Permeable Pavements

Design Report and Plan Development

Webinar – Advanced Permeable Pavement for Storm Water Management

February 17, 2015

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Permeable Pavement (1008)

• VII. Plans and Specifications
  – Design Report
  – Plans
  – Specifications
Design Report

- Per criteria in Standard
- Describes the intended use and objectives of the pavement system
- Presents hydrologic and hydraulic computations used for design
- Presents pollutant removal calculations
Permeable Pavement Test Plot
Design Report

• Includes plan view exhibits
  – Tributary area
  – Flow paths
  – Run-on ratios
Hausmann Nature Center – Lapham Peak
Effective Infiltration Area

**Figure 2. Effective Infiltration Area**

**Notes:**

1. **The Effective Infiltration Area Can Be Increased By Extending The Aggregate Storage Reservoir Under Conventional Pavement Surfaces Or In Other Appropriate Areas, Such As Lawns With Soil Separator (e.g., Filter Fabric).**

2. **Effective Infiltration Area Is The Area Used To Infiltrate Runoff Into The Soil Subgrade As Defined In § 151.003(12) Of The Wis. Admin. Code.**

3. **For Permeable Pavement Systems That Will Receive Run-off From Road And/or Parking Lot Source Areas, The Ratio Of Run-on Area To Effective Infiltration Area Shall Be No Greater Than 3:1.**
Run-on and Effective Infiltration Area Ratios
Design Report

• Includes documents or reports that support infiltration design parameters
  – Infiltration rate field test results
  – Soil boring logs
  – Depth to seasonal high groundwater
Typical Soil Boring Log

**RECORD OF SUBSURFACE EXPLORATION**

<table>
<thead>
<tr>
<th>Feet Below Surface</th>
<th>Sample No. &amp; Type</th>
<th>No.</th>
<th>q (psf)</th>
<th>ql (psf)</th>
<th>qr (psf)</th>
<th>w (%)</th>
<th>PID</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-SS</td>
<td>Brown Silty fine to medium Sand, trace Clay (Possible Fill) - Moist</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9-SS</td>
<td>Gray-Silty Clay, trace to little Sand, trace Gravel - Moist</td>
<td>19</td>
<td>1.2</td>
<td>3.0</td>
<td>0.0</td>
<td>0.0</td>
<td>8</td>
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<tr>
<td>15-SS</td>
<td>Gray-Silty Clay, trace to little Sand, trace Gravel - Moist</td>
<td>15</td>
<td>2.1</td>
<td>1.2</td>
<td>0.0</td>
<td>0.0</td>
<td>8</td>
<td></td>
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<tr>
<td>20-SS</td>
<td>Gray-Silty Clay, with layers and/or lenses of Silty fine Sand, trace Gravel - Moist</td>
<td>11</td>
<td>2.6</td>
<td>2.1</td>
<td>0.0</td>
<td>0.0</td>
<td>8</td>
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</table>

Boring Terminated at 26 Feet

**WATER OBSERVATION DATA**

| WATER ENCOUNTERED DURING DRILLING: 25.5 ft. |
| WATER LEVEL AFTER REMOVAL: None |
| CAVE DEPTH AFTER REMOVAL: 20.0 ft. |
| WATER LEVEL AFTER HOURS: |
| CAVE DEPTH AFTER HOURS: |

**NOTES**

Bottom of West-1A Elevation 167.0

Bottom of West-1B Elevation 165.0
## Infiltration Rates per DNR Standards

### Permeable Pavement -- Infiltration Rates

<table>
<thead>
<tr>
<th>Permeable Pavement System</th>
<th>Infiltration Rate (in/hr)</th>
<th>Infiltration Rate (ft/sec)</th>
<th>Perm Pvmnt Area (sqft)</th>
<th>Constant Infiltration (cfs)</th>
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<tbody>
<tr>
<td>CL-1</td>
<td>0.13</td>
<td>3.00926E-06</td>
<td>847</td>
<td>0.003</td>
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<td>CL-2</td>
<td>0.13</td>
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<td>CL-4</td>
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<td>4689</td>
<td>0.003</td>
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</table>
Pavement Selection Parameters

- Permeability
- Anticipated use for the pavement – pedestrian, passenger vehicles, or heavy trucks
- Amount and type of traffic
- Degree of wheel turning movements that will occur on the pavement
- Compressive and flexural strength of the pavement
Grass-Pave with Accessible Path
Pavement Selection Parameters

• Cost -- installation and maintenance
• For permeable pavers/blocks: degree of interlock of the pavers -- impacts performance when there are a variety of travel directions
• Ability to meet ADA requirements
• Ability to be machine installed - saves time and money
City of Milwaukee - Freshwater Way
Pavement Selection Parameters

- Color and texture of the surface
- Aesthetic considerations
- Durability
- Maintenance requirements
- Ease of making repairs
Harris Bank – West Bend
Plans and Specifications

- Should allow for the determination, upon completion, of compliance of the permeable pavement system with the design and the Standard
Plans and Specifications

• Identify materials, construction processes and sequence, location, size, and elevations of permeable pavement system components
Missouri Botanical Gardens
Plans

• Erosion and Sedimentation Control
  – Including measures to prevent clogging of any portion of the permeable pavement installation
Plans

• Plan Views, showing:
  – Shape
  – Dimensions
  – Grades
  – Underdrain locations and elevations
  – Observation wells
  – Control structures
Drexel Town Square – Oak Creek
Drexel Town Square – Paving Plan
Drexel Town Square – Pavers in the Parking Lanes

2. ANGLE PARKING / PARALLEL PARKING ADJACENT TO DECORATIVE CONCRETE PAVEMENT

NOTES:
1. PARALLEL PARKING END STALLS SHALL BE A MINIMUM OF 20'.
2. PARALLEL PARKING REGULAR STALLS SHALL BE A MINIMUM OF 22'.
3. REFER TO LAYOUT AND MATERIALS PLANS FOR COLOR OF PERMEABLE PAVERS.
Plans

• Cross-sectional views, showing the location and depths of system components
Drexel Town Square
Typical Road Cross-Section

S. 6TH STREET
(DOUBLE SIDED PARKING - PARALLEL
WITH BIKE ACCOMMODATIONS)
SECTION A-A
Lakefront Gateway - Milwaukee
Permeable Pavement – Clybourn St.
Aggregate Storage Areas – Clybourn St.
Permeable Pavement Outlet Control Structures
# Permeable Pavement Outlet Control Structures

## Table of Structure Elevations and Dimensions

<table>
<thead>
<tr>
<th>Outlet Control Structure</th>
<th>Type</th>
<th>Casting</th>
<th>Rim Elevation</th>
<th>Top of Precast Elev</th>
<th>Bottom of Precast Elev</th>
<th>Height of Precast Structure</th>
<th>Top of Orifice Plate Elev</th>
<th>Bottom of Orifice Plate Elev</th>
<th>Height of Orifice Plate</th>
<th>Diameter of Orifice</th>
<th>Orifice Invert Elevation</th>
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<tr>
<td>OC - 1</td>
<td>TERRACE</td>
<td>R-1878-A9L</td>
<td>588.67</td>
<td>588.17</td>
<td>584.70</td>
<td>3.97</td>
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<td>585.20</td>
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<td>OC - 2</td>
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<td>R-3222-1A</td>
<td>588.43</td>
<td>587.43</td>
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<td>4.33</td>
<td>586.93</td>
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<td>OC - 3</td>
<td>GUTTER</td>
<td>R-3222-1A</td>
<td>588.55</td>
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<td>587.15</td>
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<td>587.62</td>
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<td>587.12</td>
<td>584.60</td>
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<td>OC - 6</td>
<td>TERRACE</td>
<td>R-1878-A9L</td>
<td>589.79</td>
<td>589.29</td>
<td>585.10</td>
<td>4.69</td>
<td>587.79</td>
<td>585.60</td>
<td>2.19</td>
<td>2 INCHES</td>
<td>586.10</td>
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<td>OC - 7</td>
<td>TERRACE</td>
<td>R-1878-A9L</td>
<td>591.06</td>
<td>590.56</td>
<td>585.18</td>
<td>5.88</td>
<td>589.56</td>
<td>585.68</td>
<td>3.88</td>
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<td>586.18</td>
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<td>OC - 8</td>
<td>TERRACE (PLAZA)</td>
<td>R-1878-A9L</td>
<td>590.90</td>
<td>590.40</td>
<td>583.79</td>
<td>7.11</td>
<td>588.72</td>
<td>584.29</td>
<td>4.43</td>
<td>2 INCHES</td>
<td>584.79</td>
</tr>
</tbody>
</table>
Detail of Permeable Pavement Block

BELGARD AQUALINE SERIES PAVERS

- MULTI-COBBLE PERMEABLE PAVER SIZES:
  12" x 12" x 80mm
  12" x 12" x 100mm
- THE TWO PAVERS SIZES ARE TO BE USED IN THREE DIFFERENT AREAS:
  1. SAND-SET CONCRETE PAVER PAVING OVER CONCRETE BASE - 80MM. ITEM SPV.0165.1001: USED IN ROADWAY MEDIAN AREAS.
  2. PERMEABLE CONCRETE PAVERS - 80MM. ITEM SPV.0165.1002: USED IN SIDEWALK TERRACE AREAS.
  3. PERMEABLE CONCRETE PAVERS - 100MM, ITEM SPV.0165.1003: USED IN ON-STREET ROADWAY AREAS.
- SEE SPV’S FOR SPECIFIC PAVER INFORMATION AND COLORS

PERMEABLE CONCRETE PAVER

REFER TO BMP - PERMEABLE PAVEMENT PLANS AND STREETSCAPE LAYOUT AND MATERIALS PLANS FOR LOCATION OF PAVERS.
Layout Pattern for Permeable Pavement Blocks
Cross-Section – Parking Lane

TYPICAL SECTION - PERMEABLE CONCRETE PAVERS IN ROADWAY

NOTE:
Each different permeable paver color is to receive a specific crushed stone color for the vertical jointing material. See special provisions.
Cross-section - Terrace

Typical Section - Permeable Concrete Pavers in Terrace Areas
Cross-section – Parking Lane and Terrace
Cross-Section – Through Planter
Permeable Pavers Installation – Harris Bank, West Bend
ABB Parking lot at UWM Innovation Campus
ABB Parking lot at UWM Innovation Campus
Pervious Concrete – Urban Ecology Center
Missouri Botanical Gardens
Specifications

• Provide a description of Contractor’s responsibilities

• Identify requirements for test reports and other evidence that materials meet the specifications
CSI Master Spec Format

SECTION 32 12 33
POROUS ASPHALT PAVING SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   2. Installation of underlying materials.
   3. Porous asphalt mix design.
   4. Porous asphalt production.
   5. Porous asphalt installation.

B. Related Sections
   1. Applicable provisions of Division 1 – General Requirements of General Requirements for Sitework shall govern Work under this Section.
   2. Section 31 05 13 – Soils for Earthwork.
   3. Section 31 05 16 – Aggregates for Earthwork.
   4. Section 32 11 23 – Aggregate Base Course.
   5. Section 32 12 16 – Asphalt Paving.
   6. Section 32 13 13 – Concrete Paving.

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials: (AASHTO)
   1. AASHTO T30 – Mechanical Analysis of Extracted Aggregate.
   3. AASHTO T163 – Soundness of Aggregates by Freezing and Thawing.
   4. AASHTO T104 – Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate.
   5. AASHTO T164 - Quantitative Extraction Asphalt Binder from Hot Mix Asphalt (HMA).

B. ASTM International: (ASTM)

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GRAEF-SPEC
1.3 SUBMITTALS

A. [Section 01 33 00 - Submittal Procedures] [Division 01 – General Requirements] [Section 31 02 00 – General Requirements for Sitework]: Requirements for submittals.

B. Product Data: Submit product information and mix design.

C. Certification: Provide Manufacturer’s Certification Report that indicates Products and Materials meet or exceed all specified requirements.

D. Submit a list of materials proposed for work under this Section including name and address of materials producers and locations from which materials are to be obtained.

E. Submit certificates, signed by materials producers and relevant subcontractors, stating that materials meet or exceed specified requirements.

F. Submit samples of materials for review and approval by [Engineer] [Engineer/Architect] [Geotechnical Engineer] [Owner’s Representative].

01/01/2014 32 12 33 - 2 Porous Asphalt Paving System

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## PART 2 - PRODUCTS

### 2.1 POROUS ASPHALT MIX

#### A. Mix Properties:

<table>
<thead>
<tr>
<th>Property</th>
<th>12.5 mm Mix</th>
<th>9.5 mm Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Binder Content$^1$</td>
<td>5.5 minimum</td>
<td>5.5 minimum</td>
</tr>
<tr>
<td>Binder Grade$^2$</td>
<td>PG 64-22</td>
<td>PG 64-22</td>
</tr>
<tr>
<td>Percent Air Voids (Va @ 50 gyrations)</td>
<td>18 – 20</td>
<td>18 – 20</td>
</tr>
<tr>
<td>Percent Tensile Strength Ratio (TSR @ 5 cycles freeze/thaw) per ASTM D4867$^3$</td>
<td>80 minimum</td>
<td>80 minimum</td>
</tr>
<tr>
<td>Percent Draindown at Production Temperature$^4$</td>
<td>0.3 maximum</td>
<td>0.3 maximum</td>
</tr>
</tbody>
</table>

$^1$ - 5.75 - 6.0 percent recommended.

$^2$ - Minimum high temperature of 64 degrees C recommended.

$^3$ - Cantabro Abrasion test is not included in mix design guidelines.

$^4$ - Effective measures to reduce draindown include use of washed manufactured sand in lieu of crusher screenings and fibers. A slight reduction in production temperature may also be considered.
3.2 POROUS ASPHALT PAVEMENT INSTALLATION

A. Mixing plant, hauling and placing equipment, and construction methods shall conform to
[Wisconsin Department of Transportation] [Illinois Department of Transportation] [Florida
Department of Transportation] Standard Specifications.

B. Use of surge bins shall not be permitted.

C. Hauling Equipment:
   1. Trucks used for hauling asphalt mixture shall have tight, clean, smooth metal bodies.
   2. Contractor shall apply a thin coat of a non-petroleum based or soap solution to prevent
      mixture from adhering to truck bodies.
   3. Each truck shall have a cover of canvas or other suitable material of such size sufficient to
      protect mixture from weather.
   4. When necessary to ensure delivery of material at specified temperature, insulate truck bodies
      and securely fasten covers.

D. Placing Equipment:
   1. Paver shall be a self-propelled unit with an activated screed or strike-off assembly, capable
      of being heated, if necessary, and capable of spreading and finishing mixture without
      segregation for widths and thicknesses required.
   2. Screed shall be adjustable to provide desired cross-sectional shape.
   3. Finished surface shall be of uniform texture and evenness and shall not show any indication
      of tearing, shoving, or pulling of mixture.
   4. Machine shall be in good mechanical condition and operated by competent personnel.
Specifications

• Require the Contractor to provide documentation of training in the installation of permeable pavement systems, or acceptable experiences or references.
Specifications

• Example Training and Certifications:
  – Pavement Technician, by the National Ready Mix Concrete Association
  – Certificate for a Permeable interlocking Concrete Technician, from the Interlocking Concrete Pavement Institute
WisDOT – Special Provision

1. Permeable Concrete Pavers – 80mm, Item SPV.0165.XXXX; Permeable Concrete Pavers – 100mm, Item SPV.1065.XXXX;

A Description
This special provision describes furnishing and installing permeable concrete pavers in the roadway, terrace, and plaza areas, as shown on the Drawings. It includes cutting of the concrete pavers to fit and setting the concrete pavers as shown on the plans; as directed by the Engineer, and as hereinafter provided.

Construction work includes the placement and setting of pavers and the addition of joint material between the pavers, and cleaning and protection of finished concrete unit paver joints and surfaces.

B Materials
Concrete Pavers:
Pavers shall conform to the following requirements set forth in ASTM C936:

1. Measured length or width of test specimens shall not differ by more than +/- 0.063 in, while measured thickness shall not differ by more than +/- 0.125 in.
2. Average compressive strength of 8,000 psi with no individual unit under 7,200 psi when tested in accordance with ASTM C140.
3. Average absorption of five (5) percent with no unit greater than seven (7) percent when tested in accordance with ASTM C140.
4. For freeze-thaw testing, the average mass loss of all specimens tested shall not be greater than (A) 225 g/m2 when subject to 28 freeze thaw cycles, or (b) 500 g/m2 when subject to 49 freeze thaw cycles. Testing shall be conducted using a three (3) percent saline solution in according to ASTM C1645.
C Construction
Install the 6-inch concrete header, and base and aggregate for plaza area as described in Wisconsin standard specification section 602 Concrete Sidewalks.

Concrete Paver System:
Verify that concrete pavers are free from dust, dirt, and stains. Do not use soiled, cracked, or broken paver units. Place and compact base layers evenly over prepared substrate surface to a maximum thickness as indicated on the Drawings. Dampen and roller compact to level and even surface. Place paver units in pattern as indicated on Drawings from straight referenced edge and maintain a joint width of 5/16-inch at all vertical edges of each paver and at abutting vertical surfaces and protrusions. Maintain straight pattern lines evenly spaced, joint lines and coursing as indicated on the Drawings. Cut pavers to fit edges with a power saw. No cut paver shall be smaller than 1/3 of a whole unit if exposed to vehicular traffic.
WisDOT – Special Provision

**D Measurement**
The department will measure Permeable Concrete Pavers in area by the square foot acceptably completed.

**E Payment**
The department will pay for measured quantities at the contract unit price under the following bid items:

<table>
<thead>
<tr>
<th>ITEM NUMBER</th>
<th>DESCRIPTION</th>
<th>UNIT</th>
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<tbody>
<tr>
<td>SPV.0165.XXXX</td>
<td>Permeable Concrete Pavers – 80mm</td>
<td>SF</td>
</tr>
<tr>
<td>SPV.0165.XXXX</td>
<td>Permeable Concrete Pavers – 100mm</td>
<td>SF</td>
</tr>
</tbody>
</table>
Specifications

• Descriptions of applicable standards, material requirements, and installation procedures.
• Requirements for system acceptance at the conclusion of construction.
Questions?