Deicing (Winter Operations) on Porous and Permeable Pavements

Laura Fay

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Center for Environmentally Sustainable Transportation in Cold Climates
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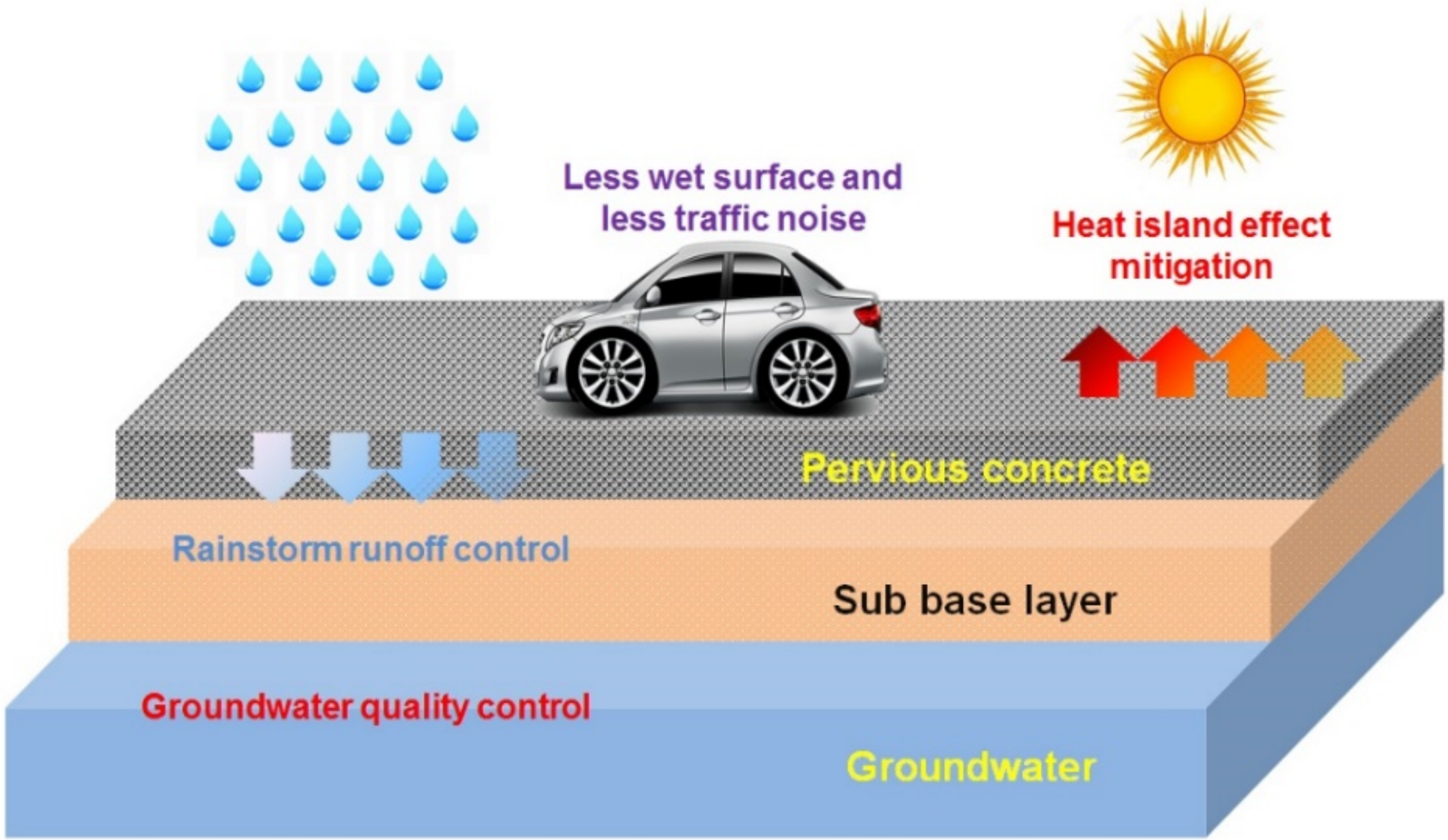
MONTANA STATE UNIVERSITY
College of ENGINEERING
Western Transportation Institute

Permeable pavements



Porous and permeable pavement (PPP)

- Pavement surfaces with porous, permeable or high macrotexture such as:
  - open graded friction courses,
  - porous European mix,
  - ultra-thin wearing surface,
  - NovaChip Portland cement porous pavement,
  - or pervious concrete.

PPP-surfaced roads

- Highway pavements with top ½ - 1 ½ inch porous/permeable surface treatment

Open-Graded overlays

- Basic Info
  - Gap-graded aggregates
  - Generally ¾ - 1 ¼ inch thick
  - Typically 15 – 24 percent air voids
- Nomenclature
  - Open-graded friction course (NJ, MA, GA)
  - Open mix type (OR)
  - Open-graded surface course (UT, NV)
  - Porous friction course (VA)
  - Porous European mix (GA)

Ultrathin Friction Course

- Basic Info
  - Gap-graded aggregates
  - Generally ⅜ - ¾ inch thick
- Nomenclature
  - Ultrathin friction course (NJ)
  - Paver placed surface treatment (NY)
  - Ultrathin bonded asphalt wearing surface (MO)
  - Ultrathin bonded asphalt surface (KS)

Why use PPPs

- Porous and permeable pavements have been successfully used by multiple transportation agencies to:
  - ✓ help reduce water splash and spray,
  - ✓ increase friction,
  - ✓ reduce potential for hydroplaning,
  - ✓ and reduce noise.

Why use PPPs

- Additional safety and environmental benefits, include as...
  - improved wet-weather skid resistance,
  - reduced splash and spray,
  - reduced potential for hydroplaning,
  - reducing light reflection,
  - reduced tire/pavement noise,
  - improved pavement smoothness,
  - reduced contribution to urban heat island effect,
  - and potential use of waste materials.

PPPs in Cold Climates

- When used in colder climates on highways PPPs tend to:
  - ✓ Freeze more rapidly,
  - ✓ transport deicing chemicals from the road surface,
  - ✓ clog from sands and other debris,
  - ✓ retain snow and ice longer than traditional dense graded pavements (DGPs) making removal more difficult.

PPPs in Cold Climates

- The use of sand is NOT recommended on PPPs because it can clog the pores and create additional maintenance.
- There is currently no consensus on winter maintenance operations specific to PPPs.
- Most strategies are developed in-house or on-the-fly.
- General consensus -> a quick response is needed, but requires flexibility in timing and based on weather conditions.

PPPs in Cold Climates

- ***Porosity*** and ***texture*** tend to be the leading material properties of PPPs that affect their performance in winter conditions.
- PPP porosity ->
  – infiltration of water and deicing chemicals through the pores
  – pumping of water and salts to the surface from traffic

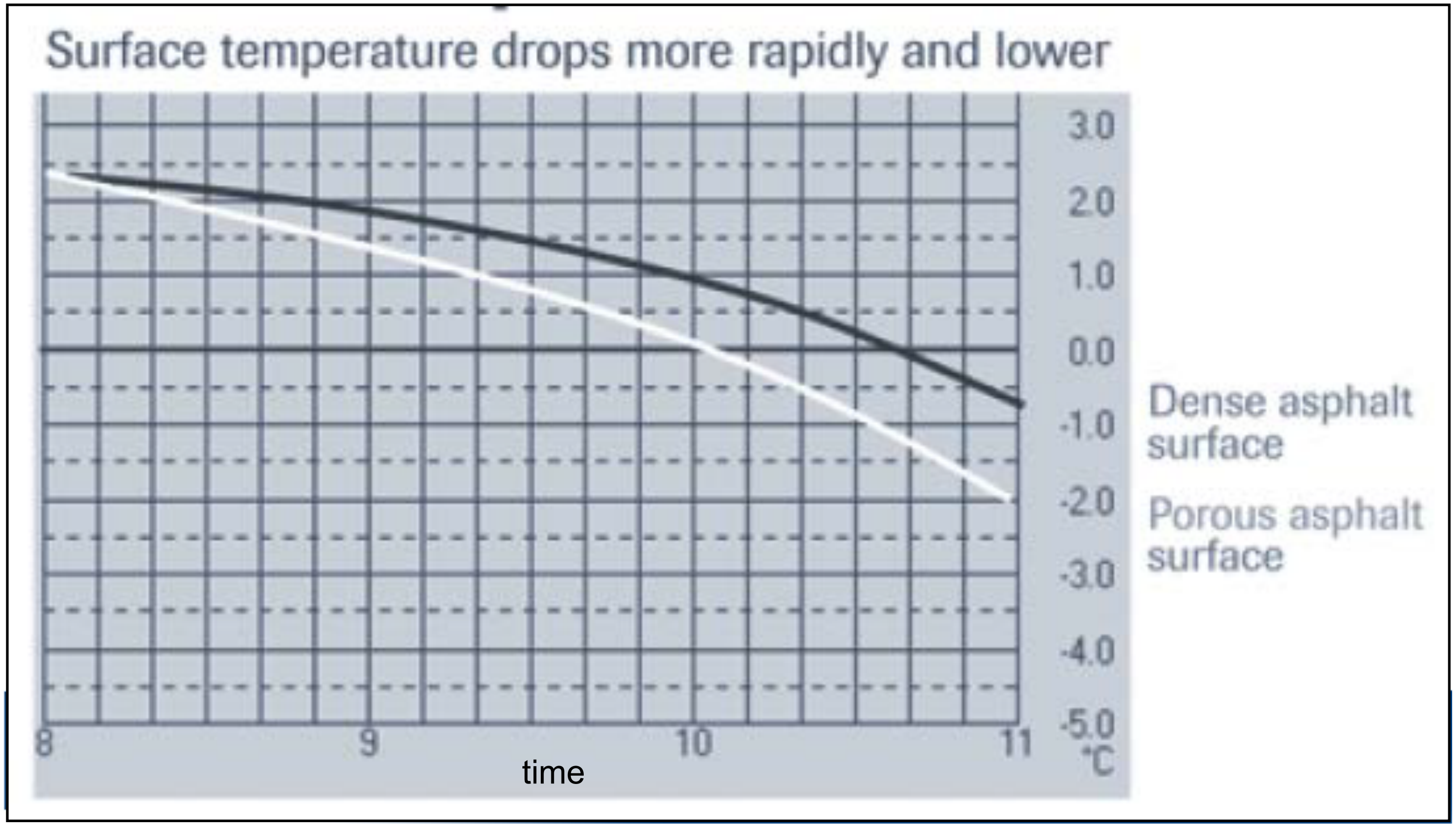
PPPs in Cold Climates

- PPP pavements have lower thermal conductivity and greater surface area
- PPP pavements are generally
  - about 2 to 4°F colder,
  - freeze quicker, and
  - remain colder longer.
- Critical temperature range is just below freezing (27-32°F).

PPPs in Cold Climates

- PPPs perform differently than DGPs at lower temperatures due to different thermodynamic properties of the pore spaces.

Road surface temperature drops below freezing sooner.



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PPPs in Cold Climates

- The insulating effect of PPPs inhibits heat transfer from the subgrade and can result in a frozen surface, while an adjacent DGP remains above freezing.

PPPs in Cold Climates

- Three winter conditions that require diligent management of PPPs
  1. freezing fog/hoar frost,
  2. frozen wet surfaces from rain on snow or ice,
  3. and snow or sleet/hail

  Which can all lead to a decrease in friction (slippery road conditions)

Traffic effects

- In winter PPPs dry slower because traffic brings moisture back to the road surface via “air pumping” from tires.
- This can lead to ice formation during freezing temperatures.

Traffic effects

- Liquid and solid deicers that appear to have been lost to the void space can be "pumped" up to the road surface by heavy traffic.
  - Anti-icing, black ice prevention (but you cannot count it)

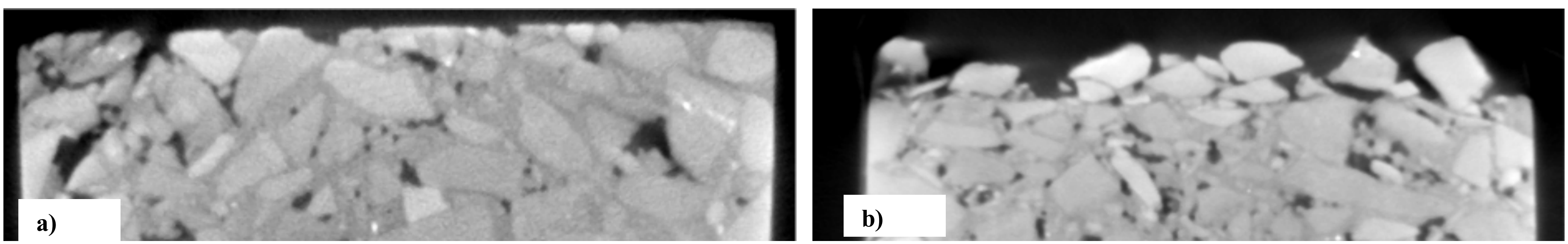
*Road managers have tried to encourage this by routing traffic to a single lane or reducing speeds.

Traffic effects

- Slush can reduce PPPs performance, and also be “pumped” back up the road surface by traffic.
- Traffic can break up thin ice on PPPs due to the macrotexture.
- With sufficient traffic volumes, drivers may not notice a difference in DGPs and PPPs during winter conditions.

Plowing PPPs

- Removal of bonded ice on PPPs is more difficult than on DGPs.
- Ice gets “keyed” into the macrotexture due to the open structure.



Mechanical keying a) CT image of DGP, b) CT image of DGP with chip seal.

Plowing PPPs

- PPP require more force to plow snow from the pavement.
- Plowing on PPPs can cause damage the pavement surface, plow blade and create unsafe driving conditions such as gouging, chatter, and other damage to the pavement surface.
- Some states in the US no longer use PPPs in snowy regions due to damage from plowing and tire chains.

Plowing PPPs

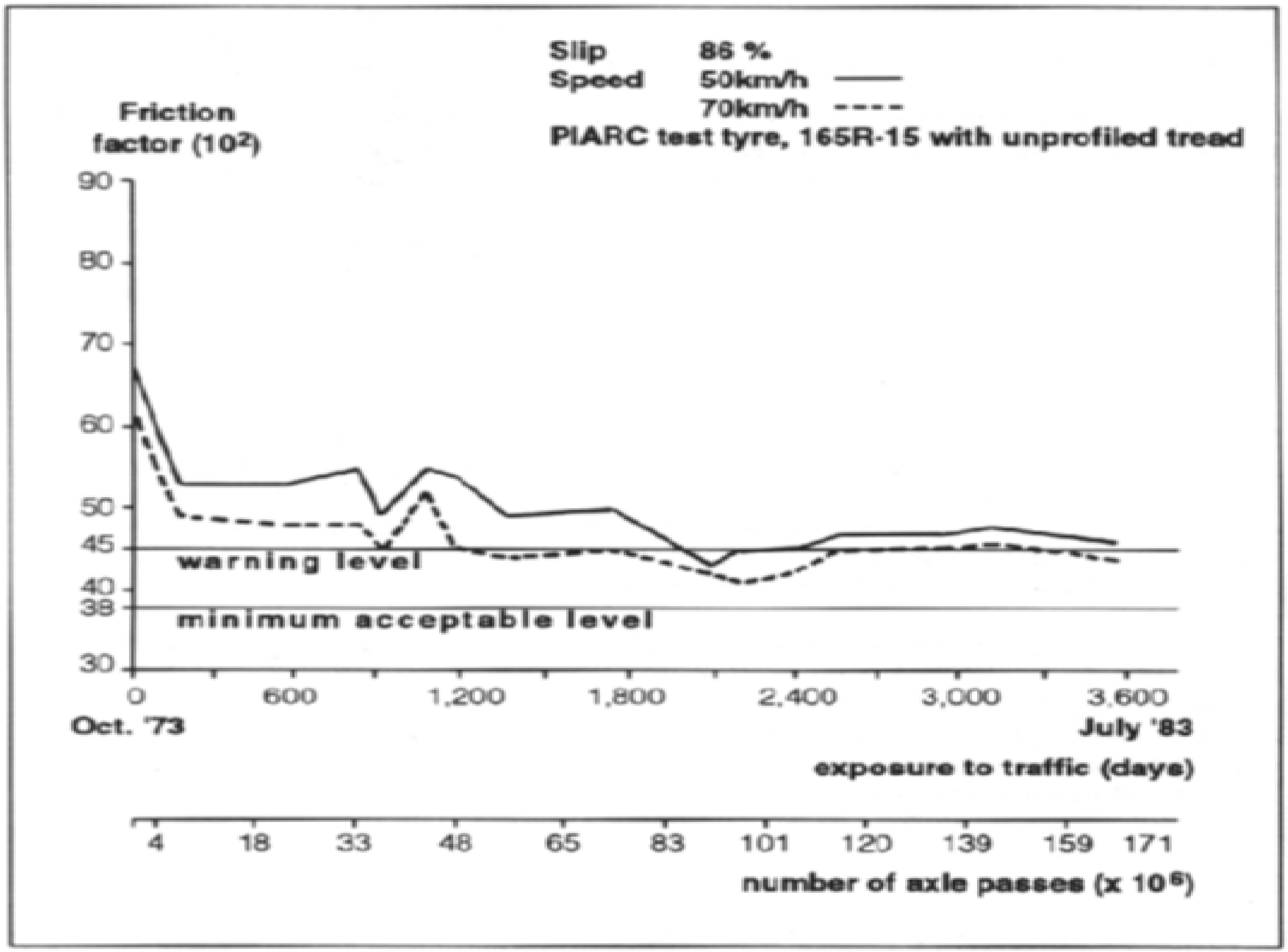
- Suggestions to reduce damage to PPPs include –
  - setting the plow blade 1 inch above the road surface,
  - or waiting until two inches of precipitation has accumulated.
  - Steel plow blade are NOT recommended on PPPs.

Friction of PPPs

- Testing has shown PPP friction after plowing was consistently greater than was measured on DGPs.
- PPPs may appeared more snowy (white), but the snow gets trapped in the pores and the pavement still has a higher friction than dense pavements.

Friction of PPPs

- Overtime traffic can reduce on PPPs friction by polishing and abrasion of surface aggregate.



Deicing PPPs

- Treatment of transition the zones between PPPs and DGPs is critical.
- Higher application rates and more frequent applications of liquid and solid products are often needed on PPPs to reach the same LOS.
- There is no consensus on whether pre- or during storm applications work best.

Deicing PPPs

- Salt brine was most effective in reducing snow–pavement bond compared to dry and prewet solid salt, but did not result in greater residual friction.

Safety of PPPs in winter

- There is no clear consensus on how PPPs affect accident rates.
  - Site specific conditions heavily influence this.
- Suggested practices to increase safety include
  - ✓ providing signage at the transition zones between PPPS and DGPs,
  - ✓ providing timely weather updates,
  - ✓ modifying speed limits or reducing the number of lanes.

Moving forward with PPPs

- Recommendations regarding best winter maintenance practices on PPPs are not clear and generally not quantified.
- We need more hands on the ground providing input, research, and data.

Pros of PPPs in winter

- Good drainage and macrotexture limit ice formation on wet surfaces
- Ice formation within wheel paths covered in snow is reduced due to the macrotexture and permeability
- Friction values are generally the same or better than DGPs
- Improved surface drainage, reduce glare and spray during wet conditions

Cons of PPPs in winter

- Freezes sooner and for a longer period of time than DGPs.
- Surface dries slower due to moisture trapped in the voids that is “pumped” to the surface by traffic, which can lead to icing when adjacent DGPs are dry.
- Sanding is not recommended to improve friction because of the potential to clog PPPs.
- May require higher application rates of deicers or more frequent application of deicing chemicals for longer durations.

Cons of PPPs in winter

- Snow and ice tend to stick to PPPs sooner because the surface is generally cooler.
- Snow and ice remain longer because salts have dissipated from the pavement surface.
- Preventative salting (anti-icing) is not as beneficial because the salt penetrates into the void structure; this is less problematic in highly trafficked areas or if larger salt grains are used.
- Icing problems can occur in the transition zone between PPPs and DGPs due to a lack of deicers being carried over by traffic

Nevada DOT project

- NDOT began constructing a pervious concrete pavement near Lake Tahoe. Specifications for this installation included a 7″ thick pervious concrete pavement surface over an 8″ thick aggregate drainage layer and 6″ thick geotextile-encapsulated sand bed.

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Nevada DOT project

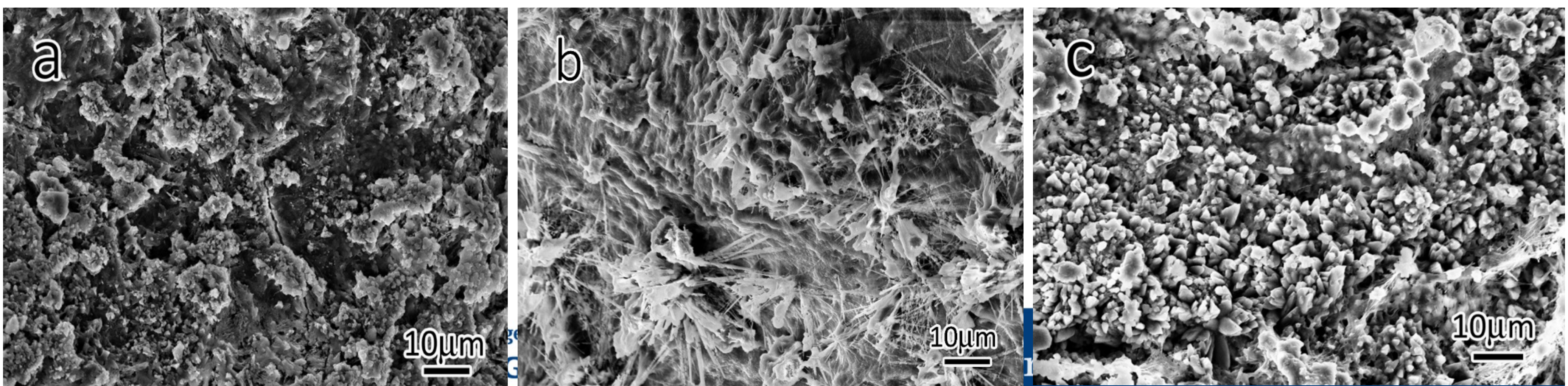
- Premature raveling of some pervious concrete segments was observed in the field.
- Scanning electron microscope (SEM) of core samples observations showed that the samples with limited distress feature a well-maintained cement binder phase

Nevada DOT project

- Samples with moderate distress feature some needle-shape precipitates embedded in the cement binder phase
- Samples with severe distress feature a large amount of micro-sized crystalline precipitates instead of cement binder phase.

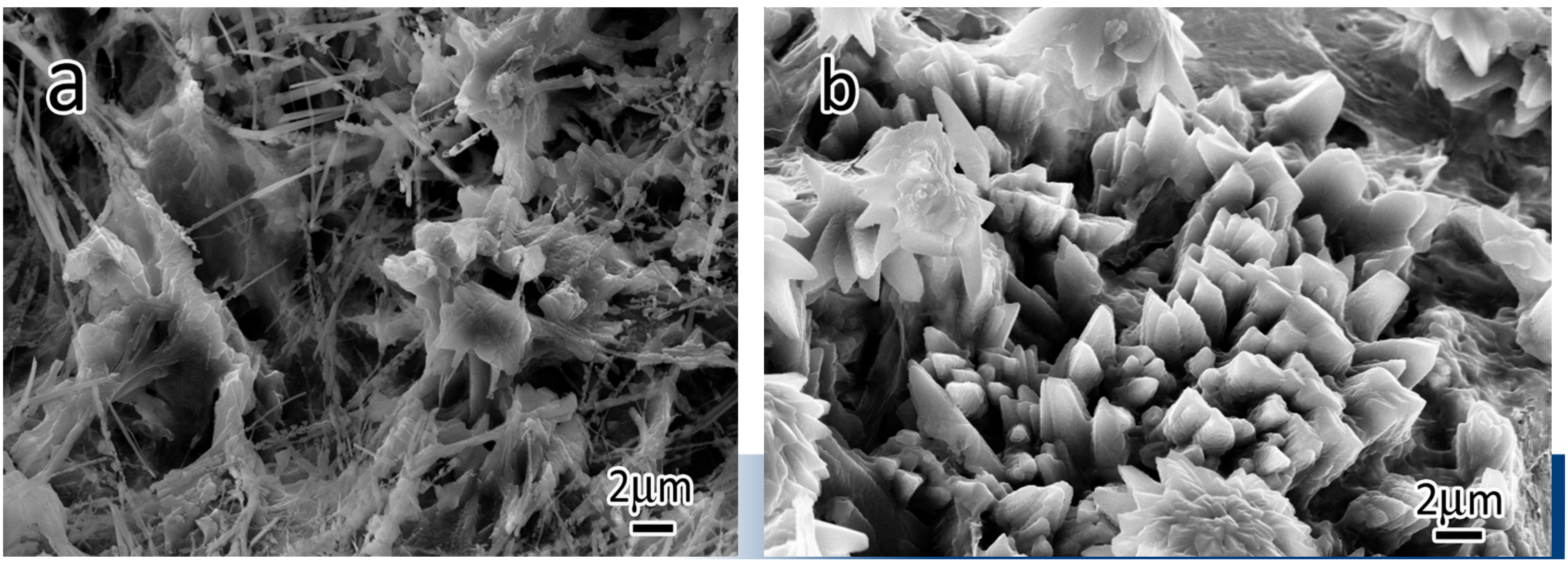
Nevada DOT project

- Low magnification fracture surface SEM morphologies of the samples cored from SR431 site a) limited, b) moderate, and c) severe



Nevada DOT project

- High magnification fracture surface SEM morphologies of the samples cored from SR431 site, a) moderate, and b) severe.



Nevada DOT project

- The specific mechanism responsible for the premature failure of pervious concrete remains unclear and merits further investigation.
- Distresses observed in pervious concrete may have originated from ->
  - the construction practice (insufficient compaction at some locations),
  - later aggravated by exposure to freeze/thaw cycles, deicers, and mechanical loading in the service environment.

Work based on….

- Clear Roads – *Snow and Ice Control on Porous and Permeable Pavements: Literature Review and State of the Practice*

https://trid.trb.org/view.aspx?id=1288499

- Nevada DOT – *Evaluation of pervious concrete mixes in areas subject to snow plow operations and abrasive and salt applications*

https://trid.trb.org/view.aspx?id=1312609

Questions ?

Laura Fay

laura.fay1@montana.edu

406.600.5777