

# Permeable Pavement: What's it Doing on My Street?

An introduction to permeable pavement alternatives  
March 2007



The University of Rhode Island Cooperative Extension, in partnership with the Rhode Island Department of Health, Source Water Protection Program.

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## An Introduction to Permeable Pavement Materials

Whether you're a municipal planner, a professional contractor, an environmental consultant, or a homeowner with a driveway, a little information about permeable pavements can explain why you might want to consider these popular alternative construction materials.

Over the last two decades, a wide range of permeable pavement materials have become readily available and widely used as alternatives to conventional pavement construction materials. Permeable pavements have proven to be practical, cost-effective, and watershed-friendly due to their ability to reduce stormwater runoff. Because these permeable materials allow water to pass through the surface (in the case of porous asphalt and concrete) or through void spaces (in the case of concrete pavers or grid pavers), both runoff volume and water quality impacts are reduced. This infiltration of runoff can reduce nuisance flooding, recharge groundwater supplies, filter out pollutants, and help keep drinking water healthy.

Permeable pavements are appropriate for a variety of uses, such as pedestrian walkways, driveways, overflow parking areas, parking lots, and residential roads. For the best success, a few key factors must be considered when undertaking a project involving permeable pavement alternatives:

- 1. Choose the correct pavement for the task at hand.** Permeable pavement options vary depending upon whether the pavement will receive light, moderate, or heavy use. Therefore, it is imperative to choose the right material for the expected use.
- 2. Prepare the subbase.** Choose the appropriate subbase preparation for the application. The type of subbase used and depth of the subbase materials determine the amount of infiltration provided, as well as durability over time. In locations with poor soils or numerous freeze-thaw cycles, a thicker subbase is usually required. **Install properly.** In many cases, the manufacturer will install, oversee the installation, or recommend certified contractors.
- 4. Understand and carry out maintenance requirements.** Appropriate maintenance is critical to the continued effectiveness and durability of permeable pavement materials.

In order to help you evaluate which permeable pavement alternative will best suit your needs, this booklet describes the types of permeable pavements currently available. The permeable pavement information presented in this booklet is organized into three categories according to strength and durability: (1) Concrete block pavers, which have the highest load bearing capacities, followed by (2) porous asphalt and concrete pavements, and then (3) plastic grid pavers. We begin with a one-page overview of these three categories, followed by more detailed information on various materials and products available in each category, with case studies of constructed projects. For more information about a product, contact local distributors or installers. This booklet may not include all products available, nor does it constitute an endorsement of any product. Any errors or omissions are the sole responsibility of the authors. Throughout this booklet, the terms permeable, porous, and pervious are used interchangeably.

## Concrete Block Pavers

These pavers are constructed primarily from concrete. They interlock with one another, but leave open, void space between the pavers to permit water to infiltrate into the underlying gravel reservoir. The thickness of the gravel subbase, and the type of material used to fill in the void spaces, determines the amount of infiltration achievable. A typical concrete block pavement installation consists of a soil subgrade, a gravel base, a layer of bedding sand, and the grid pavers. The void space around the pavers can be filled with either gravel, or soil and grass.

Block pavers are recommended for use in parking lots, overflow lots, residential streets, medians, driveways, sidewalks, fire lanes, pedestrian plazas, and roof ballast. Proper site preparation, installation, and maintenance are key to the block pavers' long-term success. Examples of some of the concrete block pavers that are described in greater detail on the attached sheets are shown below.



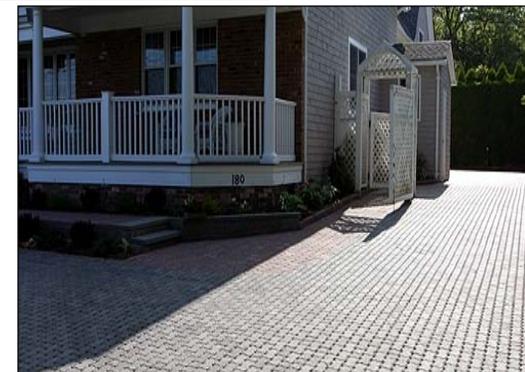
Fire access paved  
with Hastings  
Checker Block



Driveway paved  
with Turfstone



Parking lot paved  
with SF-Rima



Driveway paved  
with Aquaterra

## **Porous Pavements**

Porous asphalt and porous concrete are very similar to their conventional counterparts, but they are mixed without the fine particles (i.e., those less than 600  $\mu$ ) to allow for the passage of stormwater through the surface of the pavement. After the water passes through the porous surface, it is temporarily stored in an underlying crushed rock storage reservoir (called a “recharge bed”) and slowly released into the underlying soils. A geotextile filter fabric is placed on the floors and sides of the recharge bed to prevent fine soils from migrating into the bed.

The load-bearing capacity of porous pavements is less than conventional pavements, because of the absence of the fine particles. Therefore, large commercial vehicles should not be permitted to park in lots paved with porous pavements. Porous pavement projects require less stormwater pipes and inlets than conventional pavement, and detention basins are not required.

The long-term success of any porous pavement project is dependent upon proper site positioning, design, construction, and maintenance. Premature clogging and infiltration failure can result from a failure to properly test for soil drainage capacity and water table height, to protect paved areas from construction-related sediment, or to conduct recommended periodic maintenance. The use of porous pavement materials is recommended for passenger vehicle parking lots, overflow or event parking areas, roadways with light traffic (i.e., residential subdivision streets), driveways, bike paths, and pedestrian walkways.



Porous asphalt pathway at  
Swarthmore College  
(Photograph courtesy Cahill Associates)



Porous asphalt parking lot at  
University of Rhode Island



Porous concrete sidewalk at  
Penn State University  
(Photograph courtesy Cahill Associates)

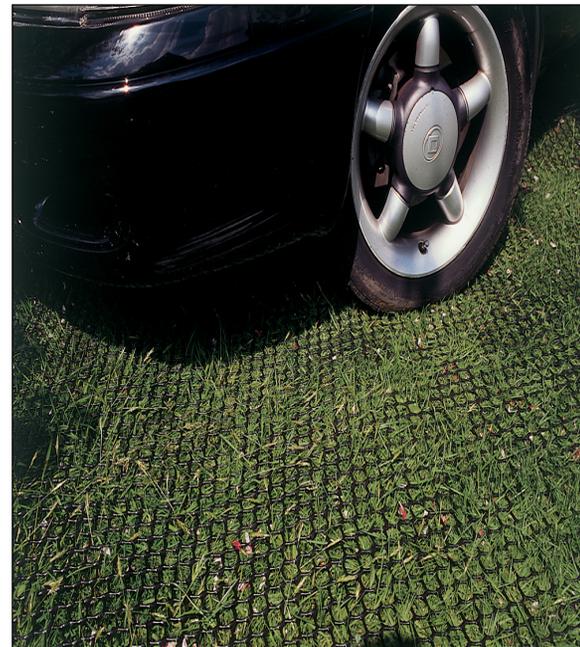
## **Plastic Grid Pavers**

These pavers are plastic grids with void spaces that can be filled with either gravel, or soil and grass. Gravel is a better choice for more frequently used areas. These pavers are constructed primarily from recycled plastic.

Due to their flexibility, plastic grid pavers can be used on sites with uneven terrain, but they do not have as much intrinsic strength as do concrete pavers. The plastic grid pavers' load bearing capacity ranges from 24,000 lbs/ft<sup>2</sup> to 823,680 lbs/ft<sup>2</sup>. They do not require drains, detention or retention ponds, or any other associated drainage facility. However, proper site placement, installation, and maintenance are key to their overall success. For example, it is important to avoid directly routing large volumes of runoff from adjacent impervious areas onto the grid pavers, because that could clog the voids with sediment. Plastic grid pavers are recommended for use in parking areas, residential driveways, fire lanes, emergency access roads, golf cart paths, sidewalks, and bike paths.



Driveway paved with Netpave 50



Driveway paved with Turfguard

# **Concrete Block Pavers Fact Sheets**

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Aquaterra™</b></p> <p><b>Description:</b> These pavers are small (8.9" x 4.4" x 3.125") impervious concrete blocks that interlock with one another, but leave void spaces between the adjacent blocks to permit the infiltration of water. The void spaces are filled with gravel. The paver is constructed with Portland cement.</p> <p><b>Manufacturer:</b> Unilock. Additional information at <a href="http://www.unilock.com/Product.asp?Product=114">http://www.unilock.com/Product.asp?Product=114</a></p> 	<p>Suitable for residential and emergency access roads, driveways, and parking lots.</p>	<p>Mean compression strength is greater than 1,584,000 lbs/ft<sup>2</sup> (11,000 psi). In comparison, a concrete slab has a mean compression strength less than 432,000 lbs/ft<sup>2</sup> (3,000 psi).</p> <p>The pavers have a lifetime guarantee and are easy to repair.</p>	<p>Installation requires a contractor. The thickness of the gravel base depends upon the anticipated loads, necessary stormwater drainage, and subgrade soil conditions.</p> <p>For residential uses on adequately drained soil, the gravel base can be omitted and the block pavers placed directly on the sand bedding layer.</p> <p>For heavier vehicle loads or frequent usage, a minimum of 6" of compacted gravel base is recommended.</p> <p>The sand bedding layer is loosely spread by hand-screening or with equipment to a depth of at least 1". The pavers are placed in the bedding layer by hand or machine and the void spaces surrounding the pavers are filled with gravel.</p>	<p>Periodic maintenance is required to clean silt and debris from the voids/drainage openings with street sweepers and refill the displaced gravel when necessary</p> <p>Salts and sands should be used sparingly, if at all, for deicing in the winter.</p> <p>A snowplow may be used to clear the surface. The blade does not need to be lifted.</p>	<p>Price of pavers is ~ \$ 2.98 per ft<sup>2</sup>.</p> <p>A project calculator for estimating project costs is available online at <a href="http://www.unilock.com/ProjectCalculator.asp">http://www.unilock.com/ProjectCalculator.asp</a></p>	<p>Unilock will provide information on at least two authorized contractors that can supply labor and materials to interested parties.</p>

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>UNI Eco-Stone®</b></p> <p><b>Description:</b> These pavers are small (~9"x 4.5"x 3.125") impervious concrete blocks that interlock with one another, but leave joint spaces (0.125") between the adjacent blocks. The void spaces are filled with gravel. The paver is constructed with Portland cement, and the design creates voids comprising ~12% of the surface area. Infiltration occurs through the funnel shaped openings created by the notch configuration molded into each unit.</p> <p><b>Manufacturer:</b> Unilock, and Ideal Concrete Company. Additional information at <a href="http://www.unilock.com/Product.asp?Product=108">http://www.unilock.com/Product.asp?Product=108</a> and <a href="http://www.idealconcreteblock.com/pavers.cfm?id_name=11">http://www.idealconcreteblock.com/pavers.cfm?id_name=11</a></p> 	<p>Suitable for residential and emergency access roads, driveways, and parking lots.</p>	<p>The average compression strength is at least 1,152,000 lbs/ft<sup>2</sup> (8000 psi), with no individual unit less than 1,036,800 lbs/ft<sup>2</sup> (7200 psi).</p> <p>The pavers have a lifetime guarantee and are easy to repair.</p>	<p>Installation requires a contractor. The thickness of the gravel base depends upon the anticipated loads, necessary stormwater drainage, and subgrade soil conditions.</p> <p>For residential uses on adequately drained soil, the gravel base can be omitted and the block pavers placed directly on the sand bedding layer.</p> <p>For heavier vehicle loads or frequent usage, a minimum of 6" of compacted gravel base is recommended.</p> <p>The sand bedding layer is loosely spread by hand-screening or with equipment to a depth of at least 1". The pavers are placed in the bedding layer by hand or machine and the void spaces surrounding the pavers are filled with gravel.</p>	<p>Periodic maintenance is required to clean silt and debris from the voids/drainage openings with street sweepers and refill the displaced gravel when necessary.</p> <p>Salts and sands should be used sparingly, if at all, for deicing in the winter.</p> <p>A snowplow may be used to clear the surface. The blade does not need to be lifted.</p>	<p>Price of pavers begins at \$3.07/ft<sup>2</sup>.</p> <p>A project calculator for estimating project costs is available online at <a href="http://www.unilock.com/ProjectCalculator.asp">http://www.unilock.com/ProjectCalculator.asp</a>.</p>	<p>Acker Stone. Contact Rudy 13296 Temescal Canyon Rd., Corona, CA. (800) 258-2353</p>

## **UNI Eco-Stone® Example Application -- Jordan Cove National Project in Waterford, Connecticut**

**Site Description:** Some of the cul-de-sacs, streets, and driveways in the Best Management Practices (BMPs) section of the Jordan Cove National Project in Waterford, CT, are paved with UNI Eco-Stone pavers. The Jordan Cove Urban Watershed Section 319 National Monitoring Program Project is a ten-year study designed to ascertain how the quality and quantity of stormwater runoff is affected by pollution prevention BMPs used throughout an urban subdivision.

**Design Details:** Approximately 15,000 ft<sup>2</sup> of the UNI Eco-Stone pavers were installed in the BMPs watershed to construct a 6.1 m-wide road (~20 feet), the cul-de-sacs, and some of the homeowners' driveways.

**Costs:** The cost of constructing the road and curbs with UNI Eco-Stone pavers and conventional asphalt was \$102,500 and \$18,860, respectively. The cost of the driveways and driveway aprons paved with UNI Eco-Stone pavers was \$7,896 and \$1,318 per lot, respectively, whereas the conventional asphalt driveways and driveway aprons cost \$1,318 and \$280 per lot, respectively. Additional cost information is available online at [http://www.canr.uconn.edu/jordancove/bmp\\_costs.htm](http://www.canr.uconn.edu/jordancove/bmp_costs.htm).

**Maintenance:** Periodic maintenance is required to clean silt and debris from the voids/drainage openings with street sweepers, and to refill the displaced gravel.

**Contacts:** Bruce Morten, Aqua Solutions (860) 295-1505 or [Aquasoln@aol.com](mailto:Aquasoln@aol.com)



Photography: University of Connecticut NEMO website ([http://www.canr.uconn.edu/jordancove/new\\_page\\_4.htm](http://www.canr.uconn.edu/jordancove/new_page_4.htm))

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>SF-RIMA™</b></p> <p><b>Description:</b> These pavers are small (8.66" x 8.66" x 3.125") impervious concrete blocks with a total of six spacers along the edges that can either interlock with one another or be placed spacer-to-spacer for additional void space. The void spaces between the adjacent blocks permit the infiltration of water to the underlying permeable base and subbase materials.</p> <p>When the spacers are placed against the adjacent paver stone a 0.5" joint is formed that can be filled with gravel. When the spacers are placed against other spacers, a 1" joint space is formed that can be filled with soil and grass. The former has ~8.5% open area whereas the latter has ~22% open area.</p> <p><b>Manufacturer:</b> SF Concrete Technology, Inc. Additional information is available online at <a href="http://www.sfconcrete.com/products/sfrima/description.html">http://www.sfconcrete.com/products/sfrima/description.html</a></p> 	<p>Suitable applications for the gravel-filled pavers include parking lots, residential roads, driveways, sidewalks, and patios.</p> <p>Suitable applications for the grass-filled pavers include overflow parking lots, street medians, driveways, patios, and garden paths.</p>	<p>The compression strength is at least 1,152,000 lbs/ft<sup>2</sup> (8000 psi).</p> <p>The pavers have a water absorption maximum of 5%.</p> <p>The pavers have a lifetime guarantee and are easy to repair.</p>	<p>Installation can be done by a contractor or homeowner. The thickness of the gravel base depends upon the anticipated loads, necessary stormwater drainage, and subgrade soil conditions.</p> <p>The overlying bedding layer should not exceed 1" in thickness. The pavers are placed in the bedding layer and the void spaces surrounding the pavers are filled with either gravel or soil and grass, depending on which design (i.e., spacer-to-side or spacer-to-spacer) was chosen.</p>	<p>Maintenance of grass-filled pavers includes mowing, irrigation, fertilization, and seeding.</p> <p>For gravel-filled pavers, intermittent replacement of gravel may be necessary over time.</p> <p>Deicing salts should not be used because it will kill the grass.</p> <p>A snowplow may be used to clear the surface. The blade does not need to be lifted.</p>	<p>Price of pavers ranges from \$3.10 to \$3.20 per ft<sup>2</sup>. They are sold in bundles of 67 ft<sup>2</sup>.</p> <p>When the pavers are filled with gravel, 2.7 stones are required per sq. ft. When the pavers are filled with grass, 1.9 stones are required per sq. ft.</p>	<p>Hensell Materials 4475 N. Highway 101 Eureka, CA 95501 (707) 443-9785</p> <p>Basalite Tracy, CA (209) 833-3670</p>

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Turfstone</b></p> <p><b>Description:</b> This product is a light-duty lattice-pattern concrete paver, with approximately 60% impervious area. The diamond-shaped openings within the lattice pattern can be filled with either soil and grass, or gravel. The pavers are 16" x 24", and come in three heights (3 cm, 8 cm, and 10 cm).</p> <p><b>Manufacturer:</b> Unilock; Ideal Concrete Block Company; Cambridge Pavers; and Nicolock.</p> <p>Additional information at <a href="http://www.unilock.com/Product.asp?Product=112">http://www.unilock.com/Product.asp?Product=112</a>, <a href="http://www.idealconcreteblock.com/pavers.cfm?idname=11">http://www.idealconcreteblock.com/pavers.cfm?idname=11</a>, and <a href="http://www.Hiwayconcrete.com/html/Nicolock.html">http://www.Hiwayconcrete.com/html/Nicolock.html</a>.</p> 	<p>Suitable for overflow parking areas, emergency vehicle access roads, patios, driveways, spillways, and embankments.</p>	<p>The average compression strength of the Turfstone manufactured by Unilock is 720,000 lbs/ft<sup>2</sup> (5000 psi), with no individual unit less than 648,000 lbs/ft<sup>2</sup> (4500 psi).</p> <p>The compression strength of the Turfstone manufactured by Cambridge is 1,440,000 lbs/ft<sup>2</sup> (10,000 psi).</p> <p>The pavers have a lifetime guarantee and are easy to repair.</p>	<p>May be installed by contractor or homeowners.</p> <p>A gravel base may be required to provide additional stability, based on soil type and use expectations. The base is usually 6" of compacted gravel, but can vary based on intended use.</p> <p>Geotextile reinforcement is recommended between the subbase and gravel base for vehicular traffic.</p> <p>The pavers are embedded in ~ ¼ to ½ inch of concrete sand, and should not be compacted.</p> <p>The final level of topsoil/gravel should be flush with surface.</p>	<p>Maintenance for grass-filled pavers includes mowing, irrigation, fertilization, and seeding.</p> <p>For gravel-filled pavers, intermittent replacement of gravel may be necessary over time.</p> <p>Deicing salts should not be used because it will kill the grass.</p> <p>A snowplow may be used to clear the surface. The blade does not need to be lifted.</p>	<p>Price of pavers is ~ \$3.08 per ft<sup>2</sup>.</p> <p>The 16" x 24" pavers cost ~ \$9.25 each.</p> <p>A project calculator for estimating project costs is available online at <a href="http://www.unilock.com/ProjectCalculator.asp">http://www.unilock.com/ProjectCalculator.asp</a>.</p>	<p>Hensell Materials 4475 N. Highway 101 Eureka, CA 95501 (707) 443-9785</p> <p>Lynsco Garden Materials 19 Seaport Boulevard Redwood City, CA (800) 459-6478 (Special order only)</p> <p>Maccon Masonry Materials 367 Bayshore Boulevard San Francisco, CA (415) 285-5025</p> <p>Vic Hannon Landscape Anderson, CA (530) 347-6011</p>

## **Turfstone Example Application -- Purchasing Building, University of Rhode Island, Kingston, Rhode Island**

**Site Description:** An emergency vehicle access road was constructed with Turfstone on the University of Rhode Island's Kingston campus.

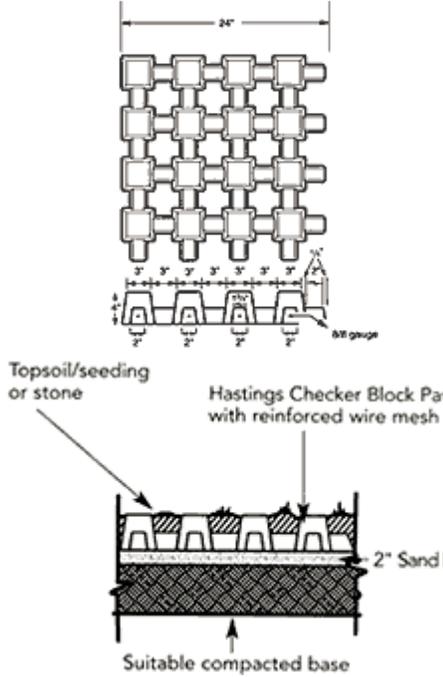
**Design Details:** The area where this access road was constructed is prone to mud formation when the top layer defrosts on a cyclical basis in the spring. The University wanted to ensure a stable foundation for emergency access vehicles.

**Maintenance:** Regular maintenance includes mowing, irrigation, and fertilization.

**Notes:** According to David Bascom, Assistant Director of the Landscapes and Grounds Department at the University of Rhode Island, the Turfstone emergency access road is easy to maintain and has held up very well.

**Contact:** David Bascom, Assistant Director of the Landscapes and Grounds Department. (401) 874-5515 or [b'snest@uri.edu](mailto:b'snest@uri.edu)



Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Hastings Checker Block®</b></p> <p><i>Description:</i> This product is a light-duty, square (2'x2') lattice concrete paver with small cross-shaped internal openings that can be filled with either soil and grass, or gravel. The ratio of grass or gravel to concrete is ~70%.</p> <p><i>Manufacturer:</i> Hasting Pavement Company. Additional information <a href="http://www.hastingspavers.com/chblock.html">http://www.hastingspavers.com/chblock.html</a></p>  <p>The technical drawing includes a top view of a 2' x 2' paver grid with dimensions: overall width 24", overall height 24", and individual block dimensions of 3" x 3" with 1/2" gaps. A side view shows the paver's profile with a 1/2" depth and a 2" sand layer below it. Labels include 'Topsoil/seeding or stone', 'Hastings Checker Block Paver with reinforced wire mesh', '2" Sand', and 'Suitable compacted base'.</p>	<p>Suitable for overflow parking, service roads, fire access lanes, and tree pits.</p> <p>Suitable for stabilizing embankments along water bodies.</p>	<p>Achieves a concrete strength of 5,000 psi.</p>	<p>A base can be either undisturbed earth or fill compacted to 95% maximum dry density.</p> <p>Sand is placed in a 2" compacted layer over the base.</p> <p>The void can be filled either with crushed gravel or topsoil.</p>	<p>Grass can be maintained using a conventional lawn mower.</p>	<p>The 2' x 2' pavers are sold in bundles of 20, which covers 80 square feet.</p> <p>Price is determined by retailer and size of project.</p>	<p>Direct Sales, contact::</p> <p>Pam Holzman Hastings Pavers Sales Coordinator (301) 620-0100 <a href="mailto:info@hastingsarchitectural.com">info@hastingsarchitectural.com</a></p>

# **Porous Pavements Fact Sheets**

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Porous Concrete</b></p> <p><i>Description:</i> This product is a specially formulated mixture of Portland cement, uniform open-graded coarse aggregate, admixtures, and water to create a material with 15-25% void space.</p> <p>Water is able to percolate through the void spaces into the underlying crushed rock reservoir and soil mantle. Impervious concrete and porous concrete utilize the same mixing and application equipment.</p> <p>Additional information at <a href="http://www.thcahill.com/pconcrete.html">http://www.thcahill.com/pconcrete.html</a></p> 	<p>Suitable for parking lots, residential streets, plazas, play courts, bike paths, driveways, and sidewalks.</p> <p>It is much more difficult to get the porous concrete mix right in comparison to porous asphalt. In addition, it is much coarser looking than conventional concrete. Therefore, porous asphalt is often a better option for smaller areas where aesthetics are an important factor.</p>	<p>The load-bearing capacity of porous concrete is usually between 259,200 and 345,600 lbs/ft<sup>2</sup> (1800-2400 psi), depending on soils. Soils with high permeability, such as sands and sandy loams, have the best ability to carry loads.</p> <p>Porous concrete becomes stronger and more stable when it gets wet. Therefore, it does not deteriorate as fast as other paving materials.</p> <p>Expected lifespan of 15-20 years if properly sited, designed, installed, and maintained.</p>	<p>The porous concrete is installed over a 1" layer of chocker course and bed of uniformly graded, clean washed crushed rock that is usually 18-36" deep.</p> <p>A layer of geotextile fabric separates the crushed rock from the underlying soil, to prevent any fines from moving up into the storage bed.</p> <p>The bottom of the recharge bed is excavated to a level surface and is not compacted, to allow the water to distribute and infiltrate evenly over the entire bottom bed area.</p>	<p>Vacuum sweeping to remove sediment that has accumulated on the surface.</p> <p>Annual inspection of the surface for deterioration.</p> <p>Potholes and cracks can be filled with patching mixes unless more than 10% of the surface needs to be repaired. Spot clogging may be fixed by drilling 0.5" holes through the pavement layer every few feet.</p> <p>Winter abrasives should not be applied on the pavement surface. Deicing salts should not be applied near groundwater drinking supplies, but environmentally-benign deicers are permissible. Snow-plow blades must be raised ~1" to protect the surface.</p>	<p>The price of porous concrete is about four times greater than the price of porous asphalt. The cost depends on the amount produced, and usually costs somewhere between \$2.00-\$4.00/ft<sup>2</sup>.</p> <p>The underlying stone bed is usually more expensive than a conventional compacted sub-base, but is offset by the reduction in stormwater pipes and inlets, and elimination of detention basins.</p> <p>Generally, porous pavement installation does not require deep excavations, and there is less earthwork than for conventional concrete.</p>	<p>Mercer Fraser 77 W. 2<sup>nd</sup> Street Eureka, CA 95504 (707) 725-8667</p> <p>Eureka Ready-Mix 4945 Boyd Rd. Arcata, CA 95521 (707) 822-1795</p>

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Porous Asphalt</b></p> <p><i>Description:</i> This product is an open-graded coarse aggregate that is bonded together with standard bituminous asphalt. Unlike conventional asphalt, it does not contain the small fine particles (&lt;600 μ), which permits the infiltration of water through the pavement into the underlying crushed rock reservoir and soil mantle.</p> <p>Impervious asphalt and porous asphalt utilize the same mixing and application equipment.</p> <p>Additional information at <a href="http://www.thcahill.com/pasp_halt.html">http://www.thcahill.com/pasp_halt.html</a></p> 	<p>Suitable for passenger vehicle parking lots (i.e., daily, overflow, or event parking), light traffic residential streets, play courts, bike paths, and sidewalks.</p> <p>Driveways are usually too small for a contractor to prepare the specialized mix. Homeowners interested in other permeable options are referred to the fact sheets on block pavers and plastic grid pavers.</p>	<p>The load bearing capacity of porous asphalt is less than that of porous concrete.</p> <p>Sufficient asphalt content (5.75- 6% bituminous asphalt by weight) is essential to pavement durability. Sites that used lower asphalt content show surface scuffing and/or raveling on the surface.</p> <p>Decreases in black ice formation on porous asphalt compared to conventional asphalt have been reported.</p>	<p>The porous asphalt is installed over a 1” layer of chocker course and bed of uniformly graded, clean washed crushed rock that is usually 18-36” deep. A layer of geotextile fabric separates the crushed rock from the underlying soil to prevent any fines from moving up into the storage bed.</p> <p>The bottom of the recharge bed is excavated to a level surface and is not compacted to allow the water to distribute and infiltrate evenly over the entire bottom bed area.</p>	<p>Vacuum sweeping to remove sediment that has accumulated on the surface. Materials removed by the vacuum must be disposed of properly.</p> <p>Annual inspection of the surface for deterioration or spalling (i.e., surface disintegration).</p> <p>Potholes and cracks can be filled with patching mixes unless more than 10% of the surface needs to be repaired. Spot clogging may be fixed by drilling 0.5” holes through the pavement layer every few feet.</p> <p>Winter abrasives should not be applied. Deicing salts should not be applied near groundwater drinking supplies, but environmentally- benign deicers are permissible. Snow- plow blades must be raised ~1” to protect the surface.</p>	<p>On a yard-by-yard basis, the cost of porous asphalt is about the same as the cost of conventional asphalt (i.e., \$0.50-\$1.00/ft<sup>2</sup>).</p> <p>The underlying stone bed is usually more expensive than a conventional compacted subbase, but is offset by the reduction in storm-water pipes and inlets, and elimination of detention basins. Generally, porous pavement installation does not require deep excavations, and there is less earth-work than for conventional asphalt.</p> <p>Current installations average between \$2,000 and \$2,500 per parking space for parking, aisles, and stormwater management.</p>	

## Porous Asphalt Example Application – The University of Rhode Island’s Porous Asphalt Parking Lots

**Site Description:** Two porous asphalt parking lots were built in 2002 and 2003 at the University of Rhode Island (URI) to provide 1,000 additional parking spaces near the newly constructed Ryan Convocation Center, a venue for sporting, community, and family events.

**Design Details:** The larger porous asphalt parking lot (800-vehicles) is 5.5 acres, while the smaller lot (200-vehicles), which is a retrofit of a pre-existing lot, is 1.47 acres. The layer of porous asphalt in the two lots is 2.5 inches thick, with a slope of less than 2% to allow for maximum seepage through the pavement. Located below the layer of porous asphalt is a 1-inch thick layer of choker course and 3 to 3.5 feet of uniformly-graded, clean crushed rock. The crushed rock has approximately 40% void space to receive, temporarily store, and infiltrate the incoming rainfall and any sheetflow from the adjacent landscaped areas. The crushed rock storage reservoir is separated from the underlying subsurface materials by a layer of geotextile filter fabric. The purpose of this fabric is to prevent the movement of fine soil particles into the overlying reservoir, which could impede the infiltration of surface water into the storage bed. The entrance areas of the parking lots are paved with conventional bituminous asphalt, because of heavier use and sediment deposition from tires as vehicles enter the lots. Landscaped parking lot islands were designed as bio-infiltration areas throughout the parking lots, to provide a secondary route of infiltration during intense rainfall and in case the pavement surface begins to clog. The outer areas of the lot are landscaped with trees, and grass is maintained around the parking lots’ boundaries to keep wind-blown dust (from nearby agricultural activities and eroded soil) from accumulating on the porous asphalt.



Soil excavation and placement of crushed rock.



Stone reservoir surrounded by geotextile filter fabric.



Rainwater infiltrates the porous asphalt, yet accumulates on adjacent areas paved with conventional materials.

**Costs:** The construction costs for building the two porous lots totaled \$3,033,700. The design fees were approximately 10% of the construction costs. Therefore, the cost per parking space was approximately \$3,337. It is important to note that this particular project had site specific costs such as the demolition of a dairy barn, removal of stone masonry walls, and installation of emergency telephones and security cameras, which would not be encountered in all porous parking lot situations. The construction costs of URI's two porous parking lots were comparable to equivalent-sized conventional parking lots.

**Maintenance:** University personnel are responsible for the maintenance of the porous parking lots. Cahill Associates and Beta Group Inc., the two design firms, recommend vacuuming the lots at least four times per year with a commercial cleaning unit; maintaining the adjacent vegetation; not applying sand or deicing salt to the pavement surface, but using environmentally-benign deicers such as Ice Ban instead (because of the proximity of the Pawcatuck aquifer), plowing with the blade lifted 1" higher than normal, and inspecting the surface annually for signs of deterioration or spalling.

**Notes:** According to David Bascom, Assistant Director of the Landscapes and Grounds Department at URI, there have not been any instances of water ponding on these lots after rainfall events, even very intense ones. However, he has observed some ice buildup following freezing rain events, because the water freezes on the surface before it has time to infiltrate through the layer of porous asphalt. He also notes that the environmentally-benign deicer Ice Ban does not work as well as more conventional chemicals or salts if it is not applied within thirty minutes of a snow event. The University's maintenance crew has also started to see some surface defects at the northeast corner of the parking lot, which has been attributed to outright abuse from people turning their wheels while their vehicles remain stationary. According to Dan Wible, of Cahill Associates, this type of unraveling is not unique to porous parking lots, and laboratory research has shown that the unraveling does not compromise the drainage capabilities of the porous lots. If one wants to repair the surface for aesthetic purposes, areas less than 50 square feet can be patched with standard asphalt, while those greater than 50 square feet should be patched with an approved porous asphalt. Those interested in learning more about the porous asphalt parking lots at URI are referred to the case study *The University of Rhode Island's Permeable Parking Lots* at <http://www.uri.edu/ce/wq/NEMO/Publications/PDFs/PP.URICaseStudy.pdf>.

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# Plastic Grid Pavers Fact Sheets

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Grasspave<sup>2</sup></b></p> <p><i><b>Description:</b></i> This product is comprised of connected plastic circular rings that can be filled with a soil/sand mix and grass. The pavers have 92% pervious area and are constructed with 100% post-consumer high-density polyethylene plastic. The high void space permits excellent root development and storage capacity.</p> <p><i><b>Manufacturer:</b></i> Invisible Structures Inc. Additional information at <a href="http://www.invisiblestructures.com">www.invisiblestructures.com</a></p> 	<p>Suitable for various types of parking lots (i.e., overflow, event, employee, handicap), on-street parking, driveways, fire lanes, emergency access roads, utility access, pedestrian access, golf cart paths, and infiltration basins.</p>	<p>Load capacity is 823,680 lbs/ft (5,721 psi, which is nearly two times the strength of 2" of concrete).</p> <p>It has UV inhibitors.</p> <p>In sandy soils, it can absorb up to 6" of rainfall over 24 hours.</p>	<p>Installed on top of a sandy gravel subbase. It is unrolled and pinned into place.</p> <p>The plastic rings and spaces between them are filled with a soil/sand mix and planted with grass. The sand in the mix helps to ensure proper drainage, proper oxygen and carbon dioxide levels, strength, and stability.</p>	<p>Maintenance includes mowing, irrigation, fertilization, and seeding.</p> <p>Individual grids may need to be replaced over time.</p> <p>Existing equipment can be used for snow removal, as long as skid plates/rollers are adjusted to keep the plow blades 1" above the surface.</p>	<p>Price of pavers is ~ \$2.00/ft<sup>2</sup>.</p> <p>Installation cost is highly variable, depending on the size of the project. For a 10,000 ft<sup>2</sup> project, the cost will be ~\$2.50/ft<sup>2</sup>, which includes the gravel subbase layer, seeding etc.</p>	<p>Invisible Structures, Inc. 14704-D East 33<sup>rd</sup> Place Aurora, CO 80011 (800) 233-1510 <a href="http://www.invisiblestructures.com">www.invisiblestructures.com</a></p> <p>Distributors in CA = Gerson Co. (206) 595-2203 <a href="mailto:andy@isomedia.com">andy@isomedia.com</a></p> <p>GeoOptions 888 Howe Rd Martinez, CA 94553 (925) 335-9220 <a href="mailto:sales@geooptions.com">sales@geooptions.com</a></p> <p>Pace Supply 3033 Dutton Ave Santa Rosa, CA 95407 (707) 547-4447 Contact: Eric Moody <a href="mailto:emoody@pacesupply.com">emoody@pacesupply.com</a></p>

## **Grasspave<sup>2</sup> Example Application – West Farms Mall**

Emergency access roads paved with Grasspave<sup>2</sup> have been installed at St. Andrews school in Barrington, Rhode Island., the Naval War College in Newport, Rhode Island, and AMG Headquarters in Beverly, Massachusetts. This product has also been used for overflow parking lots; a case study of a parking lot in Connecticut is presented below.

**Site Description:** The West Farms Mall overflow parking lot was built to provide 700 additional parking spaces during the peak seasons, and it was paved with Grasspave<sup>2</sup>.

**Design Details:** The overflow parking lot covers approximately 200,000 ft<sup>2</sup>, and athletic paint is applied each November to demarcate the parking spaces. A few drains were installed under the Grasspave<sup>2</sup> to ensure proper drainage during very heavy storms.

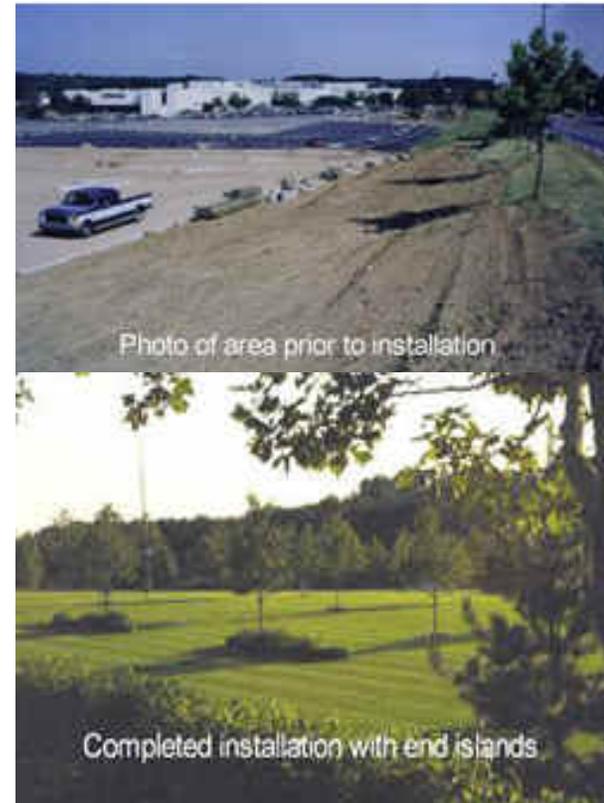
**Costs:** The total cost of the paving system (including the base layers) was estimated to be less than half of the projected cost of a detention pond that would have been required if conventional asphalt paving was installed.

**Maintenance:** The overflow lot requires mowing on a regular basis and must be watered and fertilized occasionally. The lot must be plowed in the winter with rollers to ensure that the surface is not damaged. The entrances to the aisles have begun to show some signs of wear and will need to be replaced. The West Farms' maintenance staff is responsible for the year round care of the lot.

**Notes:** According to the University of Connecticut's Nonpoint Education for Municipal Officials (NEMO) website, Joe Leiberis, West Farms' facilities director, stated that after four years of having the Grasspave<sup>2</sup> overflow parking lot, he no longer worries about it. He is happy with its durability after witnessing how well it can handle the winters, summers, hurricanes, and heavy traffic. Additional information on this case study can be found at [http://web.uconn.edu/nemo/case\\_studies/west\\_farms\\_cs.htm](http://web.uconn.edu/nemo/case_studies/west_farms_cs.htm).

**Contacts:** Richter & Cegan Inc., Landscape Architects and Urban Designers [rcinc@richtercegan.com](mailto:rcinc@richtercegan.com)

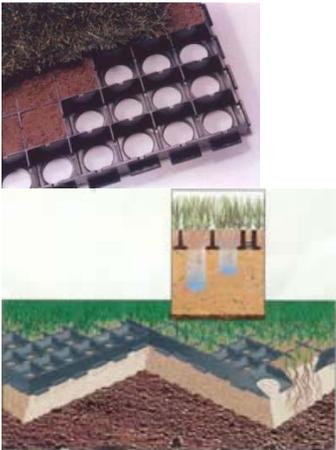
Photography: UCONN NEMO website  
([http://web.uconn.edu/nemo/case\\_studies/west\\_farms\\_cs.htm](http://web.uconn.edu/nemo/case_studies/west_farms_cs.htm) )

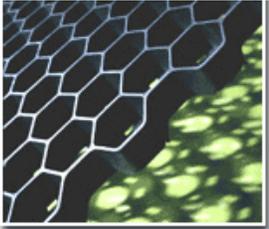


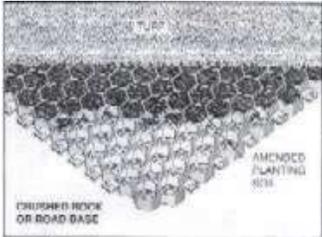
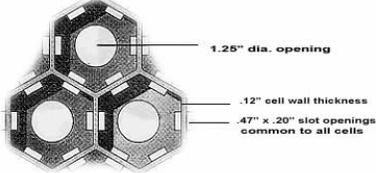
Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Gravelpave<sup>2</sup></b></p> <p><b>Description:</b> This product is comprised of connected plastic circular rings that can be filled with gravel. It has a porous geotextile filter fabric backing to hold the small gravel aggregate particles in place. The pavers have 92% pervious area and are constructed with 100% post-consumer high-density polyethylene plastic.</p> <p><b>Manufacturer:</b> Invisible Structures Inc. Additional information at <a href="http://www.invisiblestructures.com">www.invisiblestructures.com</a></p> 	<p>This product should be used in areas where higher traffic would injure grass. It is suitable for permanent and overflow parking lots, parking aisles and bays, handicap parking spaces, driveways, service and access roads, parks, trails, boat ramps, golf courses, high-use pedestrian areas, and infiltration basins.</p>	<p>Load capacity is 823,680 lbs/ft<sup>2</sup> (5,721 psi, which is nearly two times the strength of 2" of concrete).</p> <p>The circular rings, when filled with 1" of gravel and placed above a 6" thick standard road base of sandy gravel, can percolate approximately 35" of rain/hr.</p>	<p>Installed on top of a sandy gravel subbase. The depth of the subbase is dependent upon site conditions and intended use.</p> <p>The Gravelpave<sup>2</sup> is unrolled and pinned into place. The plastic rings and spaces between them are filled with 1" of gravel.</p>	<p>Replacement of gravel fill over time.</p> <p>Replacement of specific grids over time.</p> <p>Existing equipment can be used for snow removal as long as skid plates/rollers are adjusted to keep the plow blades 1" above the surface.</p>	<p>Price of pavers is ~ \$2.25/ft<sup>2</sup>.</p>	<p>Invisible Structures, Inc. 14704-D East 33<sup>rd</sup> Place Aurora, CO 80011 (800) 233-1510 <a href="http://www.invisiblestructures.com">www.invisiblestructures.com</a></p> <p>Distributors in CA = Gerson Co. (206) 595-2203 <a href="mailto:any@isomedia.com">any@isomedia.com</a></p> <p>GeoOptions 888 Howe Rd Martinez, CA 94553 (925) 335-9220 <a href="mailto:sales@geooptions.com">sales@geooptions.com</a></p> <p>Pace Supply 3033 Dutton Ave Santa Rosa, CA 95407 (707) 547-4447 Contact: Eric Moody <a href="mailto:emoody@pacesupply.com">emoody@pacesupply.com</a></p>

Example Application: The West Farms overflow parking lot, which was presented in the preceding case study, used Gravelpave<sup>2</sup> for the heavier traveled aisles, and is satisfied with the product.

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Drivable Grass<sup>®</sup></b></p> <p><i>Description:</i> This product consists of poly-reinforced concrete muffins that are connected by a grid system. Mats are produced in 2' x 4' sections.</p> <p>The muffins flex and conform to uneven ground surfaces without coming apart. Pre-manufactured holes and cracks allow for root penetration through the mat into subgrade soil, anchoring it firmly into place.</p> <p><i>Manufacturer:</i> Soil Retention. Additional information at <a href="http://www.soilretention.com">http://www.soilretention.com</a></p> 	<p>Suitable for driveways, patios, emergency vehicle access lanes, and overflow parking lots.</p>	<p>When installed over a proper base and subbase, this product can withstand axial loads up to 80,000 lbs.</p> <p>Even when saturated, Drivable Grass<sup>®</sup> maintains the characteristics of a drivable, grassy surface, while minimizing wheel rutting and water runoff.</p>	<p>Installation requires a contractor or can be done by a homeowner. Area should be prepared and filled with a compacted aggregate subbase layer, followed by a thin layer of sand, with the permeable surface placed on top. Prepare with soil and seeded with grass.</p> <p>The thickness of the subbase is dependent upon vehicle loading and subgrade strength. It usually ranges from 4-20", with the greater thickness used in cases of weak subgrade conditions or where used by heavy vehicles.</p>	<p>Maintenance includes mowing, irrigation, fertilization, and seeding.</p>	<p>Price of pavers is ~ \$2.87/ft<sup>2</sup>.</p> <p>\$22.99 per 2' x 4' mat, and \$12.99 per 2' x 2' mat</p> <p>The costs of the base, subbase, and installation vary based on site conditions.</p>	<p>Soil Retention 2501 State St, Carlsbad, CA (800) 346.7995 <a href="mailto:sales@soilretention.com">sales@soilretention.com</a></p> <p>Freshwater Farms Contact: Rick 5851 Myrtle Avenue Eureka, CA 95503-9510 (707) 444-8261 ext. 14</p> <p>Dazey's Supply 3082 Redwood Dr. Redway/Garberville, CA 95560 (707) 923-3002</p>

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Geoblock Porous Pavement System</b></p> <p><i>Description:</i> This product consists of a series of interlocking, high-strength blocks (~20" x 40" x 2") that can be filled with soil and grass. The cellular structure protects the crown of the grass, reduces rutting, and prevents the soil from being compacted. The paver is constructed with up to 50% recycled plastic, and has 87% top open area and 40% bottom open area per unit.</p> <p><i>Manufacturer:</i> Geosystems. Additional information at <a href="http://www.prestogeo.com">www.prestogeo.com</a>.</p> 	<p>Suitable for access roads (emergency &amp; utility access lanes), auxiliary parking areas, driveways, pedestrian walkways, wheelchair access ways, golf cart paths, shoulders, and aprons.</p>	<p>Total load bearing capacity is 130,000 lbs/ft<sup>2</sup></p> <p>The product has chemical resistance</p> <p>The 87% top open area per unit and 40% bottom open area per unit allows for high rates of percolation.</p>	<p>To maximize permeability, the pavers should be installed over a rock and sand subbase and filled with sandy loam topsoil. Prior to installation, it is necessary to remove all foreign materials.</p> <p>The recommended subbase ranges between two to six inches depending on the designated loads.</p> <p>Ordinary tools can be used to cut the units and no special fasteners or connection devices are required for installation.</p>	<p>Maintenance includes mowing, irrigation, fertilization, and seeding.</p> <p>Minor grid replacement after 10 years.</p>	<p>Price of pavers is \$2.75 per ft<sup>2</sup>.</p>	<p>Manufacturer = <a href="http://www.prestogeo.com">www.prestogeo.com</a> (800) 548-3424 or (920) 738-1118</p> <p>Distributor in CA = Soil Stabilization Products Company (800) 523-9992</p>

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Grassroad Pavers<sup>8</sup> Plus</b></p> <p><i>Description:</i> This product is comprised of interlocking plastic grid units (48" x 24") with a hexagon mat design that can be filled with soil and grass. The honeycomb matrix helps to reinforce the soil and protects the root structure of the vegetation. The paver is constructed with high density plastic and is capable of resisting compression, impact and lateral movement.</p> <p><i>Manufacturer:</i> NDS Incorporated. Additional information is available online at <a href="http://www.grassroad.com">www.grassroad.com</a></p> 	<p>Suitable applications include access roads, driveways, RV access, boat parking areas, sidewalks, and paths.</p>	<p>Load bearing capacity on the hexagonal vertical walls is 120,000 lbs/ft<sup>2</sup>.</p>	<p>Installation does not require a contractor. Homeowners can often do the installation themselves.</p> <p>The pavers are snapped together by the Flex Lock nesting system, and placement times can range as high as 800 sq. ft/hr.</p> <p>After the pavers are placed over a proper subbase, which is site dependent, the pavers are filled with either seed or sod.</p>	<p>Maintenance includes mowing, Irrigation, fertilization, and seeding.</p> <p>Replacement of sections over time.</p> <p>The snowplow blade should be either raised slightly or outfitted with a flexible rubber bottom piece, to ensure that the paver is not lifted from the surface.</p>	<p>Price of pavers is \$5.38 per ft<sup>2</sup>.</p> <p>The pavers are 4' x 2', and are sold in packages of 16 or 24. The cost is \$43 per paver.</p>	<p>Manufacturer = NDS Inc. 851 N. Harvard Ave. Lindsay, CA 93247 (800) 726-1994 <a href="mailto:nds@ndspro.net">nds@ndspro.net</a></p>

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Tufftrack Grass Pavers</b></p> <p><i>Description:</i> This product is comprised of interlocking plastic grid units (~24" x 24" x 1.5") with a hexagon mat design that can be filled with soil and grass. The honeycomb matrix helps to reinforce the soil and protects the root structure of the vegetation. The paver is constructed with high- density plastic and is capable of withstanding light or heavy vehicular traffic. It resists compression, impact, and lateral movement.</p> <p><i>Manufacturer:</i> NDS Incorporated. Additional information at <a href="http://www.sitefabric.com/tufftrack_grass_pavers.htm">http://www.sitefabric.com/tufftrack_grass_pavers.htm</a></p>  <p><b>Group of Three Nested Cells</b></p> 	<p>Suitable applications include parking lots, overflow parking lots, emergency access roads, driveways, RV parking pads and roadways, pedestrian walkways, bike paths, and golf cart paths.</p>	<p>The empty pavers have an ultimate compression load rating of 98,500 lbs/ft<sup>2</sup>.</p> <p>UV inhibitors and chemical resistance.</p>	<p>For heavy load and fire lane access the planting base should be 1" to 1.5" and the sub-base 6" to 8".</p> <p>For light to medium weight, only a 4" planting bed under the paver is required.</p> <p>The tongue and groove latching system allows for fast assembly. Once assembled the pavers are filled with either seed or sod.</p>	<p>Maintenance includes mowing, Irrigation, fertilization, and seeding.</p> <p>Replacement of sections over time.</p> <p>The snowplow blade should be either raised slightly or outfitted with a flexible rubber bottom piece to ensure that the paver is not lifted from the surface.</p>	<p>Price of pavers is \$5 per ft<sup>2</sup>.</p> <p>Pavers are 2' x 2' x 1.5" high, and cost \$20 per paver.</p>	<p>Manufacturer = NDS Inc. 851 N. Harvard Ave. Lindsay, CA 93247 (800) 726-1994 <a href="mailto:nds@ndspro.net">nds@ndspro.net</a></p>

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Local Retailer
<p><b>Netpave 50</b></p> <p><b>Description:</b> This product is comprised of ~20" x 20" x 2" square, flexible plastic grid units with small openings that can be filled with either gravel, or soil and grass. The cellular structure helps to retain the gravel by preventing displacement, while the open base enables unrestricted root growth and high levels of infiltration. The paver is constructed with 100% recycled plastic, and the units are connected together with 'T' lugs and slots, eliminating the need for pins.</p> <p><b>Manufacturer:</b> Netlon Turf Systems. Additional information online at <a href="http://www.netlon.co.uk/turfsystems/prod-netpave50.htm">http://www.netlon.co.uk/turfsystems/prod-netpave50.htm</a></p> 	<p>Suitable for permanent and overflow parking lots, driveways, fire and emergency access roads, and bicycle/walking paths.</p>	<p>Load bearing capacity is ~27,870 lbs/ft<sup>2</sup></p> <p>Product lifetime: 120 years. It has both chemical and ultraviolet resistance.</p>	<p><b>Gravel Installation</b></p> <p>Remove topsoil and add a subbase. The depth requirements range between 7.5-28.5" for fire truck emergency access to 6-21" depth for light vehicles and overflow parking lots. A 0.8-1" thick layer of gravel is placed over the subbase. The pavers are placed on top and additional gravel (preferably 2 to 5 mm) is used to fill the paver cells to the top. The pavers can be cut using either a hand or power saw to fit around obstructions and contours.</p> <p><b>Grass Installation</b></p> <p>The subbase preparation is the same as above. A 2-3" layer of 60:40 root-zone (sand:soil blend) is placed over the subbase. The pavers are placed on top and 1.6" of the root-zone is placed within the pavers' cells. The surface may be used immediately, but it is preferable to let the grass become fully established before use. The pavers can be cut using either a hand or power saw to fit around obstructions and contours.</p>	<p><b>Gravel pavers</b> may require intermittent replacement of gravel and minor grid replacement over time.</p> <p>A snowplow blade should be either raised slightly or outfitted with a flexible rubber bottom piece to ensure that the Netpave is not lifted from the surface.</p> <p><b>Grass pavers</b> maintenance includes mowing, irrigation, fertilization, and seeding.</p> <p>Mower blades should be set high for the first 2-3 cuts.</p>	<p>Prices of pavers ranges from \$2.00 -3.00 per ft<sup>2</sup>. Pavers are ~ 20" x 20" x 2" (4 per m<sup>2</sup>). The exact price depends upon quantity, material, and logistics.</p> <p>The subbase material cost varies based on site conditions and depth of the subbase.</p> <p>Grid Tech provides all of the materials and labor as packages. Quotes can be given following site visits. They try to work first and foremost with the native on-site soils.</p>	<p>Grid Technologies Admiral Gate Tower Suite 507 221 Third Street Newport, R.I. 02840 <a href="http://www.gridtech.com">www.gridtech.com</a> (401) 849-7920</p> <p>Soil Scientist available for site development.</p>

## Netpave 50 Example Application - Middletown's Soccer Field

**Site Description:** The Middletown, Rhode Island, soccer field parking lot was built in October 1999 and paved with Netpave 50.

**Maintenance:** Thomas O'Loughlin, the Public Works Director for the Parks and Recreation Department in Middletown, states that he has to periodically top off the gravel because it tends to wash out overtime. The grid has not deteriorated or failed, and overall he has been very pleased with the results.

**Notes:** Overall, this has been a successful application, but it does demonstrate the need to ensure that the natural drainage patterns of the site are incorporated into final design plans. According to Arthur Erhardt, the President of Grid Tech, the puddling water and deposition of fine material shown in the center of the parking lot area is due to the fact that the contractors hired to build the lot did not place the storm drain in the correct location or use the soil recommended by Grid Tech. Cars park on both sides of the lot, and as shown in the picture below, the grass continues to grow and in many areas completely covers the pavers.

### **Contacts:**

Thomas O'Loughlin  
Public Works Director  
Middletown Parks and Recreation Department  
(401) 846-2119  
[publicworks@ci.middletown.ri.us](mailto:publicworks@ci.middletown.ri.us)

Arthur Erhardt  
President of Grid Tech  
(401) 849-7920  
[info@gridtech.com](mailto:info@gridtech.com)



Middletown soccer field parking lot shortly after construction



Middletown soccer field parking lot in June 2004

## Netpave 50 Example Application - Coventry Center Greenway

**Site Description:** A one hundred-foot test section of Netpave 50 was installed by contractors hired by the Rhode Island Department of Environmental Management (DEM) at the Coventry Center Greenway bike path in 2003.

**Costs:** The cost of paving this section of the Coventry Center Greenway with Netpave 50 was approximately two times the cost of standard bituminous asphalt.

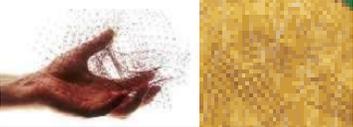
**Notes:** An in-house DEM construction crew installed a 50-foot long section of Netpave 50 at the Nicholas Farm Management Area in 2001. Lisa Lawless, an engineer at DEM, stated that the in-house crew did not construct any shoulders and that unraveling began to occur shortly after installation. Therefore, the Coventry Center Greenway test installation was built with a stabilized shoulder and has held up much better. Lisa Lawless stresses the importance of a good stabilized shoulder and adequate gravel cover. The DEM has been very pleased with the test section and is planning on paving the entire western end of the bike path, which is 2.1 miles, with the Netpave 50.

**Contacts:** Lisa Lawless, Engineer at the R.I. DEM (401) 222-2776 ext. 4312, [llawless@dem.state.ri.us](mailto:llawless@dem.state.ri.us)



Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Retailer
<p><b>Netpave 25</b></p> <p><b>Description:</b> This product is comprised of ~20" x 20" x 1" square, flexible plastic grid units with small openings that can be filled with soil and grass. The open base of the paver enables unrestricted root growth and high levels of infiltration.</p> <p>The paver is constructed with 100% recycled plastic, and the units are connected together with 'T' lugs and slots, eliminating the need for pins.</p> <p><b>Manufacturer:</b> Netlon Turf Systems. Additional information at <a href="http://www.netlon.co.uk/turfsystems/prod-netpave25.htm">http://www.netlon.co.uk/turfsystems/prod-netpave25.htm</a></p> 	<p>Intended for use on existing grass surfaces to provide a level of protection intermediate between the Netpave 50 and TurfGuard.</p> <p>Suitable for parking lots, driveways, and paths.</p>	<p>It is able to support light traffic on firm ground, but it is not designed to compensate for weak ground conditions where more structured solutions are necessary. Load bearing is ~27,870 lbs/ft<sup>2</sup>.</p> <p>To determine if Netpave 25 is suitable, Netlon advises people to drive a vehicle onto the area after a heavy rainfall. If it does not rut, than this product is appropriate.</p> <p>Product lifetime: 120 years. It has both chemical and UV resistance and is resistant to deformation and fracture, and able to conform to irregular surfaces and gradients.</p>	<p>Installation does not require substructure or excavation. It is simply laid upon the grass surface. Prior to installation, the existing grass should be cut as short as possible and depressions should be filled with a blend of sharp sand and topsoil to firm the surface.</p> <p>The Netpave 25 should be laid out from one edge to the opposite side with all of the lugs facing in the direction of laying.</p> <p>The area can be used immediately following installation, but it is preferable to let the grass become fully established before use.</p>	<p>Maintenance includes mowing, irrigation, fertilization and seeding.</p> <p>Mower blades should be set high for the first 2-3 cuts.</p> <p>A snowplow blade should be either raised slightly or outfitted with a flexible rubber bottom piece to ensure that the Netpave is not lifted from the surface.</p>	<p>Price of pavers ranges from \$2.00 - \$3.00 per ft<sup>2</sup>, and is dependent upon quantity, material and logistics.</p> <p>Pavers are ~20" x 20" x 1" (4 per m<sup>2</sup>).</p>	<p>Grid Technologies Inc. Admiral Gate Tower Suite 507 221 Third Street Newport, R.I. 02840 <a href="http://www.gridtech.com">www.gridtech.com</a> (401) 849-7920</p>

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Retailer
<p><b>Turfguard</b></p> <p><i>Description:</i> This product is comprised of plastic mesh that is laid over a pre-existing grass surface. The paver is constructed with polyethylene, which is tough, flexible, long-lasting, and suitable for occasional access on stable ground.</p> <p><i>Manufacturer:</i> Netlon Turf Systems. Additional information online at <a href="http://www.netlon.com/turfsystems/prod-turfguard.htm">http://www.netlon.com/turfsystems/prod-turfguard.htm</a></p> 	<p>Suitable for occasional access routes for light vehicles, overflow parking lots, driveways, taxiways for light aircraft, and pedestrian walkways.</p>	<p>Tensile strength: 5.8kN/m (397 lbs/ft)</p> <p>Product lifetime: 120 years</p>	<p>Installation does not require a contractor or any groundbreaking. Homeowners can easily install it.</p> <p>To install Turfguard, unroll it and lay it flat on a grass surface that has been leveled out with a 70:30 mixture of sharp sand and topsoil. Anchor in place with Netlon pegs or staples.</p>	<p>Mower blades should be set high for the first 2-3 cuts. Occasional light rolling, irrigation and fertilization are necessary.</p> <p>Plow blade on casters to ensure that the Turfguard is not damaged.</p>	<p>The price of Turfguard is ~ \$0.60 per ft<sup>2</sup>.</p> <p>It is available in 30m x 2m rolls (~98 ft. x 6.6 ft), and costs about \$390 a roll.</p>	<p>Grid Technologies Inc. Admiral Gate Tower Suite 507 221 Third Street Newport, R.I. 02840 <a href="http://www.gridtech.com">www.gridtech.com</a> (401) 849-7920</p>

Type of Pavement	Applications	Performance	Installation Details	Maintenance	Costs	Retailer
<p><b>Advanced Turf</b></p> <p><i>Description:</i> This product is comprised of small pieces of plastic mesh, approximately 2”x 4”, that are blended with a high sand content growing medium to form a stabilized root-zone that can support heavier loads than regular grass. The mesh grids are constructed with polypropylene, which is non-toxic, insoluble, non-absorbent, and inert to any of the chemicals likely to be found in the root-zone.</p> <p><i>Manufacturer:</i> Netlon Turf Systems. Additional information online at <a href="http://www.netlon.com/turfsystems/prod-advancedturf.htm">http://www.netlon.com/turfsystems/prod-advancedturf.htm</a></p> 	<p>Suitable for event areas, sport playing fields, occasional use access roads, overflow parking lots, airstrips and taxiways, and playgrounds. The advanced turf/high sand blend can be either 4, 6, or 8” thick. The deeper depth should be installed in areas anticipating heavier loads (i.e., vehicles)</p>	<p>This product when installed over a proper base and subbase can withstand axial loads up to 12 tons (24,000 lbs).</p> <p>Product lifetime: 120 years.</p>	<p>Installation requires a contractor. A sand:soil:Netlon mesh blend is placed over an aggregate subbase layer, and seeded with grass. The thickness of the subbase is dependent upon vehicle loading and subgrade strength. It usually ranges from 4-20”, with greater thickness used in cases of weak subgrade conditions or use by heavy vehicles.</p>	<p>Maintenance includes mowing, irrigation, fertilization, and seeding.</p> <p>If the grids migrate to the surface over time, a lawn mower should be able to cut through them. A flame torch can also be used to melt them away, or the area can be top dressed and reseeded.</p>	<p>The price of Advanced Turf is \$1.00 per ft<sup>2</sup> (at the surface) with 4” depth. This price does not include blending the materials into the soil or installation.</p> <p>The costs of the base, subbase, and installation vary depending on site conditions.</p> <p>Grid Tech provides all of the materials and labor as a package, and quotes can be given following site visits.</p>	<p>Grid Technologies Admiral Gate Tower Suite 507 221 Third Street Newport, R.I. 02840 <a href="http://www.gridtech.com">www.gridtech.com</a> (401) 849-7920</p>

## Advanced Turf Example Application - Brown University's Lincoln Field

**Site Description:** An advanced turf system was installed in Lincoln Field on Brown University's campus in 1994. Lincoln Field, in Providence, Rhode Island, is a low-lying area that was subject to frequent flooding prior to the installation of the ATS.

**Design Details:** A contractor installed eight inches of the advance turf / high sand content growing medium above properly prepared base and subbase layers. This composite design (i.e., the layer of ATS/sand mix, the subbase, and base) took into account the specific conditions of the site and the anticipated use by occasional vehicular traffic and numerous University events.

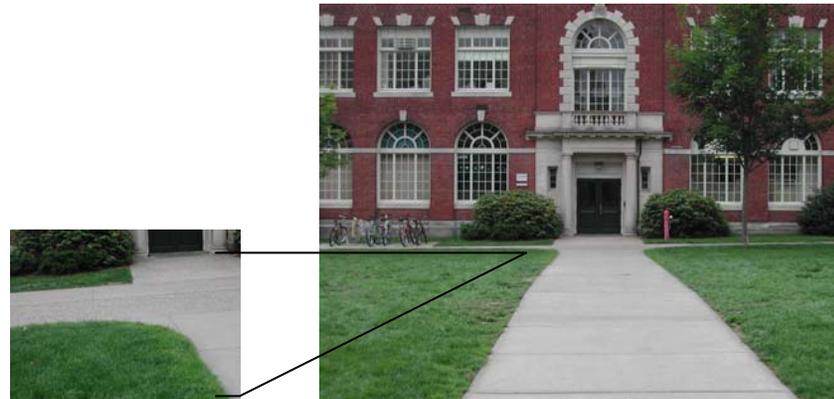
**Maintenance:** According to Patrick Vettere, the Ground Superintendent, this area requires a lot more watering than other grass areas on campus. A few grids were visible on the surface in June 2004, but these can either be cut up by a lawn mower or melted with a flame torch.

**Notes:** Patrick Vettere also stated that it took a while for the organic material to take hold. In hindsight, he believes that they should have probably used a little more organic material. Overall though, he is very happy with how well the ATS system has worked and held up over the past ten years.

**Contacts:** Patrick Vettere, Brown University Ground Superintendent



Lincoln Field prior to the installation  
(March 1994)



Lincoln Field ten years after installation (June 2004)



ATS poking  
through soil

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