Welcome

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The Full Scale Mechanics of Surficial Slope Stabilization

Bob Lyne
Geobrugg North America, LLC
Regional Manager – SE USA

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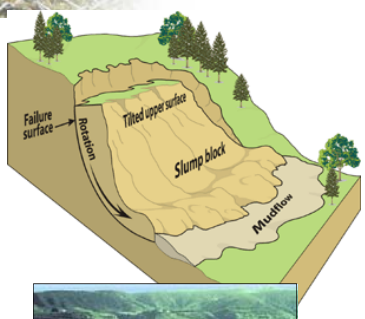
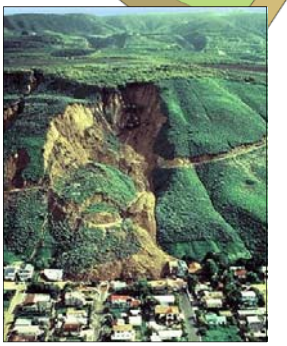
Overview of content

1. Slope stabilization options
2. The anchored mesh system
3. Full scale testing
4. Results of full scale testing





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Slope Stabilization

Stability problems can occur as a result of

- Hillside water, saturation, water pressure in critical joints
- Stratification / joints unfavorably orientated
- Erosion
- Change of slope geometry
- Extraordinary effects (earthquake, etc.)
- External loads (traffic, etc.)
- Installed solutions, not properly designed for the conditions

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Stability problems: Soil slope failure

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Stability problems: Disadvantageous stratification

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Stability problems: Stability problems downslope

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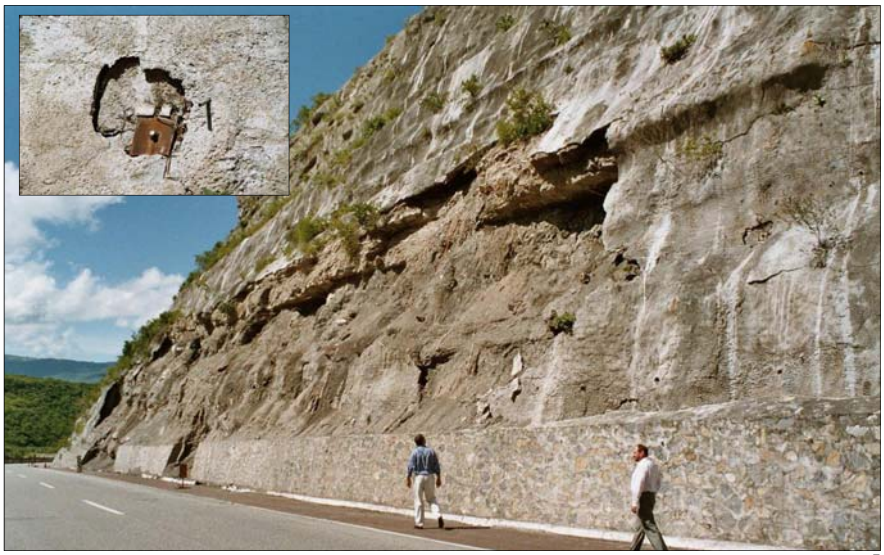
Hard facing: Shotcrete



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Hard facing: Shotcrete

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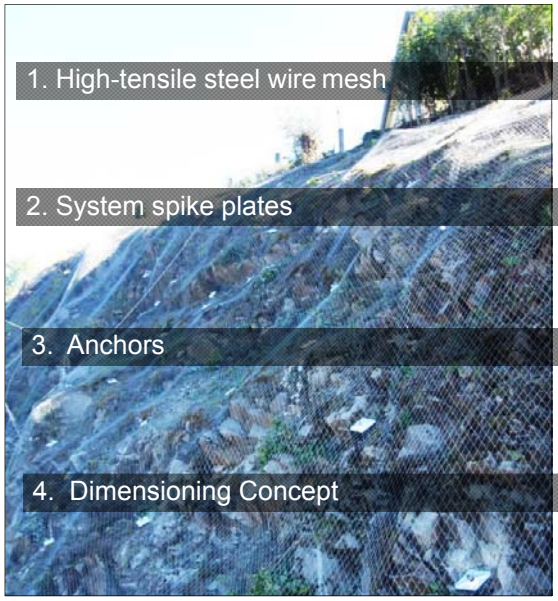
Soft facing: Geotextiles

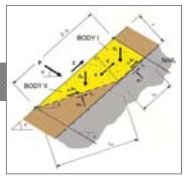
- Facing has no static function
- No noteworthy force transmission possible

Flexible Facing - Mild steel mesh

The anchored mesh system



1. High-tensile steel wire mesh
2. System spike plates
3. Anchors
4. Dimensioning Concept



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High tensile wire mesh

High-tensile steel wire: **<u>> 256 ksi</u>**

- 2mm wire → 1,200 lbs.
- 3mm wire → 2,800 lbs.
- 4mm wire → 4,900 lbs.

DTWM (3mm) → ~ 800 lbs.

Extraordinary Load Transfer

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The dimensioning concept (surficial instabilities)

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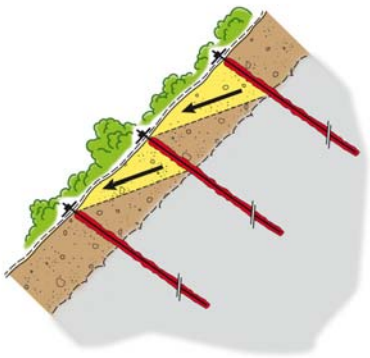
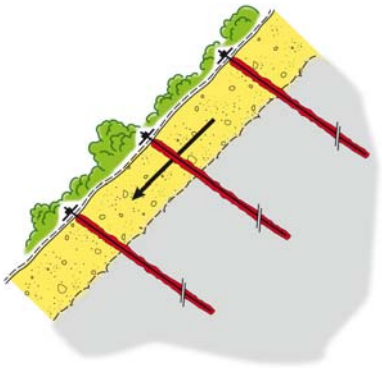
The dimensioning concept comprises two investigations

1. Investigation of local instabilities between single nails
2. Investigation of slope-parallel, superficial instabilities





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Small scale tests

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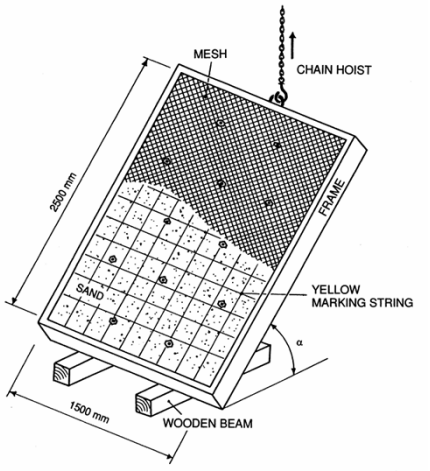

Anchored mesh system examples

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Highway 101 – near Garberville, CA

Anchored mesh system examples

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Hana Highway – Maui, HI

The anchored mesh system in comparison with shotcrete

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Advantages of the anchored mesh system

- cost effective solution
- natural appearance, allows revegetation
- a range of meshes and plates allow application to a wide variety of slope conditions
- provides effective static load transfer
- can be fully dimensioned with a design tool

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Anchored mesh system achievements

- **Public clients:** DOTs, FHWA, and others
- **Private clients:** Railroads, hydro facilities, mines, commercial, residential
- **Applications:** Soil, rock, erosion, temporary shoring
- > **6 million ft²** installed in North America
- **The system has been very successful, but …**

Full scale testing

The Giant Sandbox!

Full scale testing

Test Program Details:

- 40’ (12m) x 33’ (10m) x 4’ (1.2m)
- Instrumented anchor bars
- Load cells in boundary ropes
- Multiple soil types – rounded gravel (ϕ=33°), crushed gravel (ϕ=38°)
- Variable slope angle from 0° to 85°
- Multiple meshes and anchor plates
- ***Laser scanning to measure displacement***

Full scale testing

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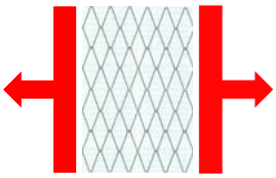
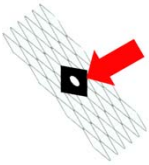
Strength properties of mesh

- Longitudinal

- Transverse

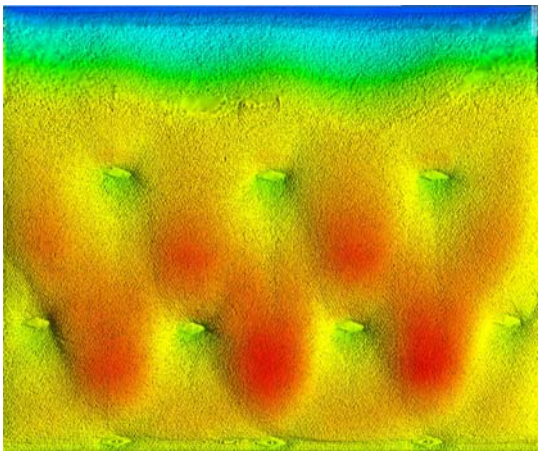


- Punching



- Mesh-plate interaction

Analysis of real sliding mechanisms



Standard duty mesh
(3mm diameter wire)

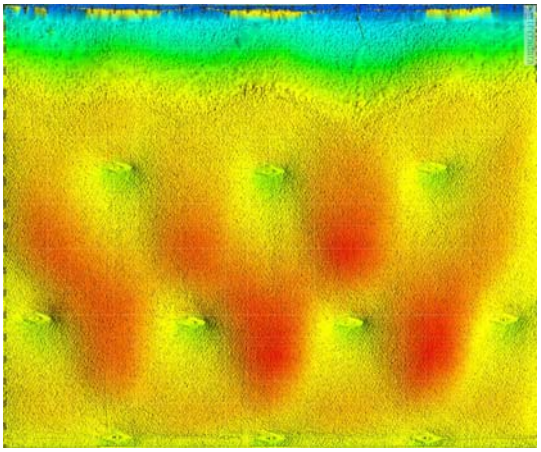
a = b = 11.5' (3.5m)

Rounded gravel

Grain size 16 - 32 mm

α = 60°

Analysis of real sliding mechanisms



Heavy duty mesh
(4mm diameter wire)

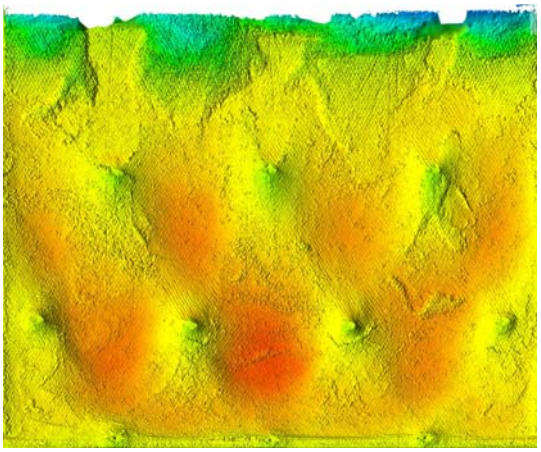
a = b = 11.5’ (3.5m)

Rounded gravel

Grain size 16 - 32 mm

α = 60°

Analysis of real sliding mechanisms



Heavy duty mesh
(4mm diameter wire)

a = b = 11.5’ (3.5 m)

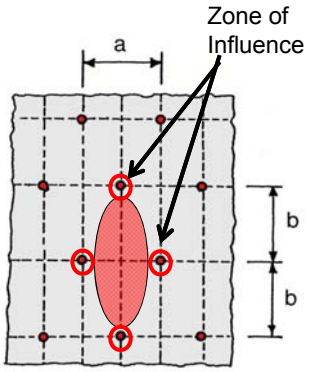
Crushed gravel

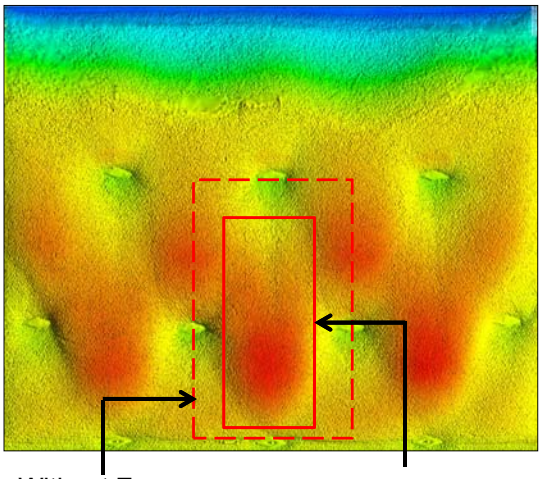
Grain size 0 - 63 mm

α = 60°

What we learned from the Full-Scale Test

- Dimensioning concept validated

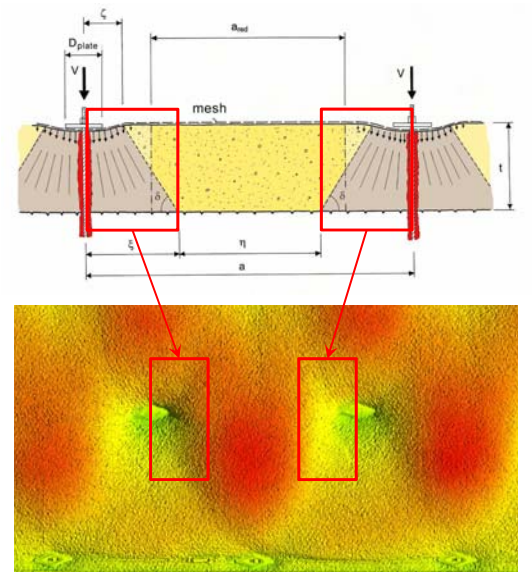




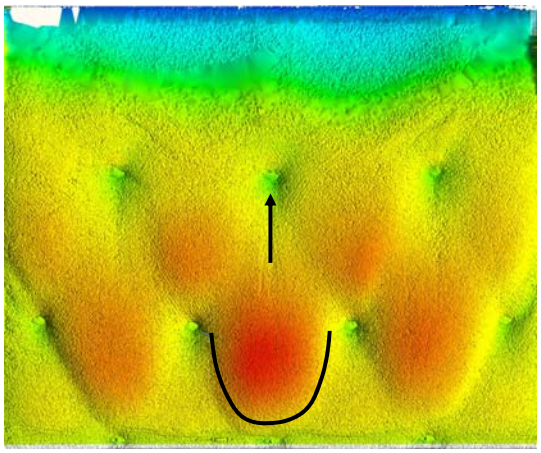
Without Zone of Lateral Influence

With Zone of Lateral Influence

Proof of lateral influence of pressure cones

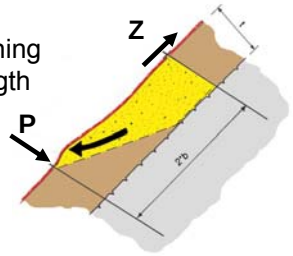


Analysis of load transfer within system



Slope Parallel Strength

Punching Strength



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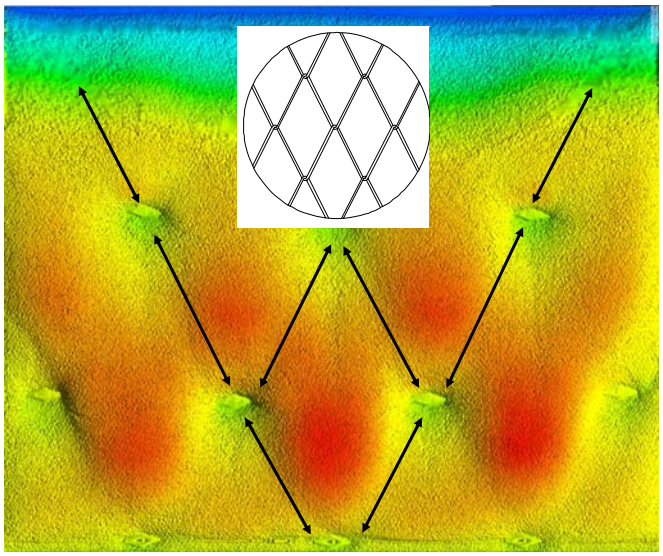

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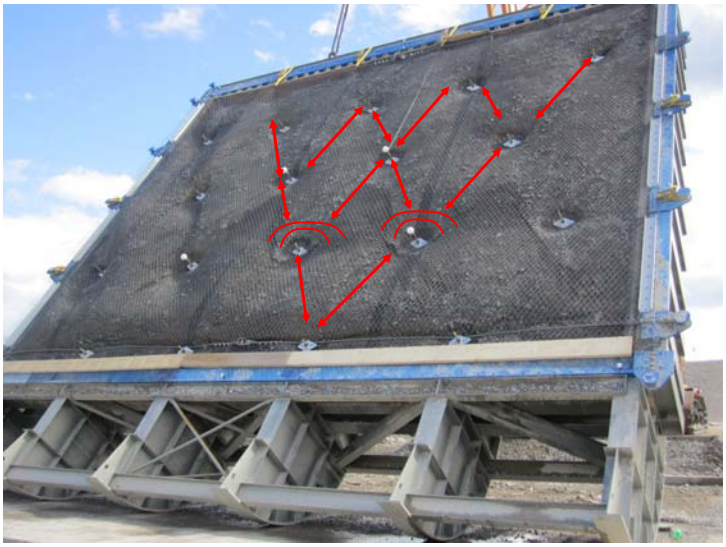
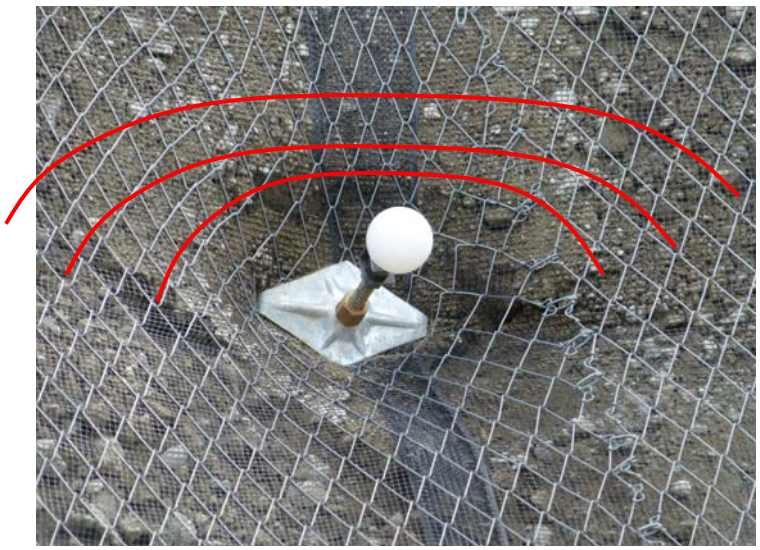
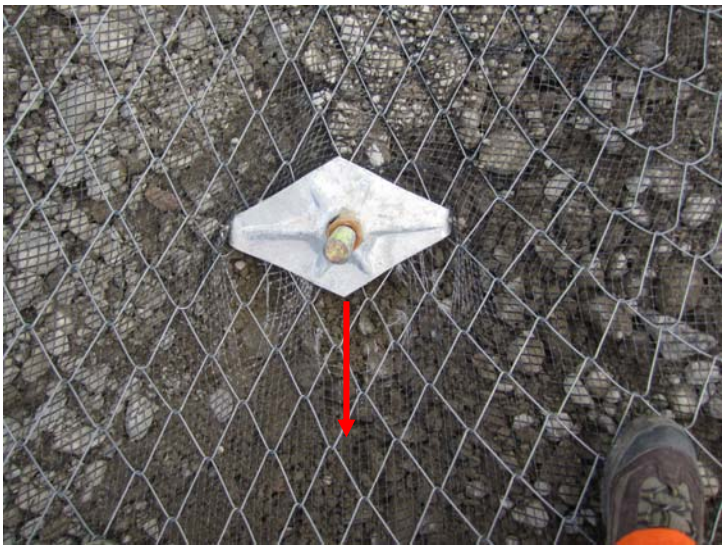


Analysis of load transfer within system



Analysis of load transfer within system



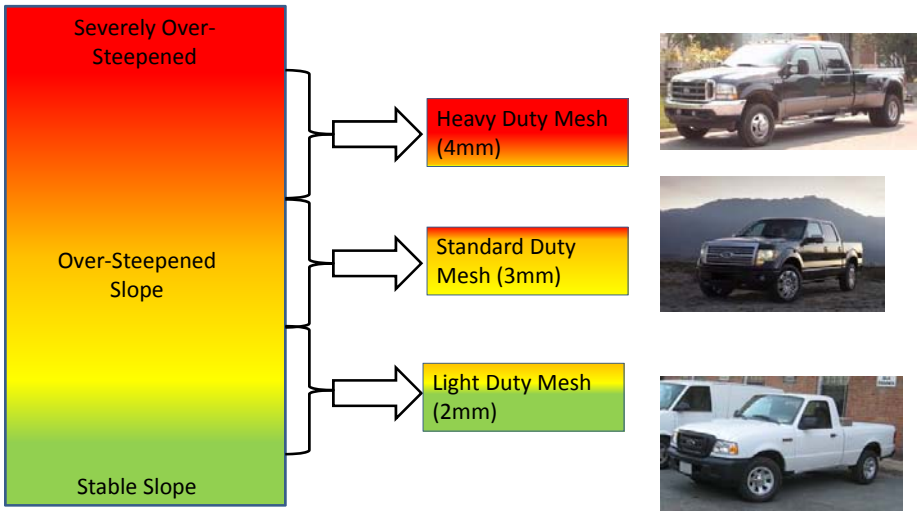
Comparison of the different slope stabilization systems

Comparison

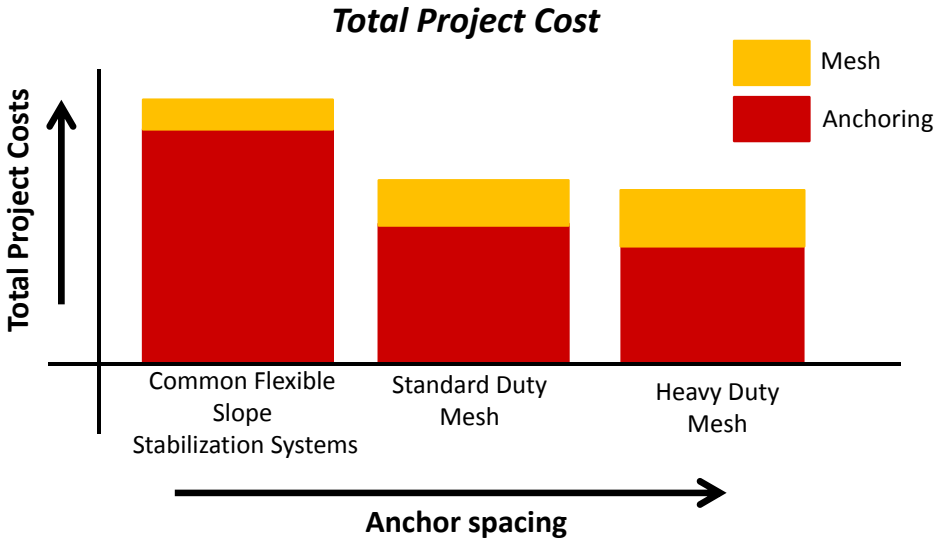
	Light Duty Mesh (2mm)	Standard Duty Mesh (3mm)		Heavy Duty Mesh (4mm)	
	Small spike plate	Small spike plate	Large spike plate	Small spike plate	Large spike plate
Friction angle [°]	33	33	33	33	33
Design level inclination [°]	42	51	55	56	60
Stabilized angle [°]	9	18	22	23	27

Load Transfer and Stabilized Angle

Mesh options



Cost Optimization



Critical load transfer

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Load transfer in a surficial stabilization system

Slope → Facing → Spike plate → Anchor → Stable subsoil

The critical load transfer occurs at the *Wire-Plate Interface*

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Strength properties of mesh

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- Longitudinal

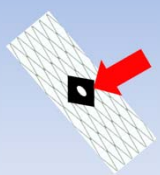
Not relevant to system performance: → Evenly distributed loads do not occur on slopes

- Transverse

Not relevant to system performance: → Gravity

The critical mesh characteristics for dimensioning and performance:

- Punching



- Mesh-plate interaction

Results

What did we learn?	Why is it important to you?
• Dimensioning concept validated →	• *Design with confidence*
• Multiple meshes and plates →	• *Stabilize more slopes, optimize costs*
• Load transfer ability of mesh determines system performance →	• *Accurately predict performance of any facing type*