Understanding Penetrating Sealers for Concrete Pavements

Better Concrete Conference
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Iowa State University
Institute for Transportation

For More Information


*** No company paid for any product names intentionally or unintentionally mentioned in this presentation.

Concrete Deterioration

- Saturation
- Chlorides

Deicing salt usage

For More Information

- Chloride
- Saturation
- Deicing salt usage

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- Chloride
- Saturation
- Deicing salt usage
Making Durable Concrete -- First

- Proper drainage → Prevent moisture from remaining in contact with the concrete.
- Reduce permeability of the concrete.
  - Low w/cm ratio
  - Use of supplementary cementitious materials (SCMs)
  - Well graded aggregates
- Curing
- Penetrating sealer
- Adequate air-void system → reduce F/T damage
- Best practice of sawing and sealing joints.


Penetrating Sealers

Common Penetrating Sealers

<table>
<thead>
<tr>
<th>Sealer Type</th>
<th>Common Name(s)</th>
<th>Mechanism of action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Film</td>
<td>Acrylics and Urethanes</td>
<td>Physical barrier</td>
<td>Polymers or copolymers of acrylic acid</td>
</tr>
<tr>
<td>Polyureas</td>
<td>Physical barrier</td>
<td>Reactive resins; Synthetic resins</td>
<td></td>
</tr>
<tr>
<td>Polyesters</td>
<td>Physical barrier</td>
<td>Reactive resins; Synthetic resins</td>
<td></td>
</tr>
<tr>
<td>Pore Blocking</td>
<td>Linseed or soybean oil</td>
<td>Physical barrier; water repellent</td>
<td>Vegetable oils</td>
</tr>
<tr>
<td>Silanes</td>
<td>Physical barrier; water repellent</td>
<td>Soaps or metallic salts from fatty acids</td>
<td></td>
</tr>
<tr>
<td>Sodium Tartrate; Silica gel</td>
<td>Physical barrier</td>
<td>Absorbent crystalline structures</td>
<td></td>
</tr>
<tr>
<td>Pore Refining</td>
<td>Sodium/lithium silicate; colloidal silica</td>
<td>Pore size reduction</td>
<td>Silicon based with no organofunctional group(s)</td>
</tr>
<tr>
<td>Pore Lining</td>
<td>Silane, Siloxane, XX Silane</td>
<td>Water repellent</td>
<td>Silicon based with organofunctional group(s)</td>
</tr>
</tbody>
</table>

*Acting as pore blocker when less than 50% active ingredient

Hydrophobic Treatments

Hydrophobic surface

Interaction between water and a nonhydrophobic or hydrophobic material; illustrated for a capillary (left) and a concrete surface (right).
So What?

• So someone walks in your door selling magic juice, how do I?
  • Know if it's real?
  • If it's there
  • If it's still working
  • How can I quantify with mortal testing?

Wait, What? NCHRP 244 isn’t a test standard or specification?

So What Do We Want?

• Reduce water movement in
  • To maintain a lower degree of saturation
• Reduce chloride movement in
  • To extend time to critical chloride threshold
• Not impede water movement out
  • To not cause unintended FT issues
• Not degrade quickly
  • To minimize vulnerable window/reapplications

Step 1) Let’s look at water in

• Absorption capacity /degree of saturation (ASTM C 1585, formation factor)

Basic Results

Fig. 2—Absorption results for initial penetrating sealer products for full-coverage application.

Results cont. (Control = 2.8mm)

• Pore size/distribution matters, you can prevent drying

Degree of Saturation

• Significant increases to time to critical saturation

Concrete and Critical Saturation

• While water in is only one piece, measurement is low cost and a good indicator of concrete performance
**Step 2) Desaturation**

- Real Air
- DI-Crack

**Step 3) Contact Angle**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>θ⁰</th>
<th>CV</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>NA</td>
<td>NA</td>
<td>Hydrophilic</td>
</tr>
<tr>
<td>LS</td>
<td>76</td>
<td>13%</td>
<td>Hydrophobic</td>
</tr>
<tr>
<td>SC</td>
<td>74</td>
<td>19%</td>
<td>Hydrophilic</td>
</tr>
<tr>
<td>40% silane</td>
<td>105</td>
<td>6%</td>
<td>Over-hydrophobic</td>
</tr>
<tr>
<td>CAS</td>
<td>120</td>
<td>15%</td>
<td>Over-hydrophobic</td>
</tr>
<tr>
<td>acrylic</td>
<td>83</td>
<td>9%</td>
<td>Hydrophobic</td>
</tr>
<tr>
<td>SME</td>
<td>100</td>
<td>16%</td>
<td>Over-hydrophobic</td>
</tr>
</tbody>
</table>

**Step 4) Chloride Penetration**

- Chloride penetration (AASHTO T259 90-day)

**Last Interesting Parting Thought**

\[
M_{osby} = \frac{Df}{t_{osby}} \times 100
\]

where: \(M_{osby}\) is the mass in g of GOSY per 100g of cementitious paste, \(Df\) is the latent heat absorbed during GOSY phase transition, \(t_{osby}\) and \(t_{f, osby}\) is the specific latent heat associated with pure GOSY phase transition, 100:0.3g.
Conclusions, Thoughts, and Recommendations

- A wide variety of chemicals and products exist which fall into the category of penetrating sealers.
- They DO NOT function along the same pathways, some are good early, some late, some good for deteriorated concrete, some terrible for certain concrete….meeting NCHRP 244 does NOT mean anything and real tests exist
- Absorption/Desorption; Desaturation; contact angle; chloride penetration should be the minimum…
- Corrosion initiation, scaling, 1D Freeze-thaw, and oxychloride could also be beneficial

Questions?

MnROAD sealer and anti-icer testing install 11/1 by UWP

Conclusions, Thoughts, and Recommendations

- The body of research strongly supports the use of penetrating sealers to improve deicer salt scaling and reduce chloride penetration on horizontal surfaces
- The value proposition, technology, and test methods are here
- However, penetrating sealers are not a panacea for bad concrete, make good concrete first, then make good concrete even better
About the Presenter

John T. Kevern, PhD, PE, FACI, LEED AP, Chair of the Department of Civil & Mechanical Engineering at the University of Missouri-Kansas City. He is an internationally recognized expert on pervious concrete, concrete durability, and non-traditional concrete applications. Dr. Kevern has been named one of the top five most influential people in the concrete industry by concrete construction magazine. He chairs AKM50 Advanced Concrete Materials and Characterization committee at the National Transportation Research Board.

John received his BS from the University of Wisconsin-Platteville and his MS and PhD degrees from Iowa State University.

Some of his current research topics include improving water quality using cement-based filters, improving concrete lifespan using hydrophobic coatings, internal curing concrete, techniques to reduce cost and improve performance of soil structures in sub-Saharan Africa, and eliminating joints in concrete pavements.