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

Cracking from edge deformation

Cracking from frost heave
Cracking mechanisms

Cracking from rutting

Reflective Cracking

Photo: HUESKER
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, Composites, 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 – continuous 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 horizontal 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 reinforcement
    ■ Pull out test
  ■ Numerical modelling
    ■ FEM analyses of reinforced road
Laboratory– full scale testing

Cyclic load tests
MSU/GTX

Heavy traffic -simulator
CRRL
Cyclic triaxial testing - NTNU

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

2-D, Axial symmetry

Volume elements for subsoil, granular material and asphalt

Membrane element for reinforcement

550 kPa, \( r = 150 \) mm

Asphalt
Granular bearing layer
Subsoil

Symmetry axis

Infinite-element
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](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 crucial 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 horizontal stress - less permanent deformations
- Existing design methods are not sufficient

- Reinforcement potentially reducing the degree of mobilisation
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 rehabilitation 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 some theoretical considerations
  - Product specific—generally 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 improved 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
Reinforcement 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

Reinforcement type 1  Unreinforced  Reinforcement type 2

Photos: SINTEF
Bearing capacity – thawing period

Asphalt pavement on unsurfaced road

Increase bearing capacity

Reduce rutting

Photo: NTNU
Hitra-Norway
Upgrading of unsurfaced road

Typical pavement section

- 4 cm Asphalt, 100 kg/m²
- 15 cm, 0-30 mm Crushed Gravel/Crushed stone
- Geogrid
- Nonwoven geotextile
- Old road structure / Peat
Separation geotextile + grid reinforcement

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

3 different types of reinforcement
Summary - applications

- Reinforcement in Asphalt overlays
  - Usually for upgrading and rehabilitation (Repaving)
  - Solutions related to deterioration mechanisms (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

Steven W. Perkins
*Montana State University*

Barry R. Christopher
*Christopher Consultants*

Nicholas Thom
*University of Nottingham*

Guillermo Montestruque
*(Please complete)*

Leena Korkiala-Tanttu
*Pöyry Infra Oy*

Arnstein Wath
*SINTEF*

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 Geosynthetics on Pavement performance
  - Design models
  - Recommendations/guidelines for design

- **Proposal R&D: Installation of geosynthetics in cold climate**
  - Experiences from installation of geosynthetics
  - Guidelines for installation and control
Let's hit the road!
Thank you for your attention!