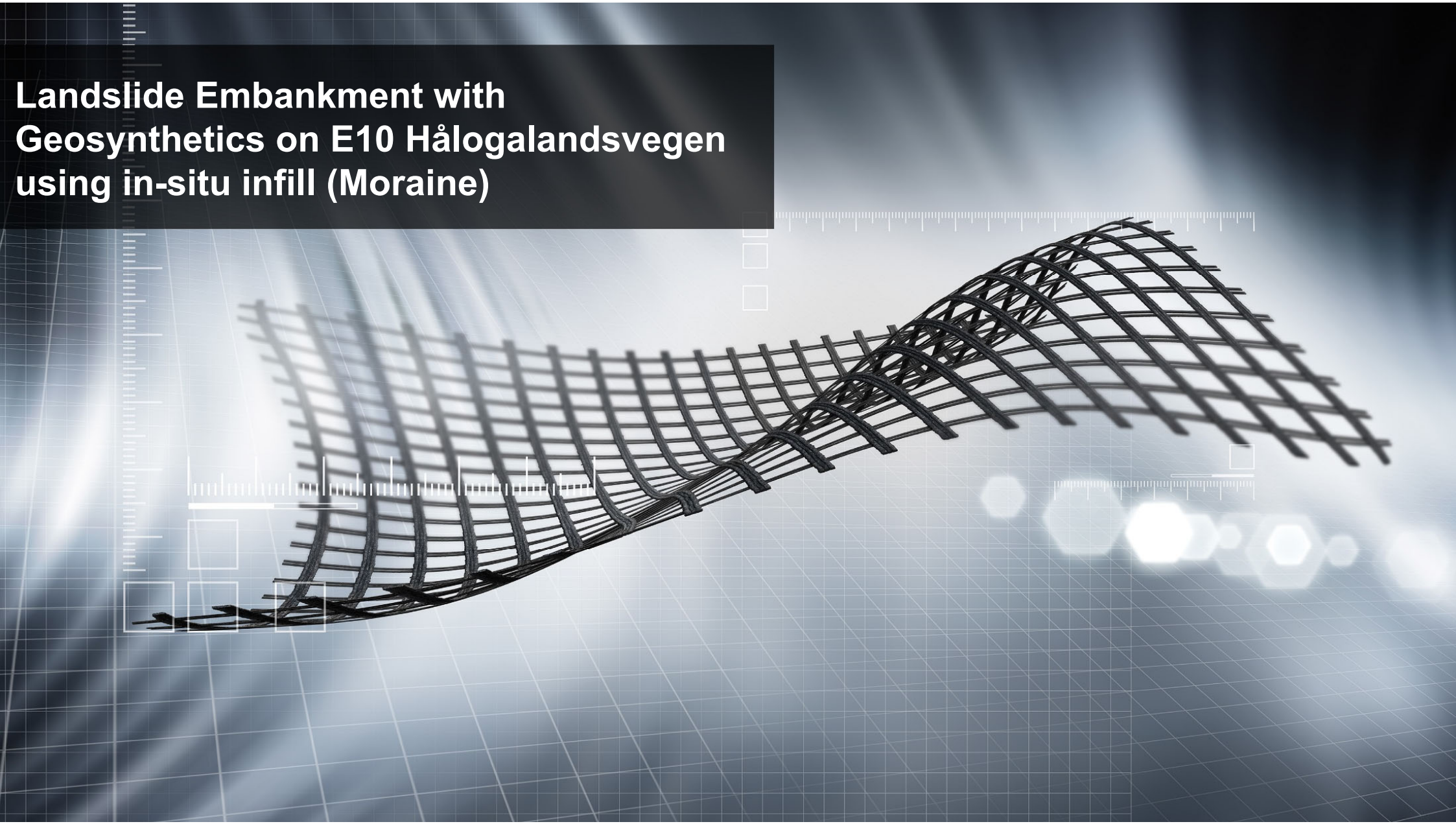
Landslide Embankment with Geosynthetics on E10 Hålogalandsvegen using in-situ infill (Moraine)



P VH#uhwdlqlqj#vwuxfwxuhv

Geosyntia

HUESKER
Ideen. Ingenieure. Innovationen.

Steep slopes

Noise barriers

Quay walls

Geohazard protection dams

Retaining walls

Bridge abutments

Architectural structures

Landslide remediation dams

Geohazards

- Avalanches
- Rockfalls
- Landslides
- Debris, mud, or lava flows
- etc.

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Case studies

Landslide stabilization

- Village in Trento, Italy

Landslide hazard

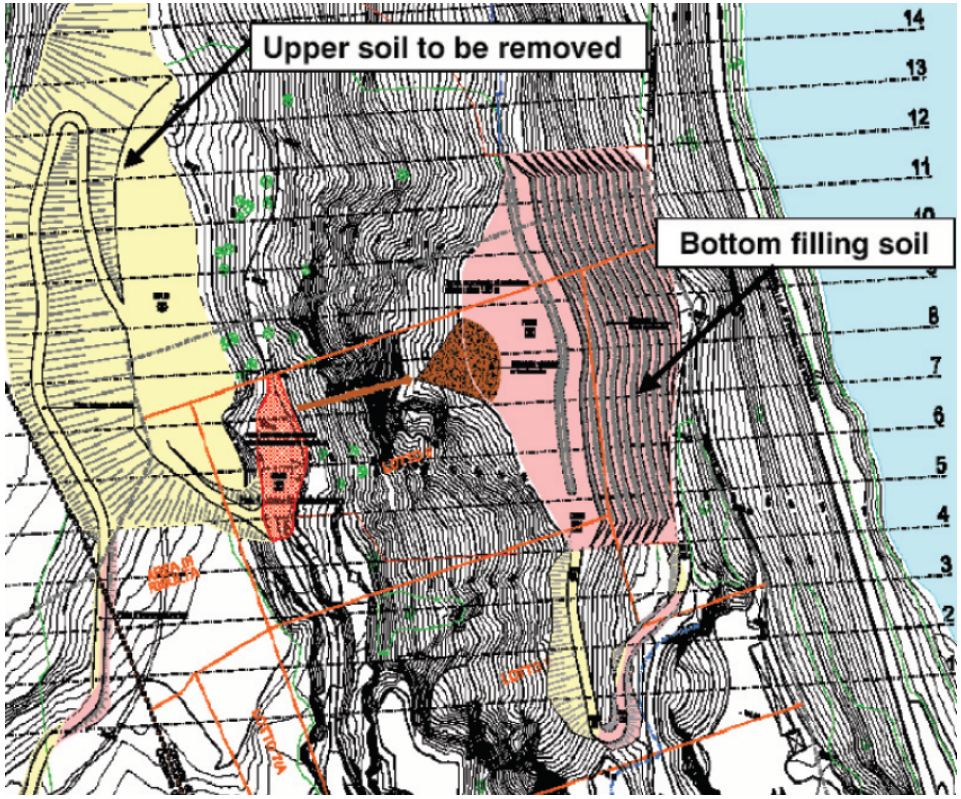
- First signals of slope instability in 1976
- In 1996 movement rate – 30-70 mm/month
- Sliding plane at depth – 15,0-19,0 m

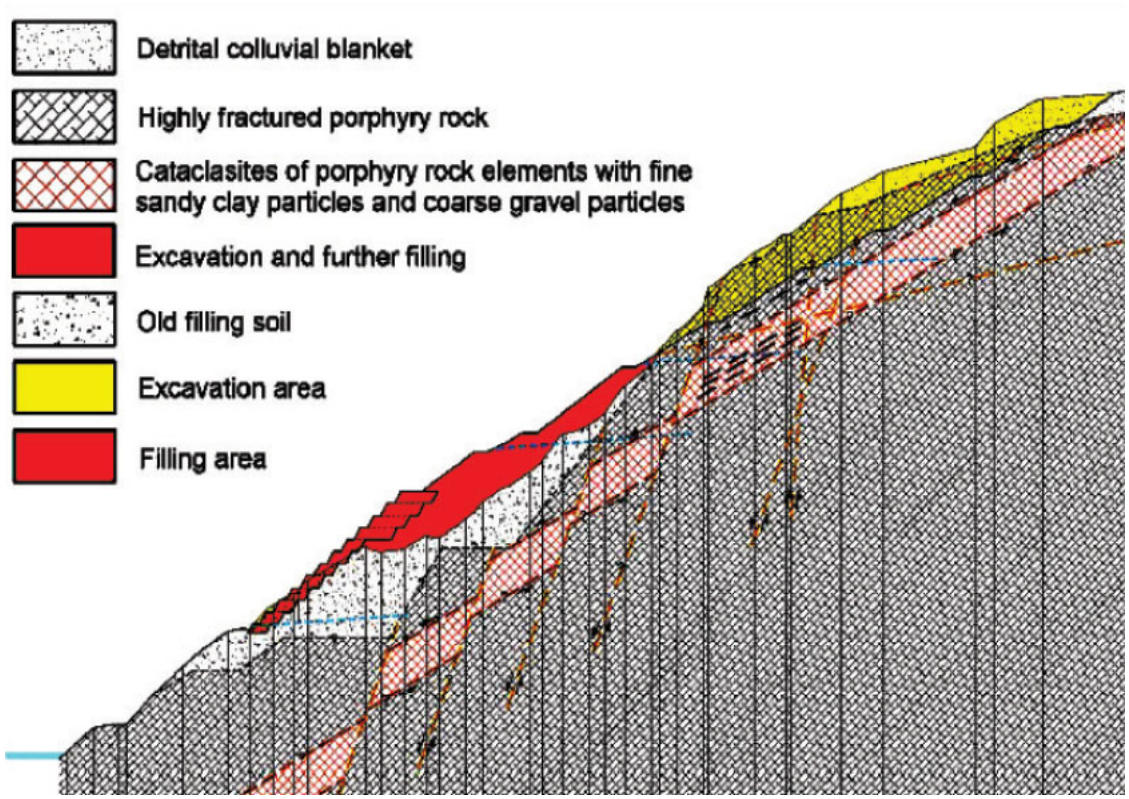
Solution

- Two reinforced slopes: 15 and 60 m
- Facing angle – 60¶
- 3.5 km of sub-horizontal micro-drains
- Instrumental automatic monitoring (inclinometers, piezometers, extensometers, magnetic settling-meters and monitoring benchmarks)

Case studies

- Landslide stabilization
- Village in Trento, Italy





Case studies

- Landslide stabilization
  - Village in Trento, Italy

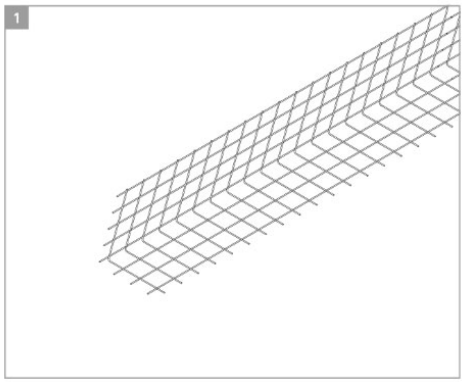
Case studies

- Landslide stabilization
  - Village in Trento, Italy

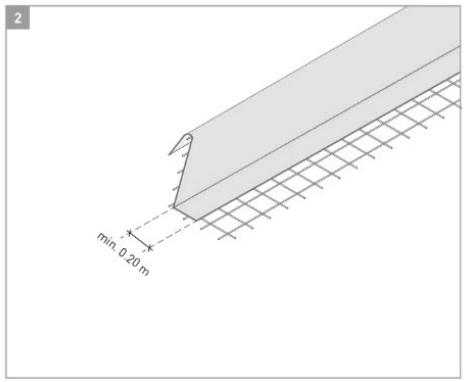
Fortrac Natur System

Installation steps

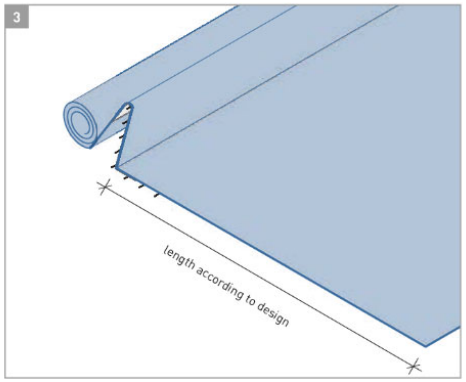
1. Lost formwork



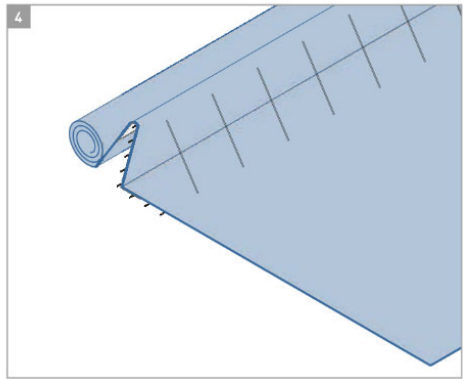
2. Erosion protection



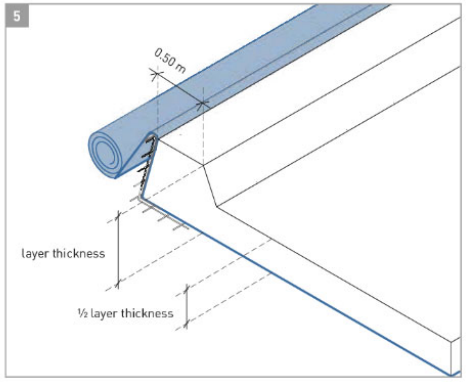
3. Geogrids



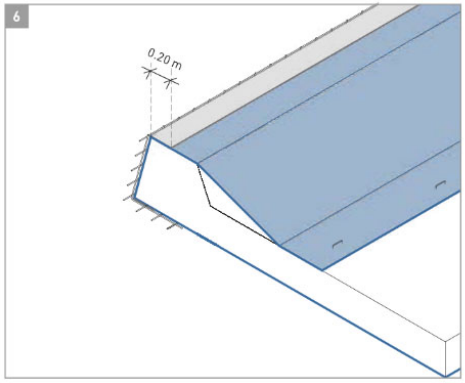
4. Steel bracing bars



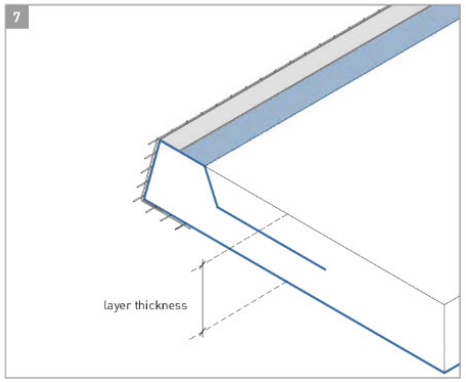
5. Filling and compaction



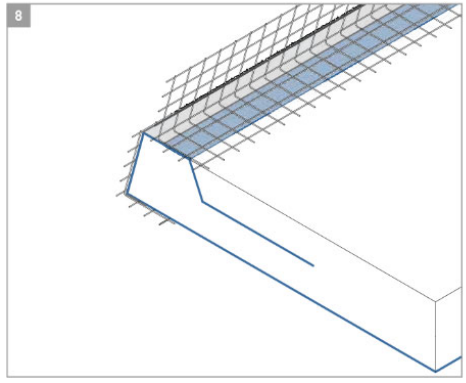
6. Wrap-around



7. Rest of fill and compaction



8. Repetition of steps



Case studies

- Rockfall protection dam
  - Road in natural park Gesäuse, Austria

www.youtube.com/watch?v=V4r7kAepPcE

Case studies

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Case studies

- Debris und flow catching dam
  - Village in Malborghetto, Italy

Fortrac Natur System

- Slope stabilization for mud flows
- Massa Martana, Italy

Case studies

- Slope stabilization for mud flows
- Massa Martana, Italy

Case studies

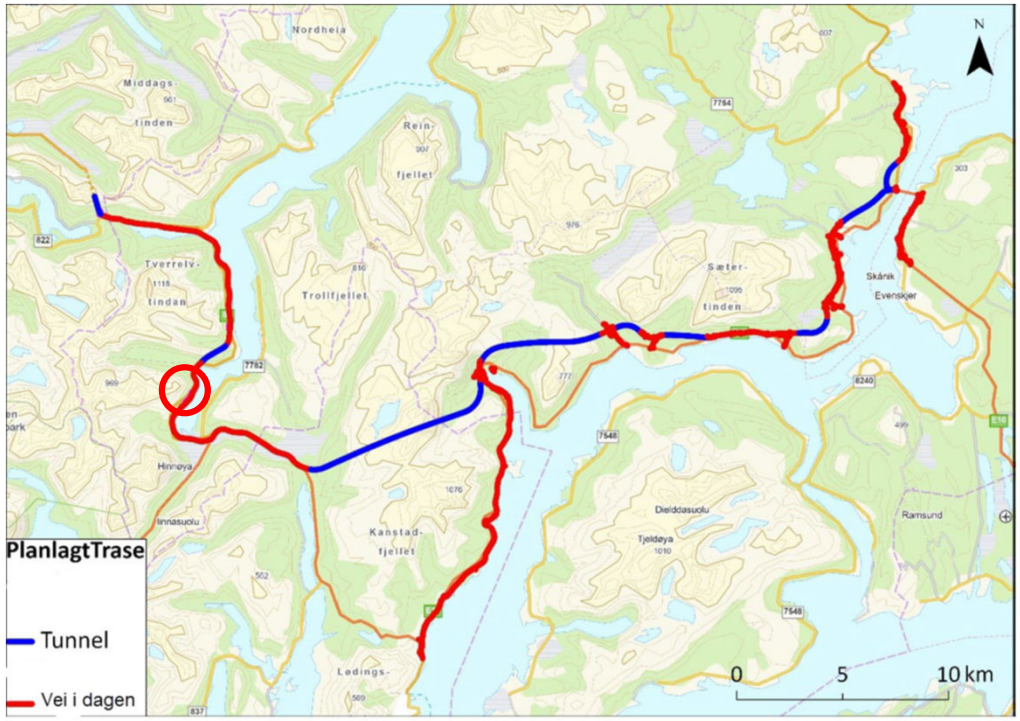
- Rockfall protection dam
- Mountainous road in Torgiovannetto, Italy

Case studies

- Rockfall protection dam
  - Mountainous road in Torgiovannetto, Italy

E10 Hålogalandsvegen

- Location of the site
  - Part of the new infrastructural road project

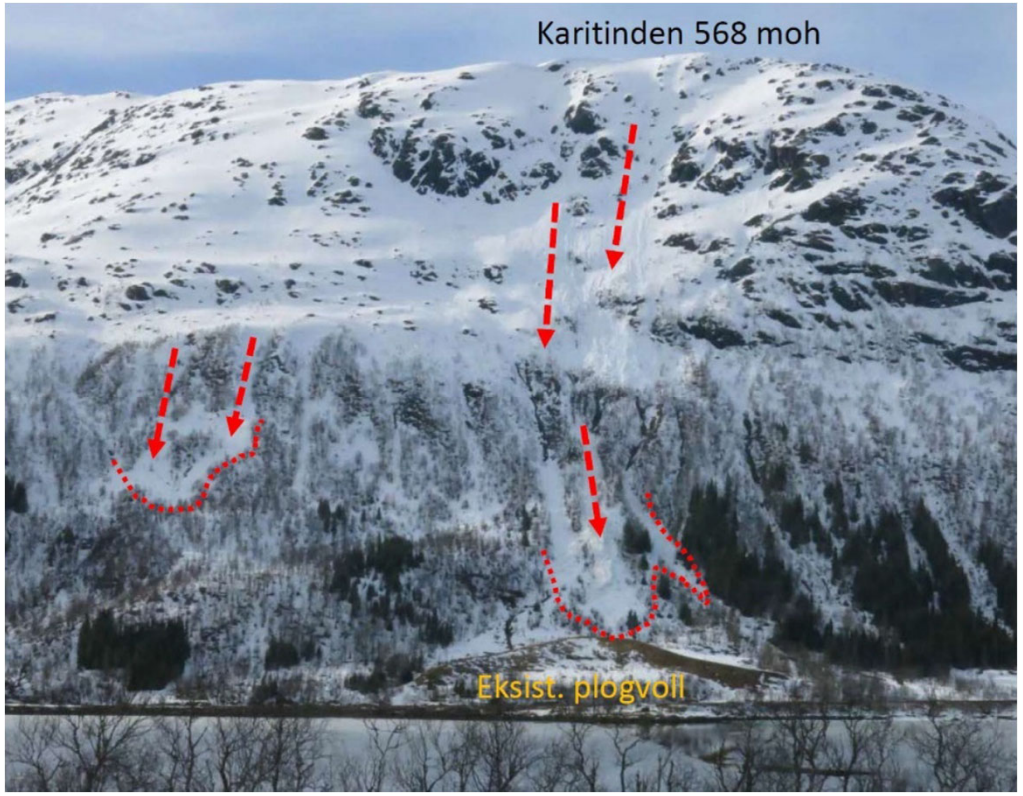


www.google.com/maps/@68.5472518,15.7426101,773m/data=!3m1!1e3?entry=ttu&g_ep=EgoyMDI1MDMwMi4wIKXMDSoASAFQAw%3D%3D

E10 Hålogalandsvegen

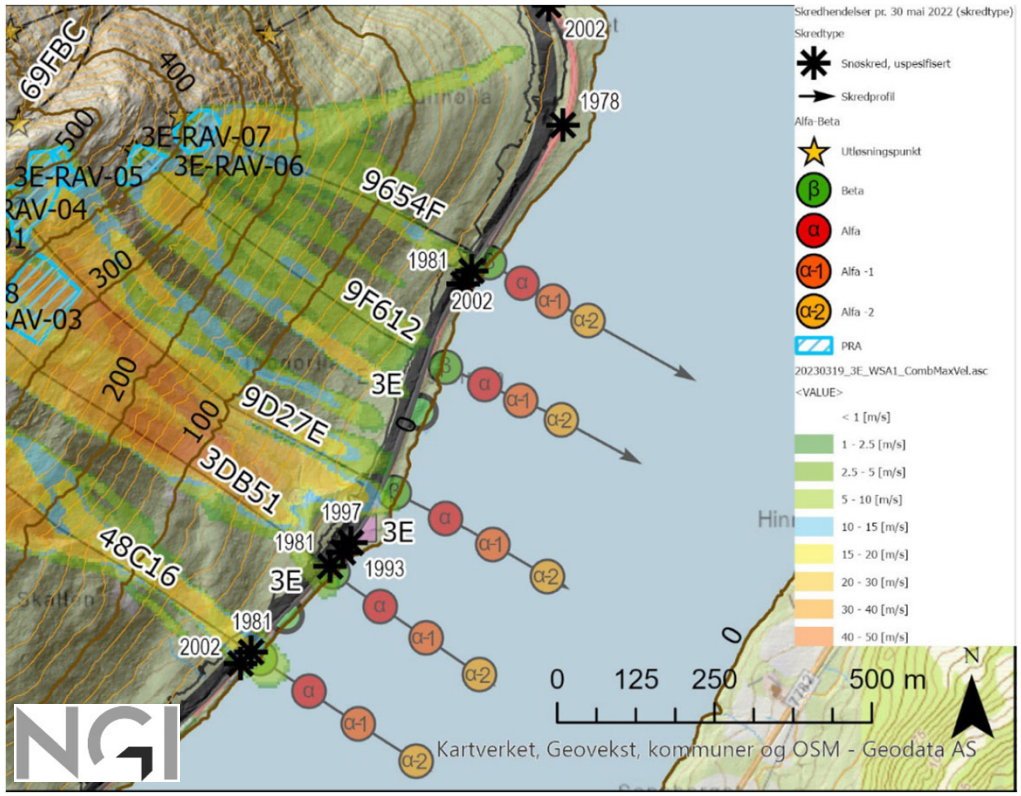
- Location of the site
  - View in summer

  - View in winter and avalanche locations

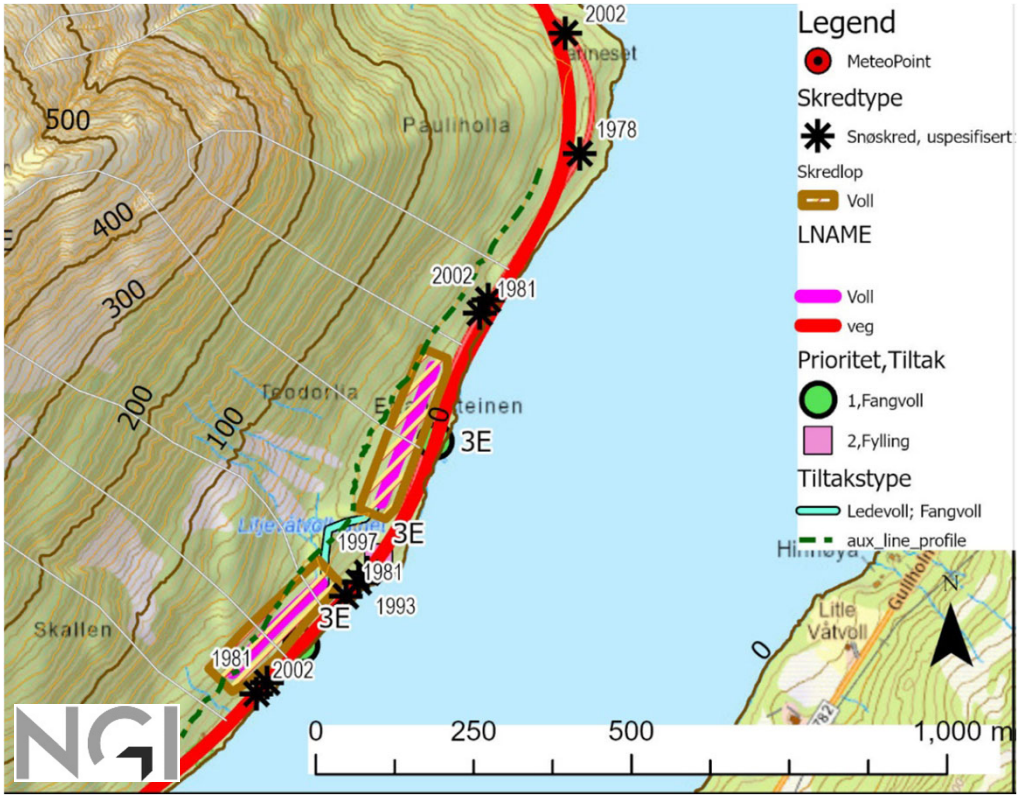


E10 Hålogalandsvegen

- Avalanche hazard estimation made by NGI
  - Avalanche locations and velocities

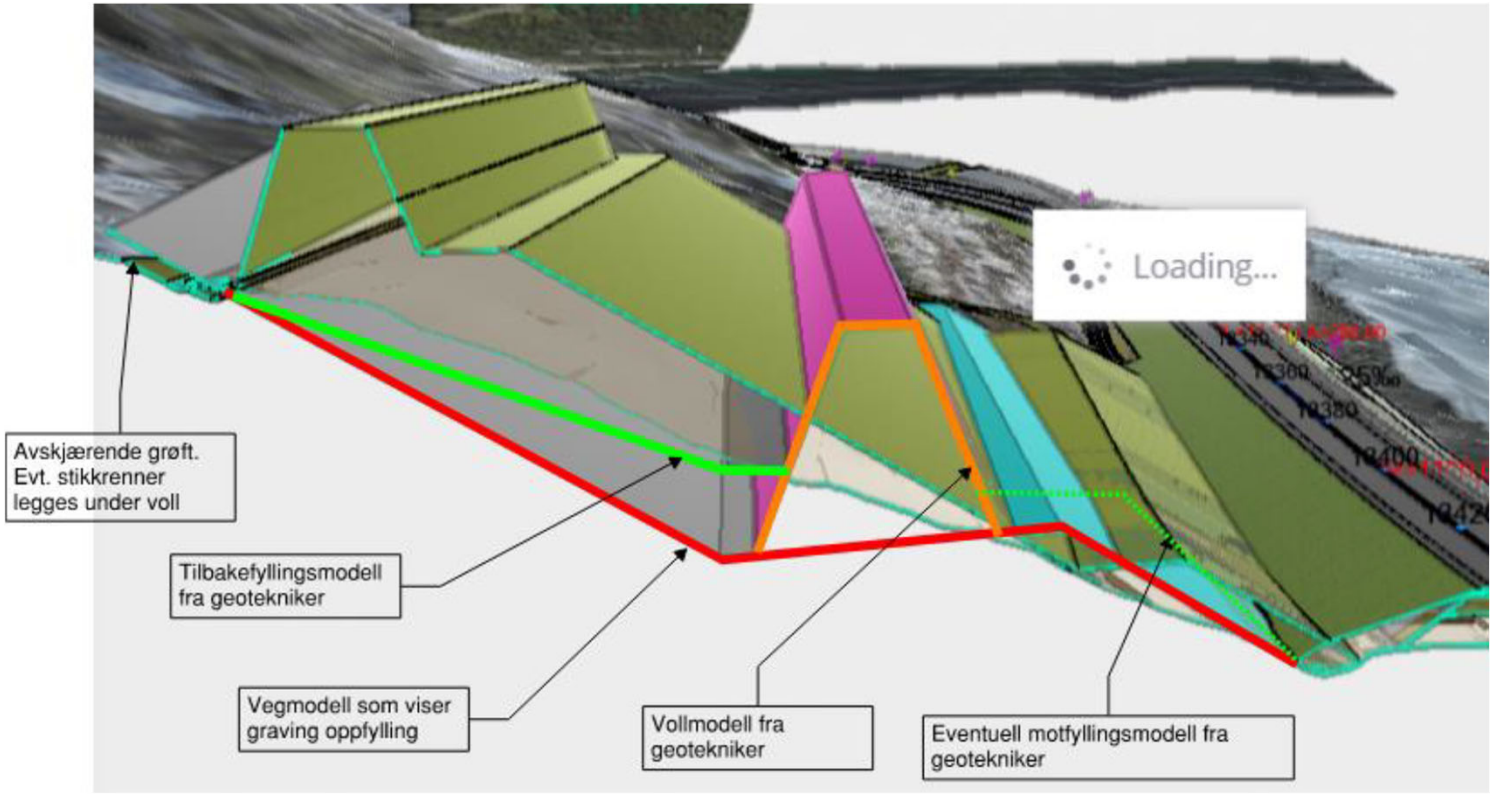


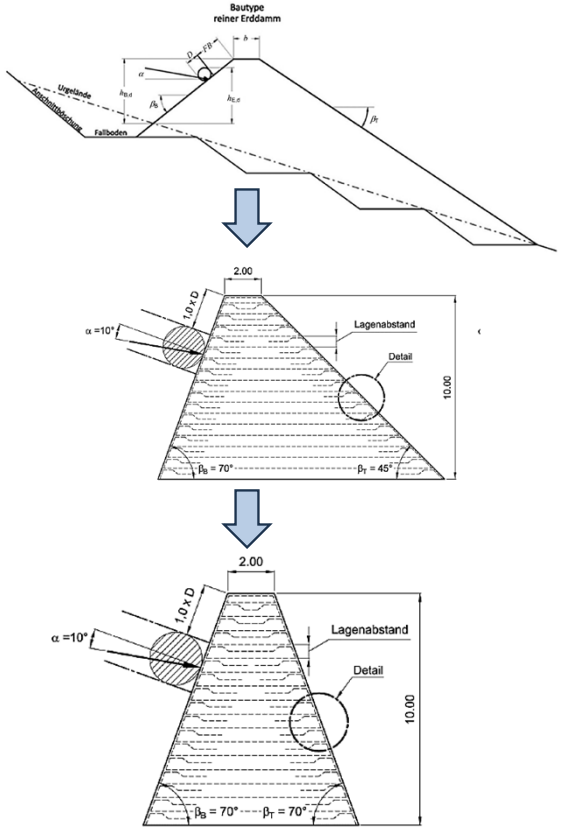
  - Locations of the protection dams



E10 Hålogalandsvegen

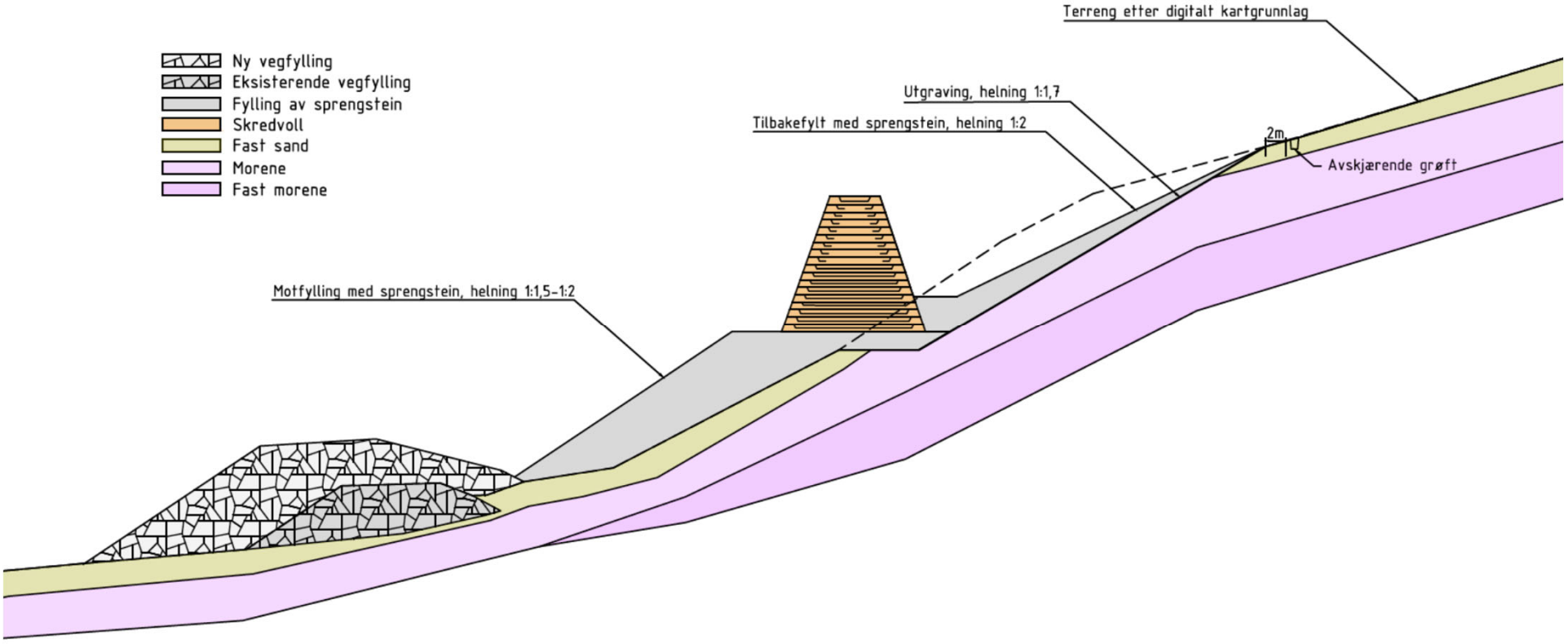
- Design of the protection dam
- Original and optimised design solutions





E10 Hålogalandsvegen

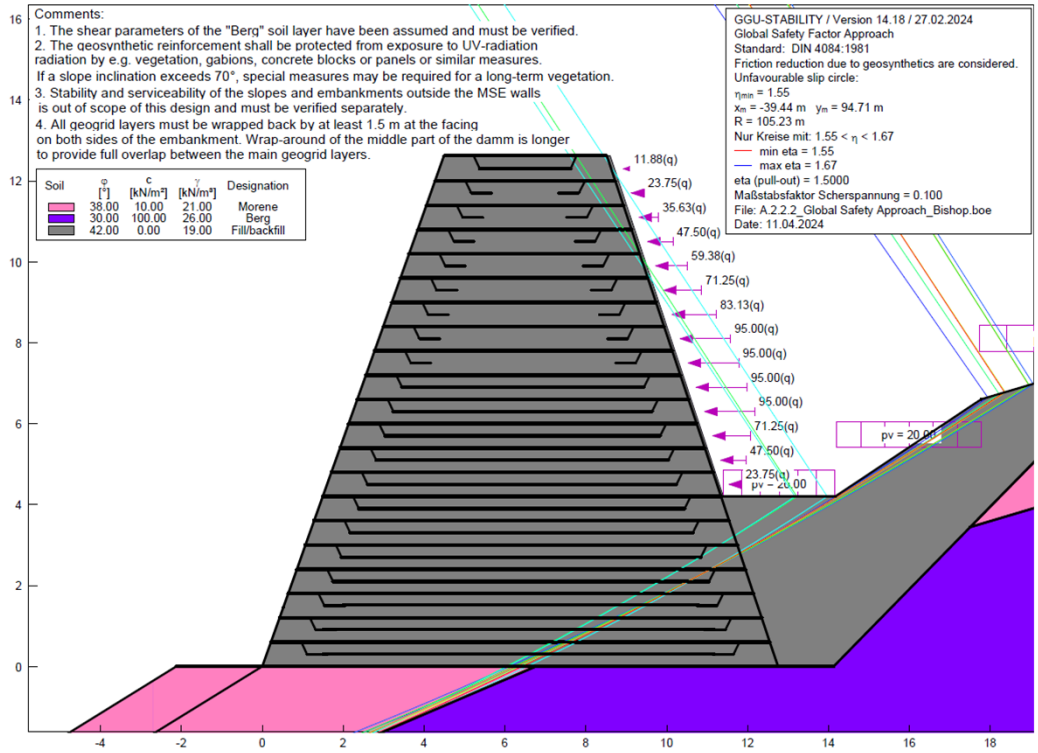
- Design of the protection dam
  - Final design solution



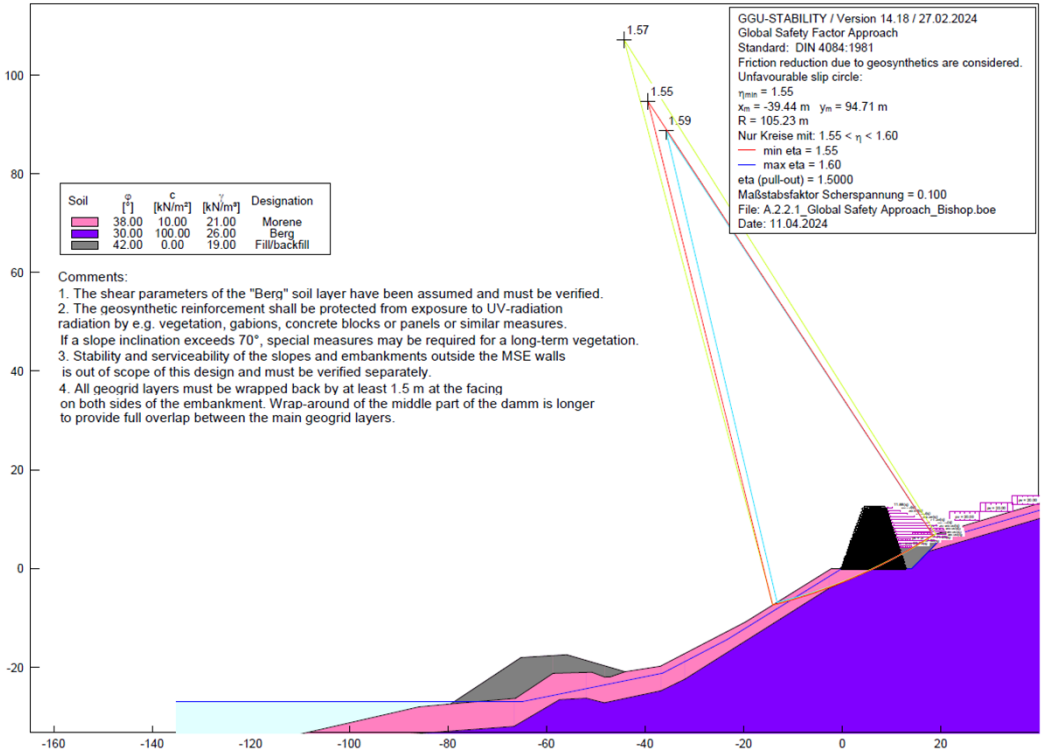
E10 Hålogalandsvegen

Design of the protection dam (analytical, GGU-Stability)

Assumptions for analyses

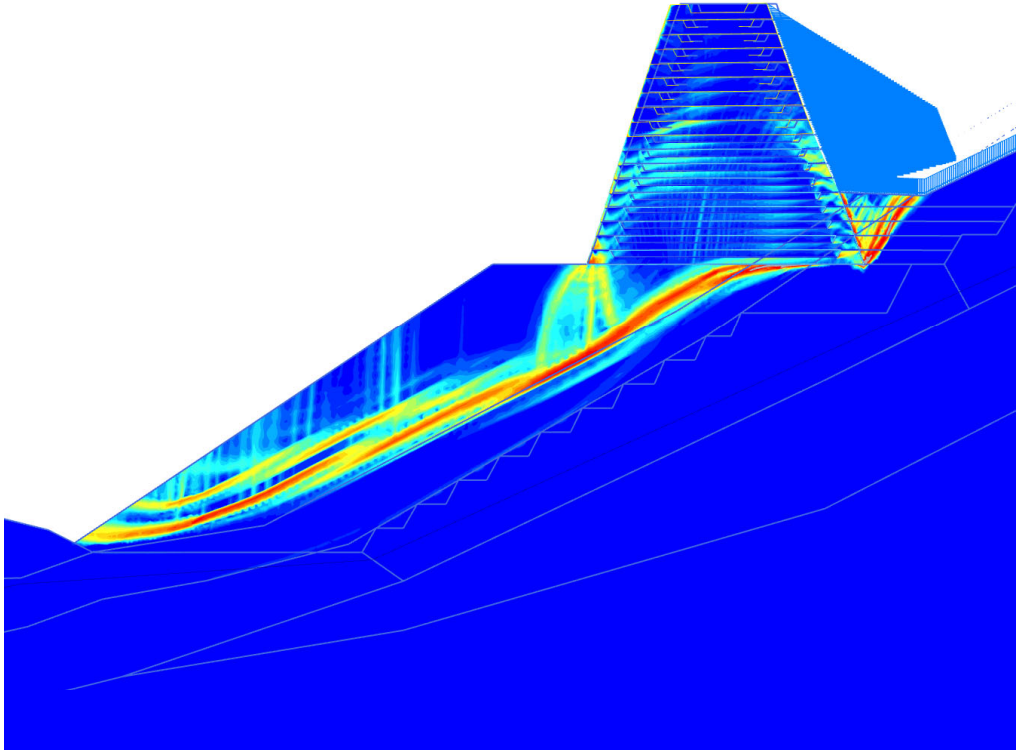


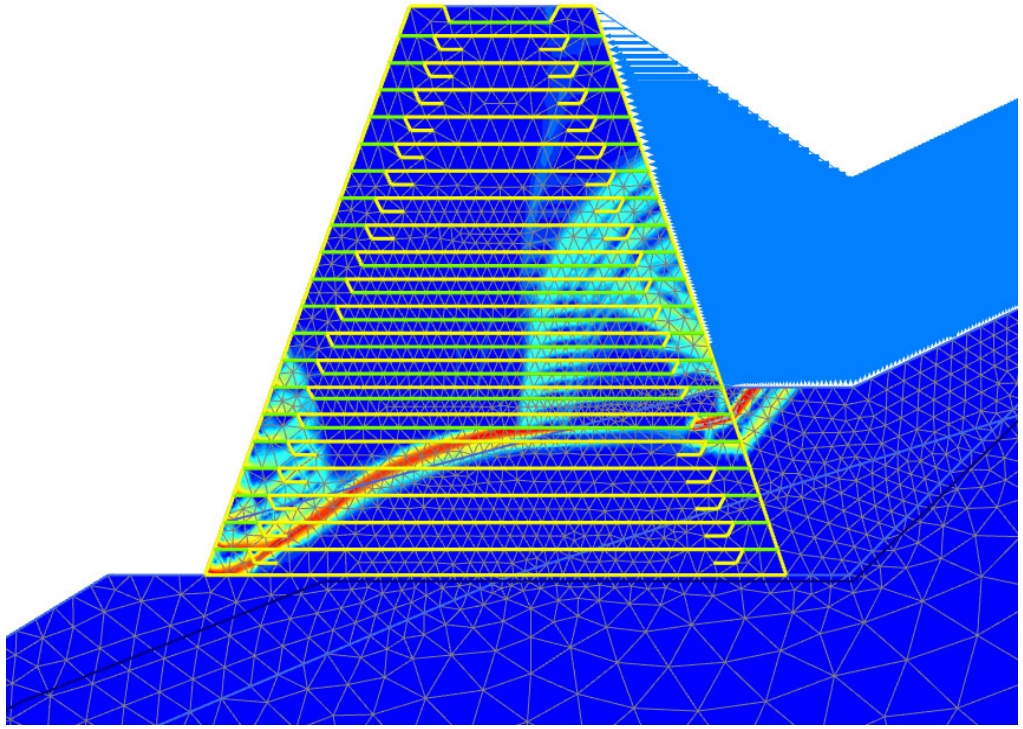
Results of the analytical stability analysis



E10 Hålogalandsvegen

- Design of the protection dam (numerical, Plaxis 2D)
  - Deviatoric strains (external)
  - Deviatoric strains (internal)

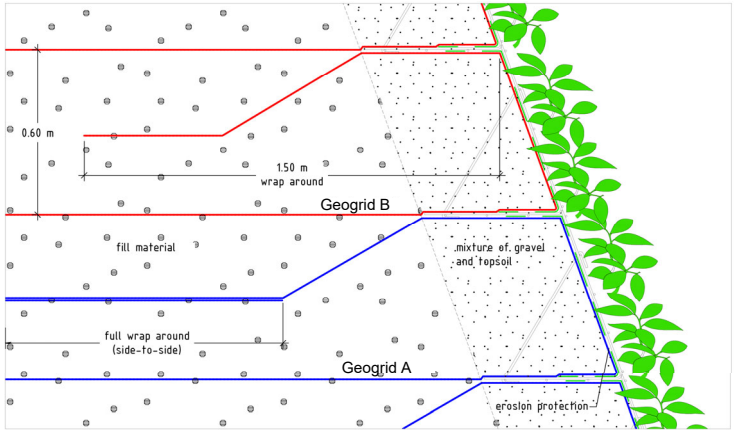


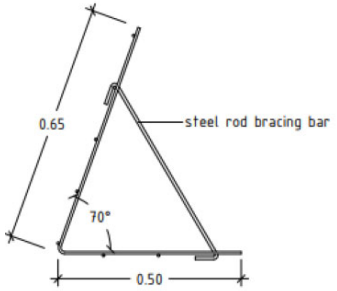


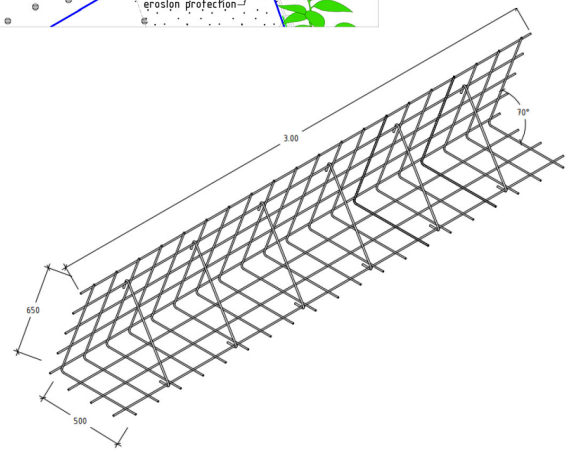
E10 Hålogalandsvegen

Highest cross-section of the protection dam

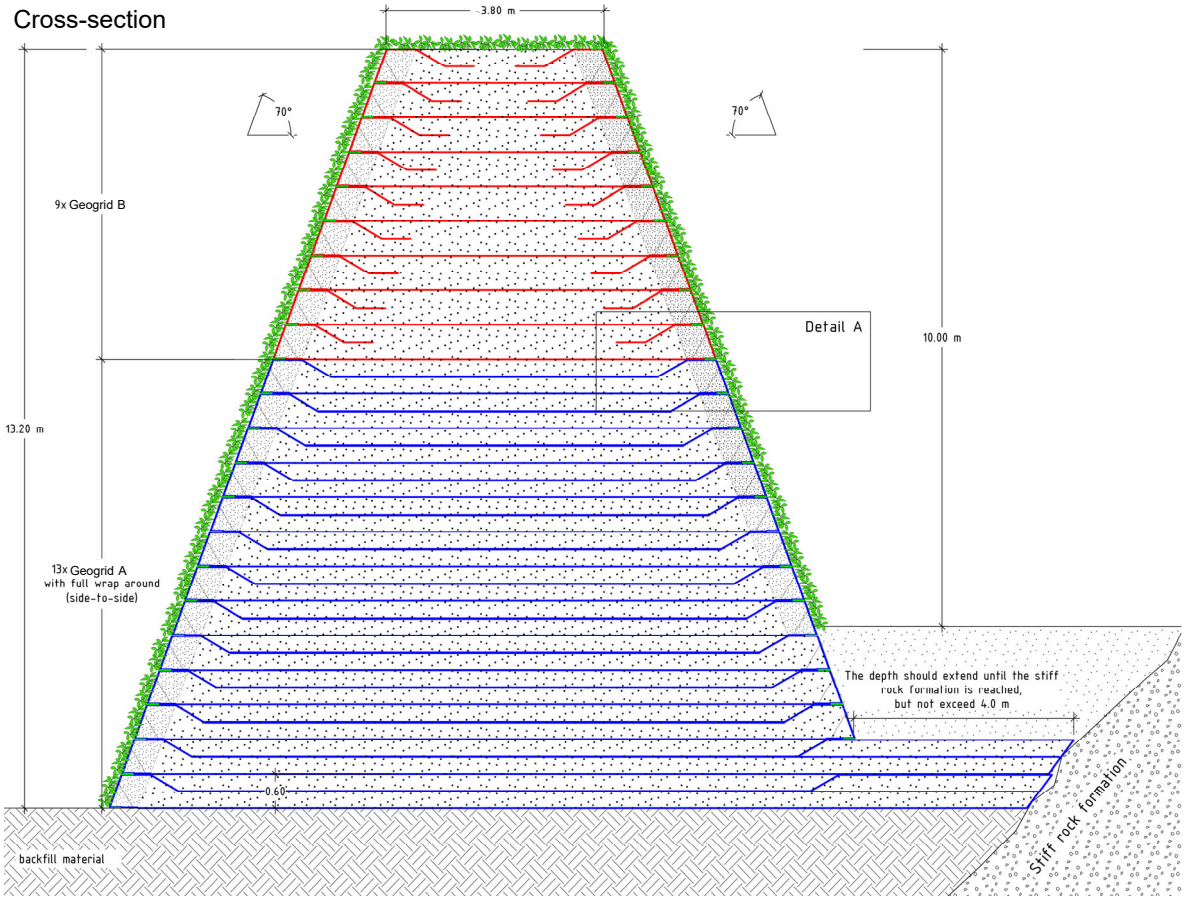
Detail A







Cross-section



E10 Hålogalandsvegen

Analysis of the in-situ soils (Moraine) as fill material

Physical and mechanical properties of laboratory tested materials

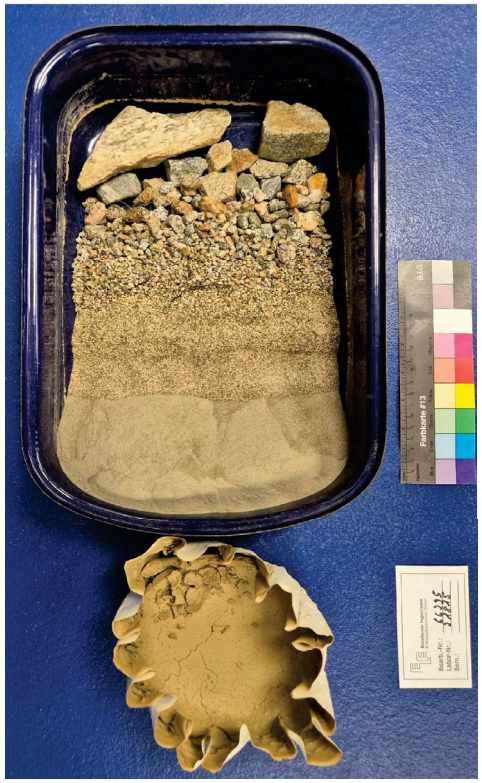
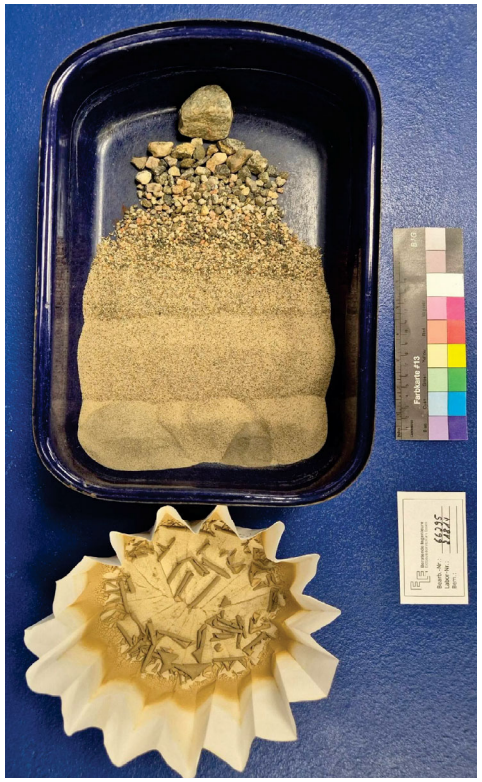
Laboratory No.	Sample name	Soil type according to grain size distribution	Water content w_n [%]
21810	Våtvoll (P 9750)	Medium and coarse sand, highly gravelly, very slightly silty	12,16
21811	Våtvoll	Gravel and sand, slightly silty	14,94
21812	Karineset (P 14150)	Fine and medium sand, highly gravelly, silty	31,36
21813	Karineset	Gravel and sand, slightly stony, slightly silty	13,21
21814	Kvirberget (P 15500)	Sand, gravelly, very slightly silty	16,24
21815	Kvirberget	Sand, gravelly, silty, slightly stony	19,81
21816	Plogvoll	Gravel and sand, slightly stony, slightly silty	10,16

Laboratory No.	Sample name	Dry density after compaction with 1x Proctor energy and w_n ρ_d [g/cm³]	Water content w_n [%]	Grain density ρ_s [g/cm³]
21810	Våtvoll (P 9750)	1,837	12,16	2,66
21813	Karineset	1,878	13,21	2,69
21814	Kvirberget (P 15500)	1,753	16,24	2,67
21816	Plogvoll	1,850	10,16	2,71

Laboratory No.	Sample name and soil type	γ_k [kN/m³]	γ'_k [kN/m³]	φ'_k [°]	c'_k [kN/m²]	$E_{s,k}$ [a)] [MN/m²]
21810	Våtvoll (P 9750) Medium and coarse sand, highly gravelly, very slightly silty	18,5	10,0	42,5	0	≥ 80
21811	Våtvoll Gravel and sand, slightly silty	18,0	10,0	42,5	0	≥ 80
21812	Karineset (P 14150) Fine and medium sand, highly gravelly, silty	18,0	10,0	37,5	2,5	≥ 80
21813	Karineset Gravel and sand, slightly stony, slightly silty	18,5	9,5	40,0	0	≥ 80
21814	Kvirberget (P 15500) Sand, gravelly, very slightly silty	17,5	9,0	40,0	0	≥ 80
21815	Kvirberget Sand, gravelly, silty, slightly stony	18,5	9,5	37,5	2,5	≥ 80
21816	Plogvoll Gravel and sand, slightly stony, slightly silty	18,5	9,5	40,0	0	≥ 80

E10 Hålogalandsvegen

- Analysis of the in-situ soils (Moraine) as fill material
  - Granulometry of laboratory tested materials

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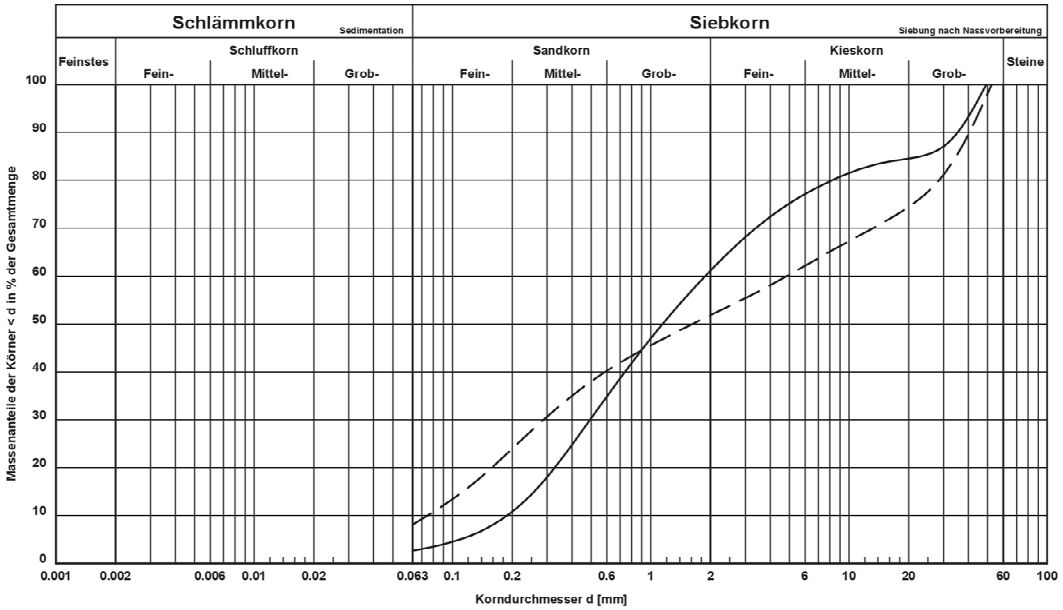
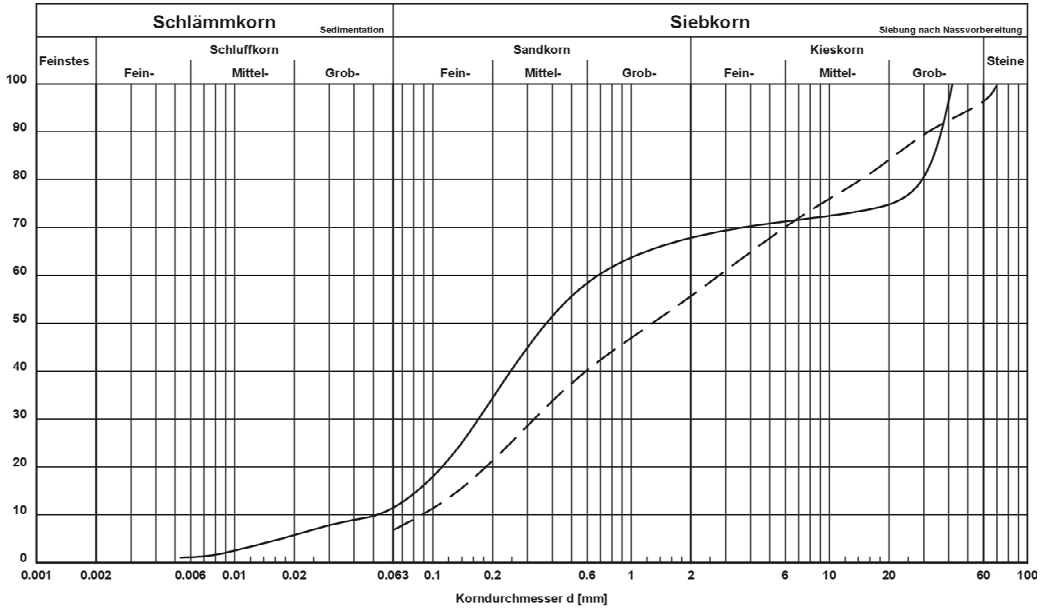
  - Granulometry of laboratory tested materials





E10 Hålogalandsvegen

- Construction
  - Preparation of the site and foundation platform

E10 Hålogalandsvegen

- Construction
  - Installation of lost formworks, erosion protection, and geogrids

E10 Hålogalandsvegen

- Construction
- Placement and compaction of fill material at the front

E10 Hålogalandsvegen

- Construction
  - Placement of fill material at the front

Questions?


How
Why
When
Where
Where
When
Why
Who
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What
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How