6.6 Pervious Pavement

Figure 6-26: The City of Menlo Park used pervious concrete for parking stalls and standard paving in the drive aisles in this public parking lot.

Best uses

- Roads and alleys
- Parking lots
- Driveways
- Bike lanes
- Sidewalks and plazas
- Where space is limited for Biotreatment

Advantages

- Flow attenuation
- Volume reduction
- Removes fine particulates
- Reduces need for treatment

Limitations

- May clog without periodic cleaning
- Higher installation costs than conventional pavement

Pervious pavement types include pervious concrete, porous asphalt, permeable concrete pavers and permeable interlocking concrete pavers (PICP). Permeable pavers allow infiltration across the entire surface of the paver while PICP utilize the joint space between the pavers for infiltration. Except for PICP, pervious pavement is generally used for areas with light vehicle loading and/or lightly trafficked areas, such as automobile parking areas. Crushed aggregate is sometimes used as pervious pavement as well. Table 6-2 shows possible applications for different types of pervious pavement. Figures 6-26 through 6-30 provide more detailed design information. The term pervious pavement describes a system comprised of a load-bearing, durable surface constructed over a subbase/base structure typically consisting of compacted, open-graded aggregate. This layer or layers temporarily stores water prior to infiltration or drainage to a controlled outlet. The surface is porous such that water infiltrates across the entire surface of the material, or in the joints, at a high rate. If an area of pervious pavement is underlain with pervious soil or pervious storage material, such as a gravel layer sufficient to hold at least the Municipal Stormwater Regional Permit Provision C.3.d volume of rainfall runoff, it is not considered an impervious surface and can function as a self-treating or self-retaining area, as described in Section 4.2.

Please note that the CALGreen Building Code does not define pervious pavement in the same way as the MRP. Projects that include pervious pavement per CALGreen requirements must also verify that the pervious pavement meets the MRP definition of pervious pavement.

The Countywide Program gratefully acknowledges the contributions of Mr. David Smith, Technical Director of the Interlocking Concrete Pavement Institute, to this section of the C.3 Technical Guidance, including pavement sections, design details, and specifications.

Table 6-2:
Types of Pervious Pavement and Possible Applications

Paver Type	Description	Possible Applications
Porous Asphalt	Open-graded asphalt concrete over an open-graded aggregate base, over a draining soil. Contains very little fine aggregate (dust or sand) and is comprised almost entirely of stone aggregate and asphalt binder; surface void content of 12-20%.	Low traffic use, such as parking lots, travel lanes, parking stalls. Surface may be too rough for bikeways.
Pervious Concrete	A discontinuous mixture of coarse aggregate, hydraulic cement and other cementitious materials, admixtures, and water which have a surface void content of 15-25% allowing water to pass through.	Sidewalks and patios; low traffic volume; low speed (less than 30 mph limit) and lighter load roadways; bikeways; parking stalls; and residential driveways.
Permeable Interlocking Concrete Pavers (PICP)	Discrete units set in a pattern on a prepared base. Typically made of precast concrete in shapes that form interlocking patterns. Solid unit pavers are made of impermeable materials, but are spaced to expose a permeable joint filled with permeable aggregates and set on a permeable base.	All uses: parking lanes, stalls and lots, private driveways, bikeways, walkways, patios, alleys, public and private roadways.
Permeable Concrete Pavers	Discrete units set in a pattern on a prepared base. Constructed of permeable concrete.	Lighter traffic areas such as walkways, bikeways and vehicle parking areas.

Design and Sizing Guidelines

The design of each layer of the pavement must be determined by the likely traffic loadings and the layer's required operational life. The thickness of the base layer is also affected by hydrologic sizing considerations. To provide satisfactory performance, the following criteria should be considered.

SUBGRADE AND SITE REQUIREMENTS

- The soil sub-grade should be able to sustain anticipated traffic loading without excessive deformation while temporarily saturated.
- The sub-grade should be either ungraded in-situ material with a permeability that allows detained flows to infiltrate within 72 hours, or the pavement system can be installed with an underdrain that will remove detained flows within the pervious pavement and base.
- Depth to seasonal high groundwater level should be at least 5 feet from the bottom of the base of the pervious pavement system, unless a different separation is recommended by the geotechnical engineer.
- Pervious pavement systems should not be used where site conditions do not allow infiltration.Grading of the soil subgrade below the pervious pavement should be relatively flat (not to exceed 2% slope) to promote infiltration across the entire area.
- A slope of 1% is recommended for pavement surface. Slopes of pervious pavement should not exceed 5%, or up to 16% with underdrains. Slopes exceeding 3% typically require berms or check dams placed laterally over the soil subbase to slow

the flow of water and provide some infiltration. Alternatively, pervious pavement systems can be terraced to step down a steep slope, maintaining level bed bottoms separated by earthen berms.

BASE LAYER

- To allow for subsurface water storage, the base must be open graded, crushed stone (not pea gravel), meaning that the particles are of a limited size range, with no fines, so that small particles do not choke the voids between large particles.
- When subject to vehicular traffic, all open-graded aggregates should conform to the following or to similar specifications as directed by the municipality: crushed material, minimum 90% with at least 2 fractured faces conforming to Caltrans test method CT 205; have Los Angeles Rattler no greater than 40% loss at 500 revolutions per Caltrans test method CT 211; and a minimum Cleanness value of 75 per Caltrans test method CT 211. Sieve analysis should conform to Caltrans test method CT 202.
- If the subbase/base layer is sized to hold at least the Municipal Stormwater Regional Permit Provision C.3.d volume of rainfall runoff, the area of pervious pavement is not considered an impervious surface and can function as a self-treating area (see Section 4.2).
- If the subbase/base layer has sufficient capacity in the void space to store the C.3.d amount of runoff for both the area of pervious pavement and the area that drains to it, it is not considered an impervious surface and can function as a self-retaining area, described in Section 4.2.
- Pervious pavement designed to function as a self-retaining area may accept runoff from an area of impervious surface that has a surface area of up to two times the surface area of the properly-designed pervious pavement area.
- If an underdrain is used, position the perforated pipe within the subgrade enveloped on all sides by a least 4 inches of open-graded aggregate and provide a non-perforated, upturned elbow pipe for outflows (see Figures 6-26 and 6-27.) A cleanout with surface access is recommended at the upturn. To be considered a self-treating area or self-retaining area, the underdrain should be positioned above the portion of the base layer that is sized to meet the C.3.d sizing criteria.
- Design calculations for the base should quantify the following:
    - Soil type/classification and soil permeability rate; if subject to vehicular traffic, k-values (psi/cubic inch) or R-values characterizing soil strength when saturated;
    - Fill type if used, installation, and compaction methods plus target densities;
    - Lifetime expected vehicular traffic loading (in 18,000 lb. equivalent single axle loads or Caltrans Traffic Index); the maximum Traffic Index = 9.
    - Drainage routing of detained flows within the open graded subbase/base as well as expected infiltration into in-situ soils, or collection in a raised underdrain if the permeability cannot meet design criteria.

PAVEMENT MATERIALS

- The pavement materials should not crack or suffer excessive rutting under anticipated traffic loads. This is controlled by designing pervious concrete and porous asphalt surfacing materials and layer thicknesses that minimize the horizontal tensile stress at their base. All pervious pavements benefit from using open-graded aggregate base materials with sufficient thicknesses and compaction that spread and minimize applied vertical stresses from vehicles.
- Pervious concrete and porous asphalt materials require narrow aggregate grading to create open voids in their surfaces. Materials choice is therefore a balance between stiffness in the surface layer and permeability. PICP requires similar types of aggregate (without cement or asphalt) placed in the joints, typically ASTM No. 8, 89, or 9 stone depending on the paver joint widths. Refer to industry association literature for grading recommendations for all surfaces.
- Paving units for PICP should conform to the dimensional tolerances, compressive strengths and absorption requirements in ASTM C936. Paving units subject to vehicular traffic should be at least 3 1/8 in. thick and have a length to thickness ratio not exceeding 3.

DESIGN AND INSTALLATION

- All designs should be reviewed and approved by a licensed civil or geotechnical engineer or as directed by the municipality.
- Design for pervious concrete should be reviewed by the concrete manufacturer or National Ready Mixed Concrete Association (NRMCA) (www.nrmca.org), or as directed, the municipality. Consult Portland Cement Association publication, *Hydrologic Design of Pervious Concrete* (2007) available from www.cement.org.
- Design for porous asphalt should be reviewed by the asphalt manufacturer, the National Asphalt Pavement Association (NAPA) (www.porousasphalt.net), or as directed by the municipality. Consult NAPA publication, *Porous Asphalt for Stormwater Management* (2008) for additional information on design, construction, and maintenance.
- Design for PICP should be reviewed by the concrete paver manufacturer, the Interlocking Concrete Pavement Institute (ICPI) (www.icpi.org), or as directed by the municipality. Consult ICPI publication, *Permeable Interlocking Concrete Pavements* 4th Edition (2011) for additional information on design, construction and maintenance.
- Installation of pervious concrete, porous asphalt, permeable pavers and PICP should be done by contractors who have constructed projects similar in size to that under consideration.

  For pervious concrete, only contractors with certification from NRMCA should be considered, and such contractors should have at least one foreman with this certification on the job site at all times. More information can be found at www.concreteparking.org/pervious/index.html and www.bayareaperviousconcrete.com

- For PICP, it is recommended that only contractors holding a record of completion in the Interlocking Concrete Pavement Institute's PICP Installer Technician Course should be considered and such contractors should have at least one foreman with this certificate on the job site at all times. More information can be found at www.icpi.org.
- All new pervious concrete and porous asphalt pavements should have a minimum surface permeability of 100 in./hr when tested in accordance with ASTM C1701. PICP should have a minimum surface permeability of 100 in./hr when tested in accordance with ASTM C1781. Test results using both methods are comparable.
- Protect excavated area from excessive compaction due to construction traffic and protect the finished pavement from construction traffic.
- Additional design resources can be found on: www.dot.ca.gov/hq/oppd/stormwtr/pervious.htm.

Maintenance Considerations:

- See Chapter 8 for specific maintenance guidance.
- A Maintenance Agreement should be provided for regulated projects with installations of 3,000 square feet or more of pervious pavement.
- The Maintenance Agreement should state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with the Maintenance Agreement. Maintenance plan templates are in Appendix G.

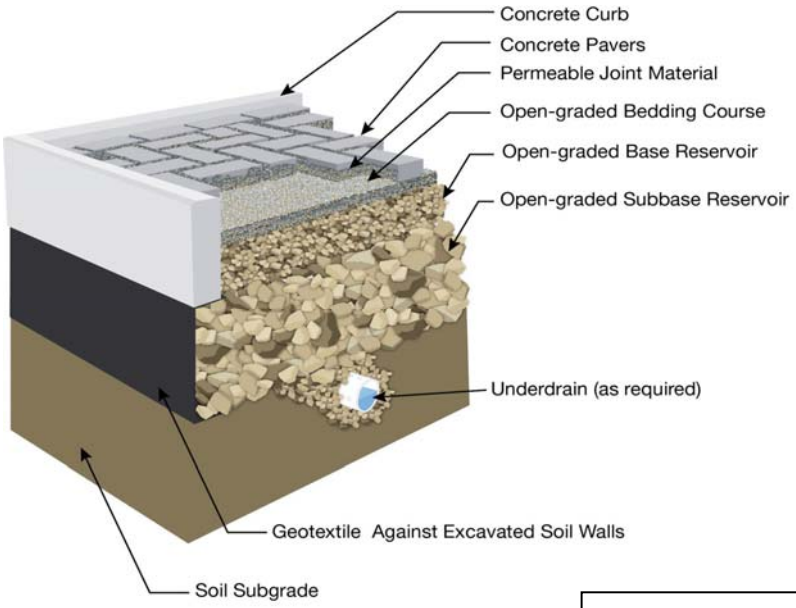
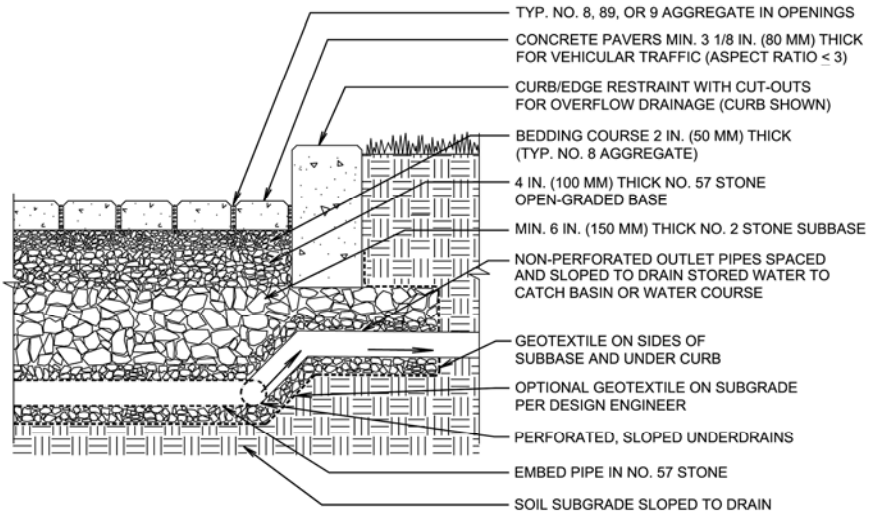


Figure 6-27. PICP designed for partial infiltration, with underdrain.
(Source: Interlocking Concrete Pavement Institute)



NOTES:
1. 2 3/8 IN. (60 MM) THICK PAVERS MAY BE USED IN PEDESTRIAN AND RESIDENTIAL APPLICATIONS.
2. NO. 2 STONE SUBBASE THICKNESS VARIES WITH DESIGN. CONSULT ICPI PERMEABLE INTERLOCKING CONCRETE PAVEMENT MANUAL.
3. NO. 2 STONE MAY BE SUBSTITUTED WITH NO.3 OR NO.4 STONE.

Figure 6-28. PICP with detail of underdrain in aggregate trench with upturned elbow.
(Source: ICPI)

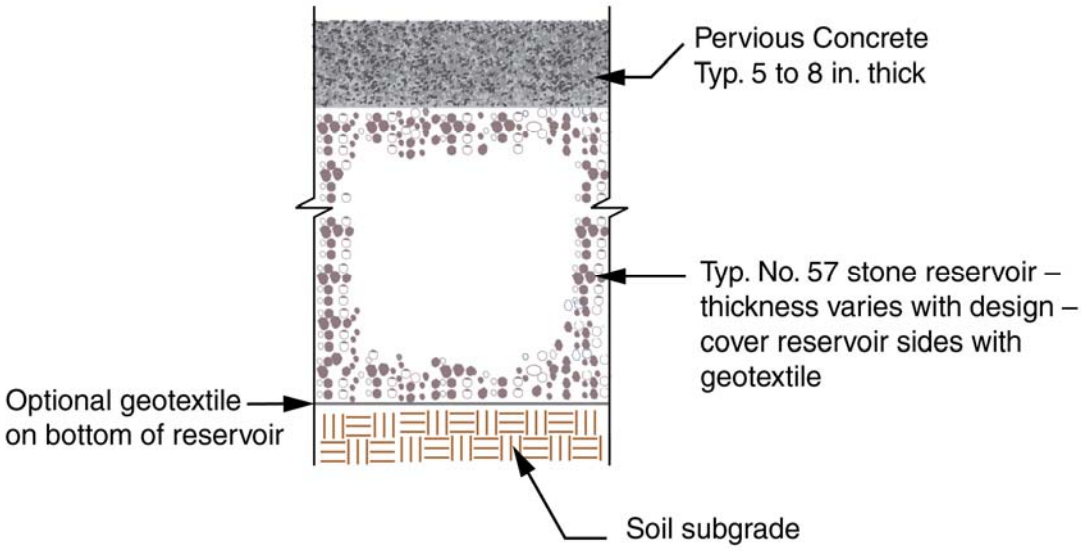


Figure 6-29. Typical Pervious Concrete Pavement (Source: ICPI)

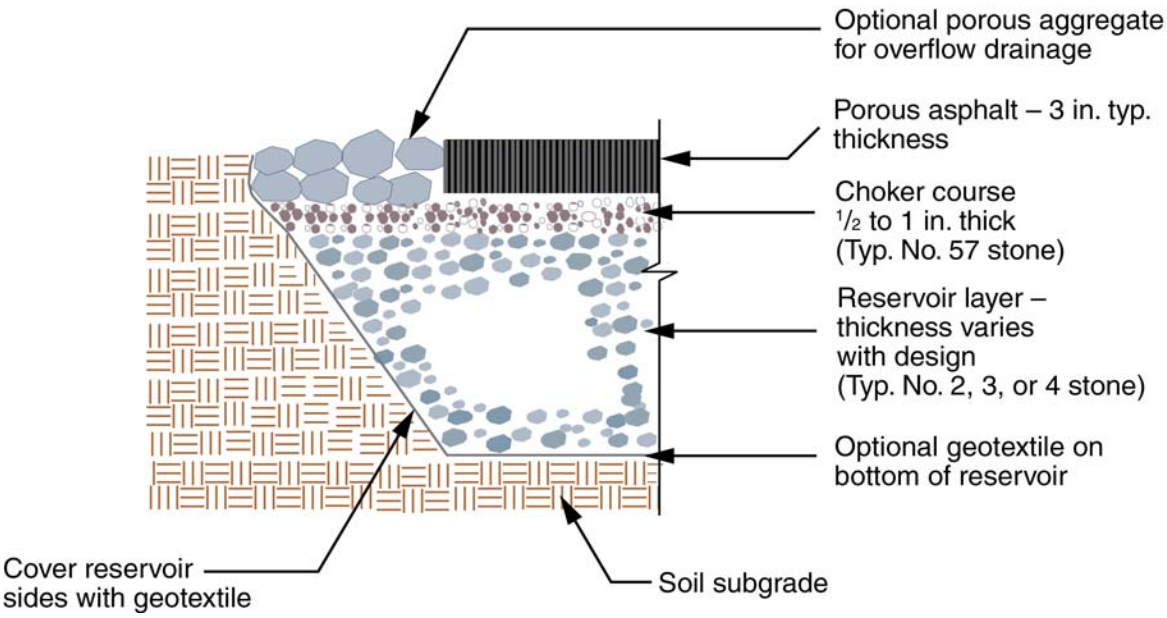


Figure 6-30. Typical Porous Asphalt Pavement Section

Note: ASTM No. 3 or 4 stone may be substituted for No. 2 stone. (Source: ICPI)

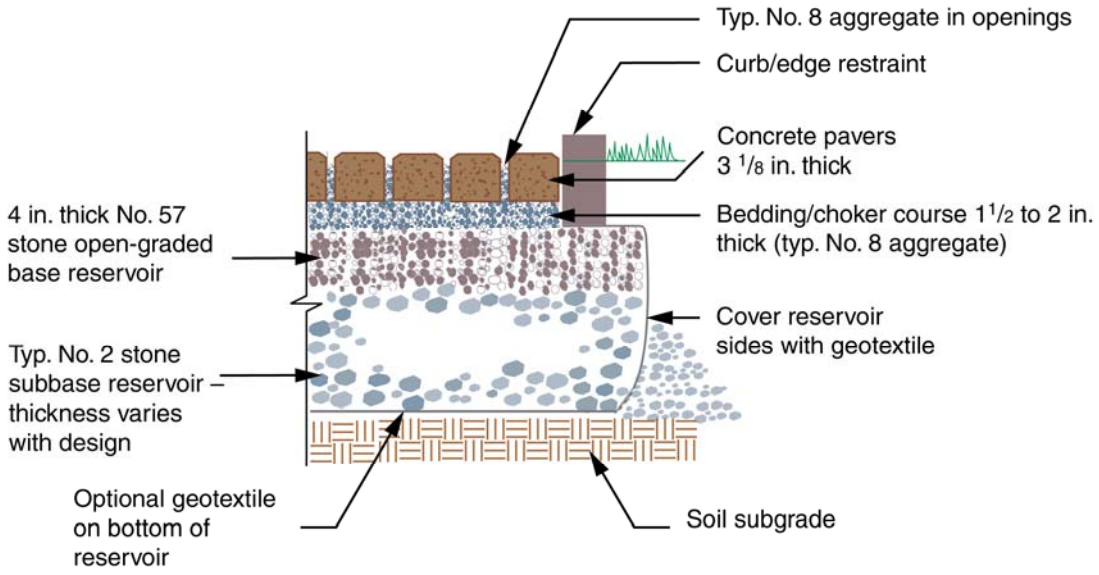


Figure 6-31. Typical Permeable Interlocking Concrete Pavement Section (Source: ICPI)

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