8th European Conference on Geosynthetics

EUROGEO 8
LILLE 2025 15-18 September

Geosynthetics in the Northern countries: geotechnical and environmental challenges

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Geotechnical and environmental challenges

- Harsh climate
  - Temperature variations
  - Frost, ice and snow
  - Sea ice
  - High ground water table
  - Wind and wave actions
- Challenging soil conditions
  - Soft and compressible subsoils
  - High ground water table
  - Quick clay

Quick clay landslides

Kråkenes Alta, Norway 2020

- Covered by ice until abt 10.000 years ago
- Marine clay deposited in salt sea water have become dry land since ice melted and salt pore water washed out - quick clay
- Becomes liquid if overloaded and collapses-possible major landslides
- No chance to stop-must prevent initial slide

Environmental effect and challenges

Flooding and landslides

Freeze/thaw actions

Climate change: More extreme weather conditions, high intensity precipitation, increased frequency of freeze/thaw cycles, snow melting occuring during winter period

Geosynthetics – the beginning

- Road construction in areas with soft subsoil
- Public road authorities were pioneers
- Road structures on peat and soft subsoil
    - Separation gtx
    - Geogrid

Design and specification

- Design very much based on experience and producer recomendations
- Not always relevant for specific nordic conditions
  - Soft subsoil
  - Low volume traffic
  - Freezing and thawing
- Need for non-product specific design and specification

- Alfheim & Sørlie (1977): Testing and classification of fabrics for applications in road constructions.
- Classification system for gsy for separation and filtration in roads
- Used by road authorities in Finland, Sweden, Iceland and Norway

Specification and certification

- Classification system basis
  - 5 application classes
  - CBR-test
  - Cone-drop test
- Recommendations for class
  - Subsoil conditions
  - Fill material
  - Construction cond
- No certification system
  - Only based on laboratory results
  - No control on laboratories or products after initial testing

- Development of common European standards-CEN TC 189

- NorGeoSpec 2002
  - R&D project Finland, Sweden, Norway
  - Laboratory and field testing

NorGeoSpec R&D-project 1998-2000

- Clients: Public road authorities in Iceland, Finland, Sweden and Norway
- Research: SINTEF, Norway and VTT, Finland
- Collection of experiences from the field
- Full scale field tests
- Laboratory testing
- Basis for NorGeoSpec 2002 specification and Certification system

NorGeoSpec rev 2012 (NGS 2012)

- Quality Product Specification, Function separation and filtration
  - 5 specification classes
  - Requirements related to results from EN test methods
    - Area weight (variation)
    - Tensile strength (min)
    - Tensile strain
    - Drop cone (Max)
    - CBR-strength
    - Strain Energy

- Quality Product Certification, Function separation and filtration, reinforcement
  - SINTEF Certification body
  - Testing at certified European laboratories
  - Certification period 2 years
  - Initial testing
  - Random sampling with limited number of test at producer or distributor

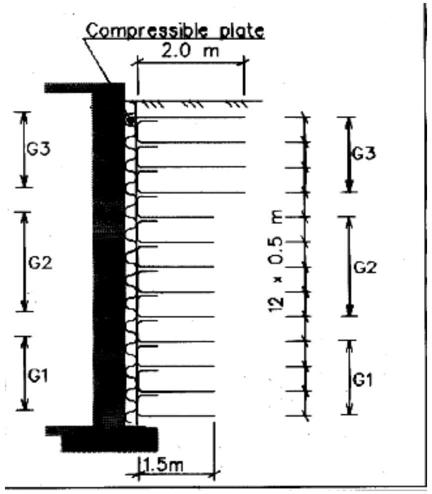
NGS 2012 - Organisation

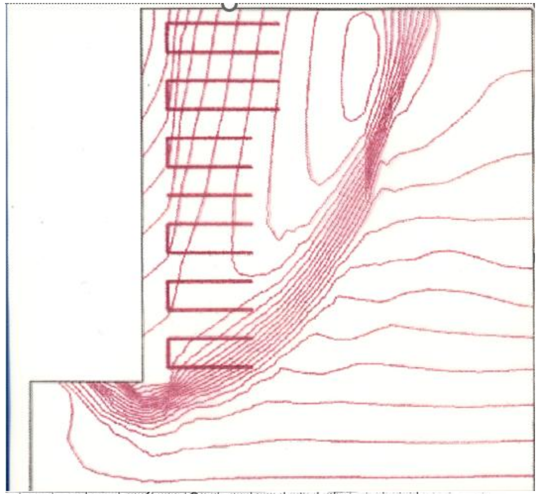
- Technical committee (TC)
  - Certification Body (SINTEF
  - Traffic authorities
    - Norway
    - Sweden
    - Finland
    - Estonia
  - Technical advisors
- Advisory board (AB)
  - TC
  - Laboratory representatives
  - EAGM (Producers)
- Technical seminars

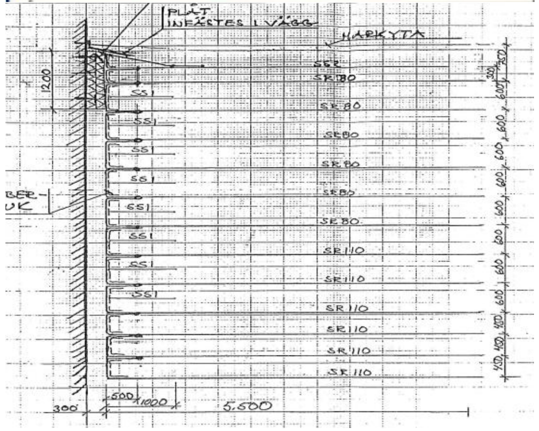
Regulations and guidelines

- Originally very much based on rules from other countries
  - UK
  - Germany
  - US
- Design and recommendations for construction not always suitable for Nordic conditions
- Examples of failures due to unsuitable structural solutions

Åre School, Sweden







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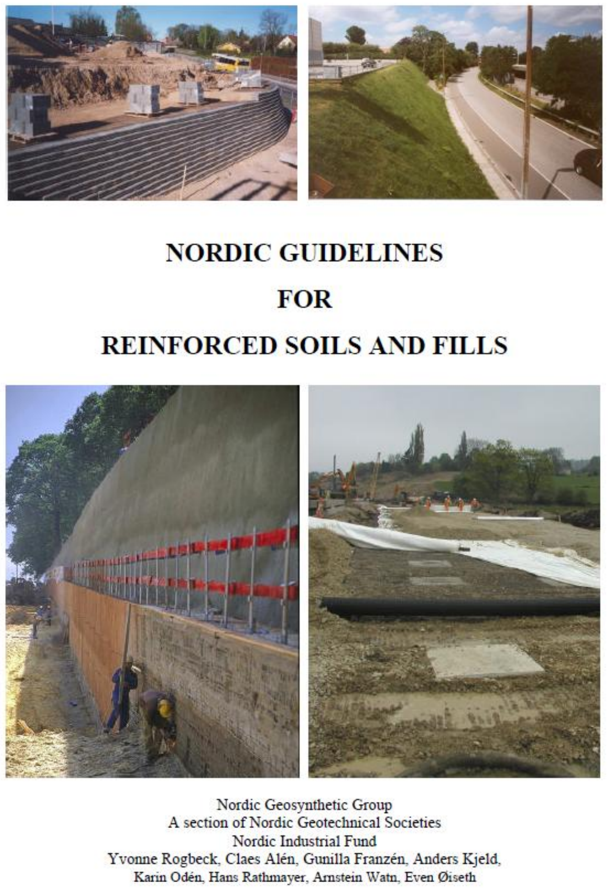
Development of Nordic guidelines

- Nordic co-operation in European Standardisation
  - Climate (low temperature, freeze/thaw)
  - Soil conditions (soft and compressible subsoils)
  - Backfill material (typically crushed angular rock)
- Nordic Guidelines for Reinforced Soil and Fills (2002-2004)
  - Geotechnical Societies in Denmark, Finland, Norway and Sweden
  - Traffic Authorities
  - Nordic Industrial Funding


NORDIC GUIDELINES

FOR

REINFORCED SOILS AND FILLS

Nordic Geosynthetic Group
A section of Nordic Geotechnical Societies
Nordic Industrial Fund
Yvonne Rogbeck, Claes Alén, Gunilla Franzén, Anders Kjeld,
Karin Odén, Hans Rathmayer, Arnstein Watn, Even Øiseth


NORDIC GUIDELINES

FOR

REINFORCED SOILS AND FILLS

Nordic Geosynthetic Group

NGF 1950

NORDISK innovations CENTER

May 2003

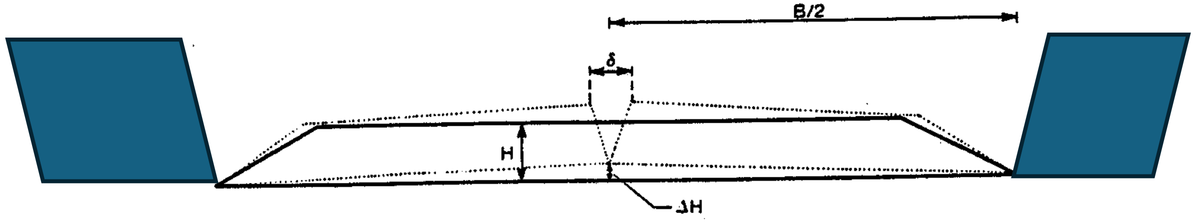
Revision A – February 2004

Stabilisation - Roads and other traffic areas

- Sparsely populated
- Many km of roads and other traffic areas per capita.
- Large part of the road network has a relatively small traffic volume
- The traffic may impose significant loading from heavy trucks from timber transport, fish farming etc
- Soft subsoil and freeze/thaw actions
- Deterioration dominated by plastic deformations
    - Heavy loads during thawing period

Edge deformations

Frost heave



Effect of geosynthetic reinforcement

- Geosynthetic has very little impact on the elastic stiffness of the road
- May significantly improve the resistance against plastic déformations (rutting, edge déformations, frost heave)
- Geosynthetics for improving bearing capacity and reduced déformations

- Test project, road on peat,1984 Vesterålen, Northern Norway

Cost Reipas project (2002-2005)

- Deterioration mechanisms and applicability of geosynthetics
- The purposes of using reinforcement reported in the survey:
  - Increase pavement fatigue life
  - Minimize differential and total settlement
  - Reduce rutting – surface and subgrade
  - Prohibit or limit reflective cracking
  - Increase resistance to cracking due to frost heave
  - Reduce natural mineral usage
  - Reduce maintenance costs
  - Increase bearing capacity
  - Bridging over voids
  - Economic construction platforms

- Reinforcement in roads is to a large extent used to reduce deterioration dependent on local conditions.
  - Foundation
  - Moisture
  - Temperature
  - Traffic conditions
  - Types of granular materials
  - Types of overlay
  - Precipitation
- Frost penetration may cause considerable frost heave during the winter and loss of bearing capacity when the frost is melting in the spring
  - Not recommended to reduce the aggregate thickness of the structure
  - Temporary roads
  - Reduce rutting during the service lifetime.

Road Reinforcement
Design models and recommendations

- R&D-project focusing on geosynthetics for road maintenance (1990-1992)
  - SINTEF
  - Road Authorities
  - Norwegian army
  - Norwegian Aviation Authorities
- Guidelines for reinforcement in roads (2006)
  - Evaluation of potential benefits from using reinforcement
  - Recommendations for design and construction
  - Reinforcement both in granular layers and in the asphalt overlay.

- GeoRePave (2004-2006)
  - Montana State University
  - SINTEF
  - Design methods for reinforced unbound base course layers in roads
    - Numerical material models
    - Numerical modelling methods
  - Beneficial effects evaluation
    - Traffic Benefit Ratio (TBR): ratio of allowable traffic passes for a reinforced base course.
    - Base Course reduction Ratio (BCR): ratio for the reinforced base thickness

Geosynthetics for reinforcement of roads and other traffic areas

- Pavement reinforcement with geosynthetics has been used for more than 40 years
- Promising potential and the beneficial effects of the reinforcement may both reduce construction costs and enhance the road performance
- Large amount of research projects
- Large number of successful projects in the field
- Pavement reinforcement still not recognised at same level as conventional methods
- Lack of technically sound models for the function mechanisms of the reinforcement
- Need proper non-product related design models

Test road Hitra, Norway (2000)

- Road rehabilitation related to damage from heavy trucks (fish-farming)

- Documented effect related to reduced plastic deformations
    - Rutting
    - Edge deformations

Installation and Construction

- Challenging conditions for installation and construction
  - Short working hours with daylight during the winter
  - Soft and frost-susceptible soils
  - Low temperatures
  - Ice, snow, and frozen subsoil
  - Installation and construction may cause damage to the products and improper installation
- The general regulations and guidelines give limitations on when installation and construction with geosynthetics can be carried out
- Restrictions on installation and construction have a major impact on the possible use and economic benefits of using geosynthetics
- Limitations related to installation in cold temperatures have major consequences
  - Construction using geosynthetic in general can’t be done during the winter
  - Basis for the limitation in cold temperatures was experiences where geosynthetics had exhibited damage by cracking when installed and covered with fill material at low temperature,

Photo: Trafikverket, Sweden

Rough-project (2018-2023)

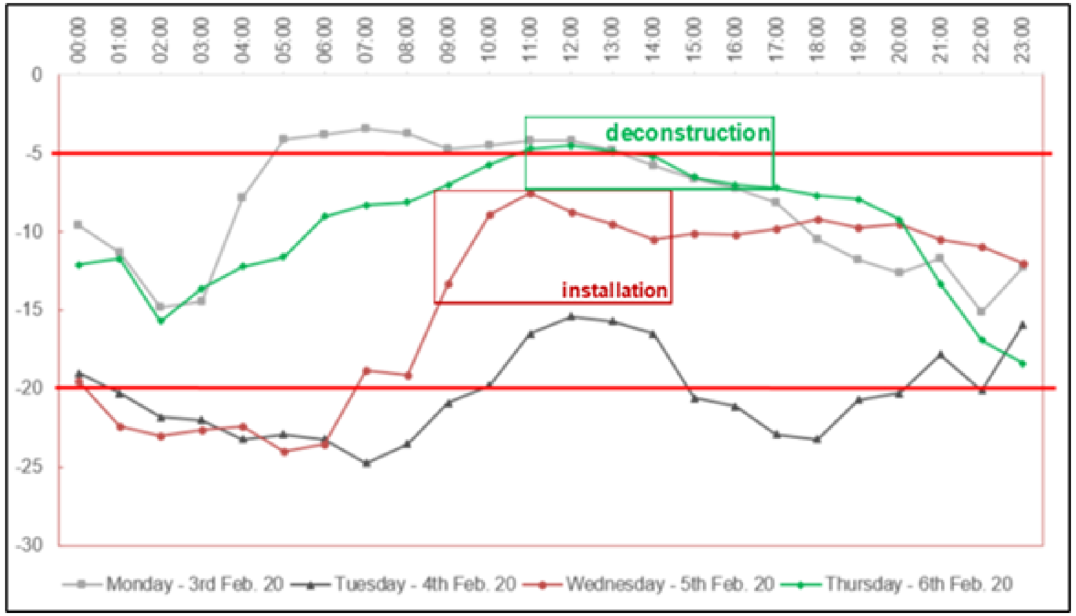
RecOmmendations for the Use of GeosyntHetics in Nordic conditions

- Special requirements for geosynthetics to ensure technically and economically optimal solutions in country-specific climates and soils
- Participants
  - Traffic Authorities in Finland, Sweden and Norway
  - Research institutes
  - Universities
  - Group of producers

- Focus on cold temperature
- Local soil conditions in the Nordic countries
- Local construction methods
- Typical aggregate materials
  - Crushed rock
- Included
  - Survey of experiences
  - Literature studies
  - Laboratory investigations
  - Full-scale field test.

Test field in Kemi Border Finland/Sweden

Installation and construction under low temperatures



Kemi - Installation and construction

Extraction of products

Really LARGE vacuum cleaner!

Rough results

- Product functions
  - Road reinforcement/stabilization
  - Filtration
  - Drainage
- 13 products
- The results from the ROUGH-project is basis for recommendation and guidelines for installation and construction with geosynthetics under Nordic conditions (2023)

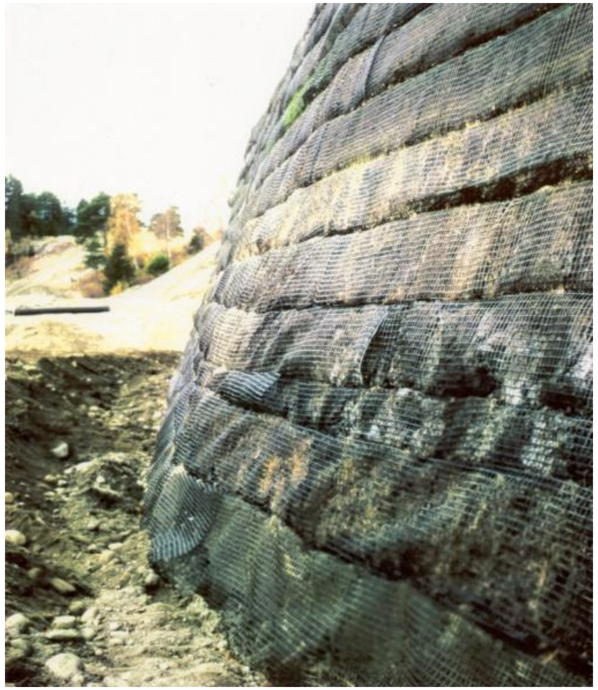
https://www.norgeospec.org/acms/recommendations-for-the-use-of-geosynthetics-in-nordic-conditions-rough/

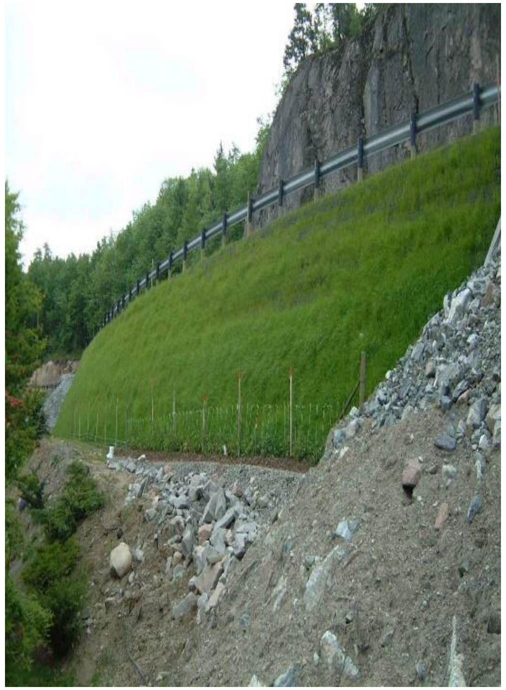
Conclusions

- If geosynthetics are correctly designed for a positive temperature (e.g., + 20 °C) for the defined geotechnical conditions of installation (type of soils, drop height, compaction, etc.), no additional installation damage is observed on the essential characteristics when the products are installed under the same conditions at - 10°C:
  - Tensile strength and tensile stiffness for reinforcement/stabilisation,
  - Robustness factor and characteristic opening size for filtration,
  - Water flow capacity for geosynthetic drainage composites.

Green vegetated slopes

- Environmentally friendly
- Economically beneficial
- Vegetation dependent on water supply
  - Back fill with fine grained soils with water
  - May cause damages from frost actions
- Geogrid reinforced slopes with peat block front
  - Moisture « magazine »
  - Frost insulation

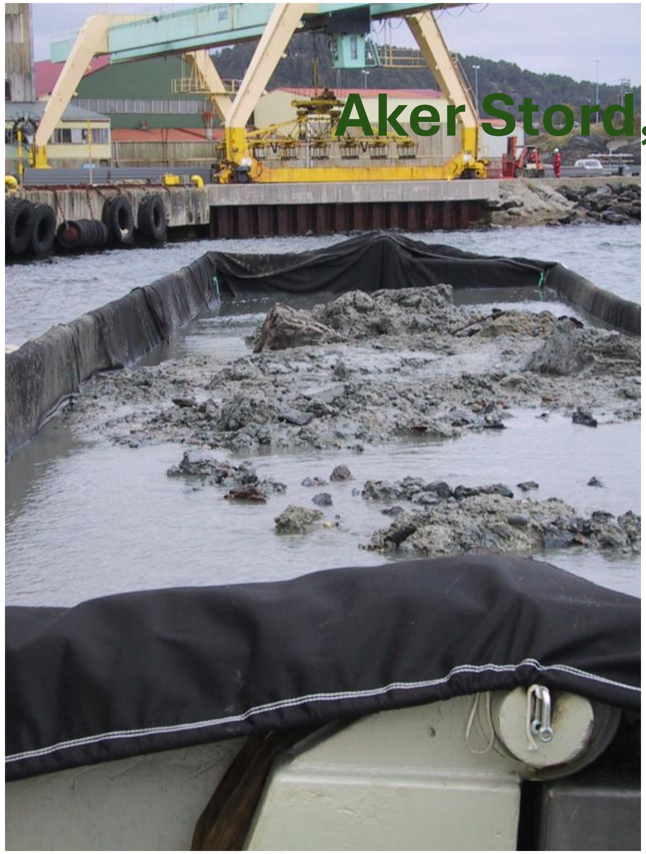




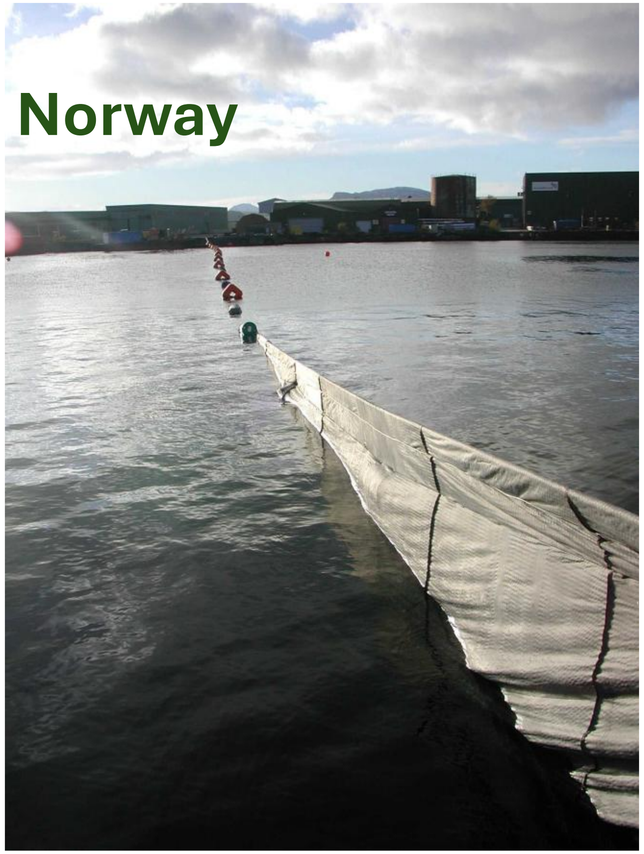
- Peat-blocks are produced from peat with a natural-based binder
- Size of 30cmx40cmx12cm

Geotextiles for dredging and deposit of contaminated masses

- Contaminated sediments in harbours are common
- Challenging and expensive operations
- Geotextiles as silt curtains in the sea and as geotubes-for deposition of the materials-
- Challenges
  - Contaminator is unknown or not available
  - Dredging may result in further spreading of contamination
  - Permanent storage requires high degree of security,
  - Complex matters: Chemical knowledge, biological, geotechnical, marine technology
  - Growing in the sea results in increased weight and increased forces from water flow



Aker Stord, Norway



Building on soft and unstable ground

- Embankments on soft subsoil can be challenging
  - Stability Settlements
  - Geosynthetics to avoid stability problems
  - Light weight material to reduce settlement
    - Light weight expanded clay
    - Foam glass

- Temporary road, Steinkjer, Norway

Soft can be really Soft

- Small lake at golf course, Kristiansand, Norway

- Geotextile in combination with bark from trees

Construction completed

Bearing capacity ok, settlements?

Steep slopes and walls in areas with soft subsoil

- Stability of wall/slope
  - Subsoil failure
  - Structural collapse
- Settlements
  - Deformation and increased stress/strain
  - Loss of functionality
- Challenging construction conditions
  - Accessability of heavy equipment

- Geosynthetic reinforced soil wall/steep slope with light weight backfill
- TeMaSi project
  - Participants
    - SINTEF
    - CNAM
    - Texinov
    - Maxit/Saint Gobain
  - Develop system for structural solution and construction method

Geosynthetics and light weight material

Geosynthetic tubes filled with Light weight expanded clay blown into the tube with continous production

Final structure having a unit weight of abt 4.5 kN/m^3 (25% of conv material)

Multiple variations of front solutions

Test Structure, Rælingen, Norway

Erosion control at sea-shore - Arctic

- Climate change has caused thawing of permafrost and increased erosion at sea-shore in several areas in the Arctic
- Increasing erosion is causing loss of land and properties
- Several attempts have been made to try to reduce the erosion from current and waves

Longyearbyen, Svalbard

GISSAC – R&D project (2006-2009)

- Gesynthetic bags for erosion protection
- Participants
  - The University Centre of Svalbard
  - SINTEF
  - Bidim/Tencate Geosynthetics
  - LrPC-Nancy
- Sand-filled geosynthetic bag
  - Resist very low temperatures
  - Wave action
  - Abrasion from ice

Harbour of Longyearbyen

- Abrasion from sea ice is the dominating action wearing down the geosynthetics
- Several bags were damaged and worn, but the flexibility of the geotextile bag structures still secured the stability
- The structures are stable, and erosion at the sites have seized.
- Proper survey & regular maintenance are necessary to insure long term behaviour,
- Appropriate environmental behaviour still to be evaluated.

Challenging conditions

- Visitors to the test site in Svea Svalbard
- Geosynthetics can resist everything but Polar Bears!

IGS in the Nordic countries

- Norwegian chapter established 2008
- Finnish chapter established in 2010
- Established common Nordic chapter in 2021
  - Finland
  - Sweden
  - Norway
  - Denmark
  - Iceland
- About 40 members
  - President Minna Leppänen, Finland

igs Nordic

INVITATION
to the
Geosynthetics Education training program
Educate the Educators event

organised by the Nordic Chapter of International Geotechnical Society

with the support of the
igs INTERNATIONAL GEOSYNTHETICS SOCIETY

Time:	Wednesday, April 7th, 2025, at 9 – 16 CET (in Sweden, Norway, and Denmark; at 10-17 in Finland and at 8-15 in Iceland)
Place:	Lund, Sweden AF-Borgen, Sandgatan 2, Gustavsalen or virtually through Zoom meeting
Language	English, questions and comments can be translated
Target group:	Especially engineers and teachers involved in teaching curricula which can incorporate geosynthetics, open to all interested
Participation fee	Free of charge, lunch and coffee provided if present

Thank you for your attention!