Pervious Concrete

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Practice Description

Pervious concrete, also known as pervious, gap-graded, or enhanced porosity concrete, is concrete with reduced sand or fines and allows water to drain through it. Pervious concrete is often constructed over an aggregate storage bed to allow for stormwater infiltration and temporary storage. This aggregate layer not only provides temporary stormwater storage but also helps to support the concrete. Pervious concrete has less sand and fines than standard concrete, which leaves stable air pockets in the concrete that allow water to flow through. This void space is generally between 15 and 35 percent. When properly installed, pervious concrete is a durable and low-maintenance paving option.

Planning Considerations

Pervious concrete can be used for municipal stormwater management programs and private development applications. The runoff volume and rate control, plus pollutant reductions, allow municipalities to improve the quality of stormwater discharges. Municipal initiatives, such as Chicago’s Green Alley program, use pervious concrete to reduce combined sewer overflows and to minimize localized flooding by infiltrating and treating stormwater on site. Private development projects use pervious concrete to meet post-construction stormwater quantity and quality requirements. The use of pervious concrete can potentially reduce additional expenditures and land consumption for conventional collection, conveyance, and detention stormwater infrastructure. Public and private developments have used pervious concrete, which is a naturally brighter surface than traditional asphalt, to reduce lighting needs and increase nighttime safety.

Pervious concrete can replace traditional impervious pavement for most pedestrian and vehicular applications except high-volume/high-speed roadways. Pervious concrete can be designed to handle heavy loads, but surface abrasion from constant traffic will cause the pavement to deteriorate more quickly than conventional concrete. Pervious concrete has performed successfully in pedestrian walkways, sidewalks, driveways, parking lots, and low-volume roadways. The environmental benefits from pervious concrete allow it to be incorporated into municipal green infrastructure and low impact development programs. In addition to providing stormwater volume and quality management, the light color of concrete is cooler than conventional asphalt and helps to reduce urban temperatures and improve air quality (Grant et al., 2003; Vingarzan and Taylor, 2003). Unlike the smoothed surface of conventional concrete, the surface texture of pervious concrete is slightly rougher, providing more traction to vehicles and pedestrians.

Design Criteria

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

Pervious concrete comprises the surface layer of the permeable pavement structure and consists of portland cement, open-graded coarse aggregate (typically 5/8 to 3/8 inch), and water. Admixtures can be added to the concrete mixture to enhance strength, increase setting time, or add other properties. The thickness of pervious concrete ranges from 4 to 8 inches depending on the expected traffic loads. Additional subsurface components of this treatment practice are illustrated in Figure 1 and include the following (National Ready Mix Concrete Association (NRMCA), 2008):

- *Choke course* - This permeable layer is typically 1-2 inches thick and provides a level bed for the pervious concrete. It consists of small-sized, open-graded aggregate.
- *Open-graded base reservoir* - This aggregate layer is immediately beneath the choke layer. The base is typically 3-4 inches thick and consists of crushed stones typically 3/4 to 3/16 inch. Besides storing water, this high-infiltration rate layer provides a transition between the bedding and subbase layers.
- *Open-graded subbase reservoir* - The stone sizes are larger than the base, typically 2½ to 2¾ inch stone. Like the base layer, water is stored in the spaces among the stones. The subbase layer thickness depends on water storage

requirements and traffic loads. A subbase layer may not be required in pedestrian or residential driveway applications. In such instances, the base layer is increased to provide water storage and support.

- *Underdrain (optional)* - In instances where pervious concrete is installed over low-infiltration rate soils, an underdrain facilitates water removal from the base and subbase. The underdrain is perforated pipe that ties into an outlet structure. Supplemental storage can be achieved by using a system of pipes in the aggregate layers. The pipes are typically perforated and provide additional storage volume beyond the stone base.
- *Geotextile (optional)* - This can be used to separate the subbase from the subgrade and to prevent the migration of soil into the aggregate subbase or base.
- *Subgrade* - The layer of soil immediately beneath the aggregate base or subbase. The infiltration capacity of the subgrade determines how much water can exfiltrate from the aggregate into the surrounding soils. The subgrade soil is generally not compacted.

Properly installed pervious concrete requires trained and experienced producers and construction contractors. The installation of pervious concrete differs from conventional concrete in several ways. The pervious concrete mix has low water content and will therefore harden rapidly. Pervious concrete needs to be poured within one (1) hour of mixing. The pour time can be extended with the use of admixtures. A manual or mechanical screed set ½ inch above the finished height can be used to level the concrete.

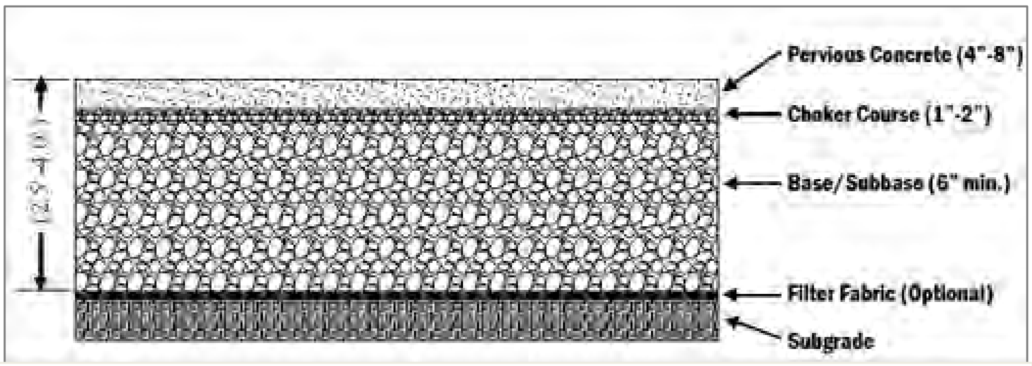

Figure 1 Typical Porous Asphalt Pavement Section (diagram adapted from USEPA, 1986)

Floating and troweling are not used, as these actions may close the surface pores. Consolidation of the concrete, typically with a steel roller, is recommended within 15 minutes of placement. Pervious concrete also requires a longer time to cure. The concrete should be covered with plastic within 20 minutes of setting and allowed to cure for a minimum of 7 days (NRMCA, 2008).

Siting Considerations

- Do not install in areas where hazardous materials are loaded, unloaded, or stored.
- Avoid high sediment-loading areas.
- Divert runoff from disturbed areas until stabilized.
- Do not use sand for snow or ice treatment.
- Periodic maintenance to remove fine sediments from paver surface will optimize permeability.

Common Problems

The load-bearing and infiltration capacities of the subgrade soil, the infiltration capacity of the pervious concrete, 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 are often used when permeable pavements are installed over clay. 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 if there is a high depth to bedrock or water table (Hunt and Collins, 2008).

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

Several factors may limit permeable pavement use. Pervious concrete has reduced strength compared to conventional concrete and will not be appropriate for applications with high volumes and extreme loads. It is not appropriate for stormwater hotspots where hazardous materials are loaded, unloaded, stored, or where there is a potential for spills and fuel leakage. For slopes greater than 2 percent, terracing of the soil subgrade base may likely be needed to slow runoff from flowing through the pavement structure. In another approach for using pervious concrete slopes, lined trenches with underdrains can be dug across slope to intercept flow through the subbase (ACPA, 2006).

Maintenance

The most prevalent maintenance concern is the potential clogging of the pervious concrete pores. Fine particles that can clog the pores are deposited on the surface from vehicles, the atmosphere, and runoff from adjacent land surfaces. Clogging will increase with age and use. While more particles become entrained in the pavement surface, it does not become impermeable. Studies of the long-term surface permeability of pervious concrete and other permeable pavements have found high infiltration rates initially, followed by a decrease, and then leveling off with time (Bean et al., 2007a). With initial infiltration rates of hundreds of inches per hour, the long-term infiltration capacity remains high even with clogging. Permeability can be increased with vacuum sweeping. In areas where extreme clogging has occurred, half-inch holes can be drilled through the pavement surface every few feet or so to allow stormwater to drain to the aggregate base. Many large cuts and patches in the pavement will weaken the concrete structure.

Cold weather and frost penetration do not negatively impact surface infiltration rates. Permeable concrete freezes as a pervious medium rather than a solid block because permeable pavement systems are designed to be well drained; infiltration capacity is preserved because of the open void spaces (Gunderson, 2008).