Geosynthetic reinforcement in road pavements
Guidelines and experiences

Myre i Lofoten 1984

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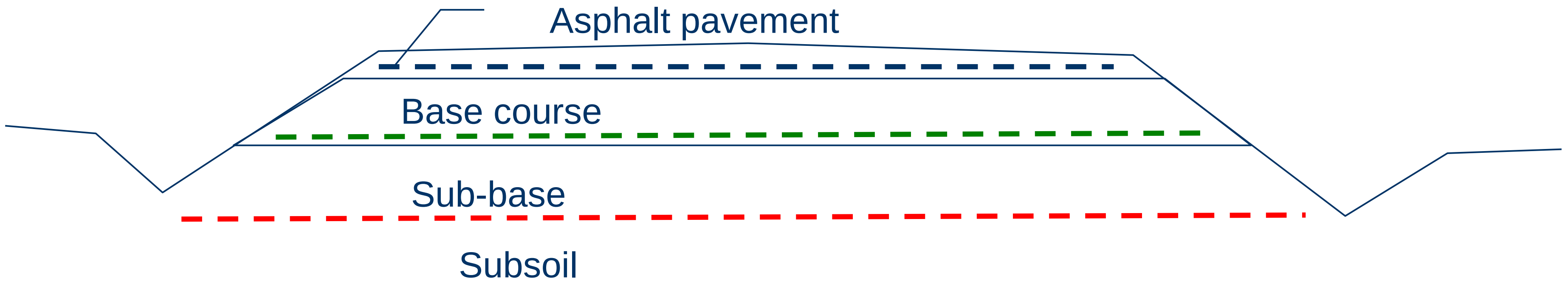
Photo: SINTEF

Hitra in Trøndelag 2008

Photo: Terratest

Geosynthetic reinforcement in road pavements



- Asphalt reinforcement
  - fatigue cracking and reflective cracking
- Reinforcement in granular layers
  - Reduce rutting, reduce thickness
- Reinforcement at subsoil
  - Access in construction period
  - Improve bearing capacity of underground
  - Reduce deformation from frost heave

Reinforcement potential benefits

- Increased resistance to fatigue cracking
- Reduced differential settlements
- Reduced rutting – pavement and subsoil
- Reduce reflective cracking
- Reduce cracking from frost heave
- Potential use of low(er) quality material
- Reduced maintenance cost
- Increased bearing capacity
- Reduced deformation and increased bearing capacity access roads/temporary road

Reinforcement in asphalt pavements

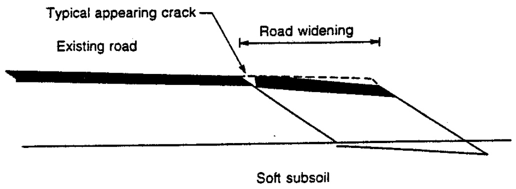
- Propagation cracking from underlaying layer
  - Reflective cracking
  - Dynamic loads
- Temperature induced cracking
  - Cracks perpendicular to the road
  - Static loads
- Frost heave
  - Longitudinal direction
  - Potential LARGE cracks (dm)
  - Large forces, static loads
- Road widening/edge deformations
  - Longitudinal cracks at road edge
  - Static loads

Cracking mechanisms

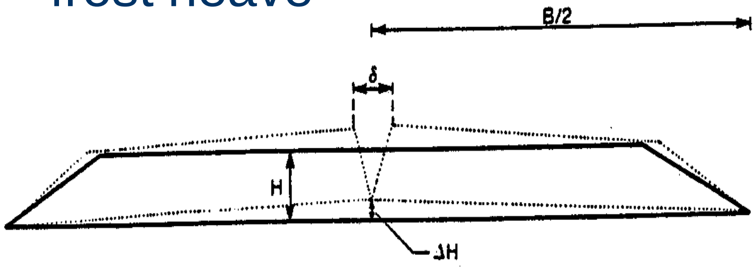
Photo: Jon Hauge

Photo: NTNU

Cracking from edge deformation



Cracking from frost heave

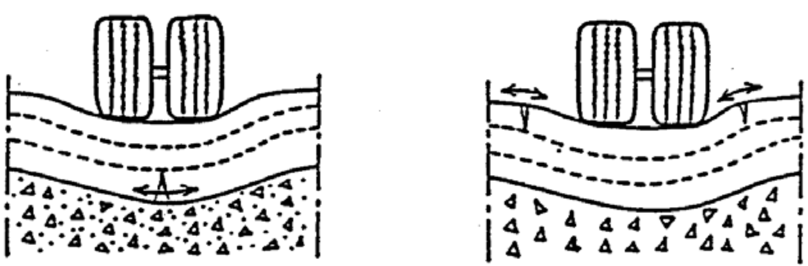


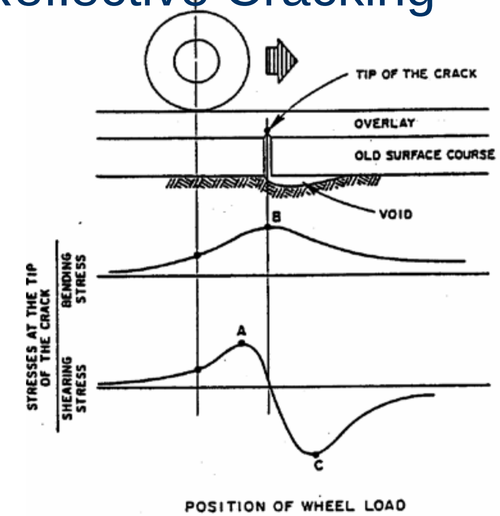
Cracking mechanisms

Reflective Cracking

Photo: HUESKER

Cracking from rutting





Reinforcement in asphalt overlays – Design and experience

- Empirically based design
  - Loading based on evaluation of deterioration mechanisms
  - Solution and type of reinforcement from experience
  - Product specific design and installation guidelines
  - Recommendations for design in proposed guidelines - NPRA
- Experience
  - Edge deformations - high strength grid - good experience
  - Reflective cracking – large variety of solutions - variable results (SRI, Composits, grid)
  - Rutting – Grid reinforcement - do not reduce rutting but may reduce cracking from rutting (and subsequently also rutting)
  - Frost heave – high strength grid –do not reduce frost heave but may reduce cracking
  - Temperature cracks - grid reinforcement – continous reinforcement to be effective
  - Installation crucial for the effect

Challenges for asphalt reinforcement

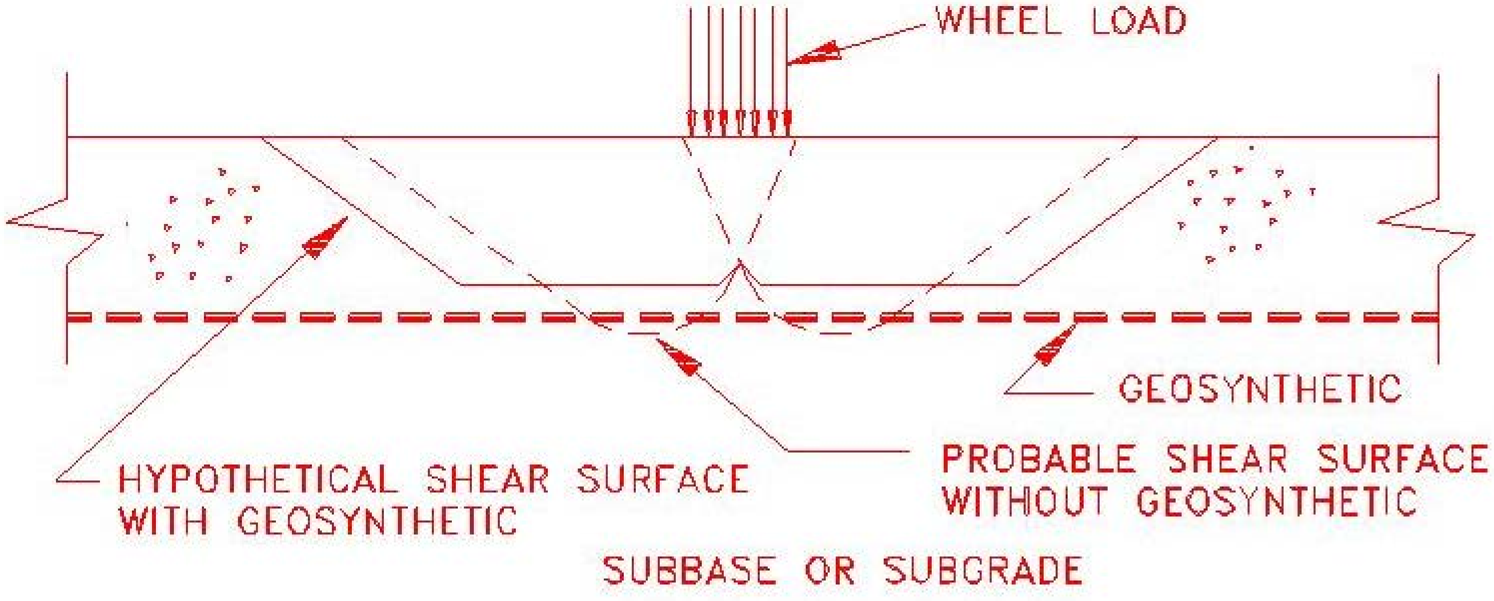
Wrinkles and overlap of reinforcement

Installation and traffic on reinforcement

Debonding

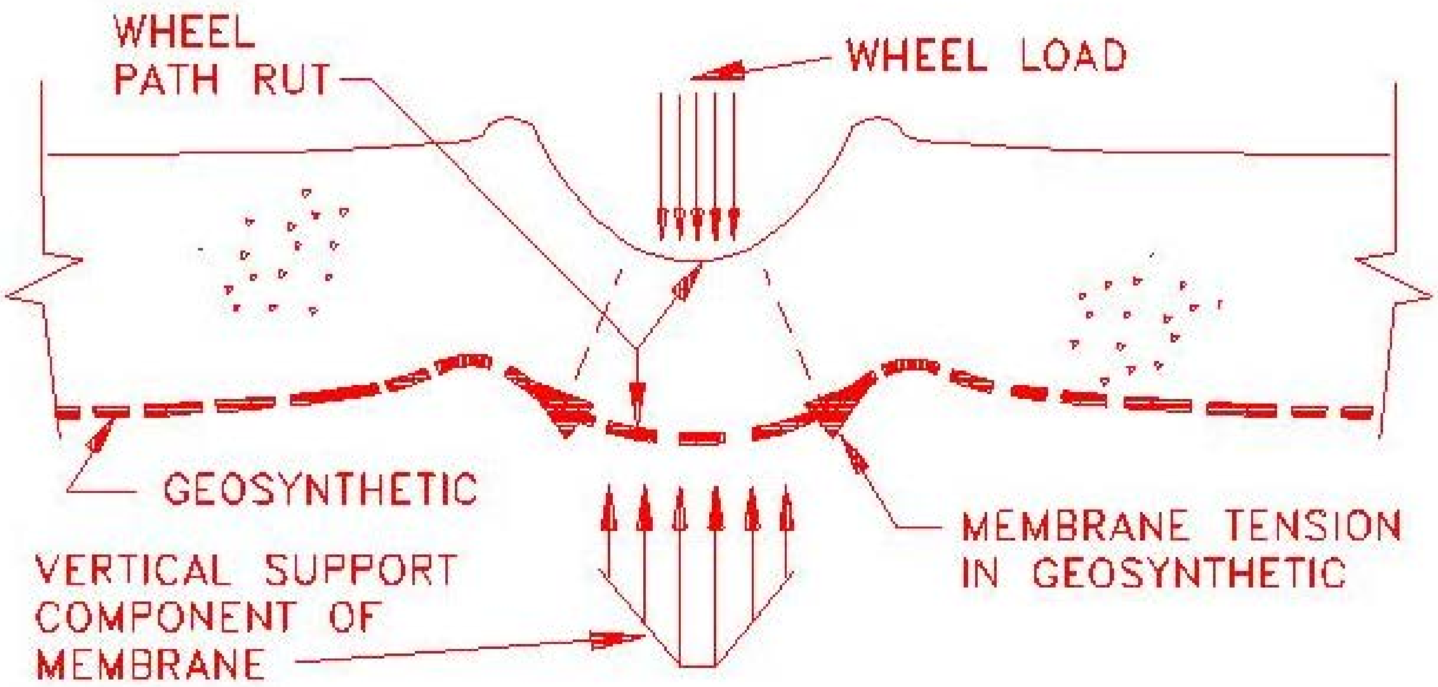
Function mechanisms - soft subsoil

Improve bearing capacity



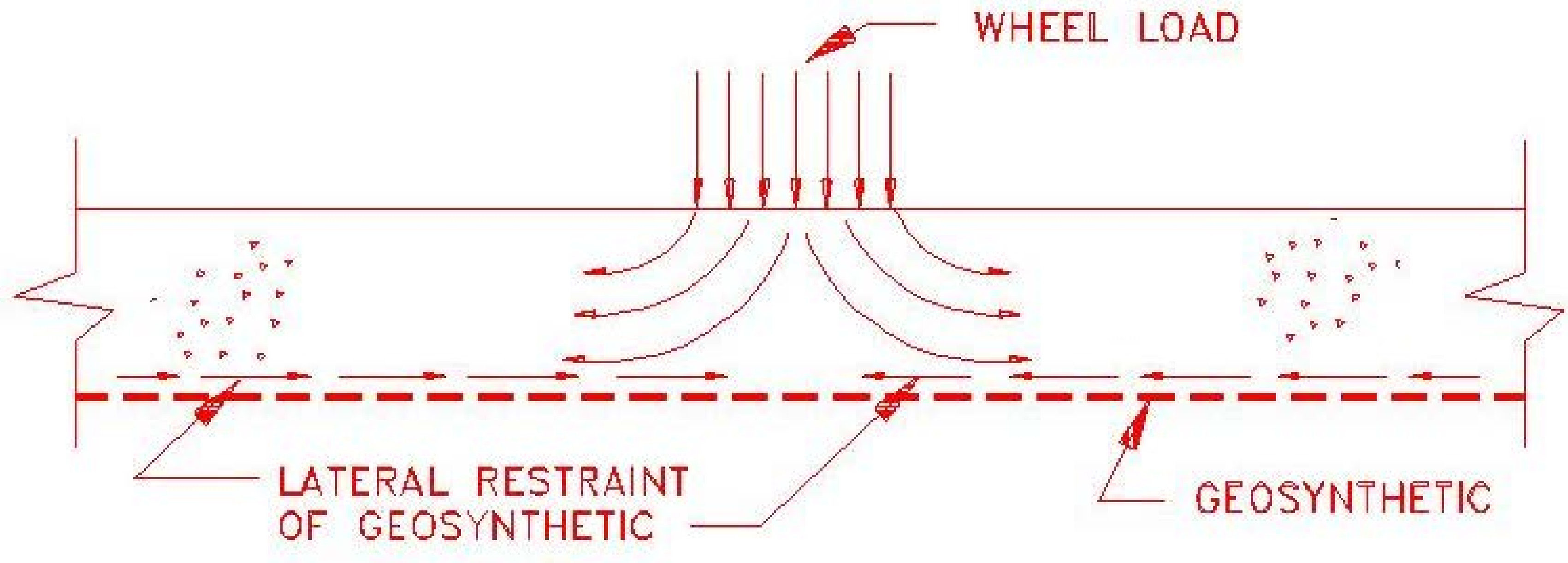
Mechanism – soft subsoil

Hammock effect



Function mechanisms
Granular layers

Improved horisontal support



R&D project - GeoRePave

- Aim
  - Develop design methods for reinforcement in bearing layers
- Includes
  - Model testing
    - Laboratory with cyclic loading
    - Heavy traffic simulator
    - Test sections with different types of reinforcements
  - Testing of material
    - Static triaxial testing
    - Cyclic triaxial testing with reinforcemetn
    - Pull out test
  - Numerical modelling
    - FEM analyses of reinforced road

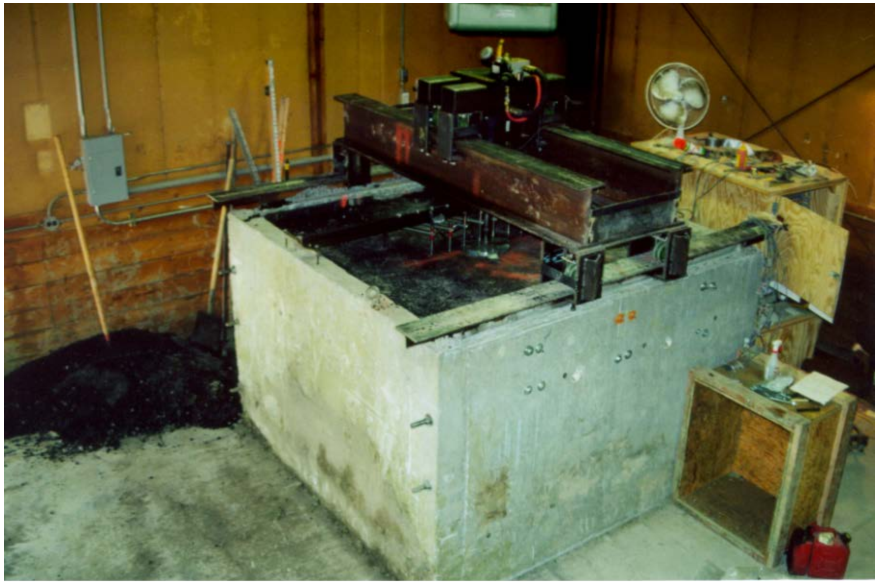
Laboratory– full scale testing

Heavy traffic -simulator

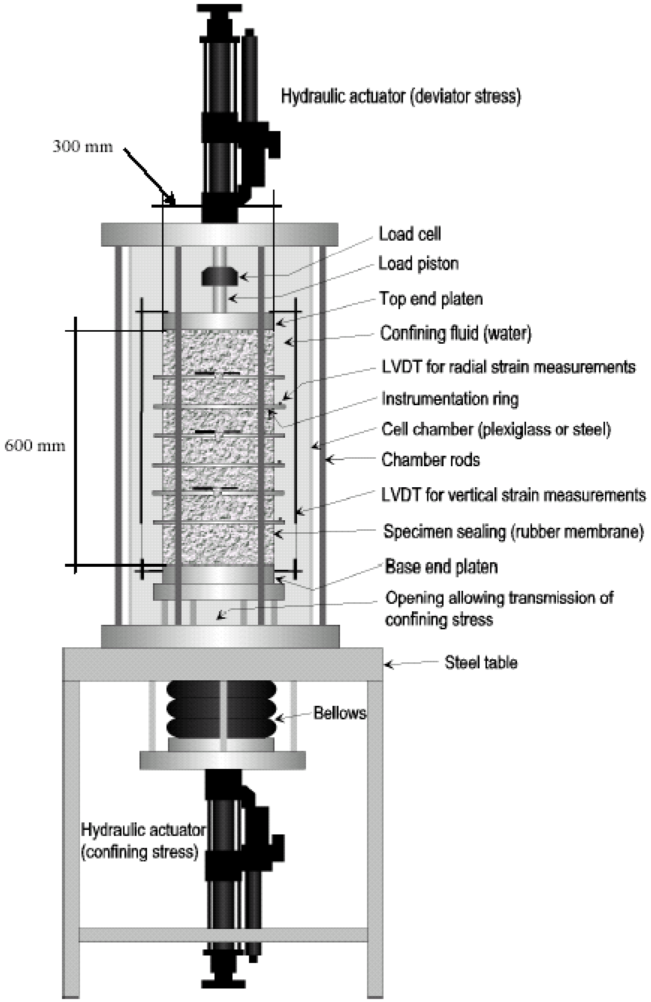
CRRL

Cyclic load tests

MSU/GTX



Cyclic triaxial testing - NTNU



- With and without reinforcement
- Reinforcement
  - Stiff grid
  - Flexibel grid
  - Woven slit film
  - Composite

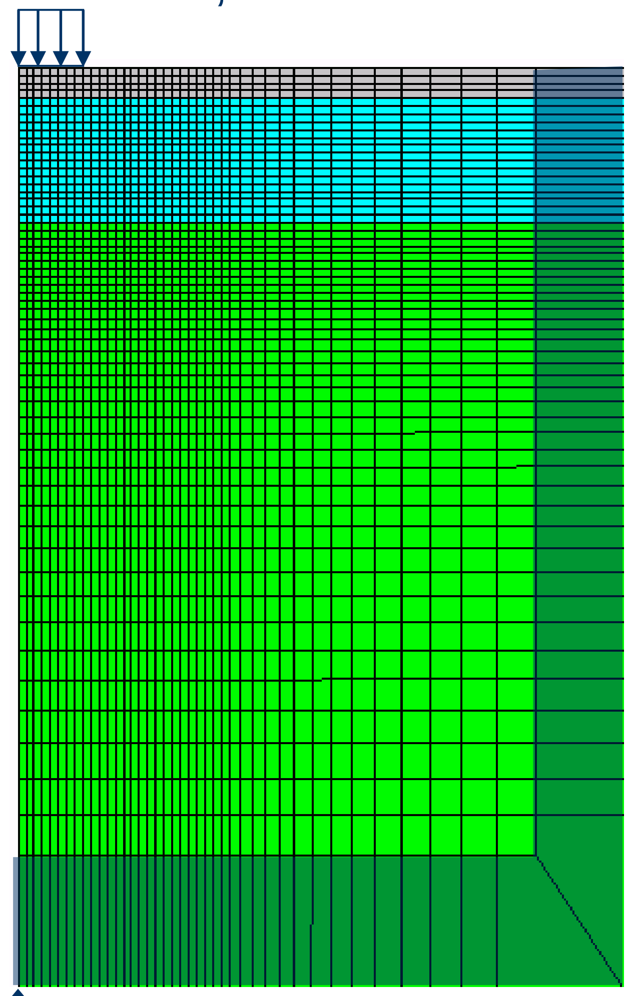
Numerical modelling

550 kPa, r = 150 mm

2-D, Axial symetri

Volum elements for subsoil, granular material and asphalt

Membrane element for reinforcement



Asphalt

Granular bearing layer

Subsoil

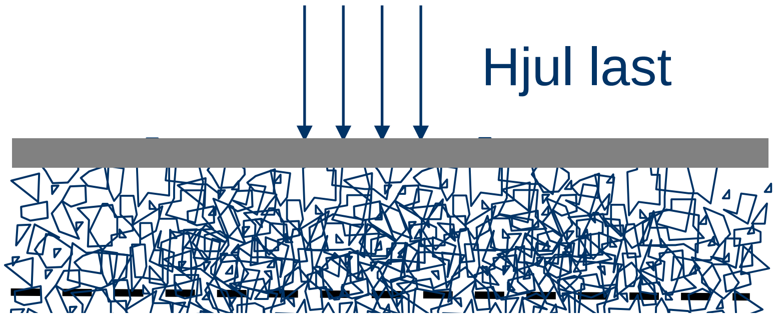
Infinite-element

Symmetri axis

Results GeoRePave

- Test verify effect from reinforcement
  - Reinforcement reduce plastic deformations
  - Numerical modelling do not show the same effect
- Cyklic triax: Reinforced samples can withstand 5 – 10 times the number of loads compared to unreinforced
  - No significant difference between types of reinforcement is found
  - Improved understanding of mechanisms
- Proposal for design model developed
  - http://www.coe.montana.edu/wti/wti/display.php?id=89.
  - Large number of input parameters (adequate testing methods missing)

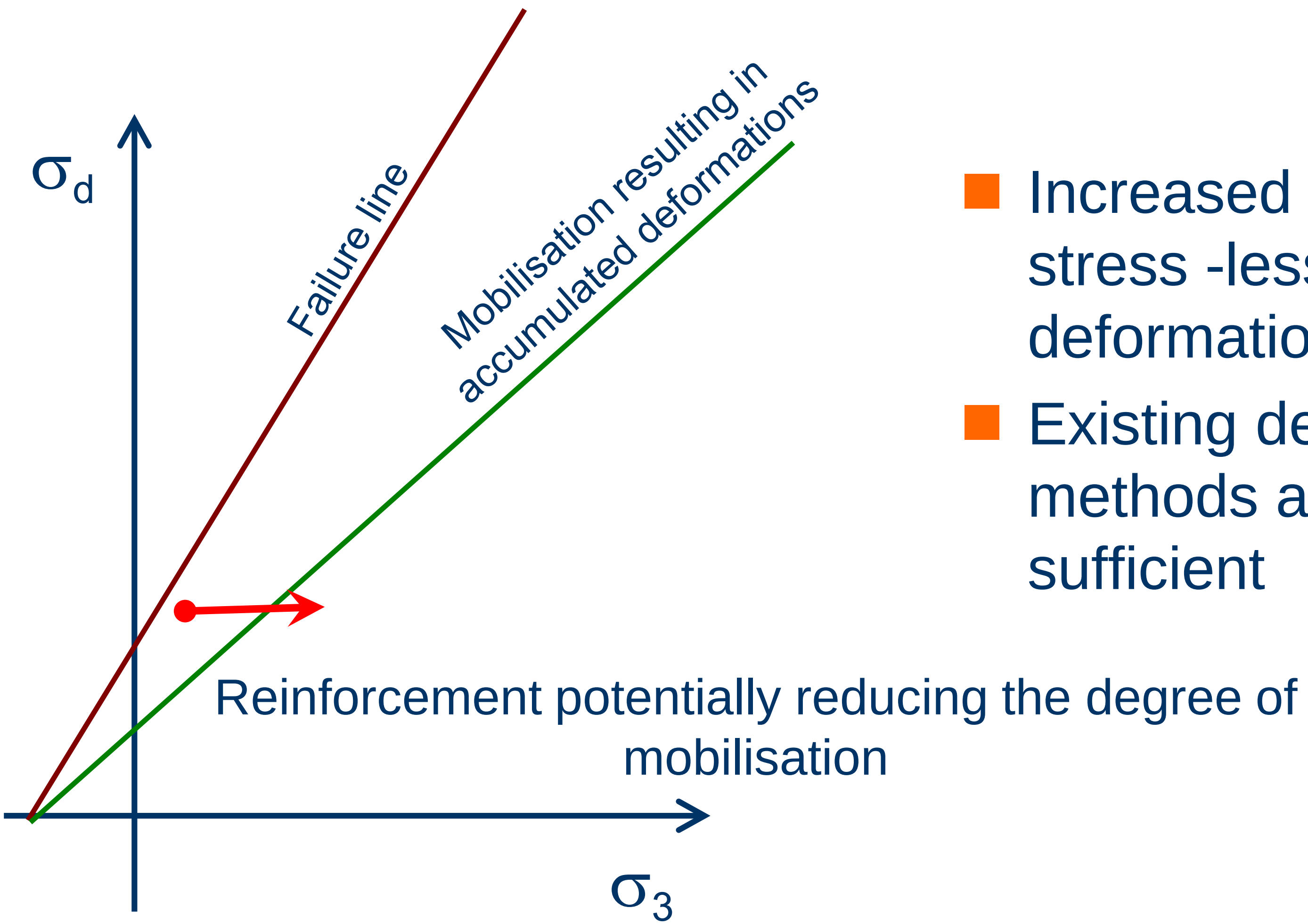
Effect: Lateral restrain



- Proper desing ⇒ small deformations
  - Low reinforcement mobilisations – stiffness more important than strength
  - Interaction reinforcement granular particles is cruicial for effect
- Bearing layer consisting of single particles
- Elastic stiffness of structure not influenced by reinforcement (?)
- Permanent deformation is the sum of ”mikroskopic” changing for each load pass
- Reinforcement can prevent the ”micro-deformations”
  - Reduces the accumulated permanent deformations – ie reduced rutting

Effect-increased lateral stress

increased resistance against deformations



- Increased horisontal stress -less permanent deformations
- Existing design methods are not sufficient

Design reinforcement in granular layers

- Field experience-reinforcement reduce permanent deformations
  - Edge deformations- good results
  - Reduced rutting – variable results
- Application
  - Proper design, good quality well compacted granular material- sufficient stiffness
    - Sufficient elastic stiffness – no need for reinforcement
  - Upgrading and rehabilitaton of existing roads
    - Reinforcement to reduce deformations
- Design requirements:
  - Reduced rutting, i.e increased traffic volume
  - Potential reduction of bearing layer – NOTE: frost protection

Existing guidelines

- General design recommendations:
  - Norway, håndbok 018: No reduction of thickness
  - Sweden, Finland and Estonia: No guidelines existing
- Product specific design methods
  - Based on field experiences and som theoretical considerations
  - Product specific-generaly not related to product characteristics
  - Some countries use product specific methods
- Proposal for guidelines (NPRA)
  - Structural solutions based on evaluation of deterioration mechanisms
  - Recommendations for reinforcement characteristics
    - Stiffness/rigidity
    - Interaction with granular material (friction, interlocking)
    - Resistance to damage – Note: Installation at low temperature
    - Handling and installation properties

Verification of effect

- Falling weight deflectometer
  - SINTEF: Method not suitable

- Plate load test (Ev2), commonly used for verification of improvd bearing capacity (Germany, UK)
  - Requires large deformations before noticeable effect
  - Can be used for verification with reinforcement on subsoil
  - Not suitable for verification in bearing layer

Reinforcment of asphalt pavement
Reflective cracking - Svalbard

Construction traffic on base layer with reinforcement

Photo: Jon Hauge

Access roads
Bearing capacity of soft subsoil

Photos: Statens Vegvesen

Lofast, Northern Norway

Test sections - reinforced accessroad

Photo: SINTEF

Test section - excavation

Photos: SINTEF

Reinforcment type 1

Unreinforced

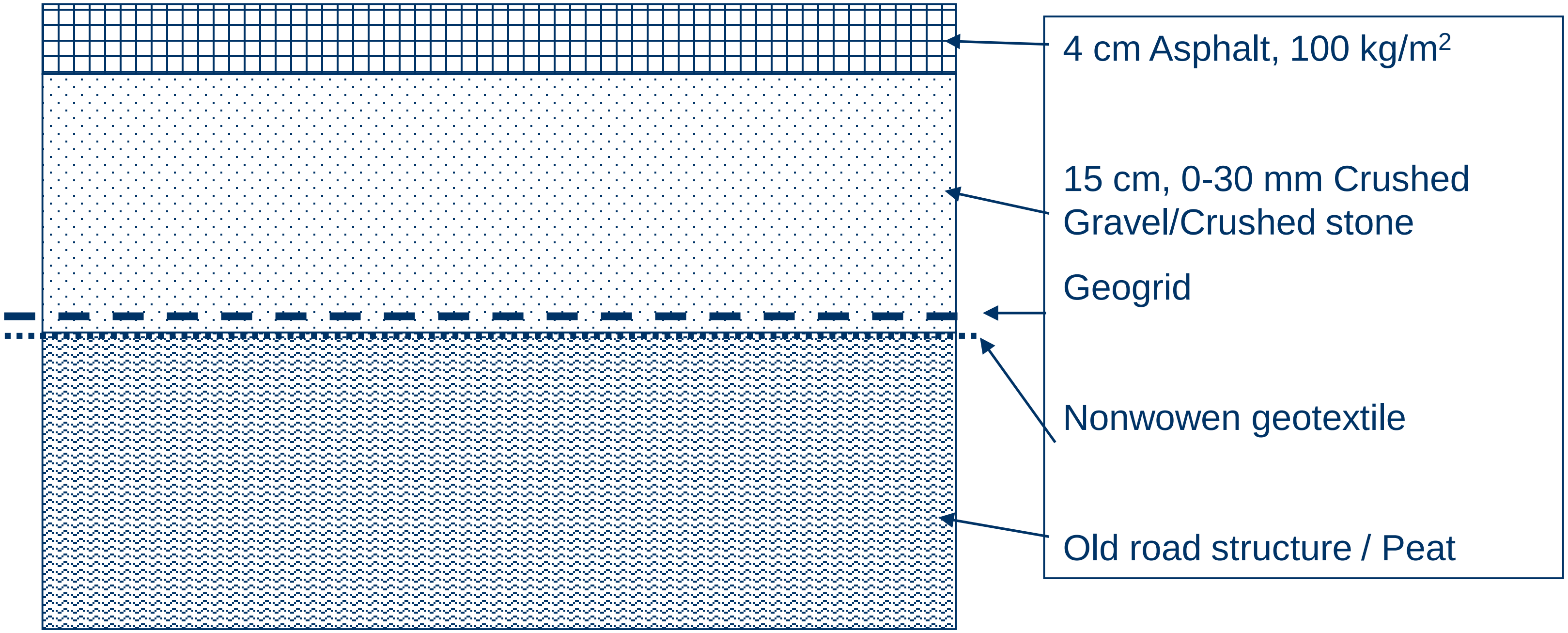
Reinforcement type 2

Bearing capacity – thawing period

Photo: NTNU

Hitra-Norway
Upgrading of unsurfaced road

Typical pavement section



Separation geotextile + grid reinforcement

Photo: Terratest

Variable substructure conditions
No effect on elastic stiffness (falling weight)
Reduced rutting
Not basis for evalution of effects of different grids

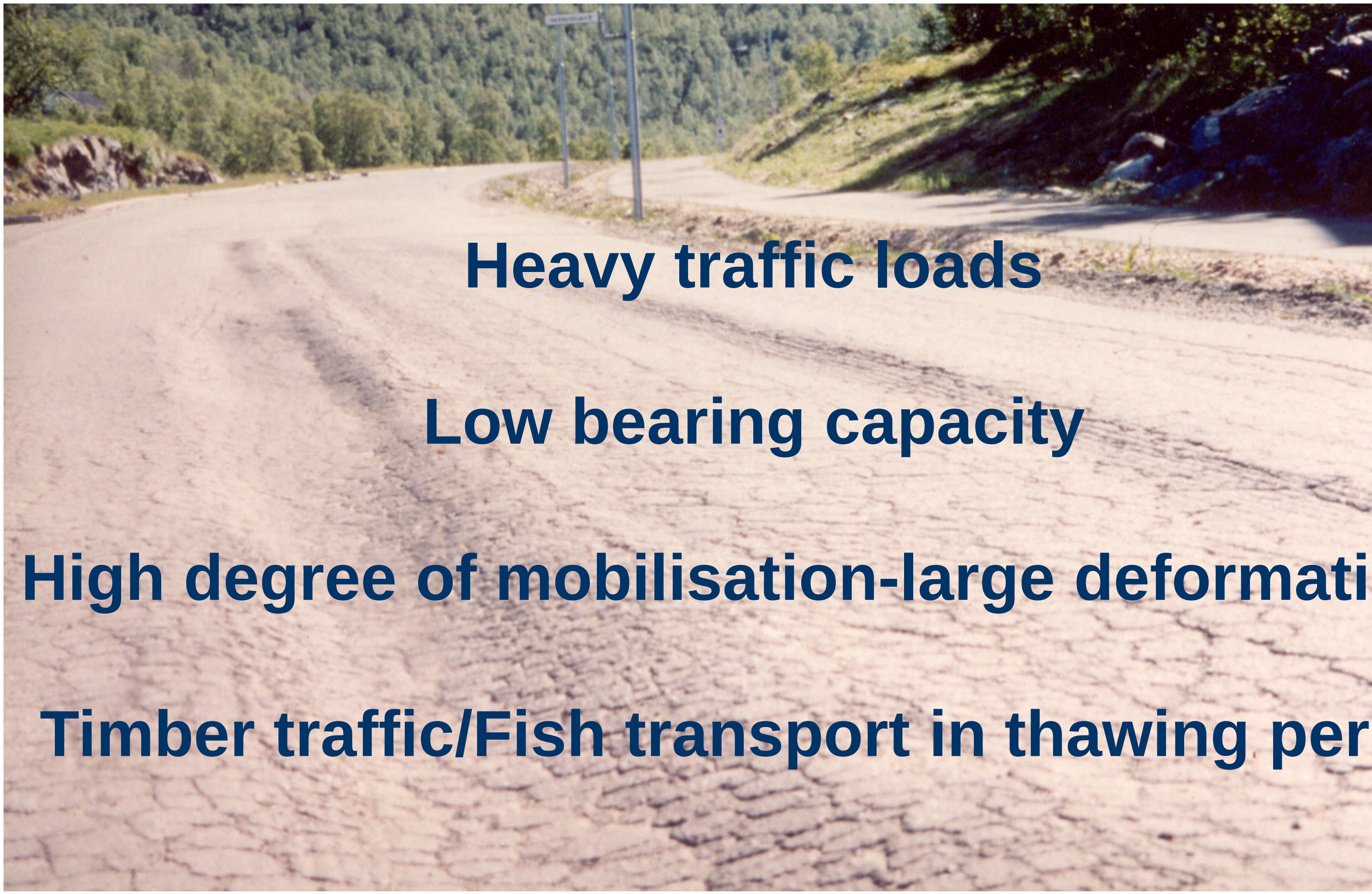
3 different types of reinforcement

Photo: SINTEF

Summary - applications

- Reinforcement in Asphalt overlays
  - Usually for upgrading and rehabilitation (Repaving)
  - Solutions related to deterioration mechanims (evaluation of cracking of existing pavement)
  - Steel grid, glassfibre grid, polymeric grids, Geotextiles (SRI), geocomposites
- Reinforcement in granular layers
  - Surfaced roads (rehabilitation and upgrading)
    - Main use: Rutting and edge deformations
    - Polymeric grids
  - Unsurfaced roads (access roads, gravel roads)
    - Main use: Bearing capacity of subsoil
    - High strength geotextiles, polymeric grids, geocomposites

Effect of reinforcement



Heavy traffic loads

Low bearing capacity

High degree of mobilisation-large deformations

Timber traffic/Fish transport in thawing period

Recent publications Gualadaruja 2010

Geosynthetics in Pavement Reinforcement Applications

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Keywords: geosynthetic, pavement, reinforcement, subgrade, base, asphalt, modeling

Challenges

- Good models to describe function and effect
- Recommended solutions and design methods
- Product independent requirements and specifications
- Guidelines for installation and control
- Methods for verification of effect

Conclusions

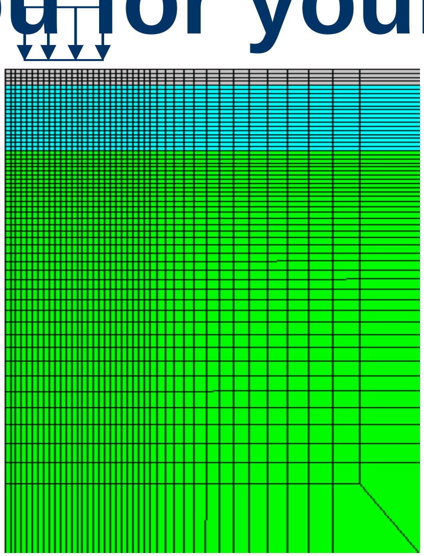
- More than 40 years of experience with Reinforcement in roads
  - Nordic countries are using considerable volumes
- Reinforcement in asphalt overlays and granular materials
- Prime applications
  - Unpaved roads/Access roads
  - Upgrading/rehabilitation of existing roads
- Experienced based solutions and design – mostly product specific
- Variable results – highly dependent on quality of installation
- General design models for design is lacking
- Methods for verification of effect is lacking

So what?

- Product certification
  - NorGeospec –extended to function reinforcement
    - Gives characteristics to be verified for this function
  - Certification of characteristics to ensure "fit for use"
- Proposal R&D: Reinforcement in roads
  - Nordic co-operation project
  - Quantifying the Influence of Geosynthrtics on Pavement performance
  - Design models
  - Recommendations/guidelines for design
- Proposal R&D: Installation of geosynthetics in cold climate
  - Experiences from installation of geosynthteics
  - Guidelines for installation and control

Let's hit the road!
Thank you for your attention!

Photo: SINTEF



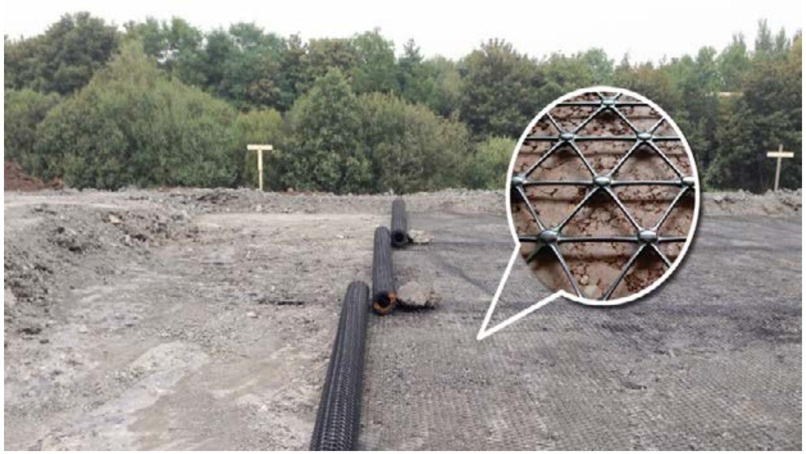


Photo: TENSAR

Photo: Statens Vegvesen