Engineering Pervious Concrete Stormwater Systems







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Overview

Inlet to Stormwater System
Design – Structural & Hydrologic
Construction & Placement
State of the Practice & Keys for Success
Routine & Winter Maintenance
New Technologies

Pervious Concrete:

- "No Fines" Concrete Interconnected voids
- Most commonly used in low traffic areas
- Inlet to Stormwater Management System
- Hydrologic Design and Structural Pavement Design



Porosity: Typically 15-25% \pm

Permeability: 60 - >1,000 in/hr

Compressive Strength: 500-4,000 psi

Rob Traver's Instrumented Pervious Concrete Plaza at Villanova University



Villanova Stormwater Partnership www3.villanova.edu/VUSP/



Shoreview MN Woodbridge Pervious Street



Westminster, MD Value Engineering: Saved \$400,000



Shelter Systems

Design and Construction

- Structural Design
- Hydrologic Design
- Good Construction Practices

Cleveland State University

Hydrologic Design: Freeze Thaw & Drawdown

Overdrain to Minimize Pavement Saturation

Underdrain to Provide Positive Drainage & Drawdown

Table 5.5 Effective RCNs for Permeable Pavements					
	Hydrologic Soil Group				
Subbase	А	В	С	D	
6"	76 ¹	84 ¹	93 ²	-	
9"	62^{3}	65 ³	77^{3}	-	
12"	40	55	70	-	
^{1.} Design shall include 1 - 2" min. overdrain (inv. 2" below pavement base) per 750 s.f. of pavement area.					
² Design shall include 1 - 2" min. overdrain (inv. 2" below pavement base) per 600 s.f. of pavement area					
³ . Design shall include 1 - 3" min. overdrain (inv. 3" below pavement base) and a ¹ / ₂ " underdrain at subbase invert.					

Hydrologic Design at Work

1. MTA Park and Ride – 550 parking spaces 1.77 acres pervious concrete

Section

Storage (porosity)

Pervious Concrete: 8" #57 Stone: 4 inches to drain invert, 12 inch total. #2 Stone: ≥ 12 inches Sand: 6 inches

Storage below invert: 6.6"

1.6" (20%) 1.2" (30%) + 2.4" (30%) above invert

3.6" (30%) 1.8" (30%)

24hr-25 year storm: 6.28" 24hr-100 year storm: 8.65"

With subgrade infiltration of 0.5 in/hr section captures and <u>infiltrates the 100 year</u> <u>storm – zero discharge!</u>

Peak wse 1.57 feet

Hydrologic Design at Work

2. PA Pervious Concrete Sidewalk Design

Proposed design:

-520 s.f. pavement	-5,700 s.f. contributing c	Irainage (run-on)
-24 inch subbase	-Total DA = 6,220 s.f.	-0.5 in/hr exfiltration

Fails Freeze-Thaw: 1.2 inch storm saturates pavement

Contrast with No Run-on:

DA = IA 1.5' subbase fully infiltrates 8.5 inch storm!

3. *Pervious Alley* Proposed design: -1,000 s.f. pavers -48 inch subbase

DA:IA = 10:1

-10,000 s.f. contributing drainage (<u>CN=95</u>) - 8-inch underdrain -minimal exfiltration

Exfiltration 0.1 in/hr: ECN 93

Exfiltration 0.52 in/hr ECN 86

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White Oak LEED Gold Community Center Montgomery County, MD

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36" Drained Subbase

White Oak LEED Gold Community Center Montgomery County, MD

Consistent Compaction through Placement

Continuous Placement & Cure

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State of the Practice for Pervious Concrete

• ACI 522

American Concrete Institute Always advancing

- NRMCA Certification
- NRMCA Education
- ASTM 1688 and 1701
- Specifications

• ACI, PCA, ACPA design software

So what can you do to get it right?

- Get a copy of ACI 522 & the ASTM's
- Have your team get the NRMCA Certification
- Get real field experience
- Educate your team
- Consult an expert!
- Design Assistance

Portland Cement Association

American Concrete Institute

PLA

American Concrete Institute

Fresh Density ASTM 1688

Standard Test Method for Density and Void Content of <u>Hardened</u> Pervious Concrete: ASTM 1754

±5 lbs

Surface Infiltration ASTM 1701

Essentials for Success

- Tight control on batch time may be extended with HSA
- Tight control on placement time 20 minutes
 MAX
- 7 day <u>uninterrupted</u> wet cure
- Tightly secured curing plastic
- Test Panels Testing & Inspection

Specifications

Beyond Hydrologic and Structural design

- ACI 522.1-13 spec (ACI 522R-10/15)
 - Materials Mix Proportions
 - Performance (e.g. 400 in/hr)
 - Constructability Analysis
 - Testing: ASTM 1688 ASTM 1701
 - NRMCA Contractor Certification
 - Test Panels acceptance and reference
 - Maximum Mix (60* min) and Install (20 min) Timing
 - Weather Extremes: Misting, Moisture & Insulating Blankets
 - Inspection and Maintenance
 - ASTM tests in progress

Good Practice & Lessons Learned: Engineering Design - Transition Curb

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Pervious Concrete Maintenance

- Routine Maintenance vs. Renovation
- Condition-based Maintenance
- Winter Maintenance
- NRMCA Maintenance Guide
- Goal of routine maintenance is to avoid Renovation

NRMCA Maintenance Guide 2015

- Minimum Maintenance Schedule
 - Inspection
 - Cleaning and Stabilization
- Maintenance Levels
 - Routine
 - Periodic
 - Deep Cleaning (Renovation)
- Winter Maintenance
 - <u>Minimize</u> Deicing Chemical Use
 - Polyurethane Plow Blades

Pervious Concrete Pavement Maintenance and Operations Guide

Inspection and maintenance

White Oak Community Center Pervious Concrete Parking Lot

Tests were given a "Leakage" classification from 1-3, depending on the size of the wetted footprint after the test. Leakage can indicate sealing/poor performance

Class 1 – very little/no leakage. Wetted footprint is no larger than the device used

Class 2 – some leakage. Wetted footprint is slightly larger than the device used

Class 3 – severe leakage. Wetted footprint is significantly larger than the device used

Baseline Infiltration Map – White Oak Community Center

215 GPS referenced drawdown tests

> Fast 8-15 sec.

> >100 sec Slow

Pervious Concrete Clogging and Maintenance Montgomery County's White Oak Community Center

Winter Maintenance

De-icing Chemicals Ineffective

Clogging and Maintenance Recap

- Routine Maintenance vs. Renovation
- Manage with a "Clogging Model": Progressive Clogging
- Monitor widely and frequently match the scale of variability
- Match monitoring and maintenance to site conditions
- Condition-based maintenance
- Emphasize Site Design to minimize clogging risk
- Routine Vacuum Sweeping

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New Technologies & Continual Improvement

- Laser Screed & Machine Placement
- Refined Mix Designs
- Curing Compounds
- Internal Curing Compounds
- Silica Fume
- Fibers
- Titanium Dioxide coatings & nanoparticles.

Conclusion

- Inlet to Stormwater BMP
- Proven Mature Technology
- Proper Design, Construction & Maintenance
- Certified Experienced Professionals
- Expert Assistance & Training Available NRMCA
- Durable Reliable Green Infrastructure Solution

Hydrologic Performance

Urban Heat Island – Rio Verde Arizona

From: <u>Pervious Concrete: Questions Answered</u>. National Center of Excellence on SMART Innovations for Urban Climate + Energy. 17 January 2007

Cuyahoga Sustainability Network

Impervious Caps and Credits

Tropical Storm Katrina Storm Totals: 31Aug 2005 - 07:27 EDT

Condition-based Maintenance

Clogging & Maintenance Effectiveness

Positive Drainage Demonstrate Cold Weather Performance

Pervious Concrete Detention

Site Preparation: Cleveland, OH

Cuyahoga Sustainability Network

Cold Weather Test Plot

Tropical Storm Katrina Storm Totals: 31Aug 2005 - 07:27 EDT

Pervious Pavement

Do

- Site specific design and testing
- Certified contractors
- Routine Monitoring & Maintenance
- Hydration & Mix design
- Full Rapid Curing
- Site Design for Protection
 - Buffer/filter/diffuse run-on
 - avoid particulate loading

Don't

- Saturate Pavement
- Standard Paving Section (6+6)
- Push the mix "tools of the trade"
- Defer maintenance to sealing
- Overload the pavement
- Over finish (sealing)
- Starve the hydration