Permeable Pavement Systems

[STRATEGY]

Brief Description

Permeable Pavement Systems, also referred to as pervious or porous paving, allow stormwater to infiltrate into the soil and eventually into the groundwater. By allowing the water to infiltrate into the ground, the water undergoes absorption, filtration and microbiological degradation; in turn, there is less pollution entering directly into the rivers, creeks, and streams. There are five types of permeable pavement systems: permeable concrete (PC), permeable asphalt (PA), plastic grid pavers (PG), concrete grid pavers (CGP), and interlocking concrete pavers (PICP).

Applications

Core spaces

Parking Lots	Roadways/Sidewalks	Driveways	Boat Ramps
Emergency Access	Paths/Trails	Plazas/Patios	Ports/Airports

(a) (b) (c) (d) (e)

(a) Concrete Grid Pavers - Driveway (Source: www.buildinggreentv.com)
(b) Permeable Pavement- Roadway/Path (Source: creativeconcrete4you.com)
(c) UNI-Eco-Stone - Plaza (Source: http://www.uni-groupusa.org/)
(d) Geoweb – Trail System (Source: http:// www.ia.nrcs.usda.gov)
(e) UNI-Eco-Stone - Patio (Source: http://www.uni-groupusa.org/)

Design Notes

- Consider traffic and/or loading criteria in project area.
- Consider climate – Rock salt may affect porosity and specific snow removal equipment may be required.
- Most permeable asphalt requires routine (every 1-4 years) vacuuming or sweeping to remove dirt and build-up in order to maintain porosity.
- Permeable pavement should be sited at least 2-5 feet above the seasonally high ground water table, and at least 100 feet away from drinking water wells.
- Materials can be specified with recycled content.

References/Useful Resources:

[1] Toolbase Services
http://www.toolbase.org/Techinventory/TechDetails.aspx?ContentDetailID=604&BucketID=6&CategoryID=11
[2] EPA, Best Management Practices – Fact Sheet.
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse
[3] Interlocking Concrete Pavement Institute® - http://www.icpi.org/

Environmental Impacts

Water Quality and Stormwater Management

- Permeable paving enhances water quality, maintains more stable base flows to streams, reduces flooding, and reduces stream bank erosion.
- Permeable pavement allows adjacent trees and other vegetation to receive more water.
- Permeable pavement reduces vehicle-related pollutants on parking areas from directly polluting water sources such as rivers and streams.

Social Benefits

Safety

- Permeable pavement systems provide a non-slip surface by absorbing water. The exposed course aggregates provide enhanced traction for vehicles and prevent driving hazards such as hydroplaning.
- Permeable pavement systems may be less reflective, which in turn causes less glare and thus safer driving conditions for motorists.

Guiding Principles[1]

Protect & Conserve Water

- Employ design and construction strategies that reduce stormwater runoff and discharges of polluted water offsite.
- Per EISA Section 438, to the maximum extent technically feasible, maintain or restore the predevelopment hydrology of the site with regard to temperature, rate, volume, and duration of flow using site planning, design, construction, and maintenance strategies.

Associated LEED Credits (NC 2009)[2]

SS Credit 6.1: Stormwater Design- Quantity Control (1 point)

- Limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff and eliminating contaminants.

SS Credit 6.2: Stormwater Design- Quality Control (1 point)

- Limit disruption and pollution of natural water flows by managing stormwater runoff.

SS Credit 7.1: Heat Island Reduction – Nonroof (1 point)

- Reduce heat islands' to minimize impacts on microclimates and human and wildlife habitats. Demonstrate 50 percent of site hardscape with open-grid pervious pavement system.

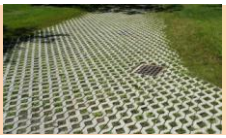
[1] Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings www.wbdg.org/pdfs/hpsb_guidance.pdf

[2] USGBC LEED Reference Guide for Green Building Design and Construction, 2009 Edition

Product Image

Cost Range

Product Types

Type	Product	Vendors	Material Cost per Square Foot	Estimated Strength (psi)	Primary Applications	Product Image
PA	Permeable Asphalt	Various	$0.50 - $1.00	500 - 4,000	Roadway, Parking Lots, Paths	
PC	Permeable Concrete	NRMCA PCA	$2.00 - $7.00	500 - 4,000	Roadway, Parking Lots, Paths	
PG With Grass	Checkerblock	Hastings Pavement Co.	$3.00 - $4.00	2,000 - 5,500	Emergency Access Areas, Driveways, Plazas	
	Geoblock®	Presto Products, Inc.	$1.00 - $2.00	2,000 - 5,500	Emergency Access Areas, Driveways, Plazas	
PG With Gravel	Geoweb®	Presto Products, Inc	$2.00 - $3.00	5,500	Roadway, Parking Lots, Yards, Paths	
	Gravelpave™	Invisible Structures, Inc	$1.00 - $2.00	5,700	Roadway, Parking Lots, Yards, Paths	
CGP	Turfstone	UNILOCK®	$2.00 - $3.00	≥ 5,000 psi	Roadway, Driveways, Patios, Boat Ramps	
PICP	UNI-Eco-stone	Uni-Group USA	$4.00 - $8.00	> 8,000 psi	Roadway, Parking lots, Ports, Airports	

Vendors

Permeable asphalt and concrete can be purchased through local asphalt and concrete vendors using the standards and specifications from the Green Construction Guide summarized in the next section.

Hastings Pavement Company Inc.
http://www.hastingsarchitectural.com/

Presto Products Inc.
http://www.prestogeo.com/

Invisible Structures Inc.
http://www.invisiblestructures.com/

UNILOCK®
http://www.unilock.com/

UNI-Group USA
http://www.uni-groupusa.org/

Oldcastle Architectural Products Group
http://www.oldcastle.com/

Pavestone Company
http://www.pavestone.com/component/option,com_frontpage/Itemid,1/

Warranty Info

Warranties for parking and road surfaces are not common due to the hard conditions to which they are subjected. May vary by vendor.

Code Restrictions

Local code requirements for stormwater management maybe impact design. Consider traffic and/or loading criteria in project area.

RECOMMENDED DESIGNS[3]:

Heavy Loads (> 6,000 psi):

Use Uni-Ecoloc® permeable pavers in conjunction with solid UNI-Anchorlock® concrete pavers for enhanced structural properties as well as permeable characteristics.

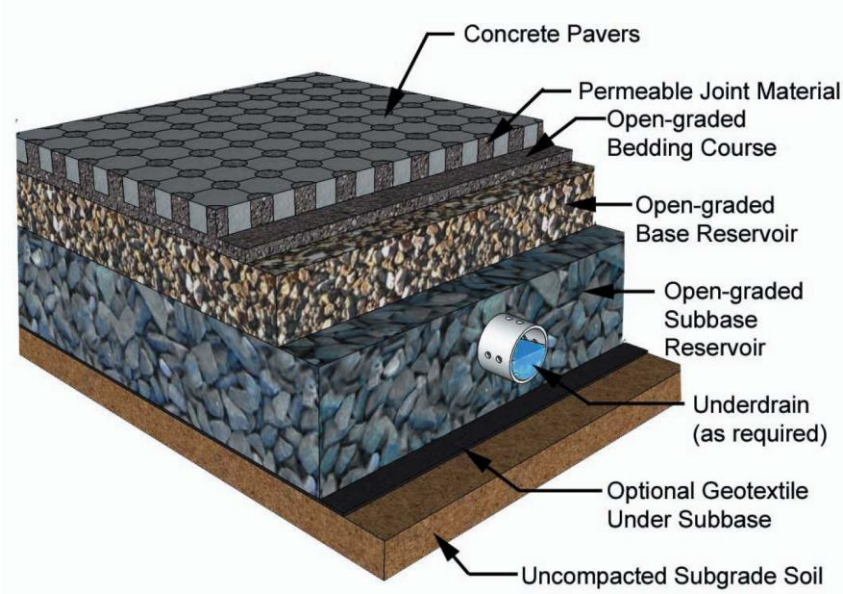


Figure 1 - Permeable Pavement Cross Section

Component	Specification
Concrete Pavers	3⅛ inch Uni-Ecoloc® in conjunction with solid 3⅛ inch UNI-Anchorlock®
Permeable Joint Material	Sharp Sand
Open-Graded Bedding Course	2 inches thick (ASTM No. 8 Aggregate)
Open-Graded Base Reservoir	4 inches thick (ASTM No. 57 Stone)
Open-Graded Subbase Reservoir	30 inches thick (ASTM No. 2 Stone)
Underdrain	As required stormwater management design
Geotextile	As required for migration of soil into the aggregate subbase or base
Subgrade	Top 12 inches compacted

Normal to Light Loads (< 6,000 psi):

Follow primary applications guidance on page 4, design varies by application and product. Follow vendor specified design specifications.

[3] Picture Courtesy of Interlocking Concrete Pavement Institute® http://www.icpi.org/

POROUS CONCRETE PAVING[4]

A. Installed system:
   1. Albedo: Minimum **Solar Reflectance of 0.3, Solar Reflectance Index (SRI) of 29**.
   2. Permeability: Minimum permeability rate **[60]** percent or not less than an infiltration rate of 1.1 inc./hr. for a 20-year design life. Determine the field water infiltration rate of in place pervious concrete in accordance with ASTM C1701.
   3. Density and void content: Determine the density and void content of freshly mixed pervious concrete in accordance with ASTM C1688. Verify that mixture proportions are as designed.

POROUS ASPHALT PAVING

A. Asphalt Cement:
   1. Recycled Content: Minimum **[5] [10]** percent post-consumer recycled content, or minimum **[20] [40]** percent pre-consumer recycled content at Contractor's option.

B. Recycling Agents: Comply with ASTM D5505; Class ER **[1] [2] [3]**.
   1. Hot recycling agents: Comply with ASTM D 4552 for hot recycling; Grade RA **[1] [5] [25] [75] [250] [500]**. Evaluate blends in accordance with ASTM D 4887.

C. Installed system:
   1. Permeability: Minimum permeability rate **[60]** percent.

UNIT PAVER SYSTEMS

A. Concrete paver systems:
   1. Concrete grid paver units: Comply with ASTM C1319.
   2. Interlocking concrete paver units: Comply with ASTM C 936.
   3. Average compressive strength of 8,000 psi (55 MPa) with no individual unit under 7,200 pounds per square inch (50 MPa).
   4. Maximum 1 percent loss in dry mass per unit in minimum 50 freeze-thaw cycles when tested according to ASTM C 67.

B. Plastic paver forms:
   1. Recycled Content: Minimum **[5] [10]** percent post-consumer recycled content, or minimum **[20] [40]** percent pre-consumer recycled content at contractor's option.

C. Installed system:
   1. Permeability: Minimum permeability rate **[60]** percent or not less than an infiltration rate of 1.1 inch/hour for a 20-year design life.

[4] Specification language modified from the Whole Building Design Guide's *Federal Green Construction Guide for Specifiers,* Section 1 32 12 43 (02795) - POROUS PAVING. Accessed August 2012 at http://www.wbdg.org/ccb/browse_org.php?o=84 (last updated January 2010).

LOOSE FILL PERMEABLE PAVING

A. Coarse Aggregate: Crushed concrete or blast furnace slag complying with ASTM D692; Recycled porcelain or other non-traditional aggregate material complying with ASTM D6155.
   1. Recycled Content: Minimum **[5] [10]** percent post-consumer recycled content, or minimum **[20] [40]** percent pre-consumer recycled content at contractor's option.

B. Mulch: As specified in Section 32 90 00 (02900) – Planting.

C. Installed system:
   1. Albedo: **[Minimum Solar Reflectance of 0.3] [Solar Reflectance Index (SRI) of 29]**
   2. Permeability: Minimum permeability rate **[60]** percent or not less than an infiltration rate of 1.1 in./hr. for a 20-year design life.

ACCESSORIES

A. Paver Bedding and Joint Sand: As recommended by paver manufacturer and as follows:
   1. Clean, non-plastic, free from deleterious or foreign matter, natural or manufactured from crushed rock.
   2. Sieve according to ASTM C 33, No. 8 stone; bedding and joint aggregate conforming to gradation, 1/2 inch 100 percent passing, 3/8 in. 85-100 percent, No. 4 10-30 percent, No. 8 0-10 percent, No. 16 0-5 percent. Joint material may also conform to No. 89 crushed stone or finer material at contractor's option.
   3. Screenings and stone dust are not permitted.
   4. Sand having material passing the No. 200 (0.075 mm) sieve is not permitted.

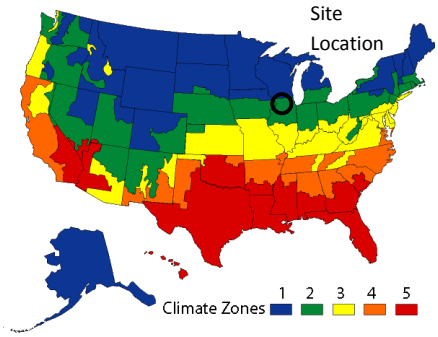
B. Reservoir stones: ASTM C 33 No. 57 crushed concrete or other recycled materials, gradation 1 1/2 in. 100 percent passing, 1 in. 95-100 percent, 1/2 in. 25-60 percent, No.4 0-10 percent, No.8 0-5 percent.
   1. Recycled Content: Minimum **[5] [10]** percent post-consumer recycled content, or minimum **[20] [40]** percent pre-consumer recycled content at contractor's option.

C. Geotextile fabric: Comply with AASHTO M288 based on application and installation conditions. Verify compatibility between geotextile and adjacent soils for filtration, clogging and permeability.

D. Edge restraints: **[Concrete]**.

U.S. Cellular Field[5]

Chicago, Illinois



Facility

- The home of the Chicago White Sox – U.S. Cellular Field

Approach

- The Illinois Sports Authority wanted all aspects of the Chicago White Sox's new home to be green, even the 265,000 sf parking lot.

Construction Details	
Pavers	3⅛" (80mm) thick Eco-Optiloc®
Square Footage	265,000
Bedding & Joints	2" thick CA-16 (ASTM No. 8 stone)
Base	6" thick CA-7 (ASTM No. 57 stone)
Subbase	8" thick recycled crushed concrete CA-1 (Equivalent to ASTM No. 2 stone)
Subgrade	Silty Sand

Results

- Currently the largest permeable pavement system in the U.S. and the first to be used by a major league sports facility.
- The hydrological design of the permeable pavement met the 2008 City of Chicago Stormwater Management Ordinance that seeks to minimize stormwater runoff from new development and redevelopment.
- Because the permeable pavement system (Eco-Optiloc®) substantially reduced stormwater runoff, the project was able to save approximately $400,000 over traditional impervious asphalt, as underground drainage systems were not required.

[5] Case Study courtesy of UNI-Group USA. http://www.uni-groupusa.org/casestudies.htm