NVF 34

Climatic Challenges in Pavement Design

"Joint Nordic/Baltic Symposium on Pavement Design and Performance Indicators".

February 13 and 14 2008

Per Otto Aursand, NPRA, Northern Region

Statens vegvesen

Klima og transport

Climate & Transportation

R&D program evaluating the effect of climate change on the road network and remedial actions

Norwegian Public Roads Administration

2007- 2010, cca 2,5 mill €

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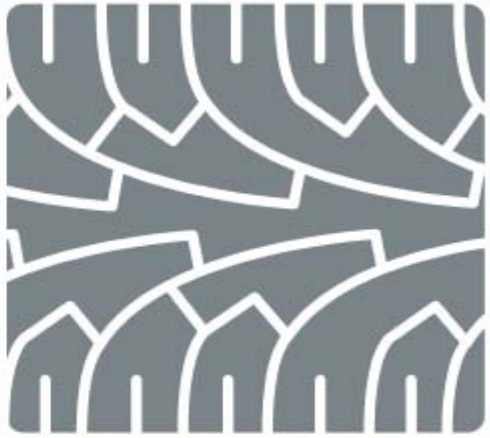

Main objective: Improve design, construction and maintenance of the road network in order to adapt to climate changes.

i.e.

Evaluate and recommend measures necessary for maintaining both safety and accessibility in a changed climate.

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Project tasks

1. Climate change and effects on road net - Survey
2. Data: collection, processing and storage
3. Flood and erosion prevention
4. Avalanches: snow-, soil-, flood slides, rock fall
5. **Bearing capacity of roads**
6. Consequences for winter operation
7. Emergency plans and susceptibility

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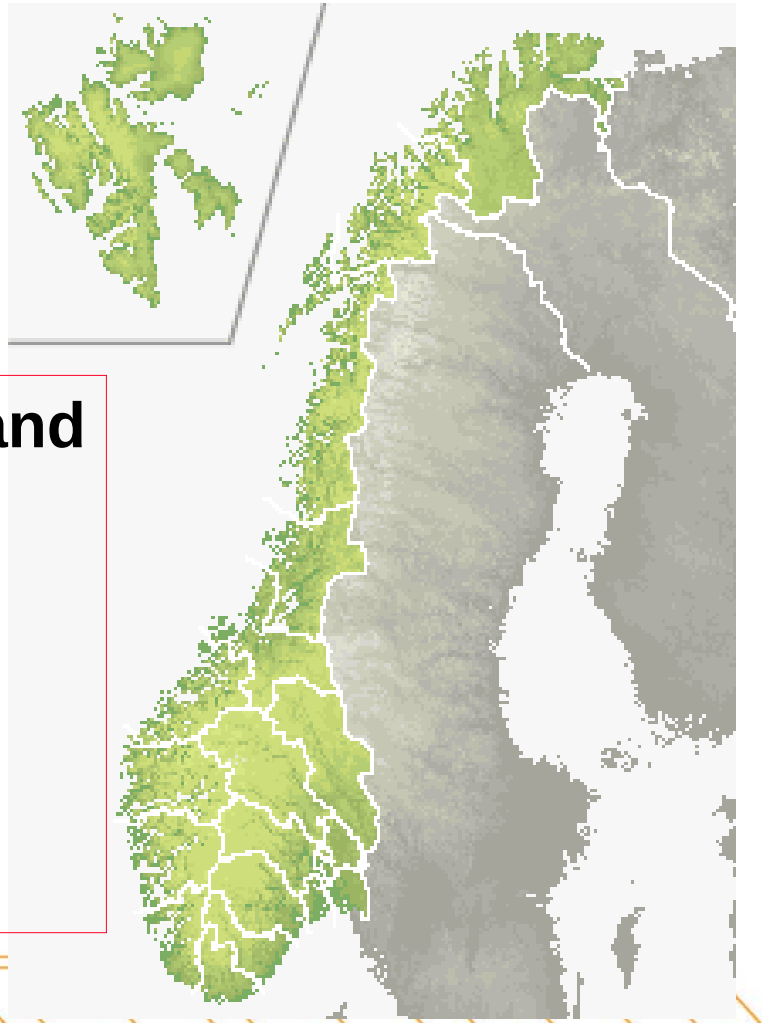
Background

The road network is influenced by climate conditions

- **Increased precipitation – frequency and intensity**
- **Milder winters**
- **Warm summers in the south-eastern areas**
- **Increased wind speeds and storm frequencies**



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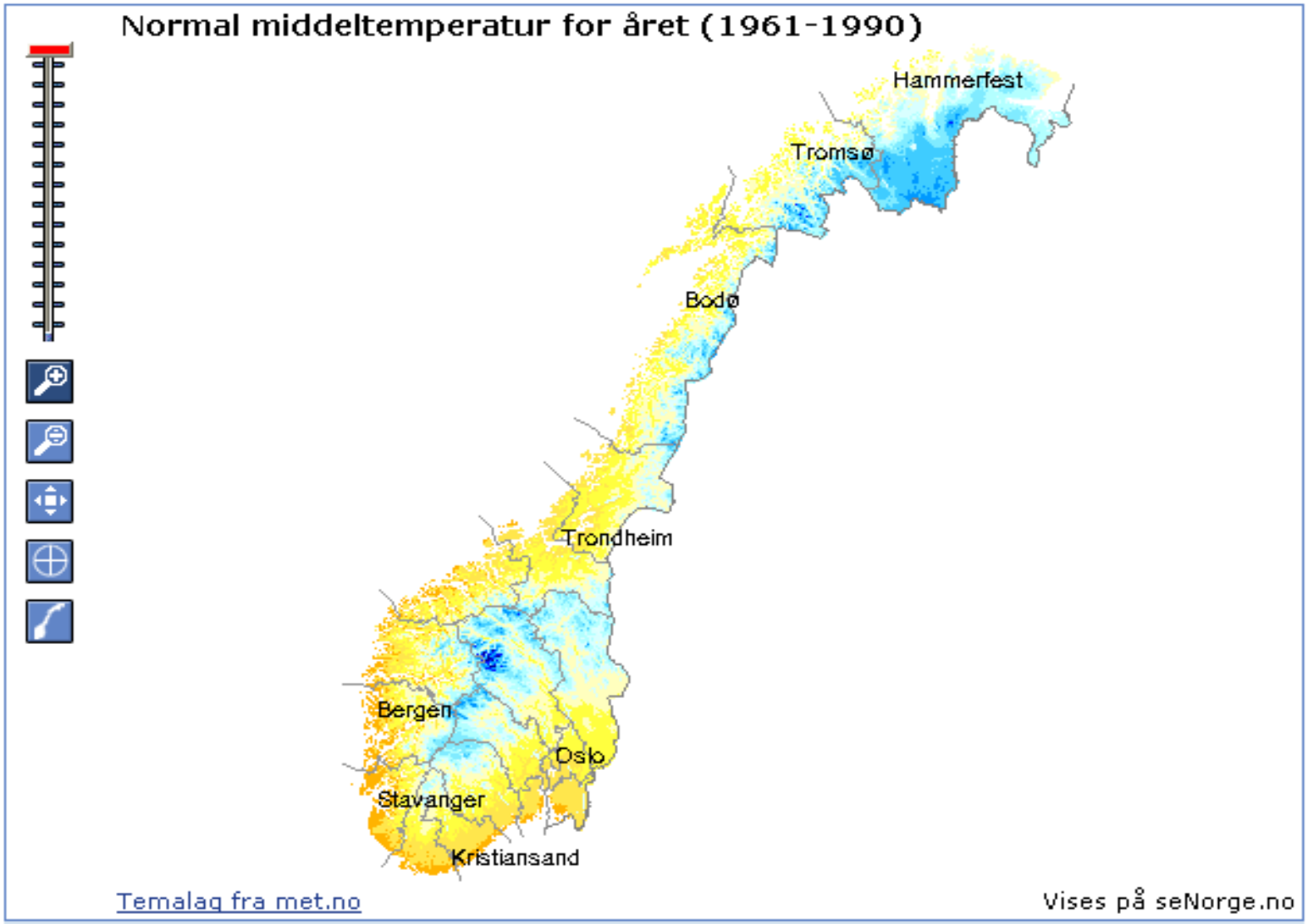
Normal mean year temperature 1961-1990



Temainformasjon

Kartet viser normal årstemperatur i lufta (i °C) for normalperioden 1961-1990.

Fargeforklaring

Grader Celsius

- Over 12
- 10 - 12
- 8 - 10
- 6 - 8
- 4 - 6
- 2 - 4
- 0 - 2
- +1 - 0
- +2 - +1
- +3 - +2
- +4 - +3
- +5 - +4
- +6 - +5
- Under +6

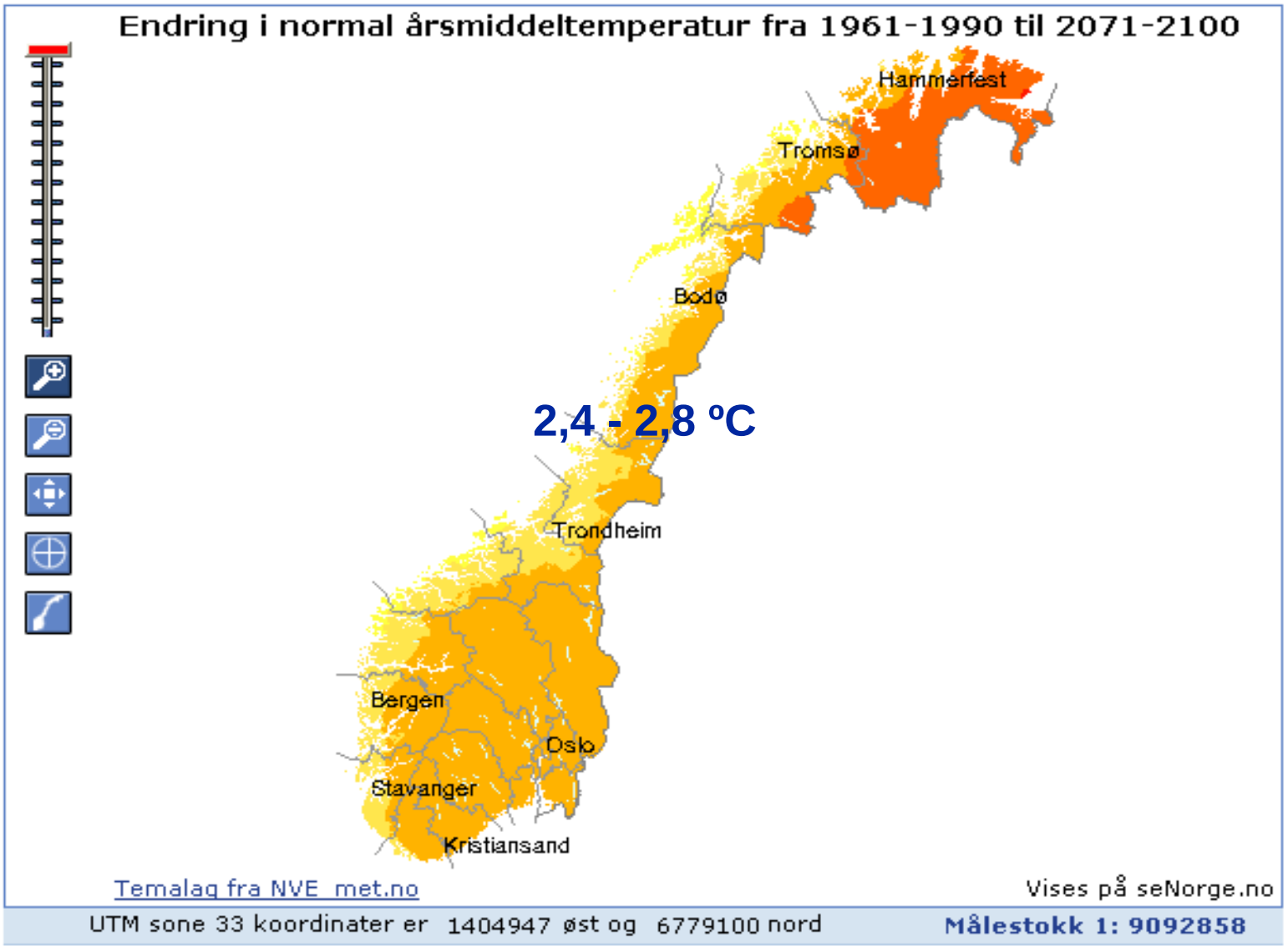
Kartforklaring

Oslo Stedsnavn

Riksgrense

Fylkesgrense

Estimated change in mean year **temperature** 1961-1990 – 2071-2100 (CICERO)



Temainformasjon

Kartet viser endring i normal årstemperatur i lufta (i °C) fra normalperioden 1961-1990 til perioden 2071-2100.

Fargeforklaring

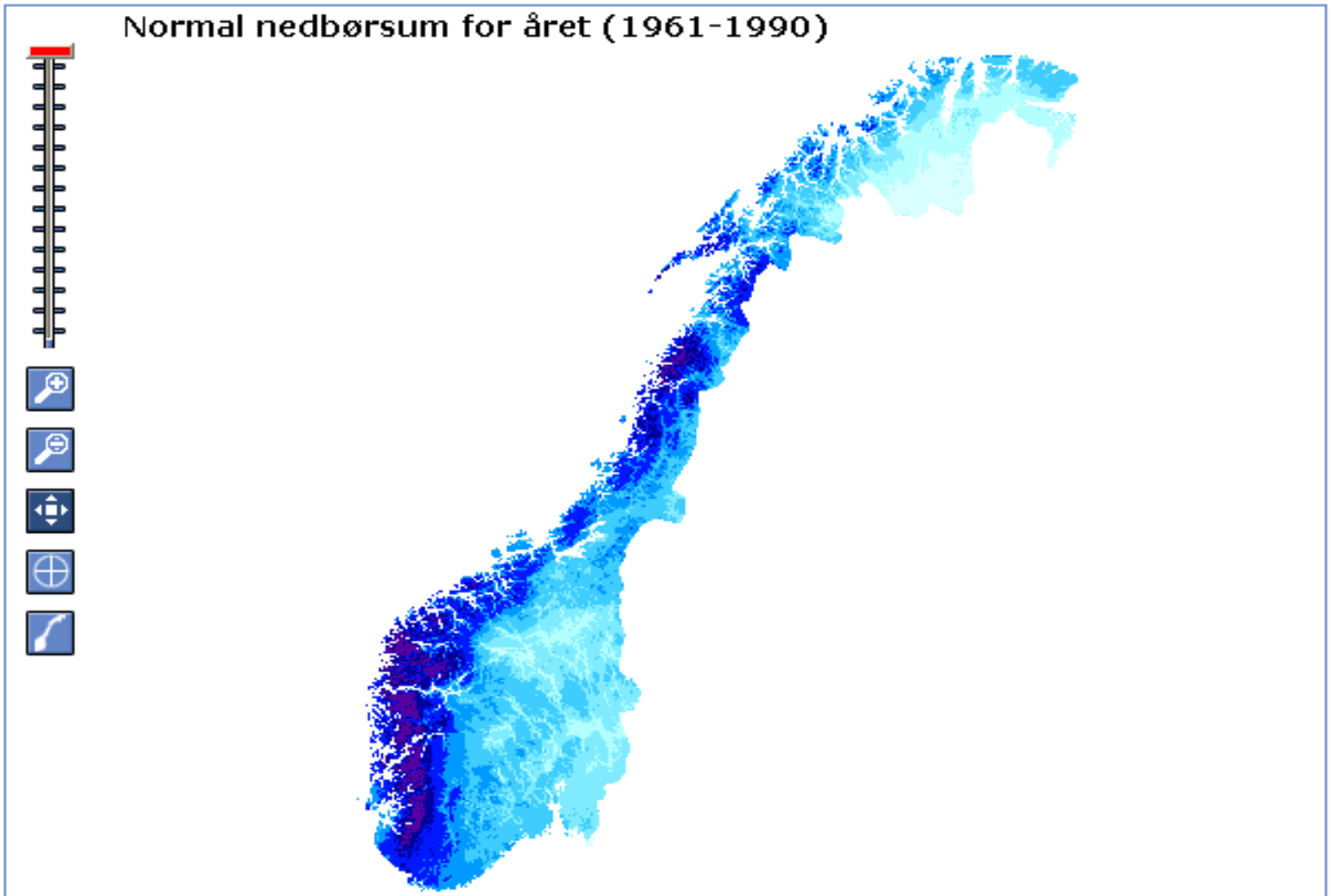
Grader

- Over 4
- 3.6 - 4.0
- 3.2 - 3.6
- 2.8 - 3.2
- 24 - 2.8
- 2.0 - 24
- Under 2

Kartforklaring

- Oslo — Stedsnavn
- Riksgrense
- Fylkesgrense
- Store vann

Normal yearly precipitation 1961-1990



UTM sone 33 koordinater er -397475 øst og 7932937 nord **Målestokk 1: 13782097**

Vis større kart | Utskriftsvennlig kart | Vis link til dette kartet | | Tilbakemelding

Temainformasjon

Kartet viser normal årsnedbør (i mm) for normalperioden 1961-1990.

Fargeforklaring

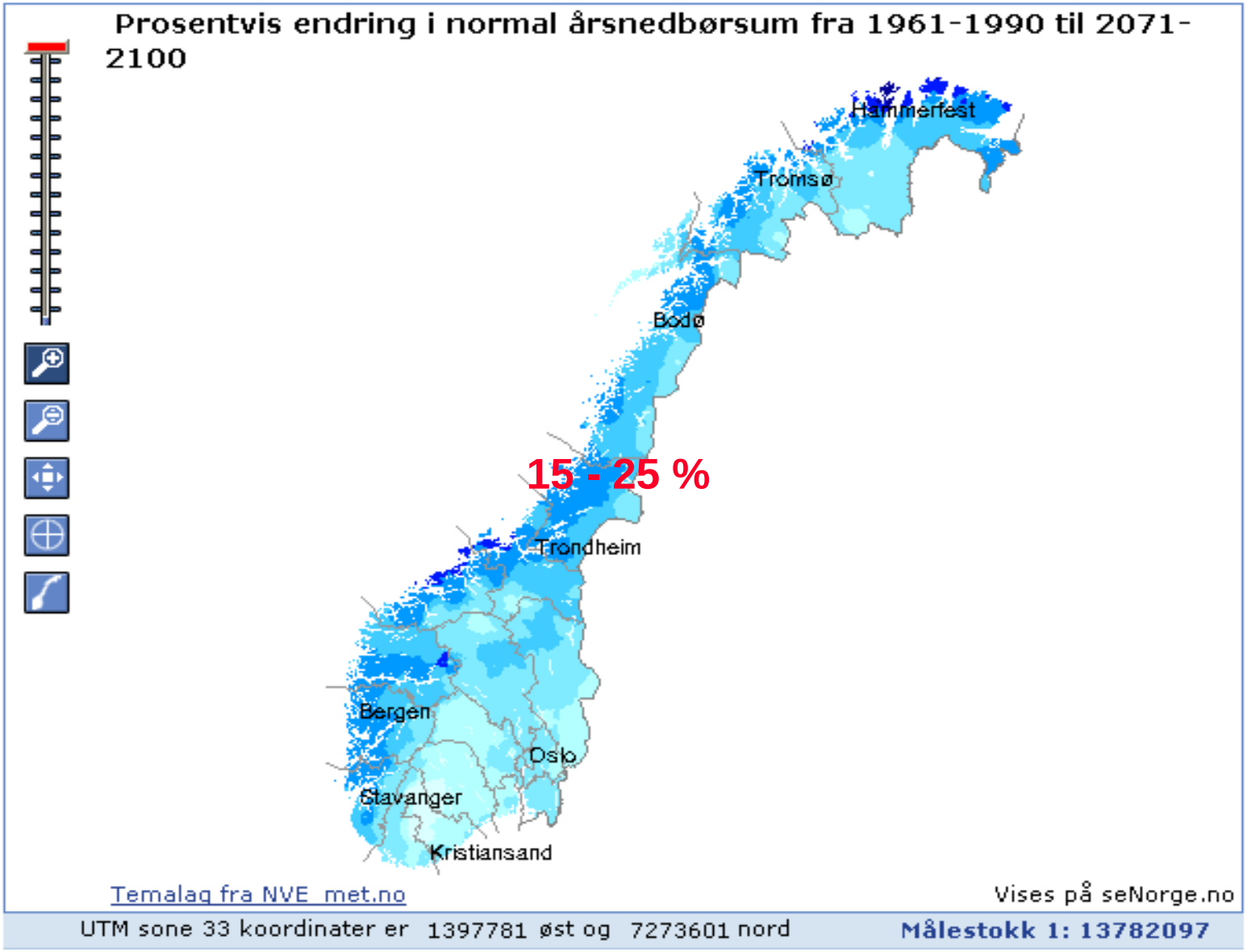
mm

- Over 4000
- 3000 - 4000
- 2000 - 3000
- 1500 - 2000
- 1000 - 1500
- 750 - 1000
- 500 - 750
- Under 500

Kartforklaring

- Oslo — Stedsnavn
- Riksgrense
- Fylkesgrense
- Store vann

Estimated change in yearly **precipitation** 1961-1990 – 2071-2100 (CICERO)



Temainformasjon

Kartet viser prosentvis endring i normal årsnedbør fra normalperioden 1961-1990 til perioden 2071-2100.

Fargeforklaring

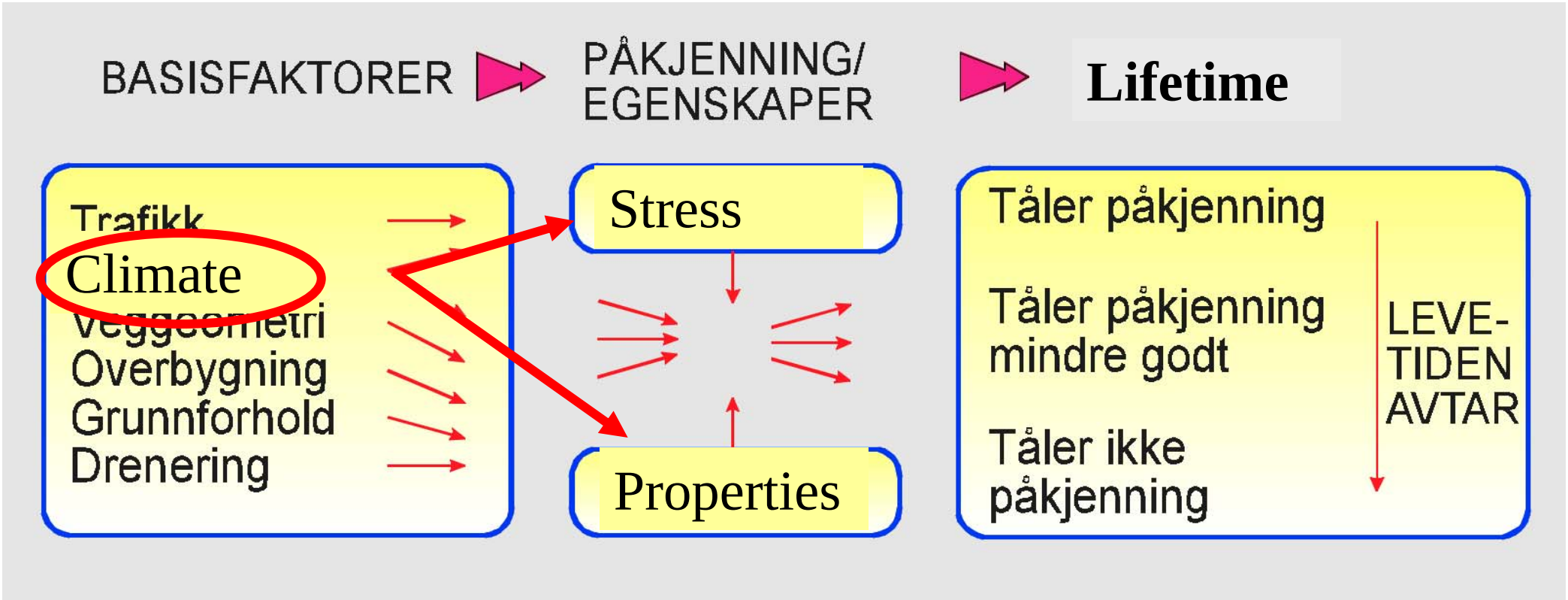
Prosent

- Over 30
- 25 - 30
- 20 - 25
- 15 - 20
- 10 - 15
- 5 - 10
- Under 5

Kartforklaring

- Oslo — Stedsnavn
- Riksgrense
- Fylkesgrense
- Store vann

Why is climate important in pavement design?



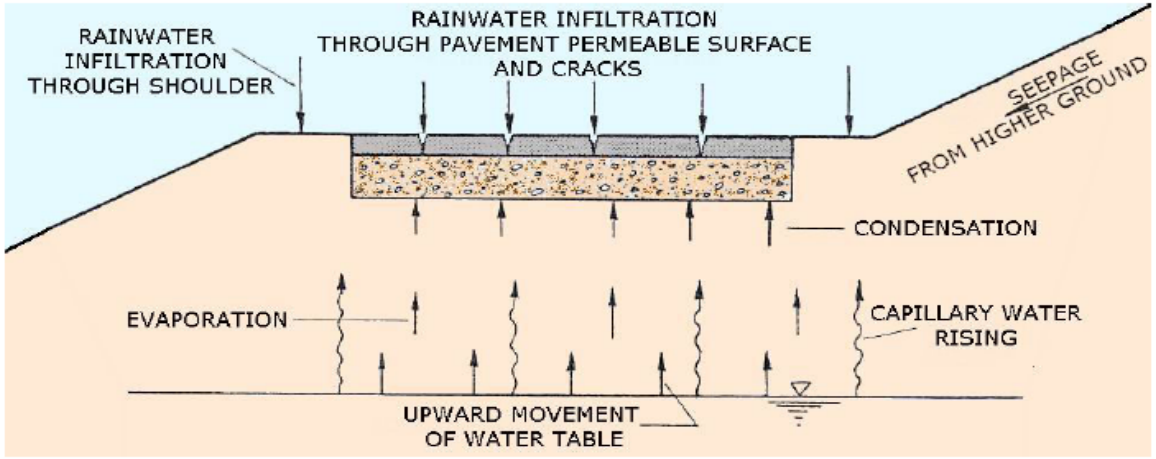
Bearing capacity of roads

Temperature increase:

decreased pavement stiffness
affects load distribution, changed frequency of freeze-thaw cycles

Precipitation increase:

higher ground water level, higher infiltration of rain water



Consequences of **increased persipitation**

Increased water content in unbound materials

Reduced bearing capacity (deformation properties and load distribution)

Increased deteriation (rutting and roughness)

Moist pavement surface

Increased wear of asphalt

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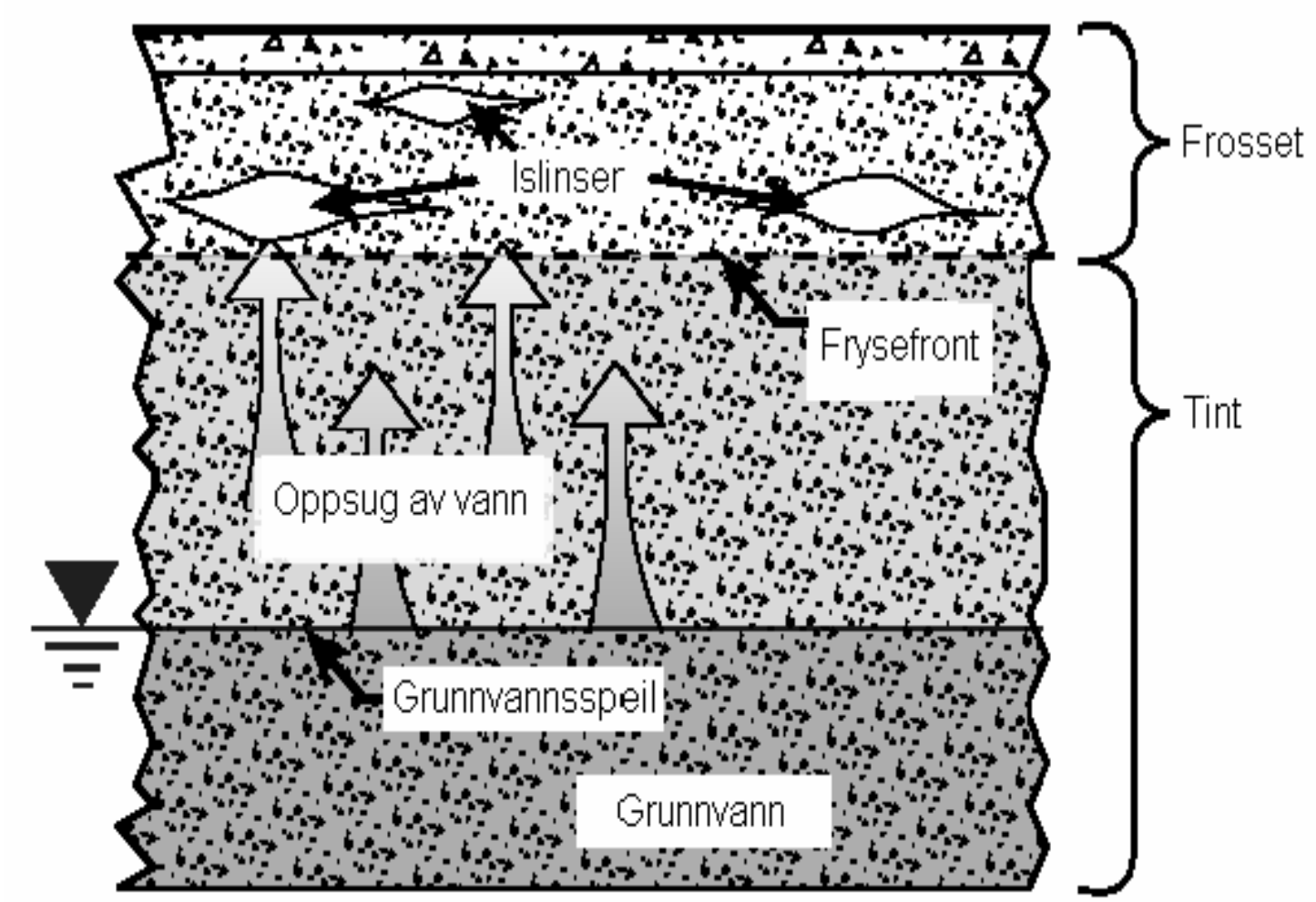
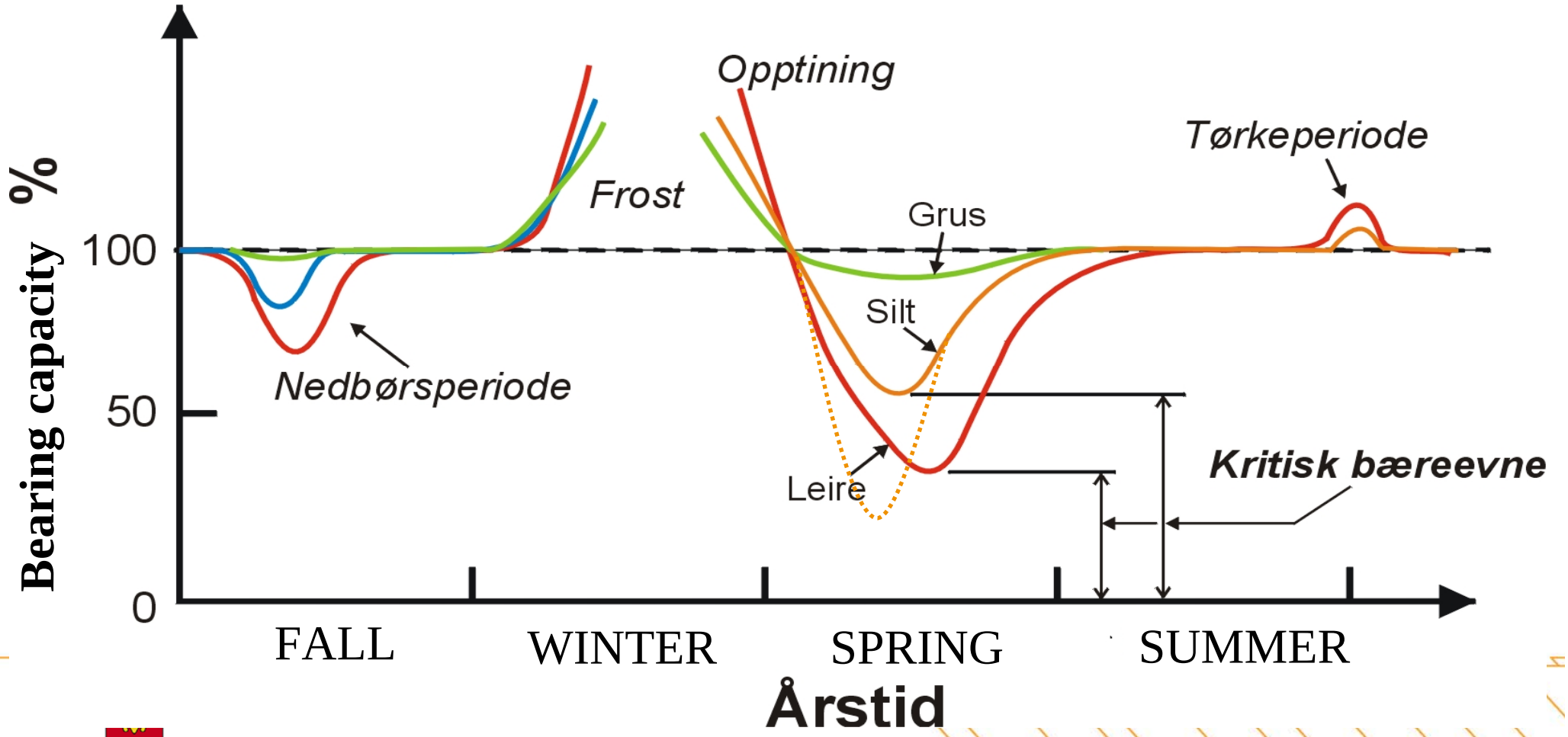
NEGATIVE consequences of **increased temperature**

- Material properties of asphalt are closley dependent on temperature due to reduced stiffness with increased temperature.
  - Reduced deformation properites
  - Reduced load distribution
  - Increased loading on sub-layers
- A frozen road is very strong, and a reduced frozen period can lead to increased deteriation
- The number of freeze-thaw cycles will increase in some areas
  - Several spring-thaw weakening periodes during one singel winter

  → Melting of the upper part of the pavement → reduced bearing capacity
- Reduced frost index, but more critical where in the construction the ice lenses from


Islinser
Frosset
Frysefront
Tint
Oppsug av vann
Grunnvannsspeil
Grunnvann

Variation of the bearing capacity during the year



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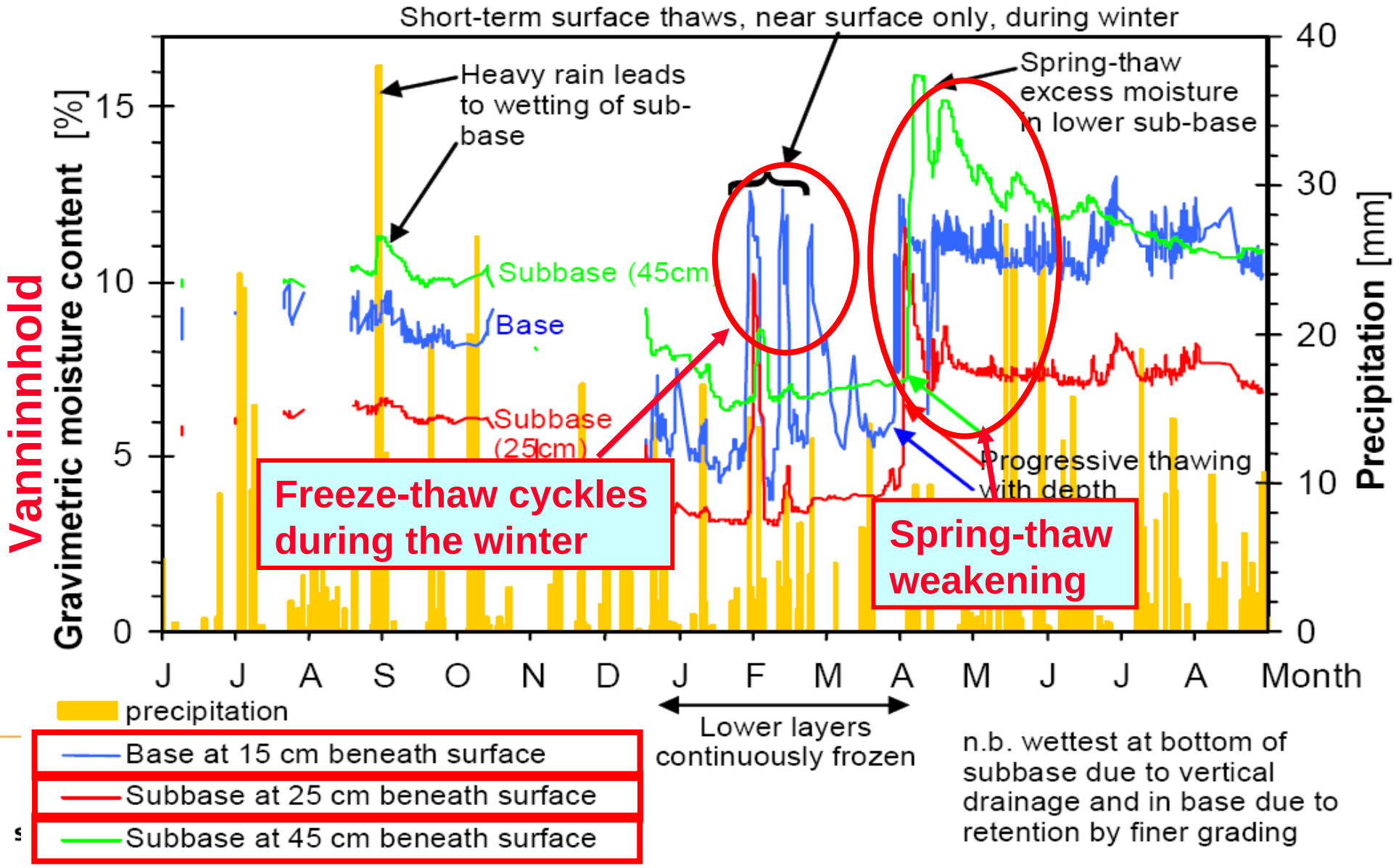
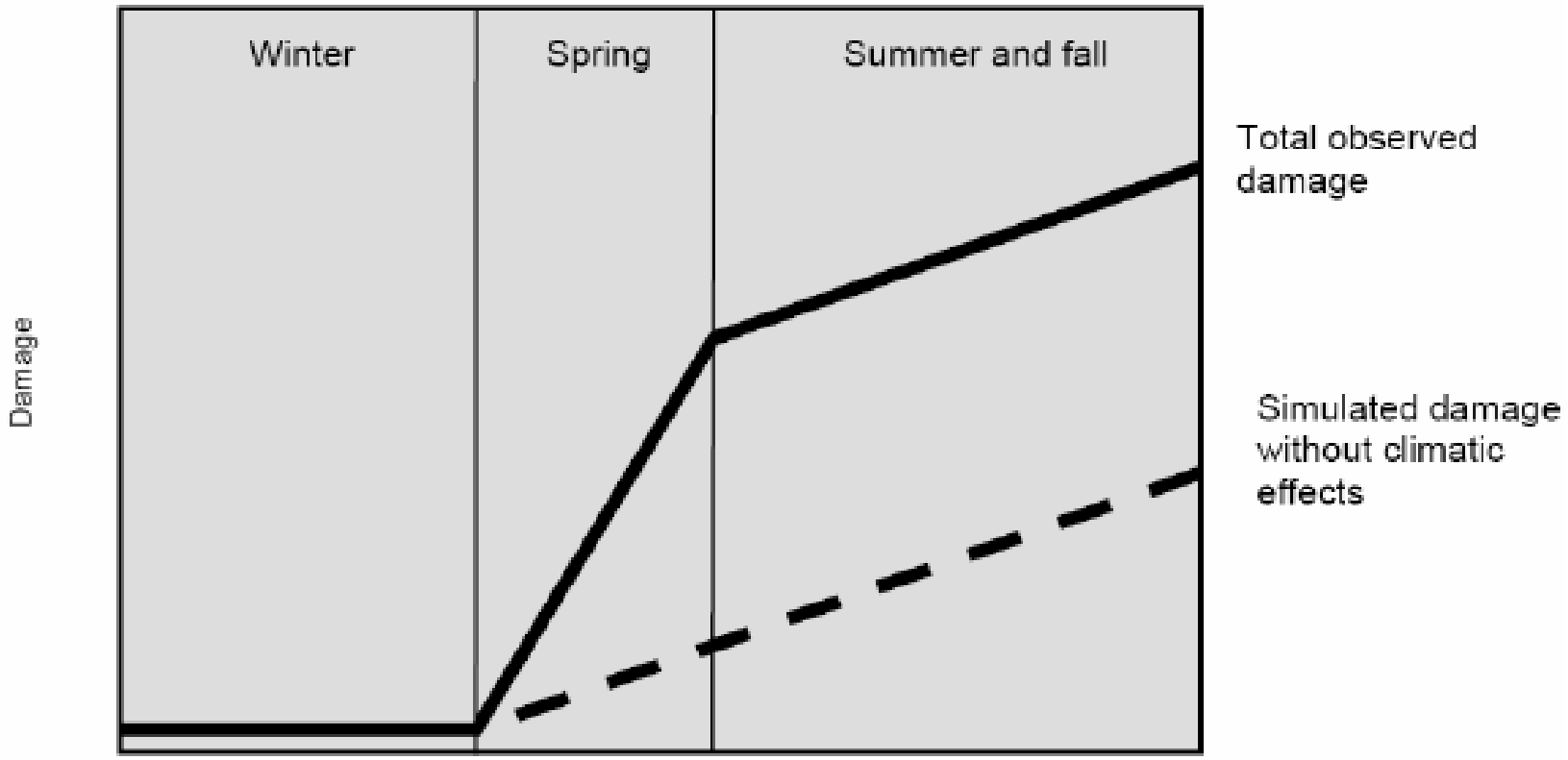
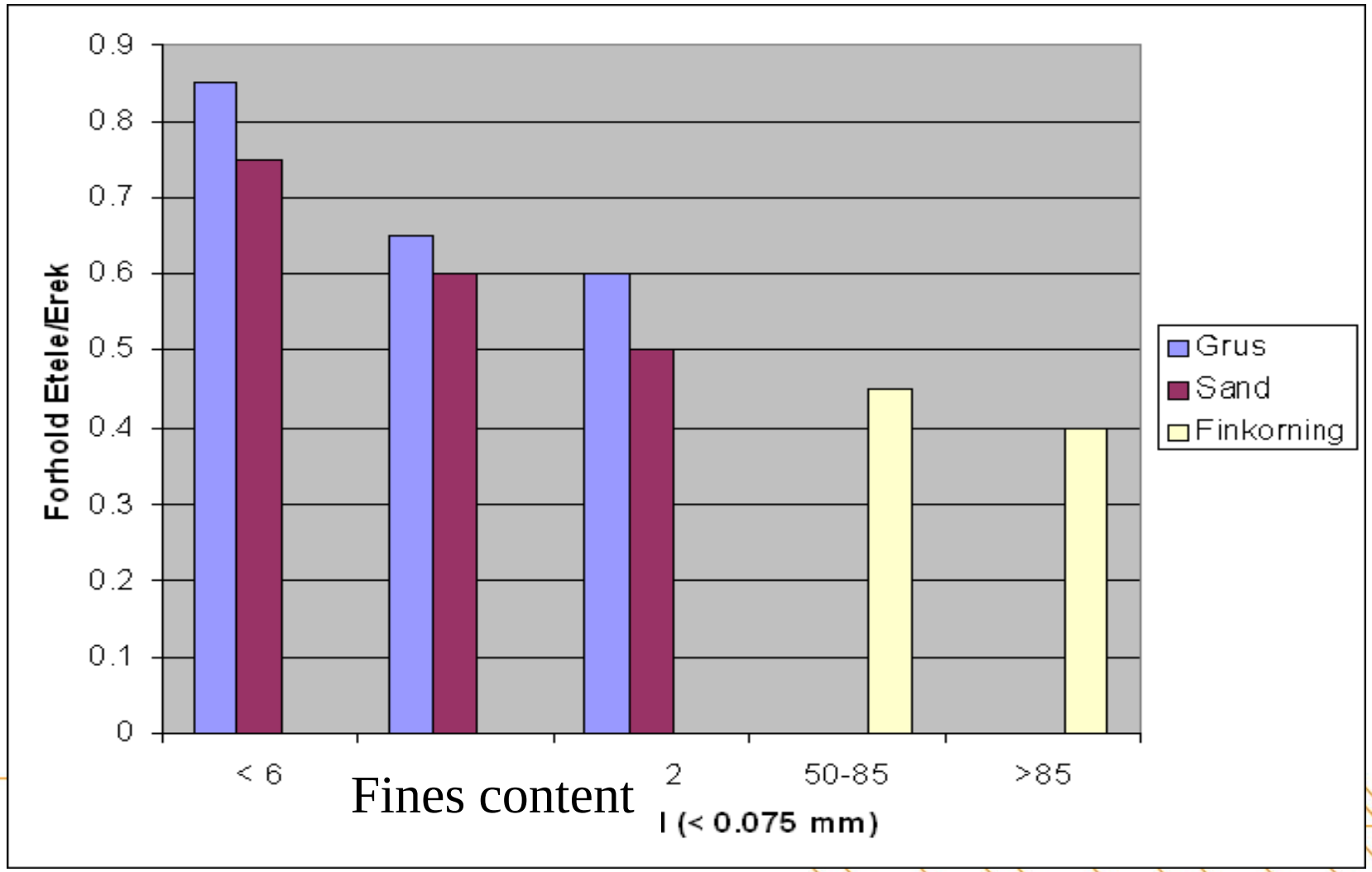
Freeze-Thaw cyckles



Scematic illustration of deteriation with and without climatic effects (Doré et al. 2006)



Examples of relative E-modulus for materials during the spring thaw weakening period



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Concequences in regions with increased frequency of freeze-thaw cycles

- Roads with poor materials high in the pavement will have **increased deteriation**. (often **low volume roads**)
- For roads with good materials in the pavement, the **concequences will be small** (**high volume roads**, main roads)
- More periods with **poor acessebility on gravel roads** → Increased need for maintenance.

POSITIVE consequences of **increased temperature**

- The number of freeze-thaw cycles will be less in some areas
- Less frost heave in some regions
- Reduced ”studded season” → redusced rutting caused by studs.

Tasks in Project task 5 -Bearing capacity of roads

5.1 How is materialparameters for road construction materials affected by changed climate?

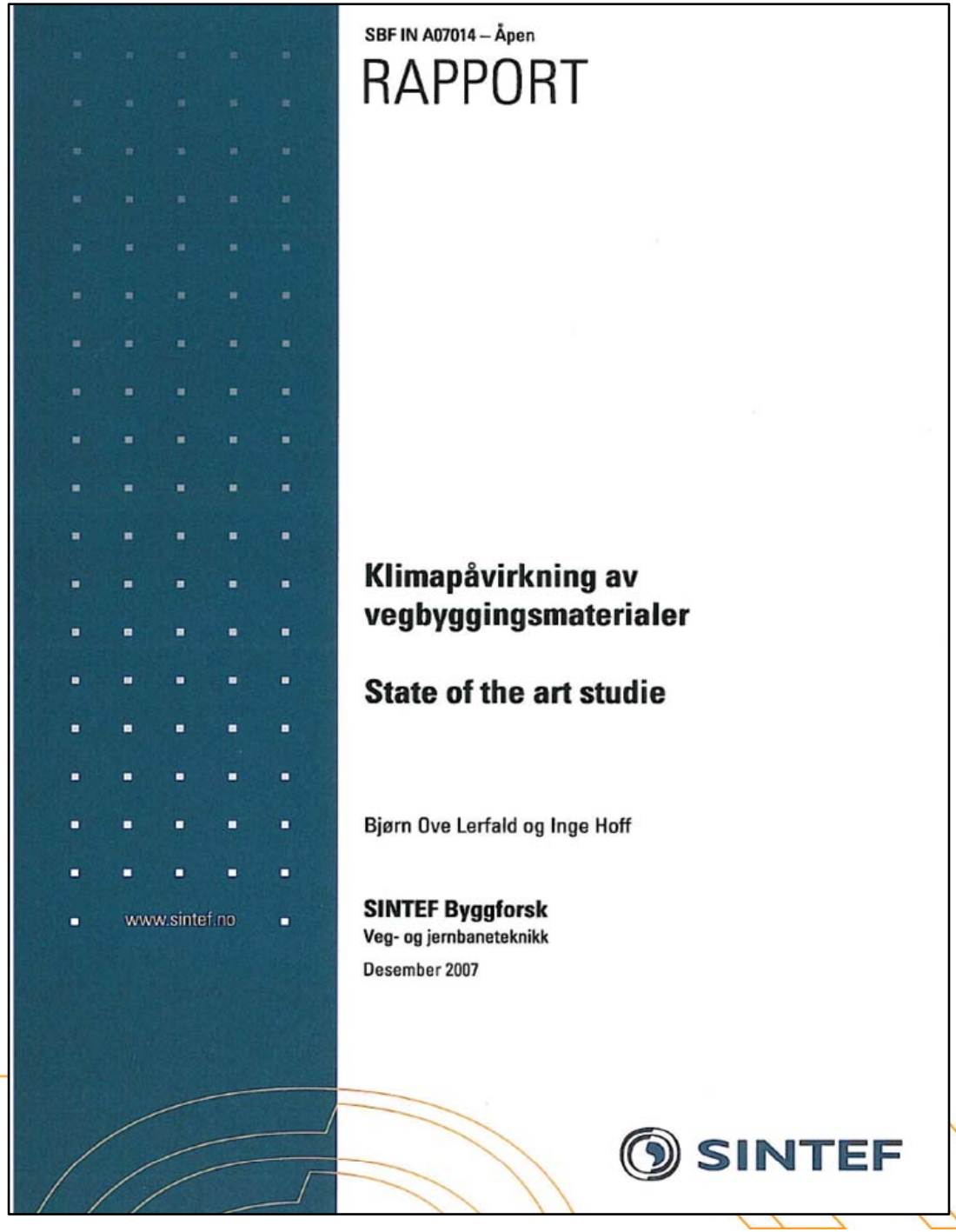
5.2 Consequences of changed climate for gravel roads

5.3 Consequences of changed climate for hard surface roads

5.4 Pilotprojects

Project task 5 – Bearing capacity of roads will be dealing with

- Choice of models for calculating consequences (for a road network)
- Calibration and abdoption of the model to Norwegian conditions
- Calculation of changes in maintenance costs
- Proposal for measures to cope with negative consequences
- Pilotproject to show practical problems the climate change can lead to, and nessesary adaptions to be made.
  - Effect of drainage on the lifetime of a road



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Tabell 1 Hvordan de ulike materialene blir påvirket av klimaendringer

	Asfaltdekker	Grusdekker	Stabiliserte bærelag	Ubundne bærelag	Forsterknings lag	Undergrunn
Mildere vintre	Lavtemp.-sprekker	Kortere frosset sesong		Telehiving	Telehiving	Telehiving
Varmere somre	Deformasjoner	Støvproblemer	Deformasjoner			
Oftere teleløsning	Sprekker	Bæreevne Framkom-melighet		Bæreevne		
Flere fryse/tine vekslinger	Bestandighet					
Mer nedbør	Bestandighet	Oppbløtning Erosjon av overflate				
Mindre snødekke	Piggdekk-slitasje	Spor				
Økt grunnvann-stand				Bæreevne	Bæreevne	Bæreevne
Økt salting	Piggdekk-slitasje					
Økt havvannstand	Kan ha betydning lokalt enkelte steder der grunnvannstanden øker pga. økt havvannstand					
Mer vind	Kan påvirke broer, skiltportaler og lignende					
Flom	Kan ha stor betydning lokalt med utvasking av materialer ol.					

Liten betydning	Positiv betydning	Negativ betydning	Usikker betydning

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VIANOVA

Klima og Transport

Delprosjekt 5
Tilstandsutvikling på vegnettet

Vurdering av EDB-system for beregning av nedbrytning av veg

ViaNova Plan og Trafikk AS
Desember 2007

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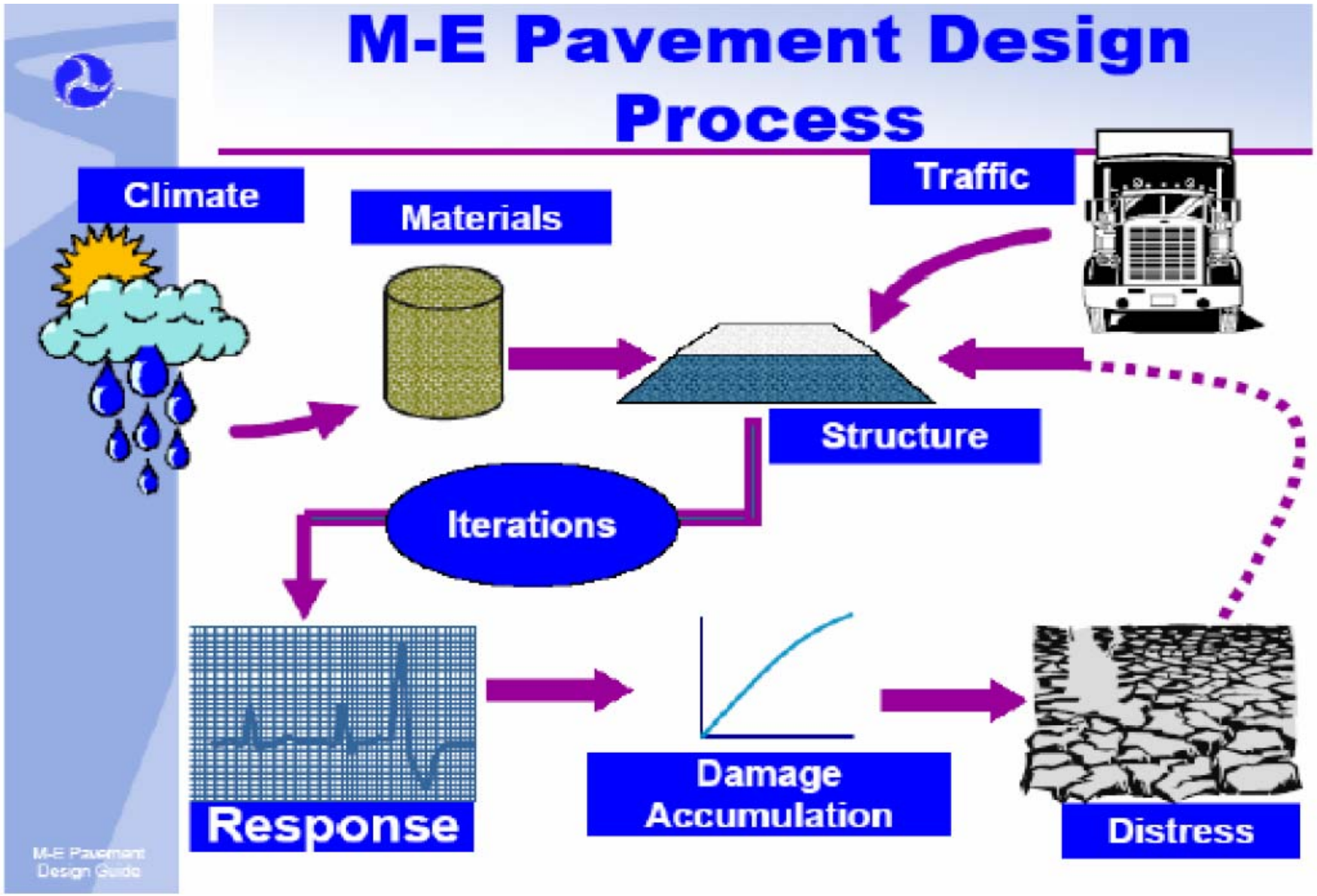
Evaluated models

Innhold

M-E Pavement Design Process



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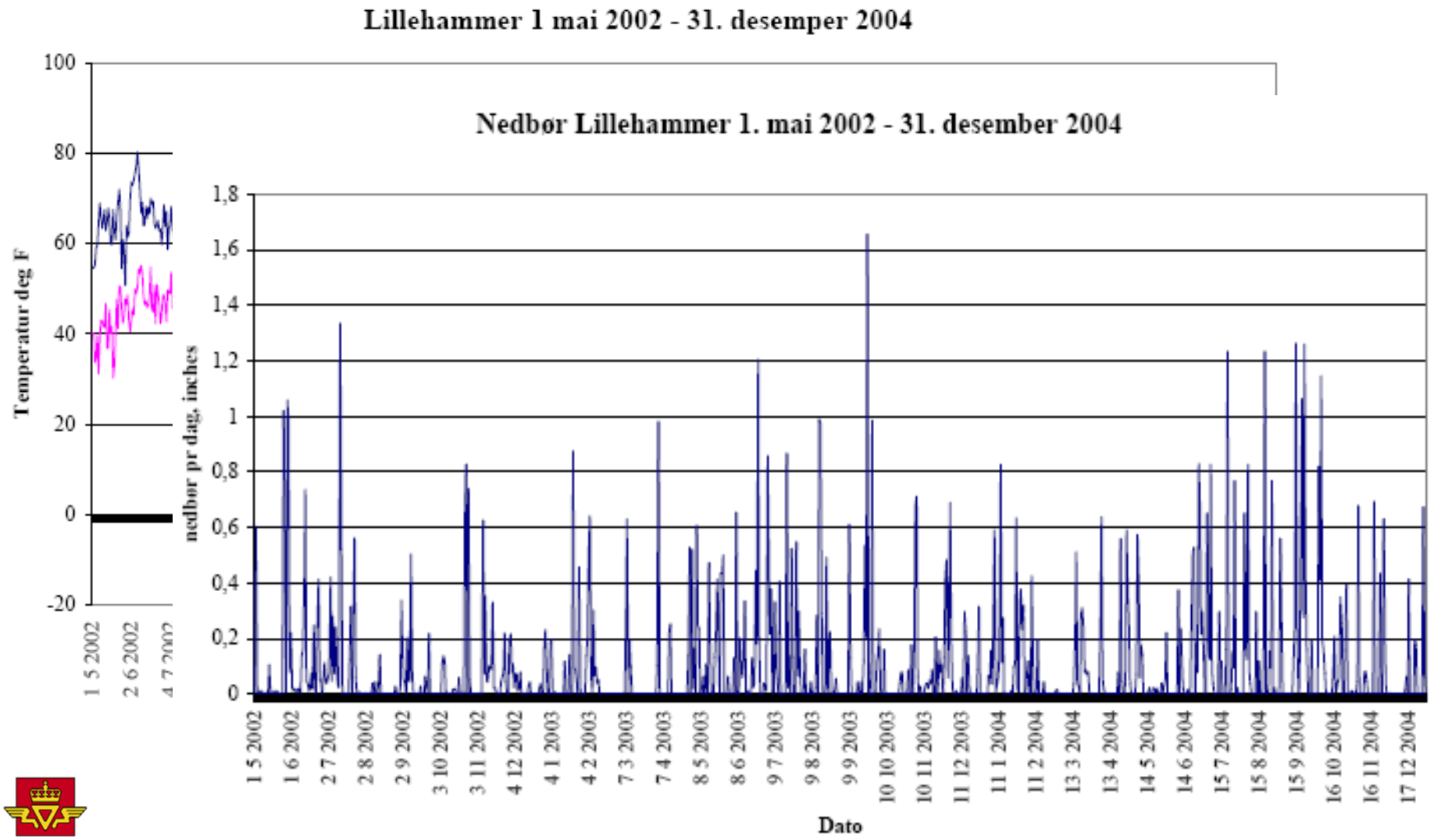
AASHTO 2002 MEDG

AASHTO 2002 uses historic data:

- Temperature
- Percipitation
- Wind
- % Solar radioation
- Depth of ground water table

Examples of climatic data in AASTHO 2002



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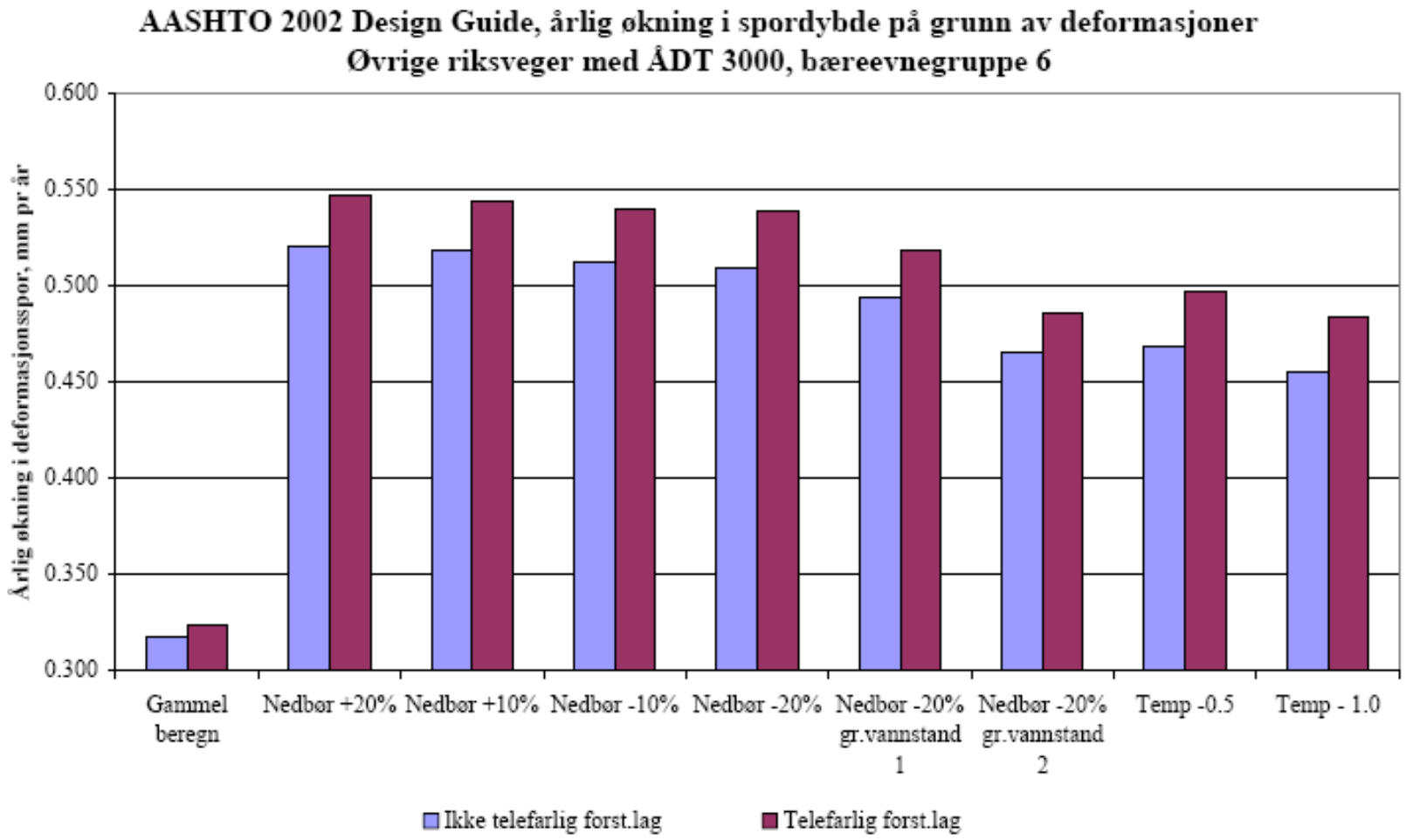
Results



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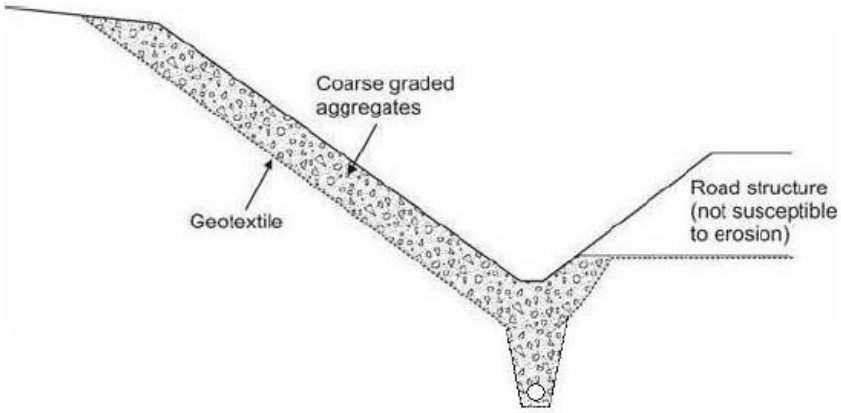
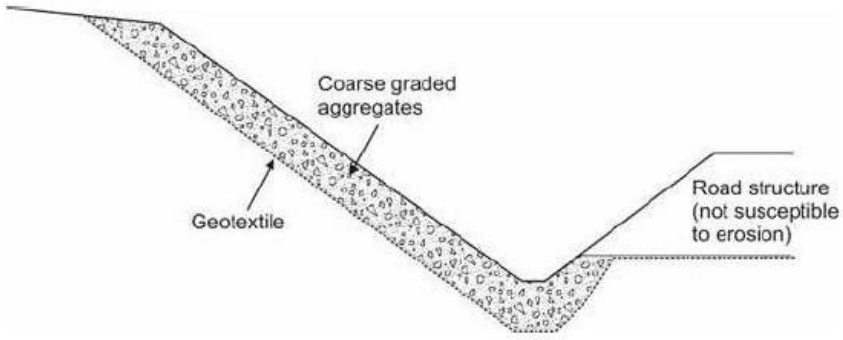
Measures to cope with negative effects of a changed climate

- Focus on **bitumen-material properties** (stiffness, PmB)
- Use of **non-water-suseptible** unbound materials
- Improved **drainage system** that removes water fast and effective from the pavement-structure

Steinsetting av skjæringsskråning med dypdrenering

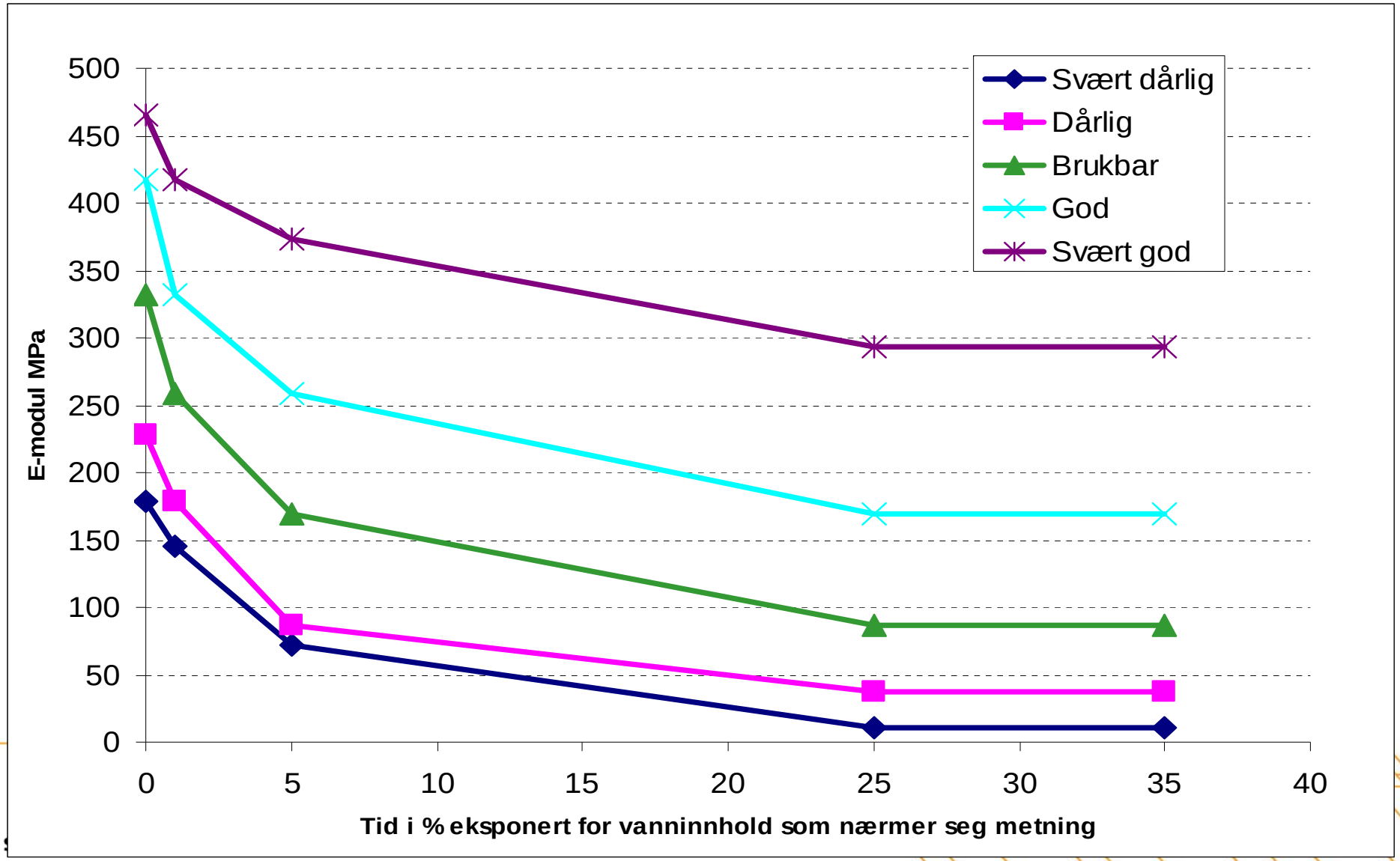


Steinsetting av skjæringsskråning med enklere form for dypdrenering



AASTHO Design Guide

Recommended E-modulus for base and sub-base depending of the quality of the drainage system



Material properties in a changed climate

Important properties for bitumen-materials:

- Good stability in high temperatures
- Resistance to water and salt → Rutting
- Flexibility to variaation of bearing capacity and uneven frost heave.

Important properties for unbound materials:

- Fines content in materials where the water content is increased

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Thank you for your attention!