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
Additional Recommendations

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 ¼” 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

<table>
<thead>
<tr>
<th>Permeability</th>
<th>D&lt;sub&gt;b&lt;/sub&gt; Base/D&lt;sub&gt;b&lt;/sub&gt; Bedding layer</th>
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<tbody>
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<td>Choke</td>
<td>D&lt;sub&gt;b&lt;/sub&gt; Base/D&lt;sub&gt;b&lt;/sub&gt; Bedding layer</td>
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<td></td>
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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
PICP Design Basics: Exfiltration Options

- Full Exfiltration
- Partial Exfiltration
- No Exfiltration

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

- 4 in. (100 mm) thick No. 57 stone open-graded base
- No. 2 stone subbase - thickness varies with design
- Optional permeable liner on bottom and sides of open-graded base
- Soil subgrade sloped to drain
- Typical No. 8 aggregate in openings
- Curbside restraint with cutouts for overflow drainage
- Concrete pavers min. 3/8 in. (80 mm) thick
- Bedding course 1½ to 2 in. (40 to 50 mm) thick (typ. No. 8 aggregate)
- Perforated pipes spaced and sloped to drain all stored water
- Outfall pipe(s) sloped to storm sewer or stream

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**No Exfiltration** - detention only

- High rock, high water table, poor soils

- 4 in. (100 mm) thick No. 57 stone open-graded base
- No. 2 stone subbase - thickness varies with design
- Inert permeable liner on bottom and sides of open-graded base
- Soil subgrade sloped to drain
- Typical No. 8 aggregate in openings
- Curbside restraint with cutouts for overflow drainage or optional overflow pipe
- Concrete pavers min. 3/8 in. (80 mm) thick
- Bedding course 1½ to 2 in. (40 to 50 mm) thick (typ. No. 8 aggregate)
- Perforated pipes spaced and sloped to drain all stored water
- Outfall pipe(s) sloped to storm sewer or stream
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
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

Filling the openings with No. 8 stone, final compaction

Excess stones removed, then final compaction
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

Keeping sediment away from the pavers
PICP Inspection Checklist

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

PICP Maintenance

Sweeper Effectiveness

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

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.
**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**

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**Features**

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
<th>Advantages</th>
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<tbody>
<tr>
<td>Units are cured before installation</td>
<td>No waiting 3 to 7 or more days</td>
<td>Immediately ready for traffic</td>
</tr>
<tr>
<td>Modular units</td>
<td>Design Flexibility</td>
<td>Can be used for many pavement type: walks, drives, parking areas, low speed roads, industrial yards</td>
</tr>
<tr>
<td>Textured surface</td>
<td>Slows traffic</td>
<td>Decreases accidents</td>
</tr>
<tr>
<td>Very dense concrete</td>
<td>High resistance to de-icing salts</td>
<td>Long wearing life and low maintenance</td>
</tr>
<tr>
<td>Modular units</td>
<td>Simple access to underground utilities</td>
<td>Short repair time, re-use existing pavers</td>
</tr>
</tbody>
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**Case Studies & Project Profiles**
Thank you!