Permeable Interlocking Concrete Paving

Practice Description

Permeable interlocking concrete paving (PICP) consists of manufactured concrete units that reduce stormwater-runoff volume, rate, and pollutants. The impervious units are designed with small openings between permeable joints. The openings typically comprise 5% to 15% of the paver surface area and are filled with highly permeable, small-sized aggregates. The joints allow stormwater to enter a crushed stone aggregate bedding layer and base that supports the pavers, while providing storage and runoff treatment. PICPs are highly attractive, durable, and easily repaired; require low maintenance; and can withstand heavy vehicle loads.

Planning Considerations

PICP can replace traditional impervious pavement for most pedestrian and vehicular applications except high-volume/high-speed roadways. PICP has performed successfully in pedestrian walkways, sidewalks, driveways, parking lots, and low-volume roadways. The environmental benefits from PICP allow it to be incorporated into municipal green infrastructure and low impact development programs. In addition to providing stormwater volume and quality management, light-colored pavers are cooler than conventional asphalt and help to reduce urban temperatures and improve air quality. The textured surface of PICP also provides traffic calming and provides an aesthetic amenity.

PICP should not be confused with concrete grid pavements (i.e., concrete units with cells that typically contain topsoil and grass). These paving units can infiltrate water, but at rates lower than PICP. Unlike PICP, concrete grid pavements are generally not designed with an open-graded, crushed stone base for water storage. Moreover, grids are for intermittently trafficked areas such as overflow parking areas and emergency fire lanes.

Design Criteria

PICP should be designed and sited to intercept, contain, filter, and infiltrate stormwater on site. Several design possibilities can achieve these design aspects. For example, PICP can be installed across an entire street width or an entire parking area. The pavement can also be installed in combination with impermeable pavements to infiltrate runoff and initiate a treatment train. Several applications use PICP in parking lot lanes or parking stalls to treat runoff from adjacent impermeable pavements and roofs. This design economizes PICP installation costs while providing sufficient treatment area for the runoff generated from impervious surfaces. Inlets can be places in the PICP to accommodate overflows from extreme storms. The stormwater volume to be captured, stored, infiltrated, or harvested determines the PICP scale required.

Specific design requirements relating to the structural stability of permeable pavements are beyond the scope of this manual. The reader is referred to the AASHTO Flexible Pavement Method for structural design requirements. The following guidelines are presented to ensure that permeable pavements are properly located, designed, and constructed to meet water quality objectives.

1. A washed aggregate base must be used, and washed 57-size stone is generally acceptable. Fine particles from standard “crusher run” will clog the pores at the bottom of the pavement and will not be allowed.

2. Low traffic volume – less than 100 axles per day. Areas with higher traffic volume may be able to use permeable pavement in parking stalls, and use regular pavement in drive aisles.

3. As shown in Figure 1 below, the seasonal high water table must be at least 2 ft below the base of the permeable pavement or gravel storage layer. Water tables approaching the permeable pavement system will not allow water to exfiltrate.

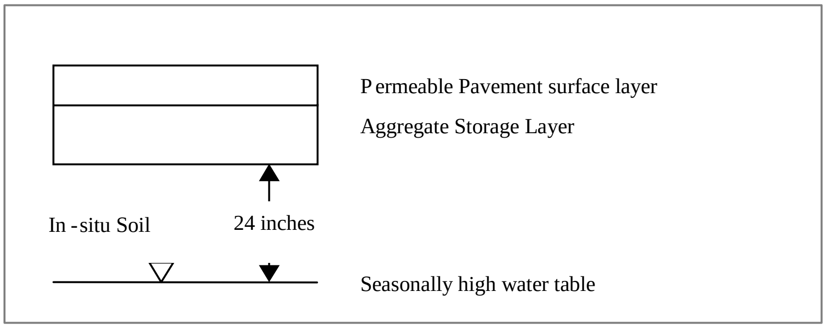

Figure 1 Schematic of Water Table Design Constraint

4. Permeable pavement should not be placed where upland land disturbance is occurring or will potentially occur. Land disturbance upland of the lot could result in frequent pavement clogging.

5. Avoid overhanging trees above the permeable pavement installation.

6. Steeper slopes can reduce the storage capacity of the permeable pavement, so it is important that the top of the soil subgrade (the bottom of the aggregate storage layer) be as close to flat as practicable (slope of ≤0.5%). If the top of the soil subgrade is >0.5%, baffles, partitions, berms, or terracing shall be installed to promote infiltration across the entire area of the subgrade and to reduce the potential for lateral flow. The surface of the permeable pavement shall be no more than 6%.

7. During preparation of the subgrade, special care must be made to avoid compaction of soils. Compaction of the soils can reduce the infiltration capacity of the soil.

8. Permeable pavement should not be designed to receive concentrated flow from roofs or other surfaces. Incidental run-on from stabilized areas is permissible, but the permeable pavement should be designed primarily to infiltrate the rain that falls on the pavement surface itself.

9. Permeable pavement systems are not allowed in areas, such as buffers, where impervious surfaces are not permitted.

10. The construction sequence will be inspected to ensure that the surface installation is planned to be completed after adjacent areas are stabilized with vegetation. Run-on to the permeable pavement from exposed areas can cause the system to perform ineffectively due to clogging.

Specific Design Considerations and Limitations

The load-bearing and infiltration capacities of the subgrade soil, the infiltration capacity of the paver surface, and the storage capacity of the stone base/subbase are the key stormwater-design parameters. To compensate for the lower structural support capacity of clay soils, additional subbase depth is often required. The increased depth also provides additional storage volume to compensate for the lower infiltration rate of the clay subgrade. Underdrains elevated above the subgrade clay soil are often used in PICP, further making it suitable for many clay soils by infiltrating some of the water and filtering and draining the remainder. In addition, an impermeable liner may be installed between the subbase and the subgrade to limit water infiltration when clay soils have a high shrink-swell potential or there is a high depth to bedrock or water table (NCSU, 2008).

Measures should be taken to protect PICP from high sediment loads, particularly fine sediment. Appropriate pretreatment BMPs for run-on to pavers include filter strips and swales. Preventing sediment from entering the base or permeable pavement during construction is critical. Runoff from disturbed areas should be diverted away from the PICP until these areas are stabilized.

Common Problems

PICP has the potential to become clogged with sediment if not protected from disturbed areas during construction activities.

Slope plays a role in applicability of PICP. Slopes greater than 2% may require additional design considerations, including terracing of soil subgrade.

PICP can cause safety concerns for disabled persons, bicycles, pedestrians wearing high-heels, and the elderly (SPU, 2009). Many PICP paver designs are ADA compliant, and other areas may require solid interlocking concrete pavements.

Maintenance

The most prevalent maintenance concern is the potential clogging of the openings and joints between the pavers. Fine particles that can clog the openings are deposited on the surface from vehicles, the atmosphere, and runoff from adjacent land surfaces. Clogging will increase with age and use. However, while more particles become entrained in the pavement surface, it does not become impermeable. Studies of the long-term surface permeability of PICP and other permeable pavements have found high infiltration rates initially, a decrease, and then a leveling off with time. With initial infiltration rates of hundreds of inches per hour, the long-term infiltration capacity remains high even with clogging. When substantially clogged, surface infiltration rates usually well exceed 1 inch per hour, sufficient in most circumstances to effectively manage stormwater. Permeability can be increased with vacuum sweeping or, in extreme circumstances, by replacing the aggregate between pavers.