ROAD SCIENCE

by Tom Kuennen, Contributing Editor

Voids Add Value To Pervious Concrete

Pervious concrete pavements reduce stormwater pollutants and enhance motorist safety.

The quick-draining attributes of pervious or permeable portland cement concrete pavement — when combined with a correctly designed subbase or catchment area — are getting attention in America's Sunbelt and Pacific Coast communities.

Photos courtesy Tennessee Ready Mixed Concrete Association

This finished parking lot in Morristown, Tennessee shows the textural differences between conventional and pervious concrete pavements.

Pervious concrete pavements can reduce road spray and hydroplaning, while removing roadway pollution from latent oils, greases, and other pollutants from the stormwater stream. As such, they can help local government agencies meet EPA Phase II stormwater pollution requirements now in effect for smaller governments.

Used on lightly trafficked roads, pervious concrete pavements have the benefit of reducing tire spray and hydroplaning.

Pervious portland cement concrete is a zero-slump, no-fines, open-graded material consisting of portland cement, coarse aggregate, perhaps admixtures, and water. These materials produce a pavement with a void structure of 20 to 25%, readily allowing water to pass through.

In some regions, void contents of 30 to 35% have been attempted, but there is a relationship between void content and compressive strength. "Our experience has demonstrated that the 20 to 25% range drains water very rapidly and enables us to attain compressive strengths between 2000 and 2500 psi," said Alan Sparkman, executive director, Tennessee Ready Mixed Concrete Association. "That makes it more suitable for vehicle traffic, because we see its primary application in parking lots."

Other uses include sidewalks, recreation trails, plazas, and other paved areas.

A pervious concrete pavement is not unlike a cement-treated permeable base, also known as a coarse aggregate drainage layer stabilized with cement.

These bases enhance pavement drainage when

Pervious concrete is placed in a parking lot at a hospital in Morristown, Tennessee. January placement required blankets instead of plastic sheets to retain moisture and heat of hydration.

Pervious concrete is lightly compacted after placement using a static roller. The site is a Morristown, Tennessee hospital parking lot.

Pervious concrete pavement helps cities and counties meet ongoing Phase II federal stormwater regulations from EPA.

used in conjunction with a system of functioning edge drains and outfalls (see Road Science: *Making Edge Drains Work*, January 2003). In New York State, designs based on equivalent single axle loads require use of a 4-inch layer of cement- or asphalt-treated permeable base below a portland cement concrete pavement.

Pervious concrete pavements are not appropriate for full-scale use on high-volume roadways, but in low-volume applications, they improve road safety due to prompt drainage of rain and meltwater.

They also offer the possibility of the need for less curbing and storm sewers in the right configuration.

Passive water treatment

But their main attraction is passive water treatment by absorption of runoff into adjacent soils, where bacteria and other microbes decompose nonpoint surface pollutants before they can reach groundwater or surface waters like streams, ponds, lakes, or estuaries. In this process they also assist in recharge of groundwater aquifers.

In its publication *Urban Stormwater Best Management Practices [www.epa.gov/ost/stormwater/usw_c.pdf],* the U.S. Environmental Protection Agency defines a porous pavement system as a system whereby stormwater runoff is infiltrated into the ground through a permeable layer of pavement or other stabilized permeable surface.

These systems can include porous concrete or asphalt, modular perforated concrete block, cobble pavers with porous joints or gaps, or reinforced/stabilized turf.

And as the Georgia Concrete & Products Association points out, there is an added environmental benefit to the use of pervious concrete in urban sites. “Pervious concrete pavements do something that pervious or open-graded asphalt pavements can’t: cut down on stored and radiated heat in summer,” says Dan Brown, P.E., director of technical services, GC&PA.

As stormwater percolates into the ground,fine material is captured within the soil.

“Pervious [concrete] pavements are less able to absorb and store heat than conventional pavements,” Brown told *Better Roads* editors.

First, the lower density of the material (15 to 25% void spaces) reduces heat storage capacity, Brown says. Also, the lighter colors of some porous pavement systems reduce the heat absorbing capacity of the pavement. “The open void structure in the porous pavement allows cooler earth temperatures from below to cool the pavement. These factors allow porous pavement systems to approach natural ground cover in heat absorbing and storage capacity,” Brown says.

Urbanization the culprit

Urbanization has a major impact on the natural balance between stormwater runoff and the local ecosystem of wetlands, ponds, lakes, and streams, notes the Federal Highway Administration in its overview, *Stormwater Best Management Practices in*

Resources Available

Many resources are available to local government road agencies as they evaluate whether pervious concrete pavement will work for them:

- The Tennessee Ready Mixed Concrete Association has a PowerPoint slide show on pervious pavement. Access it from TRMCA’s PowerPoint archive at *www.trmca.org/resources/powerpoint.htm*.

A free PowerPoint Viewer download is available from Microsoft at *www.microsoft.com/office/ork/xp/appndx/appa13.htm* and is a must-have plug-in for your browser if you don’t already have the full PowerPoint program.

- The Federal Highway Administration has a complete online overview of urban stormwater drainage problems and solutions at *www.fhwa.dot.gov/environment/ultraurb/index.htm*.
- The Mississippi Concrete Industries Association examines pervious concrete along with other concrete themes in its resources section at *www.mississippiconcrete.com/concrete_products.cfm*.
- The Georgia Concrete & Products Association has a review of pervious concrete pavement at *www.gcpa.org/pervious_concrete_pavement.htm*.
- A very thorough model Specification for Portland Concrete Pervious Pavement may be found on the GCPA site at *www.gcpa.org/specification.htm*.
- Florida contractor Kara Construction, Stuart, Florida, has an informative, if promotional Web site. Visit it at *www.perviouspavement.com*.
- The Office of Infrastructure R&D, Turner-Fairbank Highway Research Center provides the useful FHWA Environmental Technology Brief: *Is Highway Runoff a Serious Problem?* (1999). Read it at *www.tfhrc.gov/hnr20/runoff/runoff.htm*.

ROAD SCIENCE

The higher costs of installation of porous pavements can be offset to some extent by the elimination of curbs, gutters, and storm drains.

Photos courtesy Tennessee Ready Mixed Concrete Association

Frank Lennox of Signal Mountain Cement Company, Chattanooga, demonstrates porosity of pervious concrete pavement in a presentation at Athens, Tennessee.

(Inset) The large pore volume of pervious concrete absorbs prodigious amounts of water.

an Ultra-Urban Setting: Selection and Monitoring.

"Land use changes from agricultural to urban (urbanization) result in the conversion of pervious spaces, such as vegetated and open forested areas, to increased areas of impervious surface, resulting in increased runoff volumes and pollutant loadings," the FHWA says. "Roads, parking lots, sidewalks, rooftops, and other impervious surfaces decrease the infiltrative capacity of the ground and result in changes."

Pervious concrete pavements can become a low-cost "infiltration" technique that uses the interaction of the chemical, physical, and biological processes between soils and water to filter out sediments and other soluble constituents from urban runoff. As the stormwater percolates into the ground, fine material suspended in the water is captured within the soil. The resulting treated runoff percolates through to the groundwater. "The soil layer and the microbes living in the soil enhance filtration, and the vegetation aids constituent removal," the FHWA says.

"Porous concrete is about 25% more expensive than regular concrete. Requirements for site preparation or the use of specialized equipment may also increase these costs. The use of modular paving stones can be up to four times as expensive as either regular asphalt or concrete. The higher costs of installation of porous pavements can be offset to some extent by the elimination of curbs, gutters, and storm drains. In some cases this may lower the overall cost for a project," the FHWA says.

Dealing with Phase II

"Pervious concrete pavement is a great product and it meets a real need for cities and counties to deal with Phase II federal stormwater regulations," Sparkman says.

The EPA Stormwater Phase II Final Rule requires operators of Municipal Separate Storm Sewer Systems whose population exceeds 50,000 people, to obtain National Pollutant Discharge Elimination System permit coverage because their stormwater discharges are considered "point sources" of pollution.

All point source discharges are required under the Clean Water Act to be covered by federally enforceable NPDES permits. Once a permit is obtained, the conditions of the permit must be satisfied and periodic reports must be submitted on the status and effectiveness of the program.

"Municipalities and counties now are responsible for the quality and quantity of stormwater that leaves their boundaries".

The EPA says that polluted storm water runoff is a leading cause of impairment to the nearly 40% of surveyed U.S. water bodies which do not meet water quality standards. Over land or via storm sewer systems, polluted runoff is discharged, often untreated, directly into local water bodies.

Use of pervious concrete discharging to soil or underground storage facilities permits stormwater to be "cleaned" of its pollutants before discharge to surface waters, or even better, recharge of underground aquifer.

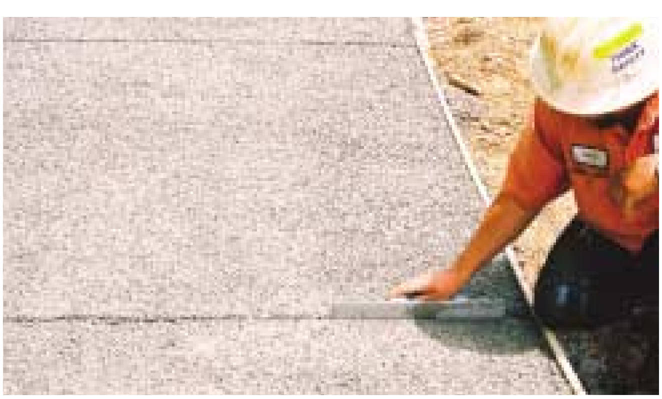
"Municipalities and counties now are responsible for the quality and quantity of stormwater that leaves their boundaries," Sparkman told *Better Roads* editors. "Private sector companies and industries have been responsible for water that leaves their sites for a number of years. Now cities and counties have that same legal responsibility."

In the past, such water has gone into water retention ponds, where particulate matter and heavy metals settle out before cleaned water is discharged into the environment. But these ponds are costly to build, aesthetically unpleasing, can be a breeding ground for mosquitoes and West Nile Virus, and in today's litigious environment, can be costly in terms of liabilities if an accident occurs. And for a government or site developer, a retention pond eats up expensive real estate space that might otherwise be available for construction.

Better to use the space beneath a parking lot or development for stormwater storage, Sparkman says. "It's hard to find real fans of retention ponds," he says. "Pervious concrete permits the owner to build a retention/detention structure that also can be used for parking."

Success in Gainesville

Such a pavement was placed in May 2003 by the city forces of Gainesville, Georgia, GC&PA's Brown says.



Gainesville, Georgia employee places expansion joint in pervious concrete sidewalk near government offices in May 2003.

Gainesville had spent considerable time and effort in restoring streams in the city to a natural condition. One such restoration was a stream near city offices. The stream had been cleaned, the banks replanted with native plants, and a pedestrian bridge built to connect the city office building with a small park and city bus transfer station.

Sidewalks, recycling container pads and picnic table pads were planned but flow of the additional runoff from these pavements into the restored creek was a concern, Brown told *Better Roads* editors. The city decided to use pervious concrete to minimize runoff into the stream.

In advance of the placement, Brown visited the public works department to discuss pervious concrete and train the city crew. A 14-cubic yard placement of pervious concrete was constructed in just four hours last May.

And pervious concrete is not limited to the Southeast. The City of Santa Monica, California is using pervious concrete as part of a sustainable city plan to improve environmental quality, reports the Southern California Ready Mixed Concrete Association. "The city is promoting a variety of strategies to reduce urban runoff," says Neil Shapiro, city engineer. "We suggest it for new projects as one way to reduce pollution and improve water quality."

Construction of pervious concrete

While pervious concrete pavements for stormwater control require subsurface percolation, most soils in this country meet that criterion.

"There are some areas of the U.S. that truly have impervious soils, but they are not common," Brown says. "If you have a high enough soil perk rate to accommodate septic tanks, it's good enough for pervious concrete pavements."

Pervious concrete does cost more than conventional concrete, but not all of a paved area needs to be pervious for it to work. "You don't have to build an entire area of pervious concrete for it to work," Sparkman said, "so long as it collects runoff from the nonpervious area. We recommend that pervious concrete be used in parking stalls, because it's the least traveled part of the lot in terms of loading, and in most cases collects the most stormwater."

Fibers may be added to facilitate the workability of the mix and minimize surface raveling, but they add cost and are not needed to keep the cement from migrating through the open-graded aggregate structure.

"The concrete is placed with such a low water-to-cement ratio, that it does not have any bearing on movement of the cement paste in the mix," Sparkman says.

Photos: Georgia Concrete & Products Association

Plastic curing tarps are an essential part of the placement of pervious concrete pavement on this 2003 project in Gainesville, Georgia. The curing tarps are needed due to low water content of pervious concrete mix.

"We usually start out with a WC ratio of 0.3, but it can vary widely depending on ambient conditions," he told *Better Roads* editors. "We placed some in January in cold conditions with 0.2, at the theoretical minimum. But if you're out in the middle of August you may have to pump the water up a little bit. You will be somewhere in the 0.25 to 0.35 range, so you're dealing with an extremely low water:cement ratio, and a very high quality paste, which is one of the reasons it's freeze/thaw durable."

Conventional Type I cements are used, with high cement factors of around 600 pounds per cubic yard. Accelerators are not desirable due to the enhanced work time required for placement. Usually, 0.375-inch stone is used, with no fines or sand. Larger aggregate may be used, but results in a coarser surface.

No finishing in the traditional sense is done to the pavement. "All the knowledge that a workman or contractor has does not apply," Sparkman says. Instead, correct placement is critical.

Forming is placed, and is set to the desired, finished elevation. All stakes must be driven down to below the top of the form. A 0.5- or 0.625-inch furring strip is placed on top of the form, to which the concrete is screeded. The concrete mix then is placed, and struck off to the top of the furring strip, which is then removed.

A static roller resting on the forms then compacts the pervious concrete mix to the tops of the form. "You're not trying to compact the concrete as much as possible, but control the void content to within a certain range," Sparkman says. "You want to make sure all aggregate makes contact, so the paste literally becomes the glue and leaves the void structure intact."

Tarp or plastic-sheet curing is essential, but spray-curing compounds are not allowed because they would have the effect of sealing the surface, which is exactly the opposite of what is desired. BR