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- Current Issue
- Subscribe
- News
- Calendar
- Glossary
- Talk
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- Register
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The Journal for Surface Water Quality Professionals

# Stormwater

## FEATURES



## What I Learned in Paver School

*The role of permeable paver systems as a stormwater management technique*

**By Michelle DeLaria**

Several low-impact development (LID) techniques are used to mimic predevelopment hydrology and reduce the negative effects of urbanization on waterways. While vegetative LID techniques such as grass swales, buffers, green roofs, and porous landscape detention areas are attractive, they have limited use and effectiveness in significantly reducing runoff volume in existing, highly impervious environments. Permeable pavers and porous pavement are techniques that can substantively reduce stormwater runoff volume *and* provide detention capacity in highly urbanized areas. Many successful installations of these materials exist around the world, yet comments and concerns about cost, cold-climate function, maintenance, and plowing linger.

Communities in the United States are increasingly regulated for the effects of excess urban runoff and are collecting millions of dollars in fees annually to manage hundreds of millions of dollars in backlogged waterway stabilization and water-quality needs. It is time to address these issues and construct our communities in a manner that produces a more functional, sustainable urban environment.

In September, I attended a one-day training class at the School for Advanced Segmental Paving in Franksville, WI, taught by instructors from the Chicago area.

The school is modeled after the European apprenticeship method; students

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learn in a classroom setting and further develop skills in an onsite installation practice area. The school was established by several leaders in the segmental paver industry who are dedicated to establishing standard methods and practices in this field. The school also offers three- and four-day classes that are tailored to the level of involvement and skills desired in paver systems. For example, there are classes to learn paver installation in variable field conditions as well as classes geared for estimators and sales people. The class that I attended included the history of paver systems, applications, benefits, and a demonstration in the practice area.

While the words *permeable*, *porous*, and *pervious* are often interchanged, in this article they are used as follows: *Permeable* refers to water moving through openings between pavers and aggregate. *Porous* refers to the material allowing water to move through it, as is the case with porous concrete and asphalt that has voids in the material because the fines are removed. *Pervious* refers to the ability of the surface of the material to accept water.

The first thing I learned is that permeable paver installations with an open-graded aggregate system are based on Roman road construction techniques from 2,000 years ago. Romans would excavate a trench and fill it with a layer of large rock on the bottom, then smaller rock, followed by a setting bed. They would then fit large stones on top of the aggregate layers for the travel surface or a "wearing course." Some sections of Roman roads are still used today with a new asphalt wearing course, although many other sections have been preserved as historical remnants throughout Europe. Roman road construction is the basis of current road construction, but instead of pavers, asphalt or concrete is used as the wearing course.



### **Pavers with Open-Graded Aggregate**

The open-graded aggregate system consists of aggregate layers placed and compacted to provide a stable surface for heavy vehicles and point loads. Pavers with the full 18-inch open-graded aggregate system also provide detention capacity. The layers from bottom to top are as follows:

- Twelve inches of 1.5-inch all-fracture-face aggregate. This is called #4 aggregate and is compacted in 4- to 6-inch lifts. Railroad ballast, which is also called #2 aggregate, may also be used for the sub-base.
- Four inches of 0.75-inch all-fracture-face aggregate. This is called #67 aggregate and is also called a choker course, because this size rock on top of 1.5-inch aggregate chokes off the top of the larger aggregate and still allows water to flow downward into the void space of the 1.5-inch aggregate. The smaller rock does not sift into the voids. This layer is also compacted. If #2 aggregate is used as the sub-base, #57, which is 1-inch rock, should be placed on top of the sub-base.
- Two inches of three-eighths-inch granite "chip" material. This is placed on top of the base course and forms the setting bed. It is important that this material be all fracture face and not rounded "pea gravel." The setting bed is not compacted.
- Pavers are placed on top of the setting bed by hand or machine. The joints between the blocks are filled with 0.25-inch material, and a compactor is run over the pavers to vibrate and "lock in" the pavers.

Fabric or other means of separating the aggregate layers is not used in this system. Current research indicates that separating aggregate layers in infiltration systems introduces a clogging layer and causes more rapid degradation of the system. Depending on the subsoil, a geogrid may be used between the soil and the base-course aggregate to increase stability.

Permeable pavers with the open-graded aggregate system have been installed

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Photo: Michelle DeLaria

The sub-base and base-course layers

over several million square feet in the Chicago area over the past 20 years. I visited several paver sites in various stages of completion with Chuck Taylor from Advanced Pavement Technology.

Taylor is an instructor at the paver school, and his company installs paver

systems in the Midwest. One site was a private road under construction in a large-lot subdivision. The road, if built using traditional methods, would have been the majority of impervious area and the greatest source of runoff.

Because the road was constructed with permeable pavers, including built-in detention provided by the aggregate layers below, a detention pond and conveyance infrastructure that is typically required to handle road runoff was not needed.



A college in the Chicago area installed permeable pavers on an 8% slope and combined the paver installation with curb cuts into sumped landscape areas.

Block pavers can be plowed and are less prone to black ice and other surface freeze/thaw problems. In addition to the void space of the open-graded aggregate system, there is more air moving through the system to keep the surface free of ice and snow as compared to impervious surfaces.



Photo: Michelle DeLaria

A level setting bed is placed using a screed board and rails.

### Cost-Benefit Analysis

The cost-benefit analysis is variable. For example, at an installation in Florida, permeable paver systems broke even after 22 years when the materials, construction, and maintenance costs were compared to concrete and asphalt surfaces. On another site in the Chicago area, after 50 years an asphalt surface would have cost 10 times as much as pavers to maintain. Additionally, comparing costs of materials and installation is not a complete and perhaps not an appropriate evaluation. In the Denver area, for example, a concrete



parking lot would cost approximately 50% more than asphalt, and a permeable paver system with the full open-graded aggregate system would cost two to three times as much as asphalt. Based on initial investment, asphalt or concrete appear to be more cost-effective than pavers. However, the cost of asphalt or concrete does not include the cost of inefficient use of land and the associated cost if a detention structure is required. Also not included are costs associated with managing offsite impacts that are generated, such as excess stormwater runoff rate and volume, pollutants washing off of impervious area into receiving waters, and future waterway stabilization needs. Pavers may have a larger initial investment, but the cost of detention is included and offsite impacts are reduced.



Photo: Advanced Pavement Technologies

and porous asphalt systems provide infiltration and can be designed for

Photo: Michelle DeLaria

One-quarter-inch aggregate is swept into paver joints.

Pavers can be plowed

detention capacity, there is a difference that may be important to some property owners. The systems have similar maintenance needs, such as using a sweeper or vacuum truck to remove surface grit, which is recommended to be done annually. However, it is possible that the subsurface may accumulate enough solid material to lose infiltration and detention capacity and that the capacity cannot be regenerated by a power vacuum. In this case, porous asphalt or concrete needs to be removed and discarded. However, paver systems are completely modular. The systems can be deconstructed, the aggregate layers cleaned, and all the products reinstalled with minimal waste. The waste-reduction potential in a paver system may be preferable.

### Summary

From a stormwater management perspective, porous asphalt, porous concrete, and permeable pavers—all with the open-graded aggregate system—are techniques that can restore permeability and infiltration and provide large storm detention in a highly urban environment. Parking lots, alleyways, driveways, fire lanes, and parking lanes on streets are common examples of impervious

flatscape areas that can instead be porous or permeable to reduce runoff. Communities can retrofit these areas to help retain the economic benefits of developed land while reducing offsite impacts.

We know how much money communities collect in stormwater fees to fund drainageway stabilization projects and water-quality programs that are the direct result of increased stormwater runoff. We know that infiltration best management practices are the only techniques that reduce stormwater runoff volume in the built environment. We know that total maximum daily loads are expensive and cumbersome to correct with our existing drainage-based land development design and infrastructure. We even know of communities that are adopting LID standards and retrofitting their urban environments to protect receiving waterways.

Perhaps instead of discussing the expenses and maintenance of runoff reduction and infiltration best management practices, we should examine the costs and ramifications of not using these techniques.

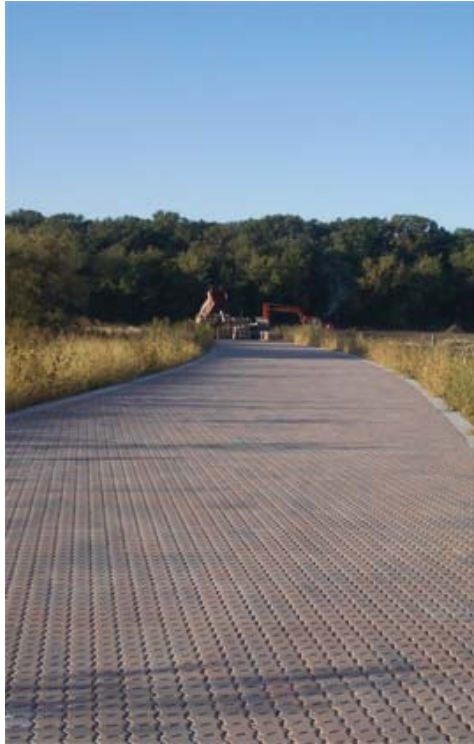


Photo: Michelle DeLaria

A private road near Chicago with detention provided in the aggregate layers underneath the pavers

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**Return To  
Table of  
Contents**

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