Concrete Solutions to Storm Water Runoff

Topics of Discussion
- Properties of Pervious Concrete
- Applications
- Benefits
- Design Considerations
- Placement Guidelines
- Freeze-Thaw Durability
- Project Review

What is Pervious Concrete?
- A No-Fines Concrete Mix
- Coarse Aggregate
- Portland Cement
- Water
- Intended for use as an open-graded drainage material
Typical Pervious Concrete Mix Design

- 550 – 650 lbs. Portland Cement
- Fly Ash / Slag Cement substitute acceptable at standard rates
- 27 ft³ Coarse Aggregate
- Aggregate size will affect drainage rate
- 0.25 – 0.35 W/C Ratio
- Sufficient water to display a wet, metallic sheen on the aggregate

Pervious Concrete Properties

- 15% to 35% air void content
- 100 to 120 lbs/ft³ unit weight
- 500 to 3000 psi strength*
- Introduction of small amount of fine aggregate can increase strength to 4000 psi (+/-)
- Compressive strength typically not used as acceptance criteria. Air void structure and unit weight are used instead.

Pervious Concrete Properties

- Drainage rate = 3-5 gal/sec/ft²
- Equivalent of 275" to 450" of rain per hour!
- More than half of all rainfall is provided in rain events that total one-half inch or less.
- 6" section with 20% voids holds 1 – 1 ¼" of rain water
<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Coefficient of Runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete or Asphalt</td>
<td>1.00</td>
</tr>
<tr>
<td>Gravel - Compact</td>
<td>0.70</td>
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<tr>
<td>Clay - Bare</td>
<td>0.75</td>
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<tr>
<td>Clay - Light Vegetation</td>
<td>0.50</td>
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<tr>
<td>Clay - Dense Vegetation</td>
<td>0.40</td>
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<tr>
<td>Gravel - Bare</td>
<td>0.35</td>
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<tr>
<td>Gravel - Light Vegetation</td>
<td>0.20</td>
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<tr>
<td>Loam - Bare</td>
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<tr>
<td>Loam - Light Vegetation</td>
<td>0.45</td>
</tr>
<tr>
<td>Loam - Dense Vegetation</td>
<td>0.35</td>
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<tr>
<td>Sand - Bare</td>
<td>0.50</td>
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<tr>
<td>Sand - Light Vegetation</td>
<td>0.40</td>
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<tr>
<td>Sand - Dense Vegetation</td>
<td>0.30</td>
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<tr>
<td>Grass Areas</td>
<td>0.35</td>
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</tbody>
</table>

Pervious Concrete should fall between these factors.
Typical Applications for Pervious Concrete

- Light Duty Parking Areas
- Nature Trails / Park Pathways
- Greenhouses / Nurseries
- Erosion Control
- Environmentally Sensitive Developments

Parking Lots & Pavements: Environmental Disasters

- Almost Total Runoff
- Public Water Needed for Vegetation
- Valuable Water Resources are Wasted
- Runoff Has Chemical Pollutants, Requiring Treatment
- Runoff is Hotter, Damaging Ecosystems
- Rapid, High Volume Runoff Requires Larger Public Drainage Facilities
- Hot Parking Lots Add to Urban Heat Island Effects

First Flush

- First 1" of rain
- Contains contaminants
  - EPA requires collection and treatment prior to release
- USGS study – Austin, TX
  - High concentration of polycyclic aromatic hydrocarbons (PAH)
- Attributed to asphalt parking lot runoff
- Runoff from asphalt-based sealants 10 times higher
- Runoff from coal-tar based sealants 65 times higher
- Source:
First Flush

- Pervious concrete pavement reduces runoff
  - Cleaner first flush
  - Captured by void structure
  - Minimization of PAH
- Soil chemistry and biology will naturally treat water
  - Oil drips and other automotive pollutants are “attacked” by naturally occurring soil microbes

An EPA BMP

- For stormwater pollution prevention
- Lower heat island effect
- Pervious concrete is eligible for LEED credit points for the USGBC Green Building Rating System.

Cost Advantages

- Savings to Municipalities
  - Reduces stormwater utility fees
  - Minimize upgrade of existing systems to keep up with development
    - Chino, CA
      - $0,000 in Pervious Concrete Parking Lot
      - City saved between $250K and $500K
- Savings to Owners/Developers
  - Eliminates need for retention ponds & other costly stormwater management practices
  - Provides for more efficient use of land development
Shelter Systems Ltd.
Westminster, MD

- Approximately 8 acres of pavement
- Saved $400,000 in underground drainagae construction costs
- Eliminated 1 1/2 acre retention pond

Pavement Design Thickness

- Hydrological Design Considerations of pavement & related base materials (stormwater storage capacity)
- Mechanical Properties (load carrying capacity)
- Choose greater thickness of these needs
- Base design important to storage as well
- Hydrological Design software is now available

Infiltration Systems

- Developed in 1970's
  - Franklin Institute, Philadelphia, PA
  - Have been used for over 20 years
• Pervious concrete: 4-6 inches typical
• Open-graded stone subbase, determined by local hydrologic conditions
• Geotex prevents movement of fines into stone bed
• Perforated pipe to capture water & let it drain (optional)

Water drains through pavement into stone bed and infiltrates slowly into underlying soil mantle
• 0.1 – 0.5 in/hr acceptable
• Total drawdown time should not exceed 5 days

Pervious Concrete Placement

Many ways to place pervious, including:
• Roller Screed
• Asphalt Paver
• Laser Screed
• Vibratory Truss Screed
Finishing: The Typical Process

• Spreading
• Strike-off
• Compacting
• Jointing/Edging
• Curing

Hydraulic Roller
Surface Texture

- Important to keep the voids open
- Do NOT use trowels
- Do NOT seal the surface
- No roller marks

Pervious Concrete Placement

- Can also use paving equipment
- May still require side forms
  - Material usually not stiff enough for edges to hold under pressure of compaction
- Conventional asphalt paver provides 90% (+/-) compaction
- For denser surface, follow behind with plate tamp or small roller

Curing

- Curing pervious concrete is perhaps more important than curing conventional concrete
- Without curing, surface will dry out and deteriorate easily
- Moist cure (7 days preferred)
Curing pervious concrete is critical due to the porosity and low W/C ratio.

6 mil poly sheeting for 7 days

Durability of Pervious Concrete

- Directly related to proper placement
- Maintain W/C ratio
- Proper compaction of pervious surface
- Proper curing is a must!
- Specify an NRMCA Certified Pervious Concrete Contractor!
Can Pervious Concrete Withstand Freeze-Thaw?

- Proper mix design
- Proper placement
- Proper maintenance

Consider Conventional Concrete

- A/E required to relieve pressures in conventional concrete mix
- Tight matrix holds moisture
- Critically saturated >91%
- A/E provides void structure for expansion of moisture during freeze
  - 4% to 8% air entrainment
  - 0.01 inch spacing factor

Pervious Concrete

- 15-35% void structure means little moisture trapped in matrix
- Less likely to be saturated
- Expansion of moisture due to freezing does not exert undue pressures on matrix
- 0.25-0.35 W/C equals high quality paste
- Air entraining admixture protects the coating paste
Freeze-Thaw Resistance
- Depends on saturation level
- Avoid critical saturation
- Maintenance
  - Annual cleaning in severe climates
- Design
  - Infiltration System
  - Secret of success is to provide the water a place to go

Snow Packing
- Anecdotal evidence suggests snow-covered pervious clears quicker than impervious surfaces
  - Less need for snowplowing
- Water drains through pavement into stone bed
  - Water does not pond & re-freeze
  - Formation of “black ice” is rare
- Open-grade beds act as insulation

Grocery Store
Denver Colorado
Sites directly across street
Photos: 5 min. differential max

Study conducted by NRMCA
Results available at www.nrmca.org

What About Clogging?
- Even if 100% clogged with dirt, pervious concrete will still be permeable
- For maintenance, clean pervious pavement with power scrubber
- And/or power wash
Let’s Look at Some Recent Projects

Cleaning can restore 90+% of original permeability

• Conventional pavement sweeper/vacuum equipment can also be used

Cleaning can restore 90+% of original permeability

Let’s Look at Some Recent Projects
Finley Stadium  
Chattanooga, TN  
OCT, 1997  
At Issue:  
Parking lot drainage & contaminated soils  
Total parking lot approximately 6 acres  
Size of pervious area  
10,000 ft²  
10 ½ ft width

- 6' stone subbase under entire parking lot  
- 4' Pervious Concrete in parking areas  
- 200,000 gal. holding capacity  
- 400,000 gal catch basin

Wet Freeze  
50 cycles/yr
Meeting the Customer’s Needs

- Required heavy duty pavement
  - 30 to 40 trucks per day
- R/M adjusted mix
  - Added 500 lbs. fine agg. per CY
  - Flexural strength = 650 psi (7 days)
  - Placed with ABG dual-compaction paver
  - Rolled with small static roller

- Approximately 8 acres of pavement
- Mix design can accommodate 80” of rain per hour
- 10 times intensity of 100 year rainfall event
• Saved $400,000 in underground drainage construction cost
• Allowed owner to close 1 ½ acre retention pond

• SR 23
• Sussex, NJ
• July, 1999
• Slope Erosion
“Yeah, but,,,"

“That will never work around here”
Park and Ride - Randolph, VT
Over 1.2 MILLION YARDS of pervious concrete was placed in preparation for the 2008 Summer Games in China.
For further information...

- Available from NNECPA

Pervious Concrete Pavements

www.perviouspavement.org