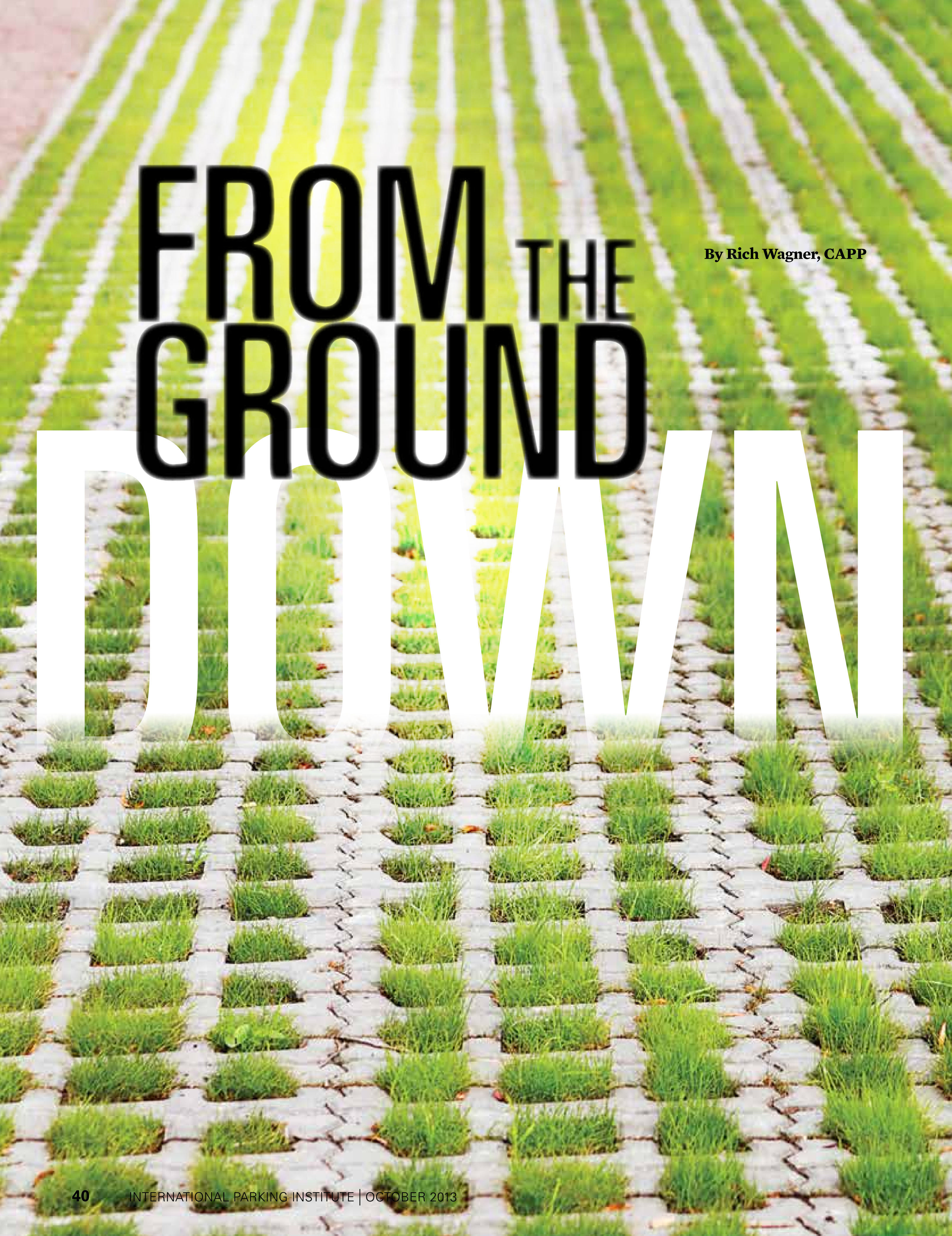
FROM THE GROUND DOWN

By Rich Wagner, CAPP



As stormwater runoff becomes a major concern, a range of permeable pavements offers an attractive alternative to standard solutions.

Permeable paving includes a range of sustainable materials and techniques for using pavements with a base and sub-base that allow stormwater to move through the surface. In addition to reducing runoff, this structure effectively traps suspended solids and filters pollutants from the water.

Although some porous paving materials appear nearly indistinguishable from nonporous materials, their environmental effects are qualitatively different. Whether pervious concrete, porous asphalt, paving stones, concrete, or plastic-based pavers, all pervious materials allow stormwater to percolate and infiltrate the surface areas. The goal is to control stormwater at the source, reduce runoff, and improve water quality by filtering pollutants in the substrata layers.

Permeable solutions can be based on porous asphalt and concrete surfaces, concrete pavers (permeable interlocking concrete paving systems, or PICP), or polymer-based grass pavers, grids, and geocells. Porous pavements and the voids between concrete pavers allow water to drain through a stone base layer. Polymer-based grass grid or cellular paver systems offer load-bearing reinforcement for unpaved surfaces of gravel or turf.

Grass pavers, plastic turf reinforcing grids (PTRG), and geocells (cellular confinement systems) are honeycombed 3D grid-cellular systems made of thin-walled high-density polyethylene (HDPE) plastic or other polymer alloys. These provide grass reinforcement, ground stabilization, and gravel retention. The 3D structure reinforces infill and transfers vertical loads from the surface, distributing them over a wider area. Selection of the type of cellular grid depends to an extent on the surface material, traffic, and loads. The grids are installed on a prepared base layer of open-graded stone (higher void spacing) or engineered stone (stronger). The surface layer may be compacted gravel or topsoil seeded with grass and fertilizer. In addition to load support, the cellular grid reduces compaction of the soil to maintain permeability, while the root channels improve it.

Porous pavements protect watersheds in new suburban development. In existing neighborhoods and towns, redevelopment and reconstruction are opportunities to implement stormwater water management practices. Permeable paving is an important component in low-impact development (LID), which is a process for land development that attempts to minimize effects on water quality.

The infiltration capacity of native soil is a key design consideration for determining the depth of base rock for stormwater storage or for whether an underdrain system is needed.

Advantages of Permeable Pavement

- **Managing runoff.** Large volumes of urban runoff cause serious erosion and siltation in surface water bodies.
- **Controlling pollutants.** Permeable paving surfaces keep pollutants in place in the soil or other material underlying the roadway, and allow water seepage to groundwater recharge while preventing stream erosion problems. They capture heavy metals and prevent them from washing downstream. In void spaces, naturally-occurring microorganisms digest car oils, leaving little behind but carbon dioxide and water. Rainwater infiltration is usually less than that of an impervious pavement with a separate stormwater management facility somewhere downstream.
- **Trees.** Permeable pavements may give urban trees the rooting space they need to grow to full size. A structural soil pavement base combines structural aggregate with soil, offering a porous surface that admits vital air and water to the rooting zone. This integrates healthy ecology and thriving cities with the tree canopy above, the city's traffic on the ground, and living roots below. The benefits of permeable pavement on urban tree

growth have not been conclusively demonstrated and many researchers have observed tree growth is not increased if construction practices compact materials before permeable pavements are installed.

Challenges of Permeable Pavement

- **Runoff volumes.** Permeable pavements are designed to replace effective impervious areas (EIAs), not manage stormwater from other impervious surfaces on-site. Use of this technique must be part of an overall on-site management system for stormwater and is not a replacement for other techniques. In a large storm event, the water table beneath porous pavement can rise, blocking the precipitation from being absorbed into the ground. The best way to prevent this problem is to allow for adequate rainwater runoff at the pavement design stage.
- **Pollutant load.** Highly-contaminated runoff can be generated by some land uses in which pollutant concentrations exceed those typically found in stormwater. These "hot spots" include commercial nurseries, recycling facilities, fueling stations, industrial storage facilities, marinas, some outdoor loading facilities, public works yards, hazardous materials generators (if containers are exposed to rainfall), vehicle service and maintenance areas, and vehicle and equipment washing and steam cleaning facilities. Due to the potential for groundwater contamination, porous pavement should not be applied at stormwater hot spots. All contaminated runoff should be prevented from entering municipal storm drain systems by using best management practices for the specific industry or activity.
- **Weight and traffic volumes.** Reference sources differ on whether low or medium traffic volumes and weights are appropriate for porous pavements. For example, near truck loading docks and areas of high commercial traffic, porous pavement is sometimes cited as being inappropriate. However, given the variability of products available, the growing number of existing installations in North America, and targeted research by both manufacturers and user agencies, the range of accepted applications seems to be expanding. Some concrete paver companies have developed products specifically for industrial applications. Working examples exist at fire halls and busy retail complex parking lots, and on public and private roads, including intersections in parts of North America with severe winter conditions.

Challenges and Considerations

Siting is an important consideration when considering permeable pavement installation. Permeable pavements may not be appropriate when land surrounding or draining into the pavement exceeds a 20 percent slope, where pavement is down-slope from buildings, or where foundations have piped drainage at their footers. The key is to ensure that drainage from other parts of a site is intercepted and dealt with separately rather than being directed onto permeable surfaces.

Cold climates, too, may present special challenges. Road salt contains chlorides that could migrate through the porous pavement into groundwater. Snow plow blades could catch block edges and damage surfaces. Sand cannot be used for snow and ice control on pervious asphalt or concrete because it will plug the pores and reduce permeability. Infiltrating runoff may freeze below the pavement, and cause frost heave, though design modifications can reduce this risk.

These potential problems do not mean that porous pavement cannot be used in cold climates; in fact, porous pavement designed to reduce frost heave has been used successfully in Norway. Furthermore, experience suggests that rapid drainage below porous surfaces increases the rate of snow melt above.

Cost

It's true that some estimates put the cost of permeable paving at two to three times that of conventional asphalt paving. Using permeable paving, however, can reduce the cost of providing larger or more stormwater best management practices onsite, and these savings should be factored into any cost analysis. Interesting to note is that the off-site environmental impact costs of failing to reduce on-site stormwater volumes and pollution have historically been ignored or assigned to other groups (local government parks, public works and environmental restoration budgets, fisheries losses, etc.). Many cities across the country are studying the use of pervious concrete quite closely and finding that new stormwater regulations are making it a viable alternative to stormwater ponds.

Longevity and Maintenance

Some permeable pavements require frequent maintenance because grit or gravel can block their open pores. This is commonly done by industrial vacuums that suck up all the sediment. If maintenance is not carried out on a regular basis, the porous pavements can begin to function as impervious surfaces. Thanks to more advanced paving systems, required maintenance can be greatly decreased. Elastomerically-bound glass pavement requires less maintenance than regular concrete paving

Plastic grid systems are gaining popularity among local government maintenance personnel, owing to the fact that they reduce the need for gravel migration and weed suppression in public park settings.

Some permeable paving products are prone to damage from misuse, such as drivers who tear up patches of plastic and gravel grid systems on remote parking lots at night. The damage is not difficult to repair, but can look unsightly. Grass pavers require supplemental watering in the first year or they may need to be re-seeded. Regional climate also means that most grass applications go dormant during the dry season. While brown vegetation is only a matter of aesthetics, it can influence public support.

Traditional permeable concrete paving bricks tend to lose their color in relatively short time; this can be costly to replace or clean and is mainly due to the problem of efflorescence.

Efflorescence

Efflorescence is a hardened crystalline deposit of salts that migrate from the center of concrete or masonry pavers to the surface to form insoluble calcium carbonates that harden on the surface. Over time, these deposits form on parking lots in a way much like stalactites in caves. Efflorescence usually appears white, gray, or black depending on the region.

After awhile, efflorescence begins to negatively affect the overall appearance of masonry or concrete, and may cause the surfaces to become slippery when exposed to moisture. Left unchecked, this efflorescence will harden and their calcium/lime deposits will begin to erode the cement paste and aggregate. In some cases, it will also discolor stained or coated surfaces.

Efflorescence forms more quickly in areas that are exposed to excessive amounts of moisture such as near pool decks, spas, and fountains, or where irrigation runoff is present. As a result, these affected regions become very slick when wet. This can be of serious concern as a public safety issue to individuals, principals, and property owners, exposing them to possible injury and increased general liability claims.

Efflorescence remover chemicals can be used to remove calcium/lime buildup without damaging the integrity of the paving surface.

Pavement Considerations

Nine different families of porous paving materials each present distinctive advantages and disadvantages for specific applications:

- Pervious concrete is widely available, can bear frequent traffic, and is universally accessible. Pervious concrete quality depends on the installer's knowledge and experience.
- Plastic grids allow for a 100 percent porous system that uses structural grid systems to contain and stabilize either gravel or turf. These grids come in a variety of shapes and sizes for use on everything from pathways to commercial parking lots. These systems have been used in Europe for more than a decade, and are gaining popularity in North America due to environmental building requirements. The ideal design for this type of grid system is a closed cell system, which prevents gravel, sand, and turf from migrating laterally.
- Porous asphalt is mixed at conventional asphalt plants, but fine (small) aggregate is omitted from the mixture. The remaining large, single-sized aggregate particles leave open voids that give the material its porosity and permeability. Under the porous asphalt surface is a base course of further single-sized aggregate that acts as a reservoir where water can be allowed to evaporate and/or percolate slowly into the surrounding soils. Porous asphalt surfaces, called open-graded friction courses (OGFC), are used on highways to improve driving safety by removing water from the surface. OGFCs are not full-depth porous pavements, but offer a porous surface course, usually .75 to 1.5 inches thick, that allows for the lateral flow of water through the pavement, improving the friction characteristics of the road and reducing road spray.
- Single-sized aggregate without any binder (e.g. loose gravel or stone chipping) is another alternative. Although it can only be safely used in very low-speed, low-traffic settings such as parking lots, its potential cumulative area is great.
- Porous turf, when properly constructed, can be used for occasional parking such as that at churches and stadiums. Plastic turf reinforcing grids can be used to support increased load, and turf transpires water, actively counteracting the heat island effect with what appears to be a green open lawn.
- Permeable interlocking concrete pavements are concrete or stone units with open, permeable spaces between the units. They offer an architectural appearance and can bear both light and heavy traffic, excepting high-volume or high-speed roads. Some products are polymer-coated and have an entirely porous face.
- Permeable clay brick pavements are fired clay brick units that feature open, permeable spaces between the units. Clay pavers provide a durable surface that allows stormwater runoff to permeate through the joints.
- Resin-bound paving is a mixture of resin binder and aggregate. Clear resin is used to fully coat each aggregate particle before laying. Enough resin is used to allow each aggregate particle to adhere to the next and to the base, leaving voids for water. Resin-bound paving provides a strong and durable surface that is suitable for pedestrian and vehicular traffic in applications such as pathways, driveways, car parks, and access roads.
- Elastomerically bound recycled glass porous pavement consists of bonding processed post-consumer glass with a mixture of resins, pigments, and binding agents.

RICH WAGNER, CAPP, is general manager with Republic Parking System. He can be reached at rwagner@republicparking.com or 860.524.0505.