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Civil Engineering
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WSU & Puget Sound Partnership Permeable Pavement LID Workshop

Design and Construction Considerations for Permeable Pavements

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Design & Construction: Topics to Cover

- Design Considerations (SvR)
- General Construction Issues (SvR)
- Site Soils & Infiltration (AESI)
- Case Study (AESI)
- Question & Answer (All)

Above photo: Woodland Park Zoo Penguin Exhibit

Bottom photo: Sport Court in Seattle

Design and Construction

- For a successful project, the team needs to follow the right BMPs for all phases:
  - Site Selection
  - Material Specifications
  - Design
  - Planning & Coordination
  - Installation
  - Construction
  - Protection of Work
  - Operations/Use as Intended
  - Maintenance
- Porous Pavement is another tool for the stormwater management kit

Terms

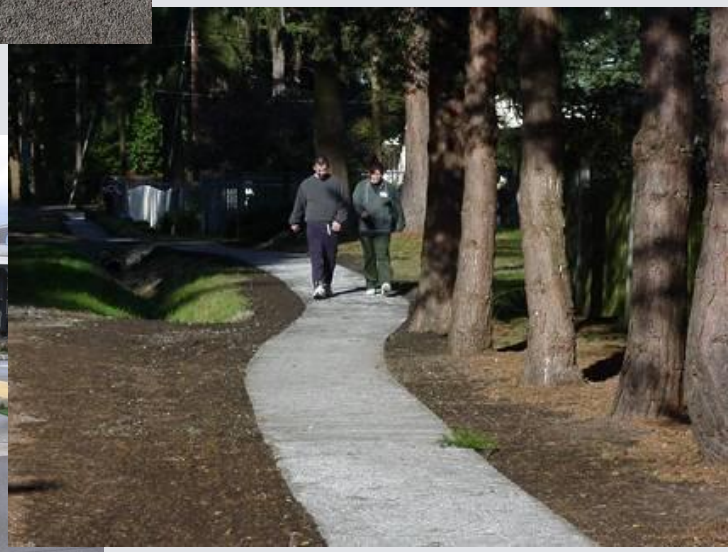
- Permeable
- Porous
- Pervious
- Are used interchangeably but essentially mean same thing…water can filter through the top wearing course.
- Paver that is permeable vs. Impermeable paver that has gaps between paver to allow water to filter through
- Pick one and be consistent in your standard plans and specifications.
- Currently moving towards standardizing to:
  - Pervious Concrete
  - Porous Asphalt
  - Permeable Interlocking Pavers

Users of Facility

Who will be the users of the facility?

- Pedestrian
- Bicycle
- Parking Lot
- Low-Volume Residential Streets
- Aesthetics

One size does not fit all. Use appropriately.



Serene Way Sidewalk

Photo by: Randy Sleight, Snohomish County

Other Applications for Porous Pavement

- Public Walkways
- Parks
- Plazas and Patios
- Parking

- Greenhouse Floors
- Surface Course for Tennis Courts
- Basketball Courts
- Noise Barriers / Walls

Private Parking lot, Seattle

Bellingham Bicycle lane

Seattle's Fremont Park

Public vs. Private Facilities

N. Gay Ave, Portland. Porous Asphalt Concrete
(2005 - 8” porous AC over 6” Subbase)

- Design Life
- Maintenance Effort
- Material Selection

32nd Ave. SW, Seattle. Pervious Concrete
(2005 – 8” PPCC over 18” subbase)

Grand Central Parking Lot, Vancouver, WA

Site Selection & Location

- Topography (ideal slopes 0 to 5%)
- Proximity to Hazardous Materials
- Potential for run-on from unstabilized areas/erosive soils
- Maintenance effort
- Low Volume traffic loading (residential street, parking lots)
- Infiltration Rate of Existing Subgrade Soil
- Follow Ecology guidelines for ground water/aquifer protection

Pervious Concrete Parking Lot, Seattle

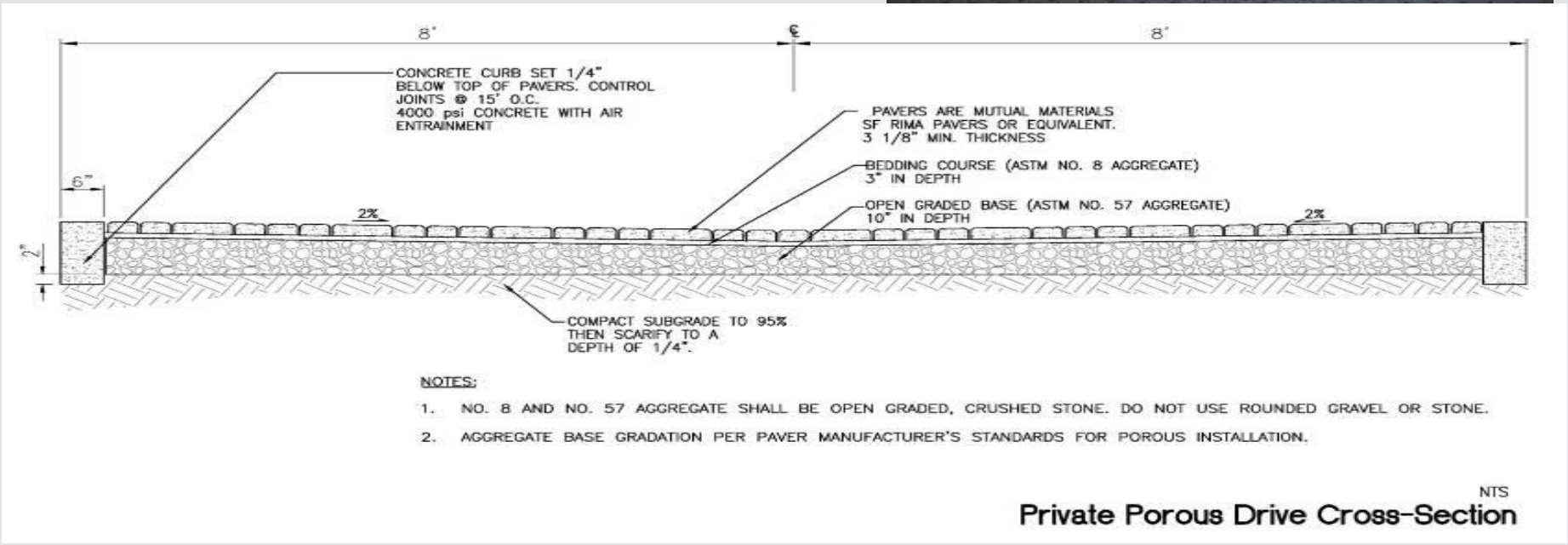
Porous Asphalt Drive, Pierce County

Photo courtesy: Timothy Lowry, Seattle Public Utilities

Stormwater Management Design Parameters

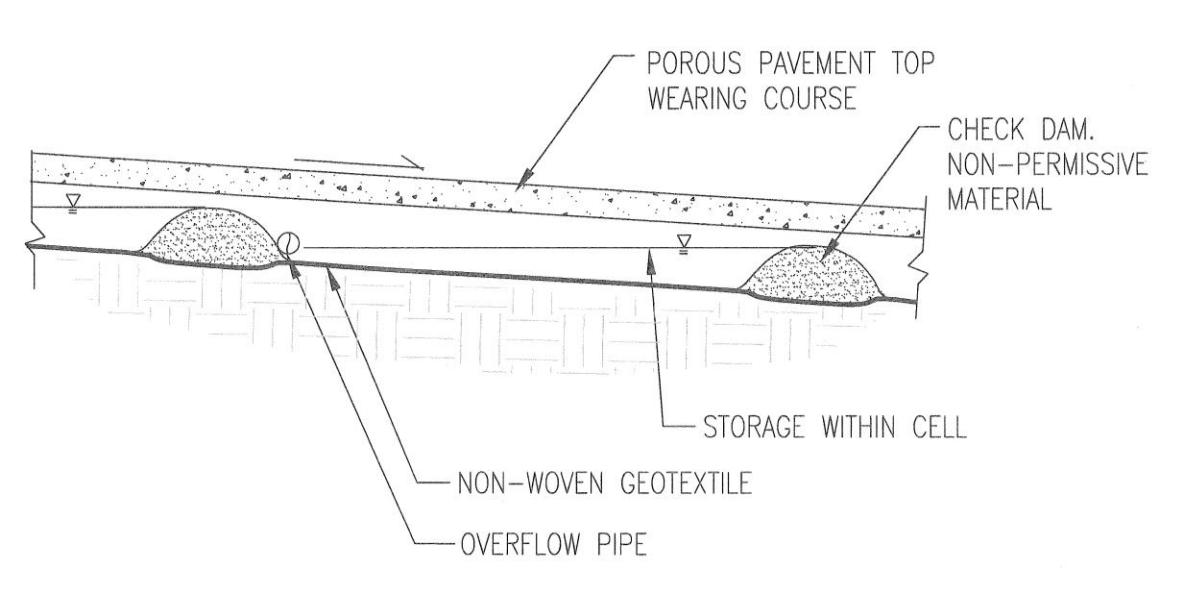
Porous pavements can be designed to provide one or more of the following:

- Reduce Impervious Footprint
- Flow Control Facility via the storage within the gravel subbase
- Water Quality Treatment (if subgrade soils are suitable)
- Other



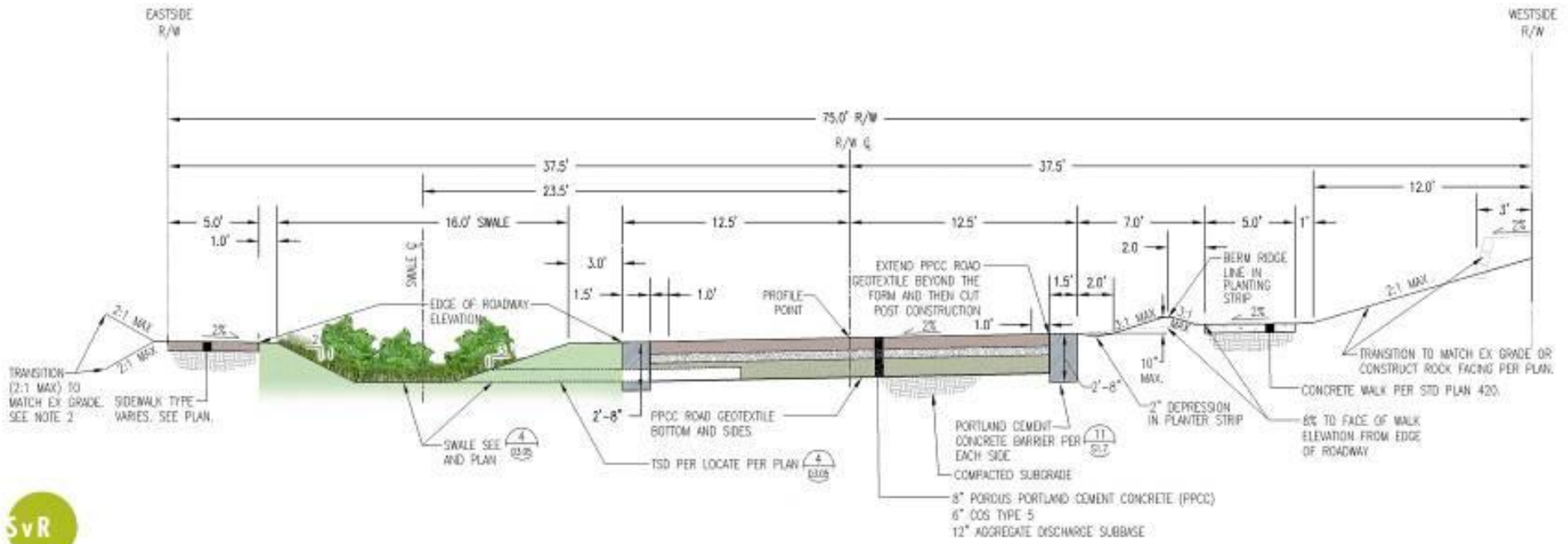
Subgrade Slope and Storage Capacity

- Ideal 0% to maximize storage but can increase excavation
- Sloped conditions (1% to 5%) reduces the amount of useable storage space but decreases amount of excavation. Use periodic impermeable check dams, or gravel trenches or other measures to allow water to backup & infiltrate.



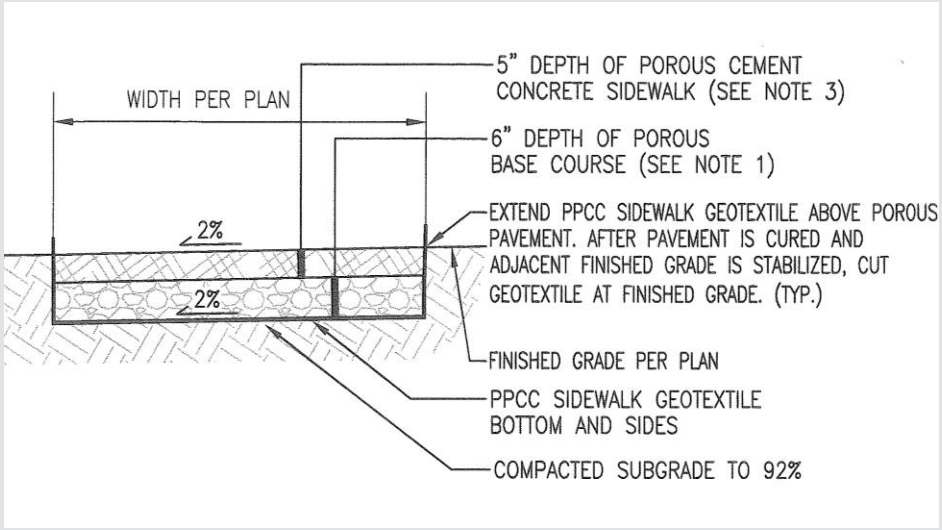
Overflow/Back-up System

- Provide for emergency overflow
- What is the flow path if water does not infiltrate?
- If 100% infiltration facility follow manual guidelines for closed depression infiltration facility
- Subsurface drain pipe? (slotted pipe above design water surface level)



Pavement Section Design

- Section includes:
  - Top wearing course
  - Leveling course (optional)
  - Gravel subbase (storage)
  - Geotextile (?)



- Design conservatively for wearing course section depth
- Follow manufacturer guidelines for proprietary products (e.g. interlocking pavers, rigid and flexible open celled grids)
- Pervious concrete is typically 1” to 2” thicker than conventional concrete but varies depending upon design parameters and site conditions.

Subbase and Subgrade Design

- 30%+/- Voids for Gravel Storage Subbase (Consult with Geotechnical Engineer)
- Subbase. Key is low fines (% passing 200 sieve), clean and interlocking fracture aggregate.
- Subbase for pedestrian areas:
  - AASHTO #57
  - 3/8” to 3/4” clean crushed gravel
  - OR per manufacturer.
- Subbase for vehicular areas:
  - Permeable Ballast (WSDOT 9-03.9(2))
  - OR per manufacturer
- Consult with Geotech to review subgrade and subbase prep.
- Scarify Existing Subgrade to Prevent Sealing of Subgrade
- Geotextile? (Consult with Geotechnical Engineer)

Specifications

- Varies with material type
- Some jurisdictions have, or are developing specs. (Seattle, WSDOT)
- Check your source if reviewing other example specs as design parameters vary
- “Specification for Pervious Concrete Pavement” from American Concrete Institute (ACI) publication 522.1-08 (update coming).
- “Porous Asphalt Pavements” from National Asphalt Pavement Association
- Follow manufacturer recommendations for proprietary products, (open celled paving grids and interlocking pavers)

Relative cost comparison for porous wearing course layer for parking lot

Pavement / Type	$$ per square foot for top wearing course layer (& bedding if required)*	Notes/Comments
Interlocking permeable pavers & rigid open celled pavers (+ 2” clean bedding layer)	$5.00 to $6.00/sf (installed mechanically) $7.00 to $12.00/sf (hand laid installs)	Based on quantity less than 40,000 sf For 100,000 to 200,000 sf, cost between $3.25 to $3.50/sf Ref. Mutual Materials.
Flexible open celled/Grid lattice paving systems	$6.75/sf (Grasspave2) $7.25/sf (Gravelpave2)	Cost based on 100 to 10,000 sf quantity. Includes clean gravel fill. Ref. Andy Gersen, Invisible Structures
Porous Asphalt	$2.15/sf (3” porous AC over 2” clean choker course)	AC recently has had wide $$ fluctuations over short period of time. Price can vary based on quantity. Ref. Mark Palmer
Pervious Concrete (8”)	$5.50 to $9.00/sf	Cost can vary among bidders.
Stormfilter vault w/cartridges from Contech to provide Basic WQ treatment per DOE	$26,000 to $37,500	Based on 20,000 sf of parking Ref. Contech rep.

*Assumptions: Based on 20,000 sf parking lot with 12” storage subbase. Clean crushed rock base for storage and overflow drains not included in above costs.

Costs can vary over time so check with suppliers and installers for latest information.

Estimate for February 24, 2009

construction

- TEST PANEL required.
  - May require multiple test panels for new installers.
  - If unable to install test panel, recommend they provide at least 3 examples of previous installations by crew from locations nearby (50 mile radius).
- Installers and Supplier Certification required.
  - Pervious Concrete : Require installers and suppliers to have National Ready Mixed Concrete Association's Pervious Concrete "Installer" Certification or the highest level of "Craftsman" certification. Local contact: Bruce Chattin with WACA.
  - If crew has no certification, then require contractor to have a construction consultant with extensive porous pavement installation experience to oversee installation.
  - Training by Manufacturer Rep and/or Manufacturer Rep to be present for installation.
- Recommend at least 2-3 persons per crew to have certification.
- Specifics to each material type to be provided at later sessions.
- Follow manufacturer guidelines for installation with proprietary products.

Temporary Erosion & Sediment Control (TESC)

- Install protection (TESC and Flow Diversion) measures prior to final excavation
- Prime contractor to inform other subs of requirements when working around pervious pavement

Maintain Erosion Control BEFORE and AFTER construction. Permanently stabilize adjacent areas.

Post Installation Testing

- Infiltration Test
- Pervious Concrete and Porous Asphalt
  - Check for raveling (pressure washer test or other means)
  - Check for uniform surface and non-sealing at the surface
  - Coring to check for consistent density and design depth
- Check for sediment contamination from uncontrolled runoff
- Open celled plastic grids, check staking is per manufacturer

Resources (1 of 2)

- American Concrete Institute 522.1-08 “Specification for Pervious Concrete Pavement”, March 2008.
- National Ready Mixed Concrete Association Pervious Concrete Publications www.nrmca.org
- “Freeze Thaw Resistance of Pervious Concrete,” National Ready Mixed Concrete Association, May 2004. www.nrmca.org
- “Pervious Concrete Contractor Certification,” National Ready Mixed Concrete Association, August 2005. www.nrmca.org
- City of Seattle Department of Planning and Development Client Assistance Memo #515. http://www.ci.seattle.wa.us/dclu/Publications/cam/CAM515.pdf
- LID Technical Guidance Manual for Puget Sound, http://www.psat.wa.gov/Publications/LID_tech_manual05/lid_index.htm
- “Low Impact Development Practices: A Review of Current Research and Recommendations for Future Directions” by Michael E. Dietz, Utah State University, Springer Science + Business Media B.V. 2007.
- “Porous Pavements,” by Bruce K. Ferguson, Taylor & Francis Group, 2005.
- Sample specifications from Florida, Tennessee and Georgia Concrete and Products Associations
- Andrew Marks from Puget Sound Concrete Specifications Council, andrew.marks@comcast.net
- Bruce Chattin from Washington Aggregates and Concrete Association, http://www.washingtonconcrete.org
- Jim Powell from Northwest Chapter from American Concrete Pavement Association, 360-956-7080.
- Local Suppliers

Resources (2 of 2)

- “Pervious Concrete Pavement” by Paul D. Tennis, Michael L. Leming and David J. Akers and Portland Cement Association and National Ready Mixed Concrete Association, 2004.
- “Villanova Urban Stormwater Partnership: Porous Concrete” By Robert Traver, Andrea Welker, Clay Emerson, Michael Kwiatkowski, Tyler Ladd, and Leo Kob in Stormwater magazine July/August 2004, pages 30-45.
- Charger Enterprises, http://www.chargerconcrete.com/SPECIFICATION.pdf
- Brett Kesterson from City of Portland
- “NC State University Permeable Pavement Research: Water Quality, Water Quantity, and Clogging,” Eban Z. Bean, EL, PhD Candidate and William F. Hunt, PhD, PE, NWQEP Notes, North Carolina State University, Number 119, November 2005.
- “Long-Term Stormwater Quantity and Quality Performance of Permeable Pavement Systems,” by Benjamin O. Brattebo and Derek B. Booth, July 1, 2003, Center for Water and Watershed Studies, Department of Civil and Environmental Engineering, University of Washington at http://depts.washington.edu/cwws/Research/Reports/permeableparking.pdf
- Pervious pavement in cold climates: http://www.perviouspavement.org/asphalt%20vs.concrete.htm
- Lower Columbia River Field Guide to Water Quality Friendly Development http://www.lcrep.org/fieldguide/examples/permeablepavers.htm
- City of Olympia www.olympiawa.gov/cityutilities/stormwater/scienceandinnovations/porouspavement.htm
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Question & Answers

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