BMP T5.15: Permeable Pavement

Purpose and Description

Permeable pavements are appropriate in many applications where traditionally impermeable pavements have been used including parking lots, sidewalks, pedestrian and bike trails, driveways, residential access roads, and emergency and facility maintenance roads.

The following are the general categories of permeable paving systems:

- Porous hot or warm-mix asphalt pavement: A flexible pavement similar to standard asphalt, but the fine material is reduced or eliminated, allowing water to infiltrate through voids formed between the aggregate in the pavement surface.
- Pervious Portland cement concrete: A rigid pavement similar to conventional concrete but with the fine aggregate (sand) component reduced or eliminated in the gradation, allowing for infiltration.
- Permeable interlocking concrete pavements (PICP) and aggregate pavers: Solid, precast, manufactured modular units. The solid pavers are (impervious) high-strength Portland cement concrete. Pavements constructed with these units create joints that are filled with permeable aggregates and installed on an open-graded aggregate bedding course. Aggregate pavers (also known as pervious pavers) are distinct from PICPs and include modular precast paving units. The units are made with similar sized aggregates bound together with Portland cement concrete with high-strength epoxy or other adhesives. Like PICP, the joints or openings in the units are filled with open-graded aggregate and placed on an open-graded aggregate bedding course. Aggregate pavers are intended for pedestrian use only.
- Grid systems: Made of concrete or plastic. Both systems can be installed on an open-graded aggregate base as well as a dense-graded aggregate base.

Applications, Limitations and Setbacks

Permeable paving surfaces are an important integrated management practice within the LID approach and can be designed to accommodate pedestrian, bicycle and auto traffic while allowing infiltration, treatment and storage of stormwater.

Limitations

- The Washington State Pollution Control Hearings Board stated in 2014 that permeable pavement is only suitable for "roadways that receive very low traffic volumes and areas of very low truck traffic". This has been interpreted to mean that it's only required to be considered (i.e. review infeasibility criteria) for roadways with an average daily volume of 400 vehicles or less. See Section 2.5.5.3 in Book 2 for a full list of infeasibility criteria, and refer to Table 2.3 for typical applications of pervious pavements.
- No run-on from pervious surfaces is allowed.
- Unless the pavement, base course, and subgrade have been designed to accept runoff from adjacent impervious surfaces, slope impervious runoff away from the permeable pavement to the maximum extent practicable. Sheet flow from up-gradient impervious areas is

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not recommended, but permissible if the porous surface flow path is greater than the impervious surface flow path.

Setbacks

The following setbacks are required for permeable pavements:

- 50 feet from the top of slopes greater than 20% with more than 10 feet of vertical relief.
- 100 feet from a landfill (active or closed).
- 100 feet from a drinking water well or a spring used for drinking water, if the pavement is a pollution-generating surface.
- 10 feet from on-site sewage drainage.
- 10 feet from an underground storage tank and its connecting pipes that is used to store petroleum products, chemicals, or liquid hazardous waste in which 10% or more of the storage volume of the tank and connecting pipes is beneath the ground.
- 100 feet from an area with known deep soil contamination.

Infeasibility Criteria

The following criteria describe conditions that make Permeable Pavement infeasible to meet Minimum Requirement #5. Citation of any of the infeasibility criteria must be based on an evaluation of site-specific conditions and documented in the LID Feasibility Checklist. Permeable Pavement is considered infeasible under the following conditions:

- Roadways and parking areas where projected average daily traffic volumes are greater than 400 vehicles.
- At multi-level parking garages, and over culverts and bridges.
- Where the site design cannot avoid putting pavement in areas likely to have long-term excessive sediment deposition after construction (e.g., construction and landscaping material yards).
- Within an area designated as an erosion hazard or landslide hazard.
- On properties with known soil or groundwater contamination (typically federal Superfund sites or state cleanup sites under the Model Toxics Control Act (MTCA)) and any of the following criteria:
  - The proposed BMP is within 100 feet of an area known to have deep soil contamination. [Note: this criterion is also a Setback.]
  - The site is in an area where groundwater modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in groundwater.
  - The proposed BMP is located in an area where surface soils have been found to be contaminated, and contaminated soils are still in place within 10 horizontal feet of the infiltration area.
  - The BMP would be within any area where it would be prohibited by an approved cleanup plan under the state Model Toxics Control Act or Federal Superfund Law, or an environmental covenant under Chapter 64.70 RCW.
- Where the site cannot be designed to have a porous asphalt surface at less than 5% slope, or a pervious concrete surface at less than 10% slope, or a permeable interlocking concrete pavement surface (where appropriate) at less than 12% slope. Grid systems upper slope limit can range from 6 to 12%; check with manufacturer and local supplier.
- Where the native soils below a pollution-generating permeable pavement (e.g., road or parking lot) do not meet the soil suitability criteria for providing treatment (Book 1, Section 3.1.5.3).
- Where seasonal high groundwater or an underlying impermeable/low permeable layer would create saturated conditions within one foot of the bottom of the lowest gravel base course.

- Where underlying soils are unsuitable for supporting traffic loads when saturated. Soils meeting a California Bearing Ratio of 5% are considered suitable for residential access roads.
- Where measured coefficient of permeability is less than 0.3 inches per hour. In these instances, unless other infeasibility restrictions apply, roads and parking lots may be built with an underdrain, preferably elevated within the base course, if flow control benefits are desired.
- Where replacing existing impervious surfaces, unless the existing surface is a non-pollution generating surface over a soil with a coefficient of permeability of four inches per hour or greater.
- At sites defined as "high-use sites" as defined in Book 1, Appendix 1-A.
- In areas with "industrial activity" as identified in 40 CFR 122.26(b)(14).
- Where the risk of concentrated pollutant spills is more likely such as gas stations, truck stops, and industrial chemical storage sites.
- Where routine, heavy applications of sand occur in frequent snow zones to maintain traction during weeks of snow and ice accumulation. Most lowland western Washington areas do not fit this criterion.
- Where the surface(s) to be paved are within setbacks given in Section 3.9.4.
- Where a professional evaluation demonstrates any condition listed below is met:
  - Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or down gradient flooding.
  - Where the site has groundwater that drains into an erosion hazard or landslide hazard area.
  - Where infiltrating and ponded water below new permeable pavement area would compromise adjacent impervious pavements.
  - Where infiltrating water below a new permeable pavement area would threaten existing below grade basements.
  - Where infiltrating water would threaten shoreline structures such as bulkheads.
  - Downslope of steep, erosion prone areas that are likely to deliver sediment.
  - Where fill soils are used that can become unstable when saturated.
  - Where there are excessively steep slopes and water within the aggregate base layer or at the sub-grade surface cannot be controlled by detention structures and may cause erosion and structural failure, or where surface runoff velocities may preclude adequate infiltration at the pavement surface.
  - Where permeable pavements cannot provide sufficient strength to support heavy loads (such as at ports).
  - Where installation of permeable pavement would threaten the safety or reliability of pre-existing underground utilities, pre-existing underground storage tanks, or pre-existing road sub-grades.

Figure 16: Permeable pavement application (Source: Vancouver McCord's Toyota)

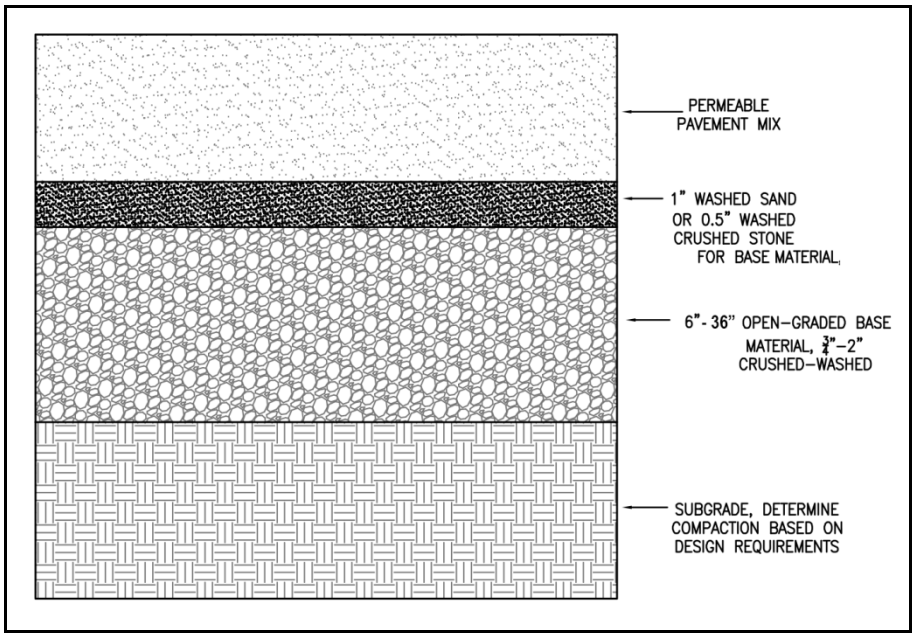

Figure 1: Permeable Pavement typical section

(Source: redrawn from City of Portland)

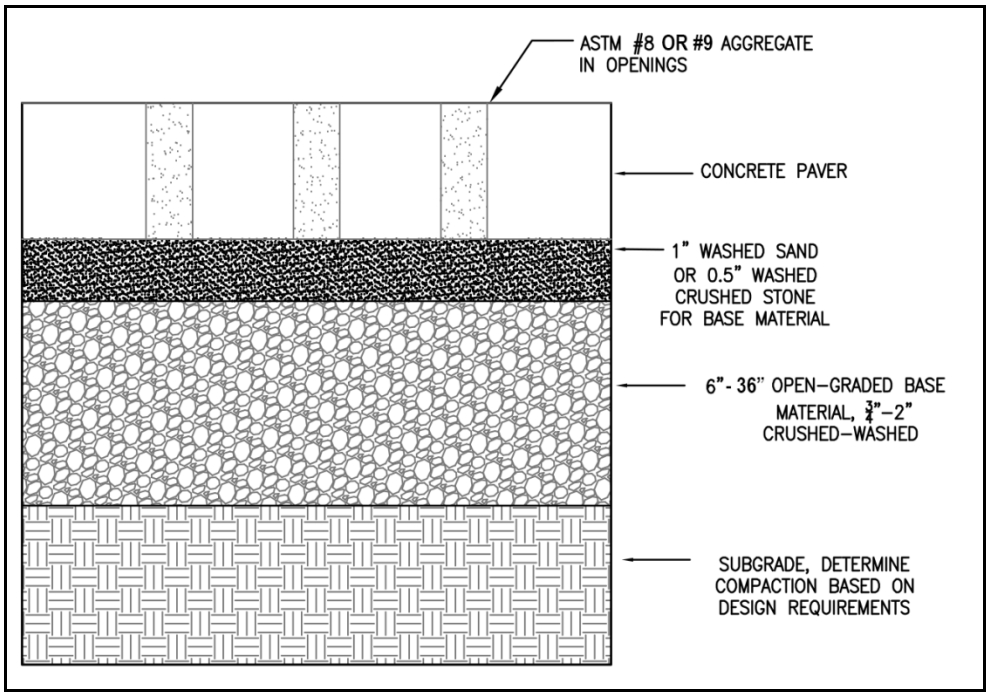

Figure 2: Permeable Pavement typical section of pavers

(Source: redrawn from City of Portland)

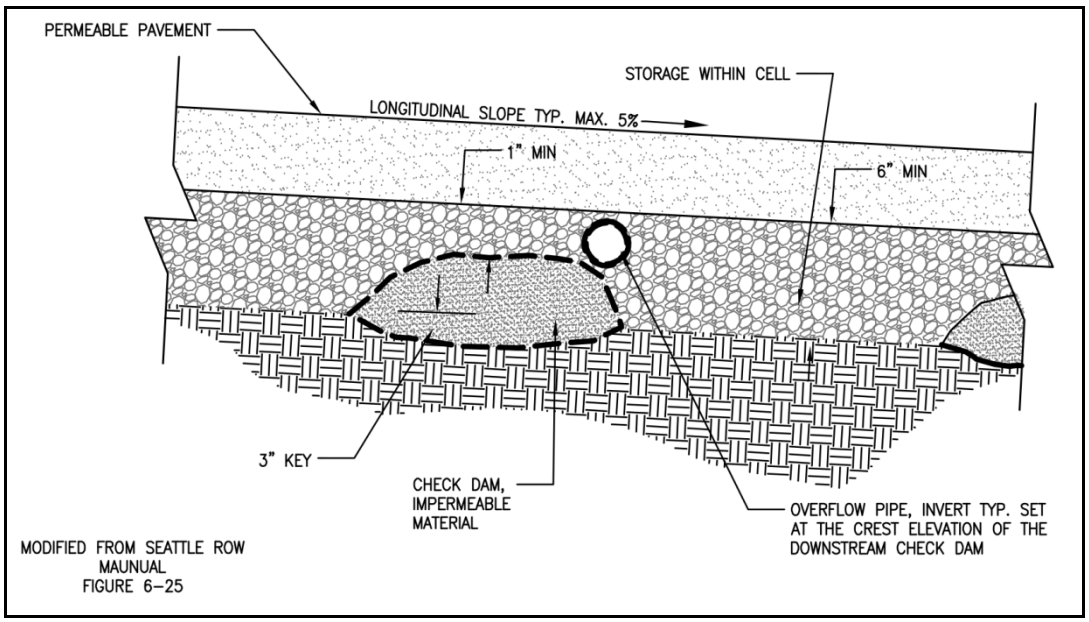

Figure 3: Permeable Pavement check dam for sloped pavement

(Source: modified from SMMWW)

Refer to the LID Technical Guidance Manual (Puget Sound Partnership, 2012) for additional information on permeable pavements. Note that where information in the guidance manual conflicts with information in this manual, the information in this manual must be used.

Design Criteria

Estimation of Long-Term Infiltration Rates

- The infiltration rate shall be determined using the testing procedures described in Book 1, Section 2.3.1.3, with an additional correction factor ranging from 0.9 to 1.0 based on the quality of the aggregate base material.

Contributing Area

- Minimizing the contributing area is preferable since run-on from adjacent surfaces can lead to clogging and reduce long-term performance of permeable pavements. Some stormwater discharge from other surfaces is acceptable if:
  - Sediment is not introduced to the subgrade or pavement surface.
  - The additional flow does not exceed the long-term infiltration capacity of the subgrade or pavement surface.

Subgrade

- The subgrade should be compacted to the minimum extent necessary for structural stability, including the following recommendations:
  - On sites where topsoil is removed and native sub-soil is exposed, no compaction may be required.
  - For areas with heavy truck traffic, some compaction may be necessary for stability.
  - Guidelines used to specify subgrade compaction are “firm and unyielding” (qualitative), and 90-92% Standard Proctor (quantitative).
- Prevent compaction when installing the aggregate base by:
  - Dumping the aggregate base onto the subgrade from the edge of the installation and then push the aggregate out onto the subgrade.

  - Dumping subsequent loads from on top of the aggregate base as the installation progresses.
- Relative uniformity of subgrade conditions is important to prevent differential settling.

Separation or Bottom Filter Layer (Recommended but Optional)
- A 0.5 inch (or smaller) layer of sand or crushed stone graded allows for infiltration across the surface, stabilization of the base layer and protection of underlying soil from compaction. This layer can also serve as a transition between the base course and the underlying geotextile material.

Wearing Layer
- A minimum initial infiltration rate of 20 inches per hour is necessary. To improve the probability of long-term performance, significantly higher initial infiltration rates are desirable.
- Porous Asphalt: Must have adequate void spaces for infiltration. A void space within the range of 16 – 25% is typical.
- Pervious Concrete: A void space within the range of 15 – 35% is typical
- Grid/lattice systems filled with gravel, sand, or a soil of finer particles with or without grass: The fill material must be at least a minimum of 2 inches of sand, gravel, or soil.
- Permeable Interlocking Concrete Pavement and Aggregate Pavers: Pavement joints should be filled with No. 8 or 9 stone.

Geotextile
- For all permeable pavement systems, geotextile material must line the sides to prevent soil intrusion if concrete curbs or other types of impermeable liners do not extend to the full depth of the base material. The geotextile material should follow the manufacturer's specifications and recommendations of the project geotechnical engineer for the particular subgrade soil and aggregate base being used.
- Geotextiles are not allowed between the permeable pavement system and subgrade because of their tendency to clog.
- Geogrids can also be used for subgrade reinforcement at the recommendation of a geotechnical engineer.

Membrane Liners and Barriers
- Membrane liners and barriers are recommended to reduce sidewall soil movement and reduction of infiltration capacity, and to protect adjacent, densely-graded subgrade material from migrating onto the aggregate base. 30 mil PVC membranes are generally used.

Storage Reservoir/Aggregate Base
- The aggregate base material should be composed of larger material (1.5-2.5 inches).
- Smaller stone may be used between the larger stones.
- Void space should be 20-40%.
- Aggregate base depth should be 6-36 inches, depending on pavement type, design and storage requirements.

Drainage conveyance
Roads should still be designed with adequate drainage conveyance facilities as if the road surface was impermeable. Roads with base courses that extend below the surrounding grade should have a designed drainage flow path to safely move water away from the road prism and into the roadside drainage facilities. Use of perforated storm drains to collect and transport infiltrated water from under the road surface will result in less effective designs and less flow reduction benefit.

Underdrain (Optional)
If an underdrain is needed to protect the pavement wearing course from saturation, then the invert of the underdrain must be

elevated at least 6 inches within the aggregate base course.

Permeable interlocking concrete pavements (PICP) Seed Mix

Seed mix within the grids for PCIP shall be as follows:

Table 3: PCIP Seed Mix

Botanical Name	Common Name	% By Weight
Festuca rubra 'Chewings'	Chewings fescue	25.00%
Lolium perenne	perennial rye grass	75.00%
TOTAL		100.00%

Quality Control and Acceptance Testing

- County to inspect subgrade prior to installation of base material
- Driveways can be tested by simply throwing a bucket of water on the surface. If anything other than a scant amount puddles or runs off the surface, additional testing is necessary prior to accepting the construction.
- Roads may be initially tested with the bucket test. In addition, test the initial infiltration with a 6-inch ring, sealed at the base to the road surface, or with a sprinkler infiltrometer. Wet the road surface continuously for 10 minutes. Begin test to determine compliance with 20 inches per hour minimum rate. Use of ASTM C1701 is also recommended.