# CONCRETE PAVING Technology

AMERICAN CONCRETE PAVEMENT ASSOCIATION

# Stormwater Management with Pervious Concrete Pavement

## Pervious Concrete Pavement

### Description

Pervious concrete pavement is a porous pavement, often with an underlying stone reservoir, that captures rainfall and stores runoff before it infiltrates into the subsoil. This pervious surface replaces traditional pavement, and allows stormwater to infiltrate directly into the ground, permitting a naturally occurring form of water treatment. Pervious concrete mixtures consist of specially formulated hydraulic cementitious materials, water, and uniform open-graded coarse aggregate (e.g., ASTM C33 Size Numbers 5, 56, 67, 8, and 89). When properly designed and installed, pervious concrete has a high percentage of void space (15% or more) to accommodate stormwater from significant storm events (see Figure 1).

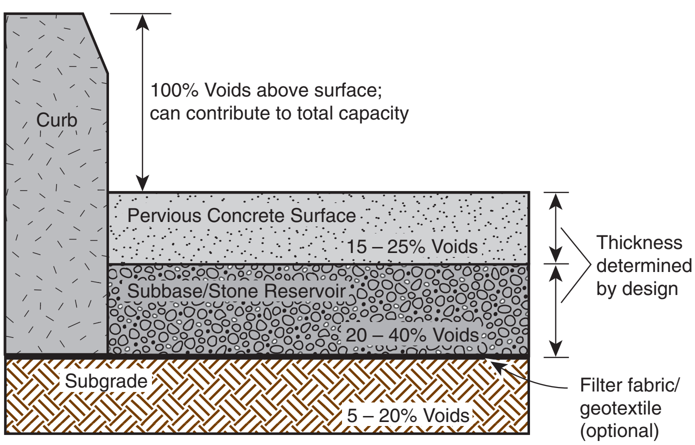


*Figure 1. Typical cross-section of pervious concrete pavement. On level subgrades, stormwater storage is provided in the pervious concrete surface layer (15% to 25% voids), the subbase (20% to 40% voids), and above the surface to the height of the curb (100% voids). After: ACI 552R-06.*

### Application

Pervious concrete pavement is ideal around buildings (e.g., walkways, courtyards, etc.), as parking lots and as low-volume roadways. Pervious concrete pavement also has some application on highways, where it can be used in shoulder and median construction for stormwater runoff mitigation. It also may be used as a surface material to reduce hydroplaning, splash and spray, and mitigate tire-pavement noise.

#### *Regional Applicability*

Pervious concrete pavement can be applied in most regions of the country, but the practice has unique challenges in cold climates. Design of the system should ensure that washout from adjacent (soil) areas is not allowed to drain onto pervious concrete pavement surfaces. Care should be taken with regard to sand being applied to the pavement surface for deicing because the sand may become lodged in the pavement surface. This is not to imply that it is impossible to use pervious concrete pavement in cold climates. In fact, anecdotal evidence suggests that snow-covered pervious concrete pavement actually may clear more quickly than impervious surfaces, reducing the need for snow plowing. Additionally, melted snow and ice will drain through the pervious concrete pavement rather than ponding and refreezing at the surface, a common occurrence with traditional impervious pavements; this action alone may minimize the need to apply deicing materials to a pervious concrete pavement.

Another concern in cold climates is that infiltrating runoff below the pavement may cause frost heave, although design modifications that provide for an



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adequate subbase layer can reduce this risk. Pervious concrete pavement structures that incorporated frost-heave-reducing design features have been used successfully in Norway (Stenmark, 1995). Successful longer term installations of pervious concrete pavements in regions of cold weather also have been documented in North America (Delatte, et al, 2007; NRMCA, 2004; and Schaefer, et al, 2006).

#### ULTRA-URBAN AREAS

Ultra-urban areas are densely developed urban areas in which pervious and naturally draining surface area is reduced. Pervious concrete pavements are ideal design options in such areas because they allow for additional use of land by eliminating the need for stormwater retention systems.

#### STORMWATER HOT SPOTS

Stormwater hot spots are areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater. These areas may include commercial nurseries, auto recycle facilities, fueling stations, storage areas, industrial rooftops, marinas, outdoor container storage of liquids, outdoor loading/unloading facilities, public works storage areas, hazardous materials generators (if containers are exposed to rainfall), vehicle service and maintenance areas, and vehicle and equipment washing/steam cleaning facilities. Pervious concrete pavement should not be used as an infiltration practice on stormwater hot spots due to the potential for ground water contamination.

#### STORMWATER RETROFIT

A stormwater retrofit is a stormwater management practice (usually structural) put into place after development has occurred to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives. The best application of pervious concrete pavement for retrofits may be on individual projects where a parking lot or low-volume road is being reconstructed.

#### COLD WATER (TROUT) STREAMS

Pervious concrete pavement can help to reduce the increased runoff water temperature commonly associated with impervious cover (Dane County, 2007 and Hunt and Collins, 2008). Stormwater ponding on or around the surface of conventional pavement is subsequently heated by the sun and hot pavement surface. By allowing rainfall to rapidly infiltrate, pervious concrete pavement eliminates this problem, helping to mitigate the potential for "thermal shock" events caused by heated stormwater flowing into nearby streams and estuaries.

## Siting and Design Considerations

### *Siting Considerations*

Pervious concrete pavement has the same siting considerations as other infiltration practices. The site needs to meet the following criteria:

- When pervious concrete pavement systems are designed with a stone reservoir, the reservoir should be of sufficient depth to accommodate stormwater storage for the design storm event.
- Design options include installation of wells or drainage channels through the subgrade and/or underground storage chambers for below surface storage of stormwater.
- If used to treat off-site runoff, pervious concrete pavement should incorporate pretreatment, as with all structural management practices.
- Pervious concrete pavement should be sited at least 3 ft (1 m) above the seasonally high ground water table, and at least 100 ft (30 m) away from drinking water wells.

### *Design Considerations*

Some basic features should be incorporated into all pervious concrete pavement designs. These design features can be divided into five categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

1. ***Pretreatment.*** The pervious concrete pavement acts as pretreatment to the stone reservoir below. Because the surface serves this purpose, periodic maintenance of the surface is an important factor in optimal performance.
2. ***Treatment.*** The stone reservoir directly below the pavement surface should be sized to attenuate

water flows from the design storm event. Typically, pervious concrete pavement is sized to treat a small event such as a water quality storm (i.e., the storm that will be treated for pollutant removal), which can range from 0.5 to 1.5 in. (13 to 25 mm). As with infiltration trenches, water can be stored in the void spaces of the stone reservoir.

3. ***Conveyance.*** Water is conveyed to the stone reservoir through the pavement surface where it then infiltrates into the ground. A geosynthetic liner should be placed below the stone reservoir to prevent preferential flow paths and to maintain a flat bottom. Designs also may incorporate some method to convey larger volumes of stormwater runoff to the storm drain system, such as the inclusion of drain pipes below the pavement, diverting stormwater flow to supplementary catchment areas for potential reuse, or other innovative devices.

4. ***Maintenance Reduction.*** One nonstructural component that can help ensure proper maintenance of pervious concrete pavement is the use of a carefully worded maintenance agreement that provides specific guidance, including how to conduct routine maintenance. Ideally, signs should be posted on the site identifying pervious concrete pavement areas. Vacuum (preferred) or pressure wash the surface annually, or more frequently if dictated by site specific conditions.

5. ***Landscaping.*** Reducing sediment loads entering the pavement can help prevent clogging. Thus, the most important landscaping feature is fully stabilized upland drainage.

## *Design Variations*

### SLOPING SURFACES

When the surface is not level, the depth of the pavement and subbase must be designed to meet the desired runoff goals, or more complex options for handling water flow may be used. Pervious concrete pavements have been placed successfully on slopes up to 16%. In such cases, trenches were dug across the slope, lined with 0.25 in. (6 mm) visqueen, and filled with rock (see Figure 2). Pipes extending from the trenches carry water traveling down the paved slope out to the adjacent hillside. Use of soil filter fabric also is recommended to prevent wash out of the subgrade (Tennis, et al, 2004).

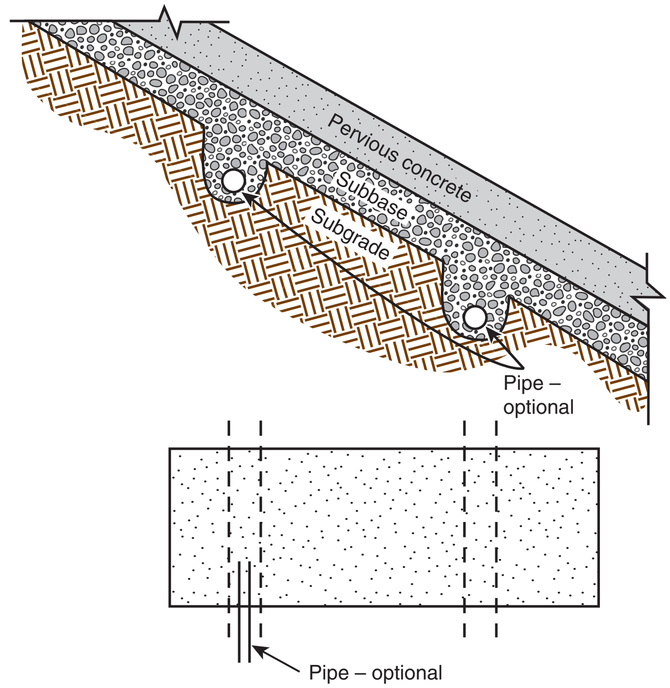



*Figure 2. Elevation (top) and plan (bottom) views of a sloped installation. For sloped pervious concrete pavements, storage capacity calculations must consider the depth of pavement, infiltration rate of subbase, and desired runoff goals. Source: Tennis, et al, 2004.*

### REGIONAL ADAPTATIONS

In cold climates, the base of the stone reservoir should be below the frost line. This modification will help to reduce the risk of frost heave.

### POORLY DRAINING SOILS

While more suitable for well-draining soils (minimum percolation rate of 0.5 in. [13 mm] per hour), pervious concrete pavement can be utilized in poorly draining soils, provided special design considerations such as those shown in Figure 3 are followed (Tennis, et al, 2004).

## Limitations

Installation/construction procedures for pervious concrete pavement differ from those used for conventional concrete pavement. Care should be taken to pre-qualify suppliers and installers for pervious concrete pavement systems. Guidance on applications, specifications and installation techniques are continually evolving and being published (ACI 522.1-08, 2008; ACI 522-R06, 2006; NRMCA, 2006).

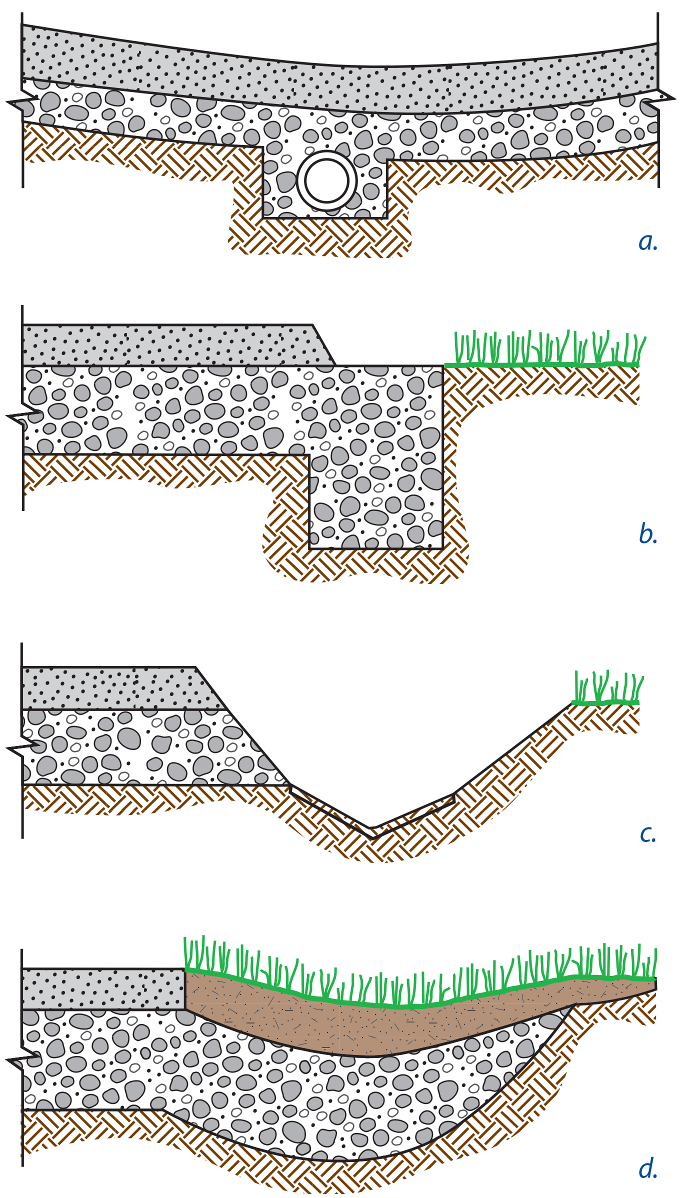
## Maintenance Considerations

For a pervious concrete pavement to perform as designed, the required maintenance schedule must be followed. In addition to owners not being aware of the presence of pervious concrete pavement on a site, negligence of required maintenance activities and schedules is the chief reason for premature pervious concrete pavement failures. Typical maintenance requirements are shown in Table 1 on Page 5.

## Effectiveness

Pervious concrete pavement can be used to substantially reduce the volume of runoff, to provide ground water recharge and to reduce pollutants in storm water runoff. Research suggests that pervious concrete pavement systems help up to 80% of the annual rainfall go towards ground water recharge (Clar, et al, 2004).

Studies conducted on long-term pollutant removal have shown that pervious concrete pavement is very effective in removal of pollutant load (Dierkes, et al, 1999), in some cases demonstrating greater than 80% efficacy in pollutant removal (Rushton, 2001).



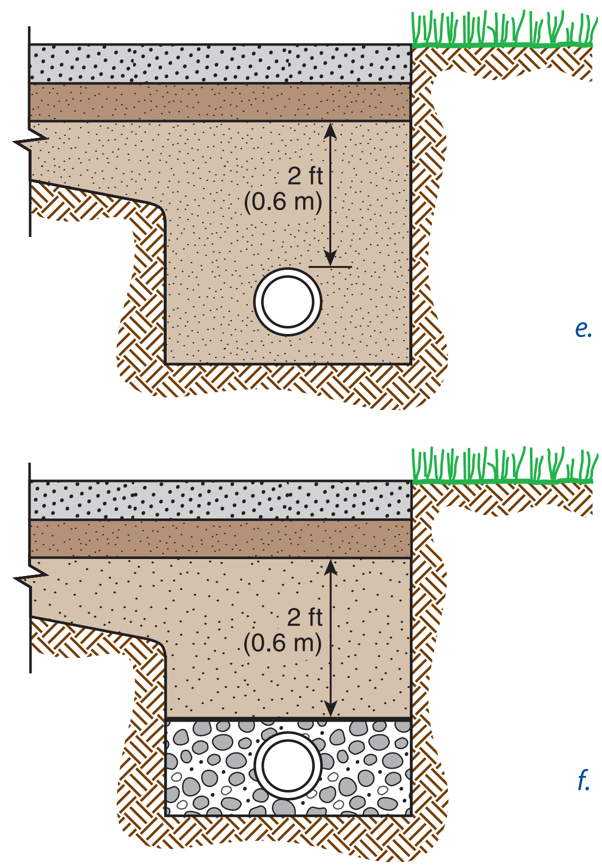




*Figure 3. Example cross-sections of alternative designs for use in poorly draining soils. (a) rock filled trench under pavement; (b) rock trench along pavement edge; (c) V-trench; (d) rock filled trench extending beyond pavement; (e) sand underdrain; and (f) sand underdrain with rock trench. After: Tennis, et al, 2004.*

**Table 1. Typical Maintenance Requirements for Pervious Concrete Pavement (Source: WMI, 1997)**

| Activity | Schedule |
|---|---|
| • Avoid sealing or repaving with impervious materials. | N/A |
| • Ensure that the pavement area is clean of debris.<br>• Ensure that the pavement dewaters between storms.<br>• Ensure that the pavement area is clean of sediments. | As needed |
| • Mow upland and adjacent areas, and seed bare areas.<br>• Vacuum/sweep the pavement surface to keep it free of sediment. | As needed |
| • Inspect the surface for deterioration or spalling. | Annually |

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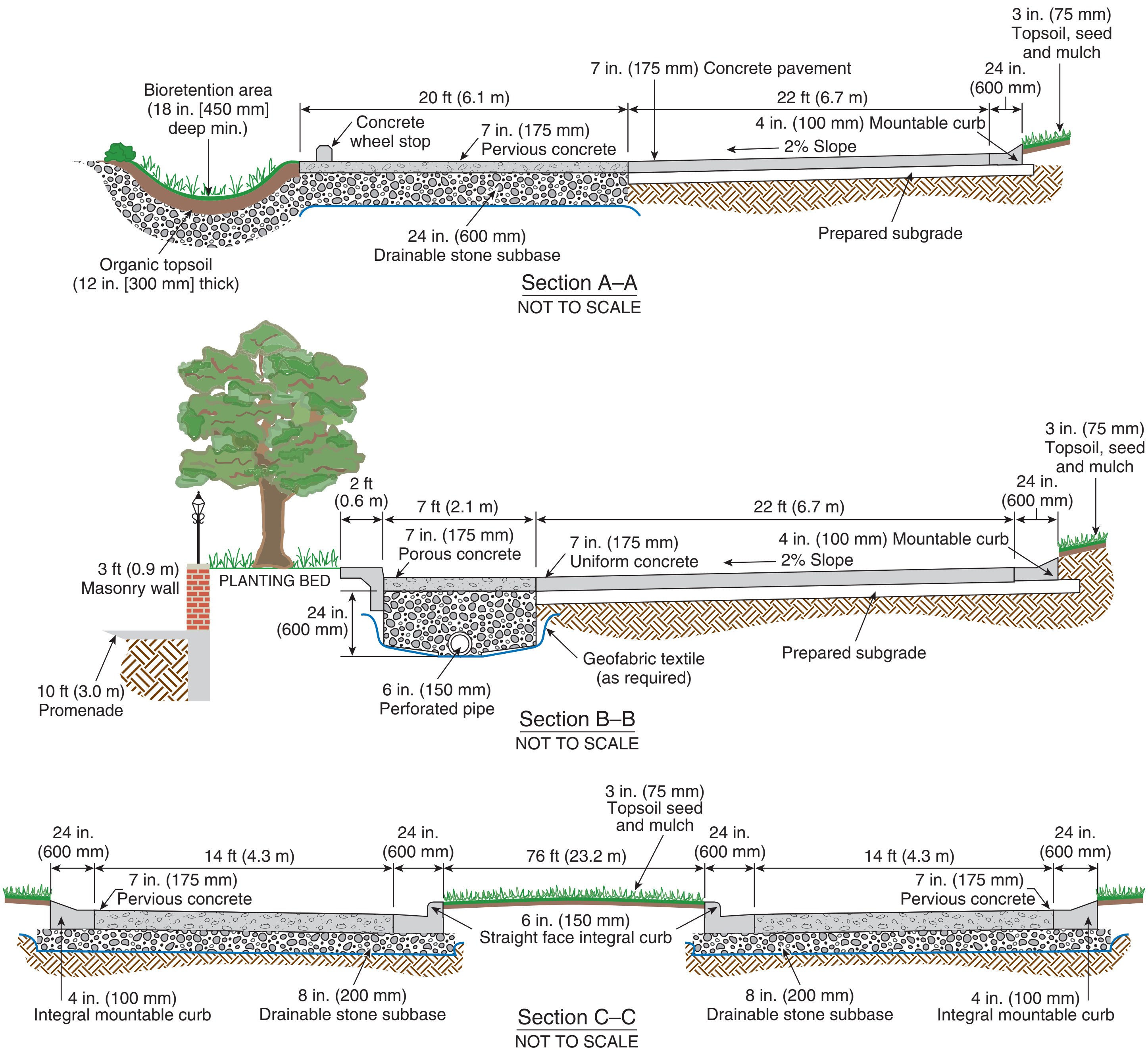


*Figure 4. Illustrations from the Lost Peninsula Marina project in Erie Township, Michigan.*

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IS334.02P