NVF Vägteknologi, Sommarmöte
Reykjavik 28/05/2018

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The Effect of Deicing Salt on the Durability of the Pavement Structure

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BEYOND THE SURFACE

DEICING SALT RELATED DAMAGES IN PAVEMENT

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E4 - Vid Höga Kusten: Salt related asphalt damages1998

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HW21 Finland: Salt Related Damages 2001

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Salt Related Problems on Asphalt Covered Dikes in The Netherland

Effect of the Extensive use of De-icing Salt on Roads with Thin Pavements

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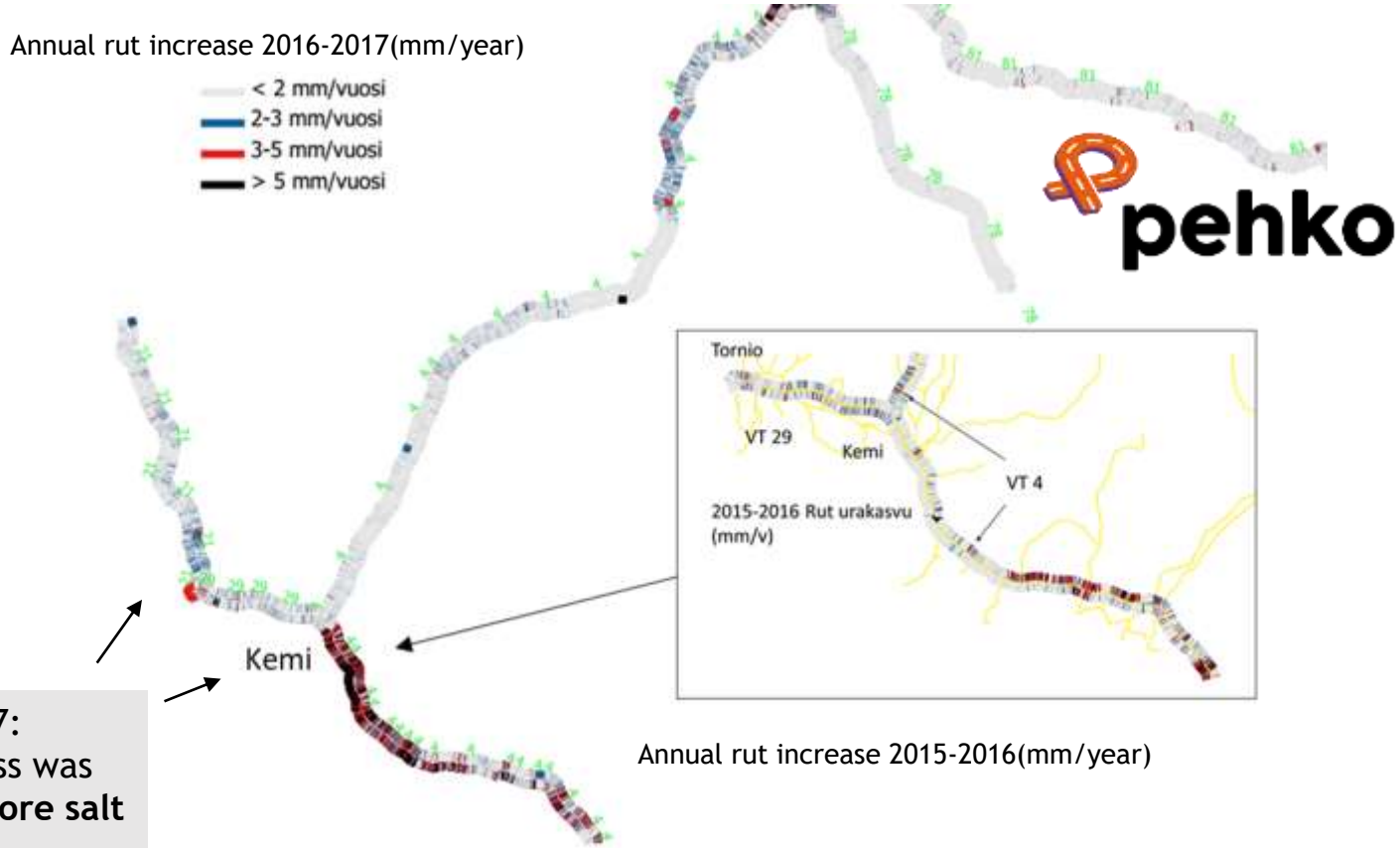

Winter 2016-2017: maintenance class was raised to: **1S - more salt 25g/m2**

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Effect of the Extensive Use of De-Icing Salt on Roads with Thin Pavements

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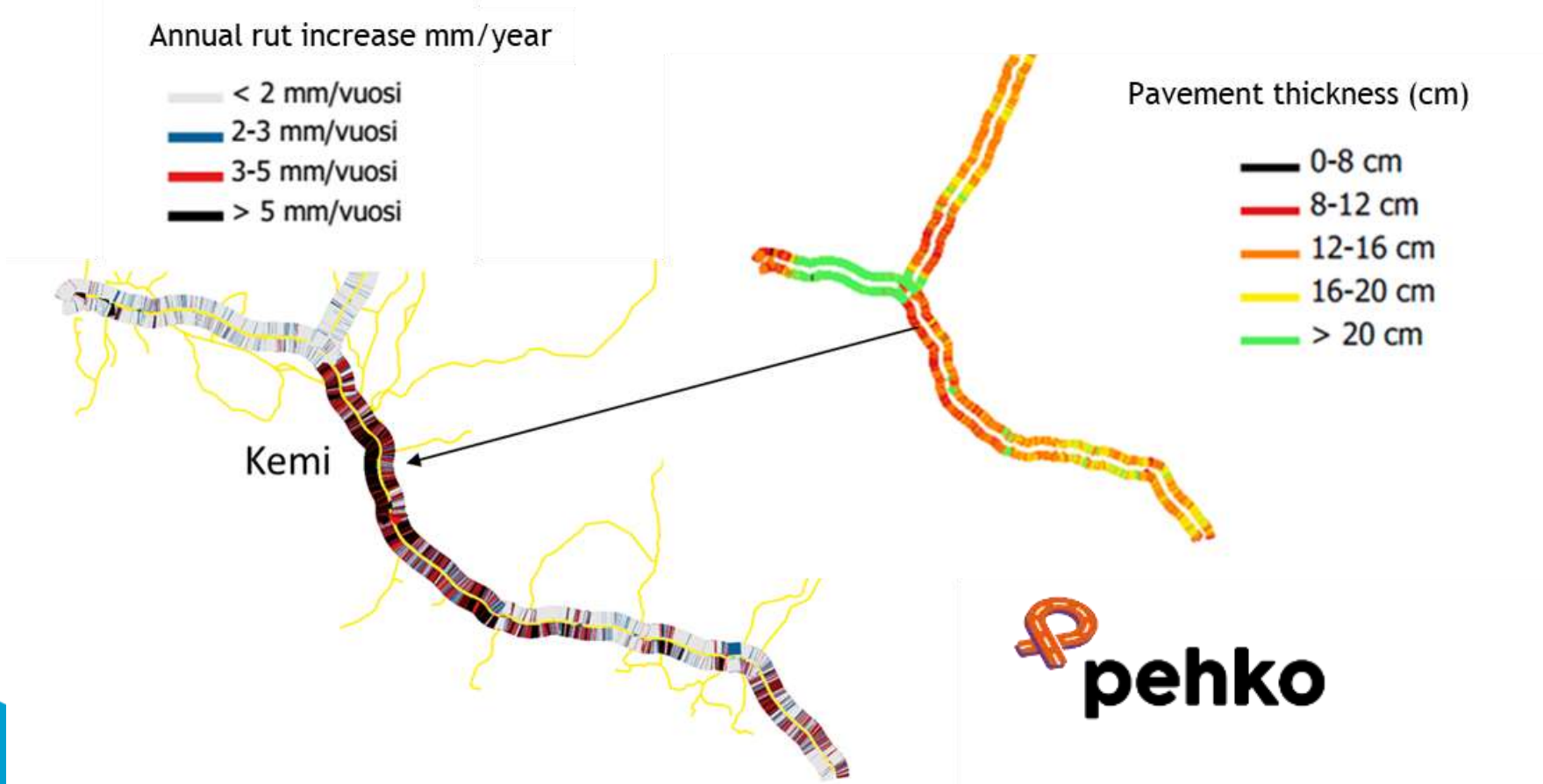

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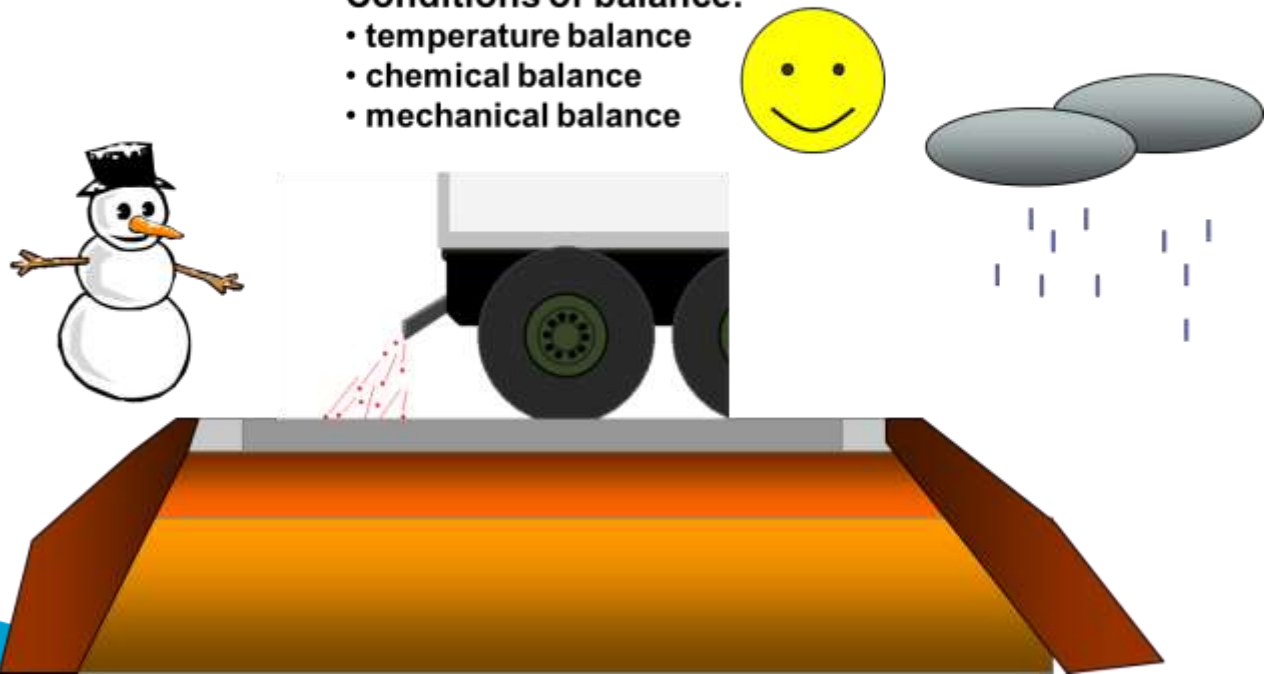
Reasons for the Problems – Can Thermodynamics Explain?

A road is a thermodynamic systems on that changes materia and energy with its surroundings

A system is in balance, if it does not have changes as a function of time

Conditions of balance:

- **temperature balance**
- **chemical balance**
- **mechanical balance**



Reasons for the Problems – Can Thermodynamics Explain?

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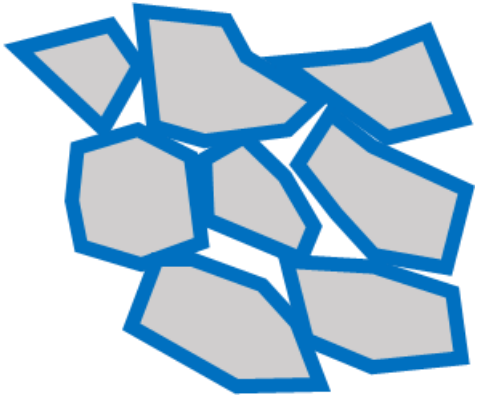
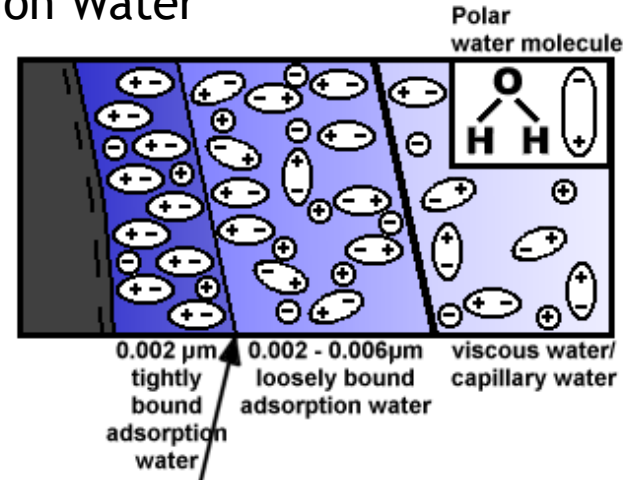
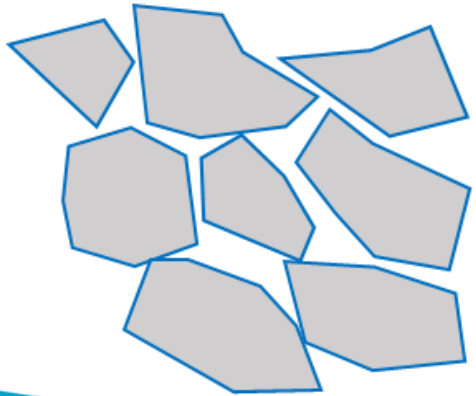
Effect of Salt to Tightly Bound Adsorption Water

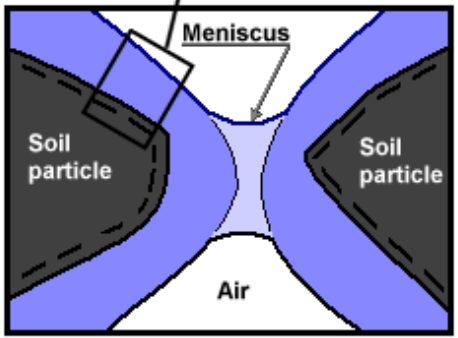
"Clean" Water





After salt added





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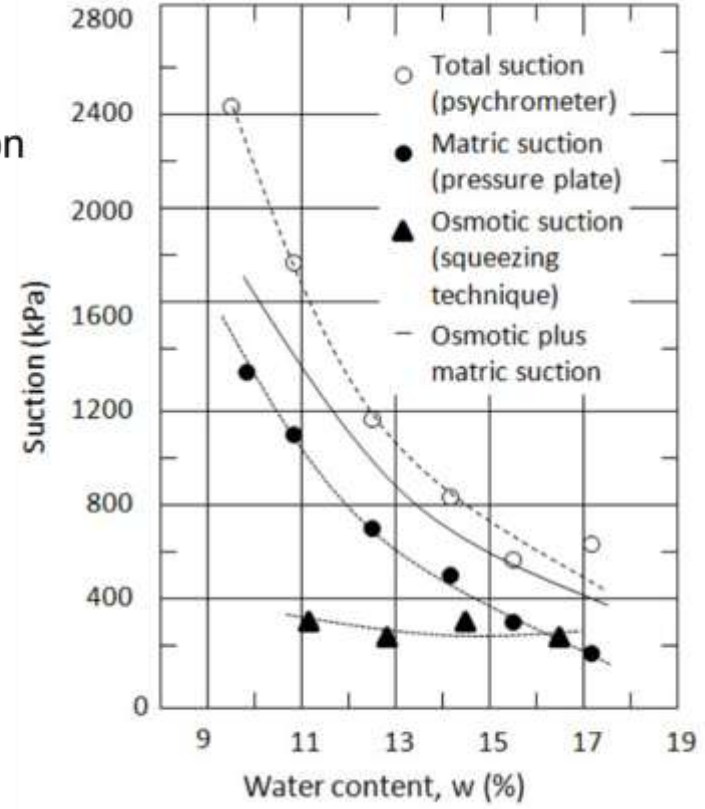
Reasons for the Problems – Can Thermodynamics Explain?

WHAT IS SUCTION?

Matric Suction
Osmotic Suction
Total Suction

1. TOTAL SUCTION =
   a) Osmotic suction +
   b) Matric (matrix) suction
   c) Gas pressure suction
   d) Gravitational suction
   e) Overburden pressure suction

2. CRYOSUCTION



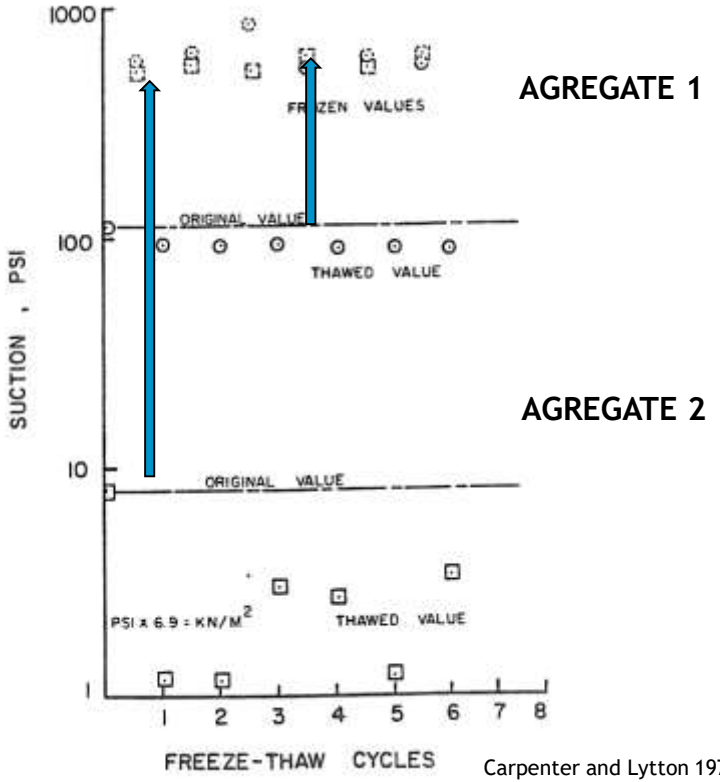
Mitchel 1975

Reasons for the Problems – Can Thermodynamics Explain?

CRYOSUCTION

- undependent of total suction

- *force that causes water (if available) to flow to freezing front, and further formation of segregation ice*



Carpenter and Lytton 1977

Reasons for the Problems – Can Thermodynamics Explain?

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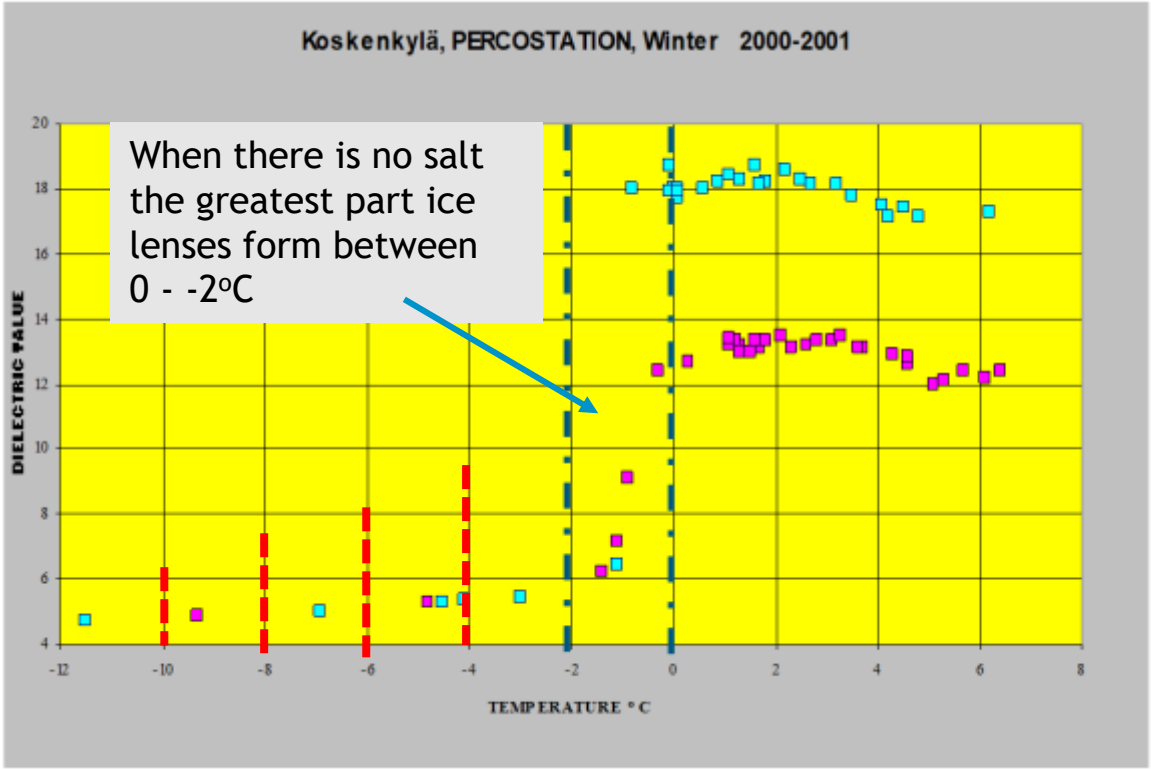
Effect of Temperature in Forming of Ice Lenses (Segregation Ice)

The key element in the formation of segregation ice is the amount of unfrozen water in frozen material.

Increasing de-icing salt lowers the freezing temperature



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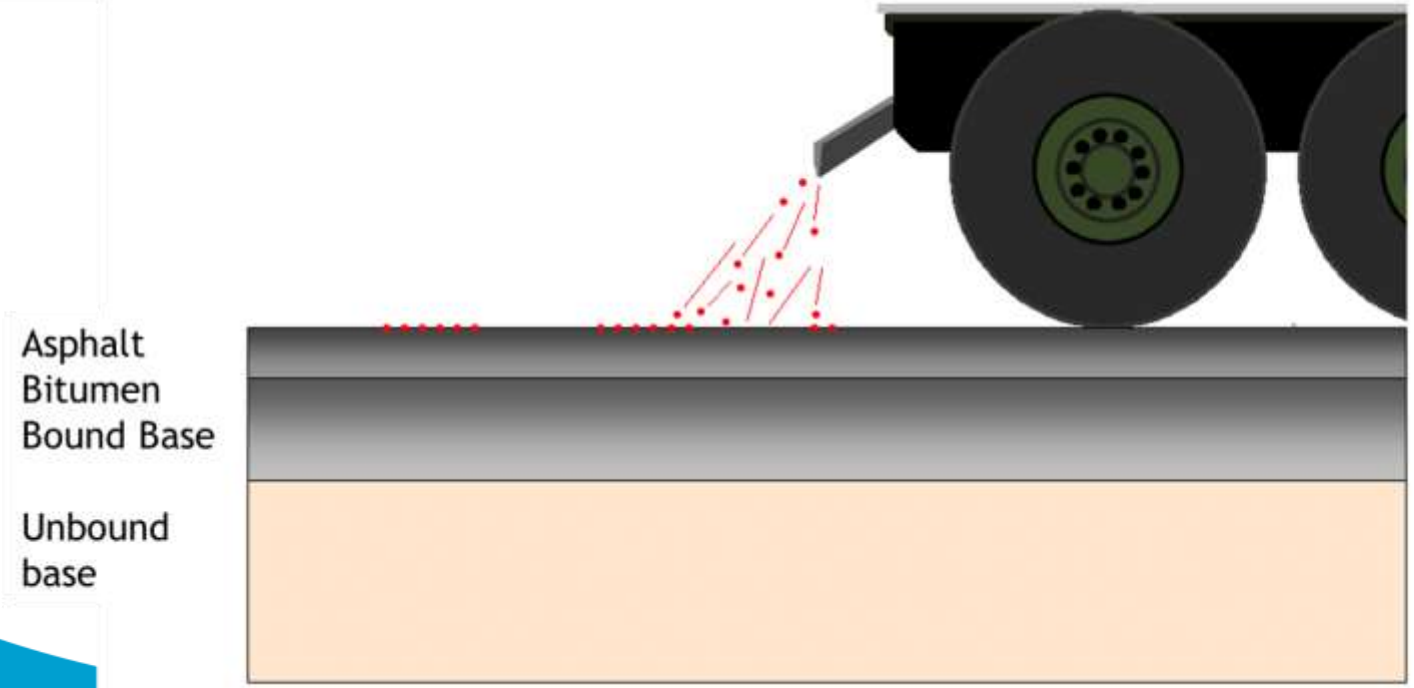
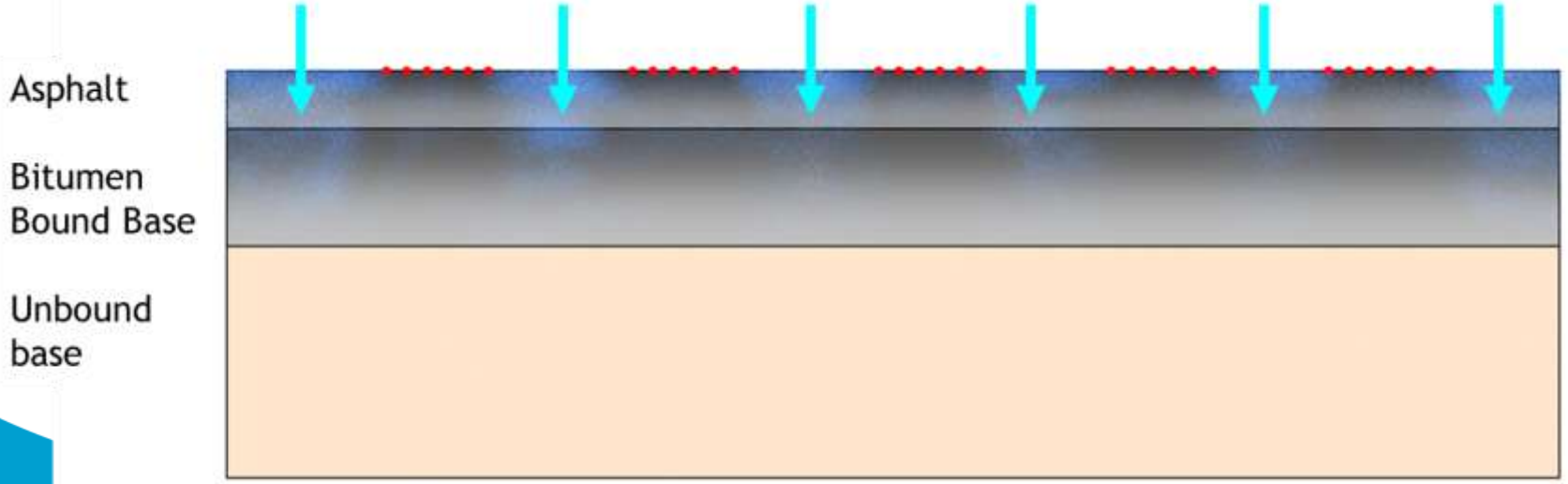
Damage Process of De-Icing Salt Related Damages in Asphalt Pavement

During the fall salty water penetrates into the pavement, parts with higher amount of salt adsorb more water due to osmotic suction



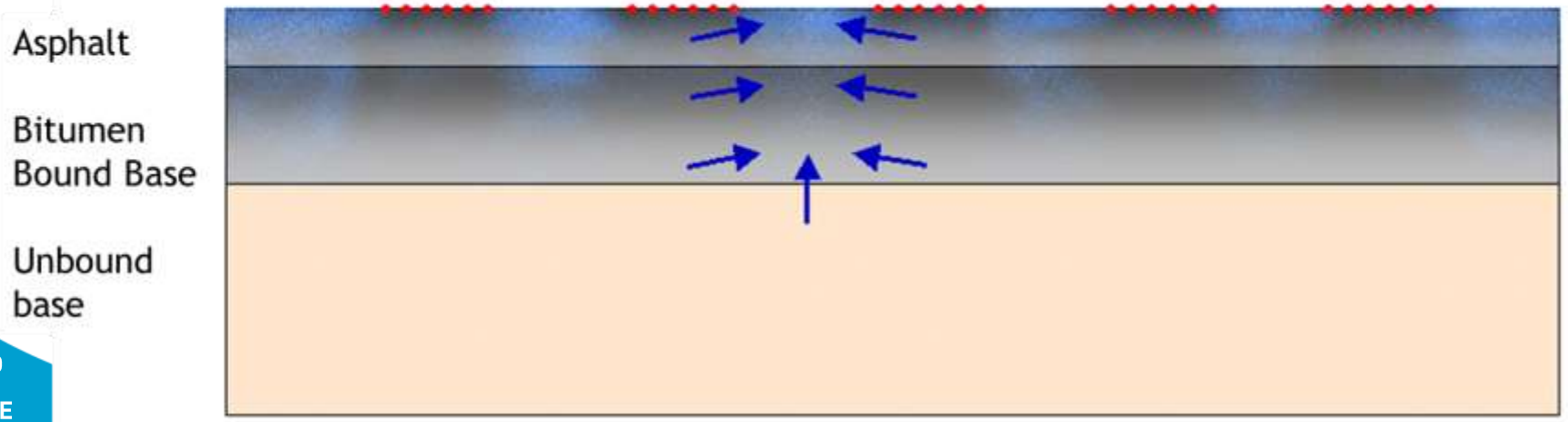
Damage Process of De-Icing Salt Related Damages in Asphalt Pavement

Due to uneven distribution of salt pavement does not freeze evenly and parts with smaller salt amount freeze first



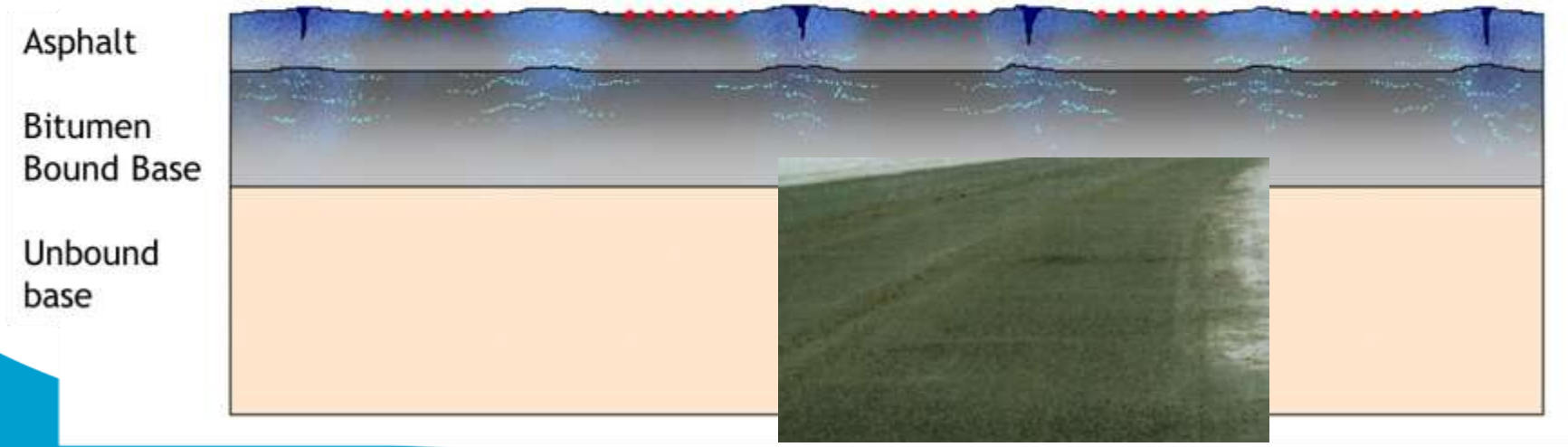
Damage Process of De-Icing Salt Related Damages in Asphalt Pavement

Cryosuction is developed, which adsorps water beneath and aside from the unfrozen parts that have more water



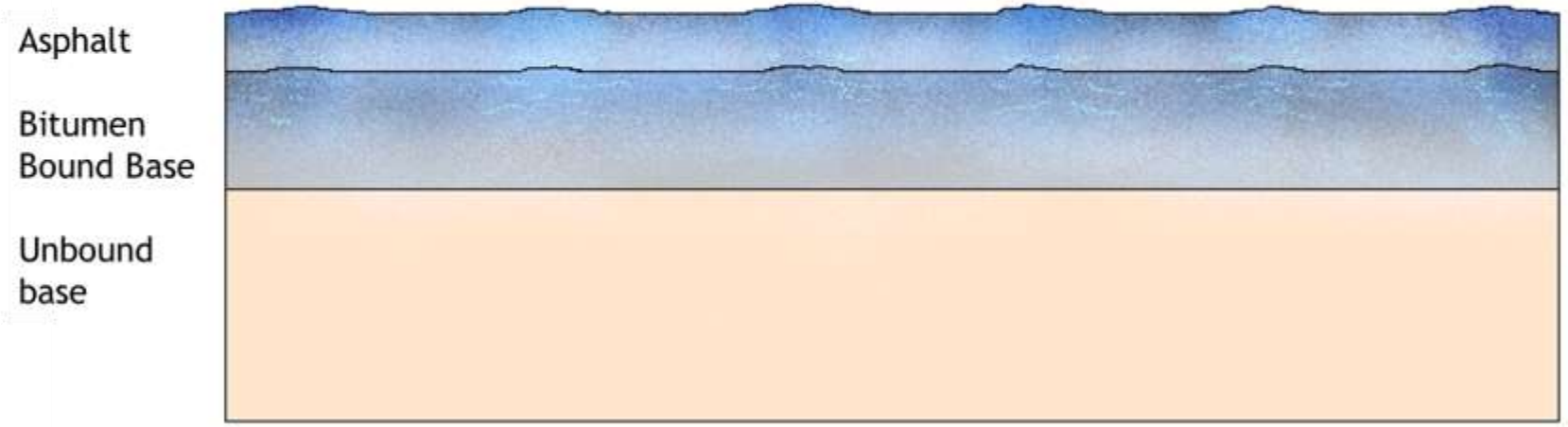
Damage Process of De-Icing Salt Related Damages in Asphalt Pavement

Bound structures get cracks allowing more water to penetrate in the pavement



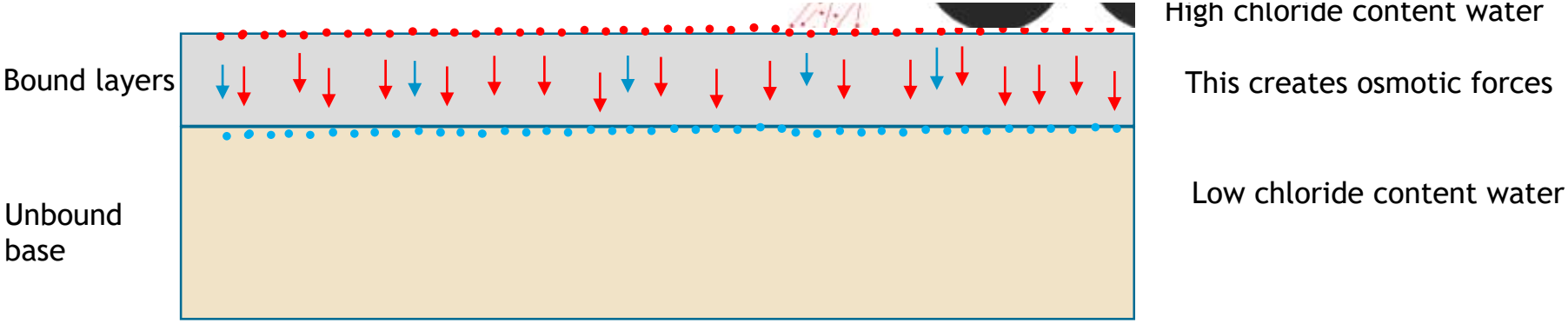
Damage Process of De-Icing Salt Related Damages in Asphalt Pavement

Whole structure freeze and differentila ”bumps” get mor even due to osmotic forces



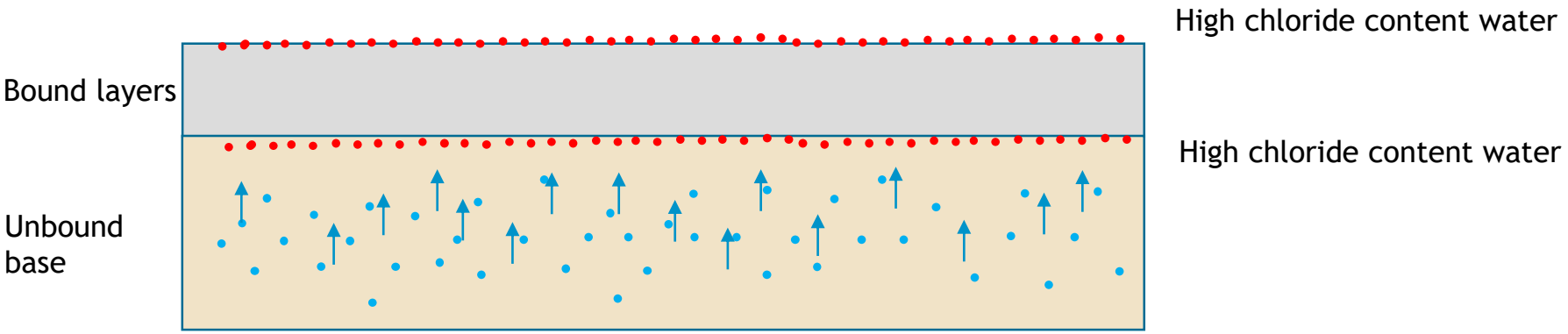
Damage Process of De-Icing Salt Related Pavement Structure Deformation

How much salt is moving depends on a) salt concentration, b) asphalt thickness and c) voids content. Higher salt content decreases also the thickness of adsorption water and thus enables easier move of the water molecules



Extensive use of deicing salt creates osmotic forces between pavement surface and pavement bottom – pavement acts as a membrane

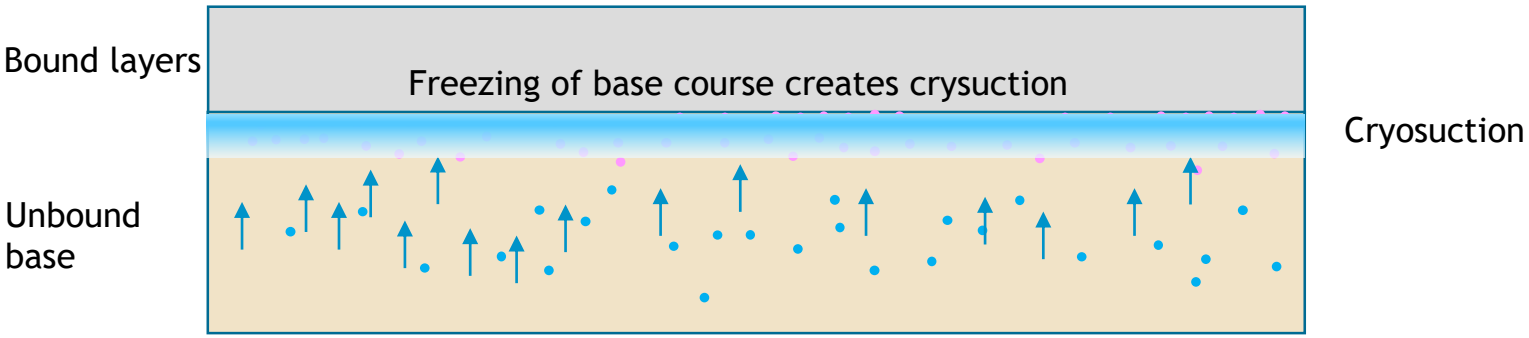
Damage Process of De-Icing Salt Related Pavement Structure Deformation



Increasing amount of salt in base course surface creates osmotic forces of base course surface and lower part of base course. This creates water moving towards base course surface – and in long term salt also moving to the lower parts of the base course.

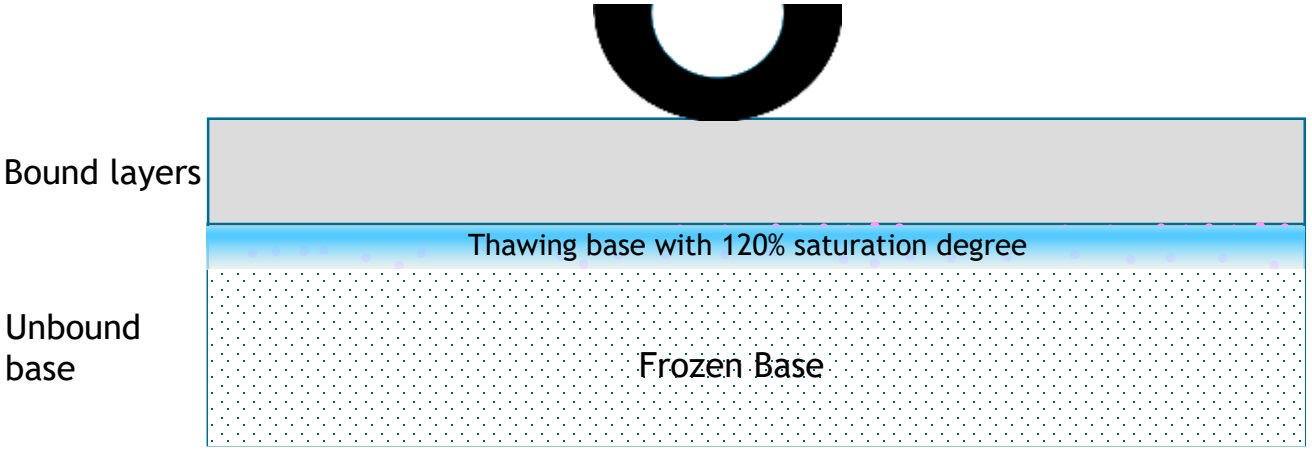
Damage Process of De-Icing Salt Related Pavement Structure Deformation

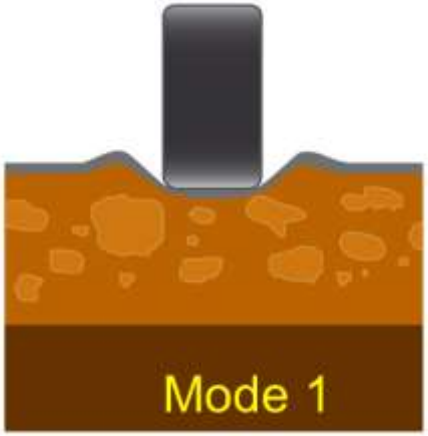
< 0°C



In cold temperatures top part of the base course starts to freeze and cryosuction will be created resulting water flow to the freezing front and formation of ice lenses under the pavement.

Damage Process of De-Icing Salt Related Pavement Structure Deformation

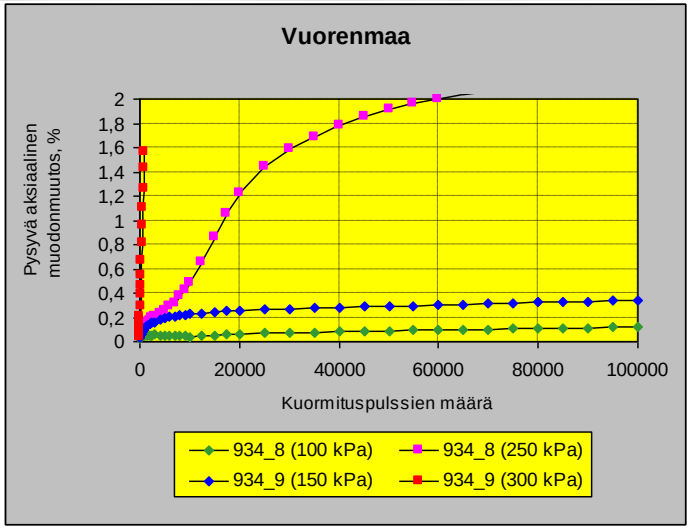




When the pavement structure starts to thaw there is supersaturated unbound base under the pavement and pavement will be exposed to permanent deformation and cracking under heavy loads.

Conclusions & Recommendations

- New roads with new pavements: use first de-icing salting round before the winter comes
- Increasing the use of deicing salt on the roads with thin pavements and/or high air voids can lead to anomalous high permanent deformations
- Safe thickness for bound layers against permanent deformation is 200 mm
- And salt is not the only solution for better winter maintenance



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