Permeable Pavement

Permeable pavement is a paving system which allows rainfall to percolate through the surface into the underlying soil or an aggregate bed, where stormwater is stored and infiltrated to underlying soil, or removed by an overflow drainage system.

Facility elements that are typically associated with permeable pavement include:

- Wearing course: The surface layer of any permeable pavement system is the wearing course. Categories of wearing courses include:
    - Porous asphalt: A flexible pavement similar to standard asphalt that uses a bituminous binder to adhere aggregate. However, the fine material (sand and finer) is reduced or eliminated, resulting in the formation of voids between the aggregate in the pavement surface that allows water to infiltrate to the underlying aggregate base.
    - Pervious concrete: A rigid pavement similar to conventional concrete that uses a cementitious material to bind aggregate together. However, the fine aggregate (sand) component is reduced or eliminated in the gradation, resulting in the formation of voids between the aggregate in the pavement surface that allows water to infiltrate to the underlying aggregate base.
    - Interlocking concrete paver blocks: Solid, precast, manufactured modular units. Pavements constructed with these units create joints that are filled with permeable aggregate and installed on an open-graded aggregate base.
    - Aggregate Pavers (or Pervious Pavers): Modular precast paving units made with uniformly sized aggregates and bound with Portland cement concrete using a high strength adhesive. Unlike concrete paver blocks, these pavers are permeable. Pavements constructed with these units create joints that are filled with permeable aggregate and installed on an open-graded aggregate base.
    - Open-celled paving grid with gravel: Concrete or plastic grids that are filled with permeable aggregate. The system can be installed on an open-graded aggregate base.
    - Open-celled paving grid with grass: Concrete or plastic grids that are filled with a mix of sand, gravel, and topsoil for planting vegetation. The cells can be planted with a variety of non-turf forming grasses or low-growing groundcovers. The system can be installed on an open-graded aggregate base.
- Inlet (optional): While permeable pavement facilities often manage only the rain falling directly on the pavement surface, they may also be designed to accept stormwater runoff from additional areas (e.g., adjacent impervious areas, nearby rooftops). Runoff can be directed to the facility by two main methods:
    - Sheet flow to the surface: Surface areas of the facility receiving runoff contributions will likely be prone to clogging due to sediment inputs, particularly in areas of concentrated inflow. These areas should be carefully inspected and corrective

maintenance should be performed as necessary to maintain the function of the pavement at these sites. In addition, the source of the sediment loads should be evaluated to determine if modifications to features in the drainage area landscape (e.g., stabilization of adjacent planted areas) would help to prevent clogging.

  - Piped flow into the aggregate base: Pipes dispersing water into the aggregate bed should be designed with cleanout access to allow pipe maintenance. Runoff that is piped into the aggregate base should be pretreated for sediment removal (e.g., screens, sumps) to protect the subbase from sedimentation and clogging. The pretreatment system must be maintained to remove accumulated sediment.

- Aggregate Base / Storage Reservoir: Stormwater passes through the wearing course to an underlying aggregate storage reservoir where it is stored prior to infiltration into the underlying soil. This aggregate bed also provides the structural function of supporting design loads (e.g., vehicle loading) for flexible pavement systems. To allow inspection of the aggregate course, some facilities have an observation port (typically installed during construction) that allows monitoring of the water levels in the aggregate bed to determine if the facility is draining properly.
- Overflow: Unless designed to provide full infiltration of stormwater, permeable pavement facilities have an overflow. Facility overflow can be provided by subsurface slotted drain pipe(s) (elevated in the aggregate bed) routed to an inlet or catch basin structure or by lateral flow through the storage reservoir to a daylighted drainage system.
- Underdrain with flow restrictor (optional): A slotted drain pipe with flow restrictor assembly may be installed at the bottom of or elevated within the aggregate storage reservoir. Permeable pavement facilities with underdrains and flow restrictors operate as underground detention systems with some infiltration.
- Signage or pavement marking can also be used to identify permeable pavement as a stormwater BMP and inform maintenance crews and the general public about protecting the facility's function (e.g., no stockpiling of soils or mulch on pavement surface).

Key Operations and Maintenance Considerations

- Installations can be monitored for adequate or designed minimum infiltration rates by observing drainage immediately after heavier rainstorms for standing water or infiltration tests using ASTM C1701.
- The following practices are recommended to maintain proper function of porous pavement systems:
  - Do not use of sealant on porous asphalt
  - Protect from construction site runoff with proper temporary erosion and sediment controls and flow diversion measures
  - Modifying utility cut procedures for permeable pavements - Protocols should recommend restoring permeable pavement section in-kind, where feasible, and

require restoring permeable pavement section in-kind where replacement with conventional pavement would impact overall facility function. Utility cuts should be backfilled with the same aggregate base used under the permeable paving to allow continued conveyance of stormwater through the base, and to prevent migration of fines from the standard base aggregate to the more open graded permeable base material (Diniz, 1980). Replacing permeable pavement with conventional pavement is acceptable if it is a small percentage of the total facility area and does not impact the overall facility function.

- A critical component of a successful maintenance program is regular removal of sediment, debris and excessive moss from the facility surface to prevent clogging of the permeable wearing course. Surrounding landscaped areas should be inspected regularly and possible sediment sources controlled immediately.
- Protect the surface from stockpiles of landscaping materials (e.g., mulch, soil, compost).
- Clean permeable pavement surfaces to maintain infiltration capacity at least once or twice annually following recommendations below.
    - Porous asphalt and pervious concrete
        - Clean surfaces using suction, sweeping with suction or high-pressure wash and suction (sweeping alone is minimally effective). Hand held pressure washers are effective for cleaning void spaces and appropriate for smaller areas such as sidewalks.
        - Small utility cuts can be repaired with conventional asphalt or concrete if small batches of permeable material are not available or are too expensive.
    - Permeable pavers
        - The Interlocking Concrete Paving Institute (ICPI) recommends cleaning if the measured infiltration rate falls below 10 inches per hr.
        - Use sweeping with suction when surface and debris are dry 1-2 times annually (see next bullet for exception). Apply vacuum to a paver test section and adjust settings to remove all visible sediment without excess uptake of aggregate from paver openings or joints. If necessary replace No 8, 89 or 9 stone to specified depth within the paver openings. Washing or power washing should not be used to remove debris and sediment in the openings between the pavers.
        - For badly clogged installations, wet the surface and vacuum aggregate to a depth that removes all visible fine sediment and replace with clean aggregate.
        - If necessary use No 8, 89 or 9 stone for winter traction rather than sand (sand will accelerate clogging).
        - Replace broken pavers as necessary to prevent structural instability in the surface.

  - Plastic or Concrete grid systems
    - Remove and replace top course aggregate if clogged with sediment or contaminated (vacuum trucks for stormwater collection basins can be used to remove aggregate).
    - Remove and replace grid segments where three or more adjacent rings are broken or damaged.
    - Replenish aggregate material in grid as needed.
    - For grass installations, use normal turf maintenance procedures except do not aerate. Use very slow release fertilizers if needed.
- Modify typical snow removal procedures, such as:
  - Using a snow plow with skids or rollers to slightly raise the blade above permeable pavers or open-celled paving grid systems to prevent loss of top course aggregate and damage to paver blocks or grids.
  - Avoiding stockpiling plowed snow (i.e., dirty snow) directly on top of permeable pavement.
  - Use deicers in moderation (e.g., salt, molasses-based and chemical deicers) if needed.

Maintenance Standards

The table below provides the minimum required maintenance standards for permeable pavement components. The level of routine maintenance required and the frequency of corrective maintenance actions may increase for facilities receiving high sediment loads (e.g., sanding) or facilities subject to extended wet, shady conditions where moss may accumulate.

Permeable Pavement			
Drainage System Feature	Potential Defect	Conditions When Maintenance Is Needed	Minimum Performance Standard
			Note: table spans multiple pages.
Permeable Pavements (all)	Material Deposited on Pavement	Runoff from adjacent pervious areas deposits soil, mulch or sediment on paving.	Soil, mulch or sediment from adjacent areas has been removed from permeable pavement and measures taken to prevent further deposition of soil/ mulch material from adjacent areas on permeable pavement.
	Vegetative Debris	Accumulation of organic debris and leaf litter. Vegetation related fallout clogs or will potentially clog voids.	Vegetative debris removed and sources trimmed/ pruned as appropriate to reduce further debris accumulation. Water infiltrates per design function.

Permeable Pavement			
Drainage System Feature	Potential Defect	Conditions When Maintenance Is Needed	Minimum Performance Standard
			Note: table spans multiple pages.
Porous Asphalt or Pervious Concrete	Surface Clogged	Surface is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate). Infiltration rate testing using ASTM C1701 indicates an infiltration rate of 10 inches per hour or less.	Surface has been cleaned/ cleared of sediment, debris, vegetation or other material and water infiltrates per design function.
	Sediment On Surface	Sediment present at the surface of the pavement.	Source of sediment has been identified and addressed, if possible. Surface of pavement is free of sediment.
	Moss Growth On Pavement	Moss growth inhibits infiltration or poses slip safety hazard.	Moss removed such that there is not a slip safety hazard and pavement infiltrates per design function.
	Pavement Damaged	Major cracks or trip hazards and concrete spalling and raveling.	Cracks or other damage to pavement repaired to grades and tolerances per design specifications; infiltration functions per design.
Interlocking Concrete Paver Blocks and Aggregate Pavers	Surface Clogged	Surface is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate).). Infiltration rate testing using ASTM C1701 indicates an infiltration rate of 10 inches per hour or less.	Surface has been cleaned/ cleared of sediment, debris, vegetation or other material and water infiltrates per design function.
	Settlement	Settlement of pavement surface (may indicate other problems).	Pavement restored to finished grades per design specifications and record drawings. Surface drainage function restored.
	Sediment On Surface	Sediment present at the surface of the pavement.	Surface of pavement is free of sediment and infiltrates per design function.
	Moss Growth On Pavement	Moss growth inhibits infiltration or poses slip safety hazard.	Moss removed such that there is not a slip safety hazard and pavement infiltrates per design function.
	Pavers Missing/ Damaged	Paver block(s) are missing or damaged.	Paver blocks repaired or replaced per design specifications and record drawings.
	Loss Of Aggregate	Loss of aggregate material between paver blocks.	Aggregate replaced per design specifications and paver manufacturer's recommendations.
	Settlement	Surface has settled in a manner that poses a safety hazard or inhibits infiltration.	Pavers restored to finished grades per design specifications and record drawings.
Open-Celled Paving Grid With Gravel	Aggregate Clogged	Aggregate is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate).	Aggregate has been cleaned/ cleared of sediment, debris, vegetation or other material and water infiltrates per design function.
	Paving Grid Missing/ Damaged	Paving grid missing or damaged.	Paving grid replaced or restored per design specifications and record drawings.

Permeable Pavement			
Drainage System Feature	Potential Defect	Conditions When Maintenance Is Needed	Minimum Performance Standard
			Note: table spans multiple pages.
	Settlement	Settlement of pavement surface (may indicate other problems).	Pavement restored to finished grades per design specifications and record drawings.
	Loss Of Aggregate	Loss of aggregate in paving grid.	Aggregate replaced per design specifications.
Open-Celled Paving Grid With Grass	Aggregate Clogged	Aggregate is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate).	Surface has been rehabilitated per manufacturer's recommendations and water infiltrates per design function.
	Paving Grid Missing/ Damaged	Paving grid missing or damaged.	Paving grid and grass surface replaced or restored per design specifications and record drawings.
	Settlement	Settlement of pavement surface (may indicate other problems).	Pavement restored to finished grades per design specifications and record drawings.
	Poor Grass Coverage	Poor grass coverage in paving grid.	Grass coverage restored per design specifications and manufacturer's recommendations.
Inlets/ Outlets/ Pipes	Inlet/ Outlet Pipe Damaged	Pipe is damaged.	Damaged pipe has been repaired/ replaced and flow capacity functions per design.
	Inlet/ Outlet Pipe Clogged	Pipe is clogged.	Pipe has been cleared and flow capacity functions per design.
	Underdrain Pipe Clogged	Plant roots, sediment or debris reducing capacity of underdrain (may cause prolonged drawdown period).	Pipe has been cleared and infiltration rate/ flow capacity of system functions per design.
	Raised Subsurface Overflow Pipe Clogged	Plant roots, sediment or debris reducing capacity of underdrain.	Pipe has been cleared and infiltration rate/ overflow capacity of system functions per design specifications.
	Outlet Structure Clogged	Sediment, vegetation, or debris reducing capacity of outlet structure.	Blockage has been cleared and outlet structure functions at full capacity per design.
	Erosion At Overflow	Native soil is exposed or other signs of erosion damage are present at discharge point.	Erosion has been repaired and eroded area stabilized.
Observation Port	Water Visible In Storage Aggregate	Water remains in the storage aggregate longer than anticipated by design after the end of a storm.	Cause or ponding investigated and addressed as needed to bring facility into conformance with design function.