Eco-Stone® Family of Permeable Pavers

A Concrete Solution To Some Big Environmental Problems

Eco-Stone® Family of Permeable Pavers

The Environmentally Beneficial Paving Systems

Stormwater Management and Control Issues

- Past emphasis was on flood control
- Today's emphasis is also on pollution
- More impermeable areas are increasing stormwater runoff
- Increased runoff is significantly degrading water quality

EPA National Pollutant Discharge Elimination System

- The EPA established NPDES stormwater regulations in the early 1990s to comply with the requirements of the Clean Water Act
- Requires the use of Best Management Practices (BMPs) to manage and control stormwater runoff

Stormwater Management Objectives

Regional authorities, counties and municipalities use a number of design goals for managing stormwater runoff:

- Capture or infiltrate the entire stormwater volume so there is zero discharge from the drainage area
- Capture and treat stormwater runoff to remove a stated percentage of pollutants

Stormwater Management Objectives

- Limit impervious cover to reduce storm-water runoff and pollutants from developments
- Maintain runoff volumes generated by development at or near pre-development levels

Stormwater Management Objectives

- Capture and treat a fixed volume of runoff, typically .75-1.5 in. (18-40mm), which usually contains the highest level of pollutants
- Maintain groundwater recharge rates to sustain stream flows and ecosystems and recharge aquifers

Typical Regulatory Reactions

- On-Site Retention
- Control Discharge Rate/Water Quality
- Limit Amount of Impermeable Areas
- Reduce Sediment/Pollution to Equal Point Sources
- Assessments

Traditional On-Site Retention

- The traditional requirement of on-site retention, such as holding ponds, weirs, or basins, cover large areas of valuable property, are costly to maintain, and can be potentially dangerous
- Critics of uniform on-site detention emphasize the importance of infiltration as a natural way to handle stormwater runoff

Traditional Pavements

- **Asphalt, Portland Cement Concrete and Solid Concrete Pavers**
  - Virtually Impervious
  - Contribute to Increased Stormwater Runoff
  - Negative Contribution to Water Quality
  - Limited Ability to Assimilate Contaminants

Porous Pavement Alternatives

- Porous Asphaltic Concrete
- Porous Portland Cement Concrete
- Grid or Turf Pavers
- Plastic Grids or Cells
- Unsurfaced Dirt Roads & Gravel
- Eco-Stone Family of Permeable Pavers

Porous Pavement Alternatives

- **Porous Asphaltic Concrete and Porous Portland Cement Concrete**
  - May be difficult to construct to spec
  - Tendency to plug up with fines and contaminants deeper within surface
  - Virtually impossible to clean or renew permeability deeper within surface

Porous Pavement Alternatives

- **Grid and Turf Pavers**
  - Utilized when green space is desired or required and for emergency access
  - Aggregate provides more reduction in runoff than turf
  - Not suitable in industrial or heavily-trafficked areas or for some pedestrian areas

Porous Pavement Alternatives

- **Plastic Grids or Cells**
  - Utilized when green space is desired or required and for emergency access
  - Aggregate provides more reduction in runoff than turf
  - Not suitable for industrial or heavily-trafficked areas or for some pedestrian areas

Porous Pavement Alternatives

- **Unsurfaced Dirt Roads & Gravel**
  - Becomes virtually impervious due to compaction and densification
  - Subject to erosion and rutting
  - Suitable only in rural settings
  - Even turf and natural areas are subject to standing water if underlying soils are saturated

Eco-Stone® Family of Permeable Pavers

An Alternative to Impermeable Pavements

UNI Eco-Stone® - The Original Permeable Paver

The original UNI permeable paver, Eco-Stone was first introduced in 1989 and established a benchmark in the paver industry for all others to meet

Ecoloc® - Industrial & Heavy-Duty Permeable Pavement

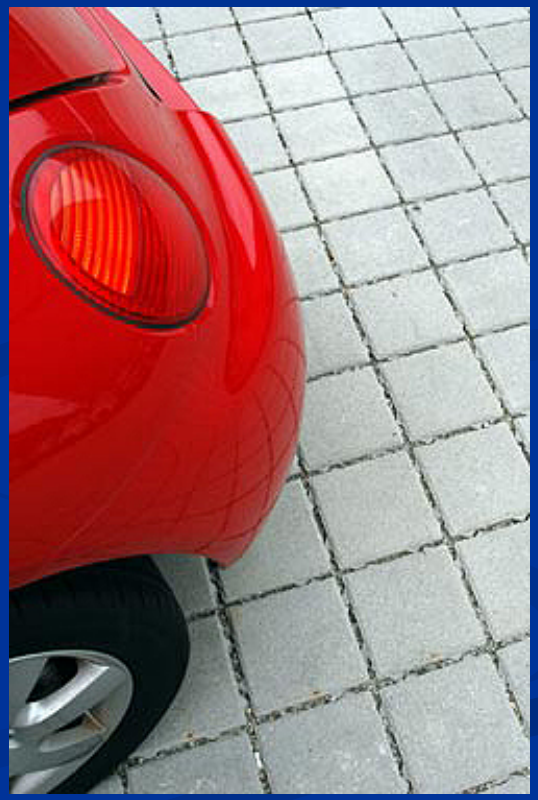
For projects where permeability is required in an industrial or heavy-duty setting – can be combined with UNI-Anchorlock® industrial traditional pavers

Eco-Optiloc® - Beauty and Strength Combined

Eco-Optiloc combines three shapes in a single unit for an attractive, yet durable permeable pavement – can be used with traditional Optiloc® pavers

Eco-Priora™ - Classic Shapes with Patented Interlock

Eco-Priora can be manufactured in squares and rectangles of various sizes that can be used alone or in combination for design flexibility – can be used for pedestrian and vehicular applications



Permeable Paver Characteristics

- Meets or exceeds ASTM C-936
- High Strength - 8000+ psi
- Low Absorption - Maximum 5%
- Skid Resistance
- Resistance to Point and Severe Loads
- Variety of Shapes & Colors
- Unlimited Design Flexibility
- Low Maintenance & Ease of Repair
- High Quality & Exceptional Durability

Permeable Paver Applications

- Residential
  - Walkways, Patios, Courtyards and Driveways
  - Subdivision Low-speed Roadways
- Commercial
  - Pedestrian Malls, Parking Areas, Plazas
- Municipal
  - Parks, Public Facilities, Sidewalks, Parking
- Industrial
  - Ports, Terminals, Depots

Features of UNI® Permeable Pavers

- Manufactured to the same ASTM C-936 “Standard Specification for Solid Concrete Interlocking Paving Units” as traditional concrete pavers
- Possesses same strength, aesthetics, durability & performance characteristics
- Unique, patented designs allow the added feature of permeability


HYUNDAI
HYUNDAI
HYUNDAI
YUNDAI

Features of UNI® Permeable Pavers

Is an EPA Best Management Practice under Stormwater Controls Category

- Limits increase in runoff from the site pre vs. post development
- Minimizes amount of pollutants in runoff
- Techniques: Infiltrates, slows velocity of runoff and retains runoff

Features of UNI® Permeable Pavers

The Eco-Stone Family of Permeable Interlocking Concrete Pavements (PICP) helps meet local, state, and regional stormwater drainage design criteria and provides compliance with the EPA's NPDES regulations

Features of UNI® Permeable Pavers

Meets EPA's Smart Growth and Green Infrastructure Goals

- Promotes comprehensive land-planning and stormwater management approaches that protect water resources and attempts to maintain pre-existing hydrologic site conditions

Features of UNI® Permeable Pavers

LEED® – Leadership in Energy and Environmental Design

- Is LEED point eligible under Sustainable Sites, Water Efficiency, Materials and Resources and Innovative Design categories of the U.S. Green Building Council's green building assessment system

Features of UNI® Permeable Pavers

UNI Permeable Pavements Support Low Impact Development Principles

- LID attempts to replicate pre-development hydrology to reduce impact of development
- Minimize hydrological impacts by reducing impervious areas, conserving natural drainage courses, and reducing clearing, grading, and pipe

Features of UNI® Permeable Pavers

UNI Permeable Pavements Support Low Impact Development Principles

- Provide runoff storage and infiltration uniformly throughout the site with small, on-site decentralized infiltration, detention, and retention using practices such as permeable pavement, green roofs, swales, and rain gardens


CVS

Features of UNI® Permeable Pavers

Low Impact Development Center

- The Low Impact Development Center has produced 4 Fact Sheets on Permeable Interlocking Concrete Pavement for Design Professionals, Municipal Officials, Schools and Universities, and Residential and Commercial Developers

Features of UNI® Permeable Pavers

Green Building Programs

- In addition to the LEED green building assessment system, green building programs such as those offered by the National Association of Home Builders and Green Globe International encourage the use of green technologies such as permeable pavement

Features of UNI® Permeable Pavers

- Runoff reductions of up to 100% depending on project design parameters
- 100% permeable surface – utilizes natural infiltration through small aggregate-filled openings/joints to reduce runoff
- Can reduce peak flows by as much as 89% and delay timing of peak runoff flow from several hours to several days
- Treats “first flush” of stormwater runoff

Features of UNI® Permeable Pavers

- Maximizes groundwater recharge and can be used with rain water harvesting technologies for re-use
- Meets or exceeds runoff local volume reduction standards with base reservoir storage
- Well-maintained PICP can reduce runoff volumes from intense rain storms – typically between 70%-90%

Features of UNI® Permeable Pavers

- May reduce heat island effect and thermal loading on surrounding surface waters
- Treats stormwater by slowing runoff velocities to allow for sedimentation and filtering by aggregates in openings and base and bioremediation
- Can be used with underground storm-water storage systems over slow-draining soils

Cost Benefits of UNI® Permeable Pavers

- Allows better land-use planning
- May reduce or eliminate drainage and retention systems required by impervious pavements
- May reduce cost of compliance with many stormwater regulations and stormwater runoff fees
- Combines detention and parking

Pollutant Removal Mechanisms

- Filtration of Solids (TSS)
- Oxidation
- Cooling
- Bio-chemical Reactions
- Adsorption and Absorption
- Collect for Treatment
  - Salts
  - Heavy Metals

Pollutant Removal Capabilities

- Pollutant Removal Efficiencies
  - Total Suspended Solids – 60-90%
  - Total Phosphorous – 65%
  - Copper – 50-89%
  - Zinc – 62-88% (Zn)

UNI® Permeable Pavement Technical Research

- Texas A & M University
- Guelph University, Ontario, Canada
- Seneca College, Ontario, Canada
- University of Connecticut
- University of Washington
- North Carolina State University
- International Research
  - Brian Shackel, Soenke Borgwardt, et al.


WATER
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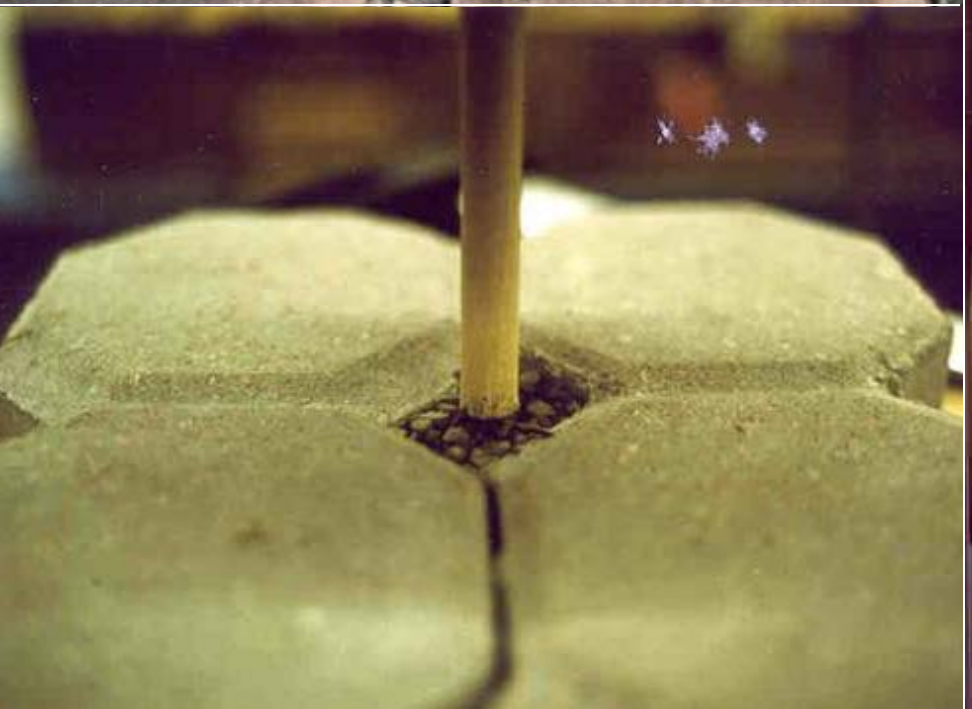
RYDER



UNI® Permeable Pavement Design Manuals & Literature

- UNI Eco-Stone Guide and Research Summary – *UNI-GROUP U.S.A.*
- Design Considerations for the UNI Eco-Stone Concrete Paver – *Rollings Engineering*
- Drainage Design and Performance Guidelines for UNI Eco-Stone Permeable Pavement – *Texas A & M Civil Engineering Department*
- UNI Permeable Paver Case Studies

UNI® Permeable Pavement Design Applications

- The Eco-Stone Family of Permeable Pavers provides highly functional and durable pavement surfaces that provide major environmental benefits
- They offer design professionals, land planners, developers, regulatory agencies, and eco-conscious homeowners new options in stormwater management


WATER CONSERVATORY

UNI® Permeable Pavement Design Applications

- Can be designed to accommodate a wide variety of stormwater management objectives
  - Capture and infiltrate entire stormwater volume = zero discharge
  - Infiltrate the increased runoff generated by development and impervious surfaces

UNI® Permeable Pavement Design Applications

- Can be designed to accommodate a wide variety of stormwater management objectives
  - Infiltrate a fixed volume of runoff from every storm
  - Infiltrate sufficient water to control the peak rate of discharge

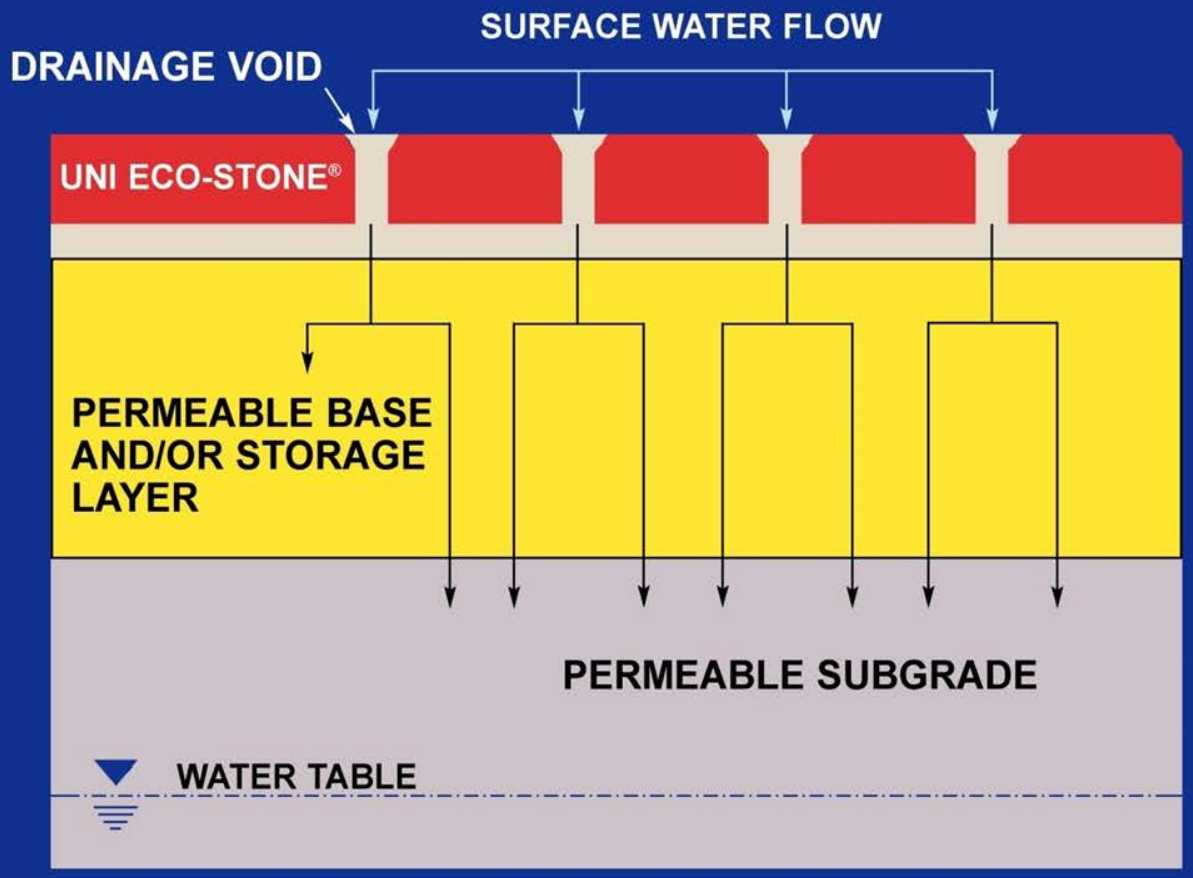
Site Selection Guidelines

- Permeable pavement site selection guidelines may be governed by local, state, and/or federal regulations – check with appropriate agencies in your area
- Permeable pavements should NOT be used for any site classified as a “stormwater hotspot” – anywhere there is a risk that stormwater could infiltrate and contaminate groundwater or wells – includes salvage yards, fueling/cleaning stations, storage areas for hazardous materials, etc.

Possible UNI® Permeable Pavement Design Applications

- Direct Flow into Subgrade
- Contaminated Flow
- Collection and Disposal of Infiltration
- Storage and Slow Infiltration
- Drain to Deeper Layer

DIRECT FLOW INTO SUBGRADE



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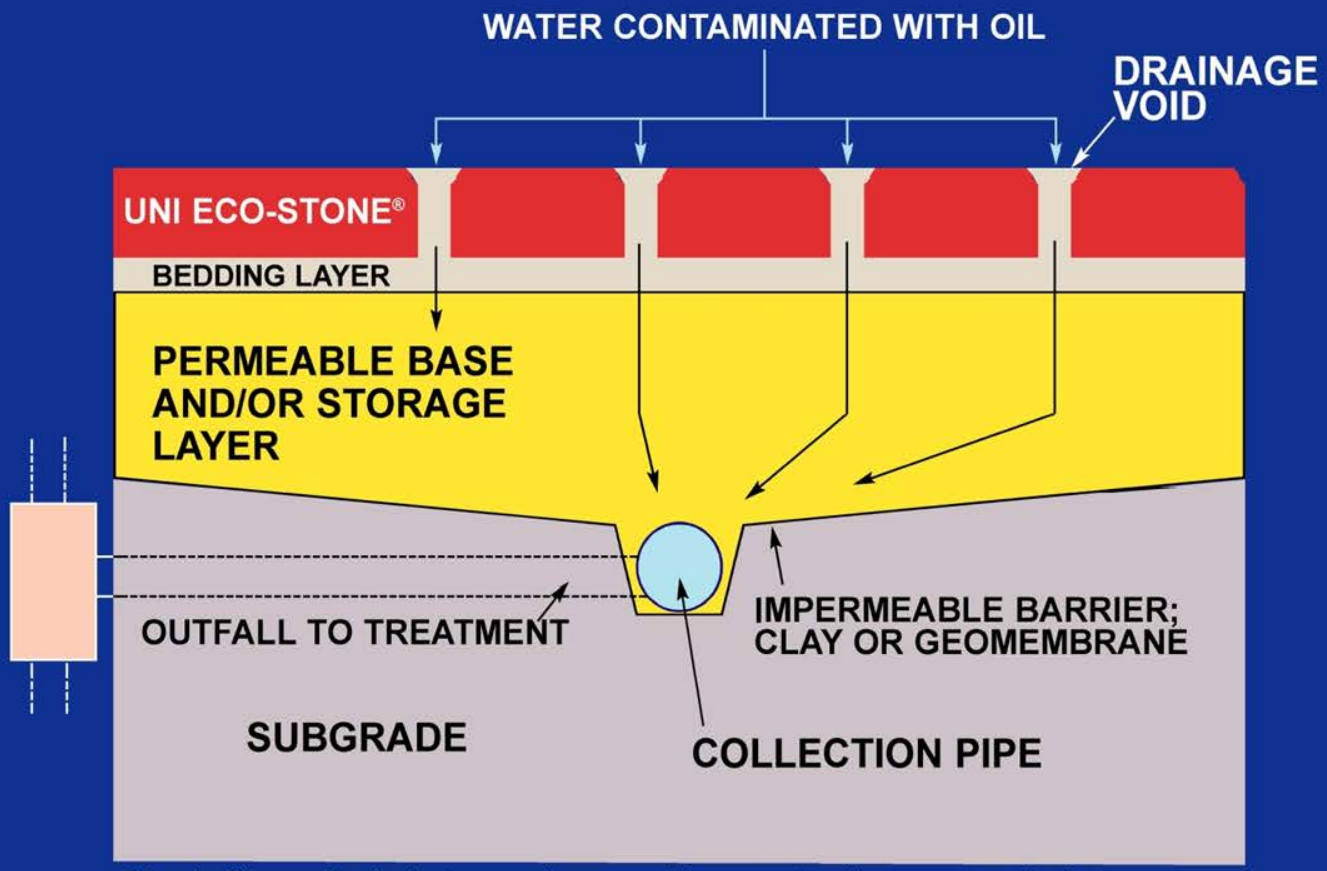
CONTAMINATED FLOW



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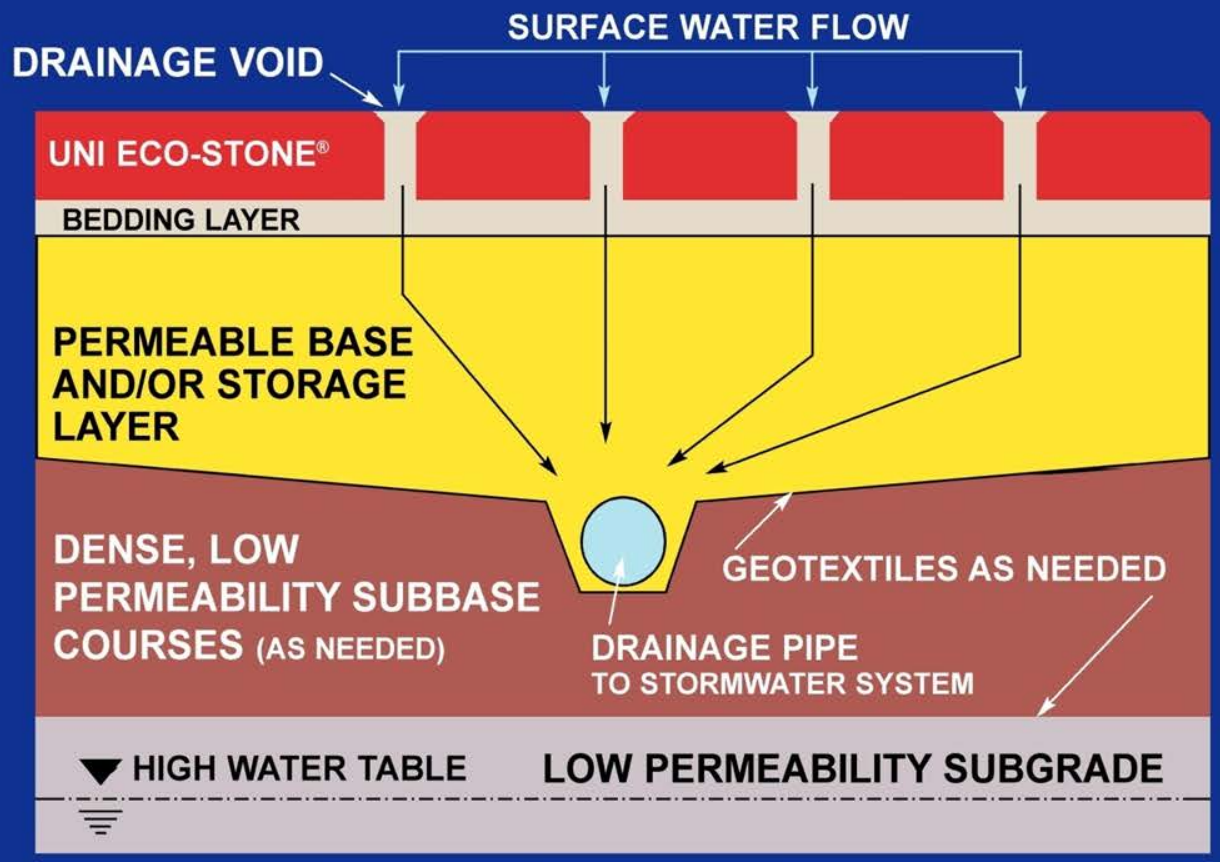
COLLECTION AND DISPOSAL OF INFILTRATION



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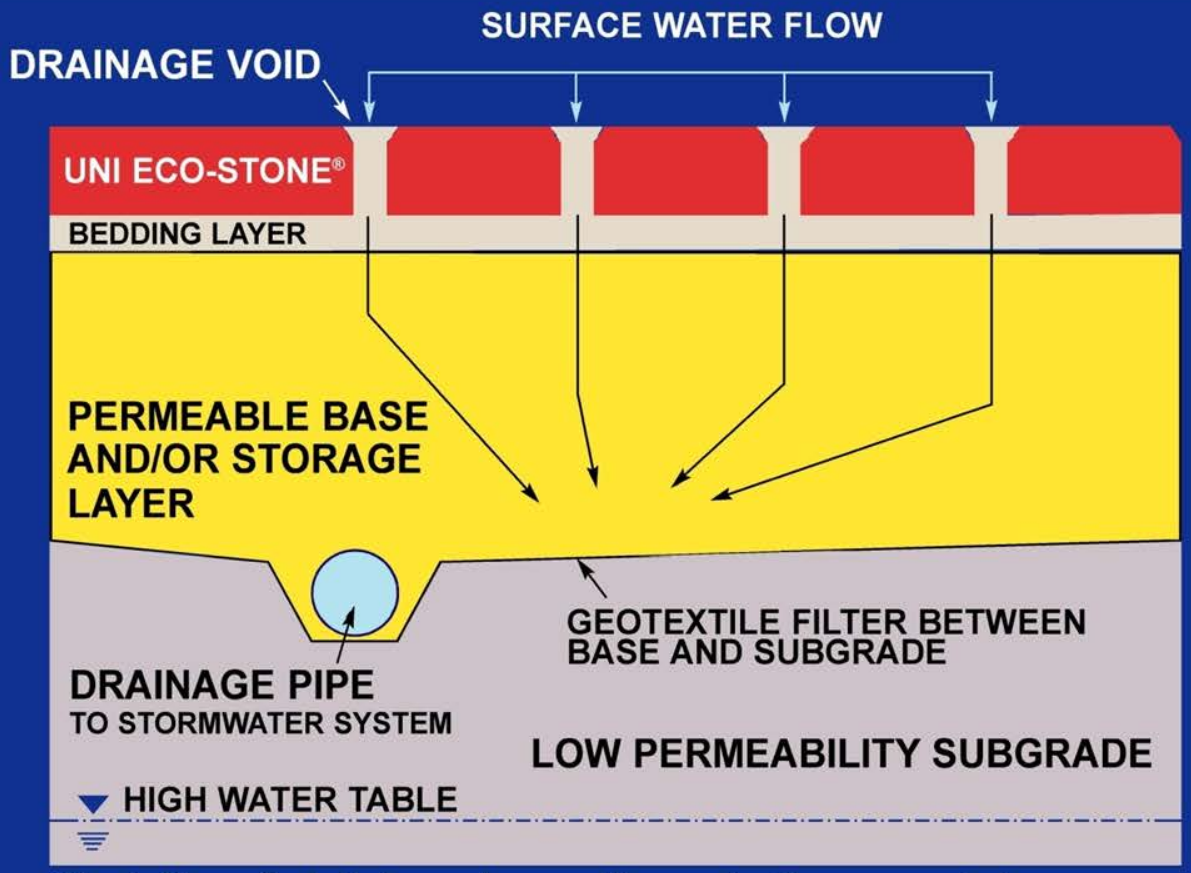
COLLECTION AND DISPOSAL OF INFILTRATION



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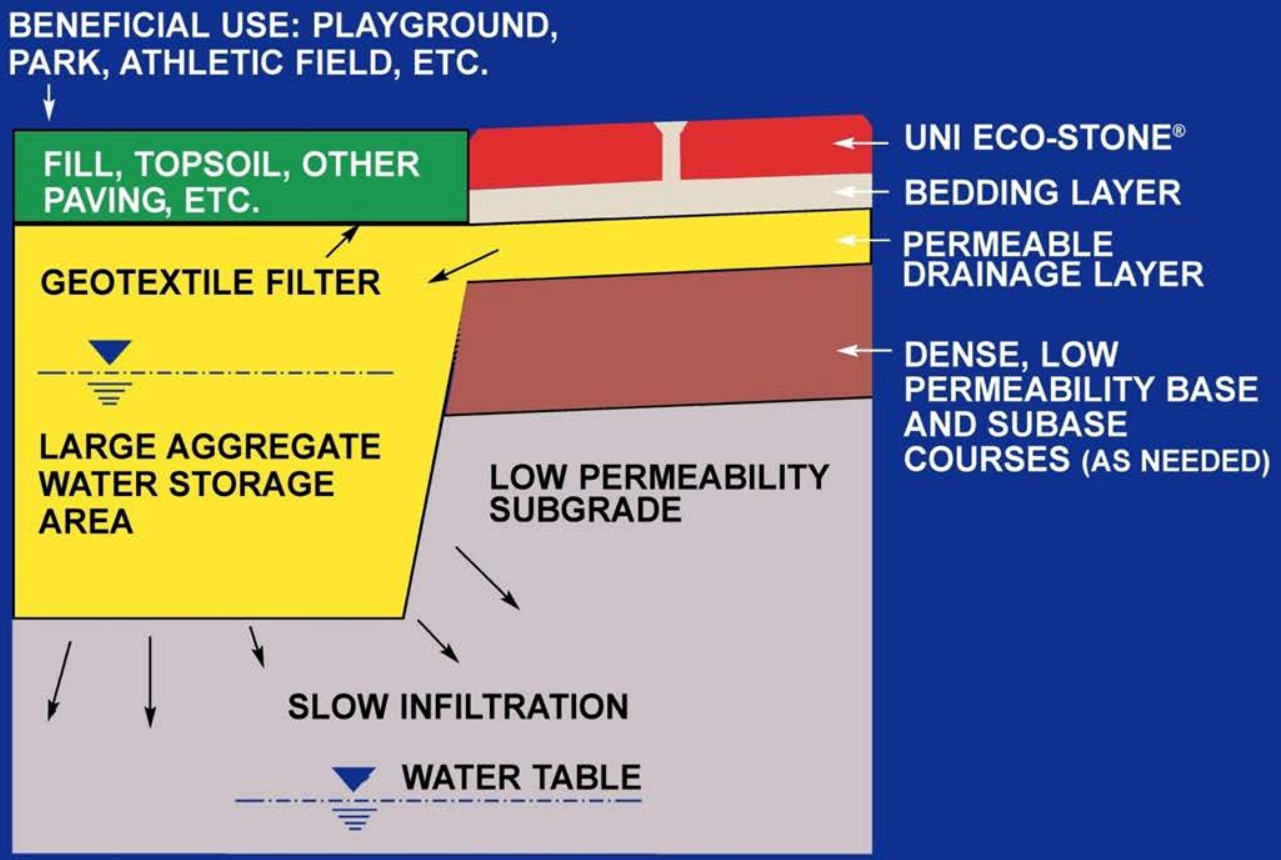
STORAGE AND SLOW INFILTRATION



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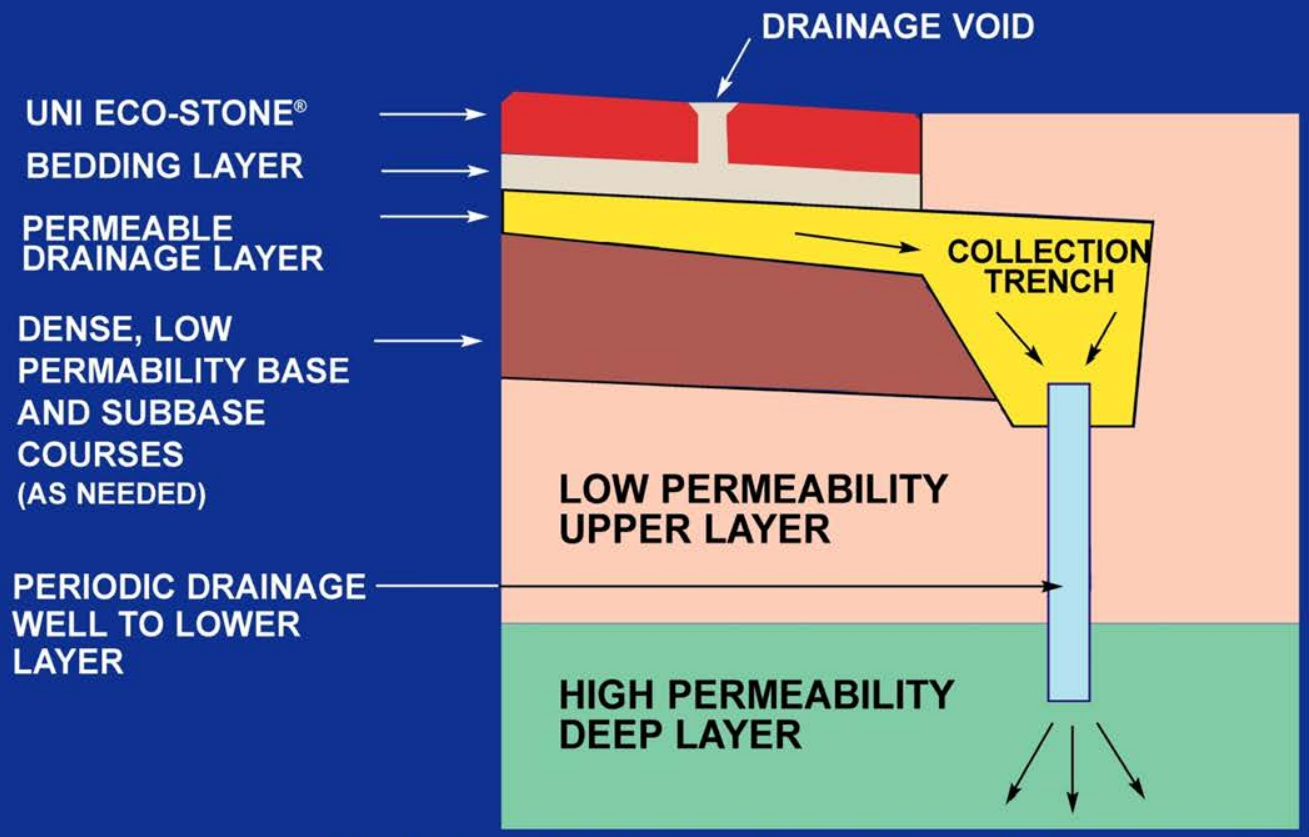
DRAIN TO DEEPER LAYER



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Lockpave Pro® Structural Pavement Design Software

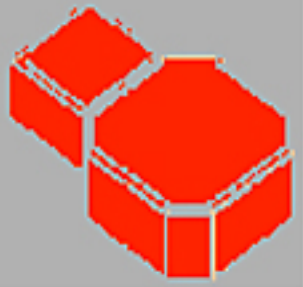
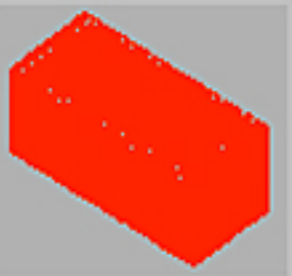
- Developed by Dr. Brian Shackel, a world-renowned authority on interlocking concrete pavements, for the structural design of UNI interlocking pavements
- Includes PC-SWMM™ PP for the hydraulic design of UNI permeable pavements

LOCKPAVE-PRO

File Settings Help Loads Drainage Frost Subgrade Pavers Pavement Type Overlay Condition

Paver Type

CHOOSE TYPE OF PAVER :-

Excellent Structural Performance	Very Good Structural Performance	Good Structural Performance	Limited Structural Performance
			
Uni-Anchorlock	Uni-Stone	Uni-Decor	Rectangular
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< Previous

Next >

PCSWMM for Permeable UNI ECO-STONE Pavements:

File Help

UNI ECO-STONE® Permeable Pavement Input Wizard

Welcome to the Input Wizard. This wizard will step you through the information required for determining the capacity of your proposed UNI ECO-STONE permeable pavement design. If you need help at any point, click on the Help button below.

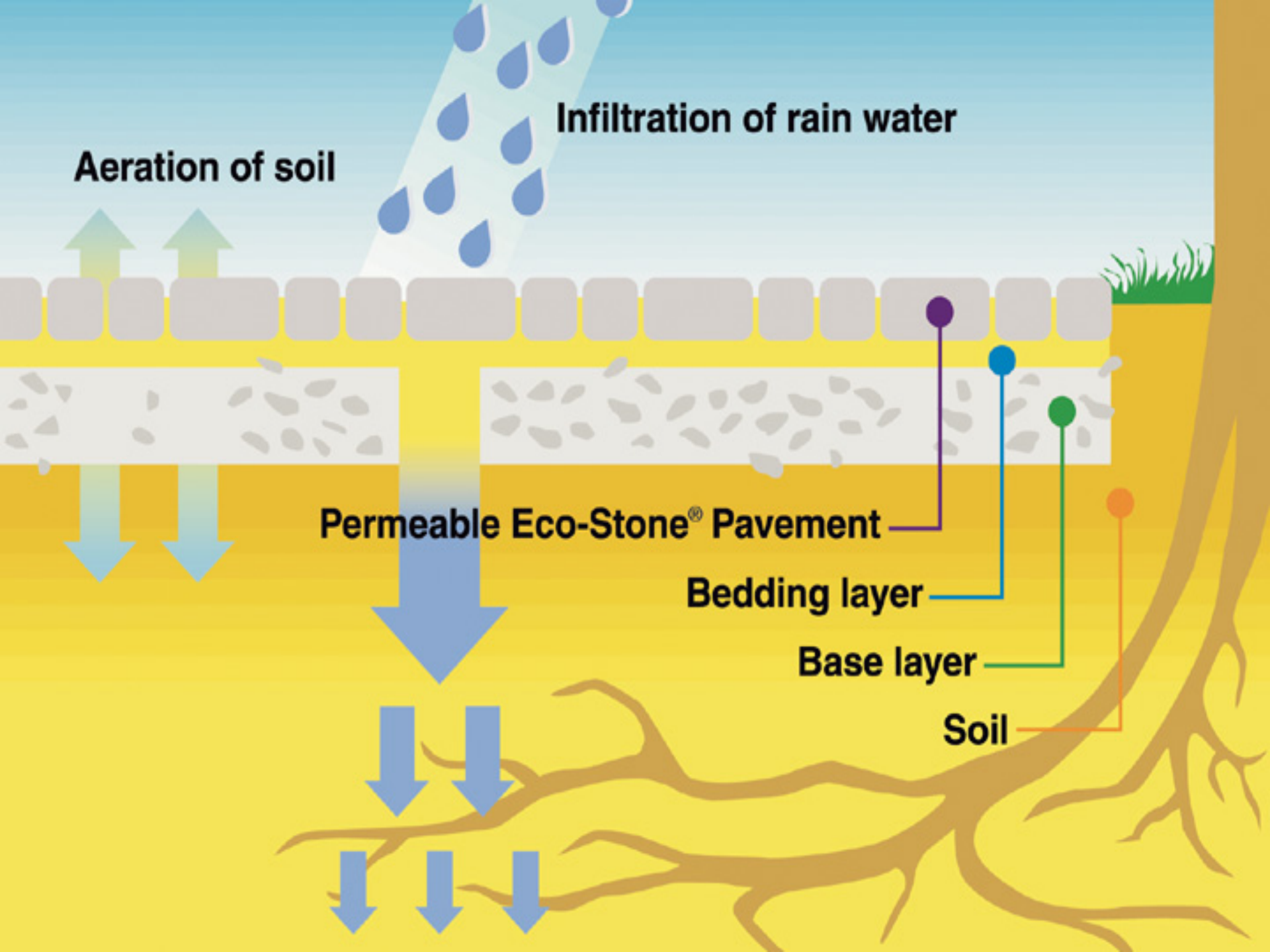
To start with, please enter the units you wish to perform the analysis with:

- (•) U.S. units
- ( ) Metric Units

Help | < Back | Next > | Run Model

UNI® Permeable Pavement Design Considerations

- The construction of a UNI Permeable Pavement is similar to traditional solid pavers, with design considerations for water in-flow
- Key factor - Ensure that the water is controlled and managed


Infiltration of rain water
Aeration of soil
Permeable Eco-Stone® Pavement
Bedding layer
Base layer
Soil

Permeable Pavement Design

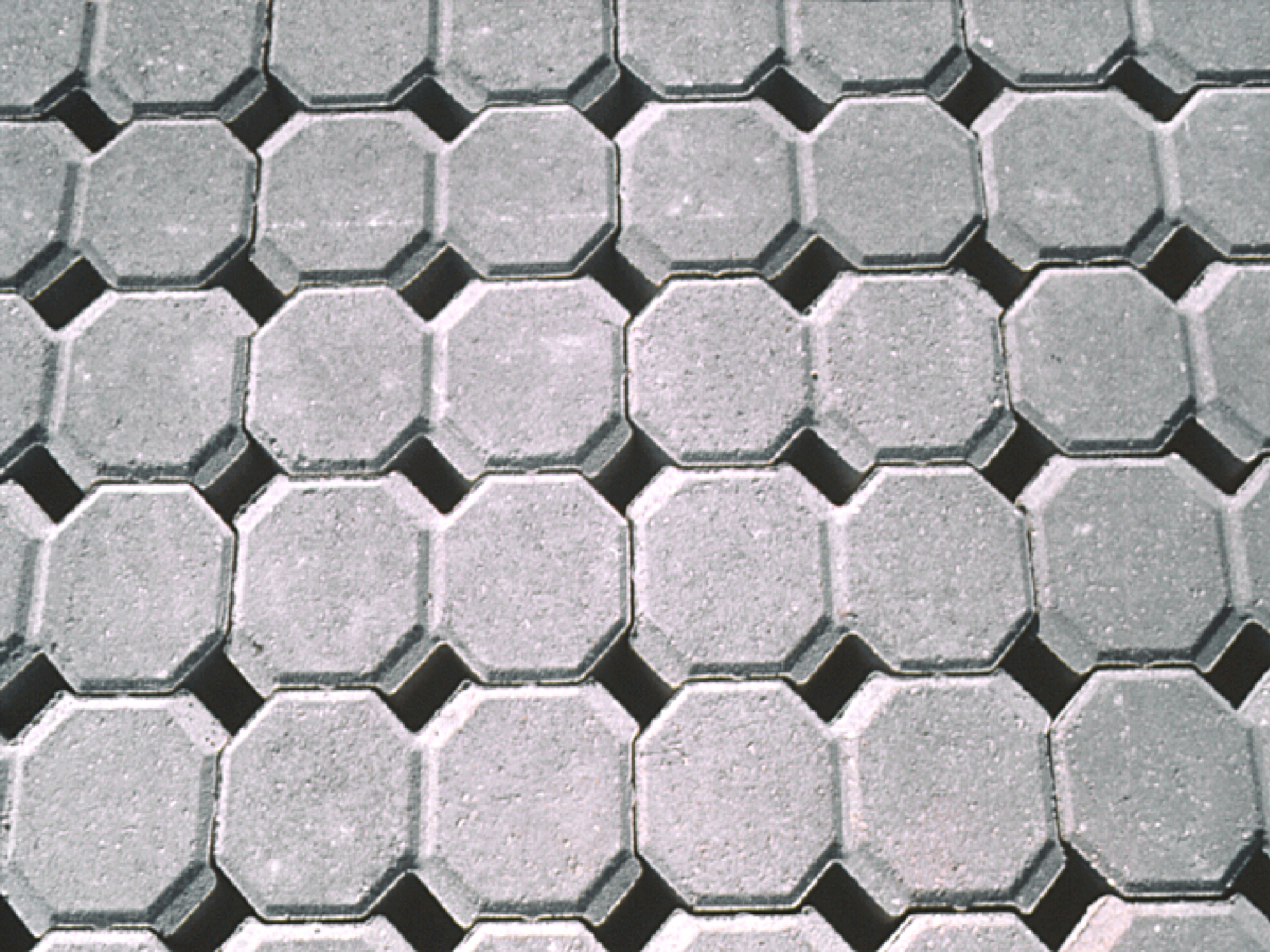
- Permeable interlocking concrete pavements require greater initial site evaluation and design effort
- They require a greater level of construction skill, inspection oversight during construction and after installation, and attention to detail
- A qualified, professional engineer with experience in hydrology and hydraulics should be consulted for permeable pavement applications

Infiltration vs. Open Area

- A common misconception when designing permeable interlocking concrete pavements is to equate the percentage of open area to the percentage of perviousness – for example, a designer or municipal agency may incorrectly assume a 15% open area is only 15% pervious
- The Eco-Stone Family of Permeable Pavers provides a 100% pervious surface than can infiltrate up to 100% of runoff depending on design parameters

Infiltration vs. Open Area

The permeability and amount of infiltration are dependent on the infiltration rates of the aggregates used in the joints and openings, the bedding layer, the base and subbase, and ultimately the subgrade, if permeable – base materials used in PICP have very high infiltration rates – from over 500 in./hr (1270 cm/hr) to over 2000 in./hr (5080 cm/hr), which is much more pervious than existing site soils



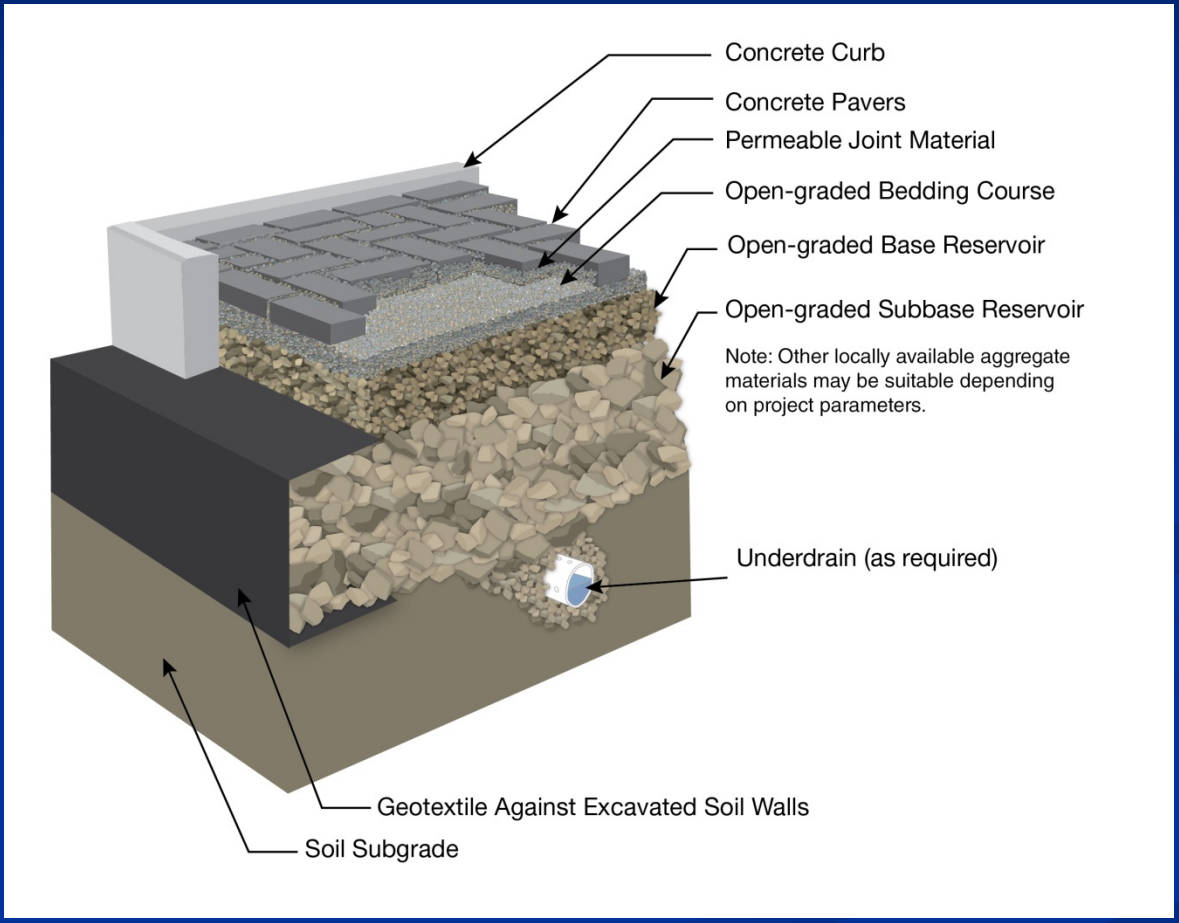
Permeable Pavement Design

- Though initial infiltration rates are very high, lifetime infiltration rates should be considered when designing PICP
- Designers may wish to use a conservative rate of 10 in./hr (25 cm/hr) as a basis for the design surface infiltration rate over 25 years in case pavement is not maintained
- With optimal construction and maintenance, longer-term infiltration rates of up to 50 in./hr (125 cm/hr) and more are possible

UNI® Permeable Pavement Design Considerations

The entire pavement system, including the UNI permeable paver surface, the underlying base, subbase and subgrade, must be designed as a complete system to ensure project objectives are met

Typical Permeable Cross-Section



UNI® Permeable Pavement Design Considerations

Factors Affecting Permeability

- Paver Physical Characteristics
- Hydraulic Design
- Slope
- Type and Size of Aggregate Material Used To Fill Drainage Voids

UNI® Permeable Pavement Design Considerations

Factors Affecting Permeability

- Aggregate Material Used for Base and Subbase
- Construction Methods
- Environmental Conditions and Existing Subgrade

Hydraulic Design

- Determine how much water flows into the pavement system
- Determine how the water will be controlled and managed within the pavement system

Slope

Permeable and porous pavements provide maximum infiltration on slopes of 5% or less – however, permeable interlocking pavements may be used on sites with steeper slopes using proper design techniques

Estimating Runoff for Stormwater Infiltration Design

- The “Rational” Method - Runoff Coefficient “C”
- Natural Resources Conservation Service Method (formerly SCS) - Curve Number “CN”
- State of Maryland – Method for Designing Infiltration Structures
- Other models – HEC-1, U.S. EPA SWMM,™ PC-SWMM™ PP, etc.

Rational Method C Values

- Coefficient of runoff (C values) for permeable interlocking concrete pavement depend on existing soil infiltration rates, base storage capabilities, and area design storms – though in all cases they are significantly less than impervious pavements
- Research to date has shown PICP has a C value range of 0.00-0.30

Rational Method C Values

SURFACE	C
Forest	0.10-0.30
Meadow	0.10-0.40
Bare Earth	0.20-0.40
Pavement (PCC or AC)	0.90-0.95
Residential, Flat, 30%	0.40
Built-up, Sloping, 70%	0.80
Commercial, Flat, 90%	0.80
UNI Permeable Pavement	0.00-0.30

NRCS Curve Number

For permeable interlocking concrete pavements, the NRCS curve number for permeable interlocking concrete pavers can range from 45-80 depending on existing soil types – by comparison, impervious asphalt or concrete ranges from 95-98

Drainage Void Aggregate Materials

- Rate at which water will flow through the paver surface is dependent on the materials used to fill voids and joints and on the slope of the pavement
- By careful selection of the drainage void aggregate materials, the designer can achieve a wide range of permeabilities for the paver surface to achieve a specific project's drainage objectives

Drainage Void & Bedding Aggregate Material

- For the bedding layer, joints and drainage voids, a hard, clean, crushed aggregate material containing no fines is recommended
- For the bedding layer, material equivalent to ASTM No. 8 is typically used – the bedding layer should be screeded to a uniform depth of 1.5 to 2 in. (40-50mm)
- For the joints and drainage voids, aggregate material equivalent to ASTM No. 8, 87, 89 or 9 may be used depending on joint/opening size

Base and Subbase Aggregate Materials

- The base and subbase are the pavement components that carry the major structural load, and they must maintain strength in presence of water for pavement stability
- A crushed, hard, durable, open or rapid-draining rock is generally recommended, though other aggregate materials, including dense-graded, may be used depending on design parameters – fines should be limited to less than 1% passing the #200 sieve

Base and Subbase Aggregate Materials

- Current industry recommendations include the following:
  - A 4" thick (100mm) open-graded base (equivalent to ASTM No. 57)
  - A minimum 6" thick (150mm) for pedestrian applications or 8" thick (200mm) for vehicular applications open-graded subbase (equivalent to ASTM No. 2 or 3)

Note: Other materials may be used depending on project design parameters – contact your UNI Manufacturer

Base and Subbase Aggregate Materials

- Thickness of the base is determined by amount of water storage required, the soil subgrade, susceptibility to frost, and traffic loads
- The water storage capacity of the base will vary with its depth and the percentage of void spaces in it – typical materials used provide a void space of 30-40%

Base and Subbase Aggregate Materials

- Your local UNI Manufacturer can provide guidance on recommended aggregate materials for use in construction of UNI Permeable Pavements in your area

Subgrade and Environmental Conditions

- The subgrade and other environmental factors also may affect the permeability and infiltration rates of PICPs
- Frost may require special design considerations, though permeable interlocking pavements have performed well in cold climates and remain stable through freeze-thaw cycles

Subgrade Soil Infiltration

- For full exfiltration into the soil subgrade the minimum soil infiltration rate is typically 0.52 in./hr (3.7×10^{-6} m/sec)
- Where soil conditions limit the amount of infiltration, some of the water may need to be drained by perforated pipe

Subgrade Soil Infiltration

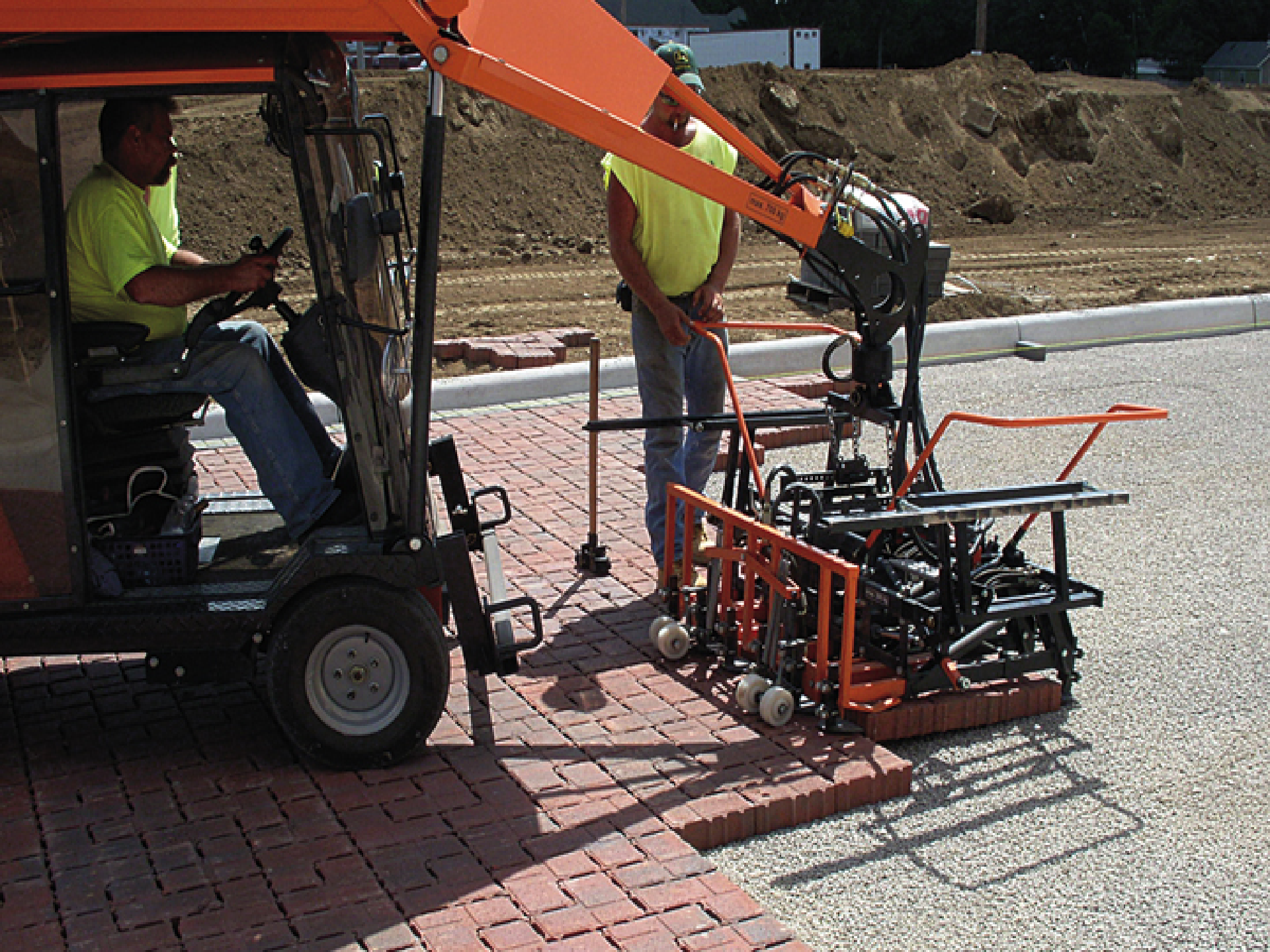
- Permeable interlocking concrete pavements may be used over clay or other low-permeability soils through the incorporation of drainage pipe or with stormwater storage systems that allow slow exfiltration into the soils
- In cases where no exfiltration should occur, an impermeable liner is used and all stored water drains to an outfall pipe

Filter Criteria

- Each material used in a PICP should be checked against established filter criteria to avoid problems with plugging and internal erosion
- Geotextile filters may be required to meet filter criteria

Construction Flexibility & Mechanical Installation

- PICP has no curing time and is ready to use upon installation
- The Eco-Stone Family of Permeable Pavers can all be installed mechanically to accelerate construction time
- Modular PICP units allow for project phasing
- Colored units can be used to mark lanes and parking spaces, reducing need for re-striping

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Special Considerations

- Drainage structures and filters tend to clog with time and some loss of permeability of these features is generally expected
- The designer needs to consider this potential for reduced water flow over life of the pavement
- Proper maintenance is encouraged for all types of permeable and porous pavements for optimal long-term performance

Maintenance of UNI® Permeable Pavements

- Fine debris may accumulate in the drainage void aggregate material over time, reducing the flow capacity
- Sediment must be kept off the pavement during and after construction
- Testing has shown it is possible to regenerate areas with reduced infiltration rates

Maintenance of UNI® Permeable Pavements

- It is recommended that PICPs be inspected and cleaned at regular intervals to ensure optimum performance – they can be maintained by street sweeping/vacuuming based on periodic inspections for ponding or areas with reduced infiltration
- The surface should be dry when cleaning and vacuum settings adjusted as needed to prevent the uptake of aggregate in the openings and joints
- Aggregate in the joints and openings should be kept full and replenished if needed

Maintenance of UNI® Permeable Pavements

- The Eco-Stone Family of Permeable Pavers can be snow plowed using typical snow removal equipment and studies have shown that less deicing chemicals are required as snow melts faster and drains through the surface
- Winter sanding is not recommended unless a small aggregate is used for traction instead of sand

Maintenance of UNI® Permeable Pavements

- Properly constructed and maintained, the Eco-Stone Family of Permeable Pavements can provide a service life of 20 to 25 years for the entire pavement structure and a 50-year life-cycle for the surface
- If underground repairs are needed, the pavers can be taken up and reinstated without an unsightly patch

Maintenance of UNI® Permeable Pavements

- If at the end of its design life the pavement no longer infiltrates the required amount of stormwater runoff, permeable interlocking concrete pavers are the only type of porous/permeable pavement that can be taken up, the base materials removed and then replaced, and the pavers reinstalled

ADA Compliance

- Permeable interlocking concrete pavers are ADA compliant for slip resistance
- If the joints and openings are not desirable in handicap areas, traditional solid pavers may be used
- Eco-Priora is specifically designed with smaller joints and minimal chamfers for use in handicap areas

The Eco-Stone® Family of Permeable Pavers

- UNI Permeable Pavers gives designers a tool with the flexibility to be used in a variety of ways to overcome stormwater management problems and decrease the adverse impact of land development
- The Eco-Stone Family of Permeable Pavers are environmentally-beneficial paving systems that emphasize infiltration as the natural way to manage stormwater runoff

Eco-Stone® Family of Permeable Pavers

A Permeable Paver for Every Application


BED BATH &
BEYOND


FIRE STATION Nº 9 HARBOURFRONT
EMERGENCY SUPPORT UNIT
A/L421

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