Stormwater Management Fact Sheet: Porous Pavement

Description

Porous pavement is a permeable pavement surface with an underlying stone reservoir that temporarily stores surface runoff before infiltrating into the subsoil. This porous surface replaces traditional pavement, allowing parking lot runoff to infiltrate directly into the soil and receive water quality treatment. There are several pavement options, including porous asphalt, pervious concrete, and grass pavers. Porous asphalt and pervious concrete appear 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 grid 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 (see the Green Parking Fact Sheet). 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 a low traffic or overflow parking area. Porous pavement may also have some application on highways, where it is currently used as a surface material to reduce hydroplaning (see the Bridge and Roadway Maintenance Fact Sheet).

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 since chlorides from road salt may migrate into the groundwater. For block pavers such as "grasscrete©," plowing may be challenging because the edge of the snow plow blade can catch the edge of the blocks, damaging the surface. This is not to say that it is impossible to use porous pavement in cold climates. 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). Another concern in cold climates is that infiltrating runoff below pavement may cause frost heave, although design modifications can reduce this risk.

Ultra Urban Areas

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

Stormwater Hotspots

Stormwater hotspots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater. These areas include: commercial nurseries, auto recycle facilities, commercial parking lots, fueling stations, feet 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 stormwater hotspots due to the potential for groundwater contamination.

Stormwater Retrofit

A stormwater retrofit is a stormwater management practice installed after development has occurred, to improve water quality, protect downstream channels, reduce flooding, or meet other watershed restoration objectives. Since porous pavement can only be applied to relatively small sites, use porous pavement as a primary or widespread method 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. Stormwater runoff ponds on the surface of conventional pavement, and is subsequently heated by the sun and hot pavement surface. By rapidly infiltrating rainfall, porous pavement can reduce the time that stormwater is exposed to the sun and heat.

Siting and Design Considerations

Siting Considerations

Porous pavement has site constraints as other infiltration practices (see Infiltration Trench Fact Sheet). A potential porous pavement 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 located at least 2 to 5 feet above the seasonally high groundwater table, and at least 100 feet away from drinking water wells.
- Porous pavement should be located only on low traffic or overflow parking areas, which are expected to be not sanded during wintertime conditions.

Design Considerations

Five basic features should be incorporated into all porous pavement practices: *pretreatment, treatment*, *conveyance*, *maintenance reduction*, and *landscaping* (for more information see the Manual Builder Category).

PRETREATMENT

In most porous pavement designs, the pavement itself acts as pretreatment to the stone reservoir below. Because the surface serves this purpose, frequent maintenance of the pavement surface is critical to prevent clogging. Another pretreatment element is a fine gravel layer above the coarse gravel treatment reservoir. The effectiveness of both of these pretreatment measures are marginal, which is one reason frequent vacuum sweeping is needed to keep the surface clean.

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, stormwater will flow over the surface and into the trench, where some infiltration and treatment will occur.

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 the *water quality storm* (i.e., the storm that will be treated for pollutant removal) which can range from 0.5" to 1.5". Like *infiltration trenches*, water can only be stored in the void spaces of the stone reservoir.

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 set storm drain inlets slightly above the surface elevation of the pavement. This allows for temporary ponding above the surface if the surface clogs, but bypasses larger flows that are too large to be treated by the system.

Maintenance Reduction

One non-structural component that can help ensure proper maintenance of porous pavement is the use of a carefully worded maintenance agreement that provides specific guidance to the parking lot, 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.

Landscaping

The most important landscaping objective for porous pavements is to ensure that its drainage area is fully stabilized, thereby preventing sediment loads from clogging the pavement.
Design Variations

Treat Other Sources

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 extend below the frost line to reduce the risk of frost heave.

Limitations

In addition to the relatively strict site constraints for porous pavement, a major limitation to the practice is the poor failure 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% over two years (Galli, 1992).

Maintenance

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 follow below:

Table 1. Typical Maintenance Activities for Porous Pavement (Source: WMI, 1997)	
Activity	**Schedule**
• Avoid sealing or repaving with non-porous materials	N/A
• Ensure that paving area is clean of debris • Ensure that paving dewaters between storms • Ensure that the area is clean of sediments	Monthly
• Mow upland and adjacent areas, and seed bare areas • Vacuum Sweep frequently to keep the surface free of sediment • (Typically three to four times per year)	As needed
• Inspect the surface for deterioration or spalling	Annual

Effectiveness

Porous pavement can be used to provide groundwater recharge and to reduce pollutants in stormwater runoff. Some data suggest that as much as 70% to 80% of annual rainfall will go toward groundwater recharge (Gburek and Urban, 1980). These data will vary depending on design characteristics and underlying soils. They both suggest high pollutant removal, although it is difficult to extract these results to all applications of the practice.

Table 2. Pollutant Removal of Porous Pavement (%) Winer (2000)	
Pollutant	**Pollutant Removal (%)[1]**
TSS	95
TP	65
TN	82
NOx	NA
Metals	98 - 99
Bacteria	NA
1: Data based on fewer than five data points	

Cost Considerations

Porous pavement is significantly more expensive than traditional asphalt. While traditional asphalt is approximately 50¢ to $1.00 per square foot, porous pavement can range from $2 to $3 per square foot, 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. On the other hand, porous pavement can create savings in terms of storm drain costs and land consumption. In addition, the cost of vacuum sweeping may be substantial if a community does not already perform vacuum sweeping operations.

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