Porous Asphalt Pavements w/ Stone Recharge Beds

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History of Porous Asphalt Pavements

- Porous asphalt mixes developed in 1930’s and 1940’s by State DOTs
- Using mixes to reduce runoff in 1970’s
- Geotextiles developed in 1979
- Current design process used since 1980
Projects Using Porous Asphalt
Kaiser Medical Facility

Modesto, CA

2005
Kaiser Facility

- 50 acre site, 4 buildings, & 10 acres of pavements
- 4,400 tons of permeable asphalt
Kaiser Facility

- All runoff from site diverted to either permeable pavement parking structure or percolation basin = NO
- Surface Runoff leaves site
Placer County

Sierra College Boulevard
Roseville, CA
Open Space

- Demonstration Project
- Parking area for open space access
Flinn Springs Park, El Cajon, CA (2007)

- Retrofit parking lot for County park
- 38,000 sf of porous asphalt and 12,000 sf of porous concrete
- Eliminate direct discharge to Los Coches Creek
- On-going quality and quantity monitoring by Kinnetic Labs
- Grant from the State of California Water Resources Control Board (and County matching funds)
San Diego County Operations Center, San Diego, CA (2005 & 2007)

- Phase I Porous: 40,300 sf of asphalt, 14,300 sf of concrete, and 8300 sf of pavers
- Phase II Porous: two mix designs of porous asphalt (both 20,700 sf) and 12,100 sf of porous concrete

On-going quality and quantity monitoring by Kinnetic Labs

Grant from the State of California Water Resource Control Board (and County matching funds)

Assistance by Richard Watson & Associates
Bay Street Demonstration Parking Lot, Fremont, CA (2007)

- Approx. 14,000 SF porous asphalt storage/infiltration system
- Regional demonstration project for the San Francisco Bay Area
- Meets new HMP requirements from Bay Area Regional Water Quality Board
- Urban redevelopment project

Soil Infiltration Testing Summary

<table>
<thead>
<tr>
<th>Test Pit</th>
<th>Depth (in.)</th>
<th>Type</th>
<th>Resultant Rate (in/hr)</th>
<th>Reduction Factor</th>
<th>Infiltration Rate (in/hr)</th>
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<td>2</td>
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<td>Infiltrometer</td>
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<td>AVERAGE*</td>
<td>22.5</td>
<td>---</td>
<td>---</td>
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</table>

* Excludes deeper soil test in Test Pit 1 due to uncharacteristically high infiltration rate
Approx. 7,800 SF porous asphalt storage/infiltration system
First use of porous asphalt in CA
Urban redevelopment project
Winner - Outstanding Government Project of the Year, Metropolitan Los Angeles Branch of ASCE
Pringle Creek Community

Salem, OR

2006
New Subdivision

- 180 Homes
- 32 Acres
- 9,000’ of porous asphalt streets and alleys
- 10% of normal runoff (roofs, streets, etc) flow into Pringle Creek
Typical Structural Section

- 1½” OGFC
- 3” ATPB
- 10” Crushed Stone
  - 1” – 2 ½”
  - 40% void
- 8” Pit Run Stone
  - 1” – 4”
Pringle Creek Typical Street
Technical Aspects

Environmental, Site Selection, Design, Materials, Construction, Maintenance
Site Selection
Project Location

- Soil permeability/infiltration rate
  - EPA recommends 0.5”/hour
  - 0.1”/hour still OK

- Depth to bedrock > 2’

- Depth to high water > 3’

- Fill – not recommended

- Frost
  - Pavement section should exceed frost depth?
Soils Investigation

- Borings and/or test pits
  - Test permeability (similar to septic tank testing)
  - Determine depth to high water table
  - Determine depth to bedrock
Design
What are Porous Asphalt Pavements?

Open-Graded HMA

½” Aggregate

Clean Uniformly Graded 2”-3” Crushed Agg – 40% Voids

Non-Woven Geotextile

Uncompacted Subgrade
Surface Features

- **Slope** – limit surface slope to 5%
  - Terrace when necessary
  - Use conventional HMA for steeper slopes

- **Provide alternative way for water to enter bed**
Other Runoff Sources

- Use to infiltrate from other impervious surfaces
  - Avoid piping water long distances
- Spread infiltration over largest area possible
  - 5:1 Impervious: Infiltration
Recharge Basin

Photo Courtesy of Cahill & Assoc
Bottom Must Be Flat

- Minimize excess stone
- Maximize infiltration area
- Less infiltration area at low depths
- Wasted Stone
Pavement Use Considerations

- Primary use
  - Parking lots
  - Roads w/ little cut or fill

- Roads/Highway Challenges
  - Cuts and fills
  - Slope
  - Variable soil conditions
  - Utilities
Materials
Aggregates

- Clean/Washed
- 1 ½” – 3” grading
- Passing ¾” sieve < 5%
- Crushed material
  - Ideally 90% 2 fractured faces (CT 205)
- LA Rattler < 35
- Consideration for local materials
Porous Asphalt

- **Open Graded Asphalt Concrete (OGFC)**
  - Not ATPB

- **Utilize Caltrans Specification**
  - Standard Specification Section 39
  - ½” or 3/8” Gradation (1” gradation is also available)
  - Method specification for compaction

- **Caltrans Mix Design Procedure**
  - CT 368 – OBC determination for OGFC
Key Mix Properties

- “open” gradation
  - Increased permeability
  - >18% air voids

- OBC = optimum bitumen content
  - Pavement durability

- Draindown
  - Constructability
  - Maintain proper film thickness
Dense Grade

- Agg-Agg Contact
- Low void content
- High Stability
Open Grade

- Agg-Agg contact
- High void content
- Good stability when confined
Binder Selection

- Conventional (PG 70-10)
  - Standard binders used in most California paving

- Polymer Modified (PG 76-22 PM)
  - Improved performance in cooler climates
  - Improved performance in high traffic
  - Resistance to thermal cracking
  - Improves constructability in cooler weather
Binders with Ground Tires

- Asphalt Rubber (RAC-O)
  - Uses tires
  - Good resistance to cracking
  - Improved durability

- Rubber Modified (PG 76-22 TR)
  - Uses tires
  - Blended at a refinery or terminal
  - Performance similar to polymer modified
Construction
Construction Scheduling

- Plan to build late in construction process
  - Wait till “dirty work is done”
  - Wait till vegetation is established
    - Or keep runoff controls in place until established
  - Can excavate bed to about 1’ above planned elevation and use for SW control
    - Excavate to plan elevation when ready
Pre-Construction Meeting

- Include Engineers, Designers, Inspectors, Contractor Personnel, Material Suppliers, Testing Personnel
- Shared understanding of construction process (minimize failures)
Protect the Surface
Bed Excavation

- Excavate bed to plan elevation using equipment w/ “soft footprint”
- Don’t compact subgrade
Non-woven Geotextile

- Spread geotextile immediately after fine grading
- Overlap fabric >16”
- Install drainage pipes if used
- Excess fabric (>4’) folded over agg. later
Stone Recharge Bed

- Place clean, single size, washed aggregate.
- Do not drive trucks on fabric
- Spread and grade with tracked equipment 8” lifts.
- Light compaction - static
- Protect pipes
Choker Course

- Place “Choker” course – ½” clean washed aggregate.
  - Purpose to lock up surface for stable paving platform
  - 1 – 2” thick
  - Grade and compact
    - Static
  - Fold excess fabric over stone to prevent contamination
Paving

- Recommend track paver
- Minimize truck movements over aggregate
  - Stability may be issue
  - Avoid disturbing agg surface – but it will happen
- OGFC Production will be less
- Mix between 200°F and 250°F when placed
Paving

- Limit hand work during paving operations
  - Reduces mix temperature
  - Difficult to work with modified binders
  - Can reduce permeability
Compaction

- Static compaction
- 1 to 2 passes with approved steel wheel roller
- Allow to cool before opening to traffic (tender)
After Compaction

- Limit traffic for 24 hours to allow pavement to cure.
- Keep sediment control in place till vegetation established.
Maintenance
Maintenance Strategies

- Use porous or dense asphalt for patching
  - If using dense, repair should not exceed 10% of total porous pavement paved area
- Cracks can be repaired using crack sealant
- Regular cleaning
  - Flush or jet wash
  - Vacuum sweeping
Maintenance DON’Ts

- Do NOT use traditional seal coat treatments
- Do not use salt or sand for de-icing
  - Salt can contaminate groundwater infiltration
  - Sand can reduce permeability
  - Snow plows OK
Recycling
Absolutely!!!

- OGFC can be processed and reused in new pavements
- Aggregate in bed can be processed and reused
- OGFC can include recycled asphalt
  - Limit to 15% maximum RAP in total mix
  - Research ongoing to increase %
Cost & Availability
Costs

- Asphalt portion similar to conventional HMA
- Gravel bed costs more than conventional subsurface construction
- Significant savings when accounting for:
  - Permitting
  - Conventional storm water management techniques
Caltrans OGFC regularly available throughout State

Considered a specialty mix

Aggregate availability can be an issue in certain locations

- Consideration for local sources
Are There Limitations to Porous Asphalt Pavements?
Challenges

- Slopes greater than 6%
  - Consider terracing
- Locations where a likelihood of a spill is real
  - Consider a filtration or wetland treatment prior to infiltration
Strategy for Water Quality

- Direct Rainfall
- Open Edge Drain
- Runoff if Impervious
- H-20 Rated Cast Iron Grate
- 2" x 6" Rectangular Emergency Overflow
- 1"Ø ORIFICE(S)
- Slag Retention Bed
- Water Quality Swale

40" - 48" to Water Table

Roof Leaders should be extended into the retention bed where possible.
Resources
Asphalt Pavement

- www.beyondroads.com
  - Overview of the asphalt industry
- www.pavegreen.com
  - Additional information on porous asphalt
- www.californiapavements.org
  - Electronic copy of today’s presentation
- www.hotmix.org
  - Technical publications on asphalt paving
Caltrans Specifications

- [www.dot.ca.gov/hq/esc/oe/](http://www.dot.ca.gov/hq/esc/oe/)
  - Caltrans construction standard specifications
  - Section 39 (Method) for OGFC

  - Caltrans test methods
  - CT368 mix design for OGFC
  - CT205 determination of crushed materials

- [http://www.dot.ca.gov/hq/esc/Translab/fpm.html](http://www.dot.ca.gov/hq/esc/Translab/fpm.html)
  - OGFC & RAC Usage Guides