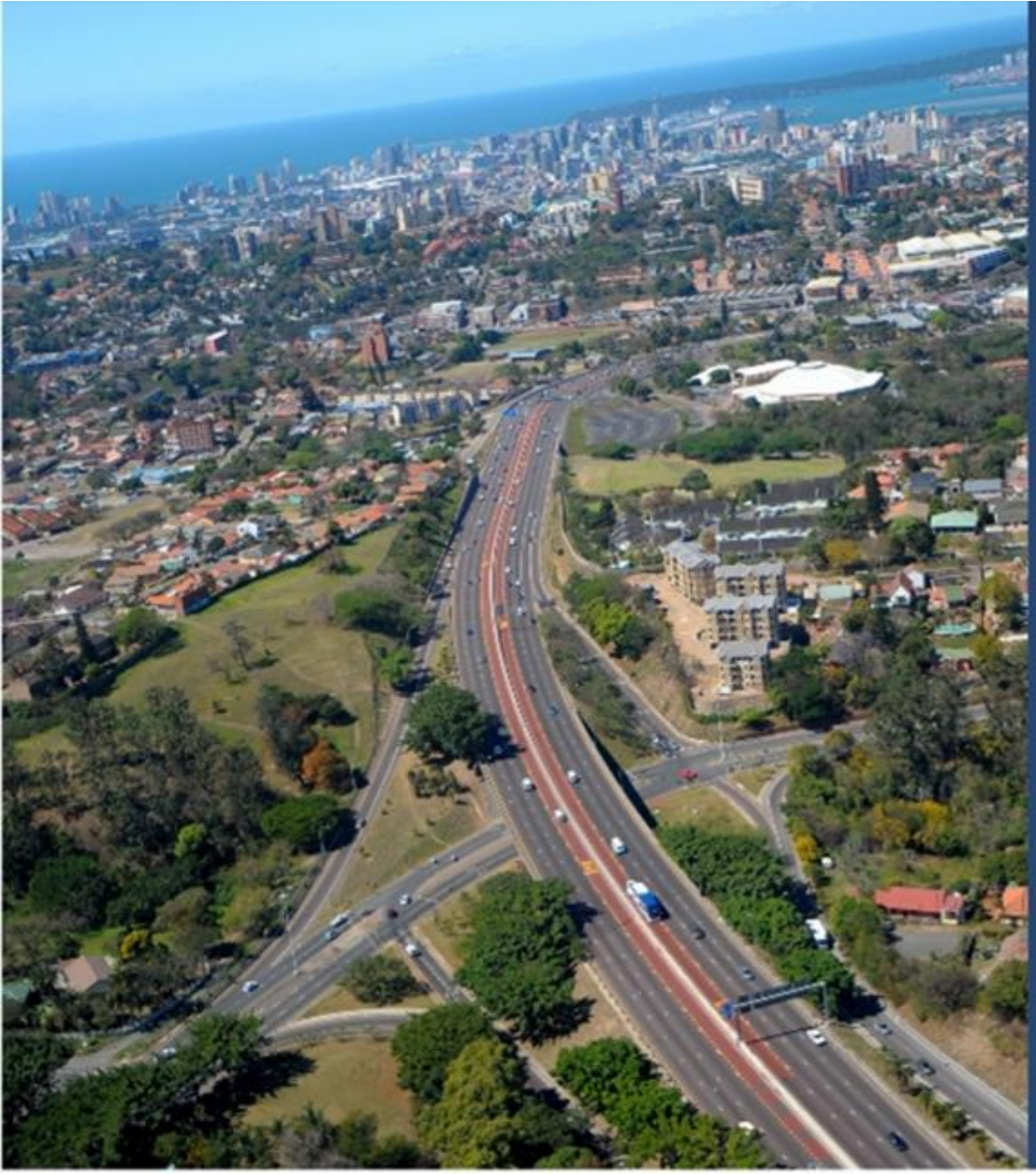
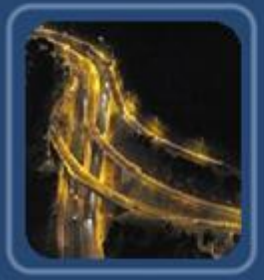


SARF

better roads



South African Road Federation

COTO 12.9
Slope Protection Measures

Presented by Louis Melis

26 July 2021

DISCRETE ROCKFALLS

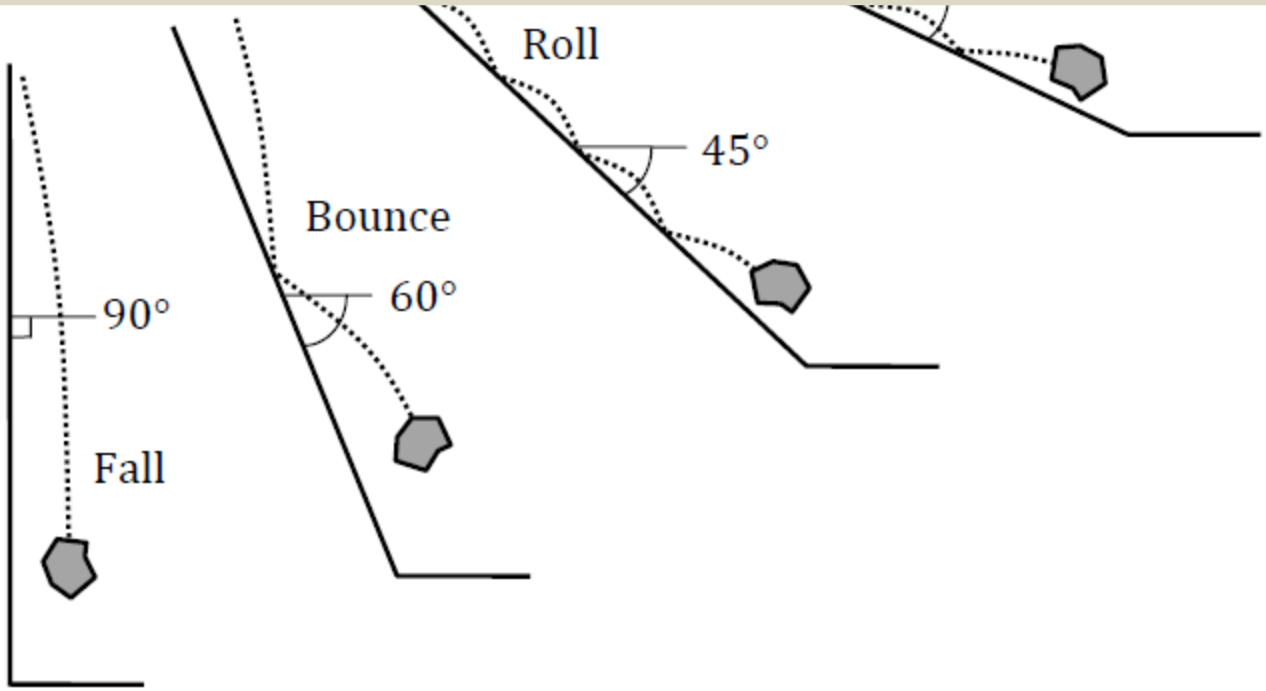


Figure 2. Relationship between motion type and slope angle (modified from Ritchie, A (1963), Evaluation of Rockfall and Its Control. In Highway Research Record 17, Figure 1 p. 25. Reproduced with permission of the Transportation Research Board).

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

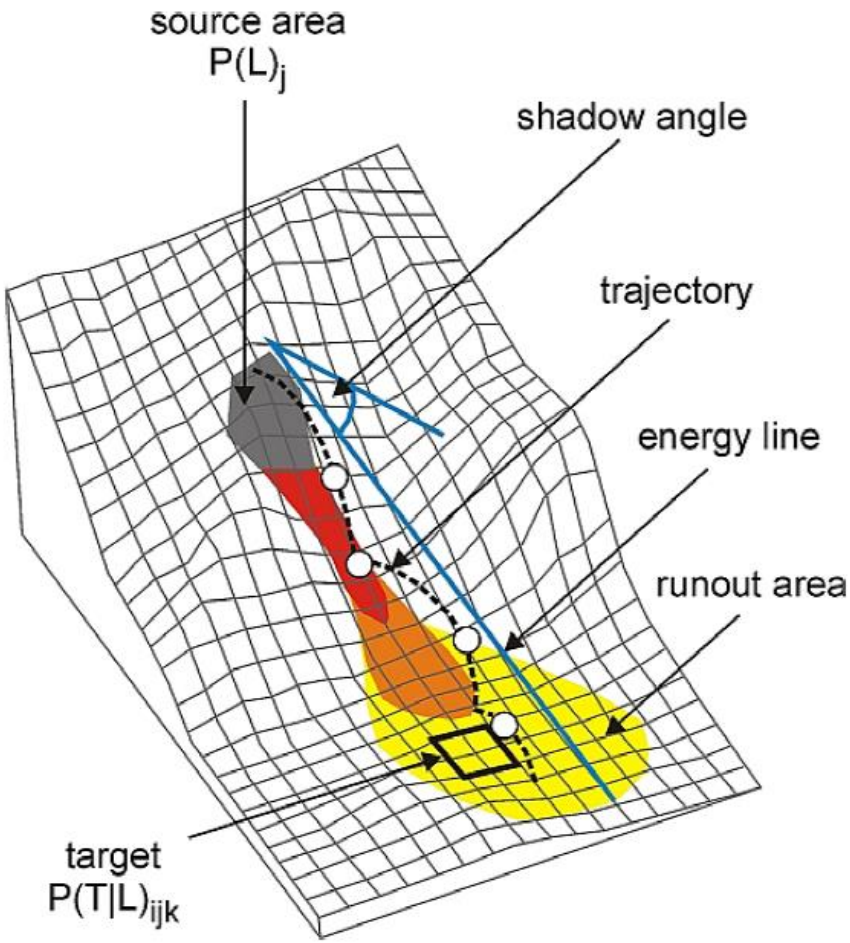


Fig. 2. Definition of rockfall hazard and related parameters (modified, after Jaboyedoff et al., 2001).

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

SHALLOW LANDSLIDES AND DEBRIS FLOWS

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

Slope Protection Systems Covered in Part 12.9 may either be in the form of Active or Passive intervention:

Active (Instability Removal/Prevention)	Passive (Instability Interception/control)
Rock barring of the Slope Surface	Anchoring of Rockfall Netting/Wire Mesh at the Crest and Draping over the Slope
Placement of Rockfall Netting/Wire Mesh over and Anchored to the slope with Dowel Bars	Catch Fence Rockfall Barriers Hybrid Catch Fence/Attenuators Catch Fence Canopies
	Shallow Landslides Fences/Barriers
	Debris Flow Fences/Barriers

ACTIVE MITIGATION:

ROCK BARRING

Rockfall Hazard Assessment and Mitgation
An Integral Requirement for the Optimal Design of Safe & Functional Slopes

ACTIVE MITIGATION:

ANCHORED ROCKFALL NETTING/WIRE MESH

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

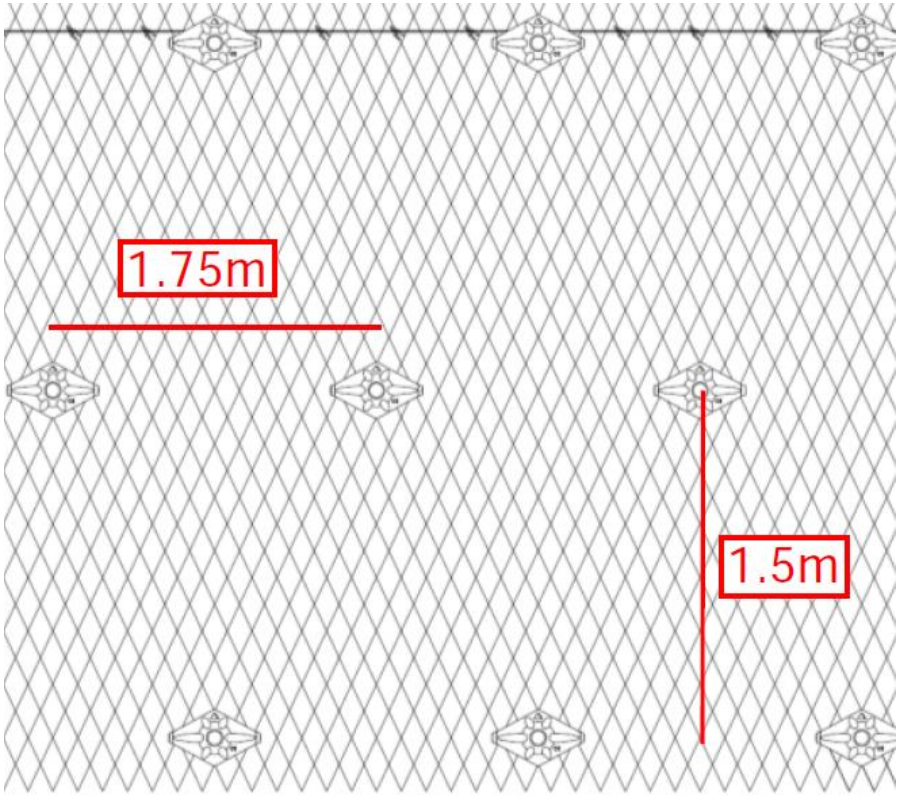
COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Anchored rockfall netting/wire mesh



COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Anchored rockfall netting/wire mesh

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Anchored rockfall netting/wire mesh

PASSIVE MITIGATION:

DRAPE MESH

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

De-coiler being set up at crest of high-wall for the next run

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

A Word on Rockfall Netting

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

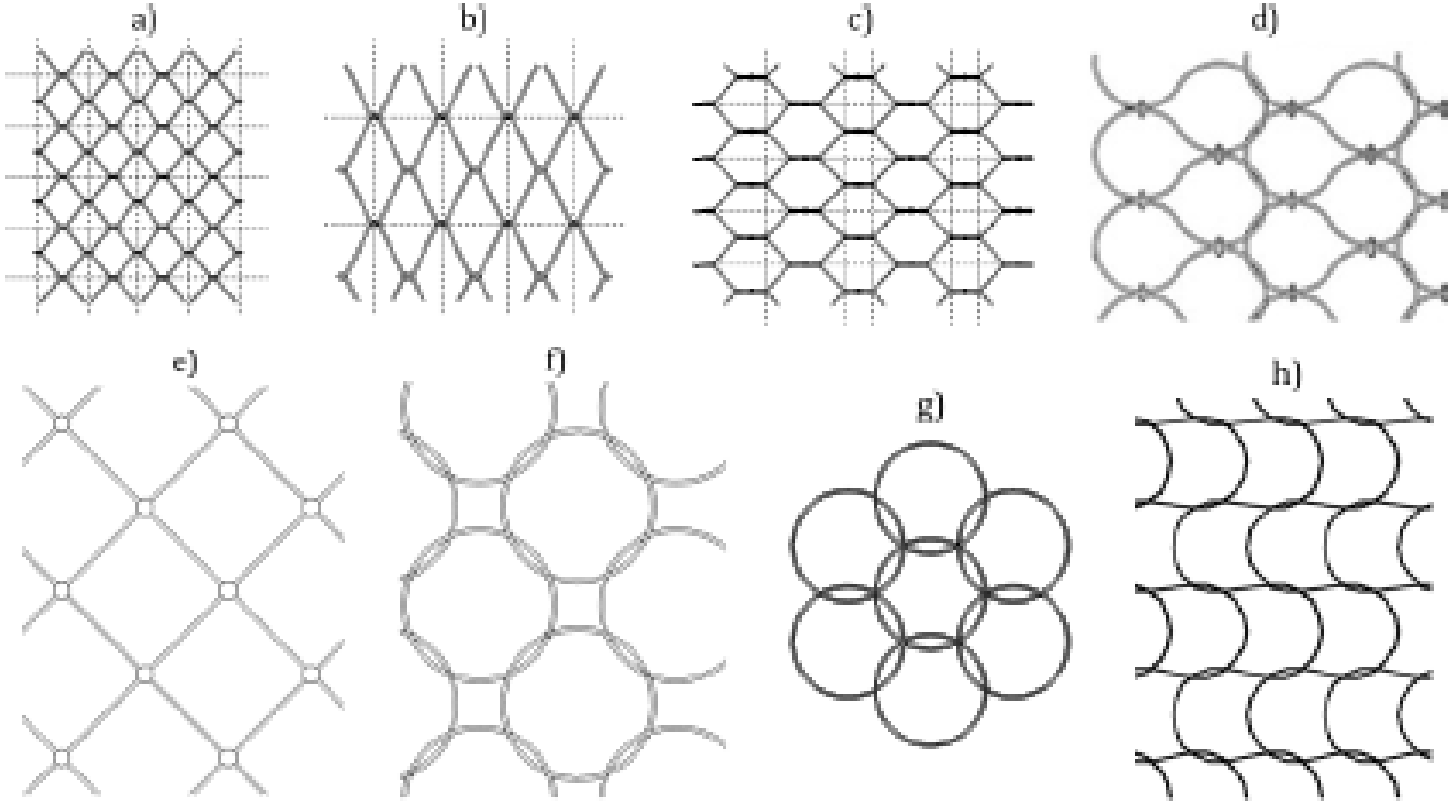


Figure 16. Different mesh constructions adopted for rockfall barriers: a) standard diamond chain-link, b) rhomboidal chain-link with high tensile steel, c) double twist, d) alternative construction (Bertrand et al., 2012), e) rope net, f-g) steel rings, h) Omega-net.

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

Increase in puncture/tearing resistance of drapery and thereby rockfall protection available

Light Mild Steel Mesh

Heavy Duty Mild Steel Mesh

High Tensile Steel Mesh

Heavy Duty High Tensile Steel Mesh

Rockfall Frequency

(No per annum)

Size of Rockfall m3/ Energy

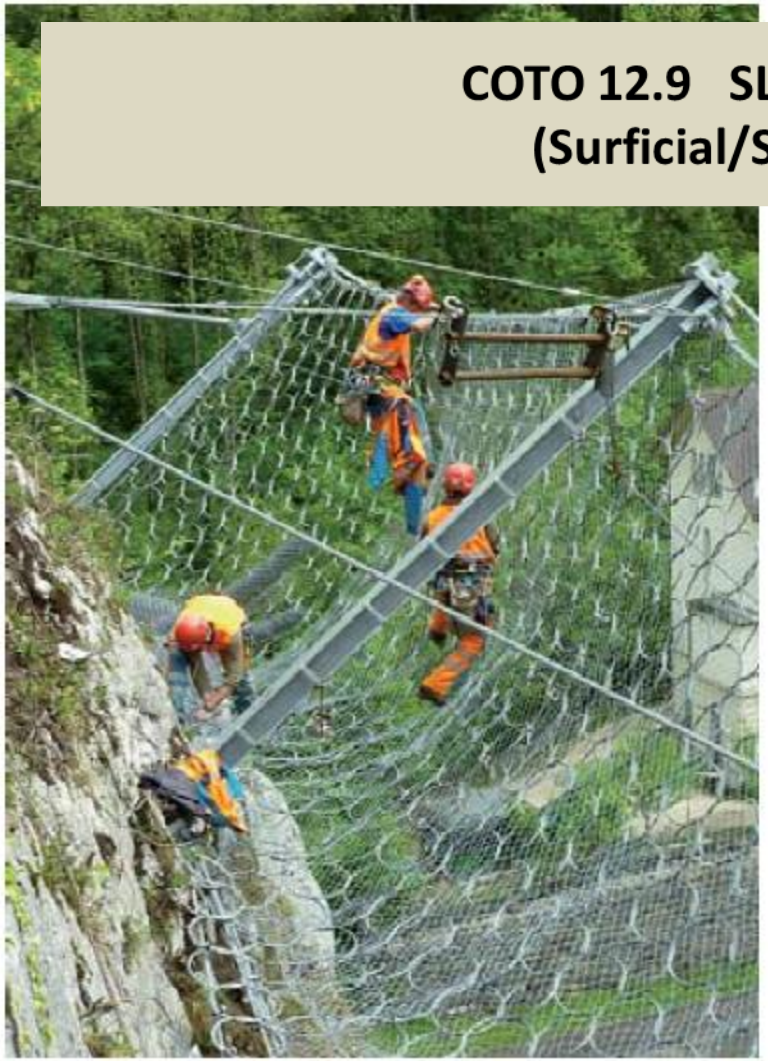
The Universal principal is that many **more, smaller rockfalls than larger rockfalls** occur from a rock face.

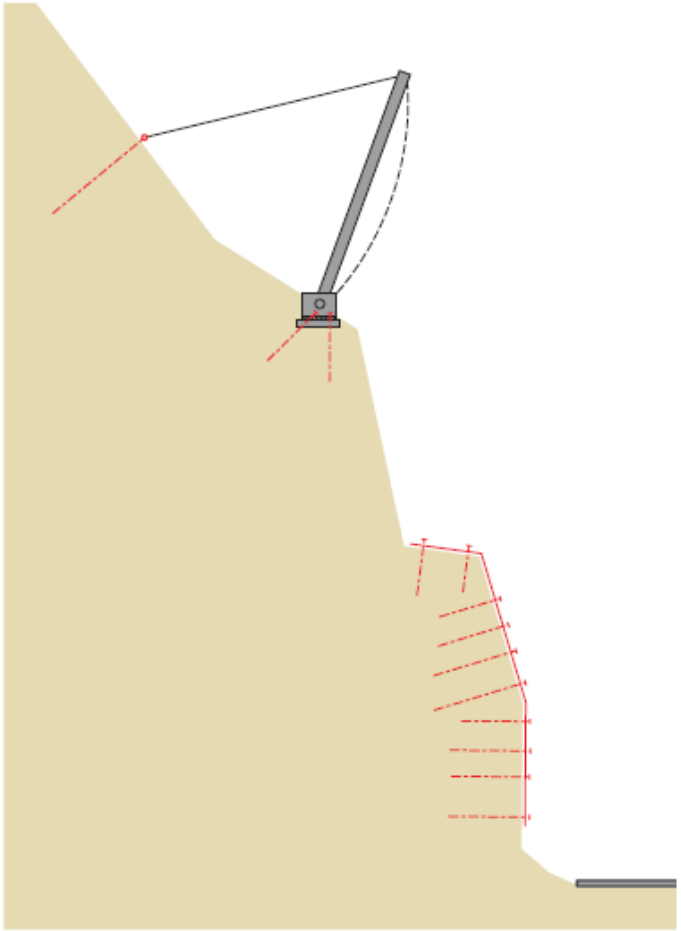
Schematic relationship between rockfall frequency, size and mitigation capacity of various drape mesh product

PASSIVE MITIGATION:

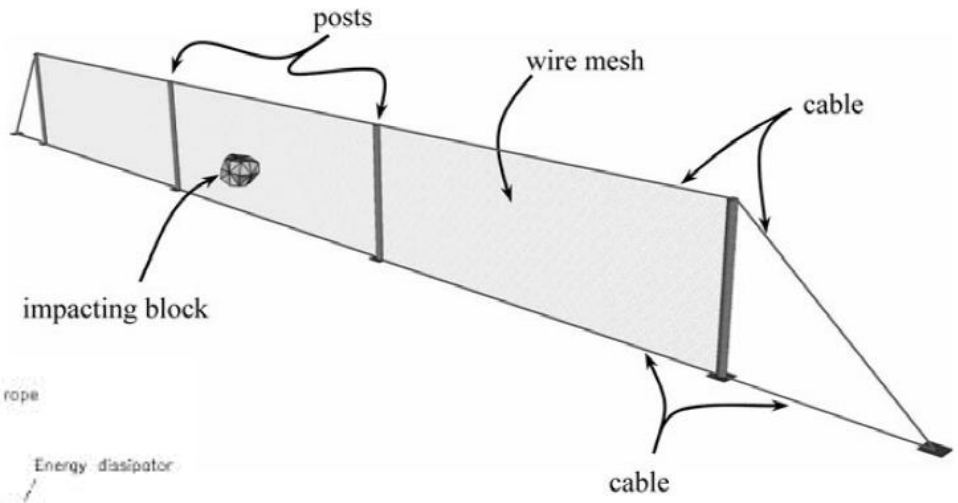
CATCH FENCES

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)





COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)



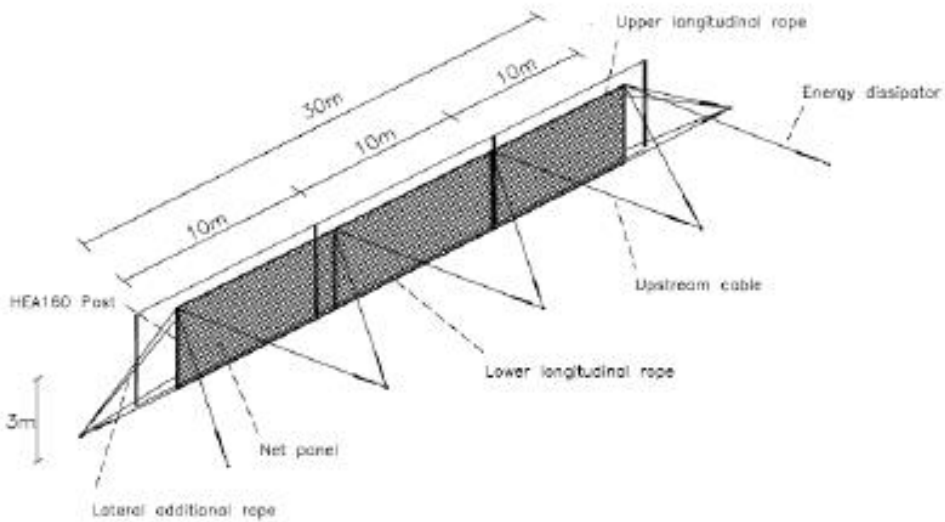


Figure 32. Sketch of a simulated rockfall barrier after Cazzani et al. (2002).

Michele Spadari

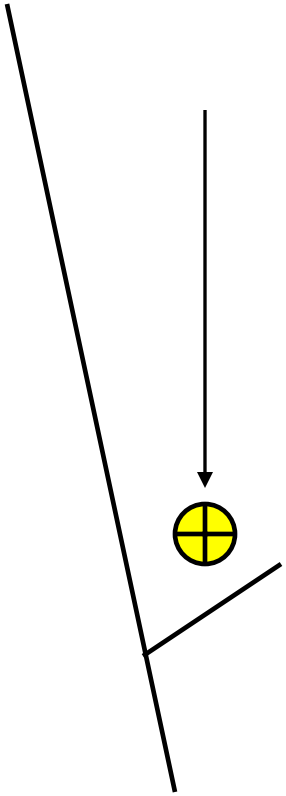
August, 2013

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

Flexible rockfall barriers & testing

- Vertical free fall
- Prescribed energies
- E = ½ MV^2
- Swiss guidelines W. Gerber - 2001
- European standards EOTA - 2007

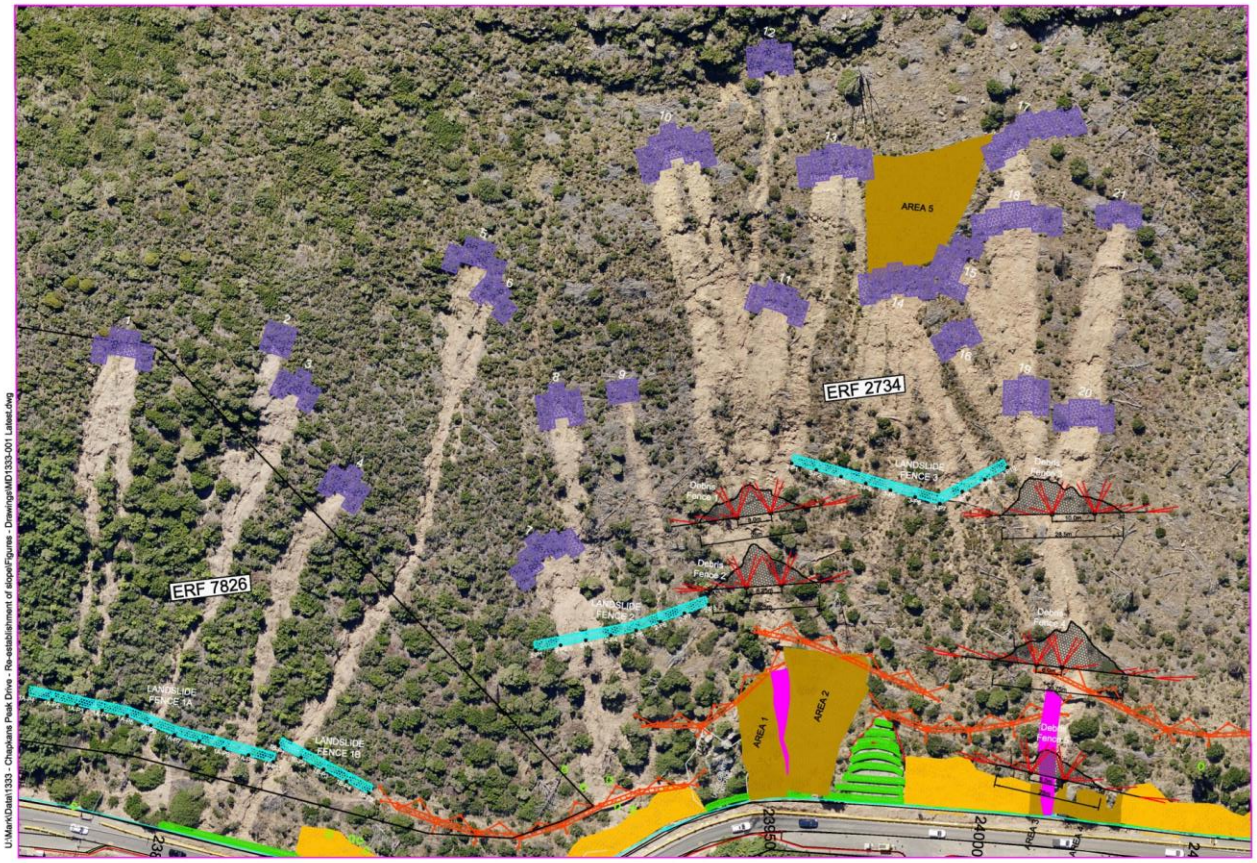


COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

TYPICAL INSTALLATION ACTIVITIES ASSOCIATED WITH ROCKFALL INSTALLATIONS

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Design Layout



1 : 750

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

Setting out

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

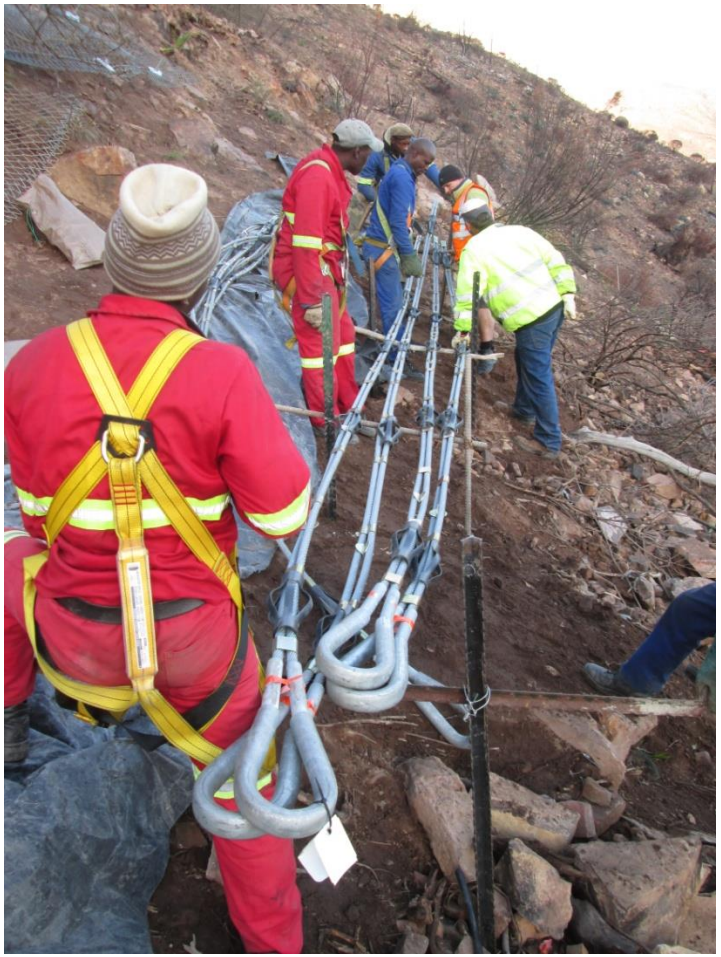
Setting out

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Dowel bar anchors

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Wire rope anchors



COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

Difficult Drilling

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

Difficult Drilling

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Difficult Drilling

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Grouting Anchors

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Inserted Wire Rope Anchor

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Concrete Plinths

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Concrete Plinths

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Concrete Plinths

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Erecting posts and cables

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Erecting posts and cables

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Installation complete

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

Installation complete

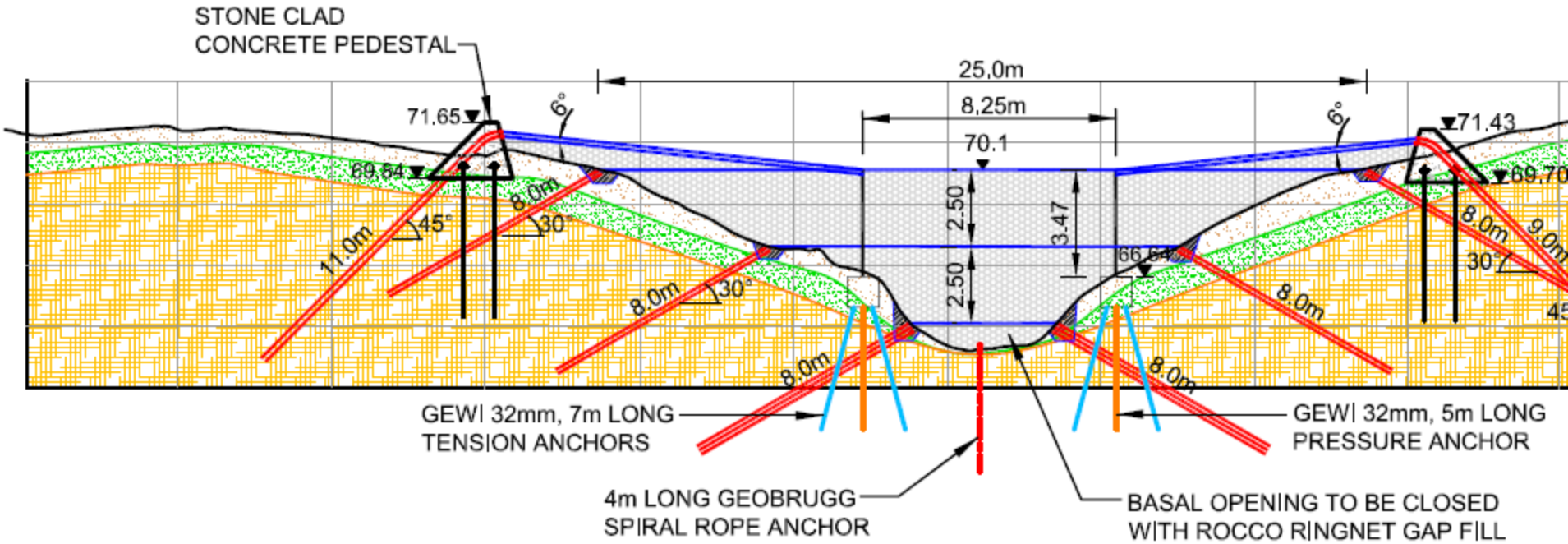
PASSIVE MITIGATION:

SHALLOW LANDSLIDE FENCES

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

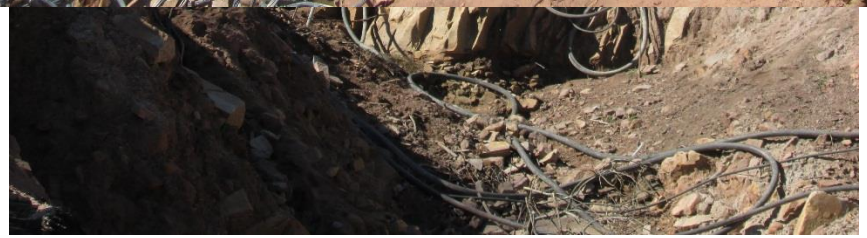
PASSIVE MITIGATION:

DEBRIS FLOW FENCES


STONE CLAD
CONCRETE PEDESTAL
25,0m
8,25m
70.1
71.65
69.54
71.43
69.70
66.54
6°
6°
2.50
2.50
3.47
11.0m
45°
8.0m
30°
8.0m
30°
8.0m
8.0m
8.0m
8.0m
30°
9.0m
GEWI 32mm, 7m LONG
TENSION ANCHORS
GEWI 32mm, 5m LONG
PRESSURE ANCHOR
4m LONG GEOBRUGG
SPIRAL ROPE ANCHOR
BASAL OPENING TO BE CLOSED
WITH ROCCO RINGNET GAP FILL

ELEVATION

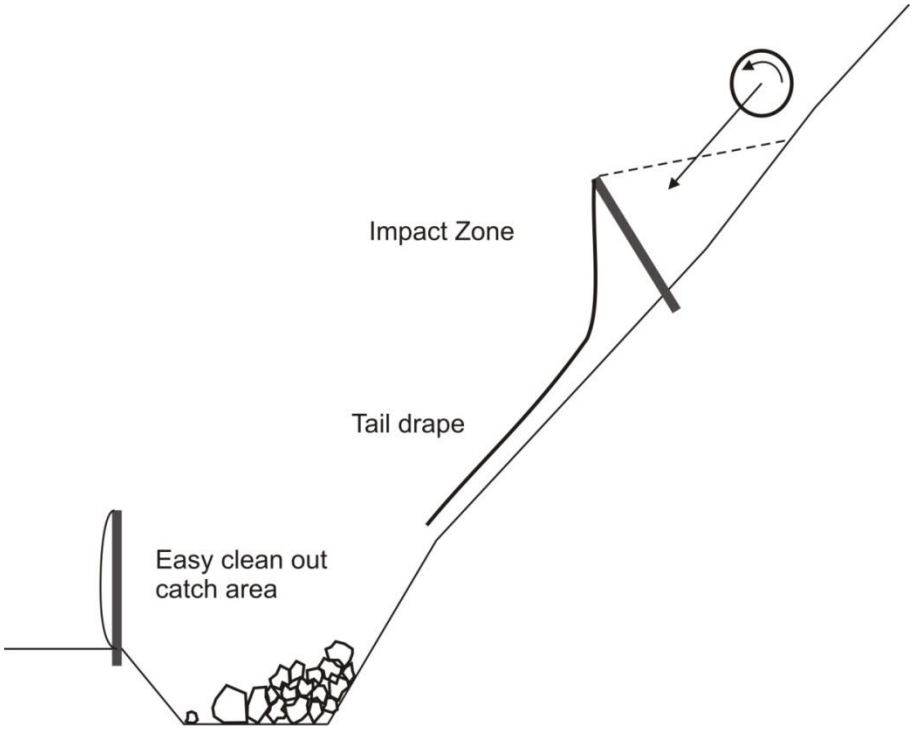
COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)



PASSIVE MITIGATION:

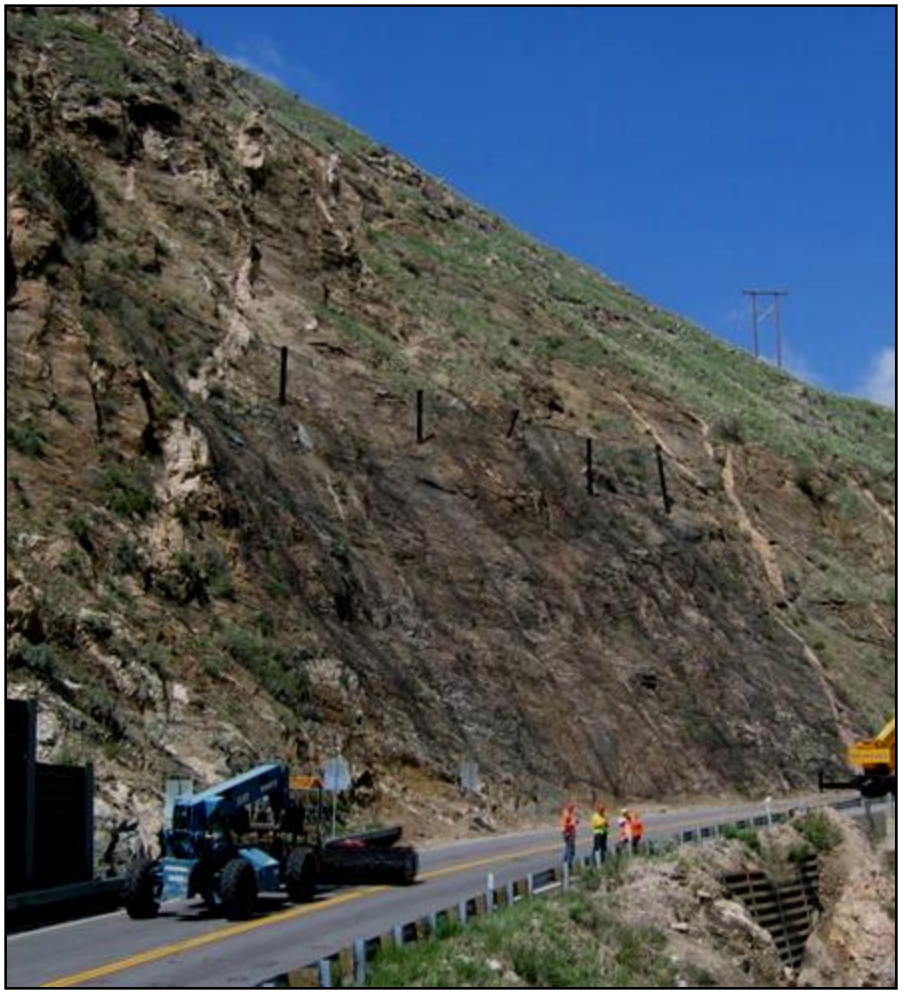
HYBRID CATCH FENCES/ ROCKFALL ATTENUATORS

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

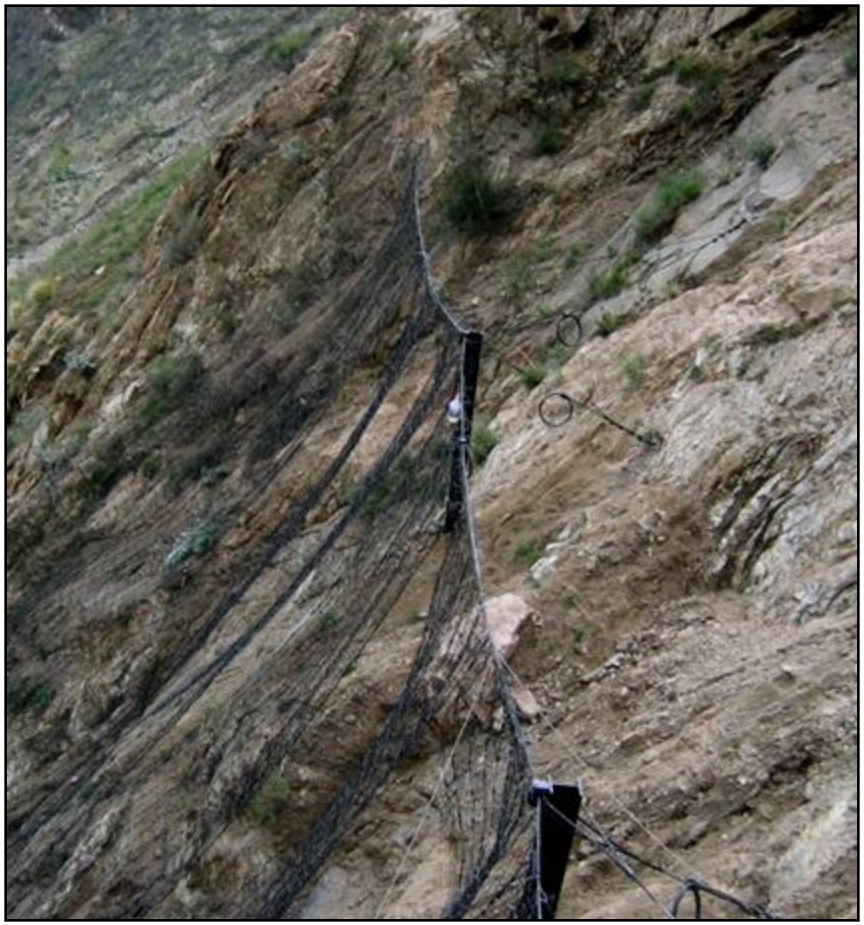


- Combine rockfall barriers and drape nets
- Intercepts and guides rockfall
- Containment ditch or fence
- With out energy absorbing break elements
- Intended low maintenance
- Attenuating series
- Open top road side drapes

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)



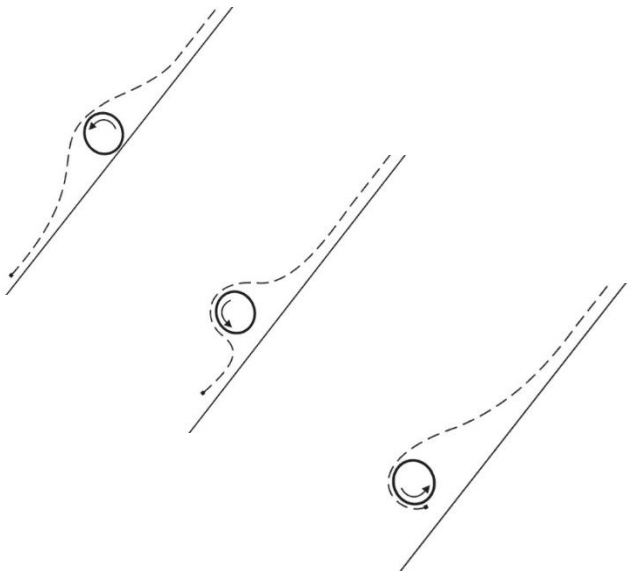
COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)



COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

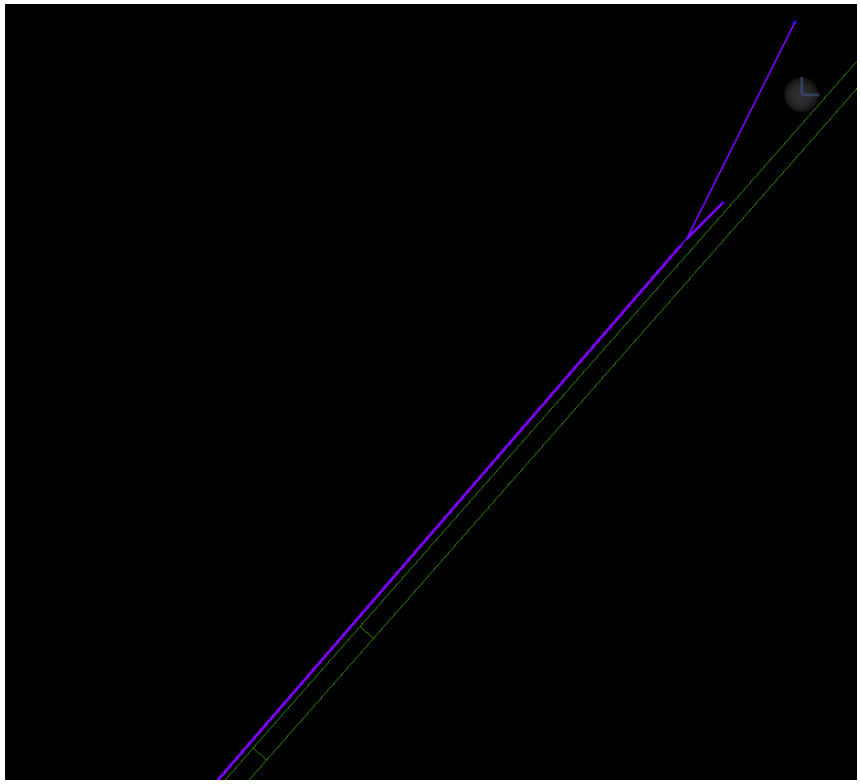
COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)



- Wrapping effect on exit generates force peaks, positive for attenuation.
- Causes most system deformations.
- Finishing of tail edge?

COTO 12.9 SLOPE PROTECTION MEASURES (Surficial/Shallow Slope Geohazards)

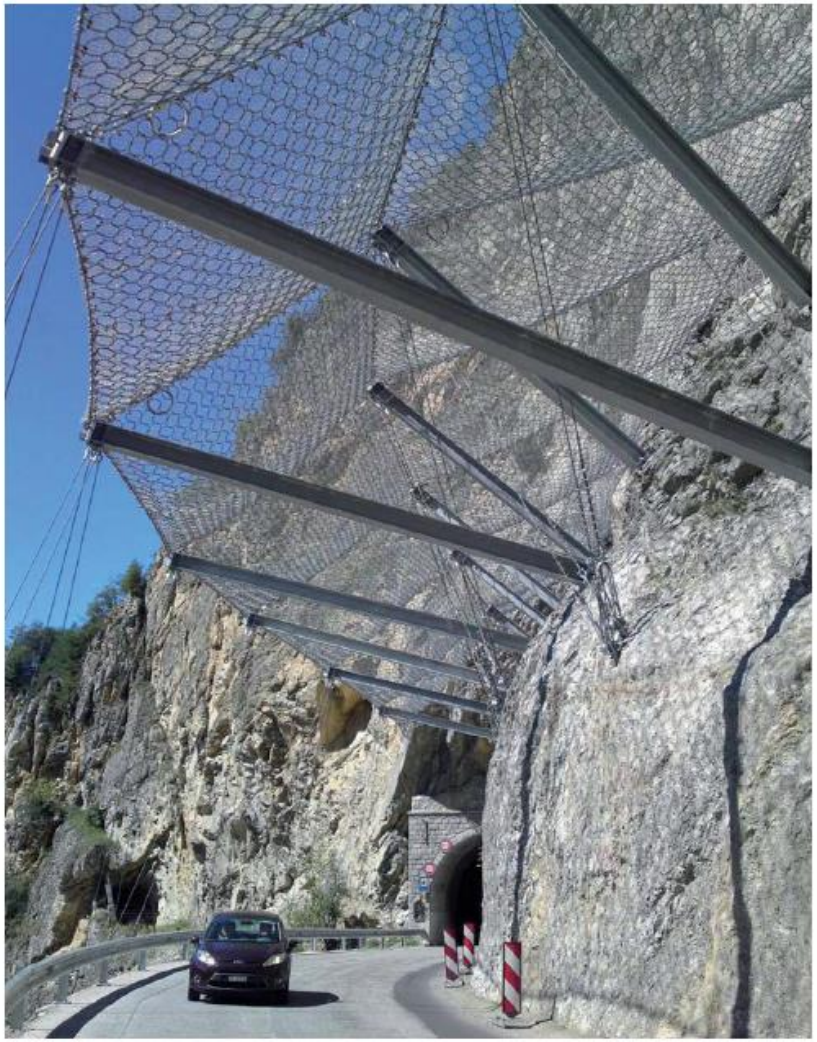
- Tests without nets – model calibration.
- Net weight and length experiments – Laboratory & FE modelling.



PASSIVE MITIGATION:

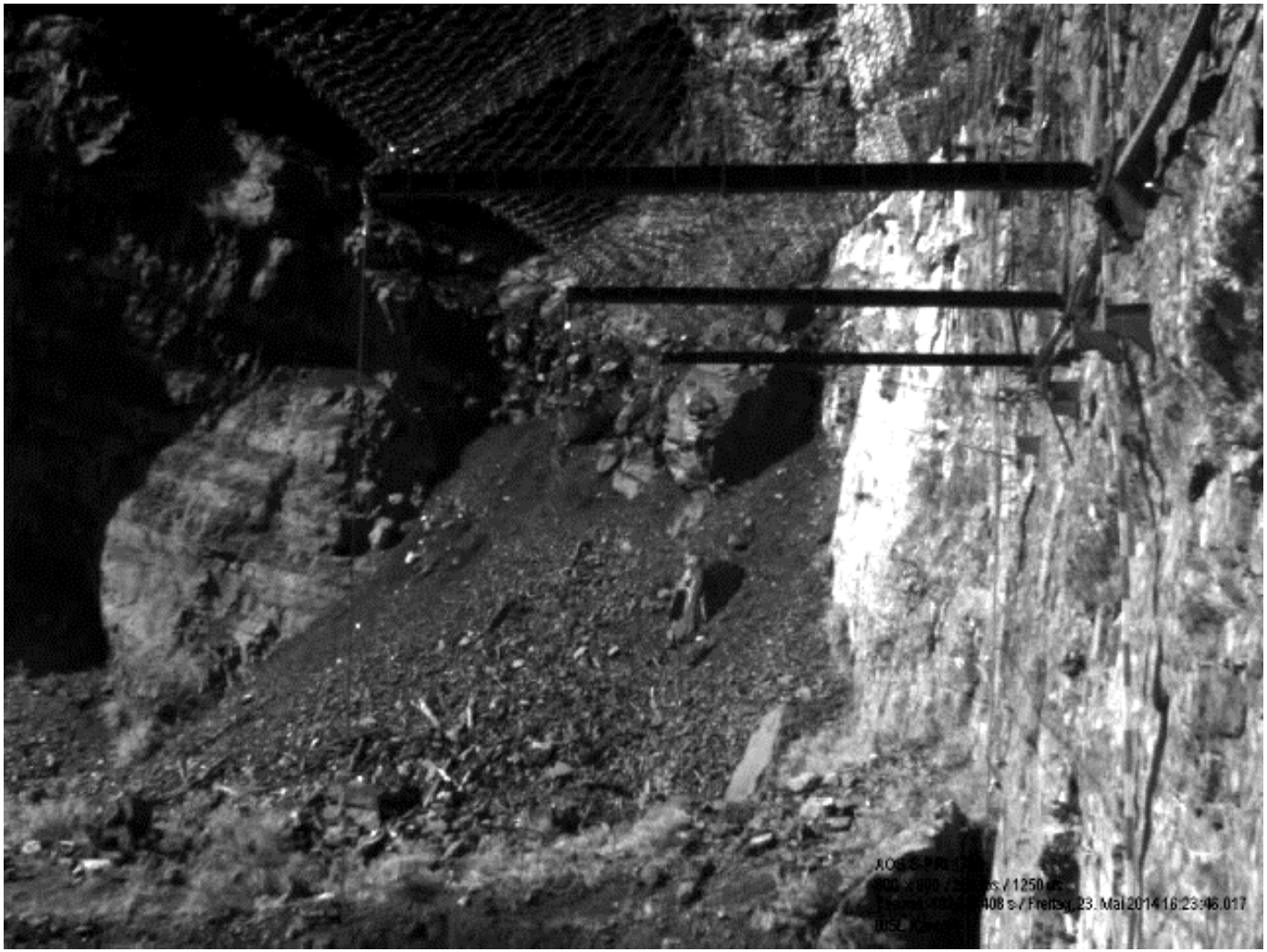
CATCH FENCE CANOPIES

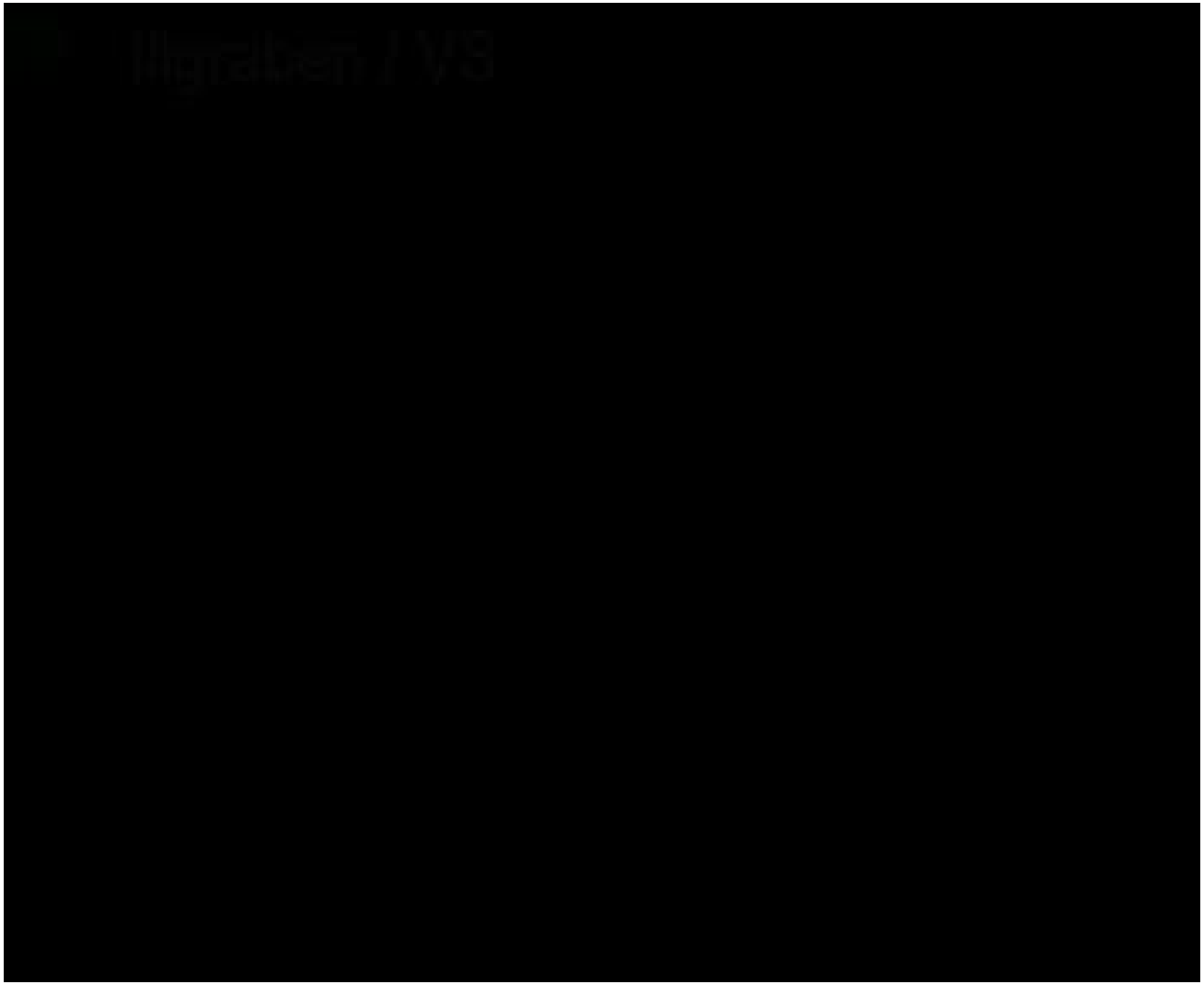
COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)



COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)

COTO 12.9 SLOPE PROTECTION MEASURES
(Surficial/Shallow Slope Geohazards)





ANY QUESTIONS?