When It Rains, It Drains!

Pervious Concrete

Stormwater Management Systems

Presented By:
Northern Virginia Concrete Advisory Council
Hosted By:
Wetland Studies & Solutions, Inc.

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We Don't Make Concrete,
We Make It Better!

Bob Banka – BASF Admixtures

201-206-0456
bob.banka@basf.com

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Concept

- **Pervious Concrete or No-Fines Concrete**
  - Stormwater Management System:
    - Soil Testing
    - Civil Engineering
    - Material Certification
    - Installer Certification
    - Testing Certification
    - Owner Maintenance

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Stormwater Management

- **Current methods of stormwater management are costly on several fronts:**
  - Infrastructure:
    - Impervious parking lots and roof tops cause more stormwater runoff and pollutant loads than any other type of land use and require stormwater collection and disposal.
      - High volume runoff requires large public drainage facilities to service runoff from private developments.
      - Runoff management is a costly aspect of new site developments.

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Environmental Concerns

- **Environmental Considerations:**
  - Stormwater collected from impervious pavements is contaminated with many pollutants.
  - As little as 10% impervious surfaces in a watershed can begin to impact downstream rivers, lakes & estuaries.*
  - A threat to streambed ecology.
  - Treatment of stormwater an important consideration.

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* Shaver ET AL. 1995

A New Approach Is Being Adopted

- Addressing stormwater issues much earlier in the design process with an objective of eliminating runoff.
- This innovative approach has been embraced over the last 27 years and started in:
  - Florida

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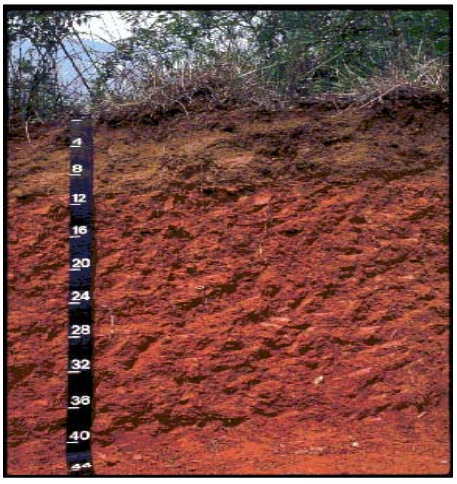
A New Approach Is Being Adopted

- Georgia



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A New Approach Is Being Adopted

- Tennessee

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A New Approach Is Being Adopted

- Oregon

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A New Approach Is Being Adopted

- California

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A New Approach Is Being Adopted

- Washington

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A New Approach Is Being Adopted

- Vermont

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A New Approach Is Being Adopted

- Wisconsin

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A New Approach Is Being Adopted

- New Jersey

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Stormwater Management System

Definition:

- A structural pavement
- Consisting of:
  - Coarse aggregate
  - Portland cement
  - Flyash or Slag
  - Water
  - Admixtures
  - Fibers

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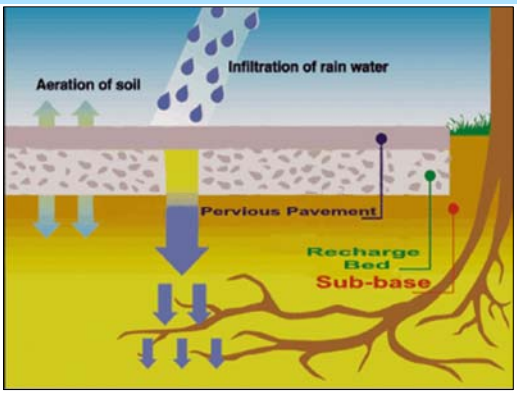
  - Flyash or Slag
  - Water
  - Admixtures
  - Fibers
- Void content range of 15% - 30%
- Designed to allow stormwater drainage to the sub-grade for filtration and ground water recharge.



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Uses For Pervious Concrete

Applications:

- Parking areas

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Uses For Pervious Concrete

Applications:

- Driveways

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Uses For Pervious Concrete

Applications:

- Sidewalks

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Uses For Pervious Concrete

Applications:

- Greenhouse floors

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Uses For Pervious Concrete

Applications:

- Road drainage control

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Uses For Pervious Concrete

Applications:

- City Streets

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Uses For Pervious Concrete

Applications:

- Eliminate swales and drainage ditches

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Uses For Pervious Concrete

Applications:

- Erosion control & slope protection

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Why Pervious Concrete?

Pollution:

- Stormwater runoff is the single largest contributing pollutant to many waterways.
- Much like a grassy swale or retention pond, pervious concrete mitigates first flush pollution and manages storm water via stormwater infiltration.
  - Acts as a dry detention system.
  - The large surface area captures, filters and aerobically degrades much of the hydrocarbon residue – the remainder can be degraded by soil bacteria, otherwise known as microbial conversion.

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Why Pervious Concrete?

Pollutant Removal of Pervious Pavement (%)	
Pollutant	**Pollutant Removal**
Total Suspended Solids	95%
Total Phosphorous	65%
Total Nitrogen	82%
Nitrous Oxides	N/A
Metals	98-99%
Bacteria	N/A

http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Infiltration%20Practice/Porous%20Pavement.htm

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Why Pervious Concrete?

Environment:

- Pervious concrete provides a green, sustainable alternative to traditional impervious pavements.
- Pervious concrete retains untreated stormwater on site and water resources are preserved.
  - Permits stormwater runoff to percolate through it rather than flood storm sewers.
  - Vegetation can be watered, reducing the need for irrigation.
  - Allows for natural recharge of the aquifer much like the natural filtering effects desired in bio-swales.

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Why Pervious Concrete?

Savings:

- Site planning is now one of the most significant aspects affecting the economic feasibility of any new development:
  - By avoiding the need for expensive drainage systems and land-consuming retention ponds, pervious concrete actually saves money.
- Helps achieve shorter construction schedules.
- Previously unfeasible sites may become realistic.

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Shelter Systems – Westminister, MD

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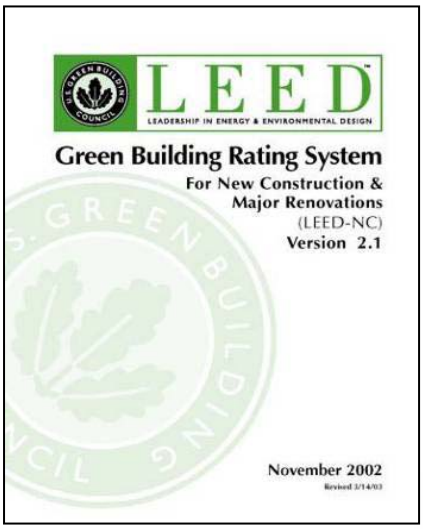
Meets LEED Requirements

- Reduce stormwater runoff
- Use Recycled Materials
- Use Regional Materials
- Reduce urban heat islands



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Porous Asphalt

- Most metals such as iron, zinc, manganese & copper have higher concentrations in asphalt parking areas
  - Can be twice as high

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Porous Asphalt

- PAH's (Polycyclic Aromatic Hydrocarbons)
  - Hydrocarbon Pollution
    - Widespread due to increasing dependence of today's society on technology derived from organic chemicals
    - Some pathways for PAH's to enter the environment are from:
      - Air pollution
      - Exhausts from cars and trucks
      - Asphalt paving materials

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EcoTrust – 721 NW 9th Ave, Portland, OR

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Why Pervious Concrete?

Runoff Reduction Per Year:

- Salem – 325 Superior Street
  - 3,700 s.f. Pervious Paving & Recharge Bed
  - 90,088 gallons per year
- Mt. Angel – Easy Storage 2
  - 74,086 s.f. Pervious Paving & Recharge Bed
  - 1,803,849 gallons per year

(based on 39.15" of rain per year)

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Why Pervious Concrete?

Environment:

- Reduces thermal pollution.
- Helps in the “Cool Communities” program by the evaporative cooling of water stored in the pavement system, reduced absorption of heat and higher reflectance because of its light color.
- Pervious concrete pavements can be placed within the drip-line of a tree because they allow air & water to pass to the roots.

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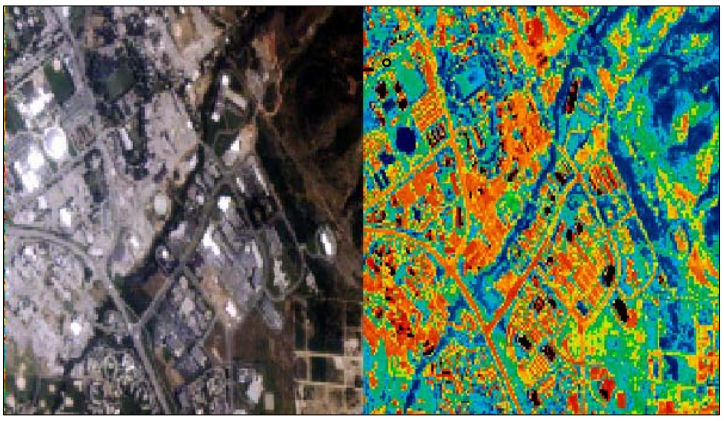
Salt Lake City

Red/Yellow = 160° - Roads & Buildings

Blue/Green = 85-96° - Water & Vegetation



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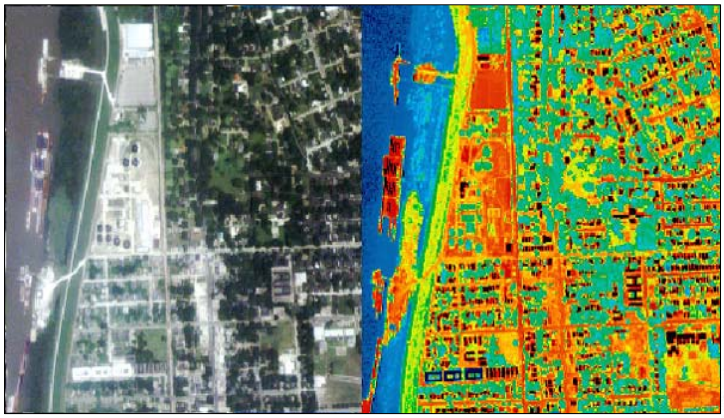
Baton Rouge

Red/Yellow = 149° - Roads & Buildings

Blue/Green = 77° - Water & Vegetation



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Sacramento

Red/Yellow = 140° - Roads & Buildings

Blue/Green = 85-96° - Water & Vegetation

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Why Pervious Concrete?

Advantages:

- Minimal Cracking
  - Attributed to the interlock of the aggregate particles which restrains the cement paste shrinkage.
  - The large void spaces make pervious concrete less susceptible to freeze-thaw cracking.
    - Each Sample is 3 cores
      - ASTM C 666-97
      - Standard Test Method for Resistance of Concrete to Rapid Freezing & Thawing
      - Procedure A
        - Results
          - 300 Freeze/Thaw Cycles Until Distress

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Why Pervious Concrete?

Advantages:

- Light color absorbs less light
  - Reduced lighting needs

    (up to 40%)
  - Safer at night due to illumination

Why Pervious Concrete?

Advantages:

- Surface Texture
  - Safe – non-slip (ADA friendly)
  - Aesthetically contrasting texture

Durability

Used successfully for over 27 years.

- Hundreds of field performance tests done:
  - Over the long-term, pervious pavements continue to function without signs of structural distress or significant clogging.

The strength and durability of pervious pavement appears to be equal to traditional materials. There are several examples of parking lots built more than twenty years ago with pervious pavement that are still structurally sound and in use. Pervious pavement is also less susceptible to freeze-thaw cracking, due to large void spaces.

http://www.gcpa.org/pervious_concrete_pavement.htm

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Maintenance

- **Void blockage**
  - Concerns about clogging of pervious pavements can be “designed out” by reducing erosion and sediment runoff through strategic design and water retaining ground cover.
  - Studies indicate that pressure washing a “clogged” pervious concrete pavement, using high volume at low pressure or vacuuming can restore 80 –90% of the permeability.

http://www.gcpa.org/pervious_concrete_pavement.htm

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Cost

A holistic view>>>

How much does pervious paving cost?

Cost depends on the type of pervious paving used and how it's figured, said Bruce Ferguson. He is director of the graduate program in landscape architecture at the University of Georgia and author of two landmark books on storm water management.

In general, if you simply compare square foot of impervious surface to square foot of pervious surface, the pervious will cost about 10 percent more, Ferguson said.

But, in large jobs such as shopping parking lots, builders can use pervious paving as a storm water management tool and spend less on installing other storm water tools such as retention basins. If ordinances are written to give builders credit for the storm water management capabilities of pervious paving, the job is far less expensive than a standard parking lot and retention basin combination. And that does not include the benefits the municipality gains through flood prevention and ground water recharge.

"What is saved is land costs," said Vincent Grevemberg, Chatham County civil engineer.

http://www.savannahmorningnews.com/smn/stories/021200/LOClosethewater.shtml

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Effectiveness

"Since the Chesapeake Bay Act, the cities in that area have become very concerned with stormwater runoff and the best ways to treat it. And, depending upon how close to the bay a development is located, there are increasingly tight building restrictions on property use. In some instances, zero runoff must be achieved before siting is even allowed. This means all rainwater that falls onto the property must be retained there. By utilizing pervious concrete, sometimes in conjunction with trenches underneath filled with open-graded stone to act as reservoirs, projects are able to achieve the zero runoff requirement. The pervious concrete allows the rainfall to seep right through the parking area, and then the reservoirs, where needed, hold the water until it can seep back into the ground.

http://www.americansweeper.com/v6n1/v6n1indupdate.html#Pervious Concrete

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Pervious Concrete Paving

- Steps for Success
  - Materials
  - Design Plans
  - Subgrade Testing & Preparation
  - Pavement Design & Specifications
  - Testing
  - Various Placing & Screeding Methods
  - Compaction
  - Jointing & Finishing
  - Curing
  - Flow Test Results

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Certification

- **Avoid the problems inexperience or improper installation can cause:**
  - Unqualified concrete installers, who probably do not have the right equipment or understand placement requirements.
    - **NRMCA Pervious Concrete Contractor Certification**

NRMCA

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Specs

1.05 CONTRACTOR QUALIFICATIONS

A. The use of a **NRMCA Certified Pervious Concrete Finisher** is strongly recommended. Prior to the bid, any Concrete Placement Contractor should be **pre-qualified** prior to being allowed to bid on project. Prior to award of the contract, the placing contractor shall furnish Owner/Engineer a statement attesting to qualifications and experience and the following:

1. A minimum of 3 completed projects with addresses.
2. Unit weight acceptance data.
3. In-Situ pavement test results including void content and unit weight.
4. Sample of Product (i.e. core or test panel)

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Specs

1.04 QUALITY ASSURANCE

A. Perform work of this section in accordance with ACI 301 and ACI 318.

B. Follow recommendations of ACI 306R when concreting during cold weather.

C. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work in this section.

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Specs

B. If the **placing contractor and concrete producer** have insufficient experience with Portland Cement Pervious concrete pavement (**less than 3 successful jobs**), the **placing contractor** shall retain an **experienced consultant** to monitor production, handling, and placement operations at the **contractor's expense**.

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Common Reasons For Failure

- **Placed By Inexperienced Contractor**
- Small Strips Used As Inverted Crown
- Direct Drainage Of Fines From Rooftop or surrounding areas
- Temporary Staging area for Mulch or Topsoil By Landscapers
- Drainage From Impervious Areas/Dirt Roads
- Lack Of Maintenance

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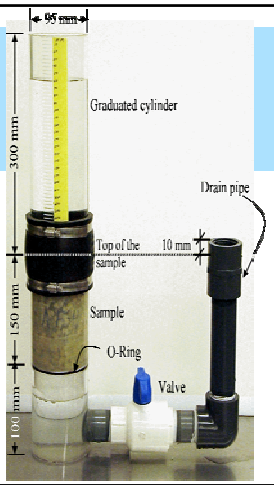
QC Testing



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Materials

- Portland Cement – ASTM C-150 – Type I or II
  - 520# - 630#
  - Known as **hydraulic cement**
    - Reacts with water to set and harden
    - Primary ingredient is limestone
- Supplementary Cementitious Materials
  - Slag < 50% replacement of cement
  - Flyash < 10% replacement of cement

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Materials

- Coarse Aggregate –
- A/C ratio of 4:1
  - Available Sizes- Need Variety – Might Cost More!!
    - 5/8" – 3/8" Blend
    - 3/8" Pea Gravel or Crushed Stone – **Most Commonly Used**
    - ¼" Barefoot Finish
- Fiber
  - Monofilament ONLY
- HSA (hydration stabilizing admixture)
- Retarders may be used – will not be effective
- VMA (Viscosity Modifying Admixture) & Superplastisizers
- Water
  - W/C ratio of .25 - .32

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Pervious Pavement Design

- **Rule of thumb**
  - 1" thicker than traditional paving
  - Latex Modified Pervious Concrete may be designed as regular pavement
  - May be graded flat, which affords the most water storage capacity
  - Slopes greater than 1% need to include erosion control considerations
    - Design under pavement dams when needed to slow the velocity of subsurface water

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Under Pavement Dams

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Under Pavement Dams

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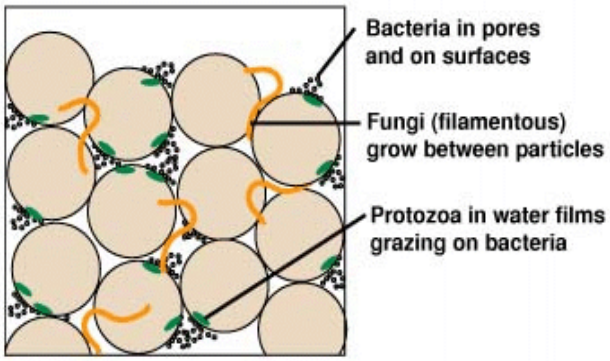
Sub-base Preparation

- **Compaction (K-Value)**
  - Minimum density of 92 – 96% of maximum density
  - Let microbes breathe



Install Non-Woven Geotextile Filter Fabric

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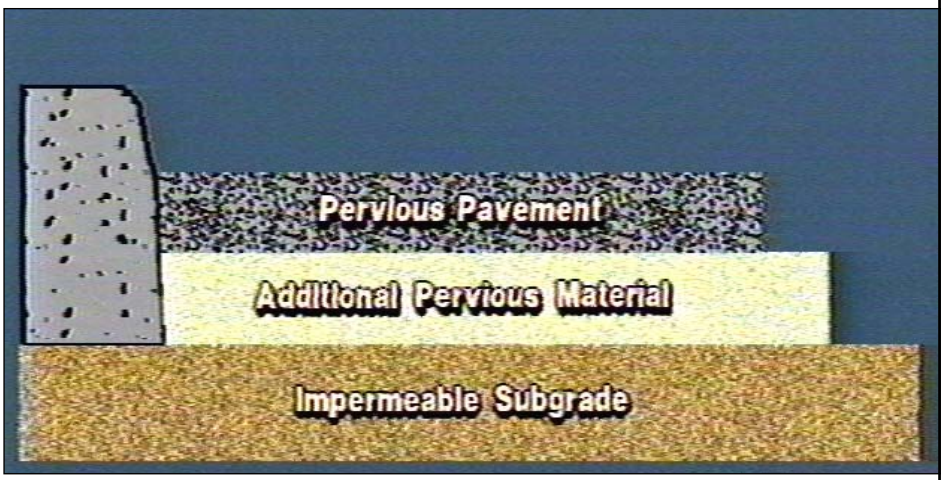
Recharge Bed Engineering



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Recharge Bed

- Open-graded crushed stone, gravels or sand are the best materials for pervious pavement recharge bed.
  - Based on perk test results
  - 1.5″ – ¼″ crushed stone is best
    - Clean
    - No minus material

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18 Minutes to Unload 10 Yards

- National average is 8 yard loads
  - Placement is slower than regular concrete

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Wetting The Recharge Bed

- Optimum Moisture
  - At the time of placement, the subgrade should be kept moist almost to the saturation point.

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Dry Subgrade

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Placing Methods - Rear Discharge

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Placing Methods – Front Discharge

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Placing Methods - Dump Truck/Asphalt Paver

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Placing Methods - Conveyor

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Placing Methods - Laser Screed

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Placing Methods - Volumetric Mixer

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Placing Methods – Plate Compactor

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Placing Methods – Vibrating Screed

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Placing Methods – Truss Screed

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Placing Methods – Modified Asphalt Paver

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Placing Methods – Evolution Paver

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Placing

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Placing

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Placing

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Screeding & Compacting

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Bunyan

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Compaction

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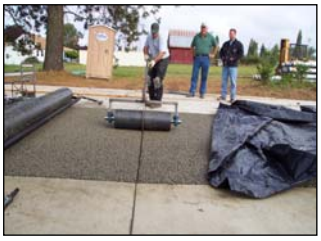
Jointing

- Joints should be at least ¼ of the thickness of the pavement. 1/3 of the thickness is best.
- Joint spacing should be no more than 20' feet apart.
- Joint rollers should have a radius machined between the flange & the roller.
- Known as "Pizza Cutter".



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Improper Jointing

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Tamping The Edges

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Improper Finishing

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Re-hydration

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Curing

- Cure for 3 – 10 days with 6-mil poly sheeting
- Start within 20 minutes or lose up to 60% of the concrete's strength!

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Improper Securing of Poly

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Improper Curing

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Improper Curing

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Results of Improper Finishing

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Results of Improper Finishing

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Results of Improper Finishing

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Results of Improper Jointing

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Results of Improper Finishing

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Results of Improper Finishing/Repair

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Results of Improper Jointing

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Results of Improper Joint Repair

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Olympia, Washington

- Year: 2000
- Owner: City of Olympia
- 1500 lineal feet of sidewalk
- Sub-grade: native soil was permeable enough
- Savings: $110,000 - land acquisition for detention ponds unnecessary

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Safeway Grocery Store
Denver Colorado

- 50,000 S.F. Parking Lot
- 2 Curb Inlets
- No Pond
- Non-woven Geo-textile
- 6" #57 Stone Recharge Bed
- 6" 3/8" Pervious Concrete
- Concrete Temperature - 70°
- Ambient Temperature At Placement 40° - 55°
- 7 Day Cure w/6 Mil Poly & Heating Blankets

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Safeway Grocery Store
Denver Colorado

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Denver – Next AM Following 12” Snow

Pervious Concrete | **Conventional Asphalt**

Sites Directly Across Street
Photos: 5 min. differential max – Courtesy of Dan Huffman, NRMCA

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S.T. Griswold Corporate Office
Williston, Vermont

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Villanova University
Pennsylvania

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Villanova University,
Pennsylvania

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Pervious Parking Areas

Florida Aquarium - Tampa – 10 years old
Dr. Betty Rushton Study

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Finley Stadium

University of Tennessee-Chattanooga

- Architect: Derthick, Henley & Wilkerson, Architects
- Engineer: Betts Engineering
- Landscape Architect: Levitt and Mills Associates
- Contractor: C & I Specialties Contracting Co.
- Supplier: Vulcan Materials
- Quantity: 1100 cubic yards

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Finley Stadium

University of Tennessee-Chattanooga

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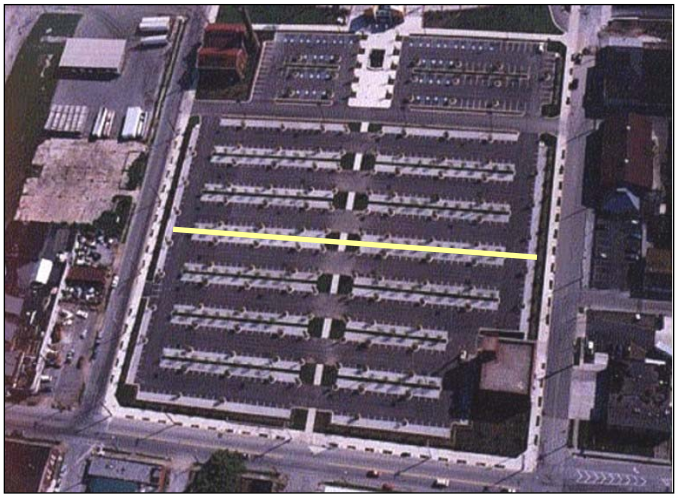
Finley Stadium

University of Tennessee-Chattanooga



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Oregon Zoo

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Oregon Zoo

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Church Parking Lot
Orlando, FL

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Pervious Concrete Can Easily Be Painted

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Pervious mixes have a water transmission capacity of 270 to 450 inches of rain per hour!

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Colored Pervious Concrete

Liquid color works best, powders are ok, dry shake does not work.

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Commercial Parking Lot

17 Years Old

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Commercial Parking Lot

17 Years Old

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Slope Protection – NJ DOT – RT. 23 – Sussex, NJ

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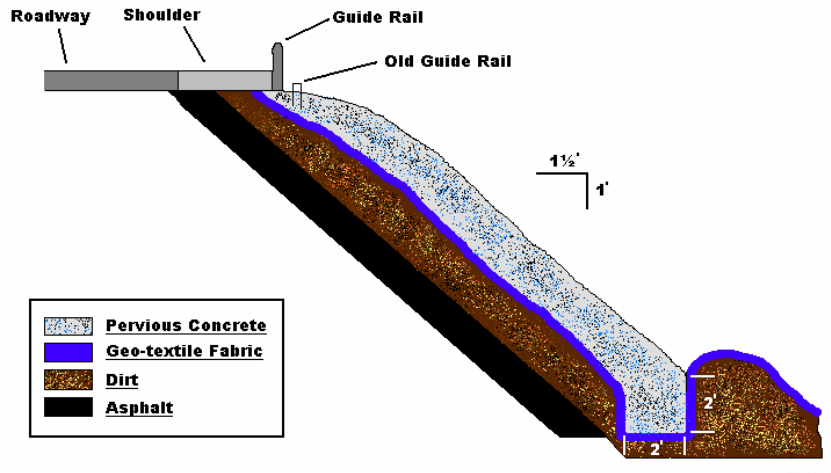
Slope Protection – NJ DOT – RT. 23 – Sussex, NJ



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Slope Protection – NJ DOT – RT. 23 – Sussex, NJ

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Slope Protection – NJ DOT – RT. 23 – Sussex, NJ

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Slope Protection – NJ DOT – RT. 23 – Sussex, NJ

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A Tool To Keep Our Lakes & Rivers Clean

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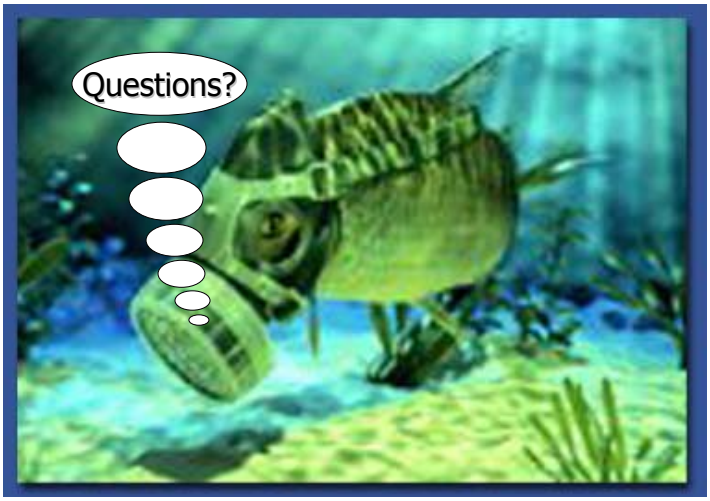
Pervious Concrete Helps Keep Freddy Healthy!



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Northern Virginia Concrete Advisory Council Expertise

- Concrete City Streets
- Recreational Multi-use Paths
- Controlled Density Fill
- Decorative Concrete
- Insulating Concrete Forms
- Self-compacting Concrete
- Waterproof Concrete
- Suggestions?






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Thank you!

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