City of Seattle Porous Pavement Case Study

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Benefits of Porous Pavement

- Paved Surface
- Water Quality Treatment
- Flow Control
- Optimizes Space within ROW utilities
- Reduces Temperature of Runoff to Streams
- Reduces Heat Island Affect
- Benefits Trees and Landscaping

Porous Cement Concrete Pavement

- Mixed with no fine aggregates
- Voids are created to allow water to flow through pavement
- Recharges groundwater
- Used in the United States for over 20 years, mainly in the Southeast Region

Existing 32nd Avenue SW

Prior to redevelopment

- Slope 3% +/-
- Drainage basin 4.6 acres
- Existing developed basin with 8 dwelling units per acre
- Road 32' wide
- Sidewalk on one side of street
- Parking on grass areas
- 40% impervious
- 60% pervious

Redeveloped 32nd Avenue SW with Porous Pavement

After redevelopment

- Drainage basin same as pre-existing
- Road 25' wide with sidewalks on both sides and no curbs.
- Westside landscape treatment to encourage on street parking.
- New Utilities
- 30% impervious
- 60% pervious
- 10% Porous Paving

January 2006

Design Goals for 32nd Ave SW

- Pilot Porous Pavement Street for City of Seattle
- Integration of Redevelopment into Existing Neighborhood
- Traffic Calming
- Provide Service for Residential Street Loading Condition
- Infiltrate the 6-month Storm Event for the Roadway Section only
- Reduce the Existing Developed Peak Flow Rate up to the 2-year Storm Event

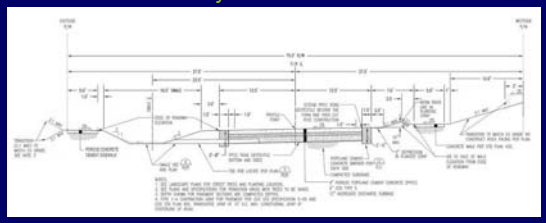
Design Parameters for Porous Cement Concrete Section

- Cement Content (564 to 600 lbs/cy)
- Mix Aggregate: AASHTO No. 8* (3/8" to No 16) or No. 89 (3/8" to 50)
- Water Cement Ratio 0.27 to 0.35*
- Voids 15% to 21%
- Field Infiltration Rate 200 in/hr through pavement
- Compressive Strength 2,000 psi
- 8" Compacted Thickness for Residential Street Loading

Design Parameters for Subbase and Subgrade

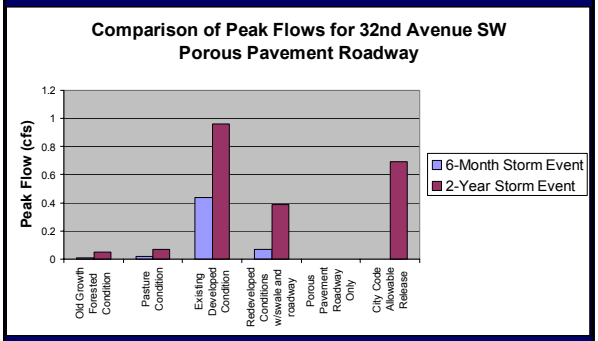
- 20% Voids for Gravel Storage Subbase
- ¾" to 1 ½" washed crushed aggregate for road subbase
- 3/8" to ¾" washed crushed aggregate for sidewalk subbase
- Compaction 92% for roadway subbase
- Scarify existing subgrade to prevent sealing of subgrade
- Maximum ponding depth within gravel storage subbase 1-foot
- Gravel Storage Subbase below freeze/thaw depth (10" to 12")
- Existing Subgrade Design Infiltration Rate 0.25 in/hr (Silty fine sand to fine sandy silts) per geotechnical review.

Other Design Parameters for 32nd Roadway Section



- Sloped subgrade with roadway in order minimize amount of excavation
- Gravel storage subbase set above other underground utilities
- Back up system (CB and Swale) for overflow during large storm events
- Depression on upslope side for collection of fines
- Coordination with other underground utilities (Electrical and Franchise Duct Bank extending 14'+ in width at some locations, new sewer and water)

Modeling Results



Modeling Results Continued

Runoff Volume Distribution during 2 year 24-hour Storm Event for 32nd Avenue SW SEA Street Subbasin for the Redeveloped Condition

Description	Runoff Volume (cubic feet)
Runoff Infiltrated into Subgrade from Gravel Storage Subbase of Roadway	6,265
Total Runoff for Basin including Volume Infiltrating below Roadway	15,200
Percentage of Runoff that is Infiltrated through Porous Pavement Roadway and into Subgrade	41%

Preconstruction & Planning

- Submittals for mix design and subbase
- Supplier submit Instructions and Criteria for Installation
- Test Panel (may require multiple test panels for new installers)
- Preconstruction & Preplanning Meetings with Installers, Suppliers, Inspectors & Designers
- Meet with neighbors to explain both the overall project and the specific treatment of 32nd Avenue. (note: sidewalks and landscaping treatments on west side)
- Install Sediment and Erosion Control Measures to redirect water away from construction area
- Preplanning for construction sequencing & truck deliveries during placement of mix

Construction of 32nd Ave SW

Before

Side Barriers

Installing Dams for Cells

Fabric at Subgrade

Gravel Storage Subbase

Placement of Porous Cement Concrete for Roadway

Moisten Subbase, Place Mix & Strike-off

Cut in joints

Roller for compaction

Protect & cover

Post Construction and Testing

- Core samples of in-place pavement
- Compacted Depth
- Unit Weight
- Voids
- Strength Test
- Field Infiltration Test
- Check surface for unraveling
- Check surface for sealing

Porous Pavement Roadway Testing Results

- Two test panels were placed (564 lbs* & 600lbs) and exceeded design requirements for strength.
  - Avg. Strength 2195*- 3380
  - Avg. Infiltration 138 in/hr- 1244* in/hr
- For Road Placement, Two Mix Designs Used to compare over time (564* lbs/cy and 582** lbs/cy)
  - Avg. Field Infiltration (1614 in/hr* & 876 in/hr**)
  - Avg. Compressive Strength (1385 psi* & 1977 psi**)
  - Avg. Voids (30%* & 26%**)
- Seattle Public Utilities to monitor performance

Porous Cement Concrete Sidewalks

- On swale side all streets (decision based on cost, surfacing and that approach is still new)
- 4" of Porous Cement Concrete Pavement over 6" Gravel Subbase

Costs & Maintenance

Costs

- Bid under a General Contractor Construction Manager (GCCM) type of contract. Three sub bidders on the major infrastructure contract package that included the entire 65 acre redevelopment area.
- Porous roadway including pavement, excavation, subbase, side barriers and underdrains: $85 to $165 per square yard.
- Porous sidewalks including pavement, excavation, subbase: $26 to $67 per square yard
- Impervious 8" depth City Cement Concrete Roadway (including subbase and excavation): $44 to $50 per square yard
- Impervious City Cement Concrete Sidewalk: $19 to $30 per square yard

Maintenance

- Vacuum or Pressure Wash as needed (expected to be annually) to remove clogging.

Lessons Learned - Roadway

- For right of way projects select locations that will not require vehicular access to adjacent properties during construction. This allows flexibility with the installation due to sequencing, weather and stabilization.
- Understanding of expectations and design intent with installer, crews, supplier, designer & inspectors.
- When staff changes occur (from Installers to Inspectors), inform them of expectations and design intent.
- Require Inspectors and Installers attend certification course by supplier.
- Minimize the depth of concrete barrier on each side of roadway to bottom of subbase.
- Sharing data and test results with Industry.

Lessons Learned - Sidewalks

- Paving around utility vaults should allow for 6 inches minimum width. The porous concrete seems to have a tendency to crack if less than this width.
- Sidewalks appear to be very straight forward however the test panel is critical for aesthetics and large projects may need to train several crews.
- Adjacent site erosion and flow control is critical.
- Covering the sidewalk may seem overkill but the message is clear protect the pavement until area is restored. It also allows flexibility with the installation due to sequencing, weather and stabilization.
- Understanding of expectations and design intent with installer, crews, supplier, designer & inspectors.
- When staff changes occur (from Installers to Inspectors), inform them of expectations and design intent.
- Require Inspectors and Installers attend certification course by supplier.
- Typical practice of maintenance along edges (to prevent grass and groundcover intrusion)
- Sharing data and test results with Industry.

Resources

- 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**
- Jim Powell from Northwest Chapter from American Concrete Pavement Association, 360-956-7080.
- Local Suppliers: Greg McKinnon at Stoneway provided consultation for High Point, 425-226-1000.
- Glacier Northwest, 206-764-3000, **www.glaciernw.com**
- "Porous Pavements," by Bruce K. Ferguson, Taylor & Francis Group, 2005.

Resources- continued

- Sample specs from Florida, Tennessee and Georgia Concrete and Products Associations
- Andrew Marks from Puget Sound Concrete Specifications Council
- Bruce Chattin from Washington Aggregates and Concrete Association, **http://www.washingtonconcrete.org**
- "Pervious Concrete Pavement" by Paul D. Tennis, Michael L. Leming and David J. Akers and Portland Cement Assoc. and National Ready Mixed Concrete Assoc.
- "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
- SvR Design Company **www.svrdesign.com**

Recognition:
Seattle Housing Authority
Seattle Public Utilities

Other agencies:
Washington State Department of Ecology
US Department of HUD
Seattle Department of Planning and Development
Seattle Department of Transportation
Seattle City Light

For more information:
www.svrdesign.com and
www.seattle.gov/util/naturalsystems

Consultants:
SvR Design Company- civil and landscape architecture
Mithun Architects and Planners

Resource consultants:
Greg McKinnon at Stoneway Concrete
Jim Powell at NW Chapter ACPA
Cedar Grove Compost
Shannon and Wilson

32nd Ave SW & NDS Contractors:
Gary Merlino Construction Company
T. Yorozu Gardening Co.
Absher Construction (GCCM)

DESIGN COMPANY

Other Porous Material Examples:

- Fremont Library/Ernst Park, Seattle, WA
- GravelPave2 System for Parking Stalls
- City of Portland Porous Asphalt and Cement Concrete Pavement

Fremont Library/Ernst Park, Seattle, WA




- Porous Cement Concrete Sidewalk
- Hillside Location
- Curvilinear layout

GravelPave2 System for Parking Stalls

Portland's Porous Cement Concrete Roadways




- Constructed in Fall 2005
- N. Gay Avenue
- 10" Concrete over 6" Subbase
- Full Street Section with PPCC
- One Street with PPCC in parking lanes only
- Reused existing curb and drain collection structures

City of Portland Porous Asphalt Pavement

- N. Gay Avenue
- 8" Porous Asphalt over 6" granular base
- Reused existing curbs and drain collection structures