Reduction in Infiltration Capacity of Porous Asphalt and a Survey of Cleaning Methods and Their Effectiveness

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Today’s Talk

- Objective
- Methods
  - Infiltration Testing
  - Cleaning Treatments
- Results & Discussion
  - Pre-Cleaning Condition & Infiltration Testing
  - Effectiveness of Cleaning Methods
- Recommendations & Conclusions
Research Objective

- Assess the change in porous surface infiltration capacity over time
- Determine the effectiveness of commercially available cleaning technologies for porous asphalt pavement

Focus is on Porous Asphalt (PA) and can be extended to Pervious Concrete (PC)
Research Questions

- How do we define “clogged”?
- To what extent is a site clogged?
- How is infiltration capacity measured?
- Can we develop better infiltration tests?
- What cleaning methods are used?
- What cleaning methods are effective?
- Are cleaning methods cost effective and scalable?
- What are general guidelines for cleaning?
Methods of Infiltration Testing

1. The surface inundation test (SI)
2. The modified surface inundation (mod SI) test
3. The modified double ring infiltrometer (DRI) test
4. The shower infiltrometer
Surface Inundation Test
Modified Surface Inundation Test
Modified Double-Ring Infiltrometer
Shower Infiltrometer
Cleaning Methods

- Hand tools & shop vacuum (SV)
- Pressure washer (PW) & detergent
- Walk behind “lawn” vacuums
  - Billy Goat KD510 (BG1)
  - Billy Goat MV650SPH (BG2)
- Sweeper vacuum truck – Elgin Whirlwind
- TIMCO 210
Pre-Treatment Usage & Maintenance

Parking

Salting

Plowing
Pre-Treatment Structural Condition
Pre-Treatment Debris & Clogging

Sediment clogging/debris due to fine sand, mulch, organic fines, crushed stone, and speed bump paint.
Infiltration capacity via the Pre-Treatment DRI test varied from 0 to 8 in/hr, all effectively clogged when slope is considered.
Pre-Tx Infiltration at Grid Locations
Long Term Observations of Infiltration Capacity
Is Infiltration Capacity Reducing?

<table>
<thead>
<tr>
<th>Variable</th>
<th>IC A (in/hr)</th>
<th>IC B (in/hr)</th>
<th>IC C (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
<td>-0.403</td>
<td>-0.681</td>
<td>-0.373</td>
</tr>
<tr>
<td>IC Loss/year</td>
<td>147</td>
<td>248</td>
<td>136</td>
</tr>
<tr>
<td>Average IC</td>
<td>1,260</td>
<td>680</td>
<td>151</td>
</tr>
<tr>
<td>r²</td>
<td>0.11</td>
<td>0.36</td>
<td>0.72</td>
</tr>
</tbody>
</table>
Great Variability to Infiltration Capacity
So What is “Clogged”

- Infiltration Capacity (IC) of porous asphalt or pervious concrete is generally orders of magnitude higher than design rainfall intensities.
- Unless placed on steep slopes (not recommended) rarely see runoff on these surfaces.
- Ponding on these surfaces from the outset occurs at locations of overcompaction and/or poor mix control.

CLOGGING – The loss of the initial infiltration capacity to such an extent that runoff or ponding occurs on portions of the surface that did not originally exhibit such conditions.
Infiltration Capacity does not equal Infiltration Rate

IC is conventionally measured with instruments that use a standing head of water. This increases the rate of surface infiltration over the rate under gravity alone.

IC and clogging need to be framed in the context of how IC is measured and reported.
Results and Discussion: Cleaning Treatments
Hand Tools & Shop Vacuum

- Good for concentrated surface debris, litter, stones
- Could not really unclog blocked pores
Pressure Washer & Detergent

- Good for unclogging compacted, clogged areas
- High pressure unclogs but blast effect spreads grit and sediments
- Low pressure sufficient, esp. with soap solution and wand at a **LOW** angle
- Worked well in conjunction with shop vac
Billy Goat KD510 (BG1)

- Not ideal, but has potential
- Did not seal to the surface
- Not as powerful
- No dust control – dust storm ensued
- Collected 15 kg sediments
Billy Goat MV650SPH (BG2)

- An improvement over BG1
- Better seal to the surface
- More powerful
- No dust control – dust storm ensued if not water pre-applied
- Operate only on moist pavement – not dry, no standing water
Elgin Whirlwind MV

- Powerful vacuum (36-in). Feeder broom effective at loosening some larger debris
- Onboard pressure washer was effective at unclogging, but some dripped back onto pavement
TYMCO 210

- Regenerative air
- Vacuum
- Good surface seal
- Air jets to dislodge debris
- Effective when surface is moistened
Testing Cleaning Treatments for Clogged Spots

- Selected several representative clogged locations
- Ran the DRI before and after treatments
- Ran several variations of treatments to determine optimum treatment
Most Effective Unclogging Method

Moisten with mild soap solution

Pressure wash at low angle

Vacuum
Testing the Effectiveness of Cleaning on Clogged Sites

Focused statistical testing of the cleaning effects on clogged sites
Treatment Effectiveness for Clogged Locations

![Graph showing treatment effectiveness for various cleaning treatments.](image-url)

- Mean IC (cm/hr)
  - Pre-Tx IC
  - Post-Tx IC
  - Tx Effect

- Cleaning Treatments:
  - Soap/BG2
  - BG1 dry
  - Soap/PWL/SV
  - PWH/BG2
  - Soap/PWH/BG2

- Tx Effect (%)
  - Pre-Tx IC
  - Post-Tx IC
  - Tx Effect
### Statistical Analysis Of Clogged Sites

<table>
<thead>
<tr>
<th>Testing Method</th>
<th>Pre-Clean IC (in/hr)</th>
<th>Post-Clean IC (in/hr)</th>
<th>p Value</th>
<th>Stat. Diff.?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mod. Double Ring</td>
<td>71</td>
<td>81</td>
<td>0.22</td>
<td>NO</td>
</tr>
</tbody>
</table>
Testing the Overall Effectiveness of Cleaning on Infiltration Capacity

Another test of cleaning was to randomly select six locations and then statistically test IC before and after cleaning.
Surface Inundation Test

Surface Inundation

IC (in/hr)

Pre-Clean
Post-Clean

Location
A
B
C
D
J
K
Modified Surface Inundation

Modified Surface Inundation

IC (in/hr)

- Pre-Clean
- Post-Clean

Location

A  B  C  D  J  K

0  500  1,000  1,500  2,000  2,500  3,000
Modified Double Ring

Double Ring Infiltrometer

IC (in/hr)

- Pre-Clean
- Post-Clean

Location

A, B, C, D, J, K
<table>
<thead>
<tr>
<th>Testing Method</th>
<th>Pre-Clean IC (in/hr)</th>
<th>Post-Clean IC (in/hr)</th>
<th>p Value</th>
<th>Stat. Diff.?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Inundation</td>
<td>907</td>
<td>932</td>
<td>0.31</td>
<td>NO</td>
</tr>
<tr>
<td>Mod. S I</td>
<td>1,327</td>
<td>1,185</td>
<td>0.11</td>
<td>NO</td>
</tr>
<tr>
<td>Mod. Double Ring</td>
<td>1,413</td>
<td>1,325</td>
<td>0.37</td>
<td>NO</td>
</tr>
</tbody>
</table>
Data Analysis Summary

- Statistically could not show IC improvement due to cleaning...”statistically not different”
- Observationally, site has much less ponding than before...”seems to be less clogged”
- Test methods yield large IC variability
- Need larger data set for stronger statistical tests
Post-Cleaning Conditions

- Aesthetics: “cleaner” edges and corners, no surface debris
- No ponding during the rain event on 11/03/07 (1.25 in. of rain)
Recommended Cleaning Strategies

- General cleaning
  - Moisten first
  - Large sites – sweeper vacuum truck
  - Small sites – yard vacuum

- Regenerating clogged areas
  - Pressure washer with simultaneous vacuum, ensuring that no blow-by or blast-effect occurs
  - Regenerative air vacuums
Recommendations for Future Research & Commercialization

- Analyze collected sediments
- Test other equipment
- Expand cleaning study to other types of pervious pavements
- Encourage manufacturers for tailored products
- Testing method can effect results
Thanks!
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