POROUS ASPHALT: DESIGN AND CONSTRUCTION

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City Engineer, City of Puyallup
POROUS ASPHALT: DESIGN AND CONSTRUCTION

- Materials and Specifications
- Performance of Permeable Asphalt
- Emerging Green Technologies for Asphalt
- Questions
POROUS ASPHALT: DESIGN AND PERFORMANCE GOALS

1. Properly integrated into site design
2. Permeable wearing course
3. Flexible Pavement Section designed for saturated subgrade conditions
4. Pavement designed to infiltrate 100% of rainfall
5. Pavement depth sufficient to eliminate frost heave
6. Durable, long lasting wearing course
7. Constructible Design (materials, sequencing)
8. Prevents or accounts for surface water run-on
9. Provides drainage redundancy (inlet, outlet)
10. Addresses potential storm water flows in subgrade/trenches
6. POROUS ASPHALT IS A GOOD PRODUCT FOR LOCAL ROADS, PARKING LOTS AND TRAILS.

Conclusions of Final Report for SR-87 project:

- “The porous pavement test section has performed satisfactorily for five years. Although a slight decrease in the infiltration rate has occurred, both the infiltration rate and the storage capacity are above the design values.”

- “Visual observation during rain storm has shown that the surface of the porous pavement section does not include sheet flow. This provides a marked difference in stripe delineation and pavement glare during night time inclement weather driving compared to conventional pavement.”
POROUS ASPHALT: CONSIDERATION FOR USE

6. Porous asphalt is a good product for local roads, parking lots and trails.
   • Parking lots are tough test-low speed turning motions
   • Resist temptation to mix porous with impermeable pavements in same section
   • Depth of section can be an issue on high volume roads-consider pervious concrete to avoid existing utilities and for life cycle cost advantages
   • Porous asphalt treated base or geogrid can help thin porous asphalt section.
POROUS ASPHALT: CONSIDERATION FOR USE

• Porous Asphalt vs. Pervious Concrete
  – Porous asphalt does not require certified installer-normal pavers can complete
  – Porous asphalt cannot be made in small batches-requires plant change
  – For high volume roads, pervious concrete may be more cost effective, both short term and life cycle cost
  – Porous asphalt can be used almost immediately vs. 7 days for concrete
  – Porous asphalt requires thicker section for higher volume or poor soils
Committee has developed a WSDOT format specification for porous asphalt (Jessica Knickerbocker, City of Tacoma lead).

Specification is currently housed on City of Tacoma’s website, at http://www.cityoftacoma.org/cms/one.aspx?objectId=81563.

Specification is focused on Puget Sound Basin in Washington, some modification of binder may be required for other regions.

This presentation will focus on the asphalt pavement, however there are many details for subgrade, site prep and aggregates as well.
POROUS ASPHALT MIX DESIGN

- **Class ½ HMA PG 70-22** (Polymer modified
- Asphalt cement **shall be** between 6.0% and 7.0% by **total weight**.
- Void Ratio between 16% and 25% at 75 gyrations
### STANDARD GRADATION

- Wider range of gradation, allows for modifications by supplier to meet other requirements
- Percent of two face fracture shall be greater than 90%

<table>
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<th>Sieve Size</th>
<th>Percent Passing</th>
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<tr>
<td>¾” square</td>
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<tr>
<td>½” square</td>
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<tr>
<td>3/8” square</td>
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GRADATION MISCUES

- Result of gradation miscue (poorly graded) on choker course
- Rutting, lack of interlocking
GRADATION CORRECTION

- Correction-added correctly graded material to existing poorly graded material.
- Rutting greatly reduced
- Subsequent areas with strictly correct rock were even better.
AGGREGATE SPECIFICATION-CHART

- Good way to see visually how gradation should look
- Original, poorly graded aggregate is near vertical line
- Replacement material has curve that emulates specification curve
POROUS ASPHALT TREATED BASE

- Porous asphalt treated base good alternative to choker course
  - Provides stable base for wearing course installation
  - Eases construction, allows for staged construction
  - Provides more structural strength vs. aggregate
  - Specifications are included on the Tacoma website
POROUS ASPHALT MIX DESIGN

• Air Voids 16-25% (ASTM D3203)
• Drain Down-ASTM D6390-05, 0.3% maximum @ 15° above design mix temperature
• ODOT has alternate ODOT TM 318 Drain Down Test-subjective
  – Consider adding fiber to mix design
  – Warm Mix seems very promising to prevent drain down
• During Construction
  – Watch for asphalt in beds of dump trucks
ASTM D6390-05
DRAIN DOWN TEST

- Constituents mixed by hand per mix design
- Placed in basket with no compaction
- Cooked in oven at prescribed temperature
- Material that drops to plate weighed and compared to 0.3% standard
- Not necessarily representative of field conditions
- Look for asphalt in the bottom of dump trucks during construction
ODOT TM 318
DRAIN DOWN TEST

• Process similar to ASTM test-but places paper directly under sample

• Tester interprets between several example percentages of drain down pictures (see picture this page).

• Like ASTM test, not likely representative of field conditions, also subjective
POROUS ASPHALT MIX DESIGN

• Anti-stripping agent should be used if supplier normally uses anti-stripping in their HMA mixes.
• Should not exceed 1% by weight of aggregates
• If having difficulty meeting minimum 6% asphalt in mix design due to drain down:
  – Consider increasing fines in aggregate—but watch void ratio
  – Consider adding fiber to mix design
• Intent of minimum asphalt content, polymer modified PG 70-22 is to provide full and durable coating of aggregate (design goal #6)
GEOGRID

- Check manufacturer's recommendations for placement
- Can reduce overall section thickness
- Section shown is proposed WSU Puyallup LID Frontage Phase 1 section
- Porous asphalt treated base also helps reduce section thickness
• Pavement section thickness needs to address:
  • Frost heave depth-lower Puget Sound basin around 1’
  • Hydrology-allow water to infiltrate before next storm
  • Structural-design flexible pavement thick enough to distribute load over assumed poor, saturated soils.

• Frost heave only concern if fine grained, poor soils=>hydrology and structural will over ride in these cases

• Hydrology and Structural generally will follow each other based on soils.
STRUCTURAL DESIGN

- WSDOT has pavement design software which can be used for this purpose (EverStress)-requires some expertise to use

- WSDOT also has design guideline tables which are functional for designing pavement thickness

- Choose the appropriate table based on traffic levels, assume poor subgrade condition for all porous pavements

- There are also some locally developed pavement design programs that may be available

WAPA has program that can be used as well:

http://www.pavexpressdesign.com/index.php
Higher volume roads will require greater pavement section thickness.

Multiple lifts of porous asphalt can be a problem, can’t tack coat.

WSDOT does not recommend porous pavement for high volume roads.

<table>
<thead>
<tr>
<th>Design Period ESALs</th>
<th>Flexible Pavement</th>
<th>Rigid Pavement</th>
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<tr>
<td></td>
<td>HMA</td>
<td>CSBC Base</td>
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<td>&lt; 5,000,000</td>
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<tr>
<td>100,000,000 to 200,000,000</td>
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WSDOT-Permeable pavement suits new construction of very low volume, slow speed locations with infrequent truck traffic.

The permeable base storage layer thicknesses shown above are based on the minimum structural needs of the permeable pavement application. Reference the WSDOT Highway Runoff Manual to determine the thicknesses based on subgrade infiltration and the pavement storage capacity needs. In some cases, additional permeable base thickness may be required for frost design purposes. Permeable base aggregate shall consist of an AASHTO 57 gradation or as approved by the State Materials Laboratory.
STRUCTURAL DESIGN

- Section used at the WSU LID Center
- Note, choker course was not used, aggregate for reservoir course was deemed adequate for working surface
- Would not recommend compaction of subgrade as shown here—typically go for firm and unyielding.
CONSTRUCTION

• Sequencing Important:
  – Plan site work to keep construction traffic off subgrade
  – Example-excavate to subgrade as moving out, back fill with aggregate from opposite end
  – Once geotextile and reservoir rock is down, can compact that and allow traffic on rock.
  – For anything but asphalt treated base, will likely need rollers around to fix/compact rock as pavers are working
CONSTRUCTION

• Watch materials and placement:
  – Look for aggregate to be porous, no sheen or sealed off areas
  – Make sure subgrade has not been compacted by construction traffic, if it has, scarify before geotextile and rock are placed.
  – Watch for asphalt in the beds of delivery trucks - indicates drain down issue
  – Make sure rollers are on the asphalt in the correct temperature range (by mix design)
  – Target compaction at 80-85% maximum Rice density (Design goal #6)
  – Standard nuke gage can be used for compaction testing
CONSTRUCTION OBSERVATION KEYS

- Check that subgrade is not compacted or sealed off
- Should be loose, open graded.
- Pavement has been designed for poor subgrade, only soft, yielding subgrade should be concern.
CONSTRUCTION SEQUENCE

- Back dump rock onto geotextile
- Spread aggregate with dozer to design depth
- Compact aggregate at full design depth.
CONSTRUCTION OBSERVATION KEYS

- Note clean, interlocking look of rock

Shoulder ballast-clean, fractured loose in place
CONSTRUCTION OBSERVATION KEYS

• Compare and contrast:
• Left cell is porous reservoir course rock
• Right cell is dense graded CSTC
CONSTRUCTION OBSERVATION KEYS

- Compare and contrast:
- Left picture is standard CSBC
- Right picture is good choker course

Clean, free draining, interlocked

Note sealed off appearance
CONSTRUCTION OBSERVATION KEYS

- Test Time!!!
- Which of the two choker courses shown would be acceptable?
- Why is the other not acceptable?
CONSTRUCTION OBSERVATION KEYS

- Make sure compaction starts within the compaction range specified by the mix design
  - Too Early (too hot) - final mat may not have desired porosity
  - Too Late (too cold) - final mat will not compact to desired density, surface may be uneven, likely candidate for raveling and eventual rutting
CONSTRUCTION TESTING KEYS

- Compared data between Tacoma and Puyallup projects

- 80-85% maximum Rice Density has been established for compaction, closer to 85% but not over better.
CONSTRUCTION OBSERVATION KEYS

- Porous asphalt will not look much different than dense graded HMA
- Left cell is porous
- Right cell is control dense graded HMA.
- Fun Fact: dense graded HMA was so porous, had to add dirt to it to clog it enough to provide run off.
• Placement and Acceptance:
  – Test for infiltration rate using modified ASTM test
    • Initial tests should average over 100”/hour
    • Remember that 1”/hour would still be adequate
  – Cities of Puyallup and Tacoma will continue testing of porous asphalt pavements to verify density range for porous asphalt
  – Look for sealed off areas in pavement. Again, only if extensive areas closed off would remedial action be required.
Several owners later, porous asphalt driveway is seal coated
POST CONSTRUCTION

• Consider installing signage advising unique nature of pavement
• Covenants or other instruments tied to land/title for private developments
MAINTENANCE

• Sweep regularly with regenerative air or vacuum sweepers
  • TOP: Tymco Model 600 Regenerative Sweeper also available with Alternative Fuel option
  • Bottom: Elgin Crosswind Regenerative Sweeper also available with Alternative Fuel option
POST CONSTRUCTION

- Other Concerns/Issues
  - Protection of pavement during building construction.
  - Homeowner/End User care of pavement.
  - Education of maintenance personnel.
  - Utility installations and road way repairs.
POROUS ASPHALT PERFORMANCE

MYTH BUSTERS
Myth #1 - Porous asphalt (and other types of porous pavements) will clog over time and is not durable.

➢ Truth – While some caution is needed to prevent careless transport of sediments and fines on to pavements, many pavements have been operating for decades with little maintenance and others that have become clogged have been successfully rehabilitated.

➢ Clogging has occurred from asphalt draining down from the surface and resetting lower in the asphalt pavement. Use of polymer modified asphalt, stiffer asphalts and sometimes the use of fibers mitigates this effect.

➢ Initial installation of porous asphalt at Walden Pond completed in 1977 still functioning.

➢ Arizona SR-87 still in use after 20 years (checking if still in place)

➢ “Several dozen large, successful porous pavement installations, including some that are now 20 years old, have been developed by Cahill Associates of West Chester, PA, mainly in Mid-Atlantic states”

➢ Use of regenerative vacuums periodically can restore pavements to installation infiltration rates or higher.
Myth #2 - Porous asphalt will rut under traffic loads.

- **Truth –**
  - The structural strength of flexible pavements comes primarily from the supporting roadway section, not the asphalt.

  - Cahill Associates experience confirms that the deeper pavement sections generally result in a more durable pavement.

  - Further, a Caltrans study performed in 1989 on the structural value of open graded asphalt-treated base and open graded asphalt concrete pavement concluded that these materials would be assigned the same structural strength value as their dense graded counter parts.

  - ODOT has also concluded in their design guidelines that open graded asphalt will be given the same structural value as dense graded asphalt.

  - Previous mix designs did not call for enough compaction, would have resulted in rutting.
Myth #3 - Porous asphalt will lead to pollution of the ground water.

- **Truth –**

  - Intuitively, porous asphalt decreases pollution risk by keeping stormwater dispersed. Not a pollution generating surface.
  - Several studies have looked at the water quality treatment that occurs at the geotextile soil interface and concluded that removal of most pollutants is very good.
  - Other studies have shown that the porous pavement itself traps many of the heavy metals with fine sediments, and adsorption occurs to neutralize them. More study is needed in this area, but so far the results are positive.
EcoStorm Plus

- Treats Stormwater With Pervious Concrete
- GULD Approved
Myth #4 - Porous asphalt is prohibitively expensive.

- Truth –
- Porous asphalt costs about 20% more than HMA.
- On a 20,000 square foot parking lot, 3” porous asphalt over 2” choker course at 2010 prices would be $43,000 ($2.15/sq ft) vs. $36,000($1.85/sq ft) for 3” Class ½” HMA over 2” CSTC.
- The cost differential above represents about 1 ea. 2-cartridge StormFilter®
- There is more depth of ballast and geotextiles for porous asphalt vs. HMA.
- Porous asphalt may replace and eliminate catch basins, pipes, water quality treatment devices and storm ponds which may actually SAVE money.
City of Puyallup 8th Ave NW project information:

• Cost of top 2 layers (asphalt and binder/leveling course) = $8.98/sf (4” asphalt and 2” permeable crushed surfacing).
• Prices are based on the following:
  – Asphalt thickness: 4”
  – Asphalt/ton: $102.00/ton
  – 2” choker coarse/ton: $41.00/ton
• Overall project cost/SF: $ 23.49/sf (note this includes EVERYTHING the City installed on the project)
• Overall project cost/LF: $587.46
• Cost of project as bid: $408,561
• Final cost of project: $369,514
• SF of roadway: 15,725 SF
• Length of road: 629 LF
• Width of road: 25 LF

Breakdown of various items:
- Porous asphalt: 480 tons
- Pervious concrete sidewalk: 344 SY
- Permeable paver sidewalk: 287 SY
- Raingarden: 10,000 SF, located in 6 different cells.
**8TH AVE NW LID STATISTICS**

**PUYALLUP’S FIRST GREEN STREET**

**Project Fun Facts**

- Total project cost: $431,700 including $270,000 construction contract, $35,000 design, $20,000 rain garden plants and materials, plus permitting fees.
- Average cost per square foot of rain garden: $6.25/SF
- Average cost per square foot for permeable pavements (roadway and sidewalks): $13.30/SF
- Project was evaluated to be approximately $100,000 less than a traditional road project that would have utilized regular asphalt, storm piping and curbside structures.
- Designer: John Knowles and Associates, Inc. – local engineering group
- Contractor: K5 Underground, Inc., a local general contractor
- Neither the designer nor contractor had specific experience dealing with porous construction and LID – now they have hands-on experience.
- Rain Gardener: Designer: Rain Dog Designs of Enumclaw
- Planting of the rain gardens was done by the street resident and citizen volunteers.
- The 2,200+ plants were planted in 3 hours by over 100 volunteers.
- It is estimated the project infiltrates approximately 90,000 gallons annually.
- The project was funded primarily by a Department of Ecology water quality grant (73%); and support by stormwater utility fees (23%).

**Timeline**

- 2009 – Citizens along project site approach the City to fix the street and use LID technology.
- 2010 – City works on funding from Ecology to leverage City money.
- 2011 – Initial site investigations begin.
- 2012 – Construction starts on project in July.
- 2013 – Remaining LID component, the rain gardens, are completed in March.

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City of Puyallup
Public Works Engineering
Stormwater Management
333 S Meridian
Puyallup, WA 98371
Other Benefits of Porous Asphalt Pavement

- Reduction of spray on higher speed roads. Infiltration helps recharge groundwater, helps base stream flows.
- Reduction of spray on higher speed roads.
- Reduction of hydroplaning.
- Reduction of glare.
- Less area required for stormwater control features.
- Reduced tire noise.
- May be less costly than standard road system, site dependant.
- Reduction in salt application
- Above all, pollution prevention by eliminating surface runoff.
Warm Mix Porous Asphalt

- Warm-mix asphalt is the generic term for a variety of technologies that allow the producers of hot-mix asphalt pavement material to lower the temperatures at which the material is mixed and placed on the road.
- Reductions of 50 to 100 degrees Fahrenheit have been documented. Such drastic reductions have the obvious benefits of cutting fuel consumption and decreasing the production of greenhouse gases.
- In addition, potential engineering benefits include better compaction on the road, the ability to haul paving mix for longer distances, the ability to pave at lower temperatures, better asphalt coverage of aggregate, and safer conditions for workers.
- Recent City of Tacoma projects have seen a dramatic reduction in drain down issues with warm mix.
CONTACT INFORMATION:

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Questions???
CITY OF PUYALLUP PROJECTS

8th Ave NW LID Retrofit

- Converted 100% impervious=>100% Pervious
- Porous Asphalt Street
- Pervious concrete sidewalk (south side)
- Permeable Paver sidewalk (north side)
- ROW rain gardens
CITY OF PUYALLUP PROJECTS

8th Ave NW LID Retrofit

• Converted 100% impervious=>100% Pervious
• Porous Asphalt Street
• Pervious concrete sidewalk (south side)
• Permeable Paver sidewalk (north side)
• ROW rain gardens
CITY OF PUYALLUP PROJECTS

Wilson Loop (Porous Alley Initiative)

- Replaced HMA section with pervious asphalt section
- Street had failed, frequent complaints
- Frequent ponding on roadway
- Utilized pervious rock shoulders
CITY OF PUYALLUP PROJECTS

6th Ave SW (Porous Alley Initiative)

- Water main replacement drove project
- Frequent street flooding events, adverse grade, no storm drainage
- Replaced HMA section with pervious asphalt section
- Utilized pervious rock shoulders
CITY OF PUYALLUP PROJECTS

Riverwalk Trail-JEB III Link

• Porous asphalt trail
• Connects to Foothills Trail
• Allows East Pioneer Way storm flows to pass laterally
CITY OF PUYALLUP PROJECTS
CLARKS CREEK PARK RIPARIAN HABITAT & POROUS MAINTENANCE ROAD

CLARKS CREEK PARK RIPARIAN HABITAT RESTORATION AND POROUS MAINTENANCE ROAD

PROJECT PARTICIPANTS:
- CITY OF PUYALLUP
- PUYALLUP WASTE WATER DISTRICT
- WILDLIFE CONSERVATION DISTRICT DRAINAGE TEAM

PROJECT SUPPORTERS:
- BONANZA RESEARCH CENTER
- RCUK-PUYALLUP RESEARCH CENTER
- CLARKS CREEK PARK ASSOCIATION
- FRIENDS OF CLARKS CREEK
- PUYALLUP WASTE WATER DISTRICT
- WILDLIFE CONSERVATION DISTRICT
- PUYALLUP WASTE WATER DISTRICT

ESTIMATED BUDGET:
- $797,000

FUNDING SOURCES:
- ECOLOGY CAPACITY GRANT $20,000
- BONANZA RESEARCH CENTER $40,000
- COMMUNITY SAFETY GRANT $48,354 (PENDING)
- TERRY HAGGAN ACCOUNT $5,950 (APRIL 2014 DATE)
- CITY OF PUYALLUP STORMWATER $10,564 (DARNT)

PROJECT DESIGN CONSIDERATIONS:
- MAINTENANCE ROAD KEEP IN CURRENT ALIGNMENT NEAR SULLY FIELDS TO AVOID CONFLICT
- ACCESS TO SULLY FIELDS MUST BE MAINTAINED
- CONTINUE TO SUPPORT ROAD USE AS TRAIL FEATURE (PATH, ADA ACCESSIBLE)
- PRESERVE DESIGNATED RENN FIVI BANINI WITH RIPARIAN PLANTING
- MINIMIZE IMPACT TO PARK WHILE INCREASING HABITAT PROTECTION
- MINIMIZE TRASH REMOVAL REQUIRED
- PLAN FOR FUTURE TRASHING OF STORM COLLECTORS WITHIN RIPARIAN AREA
- IMPROVE CURRENT VEGETATION USE PRODUCTION WITH INSTALLATION OF DOLLARDS
- CONTINUE ACCESS TO TRISH AT 27TH AND SW FOR DESERT REMOVAL
- IMPROVE MAINTENANCE ACCESS WITH ALL WEATHER, WIDE ROAD
- DEMONSTRATE LOW IMPACT DEVELOPMENT WITH POROUS GRAVEL ROAD AND SOIL AMENDMENTS
- SET EXAMPLES FOR OTHER PROPERTY OWNERS ALONG CLARK'S CREEK
- SUPPORT WATER QUALITY EFFORTS UNDERWAY ON CLARK S CREEK, Fecal, Coliform and DISOLVED OXYGEN LEVELS

PLAN NOTES:
1. 13,056 SQUARE FEET OF PROPOSED POROUS GRAVEL ROAD
2. 504 LINEAL FEET OF PROTECTIVE RILL FENCE
3. 13,100 SQUARE FEET OF PROPOSED POROUS GRAVEL ROAD
4. 10,400 SQUARE FEET OF PROPOSED POROUS GRAVEL ROAD
5. 106,000 LINEAL FEET OF PROPOSED POROUS GRAVEL ROAD
6. 106,000 LINEAL FEET OF PROPOSED POROUS GRAVEL ROAD
7. 106,000 LINEAL FEET OF PROPOSED POROUS GRAVEL ROAD
8. 106,000 LINEAL FEET OF PROPOSED POROUS GRAVEL ROAD

Washington Stormwater Center
June 17, 2015
CITY OF PUYALLUP PROJECTS

Corporate Yards South Entrance

- Pervious concrete entrance, 24’ wide
- Heavy equipment access needed because of sight distance restriction on 39th Ave SE
- Utilized porous alley mix of 1-1/4” blended with #57 rock for reservoir course
- Conservative 12” thick section
POROUS GRAVEL ALLEYS

- Using mix of 1-1/4 and #57 rock
- Allows 2-3 years between maintenance vs. one–two times/year with dense graded
- Inexpensively addresses ponding issues
CITY OF PUYALLUP PROJECTS
39TH AVE SW, 11TH ST SW TO 17TH ST SW

- Pervious concrete roadway & sidewalks
- Standard concrete for intersections
- Overall less cost than HMA
- Construction 2015
CITY OF PUYALLUP PROJECTS
WSU LID FRONTPAGE IMPROVEMENT

- Pervious concrete and porous asphalt roadways
- Testing built into design
- Standard concrete for intersections
- Phased Construction starting 2016

Cost estimates listed for each phase are Planning-Level probable costs which include Project Administration, FMAC, ROW, and Construction.
CITY OF PUYALLUP PROJECTS
SHAW ROAD, 23RD AVE SE TO MANORWOOD DRIVE

- Pervious concrete roadways and porous asphalt share use path, sidewalks
- Construction projected for 2016