

# PERMEABLE INTERLOCKING CONCRETE PAVERS



Improving our region's water quality

# **Phil Austin**

#### **Commercial Design Consultant**

- Second year with Unilock®
- 12 years experience in private landscape architecture firms specializing in hospitality design, educational systems, health care facilities and private residences
  - EDSA- Fort Lauderdale
  - Burt Hill- Pittsburgh
  - 13 Grounds Design- Pittsburgh
- Bachelor of Landscape Architecture from Michigan State University

## Questions

#### What are Permeable Pavers, How do they work and How are they maintained?

- 1. Functionality
  - Does permeable use sand setting bed?
  - What kind of infiltration can permeable pavers provide?
  - Does the application or use change the paver type and or the sub-base depth?
  - What is the average life span? Does it differ from traditional installations?
- 2. Installation
  - Are pavers really cost effective? Why are they worth it?
  - What doe they cost? Does the size of the area affect the cost?
- 3. Maintenance
  - Do weeds and grass grow in the joints?
  - Who does the Maintenance?
  - Do you have to vacuum? How often?
  - What is the projected maintenance cost? Life span cost?
- 4. Winter Concerns
  - De-Icers- specifically salt-What to use? Does salt deteriorate the paver? Clog the system?
  - Snow Plow- Damage? Use? Do you need a protective strip?



# The Use of Permeable Pavers for storm water management?







### During storm: Flooding, erosion, oil, bacteria, raw sewage





#### After storm:

No base flow, aquatic habitat lost, water shortage



## "Thought Diagram" & Objective





Current Thought

Asphalt/ Concrete Surface Drainage Retention Ponds Storage Tanks Low Bid/Initial Cost







## "Thought Diagram" & Objective



## Vertical Drainage

## Bioswales



## Innovative Thought



Life Cycle

Cost

Permeable

Pavers



## Infiltration Planters

## Rain Gardens





## **Design Considerations**

# Components of Permeable Pavers



## PAVER EVOLUTION

#### Founder Ed Bryant, introduced Uni-Stone<sup>®</sup> to North America





## What Unilock<sup>®</sup> Brings to your Project

- 1. Quality of Product
  - 2015 begins our 42<sup>nd</sup> year- First paver manufacturer in North America
  - Providing permeable solutions since the early 90's
  - Strength, Density and Absorption are the keys to concrete success

#### 2. Advantages in concrete

- Wide range of standard colors/ Custom colors available
- Different finish and texture options through EnduraColor<sup>™</sup> and EnduraColor Plus<sup>™</sup>
- 8 Different permeable options
- ADA compliant

#### 3. Mechanical Installation

- Cost competitive installation
- Often provides a cost saving to the project
- 4. Design Assistance/ Field Support
  - Assistance through the design process with details, specifications, and support
  - On site guidance for installation, problem solving, and coordination with contractors





**Turfstone-** for grass paving began in the mid-1940s, and plastic versions were invented in the late 1970s and early 1980s.

First thing people think of when they hear Permeable pavers





## **Permeable Pavements**





## Porous, Pervious and Permeable Pavements Aren't they all the same?

**Permeable pavers-** are concrete pavers separated by joints filled with crushed aggregate. Permeable pavers are different from pervious and porous pavers in that rainwater passes **around** the paver opposed to *through* it. Water enters the joints between the solid impervious pavers and flows through the paver system.

**Porous pavers-** Porous pavers generally are a cellular grid system filled with dirt, sand, or gravel. This system provides grass reinforcement, ground stabilization and gravel retention.

**Pervious pavement-** Pervious pavement allow storm water to percolate through the surface rather than running off into surrounding areas or storm drains.



## 9 Components for a Successful System

#### Crushed aggregate:

Ensures void structure and provides long-term permeability

#### Geotextile:

Prevent migration of fines from subgrade or excavation into the pavement structure.





#### Permeable Installation

## **Permeable System**





## Sand setting bed





Open surface area:

Eco-Optiloc – 12% Eco-Priora – 5, 7 and 9%

Required infiltration rate of openings:

Design storm, in. per. hr. / 0.12 Example: 5.11\* in. per. hr.(intensity) / 0.12 Required infiltration rate = 42.6 in. per. hr.

Infiltration rate of stone in openings:

Typically 500 to 1,000 in. per. hr. With a 10% lifetime efficiency:

50 to 100 in. per. hr.







## **Special Installation**

## **Sloped Surface**





## **Special Installation**

## **Sloped Surface**





## **Base and Sub-base Aggregates**

The base and sub-base are the pavement components that carry the major structural load, and they must maintain strength in presence of water for pavement stability.





## **Base Thickness Disperses Load**



- Protects subgrade
- Compensates for wet or uncompacted subgrade



## **Base Thickness per Application**

Pavement Use	Subbase ASTM #2	Base ASTM #57	Minimum Total	
Heavy Duty Industrial	14"	6"	20"	
Municipal Street	12"	6"	18″	
Light-duty Parking Lot	8″	6"	14"	
Residential Driveway	N/A	12"	12"	
Non-vehicular Sidewalk	N/A	10"	10"	

- 1. All permeable pavers require a 1.5" setting bed of ASTM #8, 89 or 9
- 2. Depths shown are Unilock recommendations and should be designed by an engineer
- 3. Rule of thumb:  $2\frac{1}{2}$  to 3" of base stores approximately 1" of water for 24 hours.



## **Unilock Storage Capacity Calculator**

	Enter criteria				Rainwater Harvest Amount Base S		Base Stora	ge Capacity	Surplus/(Deficit)	Storage	Percentage
Examples	Rain (in./hr.)	Surface Area (sf)	Base Depth (in.)	Void Space	Cubic Feet	Gallons	Cubic Feet	Gallons	Cubic Feet	Gallons	Used
Α	1	43,560.00	12	40%	3,629.96	27,153.99	17,424.00	130,340.57	13,794.04	103,186.59	20.8%
В	1	43,560.00	18	40%	3,629.96	27,153.99	26,136.00	195,510.86	22,506.04	168,356.87	13.9%
с	3.5	43,560.00	12	40%	12,704.86	95 <i>,</i> 038.95	17,424.00	130,340.57	4,719.14	35,301.62	72.9%
D	3.5	43,560.00	18	40%	12,704.86	95 <i>,</i> 038.95	26,136.00	195,510.86	13,431.14	100,471.90	48.6%
E	5.11	43,560.00	13	40%	18,549.10	138,756.87	18,876.00	141,202.29	326.90	2,445.41	98.3%
F	7.4	43,560.00	18	40%	26,861.70	200,939.50	26,136.00	195,510.86	(725.70)	(5,428.64)	102.8%

According to the USGS, a one inch per hour rainfall accumulates 27,154 gallons on one acre (43,560 square feet) of surface area.

That equals 5/8 gallons per square foot per hour. The 5.11 in. storm equals 3.18 gallons per square foot per hour.



- Considered a structural Best Management Practice (BMP) by the EPA's National Pollutant Discharge Elimination System (NPDES)
- Reduction of runoff and runoff temperature, improved water quality and detention storage in aggregate base
- Runoff coefficient varies. Actual is ZERO. Typically 0.25 to 0.35. Infiltration rate varies depending on soil permeability.
- The runoff coefficient (C) is a dimensionless coefficient relating the amount of runoff to the amount of precipitation received. It is a larger value for areas with low infiltration and high runoff (pavement, steep gradient), and lower for permeable, well vegetated areas (forest, flat land).



## **Open-graded Aggregates**



No geotextile is needed between layers of aggregate.

ASTM #2

## **Bedding and Joint Aggregate**





## **Design Considerations**

## **Bedding and Joint Aggregate**





Eclipse Black



Saturn Tan



Stormy Gray



Sunset Red



## **Mechanical Installation**

## **Features and Benefits**

- 10,000- 12,000 SF per day
- Cost competitive with poured in place concrete
- Extended season for installation
- Rapid efficiency compared to manual installation







## **Options**

- Eco-Optiloc- L Shape
- Eco-Priora- Herringbone
- Eco-Line- Linear

## **Special Equipment**



## Mechanical Screeding



Mechanical Sweeping of Joint Filler

> Mechanical Installer





# **Applications**

# Where can permeable pavers be used? Where have they been used?



## Aesthetic, Heavy-duty and Functional





#### **About Concrete Pavers**

## **Aesthetic and Functional**







Green Hills Public Library (Palos Hills, IL)

Green Hills Public Library (Palos Hills, IL)

90

Milwaukee Park Conservatory (Milwaukee, WI) Milwaukee County Parks


East Liberty Presbyterian Church (Pittsburgh, PA)



Easton Gateway(Columbus, OH)

RECREATION FQUIPMENT, INC.

**K**ÉI

Grand Traverse Fire Station (Grand Traverse, MI) Gourdie-Fraser, Inc.

90

Unilock Yard (Pickering, ON)



11



Citi Field Mets Stadium (Queens, NY) Jack L. Gordon Architects



Buckingham Fountain (Chicago, IL) Thompson Duke & Associates



Warrenville Rd (Warrenville, IL)

Warrenville Rd (Warrenville, IL)





Parkway Center (Pittsburgh, PA)



Utilizing concrete pavers or permeable concrete pavers doesn't mean sacrificing design intent or project integrity. Great designs transcend regardless of material type.

## Large Parking Lot- Eliminate Traditional Methods U.S. Cellular Field Lot L

Cost Analysis Autumn Trails

## **Pervious Cover Restrictions**

Mt. Lebanon High School





## **U.S. Cellular Field Lot L**

## Largest Permeable Lot in the US at 265,000 sf







## Traditional parking lot design

- 44 inlets/CB
- over 3,000 linear feet of RCP
- 73,100 cubic feet underground storage tank
- approx. \$2 million in underground infrastructure





## Permeable paver parking lot design

- no inlets
- no RCP or underdrain
- no underground storage tank
- up to 14" per hour of infiltration into subgrade
- 15% savings vs. traditional



## **Storage capacity:**

- 265,000 sf of paving
- x 14" of base aggregate
- x 40% aggregate void space
- = 123,667 cu.ft. storage
  - 73,100 cu.ft. required
  - 50,567 cu.ft. surplus storage













# Autumn Trails Pioneers PICP in Streets

Autumn Trails in Moline, Illinois demonstrates the cost-savings of permeable interlocking concrete pavement to developers, cities and homeowners.



## **Autumn Trails**

ltem	PICP	Concrete	Asphalt
Paving/sf	\$2.25	\$8.00	\$3.00
Excavating/sf	\$1.00	\$1.00	\$1.00
Stone/sf	\$2.00	\$1.50	\$1.50
Installation/sf	\$4.00	(in paving cost)	\$1.50
Curbs	\$1.50	\$1.50	\$1.50
Maintenance	\$0.20	0	Not known
Replacement	None	None	Every 12 years
Detention/Retention required	None	Yes	Yes
Storm Sewer System/sf paving	None	\$3.00	\$3.00
Total/sf	\$10.95	\$14.00	\$11.50
Total/linear foot – municipal street	\$171	\$218	\$179
Total/linear ft for 30 ft wide street	\$230	\$280	\$230

Table 1. Cost Comparison of Pavement Systems for Autumn Trails, Moline, Illinois

(ICPI 2007)



## **Pervious Cover restrictions**

## **Mt. Lebanon High School**



Initial Design was for 60,000SF Project is

Project is currently adding more



## **Pervious Cover restrictions**

- Mt. Lebanon Zoning Code 202.5.2.2.3:
  - Maximum Lot Coverage, nonresidential uses = 50%
- Definitions:
  - Lot Coverage: The percentage of lot area occupied by the ground area of buildings, driveways and other *impermeable* materials on such lot
  - Impervious Surface: any combination of pavement consisting of: ... (3) vitrified brick, concrete brick, ... or any other type of hard-dimensioned material laid on a base ... with joints between the units of no more than 3/8" ....
- Solution: Eco Optilock 64,600 SF
  - A little less than 2 AC permeable pavement

Area	Existing SE	Proposed SF 09-28-10
School Building	142.600	107.505
Field House Wing	,	55,500
Lot Coverage		163,005
Stadium Coverage		217590
Less Turf Field	(72,010)	(72,010)
Less Permeable Parking	, ,	(2,315)
Lot Coverage		143,265
Tennis Platform		44,965
Less Permeable Spectator Area		(2,740)
Lot Coverage		42,225
Roads, Curbs, Gutters & Parking		232,685
Less Permeable North Parking		(10,970)
Less Permeable Road Pavers		(24,665)
Less Permeable Plow Access		(675)
Lot Coverage		196,375
Sidewalks, Plazas & Steps		107,610
Less Permeable Pavers at Cochran Rd. Entrance		(2,015)
Less Permeable Pavers at Primary School Entry		(25,760)
Less Permeable Pavers along West Horsman		(5,925)
Less Permeable Pavers in Courtyard		(1,760)
Less Permeable Stadium Access Plaza		(4,490)
Lot Coverage		67,660
Gas House & Ticket Booth		240
TOTAL LOT COVERAGE SF	671,670	612,770
TOTAL LOT COVERAGE ACREAGE	15.419	14.067
PERCENT OF TOTAL SITE (28.2557 AC)	54.57%	49.79%









## **Pavements control urban tree viability**





## WINTER CONDITIONS

# Snow Plowing, De-Icing and What really happens to the water?



## **Quality Control**

#### ASTM Standard C140

- 8000 psi avg.
- 7200 psi min. unit
- 5% absorption avg.
- 7% absorption max.
- Height Tolerance less than +/- 1/8"

## Unilock<sup>®</sup> Standards

- 8500 psi min.
- 4% absorption avg.
- 5% absorption max.
- Dimensional Accuracy +/- 3/64"

Average concrete – 2,700 to 5,500 psi Porous concrete – 2,700 to 3,000 psi



## **De-Icing**

- What De-Icers should we use?
  - Sodium Chloride is the preferred De-Icer For lower temperatures use Calcium Chloride (when necessary)
- Does salt destroy the paver? The salt brine is the true killer
- Can we use Sand?

No- sand will add maintenance as it can clog the joints

• Are there other anti-skid options?

When necessary use joint material (#8, #89 or #9)

• It fails where there is freezing in winter

Design with "factors of safety" in mind

 It can't be snow plowed See upcoming slides



Porous pavement experiences less effects from frost heave than impermeable pavement. (Backstrom, 1987, 1999)





### Pavers Can't be Snow Plowed, Right?

- 1. Design: Pavers are designed with beveled or angled edges that help create a continuous smooth surface
- 2. Snow Blowers: Smaller ones use rubber paddleslarger ones use "auger like" rotating blades with skid shoes
- 3. Metal Blades are not a problem for standard surface pavers- Marks left on pavers are same as other materials
- 4. Polyurethane Blade easily adjust to irregular road surfaces & pavement without scarring, gouging, or leaving rust stains.
- 5. Rotating Broom is very effective but limited by volume of snow (inches)
- 6. Replacement: Any individual **pavers** that are damaged can easily be replaced with no signs of repair or replacement.





Permeable Interlocking Concrete Pavers Maintenance Procedure

What is the Maintenance? What do I really have to do? How much is this going to cost?



## **Common Maintenance Issues**

1. Slow draining- Runoff

2. Ponding (Bird Baths)

3. Surface Crusting

4. Weeds

5. Covered Joint Material





#### 1. Preventative:

- Removes most debris before it's trapped
- Does not require removal of joint material
  - 1. Broom
  - 2. Leaf Blower
  - 3. Rotary Brush
- 2. Restorative:
- Requires some or complete removal of the joint material
- Requires the joints to be topped off or filled
- Allows for a clogged system to be fixed
  - 1. Vacuum



## **Preventative Maintenance Solutions**

## Hand-Held Broom



- Small scale projects or isolated areas affected
- Prevents runoff
- Agitating the aggregate dissipates the ponding
- Breaks up surface crusting
- Does not allow weeds to take hold in trapped sediment



## Leaf backpack blower/vacuum



- Clean up of
   landscape
   maintenance
- Joint material remains in place
- Removal of organic material
- Does not allow sediment to build up



## **Preventative Maintenance Solutions**

## **Rotary Brush**



- For larger areas
- Removes aggregate alleviates ponding
- Breaks up surface crusting
- Does not allow weeds to take hold in trapped sediment
- \*Will require refilling the joints
- \*Poly Bristles only


#### **Preventative Maintenance Solutions**

## **Regenerative Air Sweepers**



- For larger areas
- Stream of air blowing across surface and vacuums up debris
- Prevents surface crusting
- Does not allow weeds to take hold in trapped sediment
- Should not need to top off







- Small scale projects or isolated areas affected
- Removes aggregate sediment, organic material etc.
- Does not allow weeds
  to take hold in trapped
  sediment
- Will require filling of the joint

## **Power Washing**



- Small scale projects or isolated areas
- Pushes aggregate sediment, organic material down into base
- Breaks up crusted surface
- Does not allow weeds to take hold in trapped sediment
- Will require filling of the joint



### **Vacuum Sweepers**



- Large scale projects
- Removes aggregate sediment, organic material etc.
- Does not allow weeds to take hold
- Restores a clogged system to full working order
- Will require filling of the joint







## **Remove and Reinstall**



- Maintenance means more than just the cleaning pavers-
- Fix Utilities and Repairs with little disturbance
- Fix settling issues over time
- Reuse existing material
- Repair and replace damaged pavers



# THANK YOU!

