

Porous Pavement



A porous pavement parking lot (Source: Invisible Structures, no date)

Description

Porous pavement is a permeable pavement surface with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. This porous surface replaces traditional pavement, allowing parking lot storm water to infiltrate directly and receive water quality treatment. There are a few porous pavement options, including porous asphalt, pervious concrete, and grass pavers. Porous asphalt and pervious concrete appear to be the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. Grass pavers are concrete interlocking blocks or synthetic fibrous gridded systems with open areas designed to allow grass to grow within the void areas. Other alternative paving

surfaces can help reduce the runoff from paved areas but do not incorporate the stone trench for temporary storage below the pavement. While porous pavement has the potential to be a highly effective treatment practice, maintenance has been a concern in past applications of the practice.

Application

The ideal application for porous pavement is to treat low-traffic or overflow parking areas. Porous pavement may also have some application on highways, where it is currently used as a surface material to reduce hydroplaning.

Regional Applicability

Porous pavement can be applied in most regions of the country, but the practice has unique challenges in cold climates. Porous pavement cannot be used where sand is applied to the pavement surface because the sand will clog the surface of the material. Care also needs to be taken when applying salt to a porous pavement surface as chlorides from road salt may migrate into the ground water. For block pavers, plowing may be challenging because the edge of the snow plow blade can catch the edge of the blocks, damaging the surface. This difficulty does not imply that it is impossible to use porous pavement in cold climates. Another concern in cold climates is that infiltrating runoff below pavement may cause frost heave, although design modifications can reduce this risk. Porous pavement has been used successfully in Norway (Stenmark, 1995), incorporating design features to reduce frost heave. Furthermore, some experience suggests that snow melts faster on a porous surface because of rapid drainage below the snow surface (Cahill Associates, 1993).

Ultra-Urban Areas

Ultra-urban areas are densely developed urban areas in which little pervious surface exists. Porous pavements are a good option in these areas because they consume no space. They are not ideal for high-traffic areas, however, because of the potential for failure due to clogging (Galli, 1992).

Storm Water Hot Spots

Storm water hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water. These areas include commercial nurseries, auto recycle facilities, commercial parking lots, fueling stations, storage areas, industrial rooftops, marinas, outdoor container storage of liquids, outdoor

loading/unloading facilities, public works storage areas, hazardous materials generators (if containers are exposed to rainfall), vehicle service and maintenance areas, and vehicle and equipment washing/steam cleaning facilities. Since porous pavement is an infiltration practice, it should not be applied on storm water hot spots due to the potential for ground water contamination.

Storm Water Retrofit

A storm water retrofit is a storm water management practice (usually structural) put into place after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. Since porous pavement can only be applied to relatively small sites, using porous pavement as a primary tool for watershed retrofitting would be expensive. The best application of porous pavement for retrofits is on individual sites where a parking lot is being resurfaced.

Cold Water (Trout) Streams

Porous pavement can help to reduce the increased temperature commonly associated with increased impervious cover. Storm water ponds on the surface of conventional pavement, and is subsequently heated by the sun and hot pavement surface. By rapidly infiltrating rainfall, porous pavement reduces the time that storm water is exposed to the sun and heat.

Siting and Design Considerations

Siting Considerations

Porous pavement has the same siting considerations as other infiltration practices. The site needs to meet the following criteria:

- Soils need to have a permeability between 0.5 and 3.0 inches per hour.
- The bottom of the stone reservoir should be completely flat so that infiltrated runoff will be able to infiltrate through the entire surface.
- Porous pavement should be sited at least 2 to 5 feet above the seasonally high ground water table, and at least 100 feet away from drinking water wells.
- Porous pavement should be sited on low-traffic or overflow parking areas, which are not sanded for snow removal.

Design Considerations

Some basic features should be incorporated into all porous pavement practices. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

1. *Pretreatment.* In porous pavement designs, the pavement itself acts as pretreatment to the stone reservoir below. Because the surface serves this purpose, frequent maintenance of the surface is critical to prevent clogging. Another pretreatment item can be the incorporation of a fine gravel layer above the coarse gravel treatment reservoir. Both of these pretreatment measures are marginal, which is one reason that these systems have a high failure rate.
2. *Treatment.* The stone reservoir below the pavement surface should be composed of layers of small stone directly below the pavement surface, and the stone bed below the permeable surface should be sized to attenuate storm flows for the storm event to be treated. Typically, porous pavement is sized to treat a small event, such as a water quality storm (i.e., the storm that will be treated for pollutant removal), which can range from 0.5 to 1.5 inches. As in infiltration trenches, water can be stored only in the void spaces of the stone reservoir.
3. *Conveyance.* Water is conveyed to the stone reservoir through the surface of the pavement and infiltrates into the ground through the bottom of this stone reservoir. A

geosynthetic liner and sand layer should be placed below the stone reservoir to prevent preferential flow paths and to maintain a flat bottom. Designs also need some method to convey larger storms to the storm drain system. One option is to use storm drain inlets set slightly above the elevation of the pavement. This would allow for some ponding above the surface, but would bypass flows that are too large to be treated by the system or when the surface clogs.

4. *Maintenance Reduction.* One nonstructural component that can help ensure proper maintenance of porous pavement is the use of a carefully worded maintenance agreement that provides specific guidance, including how to conduct routine maintenance and how the surface should be repaved. Ideally, signs should be posted on the site identifying porous pavement areas.

One design option incorporates 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. Although this feature does not in itself reduce maintenance requirements, it acts as a backup in case the surface clogs. If the surface clogs, storm water will flow over the surface and into the trench, where some infiltration and treatment will occur.

5. *Landscaping.* For porous pavement, the most important landscaping feature is a fully stabilized upland drainage. Reducing sediment loads entering the pavement can help to prevent clogging.

Design Variations

In one design variation, the stone reservoir below the filter can also treat runoff from other sources such as rooftop runoff. In this design, pipes are connected to the stone reservoir to direct flow throughout the bottom of the storage reservoir (Cahill Associates, 1993; Schueler, 1987). If used to treat off-site runoff, porous pavement should incorporate pretreatment, as with all structural management practices.

Regional Adaptations

In cold climates, the base of the stone reservoir should be below the frost line. This modification will help to reduce the risk of frost heave.

Limitations

In addition to the relatively strict siting requirements of porous pavement, a major limitation to the practice is the poor success rate it has experienced in the field. Several studies indicate that, with proper maintenance, porous pavement can retain its permeability (e.g., Goforth et al., 1983; Gburek and Urban, 1980; Hossain and Scofield, 1991). When porous pavement has been implemented in communities, however, the failure rate has been as high as 75 percent over 2 years (Galli, 1992).

Maintenance Considerations

Porous pavement requires extensive maintenance compared with other practices. In addition to owners not being aware of porous pavement on a site, not performing these maintenance activities is the chief reason for failure of this practice. Typical requirements are shown in Table 1. Table 1. Typical maintenance activities for porous pavement (Source: WMI, 1997)

Activity	Schedule
<ul style="list-style-type: none"> Avoid sealing or repaving with non-porous materials. 	N/A
<ul style="list-style-type: none"> Ensure that paving area is clean of debris. Ensure that paving dewaterers between storms. Ensure that the area is clean of sediments. 	Monthly
<ul style="list-style-type: none"> Mow upland and adjacent areas, and seed bare areas. Vacuum sweep frequently to keep the surface free of sediment. 	As needed (typically three to four times per year).
<ul style="list-style-type: none"> Inspect the surface for deterioration or spalling. 	Annual

Effectiveness

Porous pavement can be used to provide ground water recharge and to reduce pollutants in storm water runoff. Some data suggest that as much as 70 to 80 percent of annual rainfall will go toward ground water recharge (Gburek and Urban, 1980). These data will vary depending on design characteristics and underlying soils. Two studies have been conducted on the long-term pollutant removal of porous pavement, both in the Washington, DC, area. They suggest high pollutant removal, although it is difficult to extrapolate these results to all applications of the practice. The results of the studies are presented in Table 2.

Table 2. Effectiveness of porous pavement pollutant removal (Schueler, 1987)

Study	Pollutant Removal (%)				
	TSS	TP	TN	COD	Metals
Prince William, VA	82	65	80	-	-
Rockville, MD	95	65	85	82	98-99

Cost Considerations

Porous pavement is significantly more expensive than traditional asphalt. While traditional asphalt is approximately \$0.50 to \$1.00 per ft², porous pavement can range from \$2 to \$3 per ft², depending on the design (CWP, 1998; Schueler, 1987). Subtracting the cost of traditional pavement, this amounts to approximately \$45,000 and \$100,000 per impervious acre treated, which would be quite expensive. In addition, the cost of vacuum sweeping may be substantial if a community does not already perform vacuum sweeping operations. Finally, the practice life may be very short because the risk of clogging is high.