Technical Guide

Permeable Interlocking Concrete Pavement

A Best Management Practice to Control Stormwater Runoff

Willow Creek™
Permeable Pavers

WillowCreekPavingStones.com

ECOLOGICAL BENEFITS

- Reduce pollutant runoff into waterways
- Reduce thermal pollution of waterways
- Reduce “heat island” effect of paved surfaces
- Recharge groundwater

ECONOMIC BENEFITS

- Gain usable space on properties
- Reduce need for retention ponds
- Reduce costs of stormwater drainage
- Earn LEED credits

PERFORMANCE BENEFITS

- Eliminate puddles on paved surfaces
- Allow snowmelt to drain, eliminating re-freeze
- Low maintenance

BEST PRACTICES TO CONTROL STORMWATER RUNOFF

When stormwater runoff from parking lots, driveways, sidewalks and other surfaces gets diverted into rivers through storm sewers, the water is not available to replenish the local groundwater supply. Stormwater runoff also may carry various contaminants, such as fertilizers, pesticides, vehicle fluids and pet waste into waterways. Carrying potentially heavy concentrations of pollutants, stormwater runoff poses water quality issues in urban, suburban and rural environments.

Fortunately, awareness of the problem is growing, and mitigating technologies have become available. Newer pavement technologies, including permeable interlocking concrete pavements (PICP), allow rainwater and snowmelt to pass through paver voids into the soil directly below. The water then replenishes the local groundwater supply. PICP systems also help protect aquatic ecosystems, conserve water resources and mitigate flood risk, while supporting vehicle and pedestrian traffic.

NOTE: PICP systems should not be used on sites where stormwater infiltration could contaminate groundwater. Such sites include fueling and hazardous materials storage stations or high water tables, where soil is not deep enough to adequately filter pollutants.

A BEST MANAGEMENT PRACTICE (BMP)

Willow Creek® permeable pavers provide an attractive, high-performance PICP stormwater management option suitable for residential, commercial and public works applications. A PICP system incorporating Willow Creek permeable pavers allows water to drain quickly through the paved surface and into the subsurface through aggregate-filled voids between adjacent pavers. The water then infiltrates into the ground or can be harvested for irrigation or other uses. On-site infiltration helps keep pollutants out of waterways and also reduces downstream erosion and development costs related to drainage system installation. Willow Creek permeable pavers can be integrated with other BMPs as well, including swales, bioretention catches and rain gardens.

In the early 1990s various public agencies created regulations and BMPs to control stormwater runoff. The U.S. Environmental Protection Agency (EPA) established the National Pollutant Discharge Elimination System (NPDES) regulations. The agency continues to work with stormwater regulatory agencies and environmental organizations to promote the use of low-impact development (LID) to better manage runoff.

The U.S. Green Building Council created the Leadership in Energy and Environmental Design (LEED®) system to assess new construction. The system has been adopted by various public agencies. Increasingly, specifiers write LEED certification requirements into bid specifications, including requirements for on-site stormwater management.

The cost to install a PICP system is site-specific and needs to be compared to the cost of an urban street cross-section that performs all the functions of a permeable system. The durability and low maintenance costs of PICP systems deliver an economic advantage when factoring total life-cycle costs.

Select Series

WILLOW CREEK SELECT SERIES

Willow Creek Select Series™ permeable pavers are available in four attractive and functional families that can be laid easily by hand. Select Series permeable pavers have been tested by an independent, certified laboratory to meet or exceed permeability standards (ASTM C1781).

Slatestone™ and Slatestone Grande™ pavers deliver the look of traditional pavers and slabs while providing the full advantages of a permeable surface. Each can work alone or can be combined for expanded design options.

Dekrastone™ pavers can be laid in herringbone, basketweave and running-bond patterns alone or in combination with traditional pavers — with a seamless transition between permeable and impermeable surfaces.

Delivering a more traditional look, Eurostone™ pavers embody the perfect marriage of form and function. With their design, Eurostone pavers' three-unit pattern creates an elegant, dynamic paved surface.

INFUSION™ TECHNOLOGY By Willow Creek

INFUSION TECHNOLOGY

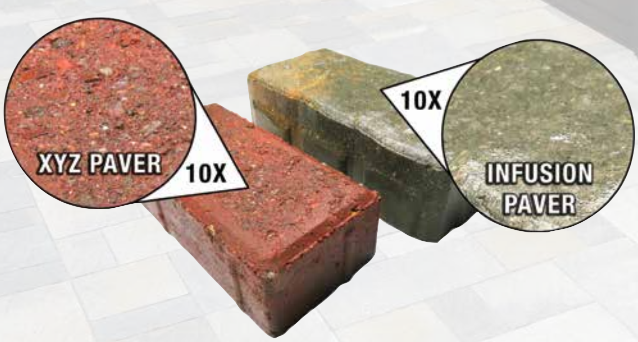
Infusion™ technology is an advanced manufacturing process that enhances not only the appearance, but also the performance, of Willow Creek Select Series pavers. The Select Series includes Willow Creek's Slatestone, Slatestone Grande, Eurostone and Dekrastone paver families. Select Series pavers are ideal for both traditional and permeable installations. Infusion technology extends the life of any paved surface, from patios and driveways to courtyards and pool decks.

- Enhances paver color and extends the life of the paver's bright, vibrant "new paver" look
- Improves stain resistance for everyday use
- Reduces absorption, making the paver more durable

Infusion technology has proven its reliability through rigorous testing. Pavers manufactured using the Infusion process have been exposed to all four seasons in the Upper Midwest to test for the effects of weathering. Timed muriatic acid durability tests prove that pavers manufactured using the Infusion process show less surface degradation than other pavers.

INFUSION™ TECHNOLOGY By Willow Creek

Acid Bath Results



Watch test video at:
willowcreekpavingstones.com/infusion-technology

Water Repellency Results

ACCESSIBILITY

Design guidelines included in the Americans with Disabilities Act (ADA) require that surfaces in pedestrian access routes be firm, stable and slip resistant. Surface openings in these areas should readily accommodate persons traveling with wheeled mobility devices, such as wheelchairs. When designed properly, PICP installations can meet ADA requirements. PICP units can be multi-colored (or painted) to indicate pedestrian access routes as well as parking stalls and lanes for vehicles.

PROPER INSTALLATION

When properly constructed, a PICP system should provide 15 to 20 years of service before major maintenance is needed. The system's service life is measured by its ability to store runoff, infiltrate it and to support vehicular traffic with little or no rutting. With regular inspection and maintenance to measure performance, identify problems and implement solutions, a PICP system can continue to function indefinitely. The PICP owner plays a key role in ensuring long-term PICP performance. However, performance begins with the contractor correctly building the open-graded subbase and base.

SUBBASE, BASE & BEDDING MATERIALS

The Interlocking Concrete Pavement Institute (ICPI) recommends certain ASTM stone gradations for the subbase, base and bedding layers (see diagram, page 6). The gradations for these stone sizes are identified with numbers. The numbers and gradations are found in ASTM D448, Standard Classification for Sizes of Aggregate for Road and Bridge Construction (See Table 1). ICPI recommends ASTM No. 2 stone subbase because it is very stable under construction equipment and has a high water storage capacity (No. 3 also works well). Also recommended are No. 57 stone for the base (over the No. 2) and No. 8 stone for the bedding layer.

Table 1. ASTM Sieve Sizes for No. 2, 57 and 8 Stone Sizes

	Percent Passing		
Sieve Size	No. 2	No. 57	No. 8
3 in. (75 mm)	100		
2.5 in. (63 mm)	90 to 100		
2 in. (50 mm)	35 to 70		
1.5 in. (37 mm)	0 to 15	100	
1 in. (25 mm)		95 to 100	
3/4 in. (19 mm)	0 to 5		
1/2 in. (12.5 mm)		25 to 60	100
3/8 in. (9.5 mm)			85 to 100
No. 4 (4.75 mm)		0 to 10	10 to 30
No. 8 (2.36 mm)		0 to 5	0 to 10
No. 16 (1.16 mm)			0 to 5

The No. 2 subbase thickness is typically 6" to 18" (150 mm to 450 mm), depending on the amount of water storage required, soil type and the amount of traffic. The water storage capacity of this layer is typically around 40 percent of the total base volume. The 4" (200 mm) thick No. 57 stone layer is used for the base and has a water storage capacity between 30 percent and 35 percent. Instead of sand, a 2" (50 mm) thick No. 8 stone functions as the bedding layer and jointing material. No. 8 stone has about 20 percent void space between its particles.

All stone materials should be crushed for the highest interlock and stability during construction and load-spreading capacity during service. There are variations on these ASTM gradations that have been successfully used across North America. Many state and provincial departments of transportation have specifications similar to the ASTM gradations. These are acceptable as long as the bedding layer chokes into the base and the base into the subbase, thereby creating a stable structure for traffic.

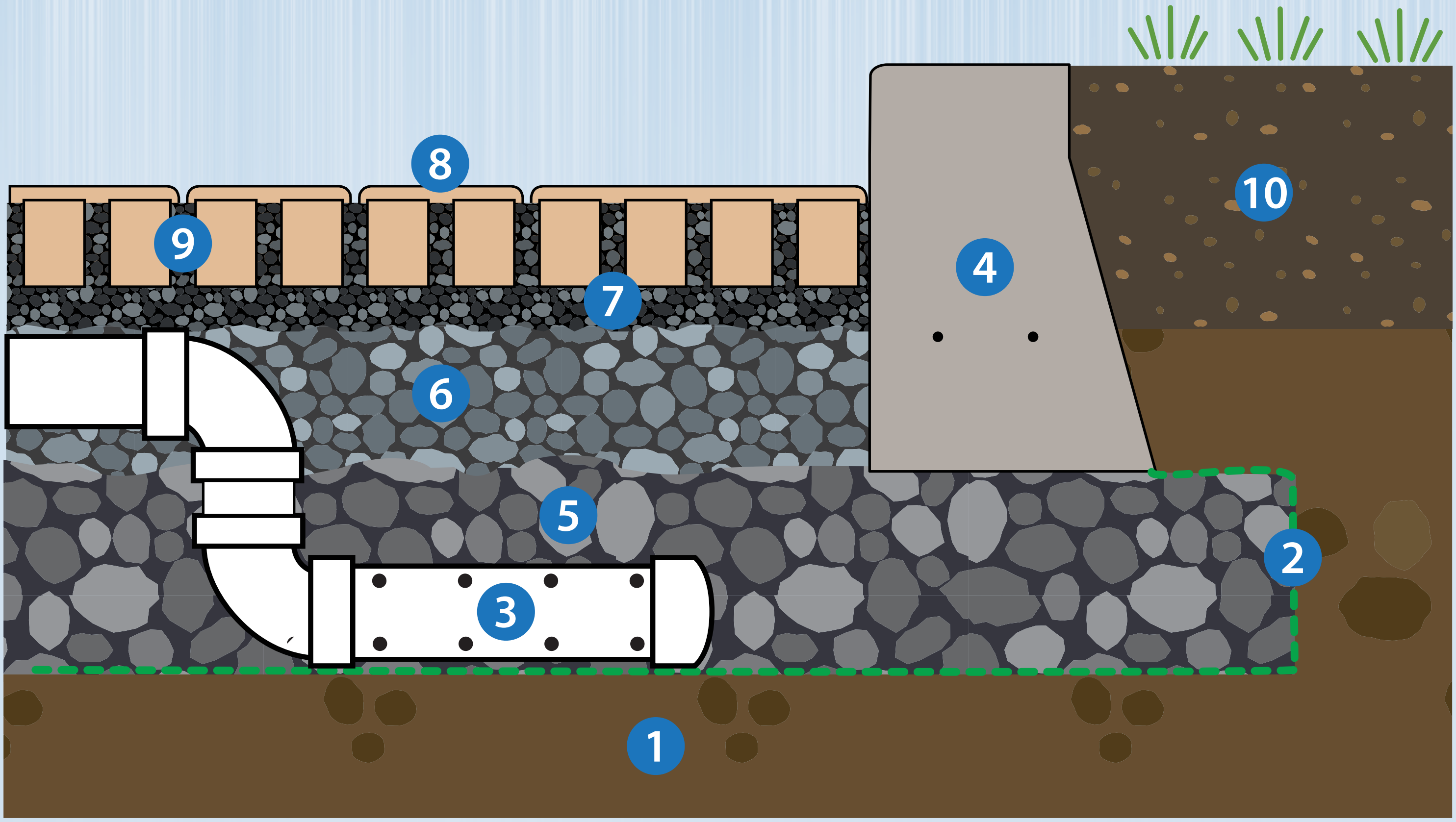
Installers should not assume that indigenous stone will be suitable for the subbase, base or bedding layers. Softer stone, such as varieties of limestone, will not always perform adequately under repeated, heavy loading. Granite and other igneous materials of similar hardness are recommended to ensure consistent, long-term performance under heavy loads.

ESTIMATING QUANTITIES

Quarries supplying crushed stone should be able to provide the bulk density of open-graded aggregate per ASTM C29 Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate. If not, the test can be done by a soils-testing laboratory. This test approximates the density in pounds per cubic foot or kilograms per cubic meter as well as the percent of open space. For example, a No. 57 stone might have a bulk density of 120 lbs./ft^3 (1,922 kg/m^3). Therefore, a U.S. ton would consist of about 17' 3" (0.48 m^3). At 4" (200 mm) thick, this would cover about 50 s.f. (4.6 m^2). Similar calculations can be done on other stone sizes when the bulk density

(continued on page 8)

Permeable Interlocking Concrete Pavement (PICP) Cross Section



Note: For illustrative purposes only.

1 SUBGRADE/SUBSOIL

Soil conditions will affect the design requirements and ultimately the performance of a permeable paver system. Site and soil analysis prior to construction should be conducted, including percolation rates, California Bearing Ratio (CBR) and other assessments. After excavation, avoid compacting the subsoil to prevent loss of infiltration. Subsoils that have less than .05" (1.27 mm) of infiltration per hour may need amendments, ex-filtration pipe and scarification. Subsoils that have higher than .5" (13 mm) infiltration per hour are considered ideal.

2 GEOTEXTILES

Geotextiles are used in permeable pavement applications when subsoil conditions require extra stability. In situations where non-woven geotextile fabric is needed, it is positioned between the subgrade and subbase aggregate (ASTM No. 2) only. Geotextile fabric is not required between aggregate material layers. The type of geotextile is determined by soil conditions and load requirements (pedestrian versus vehicular) of a specific project. Geotextile fabrics also should be considered for conditions in which soil movement might occur.

3 EXFILTRATION PIPES

The use of exfiltration pipes depends on the site's subsoil conditions, detention requirements and stormwater infiltration rate. The perforated pipe is laid along the bottom to catch the cleanest water possible. It is configured to only release water after subbase and base layers are filled. In highly permeable subsoil, exfiltration pipes might not be needed.

4 EDGE RESTRAINT

Permeable pavement containment is essential to the success of the interlock and life of the system. Failure of or missing edge restraints will adversely affect surface integrity. For vehicular applications, a cast-in-place concrete curb may be required or other special considerations for adjoining pavements. For non-vehicular and pedestrian areas, plastic edging is sufficient when a specially designed edging is used.

5 SUBBASE AGGREGATE - ASTM NO. 2

Subsoil conditions dictate the necessity of larger ASTM No. 2, crushed, angular, open-graded subbase aggregate thickness. It will provide increased structural stability on sites with poor soil conditions. A minimum thickness of 12" (304.8 mm) is required for effective performance. Subbase aggregate layer thickness must be designed to sufficiently support anticipated loads. The ASTM No. 2 subbase aggregate temporarily detains stormwater runoff in the 40 percent void-space of the material. The ASTM No. 2 has an infiltration rate of over 500" (12,700 mm) per hour.

6 BASE AGGREGATE - ASTM NO. 57

The ASTM No. 57 open-graded (no fines) base aggregate, with a minimum thickness of 4" (102 mm), serves as a transition material and is sometimes referred to as the choker course between the ASTM No. 8 setting bed and the ASTM No. 2 subbase aggregate. The infiltration rate of the ASTM No. 57 is more than 500" (12,700 mm) per hour.

7 SETTING BED AGGREGATE - ASTM NO. 8

Using the 0.25" (6.35 mm) crushed, angular open-graded chip stone instead of sand provides a smooth leveling course for setting pavers as well as additional structural interlock of the PICPs. Unlike sand, the setting bed aggregate allows for rapid water infiltration with over 500" (12,700 mm) per hour. Do not use sand as a setting bed in a PICP application.

8 WILLOW CREEK PERMEABLE PAVERS

PICPs are the most durable porous-pavement material available and are suitable for residential, commercial and public works applications. Willow Creek's minimum 8,500 psi (57 MPa), high-strength, no-slump concrete allows water to infiltrate between paver units instead of through the units. With proper installation and maintenance, Willow Creek's PICP products are firm, stable and slip resistant. A variety of color and shapes can be used in a surface to indicate pedestrian access, parking lanes for vehicles and other functionality. For more information, visit WillowCreekPavingStones.com.

9 JOINT AGGREGATE - ASTM NO. 8

As the initial filtering layer, the 0.25" (6 mm) crushed, angular chip stone captures approximately 80 percent of debris in the first 1" (25 mm) to 2" (51 mm). The secondary function of the joint aggregate is to increase the positive interlock between the paver units that is essential to the structural stability of the PICPs. The joint aggregate must always remain filled to within .25" of the top of PICP units to reduce clogging.

10 BACKFILL MATERIAL

Because a key consideration in constructing a successful PICP surface is keeping it free from sediment and fines, the backfill against a curb or edge restraint should be graded to avoid eroding and "washing" onto the permeable surface during a heavy rainfall. Adjacent properties, pavements, landscaped areas and grasses should be monitored periodically to ensure that run-off from these sources is not depositing silts and debris on the permeable surface.

is known. Open-graded stone base materials will cost more than dense-graded base materials since open-graded stone is washed and handled separately from other materials at the quarry.

SITE CLEANLINESS

Preventing and diverting sediment from entering the base and pavement surface during construction must be the highest priority. In the best case, aggregates can be dumped, spread and compacted when they arrive at the site. If aggregates are stored in piles on the site, storing them on hard pavement or on geotextile over soils will help keep them from getting contaminated by soil. Extra care must be taken to keep sediment away from the stone materials and the open excavation. Simple practices such as keeping muddy construction equipment away, installing silt fences, staged excavation, and temporary drainage swales that divert runoff away from the area will make the difference between a pavement that infiltrates well or poorly.

Moreover, the pavement should not receive runoff until the entire contributing drainage area is stabilized with vegetation. Obviously, vegetation doesn't grow overnight, and rain likely will fall after the pavement is installed. Therefore, erosion control blankets and sediment wattles can stabilize soil while grass or other vegetation starts to grow. This should be included in the construction drawings and specifications. Sometimes there is a stretch of time between excavation and base installation. The opening will collect water and sediment from rainstorms. One technique for reducing silting and clogging of soil is to excavate the base within 6" (150 mm) of the final bottom elevation. Like a temporary detention pond, this area can contain water during storms over the construction period and drain via temporary drain pipes. Sediment is allowed to collect on the surface of the soil subgrade.

Heavy equipment should be kept from the excavated area to prevent compaction. If equipment needs to traverse the bottom of the excavation, tracked vehicles can reduce the risk of soil compaction. As the project progresses and base is ready for placement, the remaining soil depth can be excavated out to the final grade prior to installing the subbase and base stone.

SOIL COMPACTION

PICP systems usually are built over native, undisturbed soils. Equipment passing over the soil subgrade surface will cause some unavoidable compaction. However, if the soil is inadvertently and repeatedly compacted by equipment during construction, there will be a substantial loss of infiltration. A loss is acceptable if the infiltration rate of the soil when compacted was initially considered during design and in drainage calculations. However, this should be verified at the pre-construction meeting with the design engineer.

In rare situations it may be necessary to compact soils (typically clays) that have a California Bearing Ratio (CBR) of less than 5 percent. This attains sufficient structural support and minimizes rutting from vehicular traffic. These soils should be compacted to at least 95 percent of standard Proctor density per ASTM D698. Nuclear density tests should be performed to verify compaction to this guideline. A network of perforated drain pipes in the open-graded base will likely be required to remove water since compaction will greatly reduce the soil's permeability. Again, compacting soils isn't common to most PICP projects.

GEOTEXTILES

Geotextiles are used in some permeable pavement applications and are optional when using a No. 2 aggregate subbase. No. 2 stone essentially acts as a filter layer while providing additional stability. For vehicular applications, high-quality woven fabric should be specified that resists puncturing by coarse, angular aggregate from compaction during construction and from repeated wheel loads during its service life. Bases should have their sides covered in geotextile. If using geotextile over the top of the soil subgrade, ICPI recommends a minimum of 1' (0.3 m) overlap in well-drained soils and 2' (0.6 m) overlap on poor-draining weaker soils (CBR < 5%). Suitable geotextile materials will vary with site conditions. Select a geotextile with a permeability well in excess of the subgrade's permeability.

OPEN-GRADED AGGREGATE BASES

No. 2 subbase material should be spread in minimum 6" (150 mm) thick lifts and compacted with a static roller. At least four passes should be made with a minimum 10-ton (9 T) steel drum roller. The roller is often in vibratory mode for the first few passes and then static mode (no vibration) for the final passes. This compaction method applies to the No. 2 and No. 57 layers. The No. 57 base layer can be spread and compacted as one 4" (100 mm) lift. Compacting is easier when all stone surfaces are moist. This enables the particles to slide and move into their tightest fitting configuration more easily. When riding on the No. 2 subbase and the No. 57 base, equipment drivers should avoid rapid acceleration, hard braking and sharp turning on the compacted layers. Tracked equipment is recommended. If the base surfaces are disturbed, they should be re-leveled and re-compacted.

A test section or mock-up of the base should be constructed and closely monitored during compaction. The section will indicate settlement of the base, and indicate when excessive compaction crushes the aggregate. This should be avoided, as crushing generates fines that can clog the soil subgrade and reduce PICP infiltration effectiveness. The test section can be used to train construction personnel on these and related aspects of PICP installation.

The work crew objective is to have no visible movement in the stone during the last compactor pass and no crushing of the stone. When all lifts are compacted the surface should then be covered with a 2" (50 mm) thick layer of moist No. 8 crushed stone. This layer of finer crushed stone is screeded and leveled over the No. 57 base. The No. 8 should be moist to facilitate movement into the No. 57. No. 8 stone should be compacted. The surface tolerance of the screeded No. 8 material should be ±3/8" over 10' (±10 mm over 3 m). Construction equipment and foot traffic should be kept off the screeded layer.

Concrete pavers should be placed immediately after the No. 8 base bedding is placed and screeded. Mechanical installation appears to be used more often as most PICP projects are large and require efficiency from these machines. After placement, the paver joints are filled with No. 8 stone and compacted with a minimum 5,000 lbs. (22 kN) plate compactor. The compactor force on the pavers pushes the No. 8 stone into the upper portion of the No. 57 stone base.

A key consideration in constructing a PICP base is keeping it free from sediment and fines. These materials come from equipment or from eroding surfaces near them. They also come from crushing stones during compaction. These situations require regular inspection on the part of the contractor to help ensure long-term PICP infiltration.

OPERATION & MAINTENANCE

PICP systems typically will require periodic visual inspections (preferably after a major rainstorm) to determine that the stormwater is infiltrating into the system. Areas that have pooled water standing on the surface need to be addressed as a remedial repair as opposed to normal maintenance.

PICP surfaces and adjoining pavement surfaces will require standard structural BMP practices for pavement maintenance regarding sweeping procedures. A vacuum sweeper may be used during dry periods to remove encrusted sediment, leaves, grass clippings, etc. Vacuum and sweeper settings may require adjustments to prevent uptake of aggregate from the paver voids and joints. Water is not used while vacuuming.

Annual cleaning is normal. But if excessive silts and fines are present, additional monitoring of buildup will be required, and the cleaning schedule will have to be adjusted to remove accumulated debris. Additional void materials may be added by mechanically or manually sweeping into joints and void areas if necessary. Refer to specifications for type and grade. It is not recommended to utilize pressure washers on open-jointed systems.

Adjacent properties, pavements, landscaped areas and grasses should be monitored periodically to ensure that run-off from these sources is not depositing silts and debris on the permeable surface. Construction traffic, agricultural areas (without ground cover), beach areas and areas subject to high winds that will carry these fine particles will require more frequent sweeping than urban areas.

REMEDIAL MAINTENANCE

A commercial vacuum sweeper can be used to remove clogged void materials from joint and void openings. This material may be recycled at a wash site, or new aggregate materials may be utilized. (Refer to specifications for size and grade.) Jointing materials are swept into joints and void openings until full, typically to the bottom of the chamfer.

WINTER MAINTENANCE

A four-season parking surface, street or plaza may be plowed with truck-mounted blades, power brooms, snow-blowers or manually shoveled. Salt may be used to melt ice, and PICP requires less than conventional pavements. Salt will affect the quality and pH of water leaving the PICP system and could require additional monitoring and analysis. Sand should not be used as this will accelerate clogging of the voids and will require more frequent sweeping. Open-graded chips may be used for traction when ice is present, but more than likely will require sweeping and removal in spring.

The Interlocking Concrete Pavement Institute's (ICPI) Tech Spec No. 23, Maintenance Guide for Permeable Interlocking Concrete Pavements, offers detailed information on maintaining PICP surfaces (willowcreekpavingstones.com/resources/brochures).

Melting snow drains immediately through permeable pavers, eliminating the risk of re-freeze.

Impervious surfaces hold standing water and slush, creating a safety hazard when water re-freezes.

Comparison of Permeable Pavement Technologies

	Permeable Pavers	Pervious Concrete	Porous Asphalt
Installs free of time and temperature constraints.	Yes. Can be installed in all temperatures with nonfrozen aggregates and soil subgrade.	No. Cannot be installed in freezing weather. Material curing process imposes time limit on installers.	No. Cannot be installed in freezing weather. Material cooling process imposes time limit on installers.
Available for immediate use	Yes.	No. Requires 7 day curing.	No. Requires 24 - 48 hour curing.
Quick, easy repair	Yes. Modular units can be replaced individually, with no effect on system performance.	No. Repairs to monolithic materials are intrusive and can compromise performance of the system.	No. Repairs to monolithic materials are intrusive and can compromise performance of the system.
Easy access to subsurface for utility work	Yes. Units can be removed and reinstalled quickly and easily.	No. Repairs to sections cut and removed create unsightly patches.	No. Repairs to sections cut and removed create unsightly patches.

For a thorough comparison guide, see "Permeable Interlocking Concrete Pavement, A Comparison Guide to Porous Asphalt and Pervious Concrete" from the Interlocking Concrete Pavement Institute (ICPI).

Willow Creek™ Paving Stones

Willow Creek™ Permeable Pavers

Willow Creek Paving Stones is a member of the Interlocking Concrete Pavement Institute (ICPI). Portions of this document are adapted from several publications available from ICPI, including the "PICP: A Comparison Guide to Porous Asphalt and Pervious Concrete" (see chart above) and the "Permeable Interlocking Concrete Pavements Manual."
The information, including technical and engineering data, figures, tables, designs, drawings, details, suggested procedures and suggested specifications, presented in this publication is for general information only. While every effort has been made to ensure its accuracy, this information should not be used or relied upon for any application without verification of accuracy, suitability and applicability for the use contemplated, which is the sole responsibility of the user. A final, project-specific design should be prepared by a qualified, licensed, professional engineer based on actual site conditions. Willow Creek Paving Stones and Willow Creek Concrete Products disclaims any and all express or implied warranties of merchantability fitness for any general or particular purpose, trademark or copyright in regard to information or products contained or referred to herein.

Unlike other pavement solutions, Willow Creek pavers meet the highest performance standards and aesthetic demands of landscape professionals throughout the Midwest. Willow Creek products are guaranteed to meet or exceed standards for concrete pavers set by ASTM International, including:

- ASTM C936 Standard Specifications for Solid Concrete Interlocking Paving Units
- ASTM C1645 Standard Test Method for Freeze-thaw and De-icing Salt Durability of Solid Concrete Interlocking Paving Units
- ASTM C1781 Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems

PROUD MEMBER icpi Interlocking Concrete Pavement Institute

Guide specifications for Willow Creek permeable pavers are available online at:
willowcreekpavingstones.com/resources/pdf/select-series-guide-specifications.pdf

U.S. GREEN BUILDING COUNCIL USGBC

Interlocking Concrete Pavers Can Earn LEED Points

Sustainable or "green" building can be achieved through LEED® or Leadership in Energy and Environmental Design. Developed by the U.S. Green Building Council (USGBC) in 1998, LEED provides voluntary guidelines for reducing energy and wasted resources from building and site design. Interlocking Concrete Pavements (ICP), including Permeable Interlocking Concrete Pavements (PICPs), are eligible for LEED credits under USGBC and CaGBC guidelines.
For information on qualifications for U.S. LEED credits visit usgbc.org.

GLOSSARY OF TERMS

AASHTO — American Association of State Highway and Transportation Officials

ASTM — American Society for Testing and Materials

Best Management Practice (BMP) — A structural or nonstructural device designed to infiltrate, temporarily store, or treat stormwater runoff in order to reduce pollution and flooding.

Choke course — A layer of aggregate placed or compacted into the surface of another layer to provide stability and a smoother surface. The particle sizes of the choke course are generally smaller than those of the surface into which it is being pressed.

Crushed stone — Mechanically crushed rock that produces angular particles.

Dense-graded base — Generally a crushed aggregate base with fines that, when compacted, creates a foundation for pavements and does not allow significant amounts of water into it. Particle sizes can range from 1.5 in. (40 mm) to smaller than the No. 200 (0.075 mm) sieve.

Fines — Silt and clay particles in a soil, generally those smaller than the No. 200 or 0.075 mm sieve.

Infiltration rate — The rate at which stormwater moves through soil or permeable pavers measured in inches per hour or meters per second.

Open-graded base — Generally a crushed stone aggregate material used as a pavement base that has no fine particles in it. The void spaces between aggregate can store water and allow it to freely drain from the base.

Permeability — The rate of water movement through a soil column under saturated conditions, usually expressed as K in calculations per specific ASTM or AASHTO tests, and typically expressed in inches per hour or meters per second.

Porosity — Volume of voids in a base divided by the total volume of a base.

Porous pavement — A surface full of pores capable of supporting pedestrians and vehicles, e.g. porous asphalt, pervious concrete (cast-in-place or precast units).

Void Ratio — Volume of voids around the aggregate divided by the volume of solids.

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