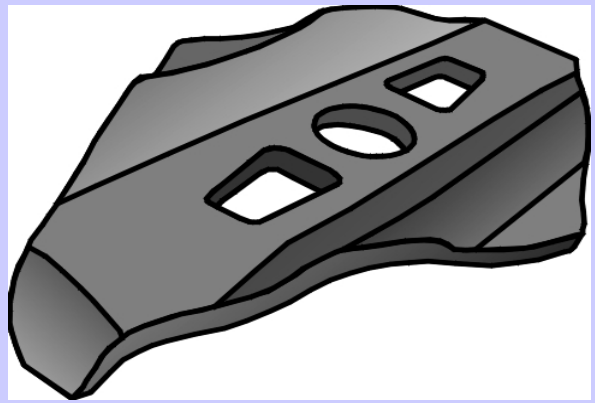
- High-tensile steel wire (> 256 KSI)
- High tensile strength of the mesh (> 10.2 kips/ft)
- Safe force transmission mesh to nail
- Low weight
- Pretensioning of the system possible
- Simple handling
- Special corrosion protection



TECCO Components: Spike Plate

Characteristics of system spike plate

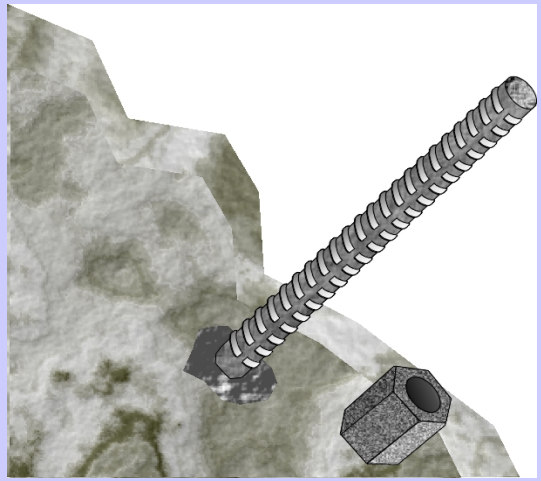
- Diamond shaped
- Specially developed for optimal load transfer
- Ridges for increased stiffness and easy rope connections
- Low weight
- Openings for vegatation



TECCO Components: Anchor

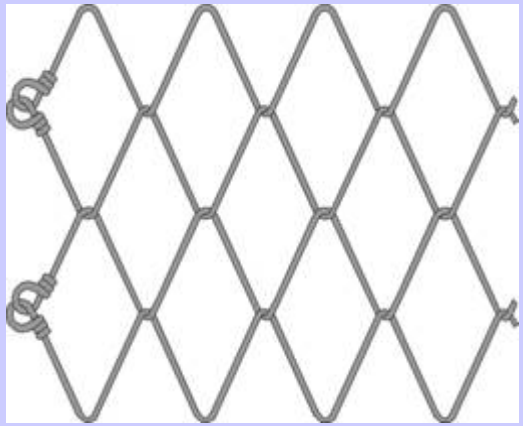
Characteristics of nails

- Standard steel bar anchors (e.g. GEWI, TITAN, Williams, etc.)
- Local products can be used
- Self drilling anchors for weak underground

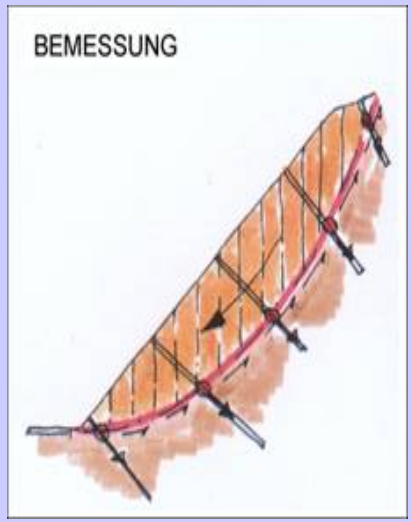


What makes the TECCO® System unique?

- Special wire with extremely high tensile strength for large bearing loads and high resistance to tearing



- Dimensioning software program **RUVOLUM®** based on common geotechnical design principles and the performance of the TECCO® system

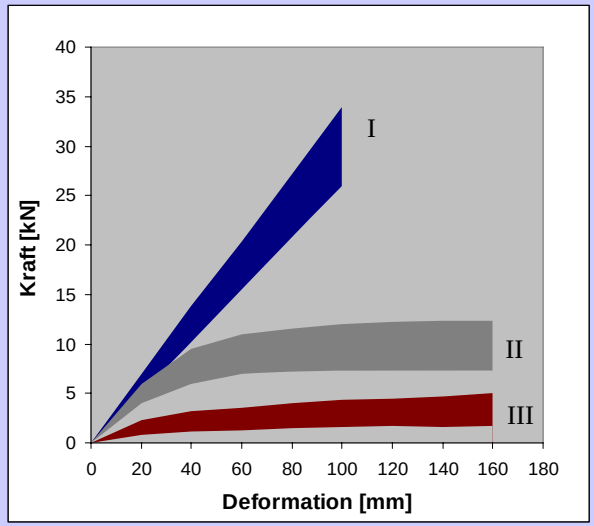


The TECCO® bearing resistance

Bearing Resistance Of
The Tecco® Steel Wire
Of Diameter 3.0 Mm
To Tensile Stress:

Z_w = 2,810 lbs

TECCO Dimensioning - Mesh Properties



- High-tensile steel wire mesh: tensile strength approx. 10.2 kips/ft
- Common steel wire mesh: tensile strength approx. 3 kips /ft
- Geogrid made of pet: tensile strength approx. 2.75 kips/ft

TECCO Performance Approval

- The performance data of the TECCO system has been checked and approved by the LGA

LGA Bautechnik GmbH
International Projects - Materialprüfinstitut

LGA

Test report summary

No. BPI 0400046/1

Your letter dated:
Your ref.: Mr. Andrea Roth
Our ref.: DDBR
Contact: Dr. Peter Brändlein
Telephone: 0049 (0) 9 11/ 6 55-5551

DAP-PL-1524.10

Client: Fatzer AG
Geobrugg Protection Systems
Hofstraße 55
8590 Romanshorn
Switzerland

Project: Slope stabilisation system
TECCO® G 65

Contract: Monitoring and supervision of laboratory testing
incl. writing of test report

Nuremberg, 2004-06-03

This test report summary contains 12 text pages.

test report G 65 2004 summary blanko.DOC / Page 1 of 12
L.G.A. - International Projects - Tillystraße 2 - D-90431 Nuremberg
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Any kind of publication – even as shortened version or as an excerpt requires the prior approval of LGA.

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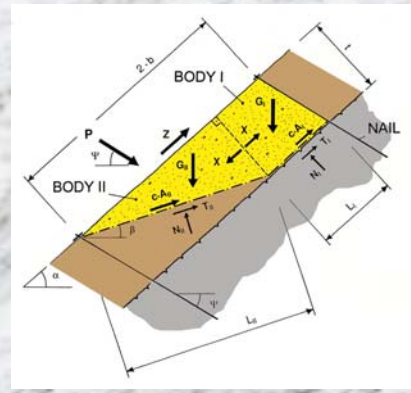
The Dimensioning Concept



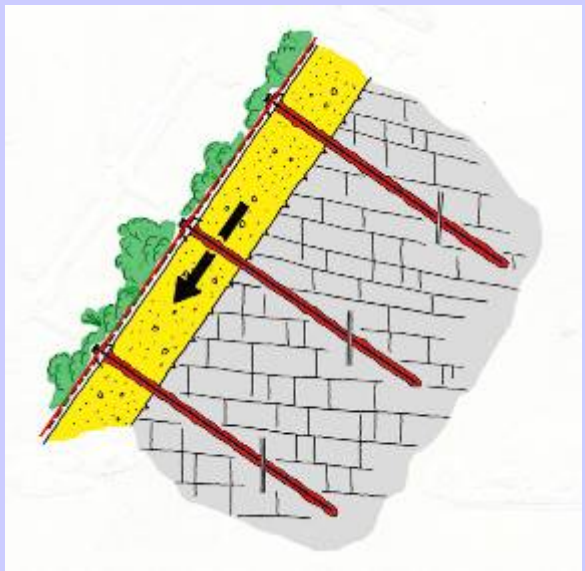
RUVOLUM

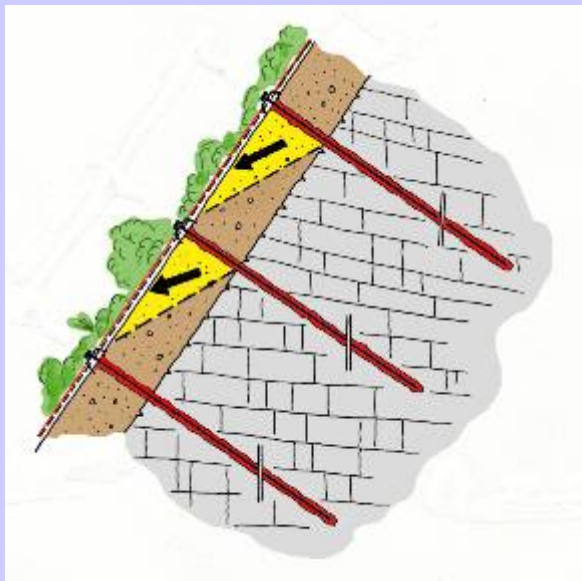
The Dimensioning Concept For Surface Protection Systems

The RUVOLUM Concept

The dimensioning concept comprises two investigations:

1. **Investigation of superficial instabilities parallel to the slope**
2. **Investigation of local instabilities between single nails**

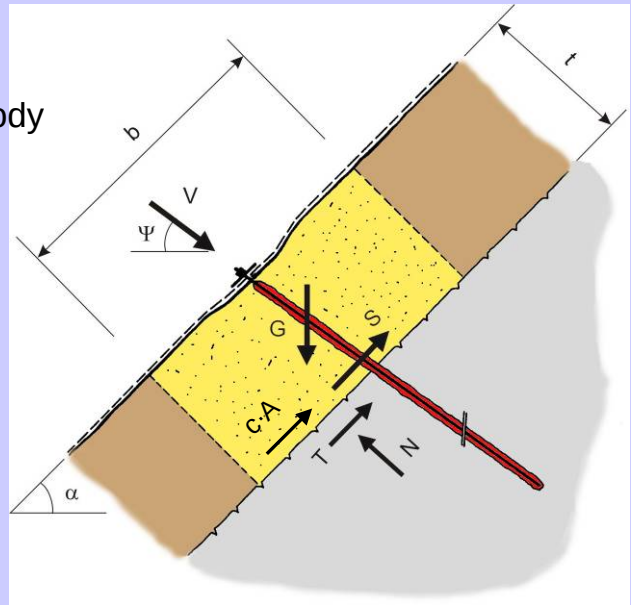


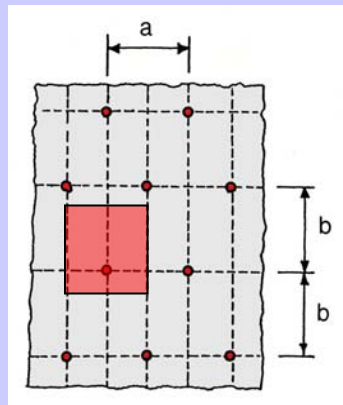


Geotechnical Analysis

Investigation of superficial instabilities parallel to the slope

G = dead weight of sliding body
s = shear force
v = pretensioning force
c · a = cohesion
t, n = reaction forces
α = inclination of the slope
γ_{mod} = model uncertainty factor



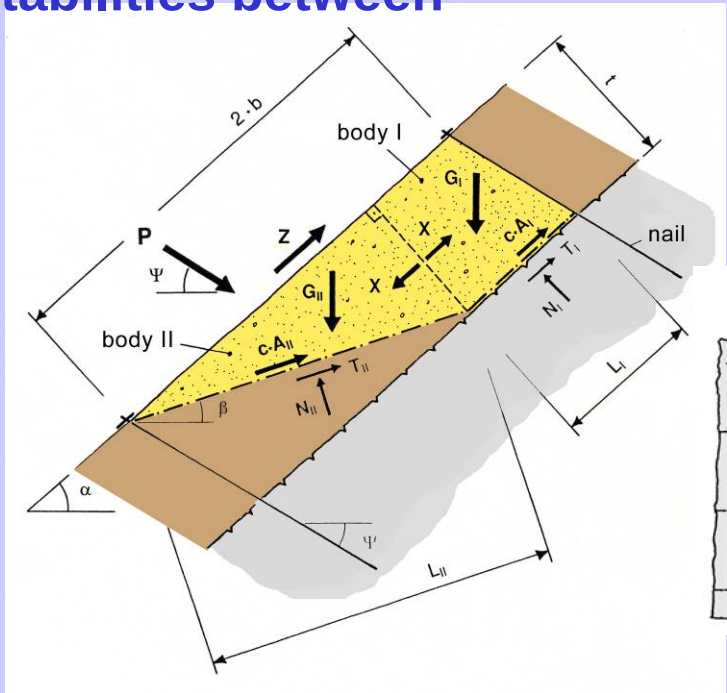


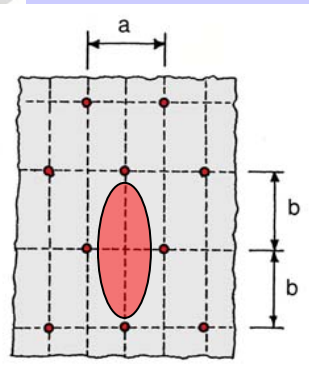
$$S\,[kN] = 1 / \gamma_{mod} \cdot \{\gamma_{mod} \cdot G \cdot \sin\alpha - V \cdot \gamma_{mod} \cdot \cos(\Psi+\alpha) - c \cdot A - [G \cdot \cos\alpha + V \cdot \sin(\Psi+\alpha)] \cdot \tan\varphi\}$$

Geotechnical Analysis

Investigation of local instabilities between the single nails

X = contact force
z = force parallel to slope
p = stabilizing force
g = dead weight of sliding body
c · a = cohesion
t, n = reaction forces
α = inclination of the slope
γ_{mod} = model uncertainty factor

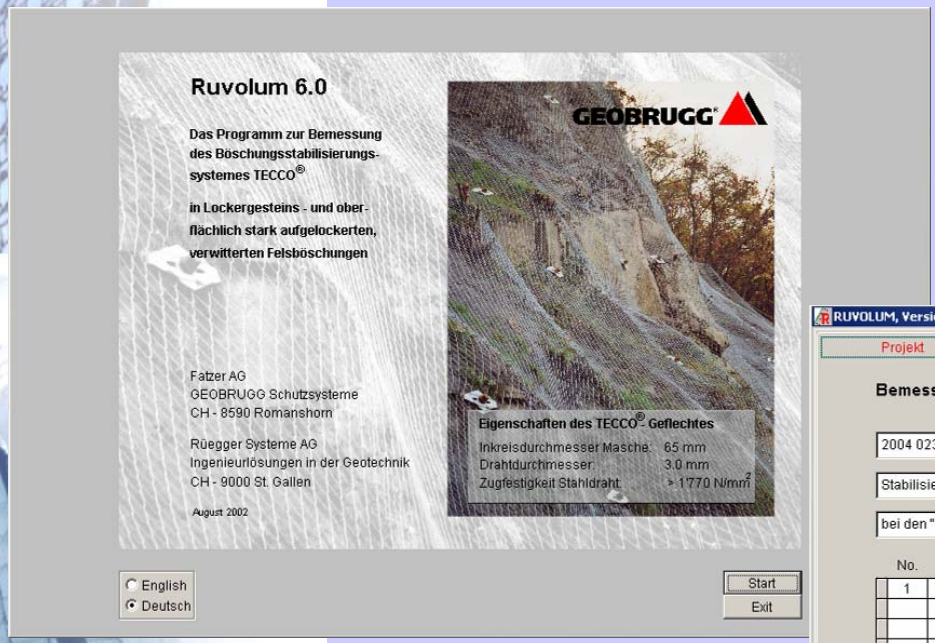




$$P\,[kN] = \frac{G_{II} \cdot [\gamma_{mod} \cdot \sin\beta - \cos\beta \cdot \tan\varphi] + (X-Z) \cdot [\gamma_{mod} \cdot \cos(\alpha-\beta) - \sin(\alpha-\beta) \cdot \tan\varphi] - c \cdot A_{II}}{\gamma_{mod} \cdot \cos(\beta + \Psi) + \sin(\beta + \Psi) \cdot \tan\varphi}$$

$$X\,[kN] = 1 / \gamma_{mod} \cdot \{ G_I \cdot (\gamma_{mod} \cdot \sin\alpha - \cos\alpha \cdot \tan\varphi) - c \cdot A_I \}$$

The RUVOLUM® Design Concept



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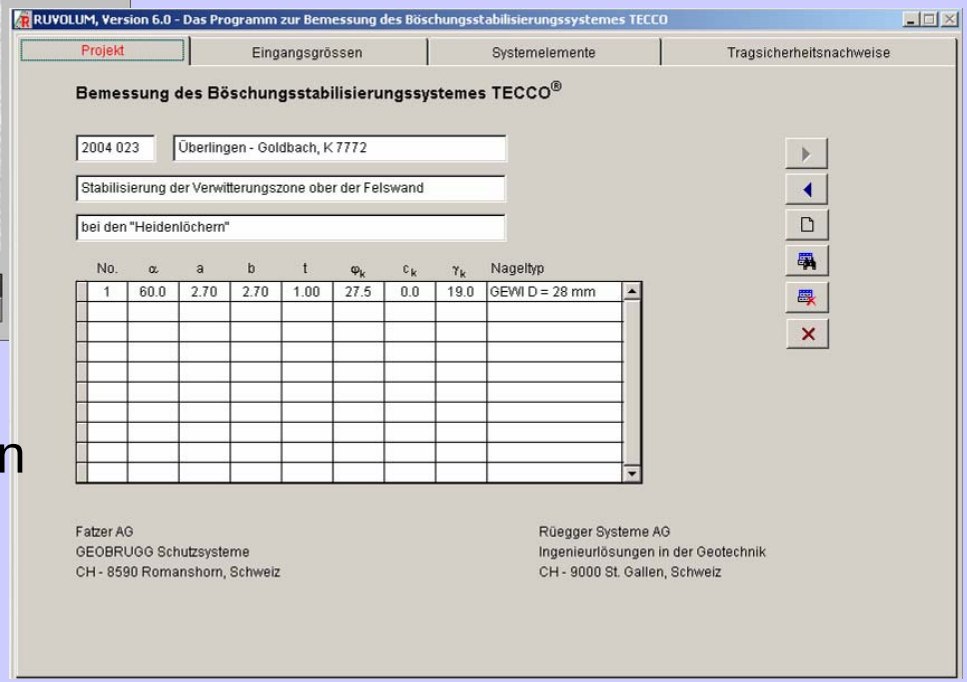


The RUVOLUM Concept has been checked and approved by:

Prof. Dr. Wichter of the University of Cottbus, Germany

The RUVOLUM® Design Concept

RUVOLUM, version 6.0 - The program to dimension the slope stabilization system TECCO

Project | Input quantities | Elements of the system | Proofs of bearing safety

Project: 051123 1 / 1

Inputs

Slope inclination	α =	60.0	degrees
Nail distance horizontal	a =	2.80	m
Nail distance in line of slope	b =	2.80	m
Layer thickness	t =	1.00	m
Radius of pressure cone, top	ζ =	0.15	m
Inclination of pressure cone to horizontal	δ =	45.0	degrees
Friction angle ground (characteristic value)	φ_k =	32.5	degrees
Cohesion ground (characteristic value)	c_k =	0.0	kN / m^2
Volume weight ground (characteristic value)	γ_k =	20.0	kN / m^3
Slope-parallel force	Z_d =	15.0	kN
Pretensioning force of the system	V =	50	kN
Nail inclination to horizontal	Ψ =	20.0	degrees
Parial safety correction value for friction angle	γ_φ =	1.25	[-]
Parial safety correction value for cohesion	γ_c =	1.60	[-]
Parial safety correction value for volume weight	γ_γ =	1.00	[-]
Model uncertainty correction value	γ_{mod} =	1.10	[-]

About nailing

- Variation a = b
- GEWI D = 28 mm
- with rusting away

Dimensioning quantities

φ_d [degrees] =	27	
c_d [kN / m^2] =	0	
γ_d [kN / m^3] =	20	

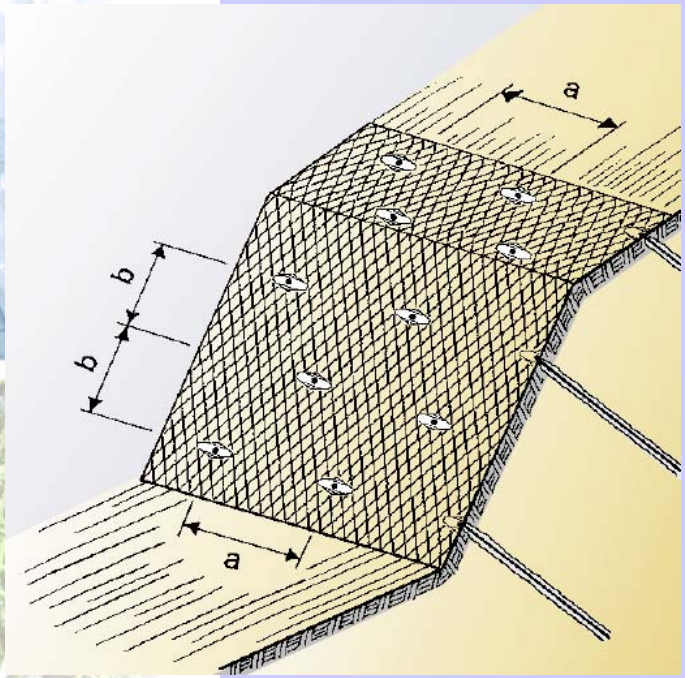
Proofs of the nail o.k

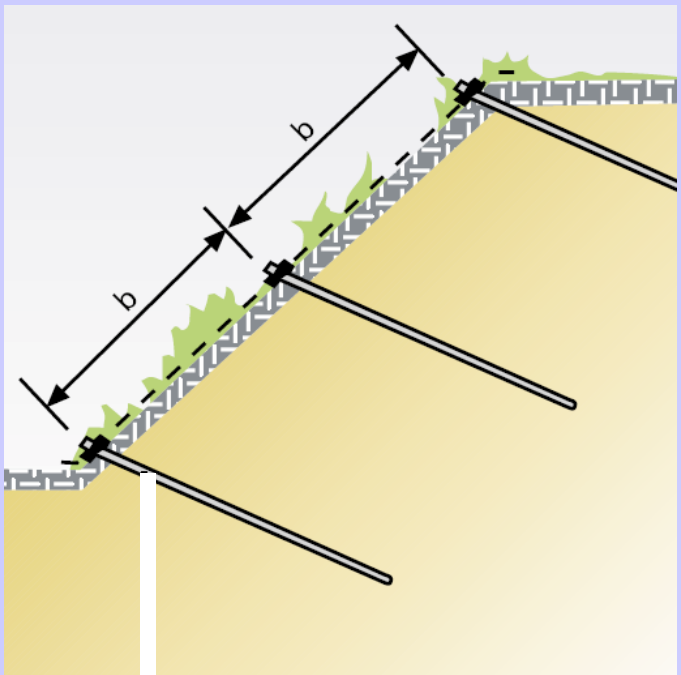
Proofs of the mesh o.k

The Dimensioning Concept

- Definition of slope condition
- Selection of nail type, nail angle

➔ Determining max. possible nail pattern (distances a & b)

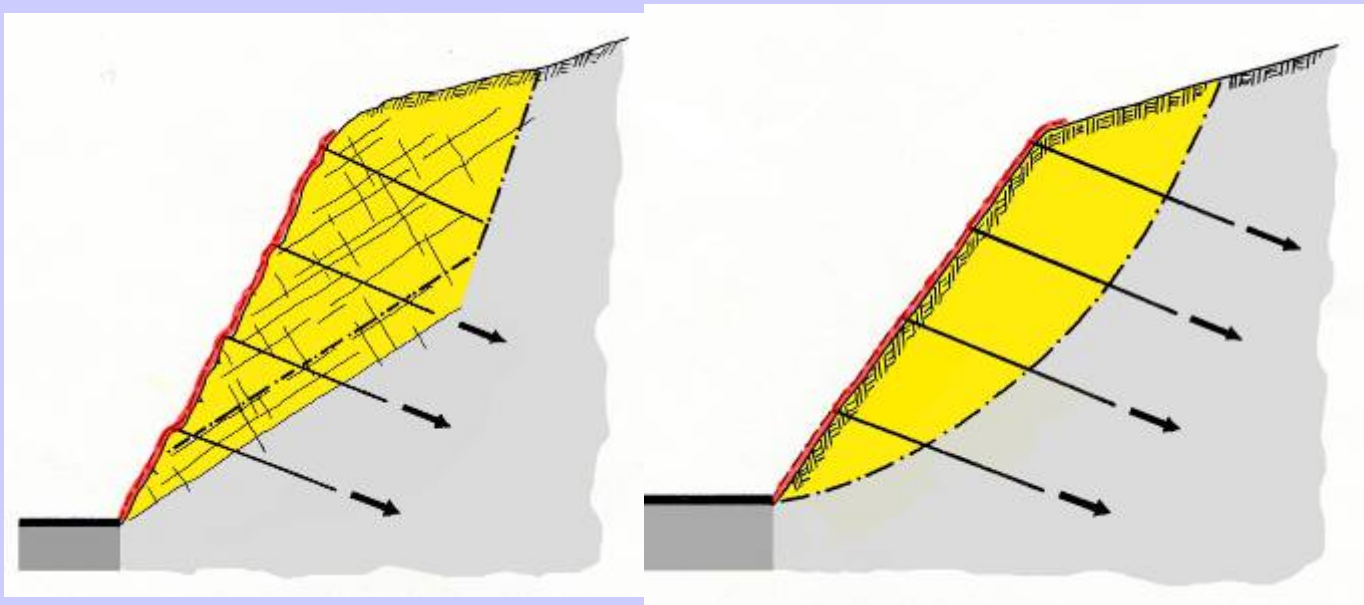




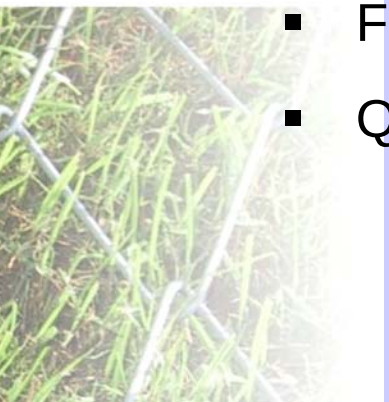
The Dimensioning Concept

Additionally to the investigations of superficial instabilities:

Proof of the terrain‘s resistance (deep sliding surfaces), using common methods to investigate the global stability (e.g. bishop)







TECCO System

Main Advantages

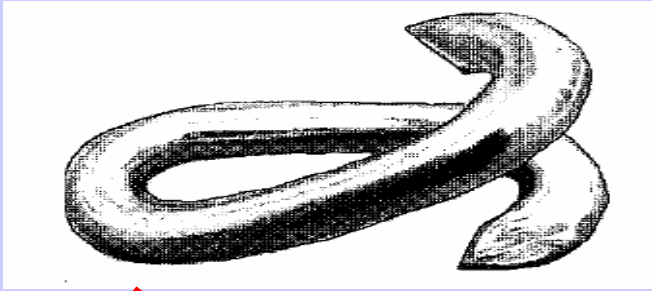
- Increased anchor grid, due to high performance mesh (less drilling works)
- Maintenance free after installation
- Low visability
- Insensitive to small creepings, movements
- Greenable by hydroseeding / greening mats
- Fully designable
- Quick and easy installation

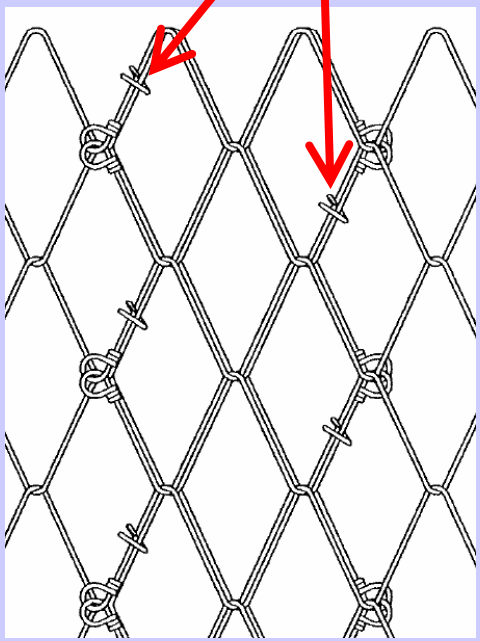
Installation - Anchoring

- No major earth movements necessary: minor preparation of slope
- Determine location of anchor points, taking into account required grid and low points in the slope
- Drilling anchor holes in difficult slopes possible by new drilling technology and drilling equipment.
- Installation and grouting of anchors (nails)

Installation - Panel Layout

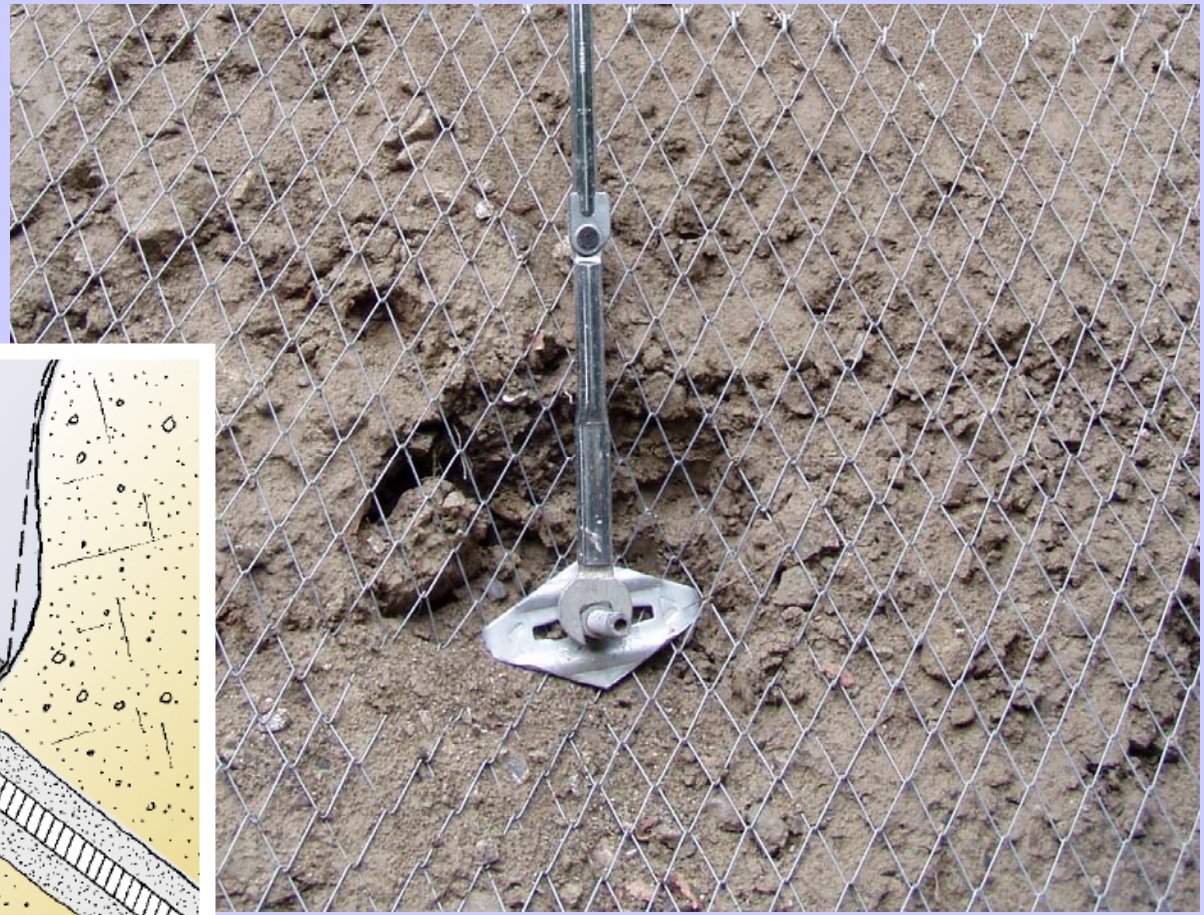
Installation - Panel Connections

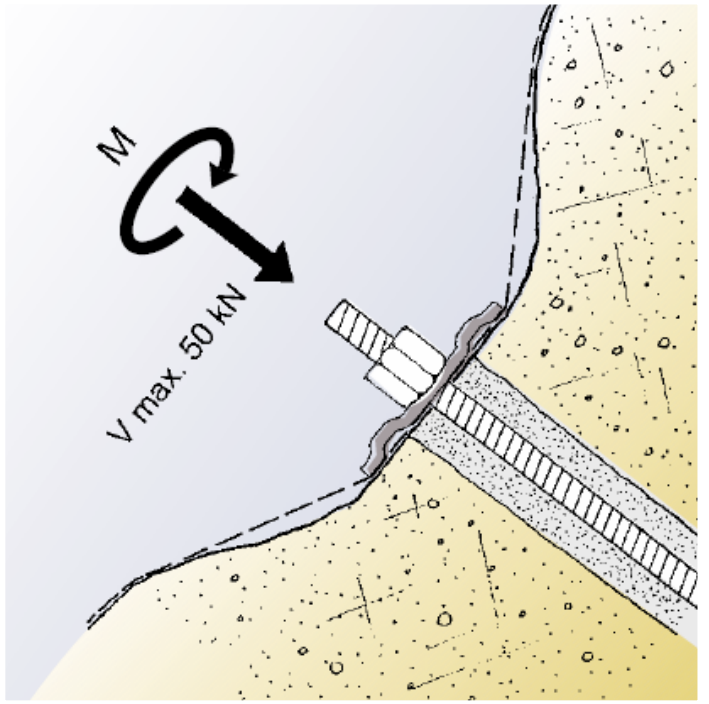




Installation – Panel Connection

Installation – Pre-tensioning

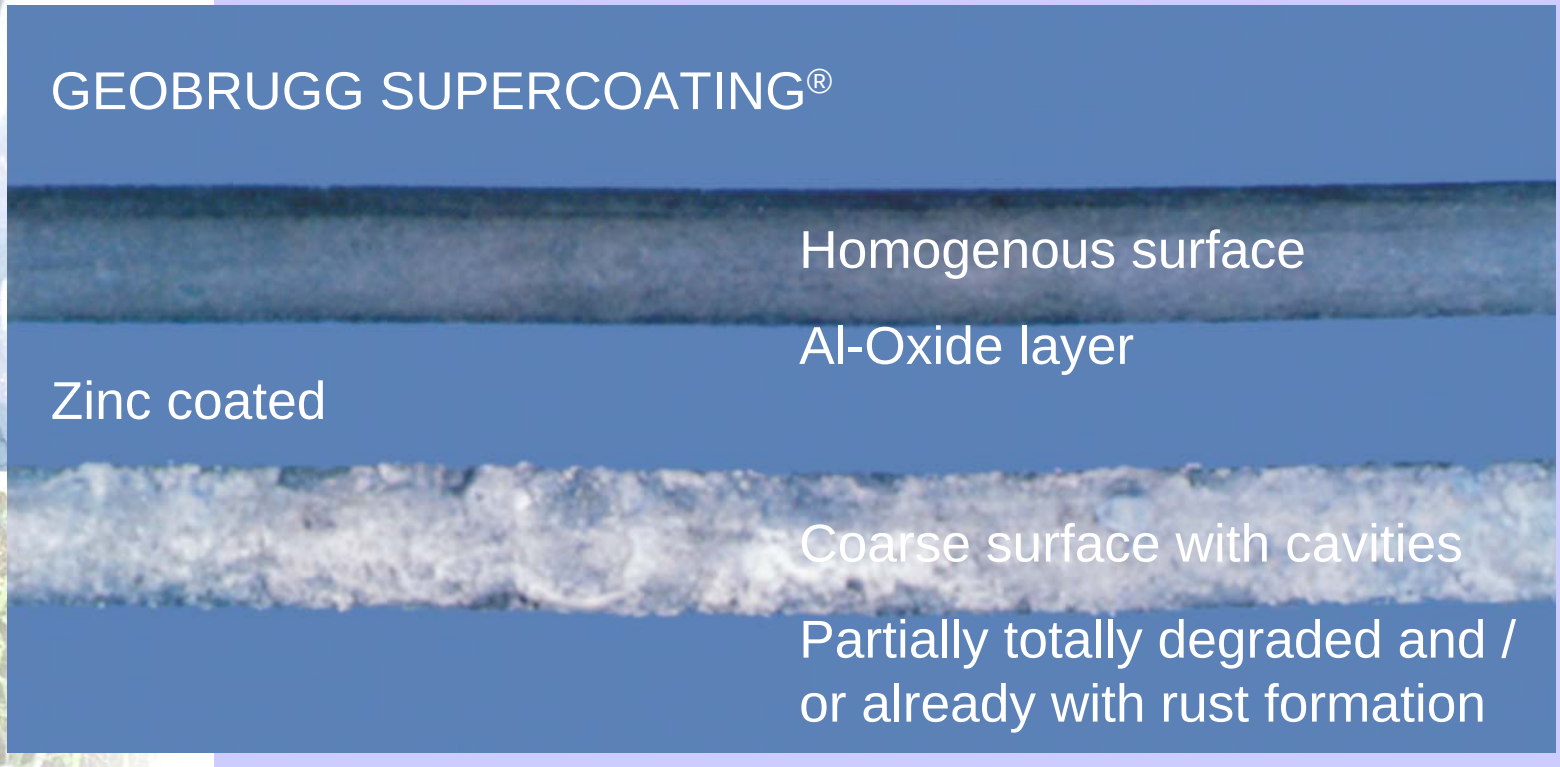




Installation – Border Connection

Corrosion Protection

After corrosion testing



Applications – Slope Stabilization

Applications – Slope Stabilization (cont'd)

Applications - Roadways

Applications - Roadways

Applications - Roadways

Applications - Roadways

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Applications – Temporary Shoring

Applications – Temporary Shoring

Applications – Streambed Scour?

Applications – Existing Stone or MSE Walls

Applications - Stabilizing River Banks

Palena River, Italy

Questions ???