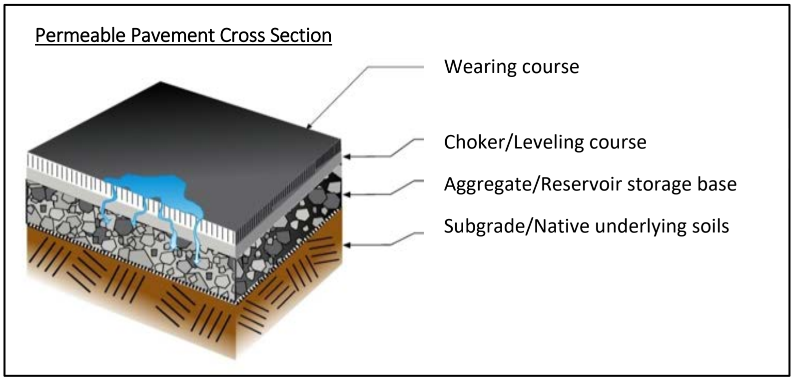
Module 3.3: Intermediate LID Design: Permeable Pavement
Section 2: Permeable Pavement Components – Considerations & Criteria



Permeable Pavement Components

All permeable pavements are generally designed as indicated in the above diagram. The components of permeable pavement systems have design criteria to consider. This includes everything from the infiltration rate of the native soil to deciding what the wearing course will be. Each section below is a brief introduction to some of these considerations.

Wearing Course

The wearing course is the top layer of a permeable pavement system – this can be porous asphalt, pervious concrete, pavers or grid structures. When designing a permeable pavement system, consider what the traffic load is going to be. Design speed, stress/torque on the pavement surface (e.g. heavy vehicles making tight radius turns) and aesthetics should all be factored into the design process. When in doubt, design conservatively for the wearing course depth. It is also important to follow the manufacturer's guidelines for proprietary products (e.g. interlocking pavers, rigid and flexible open-celled grids).

Examples of wearing courses – porous asphalt (left) and pervious concrete (right)

Examples of wearing courses – pavers (left) and grid with grass (right)

Optional Leveling/Choker Course

A choker course is sometimes installed between the wearing course and the aggregate/reservoir course in order to further stabilize and level the permeable pavement surface. Similar to the aggregate course, a successful choker course will have a gradation of material with fractured face. Often a choker course is not needed, especially if there is good fracture face with the aggregate layer below. With the right gradation and fracture face of the material, the aggregate layer will lock in place. However, sometimes the aggregate layer has some give, which is problematic for heavy paving equipment as well as into the future when the system is being used. When the wearing course is asphalt, a choker course can provide a more stable surface for paving equipment to work on.

Installation of a permeable asphalt study area at Washington State University in Puyallup. The cells denoted with yellow arrows were installed as traditional, impermeable asphalt. The rest of the cells and the lot in the foreground were all installed with permeable pavement with choker course visible (Note the choker course has visibly larger grained material (for infiltration) than the traditional asphalt foundation.)

Aggregate/Reservoir Storage Course

The aggregate/reservoir storage course allows water to be stored under the wearing course and slowly infiltrate into the subgrade soils, and also provides stable structural loading. The thickness of the aggregate course layer is controlled by the structural properties of the pavement, the design volume for storage, and infiltration rates of the subsoils. It is important to also consider if the facility will accept run on from nearby areas, as this will change both the design and the operations and maintenance requirements of the pavement. The coarse aggregate in the reservoir layer typically has 30% void space for water to infiltrate. It is important to also have a low percentage of fines (small % passing #200 sieve) in the coarse aggregate to prevent clogging. The material should be angular in shape to ensure that the aggregate particles interlock and help to better distribute pavement loads to the underlying subsoils.

Example of aggregate with fractured, angular faces to allow for a solid and permeable base/reservoir
Photo provided by MIG | SvR

For vehicular pavements, Permeable Ballast (WSDOT 9-03.9(2)) is appropriate, or that which is specified by the manufacturer. Consult with a geotechnical expert to inspect subgrade and the preparation of the subgrade. Important to maintain the design infiltration rates while also ensuring that the pavement subgrade has the adequate strength to support the pavement. It is also important to scarify the subbase to ensure that sealing of the subgrade surface doesn't occur.

Given the tighter areal confines of a pedestrian pathway and the lower loads imposed, using smaller materials are both structurally appropriate and easier to work with. For pedestrian pavements, an aggregate that conforms to AASHTO #57, 3/8 to ¾" clean crushed gravel is suitable.

Optional Geosynthetics/Geotextiles

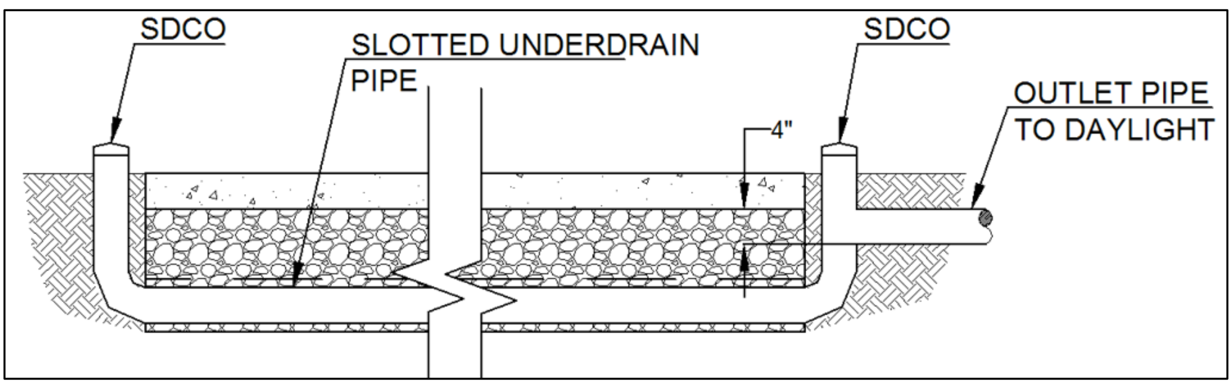
Geosynthetics can be placed between the aggregate course and the subgrade soils to address subsurface scour and/or limit material separation. Their role in permeable pavements is limited and generally not suggested, however, as they can facilitate clogging in the pavement system and inhibit infiltration into the subgrade. A situation where a geosynthetic may be used is on a sloped site where there is the potential for scour in or around check dams/berms that are discussed below. Otherwise, they are seldom necessary and rarely advised.

Native Underlying Soils

While the permeable pavement system is set up to infiltrate and temporarily store stormwater in the aggregate/reservoir course, the desired goal is to infiltrate the water into the native underlying soil (subgrade). This component of the system requires thorough investigation during the siting and design process to determine if a permeable pavement system will be a feasible option. Later in this module, we will look at ways the native soils are tested for infiltration. The minimum feasible initial infiltration rate (AKA soil saturated hydraulic conductivity) of native soils needs to be at least 0.3 inches per hour.

Optional Underdrains and Overflow

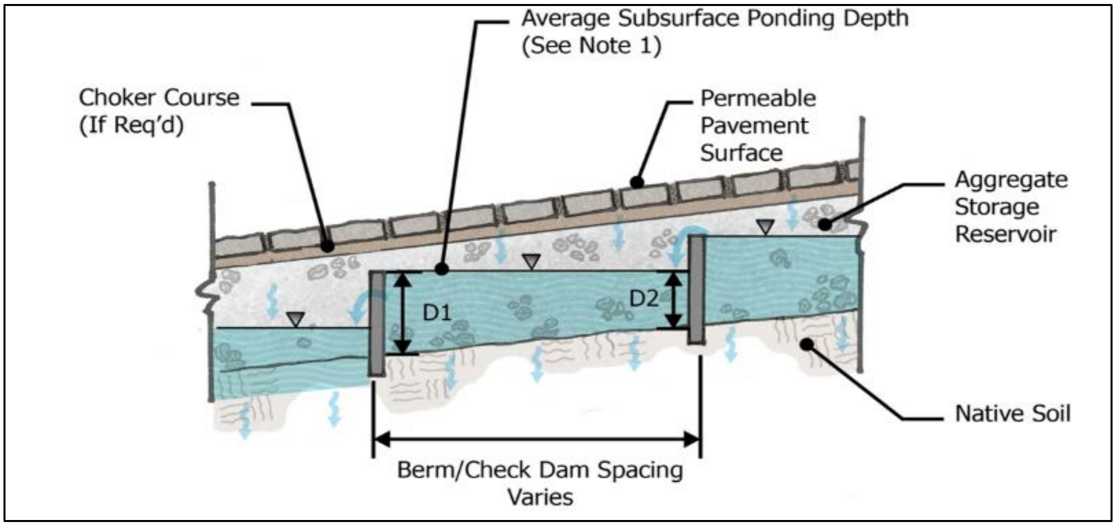
During large storm events, the volume of stormwater filtering through the permeable pavement facility may be too much for the aggregate course and the native soil to store and infiltrate. This could result in excess stormwater rising to the surface of the wearing course. Using optional underdrains and overflows can eliminate the likelihood of the wearing course becoming submerged in this way. Standard underdrains take away the water holding capacity of the system as the water is being drained away, resulting in the system no longer being considered a LID BMP. However, using slotted pipes under the pavement aggregate with an outlet overflow that is *elevated but below* (see diagram) the pavement surface creates a storage zone. This failsafe mechanism is an important consideration when infiltration rates are on the lower end of the design spectrum. These overflow pipes should typically vent into bioretention or vegetated swales.



Design diagram of a permeable pavement facility with a slotted underdrain pipe (Note the underdrain is lower than the outlet pipe to provide storage.)
Diagram by Chris Webb, Herrera

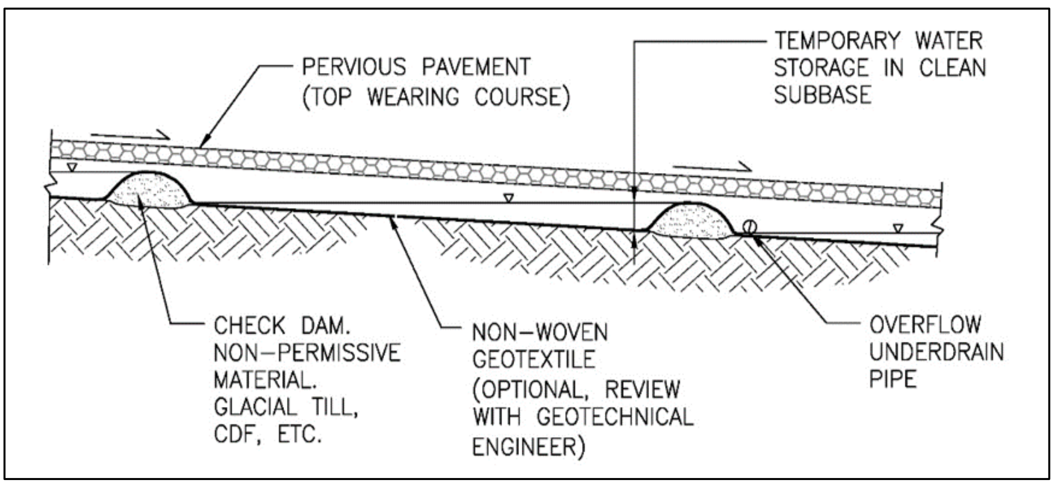
Optional Subsurface Berms/Dams

Ideally, permeable pavement sites are flat to maximize storage and uniform infiltration of water into the subsoils. However, flat slopes will also increase excavation effort during construction. Sloped conditions between 1 to 5% decreases the amount of excavation but also reduces the amount of useable storage space. A solution is to use periodic impermeable check dams if the site slope is anywhere from 1 -5%. Gravel trenches or check dams allow water to backup, pond, and infiltrate.



Cross section highlighting subsurface berms/dams

In cases where the project grade is within the upper range of slopes suitable for permeable pavements (i.e. 2 to 5%), you need to construct subsurface berms that inhibit subsurface flow velocities from scouring the subsoils through erosion. Geosynthetic textiles can also be used to protect erosion of pavement subsoils by erosive subsurface flows that might occur within the aggregate layer.



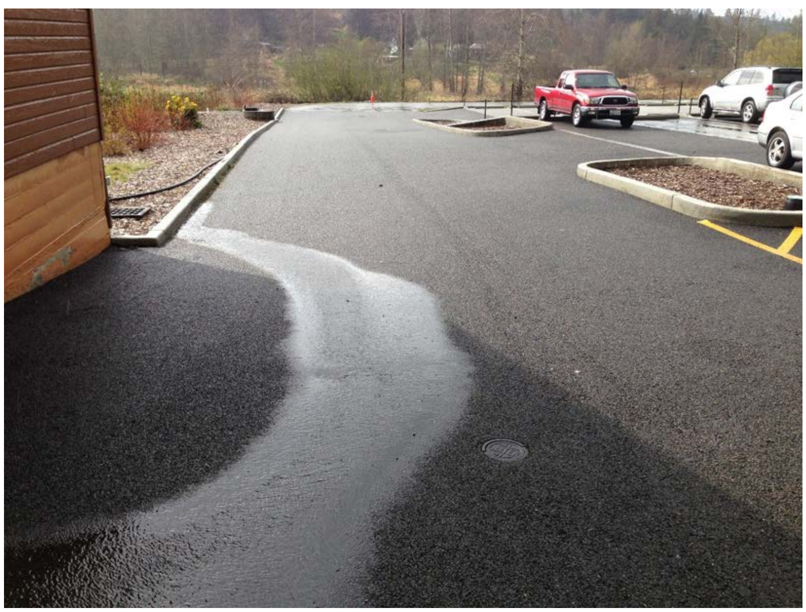
This plan calls for consulting a geotechnical engineer to verify the need/use of a geotextile fabric to reduce/prevent erosion
Graphic provided by SvR

Elevational changes are also a factor in determining the storage capacity of a permeable pavement facility on a sloped site. To model storage depths between check dams, an average depth between the check dams is calculated. The average depth multiplied by the void ratio gives the volume of possible storage in the aggregate course. If we want full infiltration then we will have to optimize depths, frequency of the check dams, and the slopes to ensure that all the water can be infiltrated. It is important to remember with steeper slopes that lateral flow cannot be neglected in the modeling calculations.

Edging

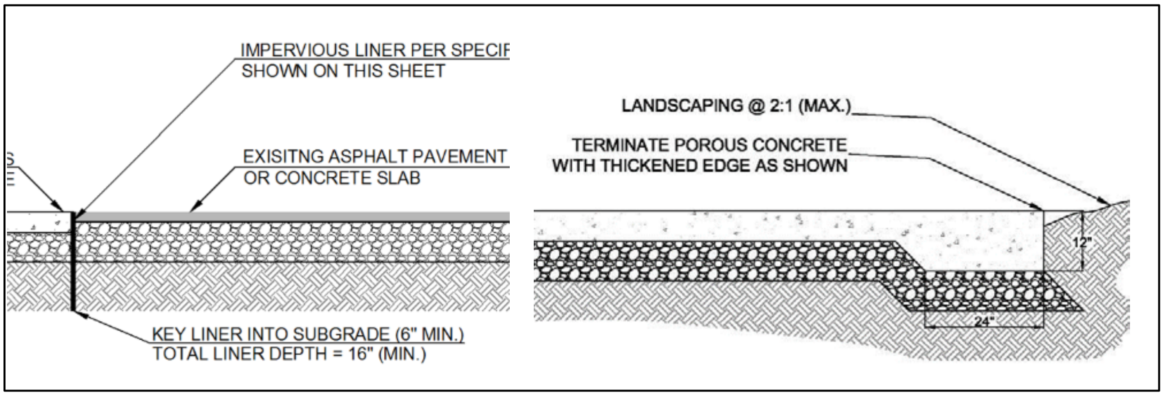
The transition between impervious and pervious pavement sections is critical as this zone can be impacted by runon and sediment loads from nearby impervious pavement. Ideally, transitions between the two types of pavement would occur at a crown or raised section to limit runon.

Clear example of edging between traditional impervious pavement and a permeable pavement parking lot



An example of runon from an impervious pavement. The transition sloped from impervious pavement toward porous asphalt, causing sediment to clog the system in the flow pattern
Photo provided by Curtis Hinman

In order limit the movement of water from the aggregate material below a permeable pavement system to that below an adjacent impervious pavement, a reinforced vertical liner keyed into the subsoils may be used. Where a permeable pavement ends or at an edge that abuts against the native soils, thickening of the pavement at that edge protects the pavement from failure. Also ensuring that the materials from the adjacent areas don't migrate onto the pervious pavement is key. One way to do this is to ensure that the elevation of the soil or landscaped bed adjacent to the pavement is below the top surface of the permeable pavement's wearing course.



Examples of edge transitions – an impervious liner used to prevent fines from the impervious pavement's subgrade migration to the subgrade of the permeable pavement system (left) and a thickened pervious concrete edge (right)