Grow Green
Permeable Paver Installation & Maintenance
November 17, 2020

Presented By
Dave Hasness, P.E.
CityStone

Contemporary feel meets design versatility for stunning results

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Interlocking Concrete Pavement (ICP)
Segmental Retaining Walls (SRW)
Permeable Interlocking Concrete Pavement
(PICP)
They paved paradise and put up a parking lot . . .

Joni Mitchell
Traditional Design:
A Shift in Thinking: Low Impact Design (LID)

The 3 D’s Paradigm

- Disconnect
- Distribute
- Decentralize
Construction of Permeable Interlocking Concrete Pavement Systems

INTRODUCTION
Permeable interlocking concrete pavement (PICP) is recognized by federal and state stormwater and transportation agencies as a Best Management Practice (BMP) and Low Impact Development (LID) tool to reduce runoff and water pollution. In addition, PICP offers unique design opportunities for addressing combined sewer overflows with green alleys and streets, as well as use in parking lot and pedestrian surfaces. Traditional stormwater management solutions focus on collecting, concentrating and centralizing the disposal of stormwater. As a key BMP and LID tool, PICP helps disconnect, decentralize and more widely distribute runoff through infiltration, detention, filtering and treatment.

The Interlocking Concrete Pavement Institute (ICPI) provides a comprehensive, 92-page manual entitled Permeable Concrete Pavement Construction Manual to reinforce and promote PICP. The manual was collaboratively developed through ICPI’s industry partners, and is a practical resource for ICPI membership and the building industry at large. The manual outlines the technical guidance and construction techniques needed to install a high-quality PICP system. This bulletin is intended for contractors and project inspectors.

Figure 1 illustrates a typical PICP cross-section with the individual components defined below.

Concrete pavers—Solid concrete pavers with molded joints and/or openings that create an open area across the pavement surface. Concrete pavers should conform to ASTM C 936 (ASTM 2012) in the U.S. or CSA A231.2 (CSA 2006) in Canada. Pavers are typically a minimum of 3 1/8 in. (80 mm) thick for vehicular areas and pedestrian areas may use 2 3/8 in. (60 mm) thick units. Pavers are manufactured in a range of shapes and colors. Filled with permeable joint material, the openings allow water from storm events to freely infiltrate through the pavement surface.
Permeable Paver Shape & Thickness

Products

Eco-CityLock® 4x12 10cm
Eco-CityLock® 4x16 10cm
Eco-CityLock® 4x8 6cm
Eco-CityLock® 5x10 8cm
Eco-CityLock® Demi 8cm
Eco-CityLock® Herringbone 5x10 8cm
Eco-CityLock® L-10 8cm
Eco-Panorama™ Demi 8cm
PICP
Open Graded Aggregate Base Materials

ASTM #8, #9

ASTM #57

ASTM #2, #3, #4

Washed - < 2% No. 200
Angular - 90% Fractured
Hard - < 40 LA Abrasion

ASTM Gradations Are Guidelines And May Be Substituted
System Components

Concrete Pavers
Permeable Joint Material
Open-graded Bedding Course
Open-graded Base Reservoir
Open-graded Subbase Reservoir
Underdrain (as required)
Optional Geotextile Under Subbase
Subgrade Soil – Uncompacted OR Compacted
Eco-CityLock Demi 4x8, 8x8, 8x12 – 3 1/8
Mueller
Austin, TX
Belvedere
Austin, TX
Permeable Paver Thickness

60mm 2 3/8”

80mm 3 1/8”

80mm-100mm 3 1/8” - 4”

Light Duty

Medium Duty

Heavy Duty
TCEQ RG-348 Approval
Innovative Technology (Sections 3.2.20, 3.4.19, 3.5.23)

Addendum Issued 12/14/11 Includes Permeable Pavers

Provides the specific technical language that has been approved by the TCEQ Edwards Aquifer Protection Program. “The TSS removal of a properly constructed permeable paver pavement is 89%.”
Porous pavement for pedestrian and vehicular uses counts as pervious cover when calculating the Water Quality Capture Volume outside the Barton Springs Zone.

Porous Pavement Adopted on 12/30/14 ECM 1.6.7E
- Expanded ECM to allow Water Quality credit for pedestrian and vehicular surface
- Open to public and privately maintained facilities such as parking lots, driveways, streets and alleys
**Impervious Cover Calculations Exclude**

- Porous pavement designed in accordance with the Environmental Criteria Manual, limited to only pedestrian walkways and multi-use trails, and located outside the Edwards Aquifer Recharge Zone.

- Fire lanes designed as prescribed by the Environmental Criteria Manual, that consist of interlocking pavers, and are restricted from routine vehicle access.
Industry Design Standard of Practices

Permeable Interlocking Concrete Pavements
5th Edition

Permeable Interlocking Concrete Pavements
ASCE/T&D/ICPI 68-18
Permeable Design Pro Engineering Software


Free Download from ICPI
Construction / Installation Processes

- Preconstruction Meeting
- Erosion and Sediment Control Measures
- Prepare Subgrade
LID

Design:

Austin Animal Center
Austin, TX
Geosynthetic Placement
Geosynthetics for Segmental Concrete Pavements

This Tech Spec provides fundamental information on geosynthetics including a brief history, uses, and basic applications for interlocking concrete pavements (ICP) and permeable interlocking concrete pavements (PICP). While this Tech Spec provides some general guidelines on engineered applications, it is not intended to provide geosynthetic engineering design advice. While many of the general principles and applications of geosynthetics are easily understood, the field of geosynthetics and the technical information available is too voluminous for a single technical bulletin. This Tech Spec is presented as an introduction to the wide range of geosynthetic materials available, as shown in Figure 1, for readers interested in this subject and its application to segmental concrete pavements.

Stabilize roadway soils and their edges. Natural fibers and fabrics were later mixed with soil to improve road quality, particularly when built on unstable soil. Such materials were also used to stabilize steep slopes and walls such as ancient ziggurats. While many of the earliest attempts to improve or reinforce soil were not recorded, there is some evidence. Some of the oldest roads in Britain utilized split logs, or a 'corduroy' road, laid over peat bogs to provide a stable platform. There is also evidence that in some cases a stabilized soil mixed with paving stones or paving blocks were placed over the corduroy road.

Obviously, natural materials in soils led to biodegradation from microorganisms. The advent of polymers in the mid-twentieth century provided longer lasting and more reliable alternatives.
Impermeable Liner & Geotextile Placement
Subbase Aggregate Placed (ASTM No. 2, 3, 4)
**PICP Construction**

**Base and Subbase Compaction**

ASTM #2/#3/#4

6" Lifts typical with surface tolerance +/- 2.5" over 10 ft

2 Passes Vibratory 10ton

2 Passes Static 10ton

ASTM #57

4" Lifts typical with surface tolerance +/- 0.75" over 10 ft

2 Passes Vibratory 10ton

2 Passes Static 10ton

To confirm compaction, use a light-weight deflectometer or a nuclear density gauge in backscatter mode
Placing Base on Subbase

Base Aggregate (No. 57 Stone)

Subbase Aggregate (No. 2, 3, 4 Stone)
Spreading the Base
Compacting the Base
Edge Restraint installed
### Table 1. Recommended edge restraints for PICP

<table>
<thead>
<tr>
<th>Edge Restraint Type</th>
<th>Pedestrian Only</th>
<th>Residential Driveway</th>
<th>Parking lot or street</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast-in-place concrete curb</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Precast concrete curb</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cut stone curb</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Compacted, dense-graded berms around PICP base perimeter with spiked metal or plastic edging to restrain Pavers</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
PAVER
BEDDING COURSE THICKNESS VARIES WITH DESIGN (TYP. #8 AGGREGATE)
4' - 6' GEOGRID APRON TENAX MS220B OR EQUAL
OPEN-GRADED BASE COURSE(S) THICKNESS VARIES WITH DESIGN (TYP. #57 AGGREGATE)

AGGREGATE IN OPENINGS
GEOEDGE PERMEABLE EDGE RESTRAINT
GEOEDGE CAPTURE PLATE 3" x 10"
1/4" - 14 x 1-1/4" HEX WASHER SELF TAPPING SCREW
Place Bedding on Base

Base Aggregate (No. 57 stone)

Bedding Aggregate (No. 8, 89, 9 stone)
Place Bedding and Screed to 1-1/2" to 2" thick
Placing Joint Aggregate and Compacting
PICP Construction

ASTM #8/#9 Vibration Into Joints

Plate Compactor Minimum 5000 lbf

Minimum 2 Repetitive Stoning / Sweeping / Vibrating Passes Prior To Continual Trafficking
PICP Construction

Inspection during construction
PICP

Inspection during construction
PICP Construction
Green Infrastructure

Chicago, IL & Portland, OR (Depaving)

• Reduced combined sewer overflows
• Less expensive than separating storm & sanitary sewers
• Supports tree growth
• Improves neighborhood character

Images courtesy of Chicago DOT
**PICP Construction**

**Permeable Pavers**
- TYP. NO. 8, 89, OR 9 aggregate in openings
- Bedding course 2 in. (50 mm) thick (TYP. NO. 8 aggregate)
- 4 in. (100 mm) thick NO. 57 stone open-graded base

**Surface Water Flows**
- Thru between pavers
- Slope 1% away from building for 10 ft (3 m)

**Building Wall**
- Cut impermeable liner flush with top of pavers
- Optional drainage board
- 30 mil thick PVC geomembrane T/W 8 oz. nonwoven protective geotextile

**Building Footing**
- Distance to suit local ground conditions

**Note:**
1. Select geotextile per AASHTO M 288.

**Foundation Wall Protection from PICP**

**Drawing No.**
ICPI-93

**Scale:**
No scale
Alleyway Construction
Return 3 to 6 months after completion of construction to inspect pavement and refill joints with aggregate.
PICP
Routine Maintenance

Periodic Inspection - Testing ASTM C1781

Designation: C1781/C1781M-14

Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems

8. Procedure

8.1 Infiltration Ring Installation—Clean the pavement surface by only sweeping off trash, debris, and other non-seated material.

\[
\geq 50 \text{ mm [2.0 in.]} \\
300 \text{ mm } \pm 10 \text{ mm [12.0 in. } \pm 0.5 \text{ in.]} \\
\text{FIG. 1 Dimensions of Infiltration Ring}
\]
## Infiltration Rate of Eco-CityLock Herringbone 5x10 Permeable Pavers

<table>
<thead>
<tr>
<th>Test No.</th>
<th>Head Water (inches)</th>
<th>Water Infiltrated (pounds)</th>
<th>Elapsed Time (seconds)</th>
<th>Infiltration Rate (inches per hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.4 - 0.6</td>
<td>40.0</td>
<td>40</td>
<td>881</td>
</tr>
<tr>
<td>2</td>
<td>0.4 - 0.6</td>
<td>40.0</td>
<td>39</td>
<td>904</td>
</tr>
<tr>
<td>3</td>
<td>0.4 - 0.6</td>
<td>40.0</td>
<td>38.6</td>
<td>913</td>
</tr>
<tr>
<td>Average</td>
<td>0.4 - 0.6</td>
<td>40.0</td>
<td>39.2</td>
<td>899</td>
</tr>
</tbody>
</table>

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Client: Pavestone, LLC  
Project: Eco-CityLock 5x10 80 mm #324  
Project No.: 20-00365-900-01  
Report No.: 14306  
Date of Service: 10/8/2020  
Report Date: 10/27/2020

Respectfully submitted,

Kenneth L. Bownds, P.E.  
Supervising Engineer  
Jack Gary  
General Manager
Maintenance Guide for Permeable Interlocking Concrete Pavements

Introduction
Permeable interlocking concrete pavements (PICP) are a proven method for reducing stormwater runoff and pollutants while supporting pedestrian and vehicular traffic. Many laboratory and in-situ research projects over the past two decades by universities, government stormwater agencies, and industry have demonstrated significant runoff and pollutant reductions with cost-saving benefits. The U.S. Federal Highway Administration [www.fhwa.dot.gov/pavement/concrete/pubs/hif15006.pdf](http://www.fhwa.dot.gov/pavement/concrete/pubs/hif15006.pdf) has published information supporting PICP use in walkways, plazas, driveways, parking lots, alleys and streets.

Like all stormwater control measures, PICP requires maintenance as it traps sediment on its surface not unlike an air conditioning filter. Larger particles are initially trapped while allowing water to pass. Some enter the jointing stone and are trapped there. The jointing stone with larger particles eventually captures smaller particles and this decreases the infiltration rate over time. While still infiltrating water, many smaller particles are trapped within the surface and interior joints. Smaller particles are trapped and eventually decrease infiltration which results in surface ponding.
<table>
<thead>
<tr>
<th>ICP (ASTM E2840)</th>
<th>Asphalt (ASTM D6433)</th>
<th>Rigid Concrete (ASTM D6433)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damaged pavers</td>
<td>Alligator cracking</td>
<td>Corner break; D cracking; Scaling, map cracking and crazing; Shrinkage cracks; Spalling, corner/edge</td>
</tr>
<tr>
<td></td>
<td>Weathering &amp; raveling</td>
<td></td>
</tr>
<tr>
<td>Depressions</td>
<td>Depressions</td>
<td></td>
</tr>
<tr>
<td>Edge restraint</td>
<td>Edge cracking; Lane/shoulder drop off</td>
<td>Lane/shoulder drop off</td>
</tr>
<tr>
<td>Excessive joint width</td>
<td>Longitudinal &amp; transverse cracking</td>
<td>Divided slab</td>
</tr>
<tr>
<td>Faulting</td>
<td>Joint reflection cracking Slippage cracking</td>
<td>Faulting</td>
</tr>
<tr>
<td>Heave</td>
<td>Bumps and sags; Swell</td>
<td>Punchout</td>
</tr>
<tr>
<td>Horizontal creep</td>
<td>Corrugation; Shoving</td>
<td></td>
</tr>
<tr>
<td>Joint sand loss/pumping</td>
<td>Bleeding</td>
<td>Joint seal damage / Pumping</td>
</tr>
<tr>
<td>Missing pavers</td>
<td>Potholes</td>
<td>Popouts</td>
</tr>
<tr>
<td>Patching</td>
<td>Patching &amp; utility cut patching</td>
<td>Patching, large &amp; small, utility cuts</td>
</tr>
<tr>
<td>Rutting</td>
<td>Rutting</td>
<td>Linear cracking</td>
</tr>
<tr>
<td>Polished aggregate</td>
<td></td>
<td>Polished aggregate</td>
</tr>
<tr>
<td>Railroad crossing</td>
<td></td>
<td>Railroad crossing</td>
</tr>
</tbody>
</table>
LID Design:

How’s that working out?

Brazos Street
Austin, TX
Cleaning Small Pedestrian Areas and Driveways

- Hand-held Bristle Broom
- Leaf Blower
- Rotary Brush with Plastic Bristles
- Wet/Dry Shop Vacuum or Walk-behind vacuum
- Power Washer
Cleaning Large PICP Areas
- Street Sweeper
- Regenerative Air Sweeper
PICP
Routine Maintenance

**Sweeping / Vacuuming Intervals**

Recommended Minimum 1 - 2x Year

O&M Cost Estimated To Be $ .02 - .05 / sf
Gragg Park Complex - Houston, TX
Gragg Park Complex - Houston, TX
Allston Way
Berkeley, CA
Eco-CityLock Series

Centro Plaza at VIA Villa
San Antonio
Sea Star Base - Galveston, TX

Quartex/ Shotblast/ Standard Finishes
LID Design:

Sea Star Base
Galveston, TX
Eco-Panorama Demi
4x8, 8x8, 8x12 – 80mm

Austin, TX
Belo Center for New Media
University of Texas
Austin, TX
Costs

Assumptions:
- Paver Thickness: 3 in.
- Bedding Layer: 2 in.
- Base/subbase: 14 in.
- Total Area: 15,000-20,000 SF
- Prevailing Wages
- Does NOT include design and excavation
- $10 - 12/SF
Technical Support

Specifications / Details / Marketing Materials
Facilitate Preliminary Design / Cost Estimation
Promote / Support Product Acceptance
Questions?

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