The Full Scale Mechanics of Surficial Slope Stabilization

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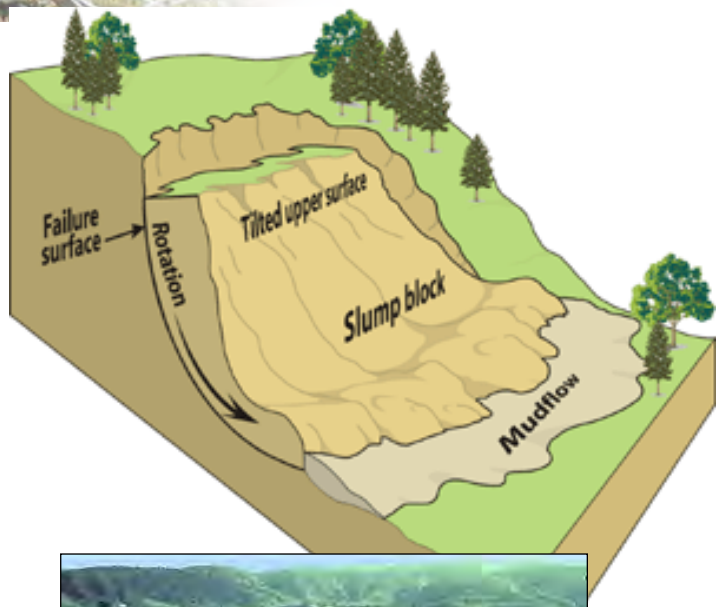
Overview of content

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



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

Stability problems: Soil slope failure

Stability problems: Disadvantageous stratification

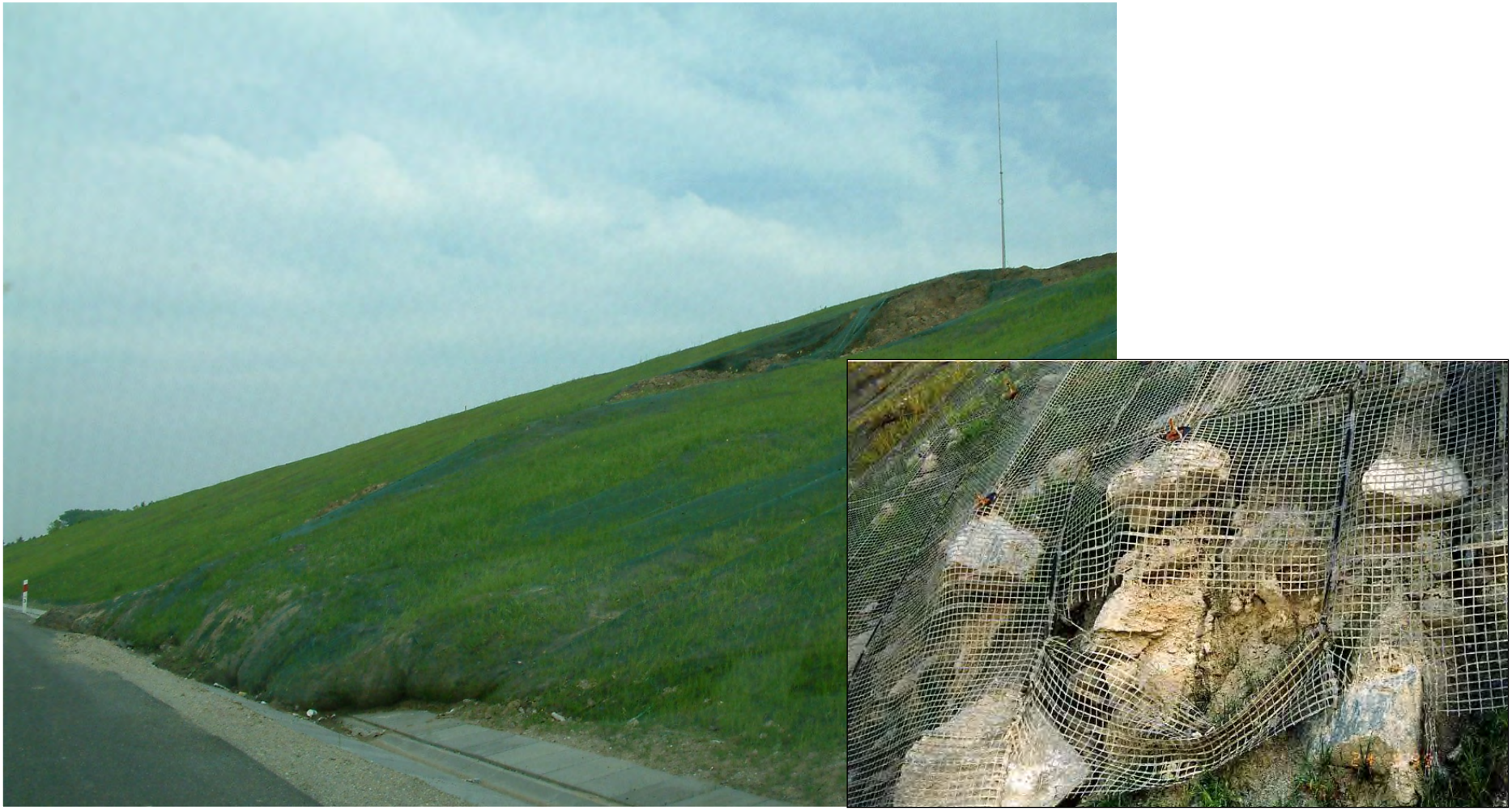
Stability problems: Stability problems downslope

Hard facing: Shotcrete

Hard facing: Shotcrete

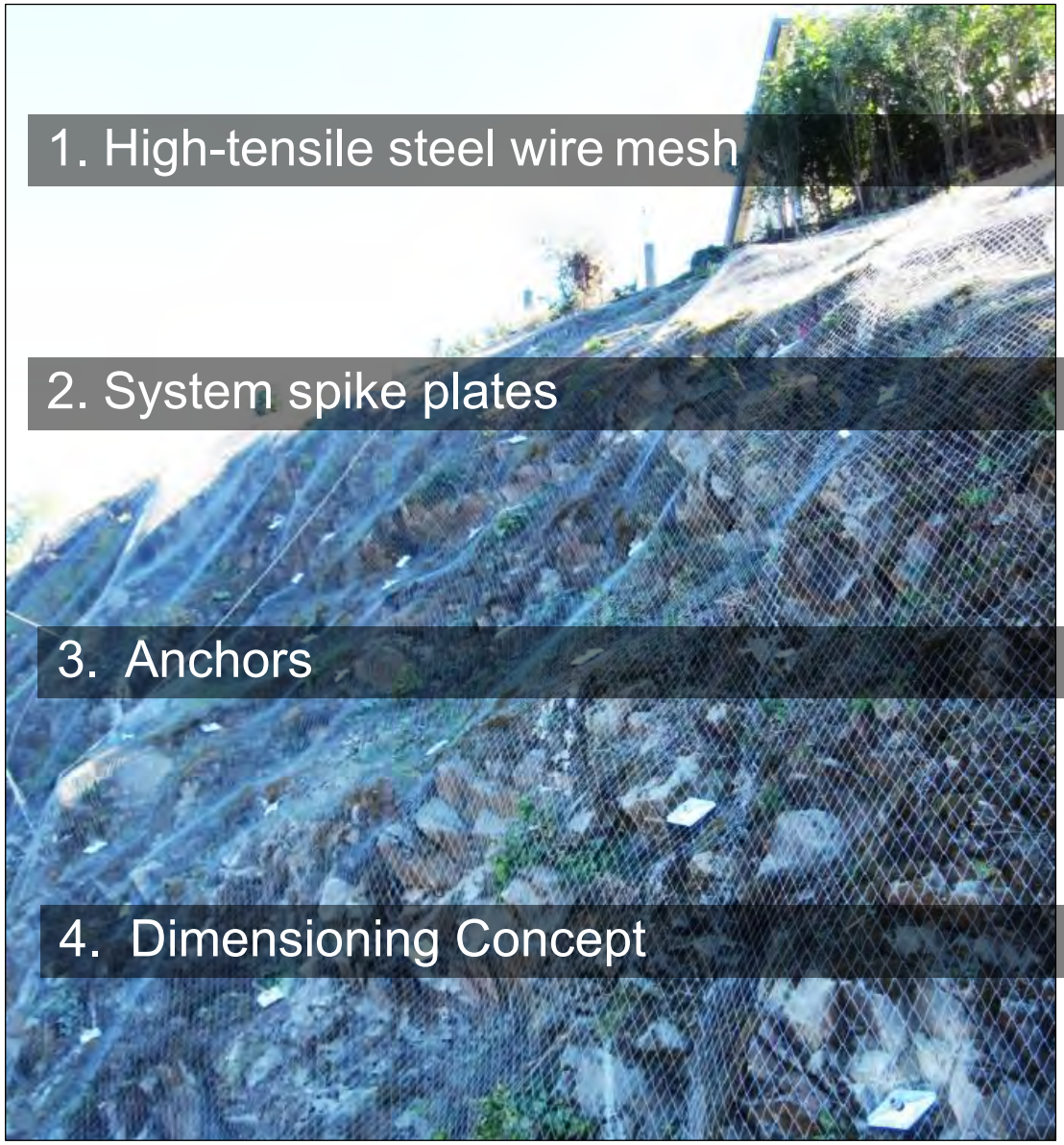
Soft facing: Geotextiles

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



Flexible Facing - Mild steel mesh

The anchored mesh system

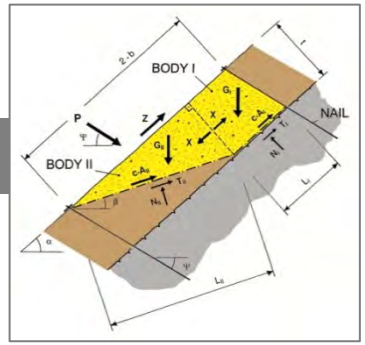


1. High-tensile steel wire mesh

2. System spike plates

3. Anchors

4. Dimensioning Concept



High tensile wire mesh

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

Extraordinary Load Transfer

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

DTWM (3mm) → ~ 800 lbs.

The dimensioning concept (surficial instabilities)

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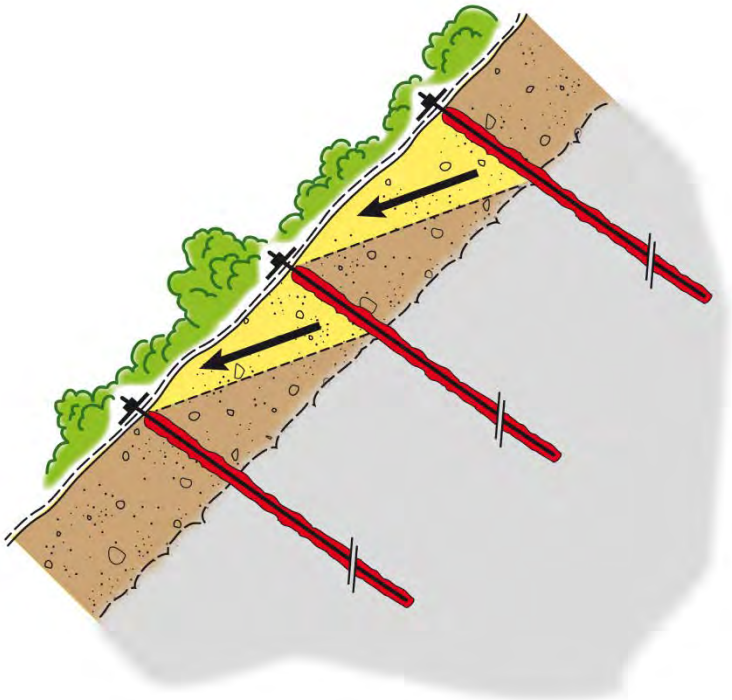
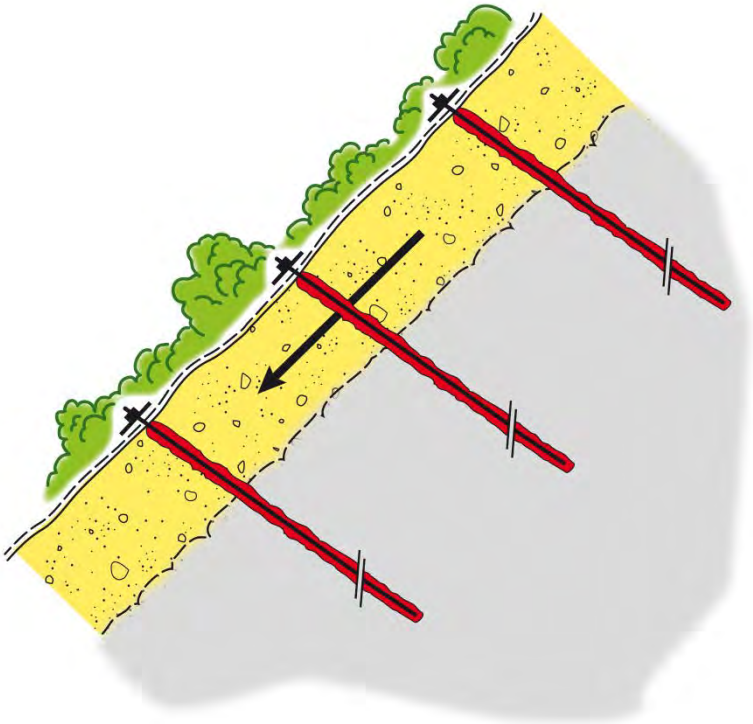
The dimensioning concept comprises two investigations

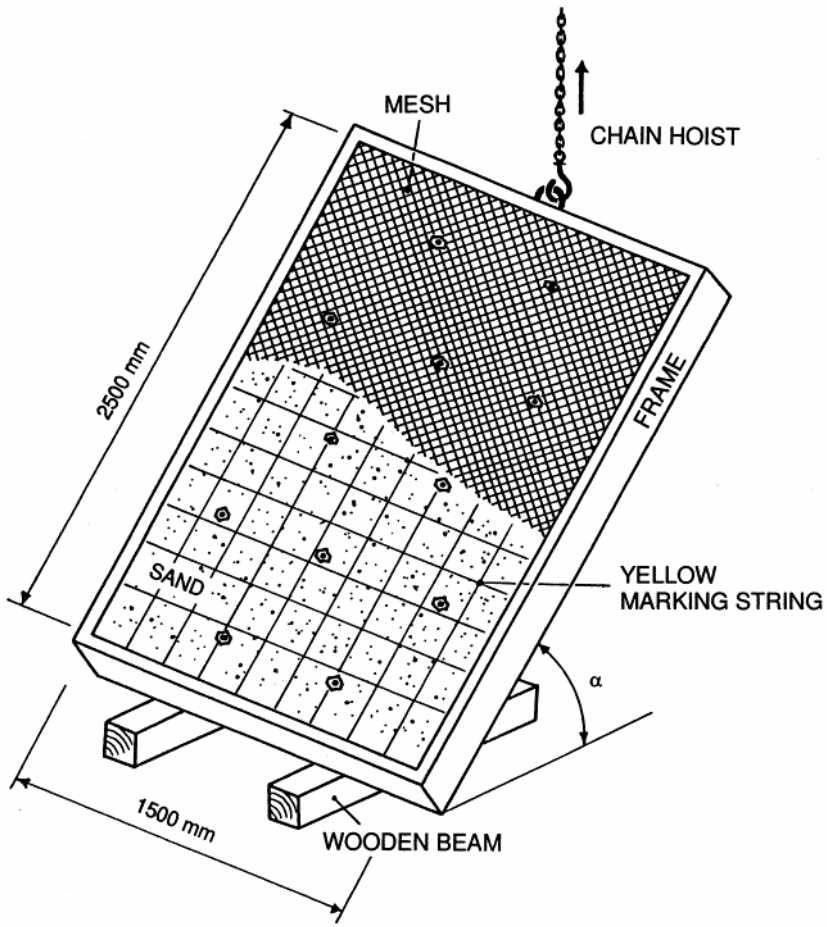
1. Investigation of local instabilities between single nails



2. Investigation of slope-parallel, superficial instabilities



Small scale tests



Anchored mesh system examples

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Highway 101 – near Garberville, CA

Anchored mesh system examples

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The anchored mesh system in comparison with shotcrete

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West Virginia -- parking lot behind a Walmart

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

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 ft^2** installed in North America

- **The system has been very successful, but …**

The Giant Sandbox!

Full scale testing

Test Program Details:

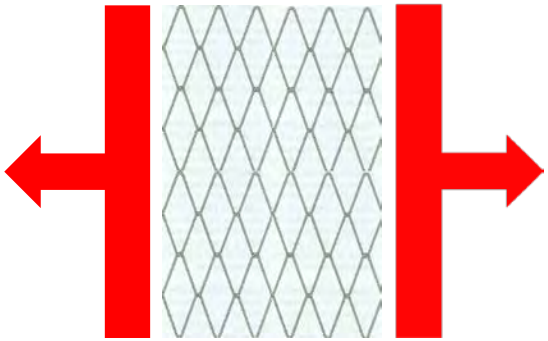
- 40’ (12m) x 33’ (10m) x 4’ (1.2m)
- Instrumented anchor bars
- Load cells in boundary ropes
- Multiple soil types – rounded gravel (ϕ=33°), crushed gravel (ϕ=38°)
- Variable slope angle from 0° to 85°
- Multiple meshes and anchor plates
- ***Laser scanning to measure displacement***

Full scale testing

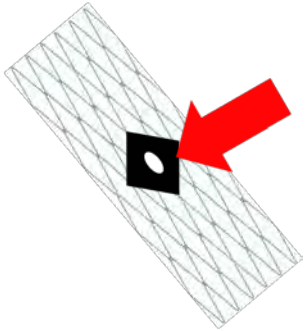
Strength properties of mesh

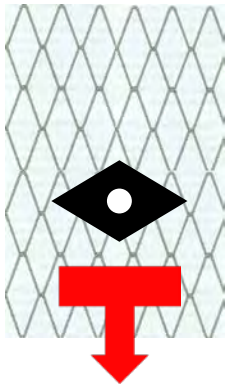
- Longitudinal

- Transverse



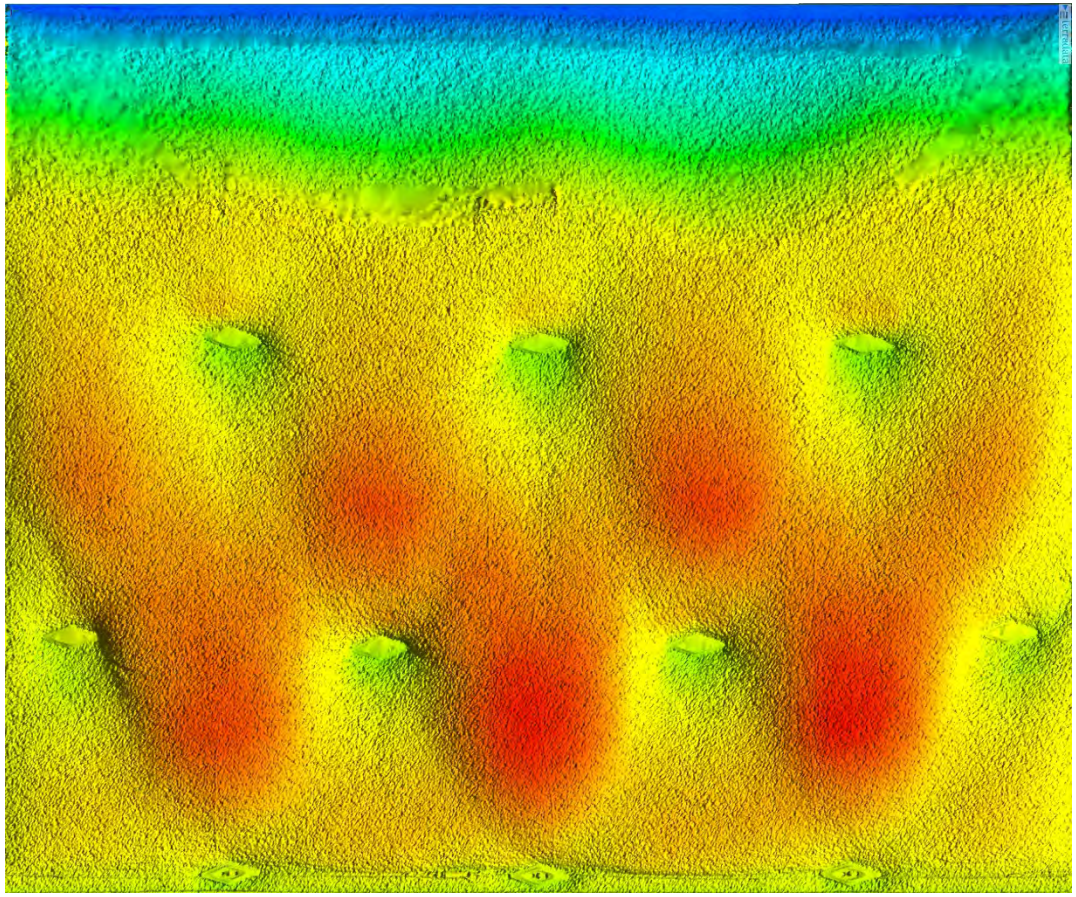
- Punching





- Mesh-plate interaction

Analysis of real sliding mechanisms



Standard duty mesh (3mm diameter wire)

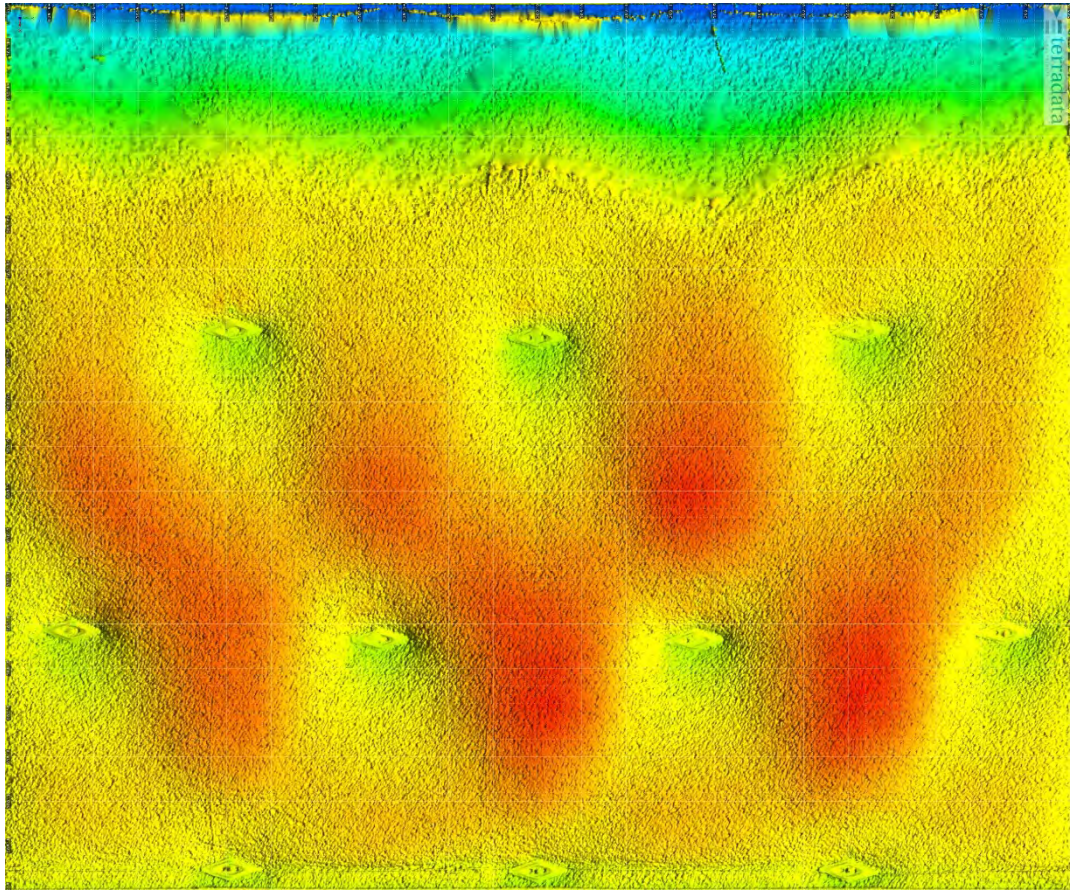
a = b = 11.5’ (3.5m)

Rounded gravel

Grain size 16 - 32 mm

α = 60°

Analysis of real sliding mechanisms



Heavy duty mesh
(4mm diameter wire)

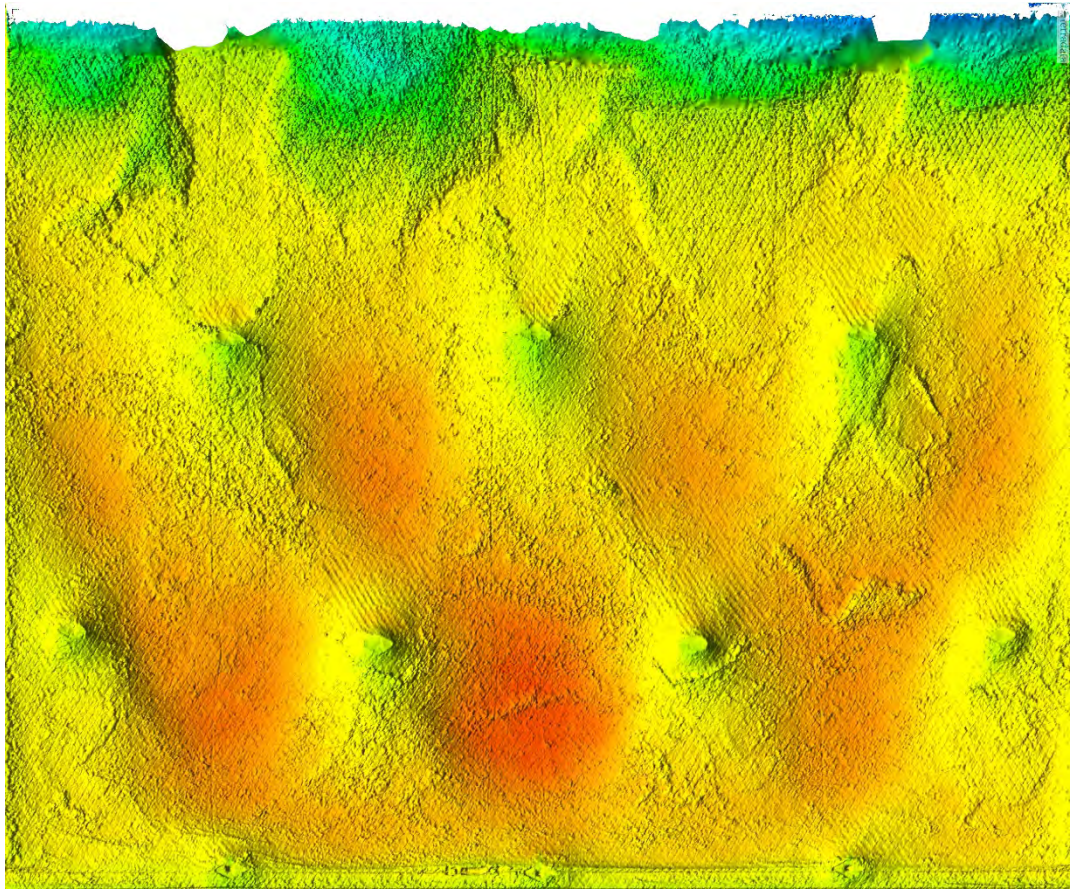
a = b = 11.5’ (3.5m)

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)

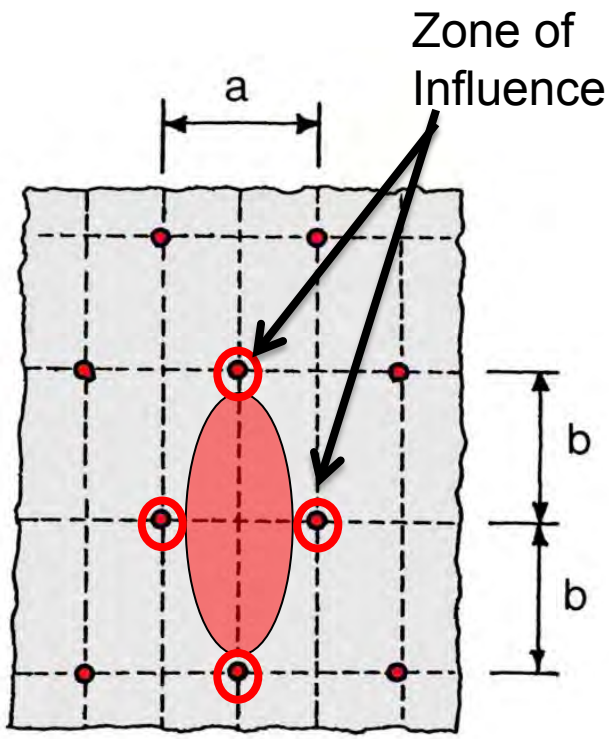
Crushed gravel

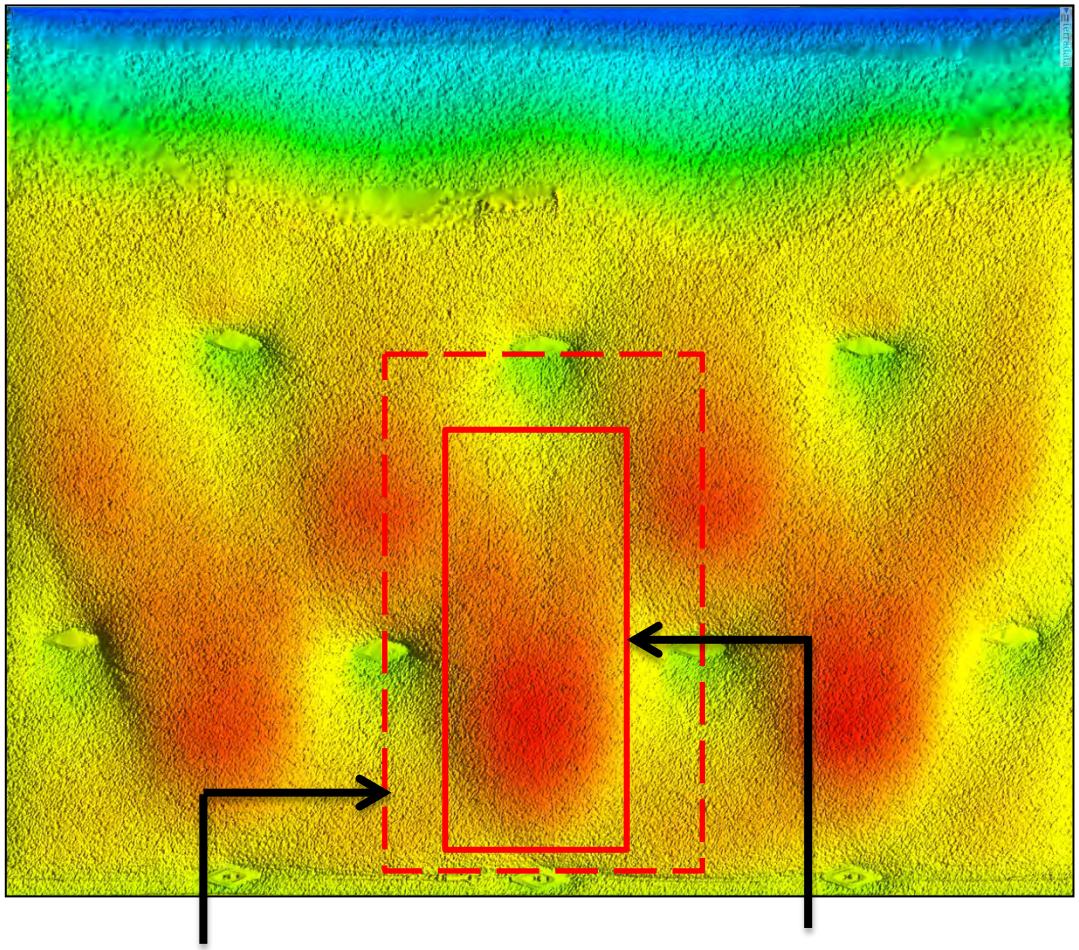
Grain size 0 - 63 mm

α = 60°

What we learned from the Full-Scale Test

- Dimensioning concept validated

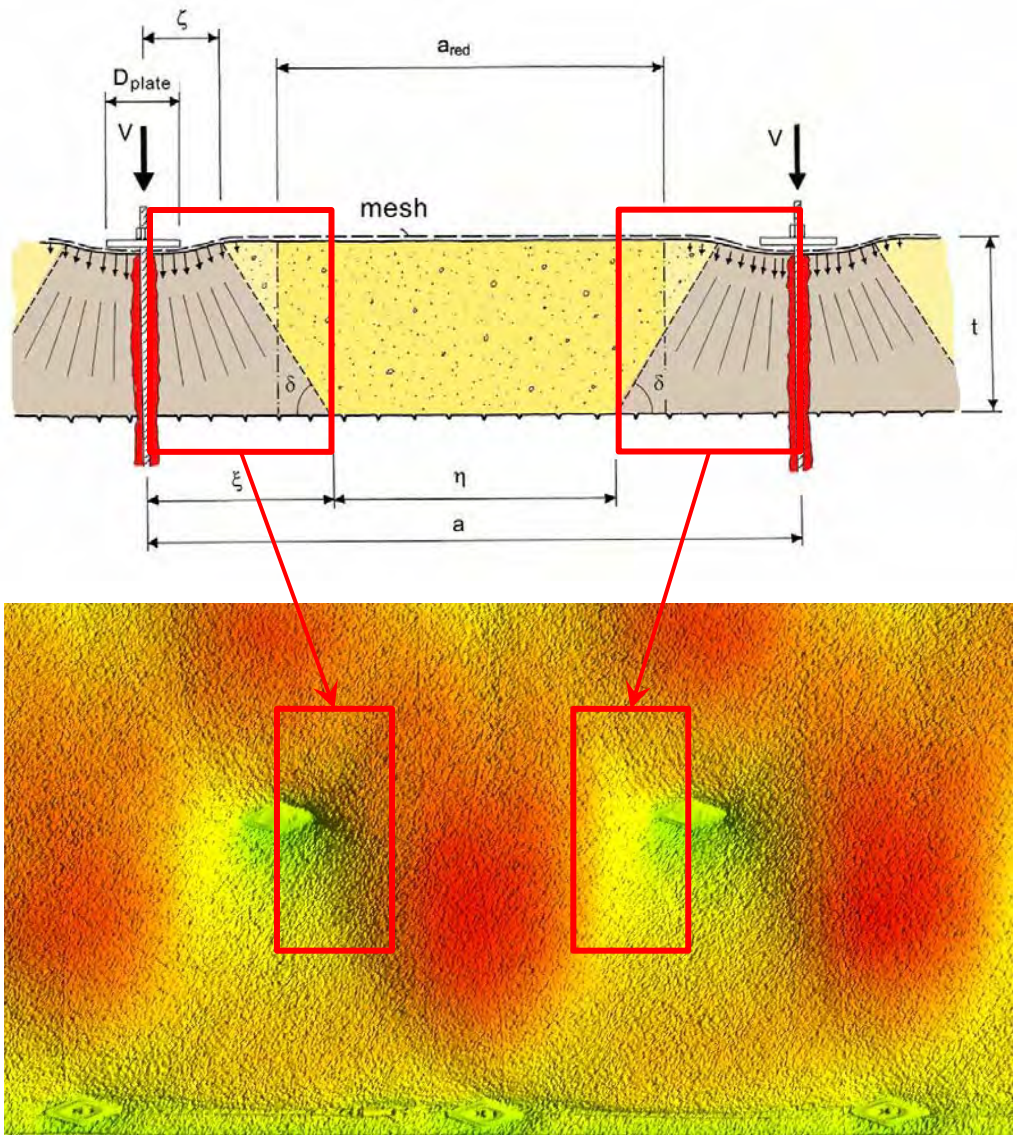




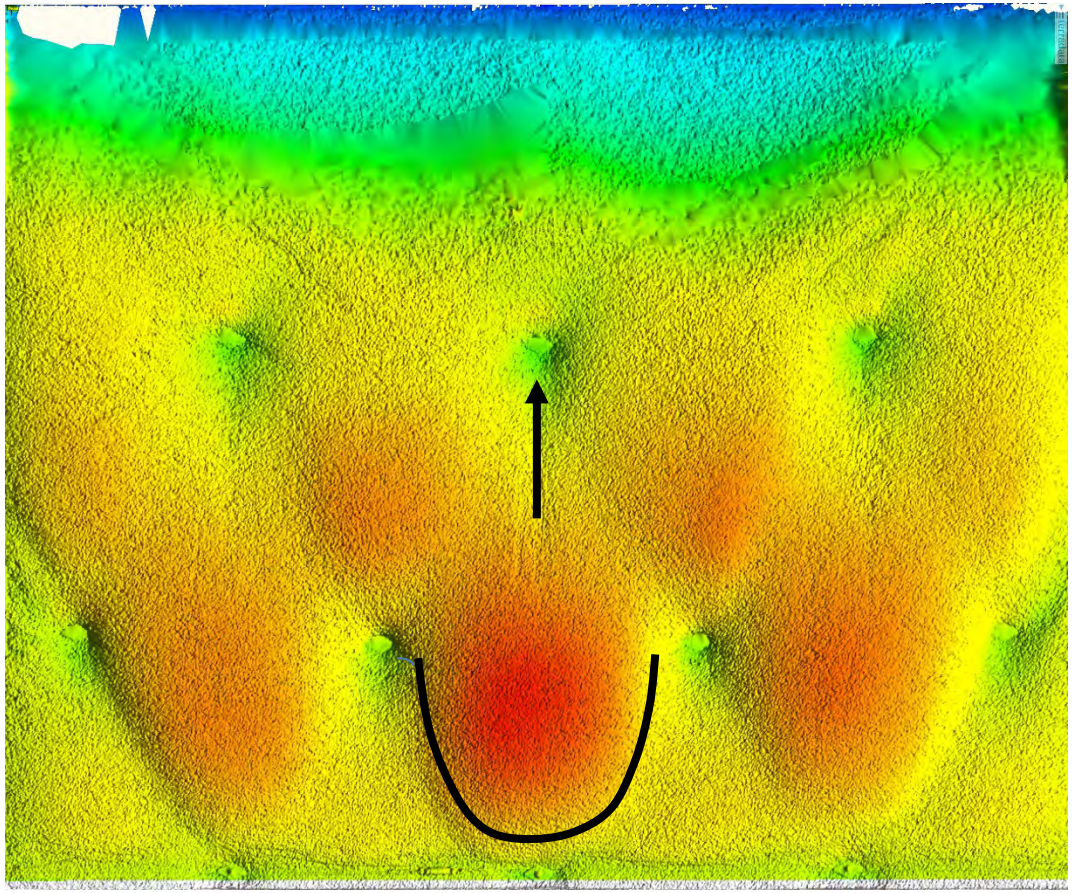
Without Zone of Lateral Influence

With Zone of Lateral Influence

Proof of lateral influence of pressure cones

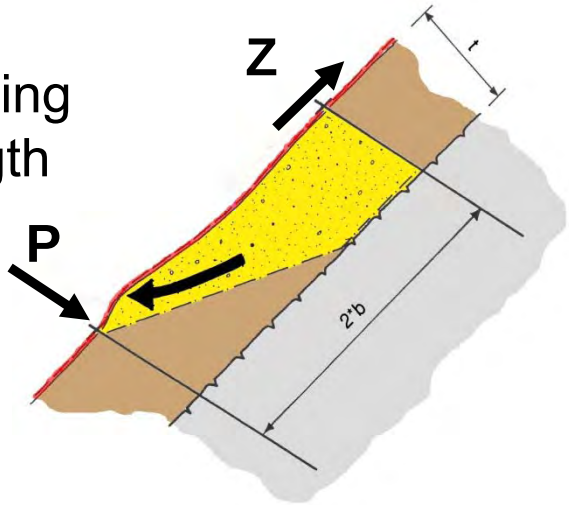


Analysis of load transfer within system

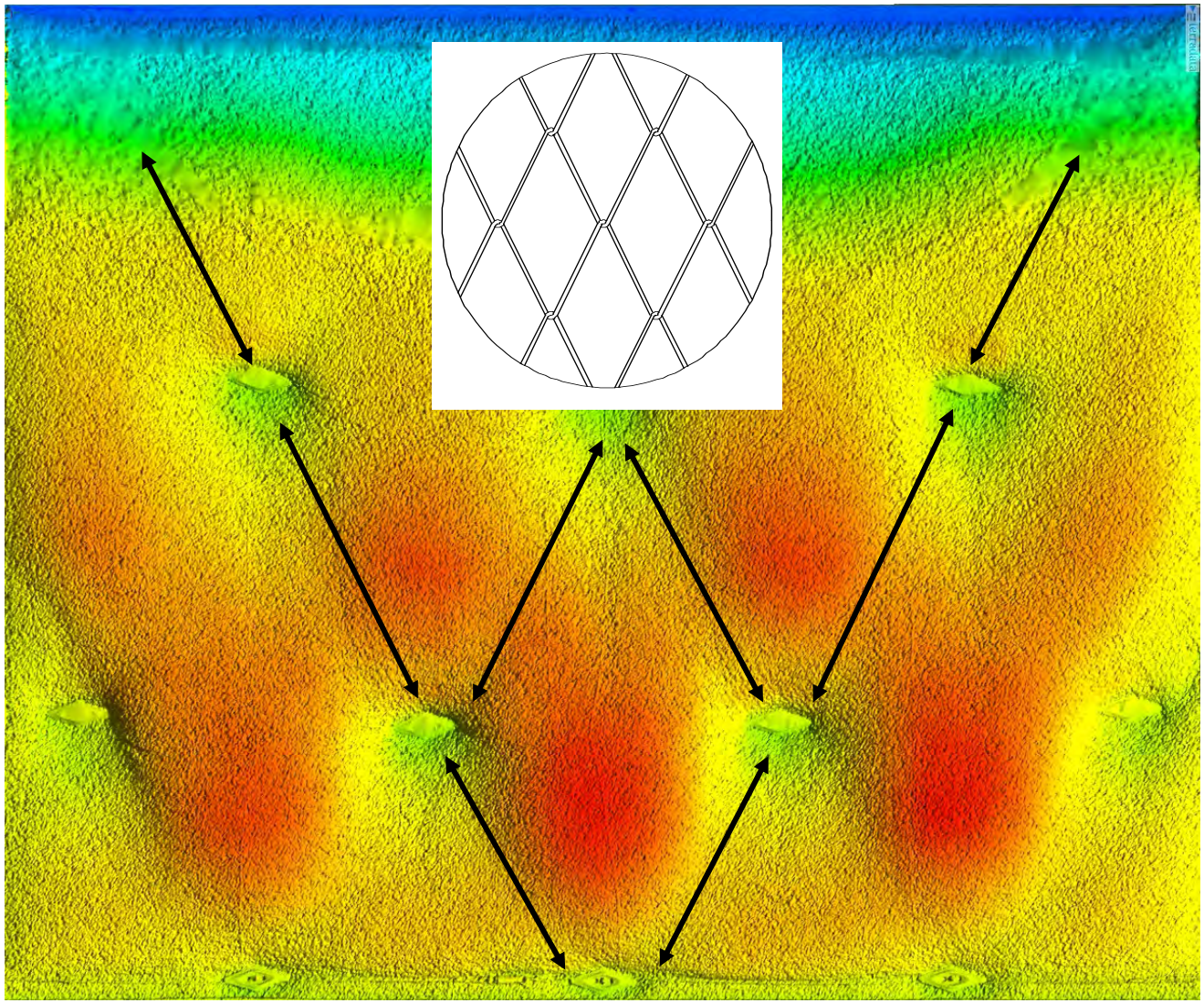


Slope Parallel Strength

Punching Strength



Analysis of load transfer within system



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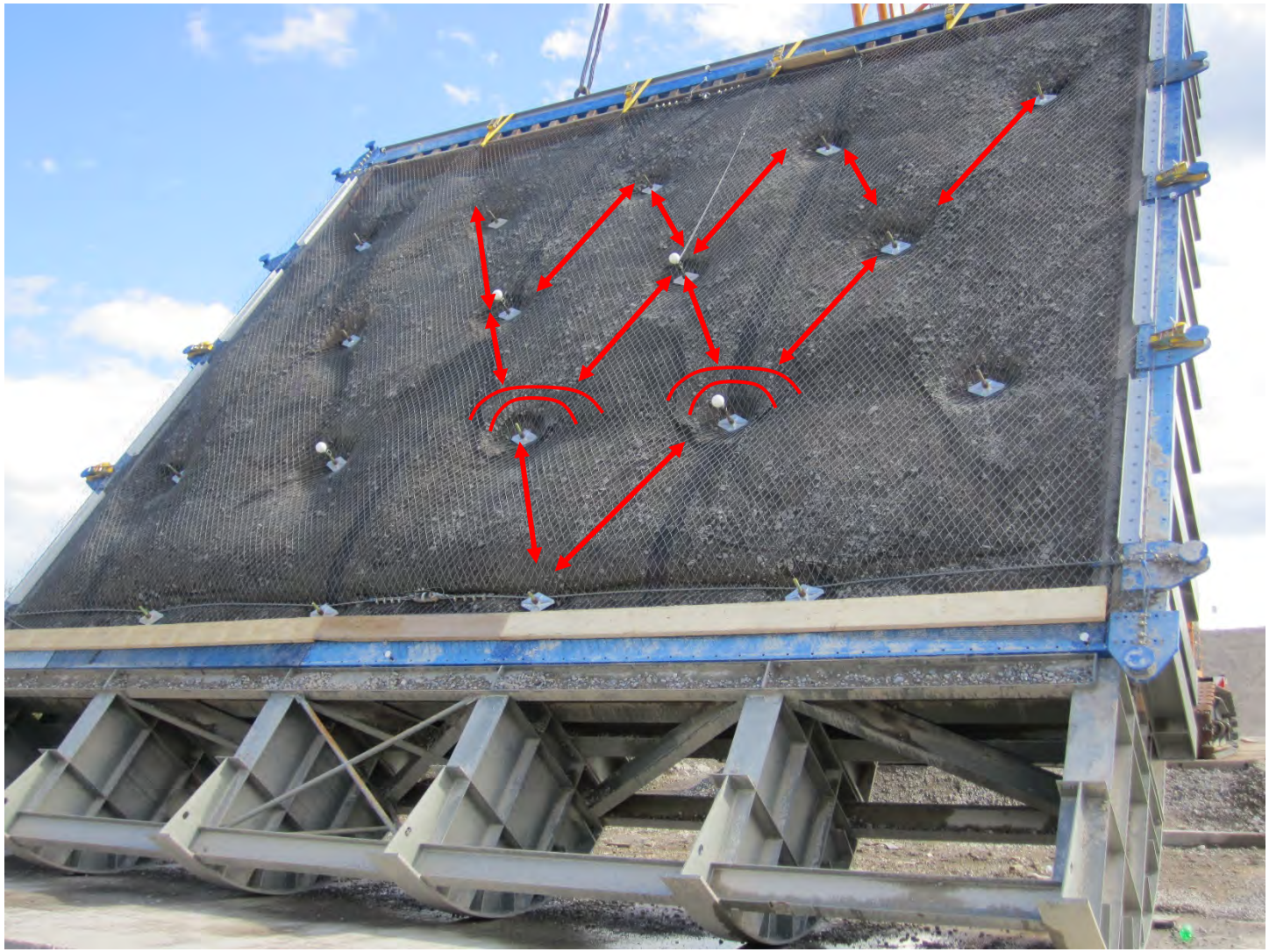

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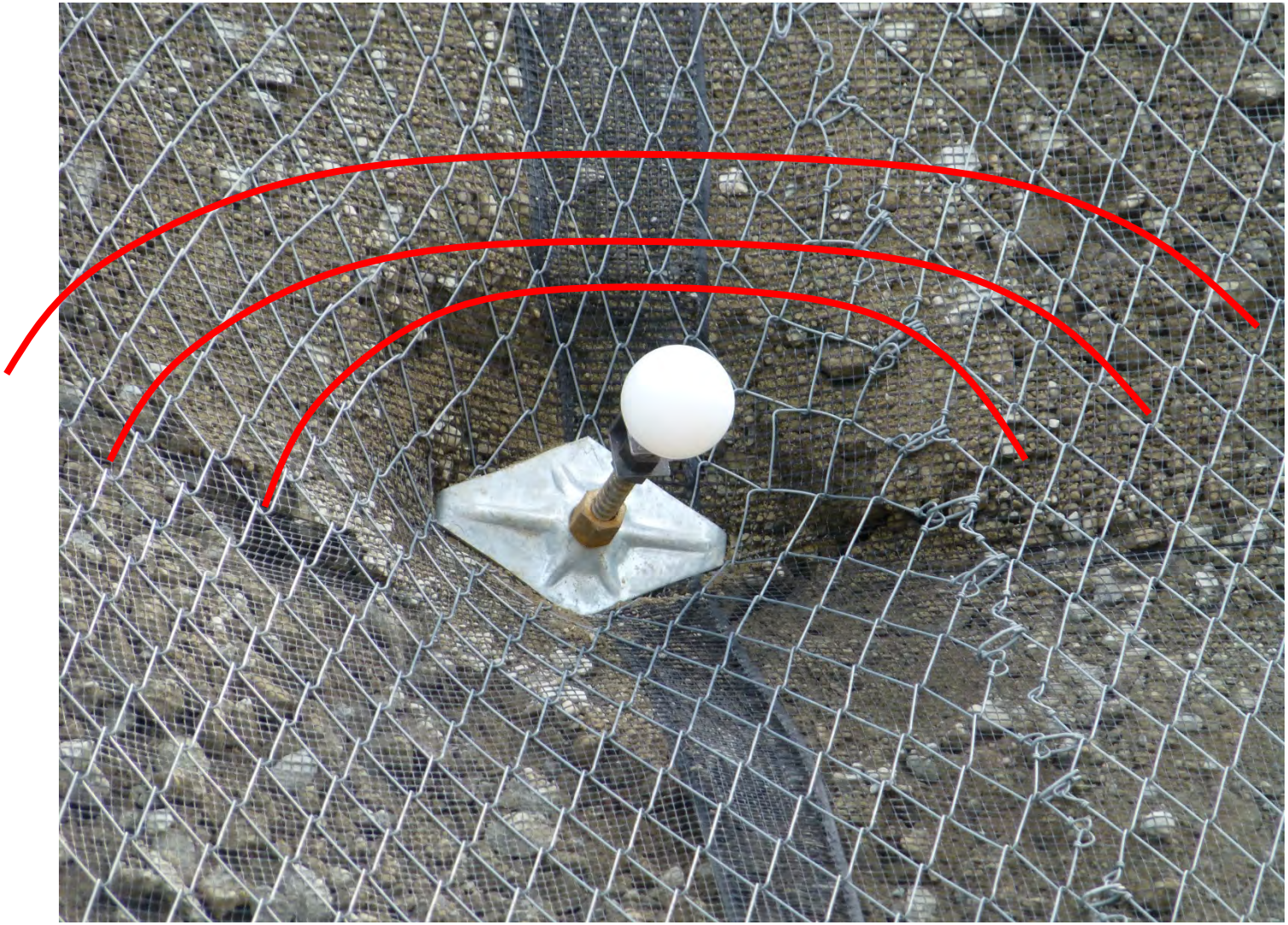

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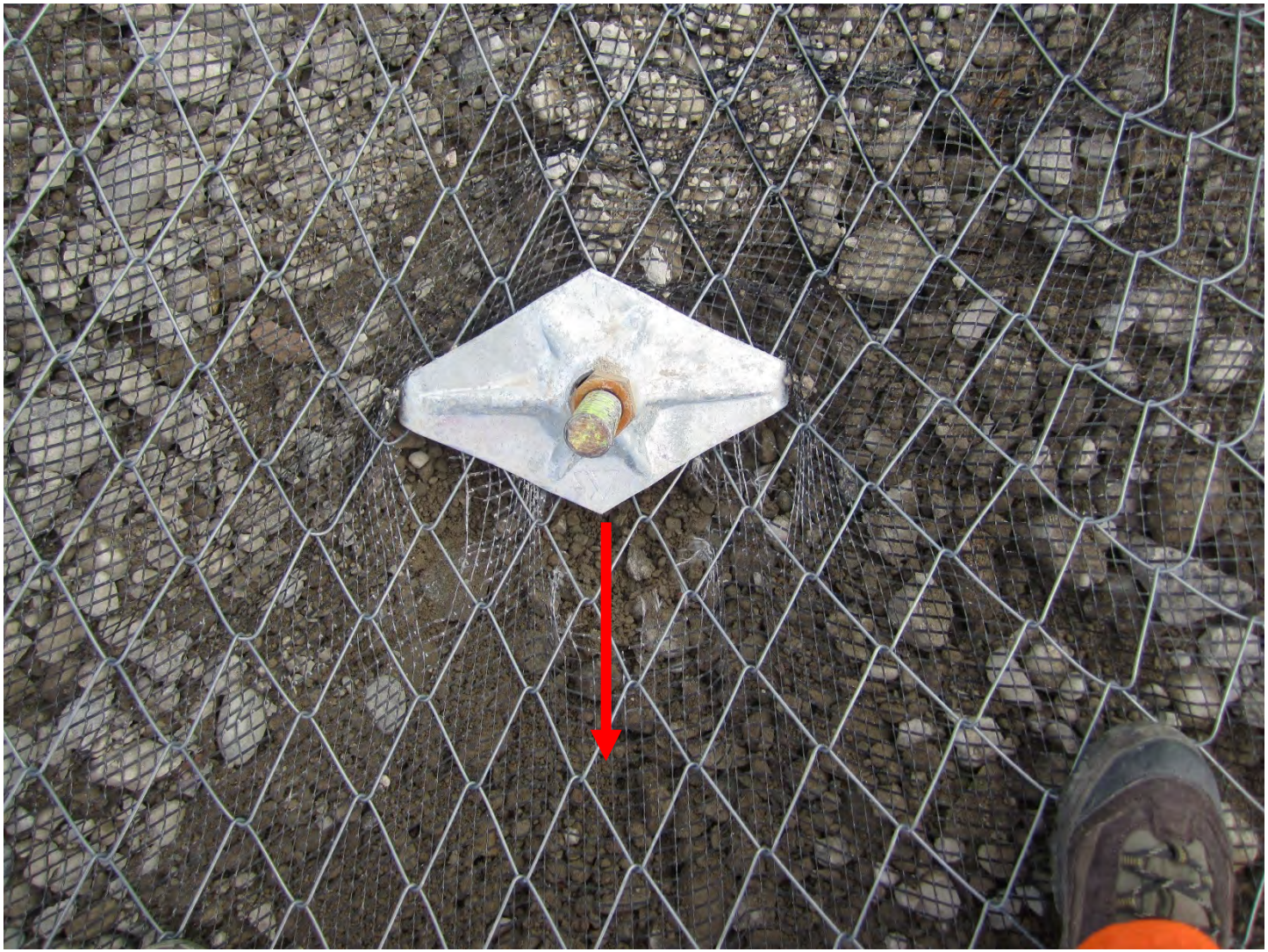

Comparison of the different slope stabilization systems

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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

Severely Over-Steepened

Over-Steepened Slope

Stable Slope

Heavy Duty Mesh (4mm)

Standard Duty Mesh (3mm)

Light Duty Mesh (2mm)

Cost Optimization

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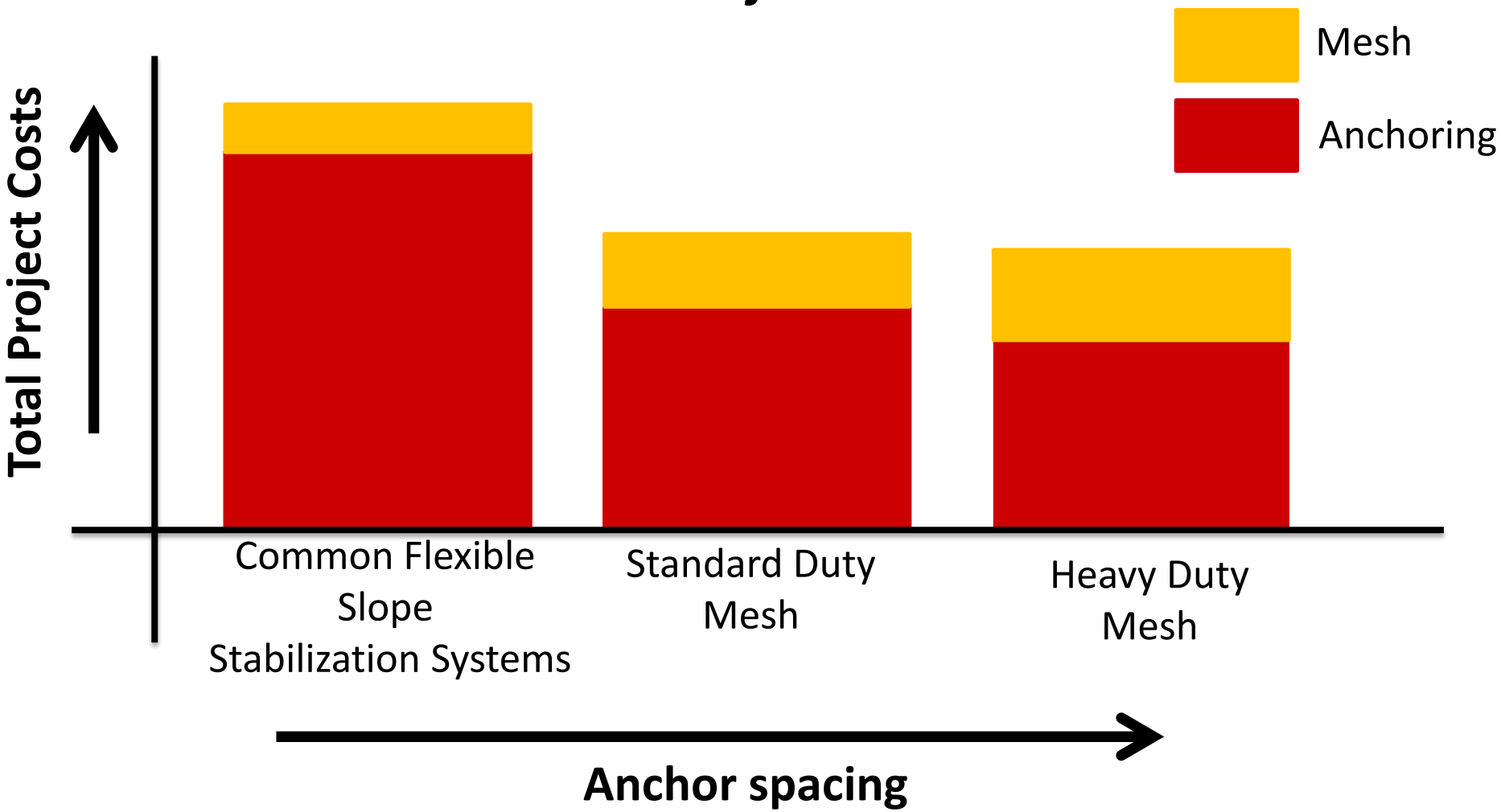
Total Project Cost



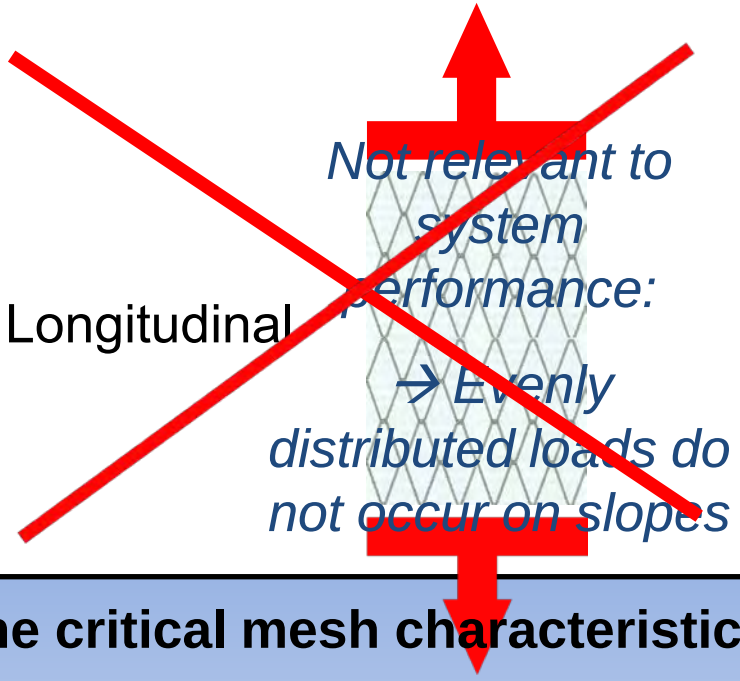
Load transfer in a surficial stabilization system

Slope → Facing → Spike plate → Anchor → Stable subsoil

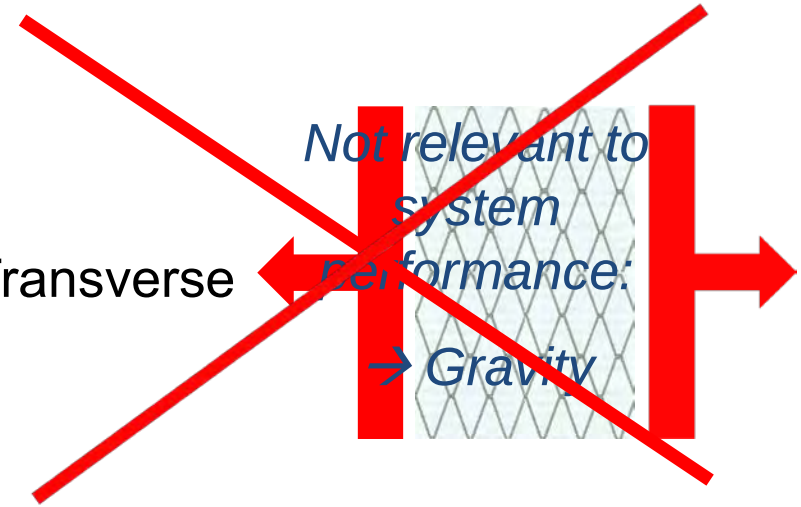
The critical load transfer occurs at the
Wire-Plate Interface

Strength properties of mesh

- Longitudinal

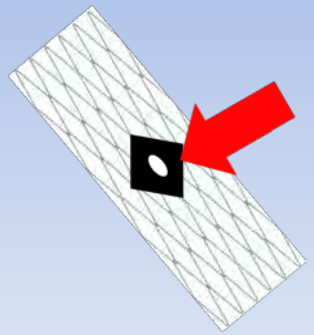


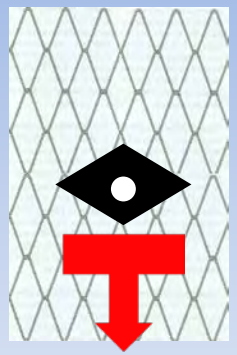
- Transverse



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*