FLEXIBLE PAVEMENTS OF OHIO

An association for the development, improvement and advancement of quality asphalt pavement construction.

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Technical Bulletin: **Porous Asphalt Pavement,** (Rev. 09June2016)

Introduction

Porous asphalt pavements are being used to reduce or eliminate storm water runoff from parking lots and other such facilities. A porous asphalt pavement is constructed over a stone-filled reservoir to collect and store storm water and to allow it to infiltrate into the soil between rainfalls. Where low soil permeability is not conducive to infiltration, a similar design can be used as a detention facility or an exfiltration solution that filters pollutants from the first flush and improves the water quality of the runoff. These designs can reduce pollution and replace expensive detention and treatment facilities. Porous pavement systems are rapidly gaining favor with designers and regulators as an economical approach to storm water management for sustainable or low-impact development. As the NPDES permit requirements have become more widely applicable, it has become necessary that developers find more innovative means of compliance. Porous pavement systems are commonly being used as part of a strategy to obtain Leadership for Energy and Environmental Design (LEED®) certification for green building projects. Another benefit of porous pavement for parking lots is the absence of ponded water on the pavement during and after rainfall. Patrons never have to step in a puddle again!

While detention basins are often used to collect and slow the rate of runoff from the impermeable surfaces of roofs and pavements and are effective, they require additional land. Especially on re-development sites, additional land may not be available or may be prohibitively expensive. The porous pavement/recharge bed design may be the solution to the problem.

Figure 1: Parking Facility of the Mansfield Art Center, Richland County, Ohio

The “Porous Pavement” concept was conceived in the Franklin Institute Research Laboratories in 1968 and was developed there under a grant from the U.S. Environmental Protection Agency during 1970 and 1971. After the final report on the project was issued, interest in the concept prompted Edmund Thelen and Leslie Fielding Howe to prepare a book about its development that included a design guide. The publication, *Porous Pavement,* was published by the Franklin Institute Press in 1978. The book is out of print; but, is still available in some technical libraries and on-line (2). The Ohio Department of Natural Resources has developed a comprehensive guide for the use of porous asphalt pavement. It is contained in the ODNR, *Rainwater and Land Development Manual*

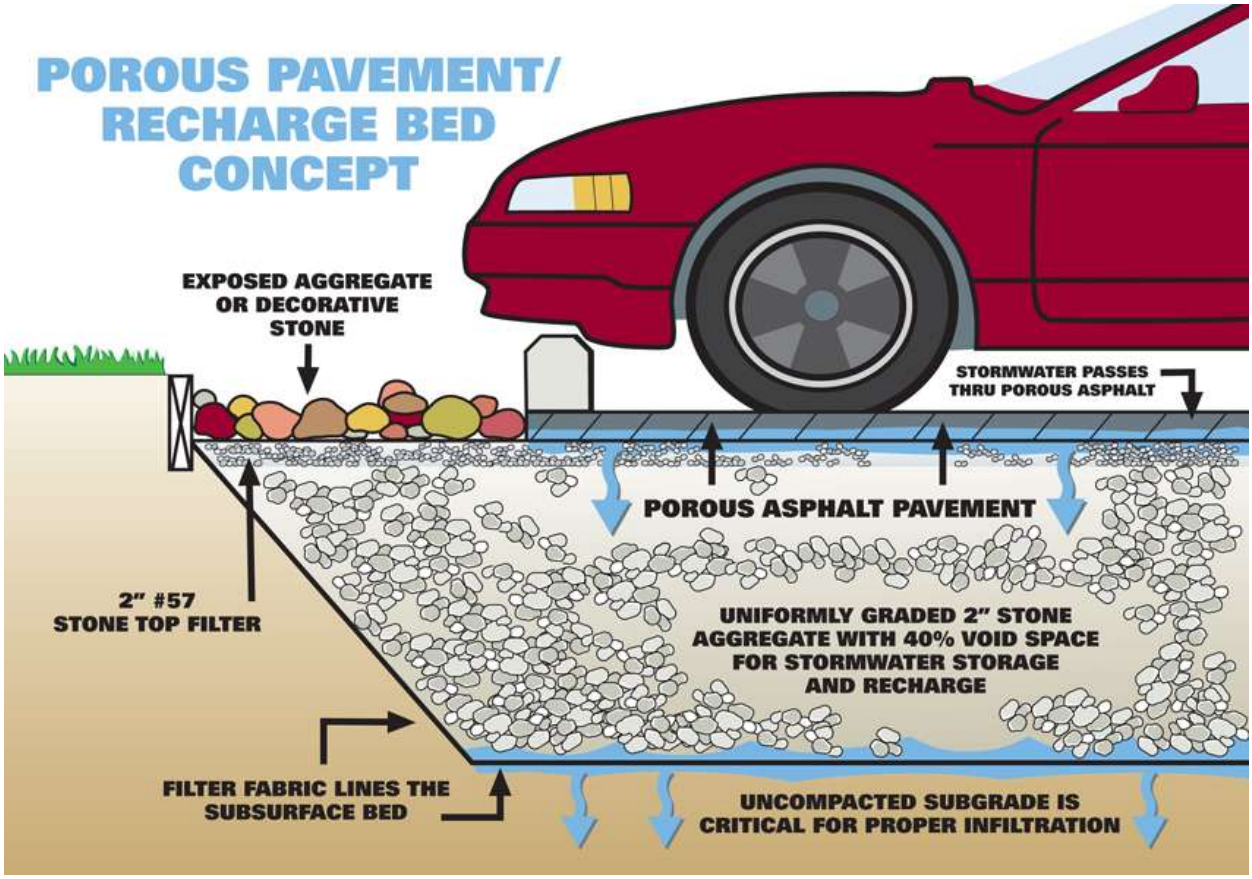
(4) and is recommended for its guidance on hydrologic design, construction and maintenance.

Design Considerations:

In considering a porous pavement recharge bed, designers must consider some key factors: soil percolation characteristics, local topography and climate, the proposed uses of the site, the traffic-loading factor, storm water regulations, site runoff and storm water quality requirements. Frost penetration depth is also a factor in determining reservoir course thickness.

The soils investigation will include a reconnaissance to determine the soil types on the site and standard percolation test(s) to determine the average permeability of the site.

A typical porous asphalt pavement recharge bed design consists of one or more porous asphalt courses, a top filter/stabilizing course, a reservoir course, filter fabric and existing soil or subgrade material. In the case of a detention or exfiltration design, this typical may be modified by the inclusion of outlet or underdrain pipes as may be appropriate.



Stone-Filled Reservoir Recommendations

The reservoir for a porous pavement storm water management facility is constructed by first excavating into undisturbed and uncompacted soil to the depth needed to contain the design storm volume. To ensure year-round operation, the bottom of the reservoir should be below 0.65 of the normal frost depth. The reservoir is lined with a geotextile fabric (Recommendtion: geotextile material meeting ODOT specification 712.09, Type B). The reservoir is then filled with No. 2 (1½ to 2½ inch) size stone and topped with a top filter/stabilizing course consisting of an approximately 2-inch thick layer of No. 57 (½ to 1-inch) size stone to stabilize and provide a paving surface for the asphalt concrete layers. Too

thick of a top filter/stabilizing layer is detrimental and may distort under hauling and paving equipment. All aggregate must be 100 percent fractured material, and having quality meeting ODOT specification 703.04.

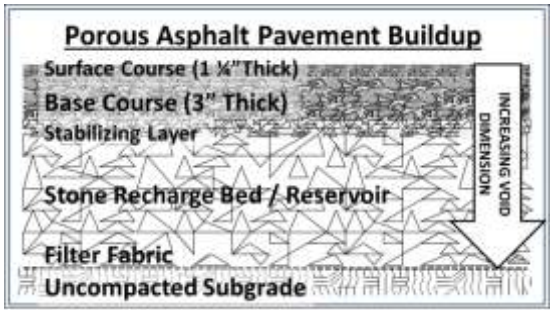
Permeability Considerations

How permeable is the porous asphalt pavement (Open-Graded HMA)? Various values have been reported in the literature. All are so high relative to the percolation values of the soil as to not present any limitation and are typically not considered in design. A permeability of 6000 ft/day is attributed to Lovering and Cedergren (1). Thelen and Howe report an asphalt permeability of 176 in/hr. (352 ft/day) (2). Roseen is quoted as saying that, "if 99% clogging were to occur, the infiltration rate would still be greater than 10 inches per hour, which is greater than most sand and soil mediums." (6) In any case, these values are orders of magnitude higher than the best soil permeability of about 6 inches per hour. Figure 2 gives a visual indication of the porosity of a porous asphalt pavement surface course.

Figure 2: Permeability demonstrated

Asphalt Pavement Thickness and Material Recommendations

For light-duty pavements, intended primarily for cars, 3 inches of porous asphalt surface course is the minimum. FPO suggests using a total of 4-1/4 inches of porous asphalt placed in 2 courses; a 3-inch base course and a 1-1/4 inch surface course. For the base course, use materials and methods meeting the requirements of FPO specification *Porous Asphalt Pavement Base Course*, dated June 9, 2016 or later. For the surface, use FPO specification *Porous Asphalt Pavement Surface Course* of the same date. These specifications can be downloaded from flexiblepavements.org on the “Sustainable Pavement” page. For pavements that will need to support heavier loads, FPO recommends using a structural thickness of asphalt concrete based on an accepted pavement design protocol. The same porous asphalt materials can be used to make up the required structural thickness.



Cost

The cost of the porous surface material over conventional Type-1 material is estimated to be approximately 40% more. The porous base is approximately 30% more compared to a normal Type-2 material.

Construction

Construction methods for the excavation and placement of the stone filled reservoir are detailed in the ODNR manual (4). Construction methods for the asphalt layers are called out in the FPO sample specifications. In general, construction equipment and methods used in placing porous asphalt pavement are the same as for conventional asphalt concrete construction with a couple of special considerations. As a result, users can expect the same levels of smoothness, speed of construction and use as with conventional asphalt pavement materials. The differences are that porous asphalt materials are not compacted to achieve maximum density and must be protected from contamination that would tend to plug the pores in the materials. Rolling is done using a minimum of two (2) passes of a static tandem steel wheel roller having a minimum weight of 8 tons to smooth the

surface and to seat the stones in the mix so that it doesn't consolidate under traffic nor ravel. The finished pavement must have 16 to 22 percent air void content (80 to 84 percent density) and an observed average surface infiltraton rate of of 100 inches per hour. Surface infiltration rate is checked using a simple infiltratation test (SIT) described in the FPO Porous Asphalt Surface Course specification.

Porous asphalt materials will cool more rapidly than conventional asphalt mixes, making it necessary for close monitoring that compaction is completed while the mix is within the compaction temperature range that facilitates compaction, typically when the binder viscosity is within 1,400 ± 200 centistokes. FPO recommended specifications require that an approved Field Quality Control Supervisor, having the porous asphalt endorsement, be on site and in control of the placement of the porous asphalt concrete.

Care must be exercised in the scheduling of construction to protect the porous pavement from contamination that might tend to clog the pores of the system. It is best to build the porous pavement last, after grading and erosion control measures are complete.

Maintenance

Porous asphalt pavements are generally maintained like conventional asphalt pavements, with a few exceptions. Sometimes cleaning is needed to remove contamination that will plug the pavement and reduce its porosity. Methods may include blowing, vacuuming or sweeping with a vacuum-type street sweeper. Surface sealants should not be used as they would tend to plug the pores in the asphalt. For snow and ice control, the owner should avoid placing abrasives or grits that would tend to plug the pores of the pavement. Otherwise, snow and ice control is similar to that for conventional asphalt pavement. Patching can be done with readily available materials without seriously impacting the operation of the porous asphalt pavement.

The owner will need to educate maintenance and grounds keeping staff on these differences, as the porous pavement will not look substantially different from conventional pavement. Posting of an informational sign (such as the example below) at the facility will help inform both customers and employees of the special features of the porous pavement.

Photo 1: Eastlake Metropark, Trumbull County, OH

All reasonable care has been taken in preparation of this Bulletin. However, Flexible Pavements of Ohio can accept no responsibility for the consequence of any inaccuracy that it may contain.

References: For more detailed information on design, construction and maintenance of porous asphalt pavements consult the following references:

(1) *Structural Section Drainage, Proceedings, International Conference on the Structural Design of Asphalt Pavement*s, 1962 in the NAPA publication, *Asphalt Treated Permeable Material – Its Evolution and Application*, QIP 117, Raymond Forsyth.

(2) *Porous Pavement*, Franklin Institute, 1978, (ISBN Number 0-89168-010-1) http://www.hotmix.org/images/stories/porous_pavement-thelan.pdf
(3) *Porous Asphalt Pavements*, NAPA, Information Series 131, 2003
(4) *Rainwater and Land Development Manual,* Chapter 2, Section 2.11, Pervious Pavement, Ohio DNR, 2012, http://water.ohiodnr.gov/water-use-planning/stormwater-management#RAI
(5) *UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds (Rev. 10/09)* http://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/unhsc_pa_spec_10_09.pdf

View the many other linked documents, case studies and resources at http://www.flexiblepavements.org/sustainability/porous-asphalt/porous-asphalt which includes charts outlining possible LEED credits.

Porous Asphalt Pavement FAQs

Q: What is the life cycle of a porous pavement? (This would apply to both permeability life and structural life.)

A: There are case studies of several examples of porous pavement installations that are still functioning well after 15 or 20 years. Dr. Robert Roseen, director of the University of New Hampshire Stormwater Center (UNHSC), has written porous asphalt pavements, "will have a longer life cycle from reduced freeze-thaw susceptibility and greater load-bearing capacity than conventional parking lot pavements." (See the article in "Stormwater" magazine, September, 2008, http://www.unh.edu/unhsc/publications and http://foresternetwork.com/magazines/

If designed, constructed, and maintained appropriately, porous pavements should have life spans at least comparable to conventional asphalt pavements.

Q: What is the rehabilitation strategy for a porous asphalt pavement?

A: Rehabilitation of a deteriorated porous asphalt surface will normally entail removing the deteriorated asphalt layer or layers to the depth necessary and repaving with new porous asphalt mixtures. Surface treatments of any kind that would tend to seal the pores in the pavement should not be used.

Q: *How does porous asphalt stand up in a snow and ice climate? Or, perhaps better asked, how does snow and ice affect porous asphalt pavement?*

A: Thelen and Howe stated in their guide (2) that 'Cold weather does not damage porous pavement. Water could freeze in the aggregate, but the voids are relatively large and there is room for expansion without damage."

Studies performed at the UNHSWC show that porous asphalt pavement performs well during sub-freezing weather and that frozen media does not reduce performance. Even the frozen pavement and infiltration bed retained a high level of permeability. (Seasonal Performance Variations for Storm-Water Management Systems in Cold Climate Conditions, Robert M. Roseen, Ph.D., P.E., M.ASCE, et. al.) (http://www.unh.edu/unhsc/publications)

Structurally, porous asphalt pavement will be durable if the reservoir is provided with suitable drainage to prevent the asphalt layers from remaining flooded during freezing weather.

Q: What type of maintenance needs to be done on porous asphalt pavements?

A: Porous pavement must be inspected and cleaned regularly to maintain the hydrologic performance of the pavement system. Agencies have had success with blowers to remove debris such as pine needles and leaves, walk-behind type vacuums and vacuum-type street sweepers for cleaning porous asphalt pavements. Some

regulatory agencies may require the property owner to have a maintenance agreement approved by the local MS4.

Typical maintenance requirements:

- Avoid clogging with construction sediments- During construction & long term
- Clean pavement to ensure pavement is free of debris and sediments -As needed (at least twice a year)
- Check to see that pavement dewaters during large storms and does not pond into surface (check observation well for appropriate water levels) -After large storms
- Inspect upland and adjacent vegetated areas. Seed and straw bare areas. -As needed
- Inspect pavement surface for structural integrity and areas in need of repair. Repair as needed. -Annually
- Snow and Ice Removal. No sand or cinders should be used on porous pavements. Instead, winter maintenance should focus on timely snow plowing and judicious use of deicing materials.- As needed, see the UNHSC publication: **Winter Maintenance Guidelines for Porous Pavements** at http://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/winter_maintenance_fact_sheet.pdf
- Avoid sealing or repaving with non-porous materials -Long-term. Areas may be repaired using the same treatment as the original permeable pavement application or, small areas (not the lowest area on a sloping section) can be replaced with standard (impermeable) pavement. In that case the stone bed of the entire pavement will continue to provide storage and infiltration as designed. Surface treatments of any kind that would tend to seal the pores in the pavement should not be used.

Q: *Is maintenance of a porous asphalt pavement any more costly than that of conventional pavement?*

A: A definitive answer is undetermined and may only be answerable on a case by case basis. As noted elsewhere in this document, porous asphalt pavements will require periodic inspection and cleaning that, depending on the location and use, conventional pavements may not require. However, these extra costs, if any, may be offset by reduced snow and ice control costs and decreased storm drainage maintenance. And, of course, the true total costs need to be compared not to just alternative pavements; but, to the total costs associated with alternative storm water management practices as well.

Q. *Does the petroleum leach out of the porous pavement?*

A. No. Study after study has shown no tendency for the petroleum asphalt to leach out of asphalt pavement. See the report of the study by Brantley and Townsend at http://www.hinkleycenter.com/images/stories/publications/townsend_98-2.pdf

Q. *What effect does clogging have on the functionality of the porous asphalt surface?*

A. The porous asphalt is many times more permeable than any soil it may be constructed over. As a result, the functionality of the system is not compromised by less than total clogging of the surface. Dr. Roseen is quoted as saying that, "if 99% clogging were to occur, the infiltration rate would still be greater than 10 inches per hour, which is greater than most sand and soil mediums."

Q. *What is the cost of a porous asphalt pavement facility?*

A. Special features such as the underlying stone bed are more expensive than conventional construction, but these costs are more than offset by the elimination of many elements of standard storm-water management systems. On those jobs where unit costs have been compared, a porous asphalt pavement is generally the less-expensive option. The cost advantage is even more dramatic when the value of land that might have been used for a detention basin or other storm-water management features is considered.

Q. *Is an approved or certified applicator required to place a porous asphalt pavement?*

A. Yes. FPO recommended specifications require that an approved Field Quality Control Supervisor, having the porous asphalt endorsement, be on site and in control of the placement of the porous asphalt concrete to ensure proper quality control and placement. While porous asphalt does not necessitate proprietary ingredients nor require the contractor to have special paving equipment or skills, proper placement does require knowledge of the different construction requirements. With the proper information, most asphalt plants can easily prepare the mix and general paving contractors can install it.