Infiltration in Permeable Pavement Aggregate Beds (Draindown)

Liv Haselbach
Civil & Environmental Engineering
Washington State University
haselbach@wsu.edu

Brandon Werner
Mina Yekkalar
Good Morning,

Part I: What are Permeable Pavements and Pervious Concrete?
Part II: Draindown Testing

Optional
Part III: Testing Methods (porosity, infiltration)
Part IV: Summary of Surface Studies
Part V: ‘Powerwashing’ Cleaning (Sloan and PACCAR)
Acknowledgements

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The City of Spokane

And thanks to Somayeh Nassiri and the many WSU students who helped.
STRUCTURED SURFACE PLUS:
Surface Infiltration
Underground Storage
Pollutant Removal: - on top - in ground - in reservoir - to air?
Permeable Pavement Systems!

What is the surface?
- Pervious Concrete
- Porous Asphalt
- Permeable Pavers

What depth should the aggregate bed be?
- For structure (loads)
- For water storage (runon and storms)
- For frost depth
Permeable pavements on slopes?

Remember it is a **System**

Be careful that the water from surrounding areas (runon) does not flow too fast and overshoot!
What is Pervious Concrete?

Mixture of:
- Coarse aggregate,
- Cementitious material,
- Admixtures, and
- Water.
- Carefully controlled amounts of water & cementitious materials are used to create a paste that forms a thick coating around aggregate particles without flowing off during mixing & placing.
Unique Structure of Pervious Concrete

- Vertical Porosity Distribution
  - Top Transition Zone
  - Micro/Macro Pores
  - Connected/Disconnected Pores
Porosity of Pervious Concrete

• Total Porosity Ranges: ~13%-40%
• Recommended: ~20-25%
• Tortuosity (vertical and horizontal flow)
• Compressive Strength(not used for specifying): Typically 1000-3000 psi. (7-20 Mpa)
How is pervious concrete placed?

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Traditional</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Aggregate</td>
<td>3</td>
<td>4+</td>
</tr>
<tr>
<td>Water</td>
<td>1/2</td>
<td>~1/3</td>
</tr>
<tr>
<td>Fines</td>
<td>2</td>
<td>~0</td>
</tr>
</tbody>
</table>

Mixed

Cured 7 days

Compacted & Covered
Part II: Community Placement Draindown
Placement

• Wet the rock before you place the concrete.
Placement
Placement

Done in seven days!
Community Hall Sidewalk Case Study Retention
Soil Moisture and Temperature Sensoring at Community Hall Sidewalk Case Study \textit{Retention}
Soil Moisture and Temperature Sensoring at Community Hall Sidewalk Case Study Retention
### Draindown Test Results from Test 1 on October 17, 2015: Zone C Observation Well

<table>
<thead>
<tr>
<th>Time (minute)</th>
<th>Water Depth (in)</th>
<th>Time (minute)</th>
<th>Water Depth (in)</th>
<th>Time (minute)</th>
<th>Water Depth (in)</th>
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<tbody>
<tr>
<td>0</td>
<td>20.25</td>
<td>16.57</td>
<td>16.25</td>
<td>39.42</td>
<td>12.25</td>
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<tr>
<td>0.75</td>
<td>19.75</td>
<td>17.93</td>
<td>15.75</td>
<td>41.67</td>
<td>11.75</td>
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<tr>
<td>1.20</td>
<td>19.25</td>
<td>20.63</td>
<td>15.25</td>
<td>43.32</td>
<td>11.25</td>
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<tr>
<td>3.32</td>
<td>18.75</td>
<td>23.15</td>
<td>14.75</td>
<td>45.40</td>
<td>10.75</td>
</tr>
<tr>
<td>5.20</td>
<td>18.25</td>
<td>25.13</td>
<td>14.25</td>
<td>47.03</td>
<td>10.25</td>
</tr>
<tr>
<td>10.40</td>
<td>17.75</td>
<td>29.15</td>
<td>13.75</td>
<td>48.33</td>
<td>9.75</td>
</tr>
<tr>
<td>13.23</td>
<td>17.25</td>
<td>33.72</td>
<td>13.25</td>
<td>50.73</td>
<td>9.25</td>
</tr>
<tr>
<td>15.02</td>
<td>16.75</td>
<td><strong>36.22</strong></td>
<td>12.75</td>
<td><strong>52.03</strong></td>
<td>8.75</td>
</tr>
</tbody>
</table>

Draindown Results

Draindown Community 29 April 2016

Time in Minutes From Starting to Fill Zone C

Water Depth in Inches

Zone C
Zone A
Soil Moisture and Temperature Sensoring at Finch Arboretum Spokane Case Study *Detention*

- Porous asphalt parking lot
Soil Moisture and Temperature Sensoring at Finch Arboretum Spokane Case Study *Detention*

- Mix of soil layers
- Weather station at GEG
PACCAR Parking Lot: WSU Pullman

Pervious Concrete
Finch Results: Mid Winter: Middle Sensors

Part III: ASTMc1754

• Standard Test Method for Density and Void Content of Hardened Pervious Concrete


• Take Mass dry (room!)

• submerge for >30 minutes

• and take mass submerged.......
ISO 17785-1

- Testing methods for pervious concrete – infiltration rate in the laboratory

ASTM C1701

- Modified using Shrinkwrap with a small lip on top and less water……
ASTM 1701 in Field
Part IV: Surface Runon Older Placements in Pullman

- Valley Playfield Walks
- Vetmed Circle
- Sloan Sidewalk
## Site Information and Winters Experienced as of Spring 2014

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Site</th>
<th>Winters</th>
<th>Paved Run-on Sources</th>
<th>Other Clogging Sources</th>
<th>Approximate Size of paved Area Producing Run-on</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPE</td>
<td>Valley Playfield East</td>
<td>4</td>
<td>Incline Standard Concrete</td>
<td>Grass/Wetlands On East Side</td>
<td>2500 ft²</td>
</tr>
<tr>
<td>VPC</td>
<td>Valley Playfield Center</td>
<td>3</td>
<td>None</td>
<td>Rubber Particles</td>
<td>Negligible</td>
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<tr>
<td>VM</td>
<td>VetMed</td>
<td>3</td>
<td>Incline Standard Concrete</td>
<td>Surrounding Landscaping</td>
<td>4000 ft²</td>
</tr>
<tr>
<td>SL</td>
<td>Sloan Sidewalk</td>
<td>2</td>
<td>Incline Standard Concrete</td>
<td>Landscaping Along Edge</td>
<td>2000 ft²</td>
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</tbody>
</table>

Summary of seven pervious pavement sites at WSU Pullman as of Summer 2015

<table>
<thead>
<tr>
<th>Site</th>
<th>Age (yr)</th>
<th>Size (sq.ft.)</th>
<th>Mix</th>
</tr>
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<tbody>
<tr>
<td>VetMed Circle</td>
<td>4</td>
<td>2827</td>
<td>Concrete</td>
</tr>
<tr>
<td>Sloan Hall Sidewalk</td>
<td>3</td>
<td>960</td>
<td>Concrete</td>
</tr>
<tr>
<td>East Valley Playfields</td>
<td>5</td>
<td>4277</td>
<td>Concrete</td>
</tr>
<tr>
<td>Center Valley Playfields</td>
<td>4</td>
<td>7262</td>
<td>Concrete</td>
</tr>
<tr>
<td>Allen Center Walk and ADA Parking</td>
<td>4</td>
<td>5924</td>
<td>Asphalt</td>
</tr>
<tr>
<td>Community Hall</td>
<td>0</td>
<td>130</td>
<td>Concrete</td>
</tr>
<tr>
<td>PACCAR</td>
<td>0</td>
<td>9370</td>
<td>Concrete</td>
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## Sloan Wintertime

<table>
<thead>
<tr>
<th>Date</th>
<th>Temp °F</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td>(2015)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 January</td>
<td>45.5</td>
<td>16</td>
<td>26</td>
<td>182</td>
<td>203</td>
</tr>
<tr>
<td>15 January</td>
<td>34.7</td>
<td>18</td>
<td>17</td>
<td>136</td>
<td>184</td>
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<tr>
<td>29 January</td>
<td>41.9</td>
<td>8</td>
<td>38</td>
<td>172</td>
<td>229</td>
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<tr>
<td>5 February</td>
<td>52.3</td>
<td>8</td>
<td>18</td>
<td>126</td>
<td>224</td>
</tr>
<tr>
<td>12 February</td>
<td>59</td>
<td>N/A</td>
<td>14</td>
<td>171</td>
<td>184</td>
</tr>
<tr>
<td>19 February</td>
<td>58.3</td>
<td>N/A</td>
<td>28</td>
<td>175</td>
<td>234</td>
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<tr>
<td>26 February</td>
<td>38.7</td>
<td>N/A</td>
<td>8</td>
<td>97</td>
<td>143</td>
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<tr>
<td>5 March</td>
<td>66.2</td>
<td>N/A</td>
<td>21</td>
<td>87</td>
<td>141</td>
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<td>12 March</td>
<td>59.4</td>
<td>N/A</td>
<td>17</td>
<td>107</td>
<td>194</td>
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<tr>
<td>16 April</td>
<td>67.1</td>
<td>N/A</td>
<td>N/A</td>
<td>99</td>
<td>132</td>
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<tr>
<td>8 May</td>
<td>69.6</td>
<td>N/A</td>
<td>N/A</td>
<td>74</td>
<td>120</td>
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<tr>
<td>22 May</td>
<td>77.5</td>
<td>N/A</td>
<td>N/A</td>
<td>70</td>
<td>108</td>
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<tr>
<td>11 June</td>
<td>82.2</td>
<td>N/A</td>
<td>N/A</td>
<td>83</td>
<td>110</td>
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<tr>
<td>April 2014</td>
<td>N/A</td>
<td>12</td>
<td>198</td>
<td>444</td>
<td>710</td>
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</tbody>
</table>
Werner, B. and Haselbach, L. (2016) *Temperature and testing impacts on surface infiltration rates of pervious concrete*, submitted Special Issue on Environmental Sustainability of Transportation Infrastructure in Cold Climates, ASCE J of Cold Regions Engineering
Part V: Maintenance Options?

• Blowing……not usually
• Street sweepers/cleaners
• Powerwashing
• Special equipment
Cleaned Sloan! Woohoo!

• September 2015
• Hose and Nozzle
• Upper ~15 feet
• Lower ~20 feet
• Just as fast now as center portion which has not been cleaned after 3 winters, but still functioning well.
Vacuum Truck

For loose gravel and dirt.
Deep Cleaning only for Clogged Areas

• Pre-wetting
Deep Cleaning only for Clogged Areas

- Powerwashing with Wet Vacuum
Deep Cleaning only for Clogged Areas

- Dislodged Dirt
Deep Cleaning only for Clogged Areas

- Function Restored
Thank you!

?