Green Infrastructure Practices: An Introduction to Permeable Pavement

Fact Sheet FS1177

Cooperative Extension

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What is Permeable Pavement?

Permeable pavement is a stormwater drainage system that allows rainwater and runoff to move through the pavement's surface to a storage layer below, with the water eventually seeping into the underlying soil. Permeable pavement is beneficial to the environment because it can reduce stormwater volume, treat stormwater water quality, replenish the groundwater supply, and lower air temperatures on hot days.

Figure 1. A cement truck discharging 2,000 gallons of water onto a permeable pavement. The water was drained from the surface in less than 4 minutes.

Background

An impervious surface is one that does not allow water to pass through it, so the surface produces stormwater runoff during rain events. Hard surfaces such as roads, parking lots, and rooftops are examples of impervious surfaces that produce stormwater runoff. This runoff can collect dirt, chemicals, trash, leaves, and grass clippings on its way to the storm drain, so the water entering the storm drainage system is often polluted. Many storm drains discharge this polluted runoff directly to local waterways such as streams, rivers, and lakes. In many older urban areas, the sanitary sewers are connected to the stormwater sewers in a combined sewer system. During large rain events, the wastewater treatment plant cannot handle the large volumes of water entering the system and both untreated sewage and stormwater runoff are discharged to the nearby water bodies. These events are called combined sewer overflows (CSOs) and they pose risks to both the environment and human health.

Permeable Pavement Systems

A permeable surface is any surface that allows water to pass through it and the term "permeable" is often used interchangeably with the terms "porous" and "pervious". Permeable pavement is a system that allows rainwater and stormwater runoff to move through the pavement's surface to a storage layer below and then to eventually seep into the underlying soil. The depth of this storage layer is usually between 6 and 12 inches, but it can be increased if more storage is required or if there are poorly draining soils below the system. These pavement systems are ideal for parking lots, driveways, alleys, sidewalks, and playgrounds. Permeable pavement systems can handle large stormwater volumes while also providing other benefits.

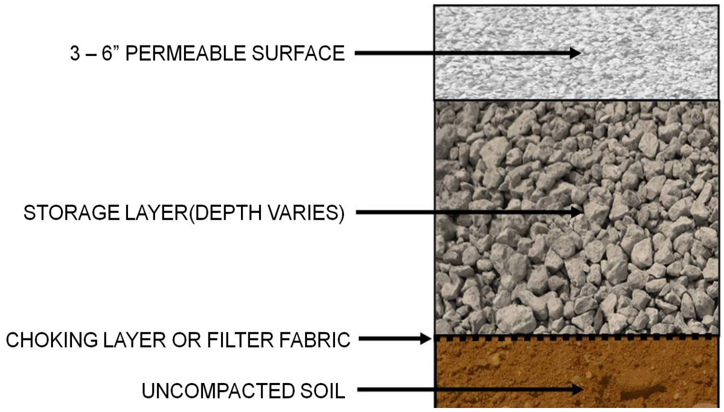

Figure 2. A schematic of a permeable pavement system.

Types of Permeable Pavement Surfaces

The differences among permeable pavement systems are found at the permeable surface, while the layers below the surface are generally similar. There is a wide variety of permeable pavement surfaces on the market today: concrete, asphalt, pavingstones, grids, rubber, glass, etc.

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Here, the most popular permeable surfaces are presented.

The words pervious, porous, and permeable are often used interchangeably, although the terms are technically different. A pervious surface is "open to passage", while a porous surface is "full of openings (pores)". A permeable surface is "capable of being passed through." The term "pervious" is used to describe permeable concrete as it is open to water passage compared to traditional concrete, while "porous" is used for permeable asphalt because of the void spaces. All of these surfaces allow water to flow through them, so they are permeable and the general pavement system will be described that way.

Pervious concrete is similar to traditional concrete, except that the fine particles are left out of the concrete mix production. This allows air to remain trapped in the mix when it's poured at the installation site. When the mix hardens, the air remains and forms void spaces that allow for water movement through the material. Pervious concrete is strong enough to be used in heavy-duty applications such as loading docks and roadway curbing, but is most often used for parking lots, sidewalks, and playgrounds. (Figure 3a)

Porous asphalt is similar to traditional asphalt, but the fine particles are not used during the asphalt mix production. Again, air is trapped in the mix and pore spaces are formed in the cured material that allow for water movement through the surface. Porous asphalt is popular with customers that want a permeable surface that looks like traditional asphalt and is often used in parking lots, driveways, and playgrounds. (Figure 3b)

Interlocking concrete pavers are typically not permeable themselves, but there are "teeth" on each paver that space the blocks evenly so water can flow in between them. The "teeth" also allow the pavers to lock together for extra stability. The spaces in between the blocks, which are typically about three quarters of an inch, are filled with crushed gravel to eliminate safety hazards. Interlocking concrete pavers are aesthetically pleasing and are practical for access to utilities, and are most often used in driveways, parking lots, and walkways. (Figure 3c)

Grid pavers are modular grids that are made of concrete, plastic, or rubber and the grid spaces may be filled with gravel, grass, or both. Grid pavers are often used for overflow parking, emergency vehicle access routes, or erosion control on problem sites and are not typically used in high-volume traffic areas. (Figure 3d)

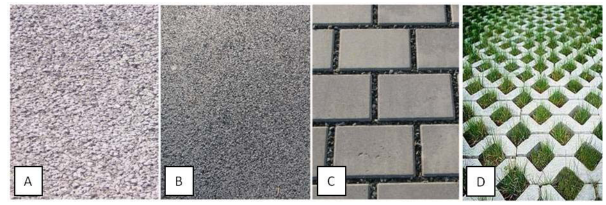

Figure 3. Permeable surfaces: (a) pervious concrete, (b) porous asphalt, (c) interlocking concrete pavers, (d) grid pavers.

Benefits of Permeable Pavement

Permeable pavement can provide environmental benefits by:

- Reducing stormwater volume – runoff is captured by the permeable pavement thereby reducing the flow of rainwater to the storm sewer, reducing flooding in local waterways, and reducing CSOs.
- Decreasing and delaying peak discharge – peak discharge is the highest rate of flow in a stream. The capture of stormwater volume by permeable pavement leads to decreased runoff to streams and spreads the storm's flow over a longer period of time, which reduces the burden on the sewer system.
- Preventing pollution – permeable pavement filters or removes stormwater pollutants as the runoff moves through the layers of the system, which leads to improved water quality. Bacteria that live in the different layers can break down and remove some contaminants such as oil and grease.
- Recharging groundwater – permeable pavement can absorb runoff and allow it to penetrate into the soil, which replenishes the groundwater supply. This groundwater also provides base flow to local rivers and streams during dry periods.
- Cooling cities and improving air quality – traditional asphalt absorbs heat throughout the day and releases it at night, keeping city air at elevated temperatures with no opportunity for cooling. This phenomenon is called the urban heat island effect. Higher temperatures lead to increased energy demand, which leads to higher emissions of air pollutants and greenhouse gases. Permeable pavement allows for greater air movement through the void spaces, which leads to cooler air temperatures. The lighter colored surfaces (pervious concrete, interlocking concrete pavers) reflect heat rather than absorb it, which also leads to cooler temperatures.

Permeable pavement can provide economic benefits by:

- Reducing or eliminating traditional stormwater management techniques reduces infrastructure costs – with permeable pavement, traditional stormwater-handling techniques are often not necessary. There will be less need for stormwater inlets and catchbasins, conveyance pipes, land for detention basins, or detention basins, themselves. The elimination of these traditional stormwater techniques can lead to big cost-savings. Table 1 shows an expenditure comparison for permeable and traditional pavement.
- Reducing stormwater fees – disconnection from the sewer system through the installation of permeable pavement reduces any sewer utility fees at the site. Some cities charge additional stormwater fees based on the impervious cover on the property. Permeable pavement can handle runoff while also reducing the impervious cover, which can lead to higher savings.
- Increasing utilization of property - since permeable pavement can be used to combine stormwater management with parking areas, the property that would have been used for a detention pond can be used for another function. This may increase income while reducing costs by having more storefront available for vendors, being able to accommodate more customers, or providing green space that attracts people to the area.
- Lowering life cycle costs because of increased durability and better freeze-thaw performance - permeable pavement can cost less in the long-term than traditional pavement due to increased durability and better freeze-thaw performance in the winter. The occurrence of potholes is greatly reduced because water does not become trapped at the permeable pavement surface the way it does with traditional asphalt. This means less patching, increased safety, and longer-lasting pavement.

Frequently Asked Questions about Permeable Pavement

- ***Can permeable pavement be used on a site with clay soils?***

  Yes, although every site is unique and should be examined for permeable pavement suitability prior to construction. One way to handle slow-draining soils is to increase the depth of the storage layer (18 inches or more). The larger storage layer allows the runoff a place to go after moving past the permeable surface without backing up. Another option for sites with clay soils is the installation of a pipe underdrain to carry excess drainage to a different location at the site or to connect to the traditional storm system. This option can also be used for runoff collection and reuse, as the drainage pipe can be connected to a storage tank or cistern and the runoff can be used for site irrigation.
- ***What about winter issues with permeable pavement?***

  There are no freeze-thaw issues with permeable pavement because runoff/snowmelt drains through the surface so quickly that there is limited opportunity for freezing. Freeze-thaw would only be an issue in a completely saturated system. Permeable pavement is also less susceptible to potholes because of this lack of surface freezing. Permeable pavement removes the risk of black ice formation because snowmelt is infiltrated by the surface right away, so there is no water left at the surface when cooler nighttime temperatures arrive. Permeable pavement also generally requires less salt because snow melts faster with permeable pavement due to air movement through the surface. Salt should be used as a de-icer rather than sand, as sand will clog the pores of the surface and greatly reduce the drainage rate of the material. Pre-treating the surface with a brine solution before and during a snow event is most effective. A regular snow plow with the blade all the

Expenditure	Permeable pavement	Traditional pavement
Surface material	✓	✓
Aggregate	✓	✓
Installation	✓	✓
Inlets	NA	✓
Conveyance pipes	NA	✓
Detention pond	NA	✓
Acreage for detention pond	NA	✓

Table 1. An expenditure comparison for permeable and traditional pavement

way to the surface is the best way to handle snow. There is no need to be delicate with these materials.

- ***What about the maintenance of permeable pavement?***

  Surface cleaning should be performed using a regenerative air vacuum for cleaning the pavement, not a street sweeper. The particles and solids that get in the permeable surface need to be sucked out and removed, not just moved around the way a street sweeper would. This maintenance should be done at least twice a year: in the spring after the last snow events, and after autumn leaf fall. If the drainage rate of the pavement seems slower, vacuuming should be performed as needed. For driveways or walkways, a pressure washer can dislodge particles in permeable asphalts and concretes. The jet must be angled very low to push the particles up and out rather than straight down, which would push the solids deeper into the material.

Figure 4. Traditional asphalt (left) and porous asphalt (right) during a rain event. The traditional asphalt looks wet and shiny, while the porous asphalt surface is relatively dry.

Conclusions

Permeable pavement is a relatively new concept in New Jersey, but its use is expected to grow in the coming years because it is an efficient stormwater management technique that provides both environmental and economic benefits while reducing impervious cover. There is a variety of permeable pavement types on the market and only the most popular have been presented here. It is recommended that permeable pavement be installed by an industry-certified contractor with a site design approved by a licensed engineer.

Links and Resources:

Video showing permeable pavement handling 2,000 gallons of water in less than 3 minutes:

youtube.com/watch?v=5NvCSw_uXZY

Interlocking Concrete Pavement Institute site:

icpi.org

National Ready Mixed Concrete Association site:

nrmca.org

New Jersey Asphalt Pavement Association site:

njapa.com

Ferguson, Bruce K. Porous Pavements. Boca Raton, FL: CRC Press, 2005.

Photo Credits:
Figure 1: Courtesy of US EPA
Figure 2: Amy Rowe, New Jersey Agricultural Experiment Station
Figure 3: a, b, c courtesy of US EPA, d courtesy of East Coast Green, Inc.
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