Permeable Interlocking Concrete Pavements

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Stormwater Management Approaches:

- Restrict impervious surfaces
- Remove pollutants (e.g., TSS, TN, TP)
- Capture/treat/infiltrate specific rainfall depth
- Detain/slowly release - reduce stream channel erosion
- Reduce post-development volumes/peak discharges to pre-development rates
- Reduce flooding volumes
- Recharge groundwater
- Reduced overflows in combined sewers

PICP supports all approaches

Permeable Interlocking Concrete Pavements (PICP)

Industry Assistance & Design Tools

System Components
- **Pavers**
- **Aggregates**
- **Edge Restraints**
- **Geotextiles**

Design Options
- **PICP Cross Sections**

Installation Guidelines

Maintenance

Cost

LEED Credits

Case Studies

Project Photos

ICPI INTERLOCKING CONCRETE PAVEMENT INSTITUTE®

Technical Assistance

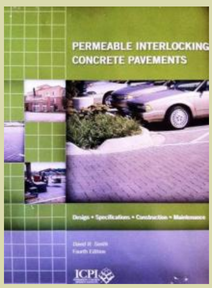
Design Professionals | Contractors | Homeowners | Universities | Media

www.icpi.org

ICPI INTERLOCKING CONCRETE PAVEMENT INSTITUTE®

PICP Design Manual

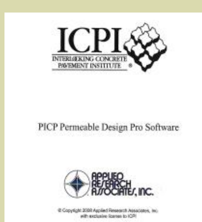
- Fourth edition
  - •Design
  - •Specifications
  - •Construction
  - •Maintenance



ICPI INTERLOCKING CONCRETE PAVEMENT INSTITUTE®

PICP Permeable Design Pro Design Software

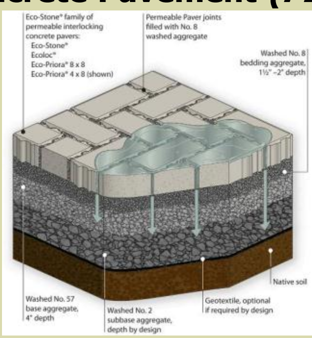
Balances system performance
- •Structural support
- •Hydraulic capacity



Additional Recommendations

www.uni-groupusa.org

Permeable Interlocking Concrete Pavement *(PICP)*



PICP Product Standards

PICP pavers meet ASTM C 936:

"Standard Specification for Solid Concrete Interlocking Paving Units," **(same as impermeable standard pavers):**

- Minimum Compressive Strength = 8,000 psi
- Maximum Absorption = 5%
- Freeze-thaw durability per ASTM C 1645
- Aspect ratio (length:thickness) guidelines apply -
  - 4:1 pedestrian only
  - 3:1 to 4:1 for residential driveways
  - 3:1 or less for all vehicular areas

Typical Paver Shapes for PICP

Drainage joints

Drainage ‘features’ or shape

PICP Aggregates

Free-draining (open graded) aggregates comply with the requirements of ASTM D 448:

- Jointing material and bedding course
  - *No. 8* aggregate, (#16 to ½” sieve)
- Base material
  - *No. 57* aggregate, (#8 to 1-1/2” sieve)
- Subbase material
  - *No. 2* stone, (3” to ¾” sieve)

PICP Aggregates

In addition to gradation requirements:

- Crushed stone
  - *90% fractured faces*
  - *Do not use rounded river rock!*
- Hard, durable material
  - *LA Abrasion < 40 per ASTM C131, min. CBR of 80% per ASTM D1883*
- No fines
  - *Less than 2% passing the #200 sieve*

PICP Aggregates

When project conditions require, or when recommended aggregates are not available:

Table 3-5. Filter criteria for PICP bedding, base and subbase aggregates

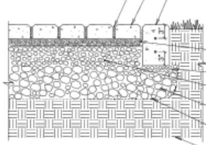
Permeability	D_{15} Base/D_{15} Bedding layer >5
Choke	D_{50} Base/D_{50} Bedding layer <25
	D_{15} Base/D_{85} Bedding layer <5

Permeability	D_{15} Subbase/D_{15} Base >5
Choke	D_{50} Subbase/D_{50} Base <25
	D_{15} Subbase/D_{85} Base <5

Source: David R. Smith, *Permeable Interlocking Concrete Pavements*, 4th edition, pg. 41

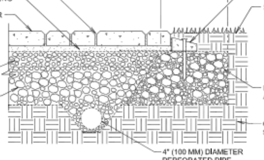
PICP Edge Restraints

- Suitable for loading conditions
  - Typically concrete (all commercial applications)



PICP Edge Restraints

Plastic & metal “staked” edging is suitable for residential applications. Use dense graded base under edging only:



Geotextiles

- Option of the design engineer
- Non-woven recommended (high water flow)
- AASHTO M-288 provides minimum requirements
- AOS selection criteria in PICP manual
- Or use manufacturer's recommendations
- Place on sides & bottom
- Minimum overlap 12 in. (0.3 m)
- Poor soils overlap 24 in. (0.6 m)
- AASHTO M-288
  - Tables 1 & 2: Strength & Subsurface Drainage Geotextile Requirements

Product Description MIRAFI

Geolon® HP-Series Woven Polypropylene Geotextiles

for Stabilization and Soil Reinforcement Applications

Mirafi® Construction Products offers a wide range of woven geotextiles for stabilization and soil reinforcement applications. These geotextiles are cost-effective reinforcement elements which improve and enhance modern construction techniques in a variety of civil engineering applications.

PRODUCT DESCRIPTION

Geolon® HP-Series products are woven geotextiles comprised of high tenacity polypropylene yarns. HP-Series Woven Polypropylene Geotextiles yield ultimate tensile strengths up to 300kN/m (20559 lbs/ft) (machine direction) per ASTM D 4595. Geolon® HP-Series products combine the properties of high tensile strength and modulus and high confinement with their ability to act as a filter and separator.

FEATURES AND BENEFITS

- Strength. Higher tensile strength at 2% and 5% than any comparable stabilization product.
- Flow. Uniform openings provide the same filtration and flow characteristics as that of a fine to coarse sand layer.
- Soil Interaction. Excellent soil confinement resulting in greater load distribution.
- Seams. Panels can be sewn together in the factory or field, providing cross-roll direction strength to facilitate installation and providing reinforcement strength.
- Cost. Woven reinforcement geotextiles provide low cost tensile strength for reinforced soil structures.

APPLICATIONS

Because of their flexibility and versatility, woven geotextiles are used in a variety of applications, including embankments on soft foundations, retaining walls, steepened slopes, and soil stabilization for road and rail construction. Environmental applications include liner support, voids bridging, and reinforcement over soft, hazardous pond closures. For any application where long term design of earth reinforcement structures are involved, Geolon® HP-Series Woven Polypropylene Geotextiles are a logical choice.

INSTALLATION GUIDELINES*

Site Preparation

Many conditions affect the degree of site preparation required to provide a working surface compatible with the selected geotextile including:

- Foundation subgrade strength and its relation to equipment mobility;
- The presence of a vegetative root mat;
- The need for removal of large trees or other obstacles.

Direct placement of the geotextile on the prepared site is usually preferable. Generally, it is advisable to leave vegetative cover such as grass and weeds in place to provide a support matting for construction activities.

Geotextile Fabrication and Placement Procedures

Placement of geotextiles can be labor intensive process. This time consuming procedure can be simplified by prefabricating geotextile panels before field placement and using experienced field installation and sewing crews.

Installation of the geotextile must conform to the lines and grades as drawn by the engineer. This may require large roll or panel placement, using manual positioning or equipment-assisted deployment.

* These guidelines serve as a general basis for installation. Detailed instructions are available from your Mirafi representative.

Geolon® HP-Series Polypropylene Woven Geotextile

Geolon® HP-Series Geotextile used in pond closure application

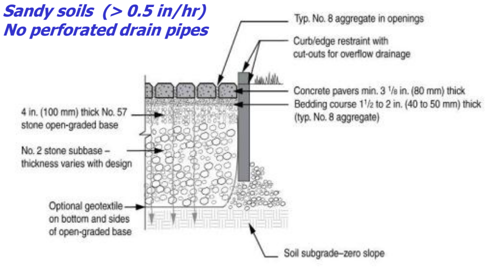
PICP Design Basics: Exfiltration Options

- ***Full Exfiltration***
- ***Partial Exfiltration***
- ***No Exfiltration***

PICP Design Basics: Exfiltration Options

Full Exfiltration

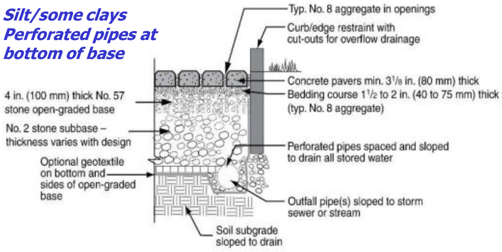
Sandy soils (> 0.5 in/hr)
No perforated drain pipes



PICP Design Basics: Exfiltration Options

Partial Exfiltration - detention & exfiltration

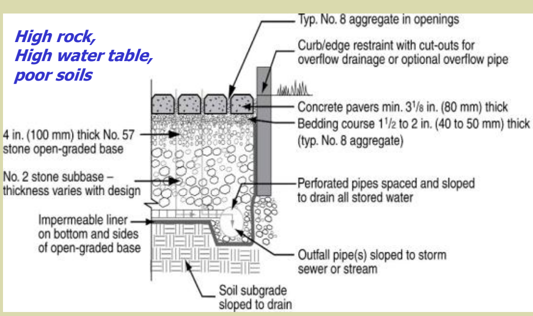
Silt/some clays
Perforated pipes at bottom of base



PICP Design Basics: Exfiltration Options

No Exfiltration - detention only

High rock, High water table, poor soils



Impermeable EPDM (or equivalent) liner

Use 'No Exfiltration' design when….

- Near water supply wells (100 ft)
- High water table (3 ft)
- High depth of bedrock
- Some fills & expansive soils
- Contain potential contaminants from entering soils & groundwater
- Rainwater harvesting

PICP Installation

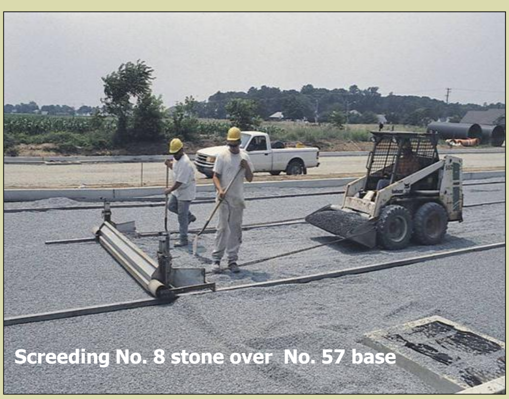
- During excavation, do not compact native soil
- Compacted soil is 30 to 90% ***less*** permeable than un-compacted soil

Keep delivery trucks off of native soil, if at all possible

Spreading Base Material

Final grading of base material

Compacting base material



Screeding No. 8 stone over No. 57 base

Mechanical Installation

Mechanical installation of PICP can decrease construction time 20-80% over manual installation

Manual paver installation:

1,000 – 2,000 sq. ft. per man per day

Mechanical paver installation:

3,000 – 10,000 sq. ft. per machine per day

Edge pavers cut and placed, then compacted

Compact before sweeping in aggregate

Keeping sediment away from the pavers

Observation well:

- Install at lowest point of pavement
- Min. 6 in. dia. perf. pipe w/cap
- Monitor drainage rate, sediment, water quality, temperature

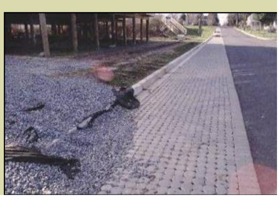
Maintenance

Annually: overall system performance inspection, check observation well , inspect after major storm, vacuum surface (once, twice, or more) to ensure optimum design life performance

Maintenance checklist (specific to each project)

Model maintenance agreement

Monitor adjacent uses



PICP Inspection Checklist

Vacuum surface	1 to 2 times annually, adjust for sediment loading
Replenish aggregate in joints	As needed
Inspect vegetation around PICP perimeter for cover & stability	Annually, repair/replant as needed
Check drain outfalls for free flow of water and outflow from observation well	Annually and/or after a major storm event

PICP Maintenance

Cost

Furnished and Installed:
$5.00 to $12.00 per sq ft

Includes:
-**Pavers placed, cut, compacted, & swept-**

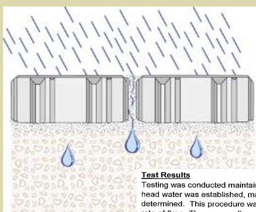
-2" of ASTM #8 Bedding Aggregate-

-4" of ASTM #57 Base Aggregate

Permeable Interlocking Concrete Pavement

Local Research / BMP's

- Dr. Derek Booth Six Year Study
- City of Tacoma Landfill Pervious Pavement Demo Project (Karen Bartlett P.E.)
- Low Impact Development Manual for Puget Sound
- 2005 KCSWDM BMP C.2.6.4



UNI PRIORA™
8x8 (200X200mm)
3/8" (10mm) Joint
Infiltration Rate > 15 in/hr after 10 years

Test Results

Testing was conducted maintaining three levels of head water above the pavers. The level of head water was established, maintained for a minimum of 30 seconds, and the rate of flow was determined. This procedure was performed multiple times at each level to verify a consistent rate of flow. The average flow rate at each level was determined and is reported in the table below.

Head Water (Inches)	Rate of Flow (Inches per Hour)
0.5	105
1.0	140
2.0	161

STATE OF TEXAS
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PROFESSIONAL ENGINEER
5/13/08

Mark L. McKay, P.E.
Senior Geotechnical Engineer

LEED Credits Achieved with PICP's

• Local Regional Materials Credit - Specifies that a minimum of 20% of building materials are manufactured regionally within a 500 mile radius. An extra point can be earned if the manufactured materials are harvested within the same radius.

• Stormwater Management Credit - The intent is to limit the disruption of natural water flows by minimizing stormwater runoff, increasing onsite infiltration, and reducing contaminants. Pervious pavements are recommended.

•Urban Heat Island reduction – The intent of is to reduce heat islands effect, minimizing impact on microclimate and human and wildlife habitats. High albedo materials and open grid paving are recommended.

PICP Benefits

Storm water management

- Reduction or elimination of the need for large detention pipes, vaults, or ponds
- Reduction of over burden of existing storm drain systems
- Reduction of the need for new conventional storm drain systems

Decreases adverse impact of land development

- Reduces potential for downstream flooding and mitigates pollution impact on surrounding surface waters

Improved Water Quality

- Lower runoff temperature
- Treatment of pollutants through infiltration
- Uses natural infiltration of rainwater to reduce or eliminate runoff maximizing groundwater recharge

Increases Property Foot Print and Land Use

Design Flexibility

LEED Credits

Features	Benefits	Advantages
•Units are cured before installation	•No waiting 3 to 7 or more days	•Immediately ready for traffic
•Modular units	•Design Flexibility	•Can be used for many pavement type: walks, drives, parking areas, low speed roads, industrial yards
•Textured surface	•Slows traffic	•Decreases accidents
•Very dense concrete	•High resistance to de-icing salts	•Long wearing life and low maintenance
•Modular units	•Simple access to underground utilities	•Short repair time, re-use existing pavers

Case Studies & Project Profiles

JORDAN COVE URBAN WATERSHED STUDY

Port of New York and New Jersey

Tacoma Community College

Snoqualmie Fire Station

Mercer Island, WA

Mercer Island, WA

Mercer Island, WA

Woodinville Condos

Lynwood Residence

Medina Development in Spanaway

Medina Development in Spanaway

The Bridge Tacoma, WA

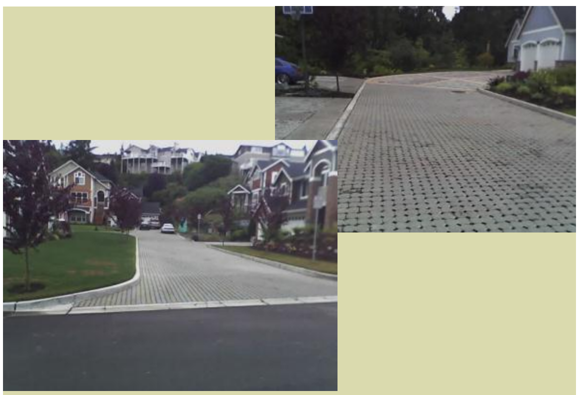
Lowes / Safeway in Lacey, WA

City of La Center, WA

City of La Center, WA

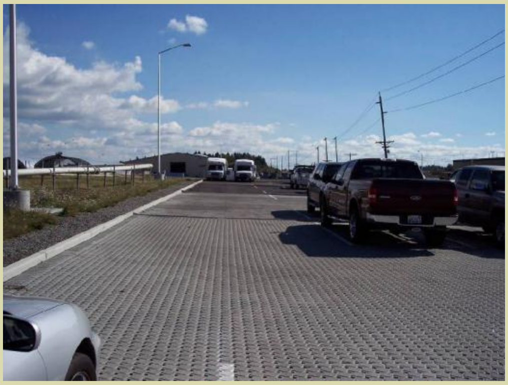
Marysville, WA Park & Ride

Railway Museum Restoration, Snoqualmie, WA



Holbrook Ave   Everett, WA

Westlake Union



Tacoma Landfill Pervious Pave Demo

Mutual Materials Branch, Vancouver, WA

Pediatric Dental Clinic, Bellingham, WA

Railroad Avenue, Bellingham, WA

Vineyard Lanes, Bainbridge Island

River Front Trail Puyallup, WA

Highpoint Development W. Seattle

South Lake Union Street Car Facility

West Seattle Mix Use Building

Columbia City Live Above, Seattle, WA

Union Station, Marysville, WA

Twin County Credit Union, Lacey, WA

Wastewater Treatment Plant, Winlock, WA

Prairie Line Trail, Yelm, WA

Parking area, Portland, OR

Wedge Park Fife, WA


Thank you!