Minnesota Porous Pavement Research

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TERRA - MnROAD Open House
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Typical Stormwater Handling Method

- Impermeable pavement
- Detention Pond/Surface Water
- Inlet
- Outlet
- Culverts

May lead to Flooding (Missouri Capital 1993)
An Alternative – Permeable Pavements

Permeable Paving also called Pervious Paving or Porous Pavement

- Allows vertical movement of water and air through the pavement and base directly into subgrade soils and groundwater.
- Properly designed permeable pavements can reduce the total runoff volumes and peak flow.

Source: Cahill & Associates
Examples of Permeable Pavements

- **Porous Turf**
  - used for occasional parking
  - counteracts the “heat island” with water transpiration

- **Single-sized Aggregate**
  - low traffic areas only, but large potential use
  - highly permeable
  - least expensive – no binder

- **Porous Pavers**
  - concrete or stone units with open, permeable spaces between the units
  - architectural appearance
  - can withstand heavy traffic, particularly interlocking paving blocks

- **Porous Asphalt and Pervious Concrete**
  - plant mixed
  - minimal fine (small) aggregates
  - high % of interconnected voids provide porosity and permeability
  - often used with permeable base course
  - withstands repeated traffic
Porous Asphalt (PA)

- Open-Graded mix with high porosity - storm water travels vertically through permeable surface, is stored in open-graded base, and infiltrates into subgrade groundwater directly.
Porous Asphalt Types

- **Porous Friction Courses (PFC) (OGFC)**
  Usually a thin wearing course of porous asphalt above impervious HMA layer – water drains out laterally.

- **Porous Asphalt (PA)**
  One or more lifts of fully permeable pavement over porous base.

*Full Depth Porous Asphalt Example:*

Source: Cahill & Associates
Porous Asphalt (PA) In Use Elsewhere

- **In the USA**
  - Most commonly used in parking lots, trails, hardscaping.
  - Few examples of full-depth PA on roadways.
  - As OGFC or PFC - Common in FL, GA, OR, CA, TX

- **In Europe**
  - Netherlands (extensive use of PA on roads)
  - Denmark, Belgium
  - Great Britain
  - Sweden (Similar cold-climate research done)
  - France, Switzerland, Italy, Spain, Greece

- **Japan**

- **And Others**
  - Australia, Canada, South Africa, Malaysia
Potential Benefits

- Reduces stormwater total runoff and storm surges
- Less structures, detention ponds, and right-of-way needed for stormwater mitigation
- Environmental benefits; water quality, runoff water temperature, recycled materials, water & air to plant roots
- Quieter pavement - lower tire & vehicle noise
- Low impact development - Leadership in Energy and Environmental Design (LEED®) credits
- Faster snow melt(?), resistant to frost heave & thermal cracking
- Safety improvements: less splash & spray, glare reduction, less hydroplaning
Potential Disadvantages

- Durability results are mixed elsewhere and not well-studied in cold climates
- Potential for clogging – leads to loss of permeability, failure of stormwater handling & environmental benefits
- Clogging incurs regular maintenance – usually pressure spray / vacuuming is employed
- Higher Costs – construction, maintenance, shorter lifespan. (May be balanced with higher cost of standard stormwater mitigation)
- Assumed lower structural contribution from porous pavement
- Increased deicing application needed(?)
LRRB 878 MnROAD Porous Asphalt Project

To study the Durability, Maintenance Needs, Hydrologic Benefits, and Environmental Considerations of a Full-Depth Porous Asphalt Pavement in a Cold Climate.

Construction - Summer 2008

Project Ends - Fall 2010
LRRB 878 MnROAD Porous Asphalt Project

- Late Summer 2008 Construction
  MnROAD Low Volume Road
- Cells 25 & 26 to be replaced with cells 85 - 89

Low Volume Road
Two porous asphalt (LRRB 878), and two pervious concrete (LRRB 879) pavement sections; one of each with a clay subgrade, and one of each with sand subgrade.

An adjacent, impermeable (sealed HMA) “control” section will also be prepared to compare durability / runoff / water quality.
Porous Asphalt - Cells 86 & 88

- No Crown - all layers
- 5" HMA Pervious (Mn/DOT Spec)
- 14" Gap-Graded Base
  - 40% Air Voids (Crushed 2" CA-15)
- Subgrade (One Cell with Clay, and one with Sand)
  - Non-Compacted

1 - Mix designed by Contractor, verified by MnDOT
LRRB 878 Research Objectives

- Evaluate performance; durability and functionality when used on a low volume roadway in Minnesota (cold climate).
- Study hydrologic benefits and quantify environmental effects.
- Provide an alternative design tool for pavement designer to effectively manage storm water on local roads.
- Use performance data to develop mechanistic-empirical design of porous pavements in cold-weather environments.
- Document necessary maintenance procedures and cost.
  - When is maintenance required?
  - Best Practices? How often?
LRRB 878 Testing Methodology

Two-year continuous Monitoring; 2008 - 2010

- Pavement performance – distress surveys, friction, fwd.
- Stormwater - flow rate & volume, compare to control cell.
- Document groundwater quality; Heavy Metals, PH, Suspended Solids.
- Monitor and document Subsurface frost and Snow & Ice issues.
- Monitor pavement clogging, test maintenance schemes.
- Noise Testing.

Instrumentation

- Piezometers, strain gauges, tipping buckets, lysimeters, thermocouples, TDRs, and permeameters.
LRRB 878 Summary of Porous Asphalt
Modified Mn/DOT Specification 2360/2350
(Based on NCAT 2000) (Key Mix Properties in green)

- PG64-34 Binder, Minimum asphalt content 5.5% - 6.5% by weight
- No recycled material
- Gradation; 100% passing ¾, 75% retained on #4 (no Class B aggregates)
- LA Rattler Loss <35% for any individual source
- Mineral Filler allowed / Maximum Draindown ≤ 3%
- Coarse Aggregate Angularity >55% (No Fine Agg Angularity Spec)
- Coarse Aggregate Absorption ≤2%
- Voids in Coarse Agg; \( VCA_{\text{max}} < VCA_{\text{drc}} \)
- Flat & Elongated ≤ 5 (5:1 ratio)
- Clay Content, Max Spall, % Lumps retained on #4
- Air Voids; 17 - 19% (ensures permeability)
- Placement of Asphalt @ 50F ambient temp, 275F mix laydown temp minimum
- Modified Lottman test; TSR ≥ 80%
- Mix Storage; 90 minutes max
- Mix to be placed with a track paver only
- 10-ton steel wheeled non-vibratory rollers only (1 or 2 passes)
- No vehicular traffic on finished surface for 24hrs, prevent surface contamination
Status of LRRB 878 Project - July 2008

- MnROAD Phase II reconstruction (2007-2009) continuing
- 2008 MnROAD reconstruction continued in April (Mainline first)
- Preliminary Geotechnical Survey work done
- Piezometers installed
- Baseline Water Quality Sampled and Tested
- Porous Asphalt Mix Design in progress
- Expect Porous Asphalt (& Pervious Concrete) Cell construction August or September 2008
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Websites & Additional Info:

- [http://www.fhwa.dot.gov/environment/ultraurb/3fs15.htm](http://www.fhwa.dot.gov/environment/ultraurb/3fs15.htm)
  FHA fact sheet – porous pavements

  US EPA Stormwater BMPs

- [www.hotmix.org](http://www.hotmix.org)
  National Asphalt Pavement Association

- [http://www.dot.state.mn.us/mnroad/index.html](http://www.dot.state.mn.us/mnroad/index.html)
  MnROAD information
Thank you