How To Use Permeable Pavements In All Soil Types

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CA/NV Cement Association
So Which Is Better?
They ALL Are!

Figure 1. Porous Asphalt Paving: A Typical Cross-Section

POROUS ASPHALT COURSE
1/2- to 3/4-IN. AGGREGATE
ASPHALTIC MIX (1.27–1.91 CM)

FILTER COURSE
1/2-IN. CRUSHED STONE (1.27 CM)
2 IN. THICK (5.08 CM)

RESERVOIR COURSE
(2.54–5.08 CM)
1- TO 2-IN. CRUSHED STONE Voids
VOLUME IS DESIGNED FOR RUNOFF
DETENTION

THICKNESS IS BASED ON STORAGE
REQUIRED AND FROST PENETRATION

EXISTING SOIL
MINIMAL COMPAC
POROSITY AND PERCOLATION
As Long As They Are Designed Properly!
Pervious Pavement: More Expensive But It Saves Money!

- Look at the site holistically. Calculate savings from:
  - Reduction or elimination of underground piping and drain inlets
  - Quicker construction schedules due to reduced grading
  - Reduced grading costs
  - Savings in storm sewer utility fees
  - Value of total land use
  - Value of quicker plan approval
  - Value of paving under tree driplines
  - Elimination of other SWPP devices
Design Considerations:

- Structural Design
- Hydrologic Design
- Aesthetics
- Economics
- Durability
- Availability of Qualified Contractors
- Life Expectancy
- Construction Staging

And many more....
Hydraulic Design
Soils reports are critical! Soil percolation capability and clay content, as well as seasonal high water table – are critical factors.

Pervious pavement can be effective in clay soils with proper design.

<table>
<thead>
<tr>
<th></th>
<th>Pathways &amp; Sidewalks</th>
<th>0-20 ADTT</th>
<th>20-100 ADTT</th>
<th>100+ ADTT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy</td>
<td>4” on native</td>
<td>6” on native</td>
<td>8” on native</td>
<td>10” on native</td>
</tr>
<tr>
<td>Silty w/ low clay</td>
<td>4” on 3-6” drain rock with filter fabric</td>
<td>6” on 3-6” drain rock with filter fabric</td>
<td>8” on 3-6” drain rock with filter fabric</td>
<td>10” on 3-6” drain rock with filter fabric</td>
</tr>
<tr>
<td>Moderate clay</td>
<td>4” on 6-12” drain rock with filter fabric</td>
<td>6” on 6-12” drain rock with filter fabric</td>
<td>8” on 6-12” drain rock with filter fabric</td>
<td>10” on 6-12” drain rock with filter fabric</td>
</tr>
<tr>
<td>Heavy clay</td>
<td>4” on 12” drain rock with filter fabric</td>
<td>6” on 12” drain rock with filter fabric and (optional) Darcy Columns</td>
<td>8” on 12” drain rock with filter fabric and (optional) Darcy Columns</td>
<td>10” on 12” drain rock with filter fabric and (optional) Darcy Columns</td>
</tr>
</tbody>
</table>
How The System Works

Rapid Infiltration rates

Ponding Zone

Pervious Pavement

Gravel base

Soil subbase

Controlling exfiltration rate
Pavement Grades

0% slope is best for detention
Sloping Installations

Figure 10. Elevation and plan view drawings of sloped installation.
Figure 8. Preparation for a sloped installation. Crushed rock drains at intervals down the slope direct water away from the pavement and prevent water from flowing out of the pervious concrete (See also Figures 9 and 10). (S. Gallego) [IMG15890]
When Pervious Pavement Abuts Existing Pavement

- **Existing Asphalt or Concrete**
- **3/4” or 1” drain rock at 6” thick**
- **Subgrade**
- **Pervious Pavement**

Water barrier of 24” wide thick visqueen run down the 12” deep excavation and 12” under the drain rock
Compaction depends on pervious pavement type, soil type and drain rock base depth.

Compaction in excess of 92% generally reduces percolation rates to undesirable levels.
Hydraulic Design Basics
Infiltration Capacity Requirements
2 Yr / 24 Hr. Storm

Hayward 2.5” – 3.0 “
San Jose 2.0” – 2.5”

www.nws.noaa.gov
Infiltration Capacity Requirements
10 Yr / 24 Hr. Storm

Hayward 4.0” – 4.5 “
San Jose 3.0” – 3.5”

www.nws.noaa.gov
Infiltration Capacity Requirements
100 Yr / 24 Hr. Storm

Hayward 6.0” – 8.0 “
San Jose 4.5” – 5.0”

www.nws.noaa.gov
## Santa Cruz Precipitation Frequency

<table>
<thead>
<tr>
<th>Frequency</th>
<th>24 hour</th>
<th>2 day</th>
<th>4 day</th>
<th>10 day</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-yr</td>
<td>3.5”</td>
<td>5”</td>
<td>6”</td>
<td>8”</td>
</tr>
<tr>
<td>10-yr</td>
<td>6”</td>
<td>7”</td>
<td>9”</td>
<td>14”</td>
</tr>
<tr>
<td>25-yr</td>
<td>8”</td>
<td>8”</td>
<td>10”</td>
<td>15”</td>
</tr>
<tr>
<td>100-yr</td>
<td>10”</td>
<td>10”</td>
<td>12”</td>
<td>20”</td>
</tr>
</tbody>
</table>

Multiple-day storm frequencies are important factors in determining required system daily drawdown rates.
Infiltration Rates By Soil Type
Under Saturated Soil Conditions

<table>
<thead>
<tr>
<th>SOIL TYPE</th>
<th>INFILTRATION in / hr</th>
<th>INFILTRATION in / day</th>
</tr>
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<tbody>
<tr>
<td>Sand</td>
<td>8.27</td>
<td>198.5</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>2.40</td>
<td>57.6</td>
</tr>
<tr>
<td>Loam</td>
<td>1.02</td>
<td>24.5</td>
</tr>
<tr>
<td>Silt Loam</td>
<td>0.27</td>
<td>6.5</td>
</tr>
<tr>
<td>Sandy Clay Loam</td>
<td>0.17</td>
<td>4.1</td>
</tr>
<tr>
<td>Silt</td>
<td>0.10</td>
<td>2.4</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>0.09</td>
<td>2.2</td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td>0.06</td>
<td>1.4</td>
</tr>
<tr>
<td>Sandy Clay</td>
<td>0.05</td>
<td>1.2</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>0.04</td>
<td>1.0</td>
</tr>
<tr>
<td>Clay</td>
<td>0.02</td>
<td>0.5</td>
</tr>
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What About Clay??

<table>
<thead>
<tr>
<th>Area Drained Per Darcy Column</th>
<th>Inches of Rainwater Over the Pavement Area Storage Capacity of the Darcy Column</th>
<th>Inches of Rainwater Storage Capacity Over the Pavement Area Including the 12” Drain Rock Layer Below the Pavement</th>
<th>24 Hour Recharge Capacity Per Darcy Column in Inches of Rainwater Over the Pavement Area</th>
<th>24 Hour Capacity for Stormwater Over the Pavement Area Assuming 15 feet of Strata With an Infiltration Rate of 2 Inches Per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 sq ft</td>
<td>10.2</td>
<td>15.0</td>
<td>68.0</td>
<td>83.0</td>
</tr>
<tr>
<td>500 sq ft</td>
<td>2.0</td>
<td>6.8</td>
<td>13.5</td>
<td>20.3</td>
</tr>
<tr>
<td>1000 sq ft</td>
<td>1.0</td>
<td>5.8</td>
<td>6.5</td>
<td>12.3</td>
</tr>
<tr>
<td>2500 sq ft</td>
<td>0.4</td>
<td>5.2</td>
<td>2.7</td>
<td>7.9</td>
</tr>
<tr>
<td>5000 sq ft</td>
<td>0.2</td>
<td>5.0</td>
<td>1.4</td>
<td>6.4</td>
</tr>
</tbody>
</table>

30 foot deep Darcy Columns can be constructed at a cost of $0.25 to $0.50 per square foot of pervious concrete pavement and can provide infiltration in areas with upper layers of expansive clay soils. A 12” base of drain rock is also required.
<table>
<thead>
<tr>
<th></th>
<th>DC 1</th>
<th>DC 2</th>
<th>DC 3</th>
<th>DC 4</th>
<th>DC 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Test</td>
<td>374 GPH</td>
<td>3440 GPH</td>
<td>3486 GPH</td>
<td>355 GPH</td>
<td>328 GPH</td>
</tr>
<tr>
<td>2nd Test</td>
<td>307 GPH</td>
<td>NA</td>
<td>NA</td>
<td>310 GPH</td>
<td>304 GPH</td>
</tr>
<tr>
<td>3rd Test</td>
<td>299 GPH</td>
<td>NA</td>
<td>NA</td>
<td>303 GPH</td>
<td>295 GPH</td>
</tr>
<tr>
<td>4th Test</td>
<td>302 GPH</td>
<td>NA</td>
<td>NA</td>
<td>301 GPH</td>
<td>303 GPH</td>
</tr>
</tbody>
</table>

These 5 Darcy Columns were spread over a 12 acre site. At 300 gallons per hour, a single Darcy Column would infiltrate 3.2 inches of rainfall per acre per day.

The soils here were 2’-4’ of silty sand underlain with a 3’-8’ hardpan layer. Without the Darcy Columns, rainfall of over 7” in a season would have resulted in ponding on the surface.

With one Darcy Column per acre the site will now store and infiltrate a full 100-year storm.
Hydrological Design – The Simple Way!!

- Design Storm of 4.0 in / 24 hr.
- Flow concentration of 1.7 / 1
- 6” structural section of pervious concrete
- 1” crushed rock for drain rock with 40% void space
- Moderately expansive sandy clay: perc rate 0.05 in / hr.
- Water table down 10 feet or more

- 6” pervious concrete holds one inch
- At 0.05 in / hr. perc rate the soil will infiltrate 1.2” per 24 hrs.
- With a 1.7 / 1 flow concentration we need to deal with 6.8 inches in 24 hrs.
- The pervious plus the soil takes care of 2.2 in / 24 hrs
- To deal with the remaining 4.6 inches we need 4.6/.4 or 11.5 inches of drain rock
Hydrological Design – The Simple Way!!

- Design Storm of 6.0 in / 24 hr.
- Flow concentration of 1 / 1
- 6” structural section of pervious concrete
- 1” crushed rock for drain rock with 40% void space
- Sandy silt soil: perc rate 0.50 in / hr.
- Water table down 10 feet or more

- 6” pervious concrete holds one inch
- At 0.50 in / hr. perc rate the soil will infiltrate 6.0” per 24 hrs.
- With a 1 / 1 flow concentration we only need to deal with the design storm – 6.0 in / 24
- The pervious plus the soil takes care of 7.0 in / 24 hrs
- No drain rock is required
Hydrological Design – The Simple Way!!

- Design Storm of 5.0 in / 24 hr.
- Flow concentration of 2/1
- 3” structural section of porous asphalt
- 24” deep bed of 2-3” cobbles with 40% void space
- 6” of ½” crushed rock choker coarse w/ 30% void space
- Silty clay loam soil: perc rate 0.06 in / hr.
- Water table down 10 feet or more

- 3” porous asphalt holds 0.5”
- 24” cobbles holds 9.6”
- 6” choker coarse holds 1.8”
- Total storage capacity 11.9”
- At 0.06 in / hr. perc rate the soil will infiltrate 1.4” per 24 hrs.
- With a 2/1 flow concentration the 5” design storm is equal to 10” of rainfall over the pavement
- Storage plus 24-hour infiltration is 13.3” which exceeds the design storm
- The system has sufficient hydraulic capacity
Summary
Important Points for Design & Construction of Pervious Pavement

- Get a soils report
- Determine pavement section thickness design based on usage and ADTT
- Determine base thickness based on design storm, soil type and flow concentration
- Use contractor's with industry certification
- If the material is relatively new in your area have a pre-bid meeting to explain about pervious pavement
- Utilize industry resources – they are free!!
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THANK YOU

Any Questions?

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www.concreteresources.net
(click on Pervious CD)