Porous Pavement

Description: Porous pavement is a paved surface with a higher than normal percentage of air voids to allow water to pass through it and infiltrate into the subsoil. This porous surface replaces traditional pavement, allowing parking lot, driveway, and roadway runoff to infiltrate directly into the soil and receive water quality treatment. All permeable paving systems consist of a durable, load-bearing, pervious surface overlying a stone bed that stores rainwater before it infiltrates into the underlying soil. Permeable paving techniques include porous asphalt, pervious concrete, paving stones, and manufactured "grass pavers" made of concrete or plastic. Permeable paving may be used for walkways, patios, plazas, driveways, parking stalls, and overflow parking areas.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides peak flow attenuation for small storms.
3 - Recharge	Provides groundwater recharge.
4 - TSS Removal	80% TSS Removal credit if storage bed is sized to hold ½-inch or 1-inch Water Quality Volume, and designed to drain within 72 hours.
5 - Higher Pollutant Loading	Not suitable.
6 - Discharges near or to Critical Areas	Not suitable especially within Zone IIs or Zone A's of public water supplies.
7 - Redevelopment	Suitable.

Advantages/Benefits:

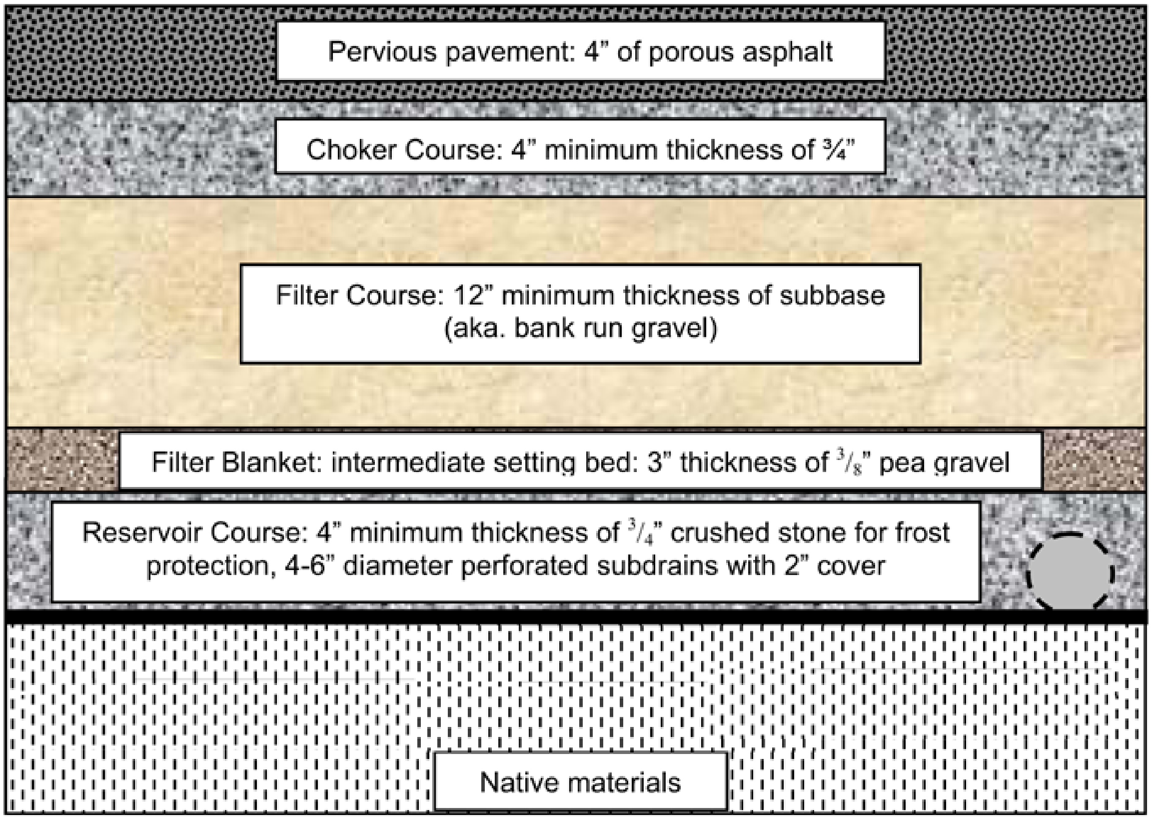
- Reduce stormwater runoff volume from paved surfaces
- Reduce peak discharge rates.
- Increase recharge through infiltration.
- Reduce pollutant transport through direct infiltration.
- Can last for decades in cold climates if properly designed, installed, and maintained
- Improved site landscaping benefits (grass pavers only).
- Can be used as a retrofit when parking lots are replaced.

Disadvantages/Limitations:

- Prone to clogging so aggressive maintenance with jet washing and vacuum street sweepers is required.
- No winter sanding is allowed.
- Winter road salt and deicer runoff concern near drinking water supplies for both porous pavements and impervious pavements.
- Soils need to have a permeability of at least 0.17 inches per hour.
- Special care is needed to avoid compacting underlying parent soils.

Pollutant Removal Efficiencies

• Total Suspended Solids (TSS)	80%
• Nutrients (Nitrogen, phosphorus)	Insufficient data
• Metals (copper, lead, zinc, cadmium)	Insufficient data
• Pathogens (coliform, e coli)	Insufficient data



adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Monitor to ensure that the paving surface drains properly after storms	As needed
For porous asphalts and concretes, clean the surface using power washer to dislodge trapped particles and then vacuum sweep the area. For paving stones, add joint material (sand) to replace material that has been transported.	As needed
Inspect the surface annually for deterioration	Annually
Assess exfiltration capability at least once a year. When exfiltration capacity is found to decline, implement measures from the Operation and Maintenance Plan to restore original exfiltration capacity.	As needed, but at least once a year
Reseed grass pavers to fill in bare spots.	As needed

Special Features

Most appropriate for pedestrian-only areas and for low-volume, low-speed areas such as overflow parking areas, residential driveways, alleys, and parking stalls.

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Applicability

Porous pavement, also known as permeable paving, is appropriate for pedestrian-only areas and for low-volume, low-speed areas such as overflow parking areas, residential driveways, alleys, parking stalls, bikepaths, walkways, and patios. It can be constructed where the underlying soils have a permeability of at least 0.17 inches per hour. Porous paving is an excellent technique for dense urban areas, because it does not require any additional land. Porous pavement can be successfully installed in cold climates as long as the design includes features to reduce frost heaving.

Porous paving is not appropriate for high traffic/ high speed areas, because it has lower load-bearing capacity than conventional pavement. Do not use porous pavement in areas of higher potential pollutant loads, because stormwater cannot be pretreated prior to infiltration. Heavy winter sanding will clog joints and void spaces. On some highways, MassHighway Department uses an Open Graded Friction Course (OGF) that has a permeable top coat but an impermeable base course. MassDEP provides no Water Quality or Recharge Credit for OGC, because it does not provide treatment or recharge. The primary benefit of OGF pavements is reductions in noise and hydroplaning.

Effectiveness

Porous pavement provides groundwater recharge and reduces stormwater runoff volume. Depending on design, paving material, soil type, and rainfall, porous paving can infiltrate as much as 70% to 80% of annual rainfall. To qualify for the Water Quality and Recharge Credits, size the storage layer to hold the Required Water Quality or Required Recharge Volume, whichever is larger, using the Static Method, and design the system to dewater within 72 hours. Porous pavement may reduce peak discharge rates significantly by diverting stormwater into the ground and away from pipe-and-basin stormwater management systems, up to the volume housed in the storage layer. Grass pavers can improve site appearance by providing vegetation where there would otherwise be pavement. Porous paving can increase the effective developable area of a site, because the infiltration provided by permeable paving can significantly reduce the need for large stormwater management structures.

Planning considerations

Porous paving must not receive stormwater from other drainage areas, especially any areas that are not fully stabilized.

Use porous paving only on gentle slopes (less than 5%). Do not use it in high-traffic areas or where it will be subject to heavy axle loads.

Consider the setback requirements when considering porous pavement:

Considerations	Setback Requirements
Slope	Less than 5%
Septic system soil absorption system	50 feet
Private well	100 feet
Public well	Outside the Zone 1
Public reservoir	Outside the Zone A
Surface Waters	100 feet
Cellar Foundations	20 feet
Slab Foundations	10 feet
Property Lines	10 feet
Minimum depth	2 feet vertical separation above seasonal high groundwater from bottom of storage layer
Frost Line	Below frost line
Bedrock	As with any stormwater exfiltration system, determine if it is feasible in locations with high bedrock. Presence of bedrock near land surface reduces the ability of soils to exfiltrate to groundwater.

Porous paving reduces the need for other stormwater conveyances and treatment structures, resulting in cost savings.

Permeable paving also reduces the amount of land needed for stormwater management.

Design

There are three major types of permeable paving:

- Porous asphalt and pervious concrete. Although it appears to be the same as traditional asphalt or concrete pavement, it is mixed with a very low content of fine sand, so that it has from 10%-25% void space.

- Paving stones (also known as unit pavers) are impermeable blocks made of brick, stone, or concrete, set on a prepared sand base. The joints between the blocks are filled with sand or stone dust to allow water to percolate to the subsurface. Some concrete paving stones have an open cell design to increase permeability.

- Grass pavers (also known as turf blocks) are a type of open-cell unit paver in which the cells are filled with soil and planted with turf. The pavers, made of concrete or synthetic material, distribute the weight of traffic and prevent compression of the underlying soil.

Each of these products is constructed over a storage bed.

Storage Bed Design
The University of New Hampshire has developed specifications for storage beds used in connection with porous asphalt or pervious concrete. According to UNH, the storage bed should be constructed as indicated in Figure PP 1 with the following components from top to bottom:

- a 4-inch choker course comprised of uniformly graded crushed stone,
- a filter course, at least 12 inches thick, of poorly graded sand or bankrun gravel to provide enhanced filtration and delayed infiltration
- a filter blanket, at least 3 inches thick, of pea stone gravel to prevent material from entering the reservoir course, and
- a reservoir course of uniformly graded crushed stone with a high void content to maximize the storage of infiltrated water and to create a capillary barrier to winter freeze thaw. The bottom of the stone reservoir must be completely flat so that runoff can infiltrate through the entire surface.

The size of the storage bed may have to be increased to accommodate the larger of the Required Water Quality and the Required Recharge Volume.

If paving stones or grass pavers are used, a top course of sand that is one inch thick should be placed above the choker coarse.

Overflow Edge
Some designs incorporate an "overflow edge," which is a trench surrounding the edge of the pavement. The trench connects to the stone reservoir below the surface of the pavement and acts as a backup in case the surface clogs.

Preparation of Porous Asphalt
Care must be taken in batching and placing porous asphalt. Unless batched and installed properly, porous pavement may have a reduced exfiltration ability. At Walden Pond State Reservation, several of the areas paved with porous asphalt did not meet the target exfiltration rate. Cores were taken and it was found that the batches had more sand and/or asphalt than was specified, and those sections had to be removed and repaved.

It is critical to minimize the amount of asphalt binder. Using greater amounts of asphalt binder could lead to a greater likelihood of "binder" or asphalt drawdown and clogging of voids. Sun light heating can liquefy the asphalt. The liquefied asphalt then drains into the voids, clogging them. Such clogging is not remedied by power washing and vacuuming. The topcoat in such instances needs to be scarified and resurfaced. The University of New Hampshire has prepared detailed specifications for preparing and installing pourous asphalt that are intended to prevent asphalt problems.

Additional Design Considerations

- Provide an open-graded subbase with minimum 40% void space.
- Use surface and stone beds to accommodate design traffic loads
- Generally, do not use porous pavement for slopes greater than 5 %.
- Do not place bottom on compacted fill.
- Provide perforated pipe network along bed bottoms for distribution
- Provide a three-foot buffer between the bed bottom and the seasonal high groundwater elevation, and a two-foot buffer for bedrock.

Cold Weather Design Considerations

Porous pavement performs well in cold climates. Porous pavement can reduce meltwater runoff and avoid excessive water on the road during the snowmelt period.

In cold climates, the major concern is the potential for frost heaving. The storage bed specifications prepared by the University of New Hampshire address this concern.

Maintenance

In most porous pavement designs, the pavement itself acts as pretreatment to the stone reservoir below. Consequently, frequent cleaning and maintenance of the pavement surface is critical to prevent clogging. To keep the surface clean, frequent vacuum sweeping along with jet washing of asphalt and concrete pavement is required. No winter sanding shall be conducted on the porous surface.

As discussed, designs that include an “overflow edge” provide a backup in case the surface clogs. If the surface clogs, stormwater will flow over the surface and into the trench, where some infiltration and treatment will occur. For proper maintenance:

- Post signs identifying porous pavement areas.
- Minimize salt use during winter months. If drinking water sources are located nearby (see setbacks), porous pavements may not be allowed.
- No winter sanding is allowed.
- Keep landscaped areas well maintained to prevent soil from being transported onto the pavement.
- Clean the surface using vacuum sweeping machines monthly. For paving stones, periodically add joint material (sand) to replace material that has been transported.
- Regularly monitor the paving surface to make sure it drains properly after storms.
- Never reseal or repave with impermeable materials.
- Inspect the surface annually for deterioration or spalling.
- Periodically reseed grass pavers to fill in bare spots.
- Attach rollers to the bottoms of snowplows to prevent them from catching on the edges of grass pavers and some paving stones.

Adapted from:
MassDEP, Massachusetts Nonpoint Source Pollution Management Manual, 2006.

References

Ferguson, Bruce, K., Porous Pavements, 2005, CRC Press. Taylor and Francis Group, Boca Raton

UNH, 2007, UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds, Revised October 2007, http://www.unh.edu/erg/cstev/pubs_specs_info/unhsc_pa_apec_07_07_final.pdf

Asphalt Pavement for Stormwater Management, http://www.unh.edu/erg/cstev/pubs_specs_info/porous_ashpalt_fact_sheet.pdf

University of New Hampshire Center for Stormwater Technology Evaluation and Verification; this research group tests and evaluates stormwater BMPs on the UNH campus.

- An article about the use of permeable pavers at the Westfarms Mall in Connecticut.
- Case Studies from Uni-Group USA, a block paver manufacturer.
- The Nonpoint Education For Municipal Officials program at the University of Connecticut has been involved in numerous permeable paving pilot projects.
- Permeable paver specifications courtesy of the Low Impact Development Center.
- Porous pavement design and operational criteria from the US Environmental Protection Agency, which also publishes a Low Impact Development Page. Also see this report on a Field Evaluation of Permeable Pavements for Stormwater Management (PDF.)
- New Jersey Stormwater Best Management Practices Manual February 2004.