Permeable Pavements

Description: Infiltration practices that are alternatives to traditional asphalt and concrete surfaces. Stormwater runoff is infiltrated into the ground through a permeable layer of pavement or other stabilized permeable surface.

Variations: Options range from poured-in-place, specially formulated concrete and asphalt that have greater void space than ordinary pavement to systems of interlocking modular pavers cast with void spaces.

Components:

- Open graded pavement mix or pavers with open surfaces
- Settling layer
- Open-graded base material
- Filter fabric
- Underdrain (where required)
- Subgrade with *minimal* compaction

Advantages/Benefits:

- Reduces runoff volume, attenuates peak runoff rate and outflow
- Reduces slick surfaces during rain
- Water quality enhancement from filtration of stormwater

Disadvantages/Limitations:

- Sediment-laden runoff can clog pervious pavement, causing it to fail
- Constant pressure in the same spot (constant vehicle braking) can collapse pores, causing pavement to fail
- Incorrect installation practices can clog pores

Design considerations:

- Same basic considerations as any paved area (soil properties, load-bearing design, hydrologic design of pavement & subgrade)
- Infiltration rate of native soil determines appropriateness and need for underdrain
- Not appropriate for heavy or high traffic areas
- Accessibility, aesthetics, maintainability

Installation considerations:

- Proper installation is crucial to ensure proper functioning
- Subgrade **cannot** be overly compacted
- Construction must be sequenced to avoid compaction and clogging pavement

Selection Criteria:

- ☐ **Water Quality 80 % TSS Removal**
- ☐ **Accepts Hotspot Runoff**
- ☑ **Residential Subdivision**
- ☑ **High Density / Ultra Urban Use**

Maintenance:

- Vacuum or jet wash to increase pavement life and avoid clogging
- Ensure that contributing area is clear of debris and sediment.

M **Maintenance Burden**

L = Low M = Moderate H = High

General Description

Permeable pavements are surfaces that can be driven over while permitting rapid infiltration of water into the underlying soil. Constructed of alternative paving materials, permeable pavements are used to locally infiltrate rainwater and reduce the runoff leaving a site. This can decrease downstream flooding, the frequency of combined sewer overflow (CSO) events, and the thermal pollution of sensitive waters. Use of these materials can also eliminate problems with standing water, provide for groundwater recharge, control erosion of streambeds and riverbanks, facilitate pollutant removal, and provide for a more aesthetically pleasing site.

Permeable pavements can be applied in areas that experience low vehicular traffic including parking lots and overflow parking areas; portions of streets such as residential parking lanes; driveways; plazas; and pedestrian or golf cart paths. There are several different forms of permeable pavements, varying from a permeable layer of paving material to grid systems. Four different types of permeable surfaces are discussed below.

Porous Asphalt: Porous asphalt differs from dense asphalt in its use of open-graded aggregate. Because no fine aggregate fills the voids between the single-sized particles, the material is porous and permeable. Porous asphalt can have a porosity of 15%-20%. A surface of porous asphalt is typically placed over a layer of open-graded gravel and crushed stone, with an underlying layer of permeable soil. There are several modifications to the standard design that can be used to increase storage capacity or pass larger flows, including the installation of a perforated pipe in the gravel sublayer, adding a layer of sand, etc.

Porous Concrete: Considered to be more durable than porous asphalt, porous concrete is a mixture of open-graded aggregate, which creates the voids in the structure, and Portland cement. The void space in porous concrete is in the 15%-22% range compared to 3%-5% for conventional pavements. Porous concrete is thought to have a greater ability than porous asphalt to maintain its porosity in hot weather. The permeable surface of porous concrete is typically installed as the top of several permeable layers, similar to the installation of porous asphalt described above.

General Description (Continued)

Plastic Grid Systems: These systems are often referred to as *geocells* and are defined by

manufactured plastic lattices or mattresses that form networks of box-like cells that are filled with earth material. The lattice is typically 1-2 inches thick and the cells are a few inches wide. Porosity and permeability of these systems is entirely dependent on the cells' fill and vegetation. Like any other pavement surface, geocells require a firm gravel base that provides strength and storage capacity as runoff infiltrates. Geocells are lightweight and easy to transport and install. However, they may similarly be jarred easily by moving traffic.

Open-Celled Paving Grids: Commonly called *block pavers or grid pavers*, these grids

are structural units, such as concrete blocks or bricks with regularly interdispersed voids that penetrate their entire thickness. Grids are made of concrete or brick and the open cells are filled with porous aggregate or vegetated soil. Block pavers are more rigid and therefore can bear larger traffic loads than plastic grid systems.

Pollutant Removal Capabilities

As they provide for the infiltration of stormwater runoff, permeable pavements trap particulate pollutants and absorb some soluble pollutants. Due to the potential for clogging, porous pavements must not be used for the removal of sediment or other coarse particulate pollutants.

Components

Several options exist for the top layer or surface of permeable pavements and should be chosen depending on strength required due to traffic loads, infiltration needs, and the manufacturers' recommendations. However, the sub layers are generally similar, consisting of four to five layers as shown in Figure 15.1. The aggregate reservoir layer can sometimes be avoided or minimized if the sub-grade is sandy and there is adequate time to infiltrate the necessary runoff volume into the sandy soil without by-passing the water quality volume. Descriptions of each of the layers are presented below:

Permeable Pavement Layer – This layer consists of a porous mixture of concrete or asphalt or a modular pavement grid of plastic, concrete, or brick and an aggregate or a vegetation medium. This layer is usually 2 to 4 inches deep depending on required bearing strength, pavement design requirements, and manufacturer's specifications.

Settling Layer – This layer consists of a 0.5-inch diameter crushed stone to a depth of 1 to 2 inches. This layer serves to stabilize the porous asphalt or concrete layer. Can be combined with reservoir layer using suitable stone.

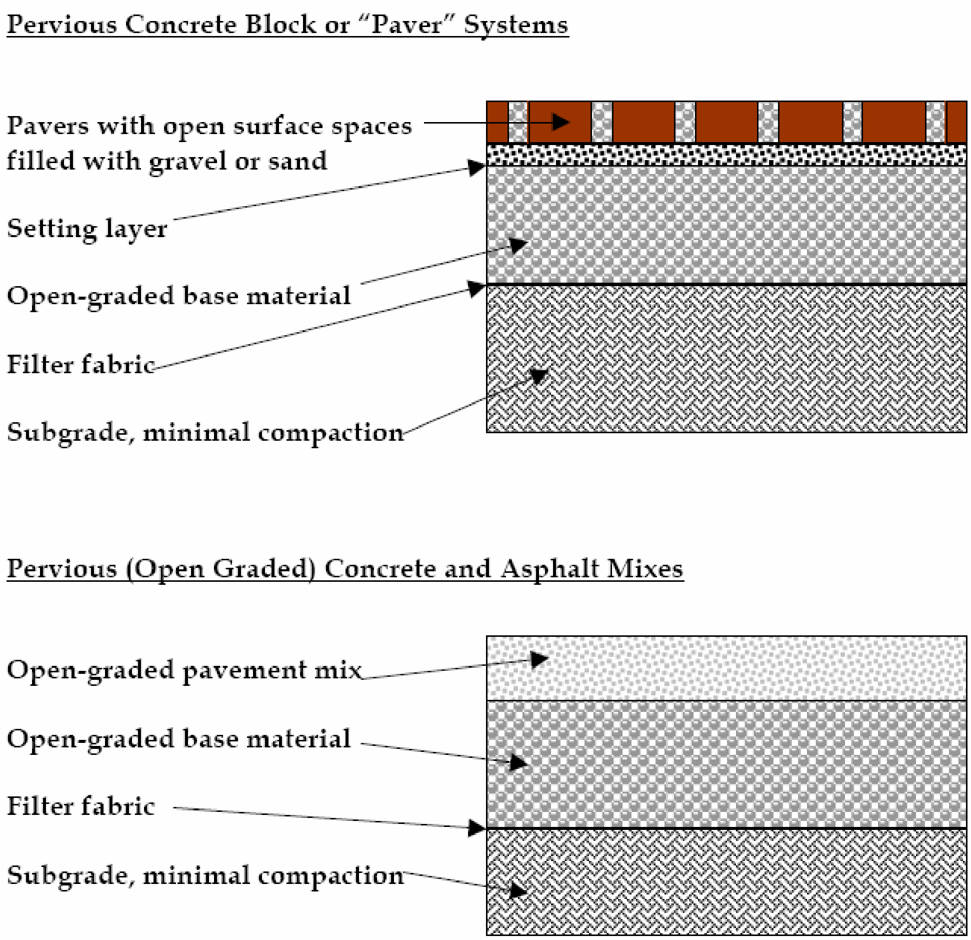
Reservoir Layer or Open Graded Base Material – The reservoir gravel base layer consists of washed, bank-run gravel, 1.5 to 2.5 inches in diameter with a void space of about 40%. The depth of this layer depends on the desired storage volume, which is a function of the soil infiltration rate and void spaces, but typically ranges from two to four feet. The layer must have a minimum depth of nine inches. The layer should be designed to drain completely in 48 hours and should be designed to store, at a minimum, the water quality volume (WQ_v). Aggregate contaminated with soil must not be used.

Bottom Filter Layer (not shown in diagram) – In cases where infiltration needs to be increased, a 6 inch layer of sand or a 2 inch thick layer of 0.5 inch crushed stone can be installed. The layer should be completely flat to promote infiltration across the entire surface. This layer serves to stabilize the reservoir layer, to protect the underlying soil from compaction, and act as the interface between the reservoir layer and the filter fabric covering the underlying soil.

Components (Continued)

Filter Fabric – It is very important to line the entire trench area, including the sides, with filter fabric prior to placement of the aggregate. The filter fabric serves to inhibit soil from migrating into the reservoir and reducing storage capacity.

Underlying Soil – The underlying soil should have an infiltration capacity of at least 0.5-inches/hour but preferably greater than 0.5-inches/hour. Soils at the lower end of this range may not be suited for a full infiltration system or may require additional infiltration measures such as a perforated pipe or additional sand layer. Test borings are recommended to determine the soil classification, seasonal high ground water table elevation, and impervious substrata, and an initial estimate of permeability.



(Source: City of Portland, Oregon, Stormwater Management Manual)

Figure 15.1 Permeable Pavement Layers

Site and Design Considerations

When designing permeable pavement systems, the infiltration rate of the native soil is a key element in determining the depth of base rock for the storage of stormwater, or for determining whether an underdrain system is appropriate. Traffic loading and design speed are important considerations in determining which type of pervious pavement surface is applicable. Pedestrian ADA accessibility, aesthetics, and maintainability are also important considerations.

The following design and site considerations must be incorporated into sites using permeable pavements:

1. The in-situ subsoils should have a high infiltration rate. Permeable pavements are appropriate for all soil types, but will require underdrain systems for soils that do not infiltrate well - hydrologic soil group D or most group C soils, or soils with a high (>30%) clay content. During construction and preparation of the subgrade, special care must be taken to avoid compaction of the soils.
2. Because even infiltration is important, the slope of the site should be less than 10% in all cases, but are not recommended to be more than 2%. Specifications are product-specific and shall comply with manufacturer's recommendations. Barriers perpendicular to the direction of drainage should be installed in sub-grade material to keep it from washing away, or filter fabric should be placed at the bottom and sides of the aggregate to keep soil from migrating into the aggregate and reducing porosity.
3. Porous pavements should only receive runoff from impervious areas. Runoff containing sediment will clog the porous paver surface.
4. Permeable pavements should not be used on sites with a likelihood of high oil or grease concentrations.
5. Not for use in drinking water aquifer recharge areas.

During construction, **do not** overly compact the soil, and avoid installing pavement during extremely high or low temperatures.

Porous paver system designs must use some method to convey larger storm event flows to the conveyance 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 accept bypass flows that are too large to be infiltrated by the porous pavement or if the system clogs.

As-Built Certification Considerations

After the porous pavement has been installed, an as-built inspection and certification must be performed by a Professional Engineer. The as-built certification must include verification of the infiltration rates of the porous pavement in addition to other design components that ensure the proper performance of the BMPs.

Maintenance

Each BMP must have an Operations and Maintenance (O&M) agreement submitted to Metro for approval and maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with the grading permit application. The O&M agreement is for the use of the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP operations and maintenance plan.

The burden of maintenance is fairly low for permeable pavements. However, failure to maintain and to abide by design and construction standards often results in failure of the measure.

Permeable pavements should be inspected regularly to ensure that the porous surface is free of sediment and that the surrounding area does not have the potential to contribute sediment-laden runoff. The surface should be vacuum swept, followed by high-pressure hosing to keep pores free of sediment. The adjacent, contributing area should be inspected to ensure that it is free of debris and litter, stabilized and mowed, and that clippings have been removed. It would be beneficial to inspect the system during a rain event to ensure that it is dewatering appropriately.

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Suggested Reading

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