January–February 2007

Technology NEWS

Iowa LTAP
Local Technical Assistance Program

Providing transportation technology transfer for Iowa's cities and counties

Inside this issue

5 Work zone awareness

6 Just for street and road workers: Identifying concrete pavement distresses

7 Just for street and road workers: Concrete pavement maintenance activities

9 SAFETEA-LU highlights for local transportation agencies

10 Stanley L. Ring Memorial Library: New acquisitions

11 Local safety grants: What do YOU think? (Respond by the end of April)

11 Conference calendar

Iowa State University's Center for Transportation Research and Education (CTRE) is the umbrella organization for the following centers and programs:

Bridge Engineering Center
Center for Weather Impacts on Mobility and Safety
Construction Management & Technology
Iowa Local Technical Assistance Program
Iowa Statewide Urban Design and Specifications
Iowa Traffic Safety Data Service
Midwest Transportation Consortium
National Concrete Pavement Technology Center
Partnership for Geotechnical Advancement
Roadway Infrastructure Management & Operations Systems
Sustainable Transportation Systems Program
Traffic Safety and Operations

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Iowa State University

Popcorn ball pavement: Pervious concrete and porous asphalt

Porous pavements—generally known as pervious concrete or porous asphalt—are designed for water to drain through them.

Cores of these pavements have a texture like popcorn balls (figure 1). Just as candy syrup binds popcorn together but leaves plenty of holes to sink your teeth into, cement paste or asphalt binder glues aggregate together but leaves a system of connected voids that allows water to percolate through the slab.

Figure 1. A "popcorn ball" textured sample of pervious concrete.

The idea of porous pavements may seem counter-intuitive. Most pavements are designed to be as impermeable as possible to restrict the entry of water, chemicals, and other liquids that could damage the slab.

However, porous pavement systems can provide unique service features. Designers should understand porous systems' potential advantages, critical design and construction considerations, potential challenges, and limited applications.

Why porous?

Porous pavement systems can provide some advantages:

Increased safety. When water drains through a slab instead of flowing across it, the pavement surface dries more quickly and less snow and ice are likely to collect on it. As a result, porous pavements can provide improved traction for both vehicles and pedestrians. They can also reduce spray from trucks and glare from wet pavement surfaces and provide a quieter ride. (Note: These potential benefits can result from full porous pavement systems, as described on page 2, and from thin, open-graded friction courses.)

Potentially lower overall costs. In some applications, porous pavement systems may eliminate the need for and/or reduce the costs of underground storm drainage, curb and gutter systems, and/or detention basins.

Reduced environmental impact. Porous pavement systems can help manage storm water runoff and mitigate its environmental effects. They do this by reducing the volume of direct runoff that can contribute to flooding and erosion.

Ground water improvements. Porous pavement systems potentially increase the volume of storm water that percolates down through the ground, replenishing ground water aquifers with naturally filtered water.

Active hazardous materials management. During rain events, pavement surface residues—oil and other fluid drip from vehicles, accidental spills of materials like pesticides or herbicides, etc.—are carried into the porous system's infiltration or recharge areas where any hazardous materials can begin to biodegrade naturally.

Generally, 90 percent of rain water–borne pollutants are found in the first 1½ inches of rainfall runoff. In Iowa, where 90 percent of all rain events produce less than two inches of rain, porous pavement systems can filter out most rain water–borne pollutants.

popcorn ball pavement continued on page 2

Acronyms in *Technology News*

AASHTO	American Association of State Highway and Transportation Officials
APWA	American Public Works Association
CTRE	Center for Transportation Research and Education (at Iowa State University)
FHWA	Federal Highway Administration
Iowa DOT	Iowa Department of Transportation
ISU	Iowa State University
LTAP	Local Technical Assistance Program
MUTCD	Manual on Uniform Traffic Control Devices
NACE	National Association of County Engineers

U.S. Department of Transportation
Federal Highway Administration

Iowa Department of Transportation

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popcorn ball pavement continued from page 1

Improved paved environment. Porous pavement systems are generally quieter and cooler than traditional pavements. The connected pores that channel water away from the surface also deflect traffic noises downward and over a greater area, effectively absorbing sounds.

Air also circulates through the connected pores. On hot days, the air over the pavement—and the pavement itself—is generally cooler than in traditional pavement environments. This can be especially important in cities where sunlight reflected from buildings and pavements causes urban heat islands.

Design features

In a porous asphalt system, the process and materials for developing the asphalt slab are generally the same as for conventional hot mix asphalt (HMA) pavements, but porous asphalt contains less sand and isn't rolled—compacted—as heavily as conventional HMA. Like conventional HMA, porous asphalt is recyclable.

In a pervious concrete system, the concrete slab is composed of coarse aggregate (but little or no fine aggregate), cement, water, and specially formulated admixtures, commonly polypropylene fibers. The only special equipment required is a vibratory screed. Like porous asphalt, pervious concrete can be crushed and recycled.

The surface pavement layer—the concrete or asphalt slab itself—is only one element in a *porous pavement system*. Other critical elements of the system include an aggregate recharge bed, lined with a geotextile filter.

- Under the porous slab is a recharge or infiltration bed of uniformly graded aggregate with a high proportion of voids. The bed temporarily stores rainwater that flows through the porous slab, enhancing in situ bioremediation of contaminants.
- A special geotextile filter fabric lines the recharge bed, separating the aggregate from the soil below. The fabric allows water to slowly infiltrate into the underlying soil, while preventing fine materials from entering the recharge bed.

Only well-designed and well-constructed porous pavement systems, with all three of these elements, have the potential to deliver the benefits listed above (figure 2).

Reports of long-term installations of porous pavement systems indicate that they can perform as designed up to 30 years or more. Some porous pavement systems have been over-designed—sometimes by a factor of 100—to address concerns that the surface layer (the porous slab) will freeze, causing surface ice to form. In fact, the aggregate filtration layer typically contains any water that might freeze.

Limitations

Several factors can limit the type and number of applications for which porous pavement systems are appropriate:

Potentially higher initial cost. Porous pavement systems may cost more to construct than traditional pavement systems because of expenses related to constructing the required recharge beds and fabric filters. These higher costs may be offset, however, by reduced expenditures for other storm water management features like sewers, land set-asides, and detention ponds.

Road bed preparation. The top 6 inches of subgrade must be granular material with less than 10 percent silt or clay. This requirement generally results in special road bed preparation.

Load-bearing strength. If cost were not an issue, both pervious concrete and porous asphalt pavement systems could be designed to meet nearly any specifications, including flexural or compressive strength. In reality, to be cost effective, porous pavement systems are generally designed to support four-wheel vehicles but not larger commercial vehicles, limiting their potential applications.

Other design limitations. In addition to load-bearing strength, a porous pavement system design must accommodate several other factors:

- Site-specific design factors:
  - Depth to water table. (Porous

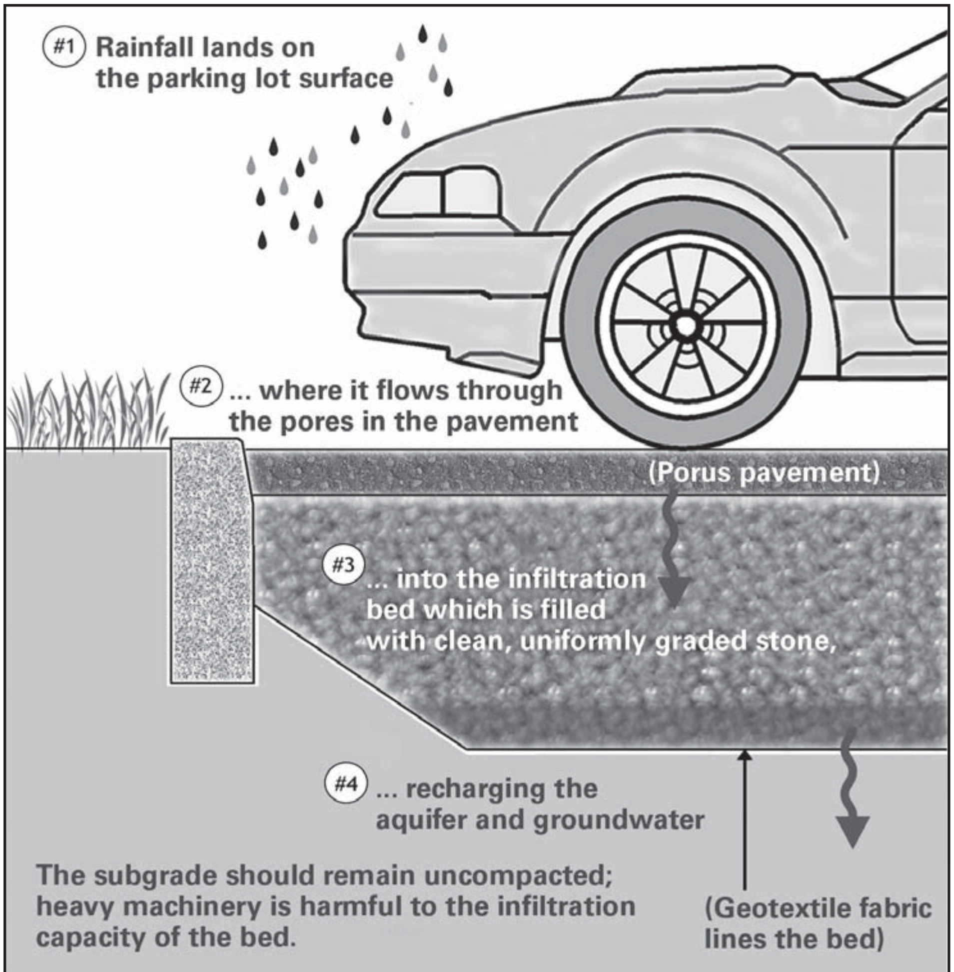

Figure 2. A well-designed porous pavement system illustration. (adapted from Cahill Associates)

Porous asphalt applications in Iowa

Since the early 1970s, it has been common practice in Iowa to apply a thin (generally 2–3 inch) surface layer of porous asphalt on asphalt pavements where vehicle skidding and/or hydroplaning is a potential problem. Such open-graded friction courses allow storm water to filter off the surface quickly, improving friction and reducing spray and glare.

To meet new requirements for managing storm water runoff, more pavement designers in Iowa are considering possible applications of porous asphalt pavement systems. Several systems have been constructed, including two parking lots at the Luther Park Center in Des Moines, installed in 2005, and a parking lot at the Prairie Ridge Sports Complex in Ankeny, installed in summer 2006. These relatively new projects are performing as expected.

pavements require a minimum distance of 2–4 feet (vertical) from the bottom of the installation to the water table.)

- ◦ Local soil characteristics. (Suitable soil and subsurface conditions are essential for porous applications, especially in terms of erosion.)
- ◦ Slope, topography. (Porous pavement systems are well suited for upland areas where the soil allows storm water to spread over large areas.)
- ◦ Hydraulic gradient.
- ◦ Climate, including frost depth and freeze-thaw cycles.
- ◦ Proximity to water wells.

- Availability of appropriate materials, including the aggregate required for the recharge/filtration layer and the geotextile.
- Relevant local, state, and federal regulations.
- Economic factors.

Maintenance issues. Porous pavements must be protected from large amounts of dust and runoff from crop fields. Special maintenance equipment—high-power water jets and special vacuum trucks and sweepers—is required to remove debris from the surface pavement pores.

Potential applications

Because porous pavement systems are generally cost-effective only at strengths that do not support heavy industrial traffic, these systems are best suited for large expanses of pavement used primarily by cars, other light vehicles, and/or pedestrians. Potential applications include the following:

- Parking lots (most common).
- Sidewalks, bicycle paths, and walkways.
- Curb and gutter systems.
- Bridge embankments.

Porous sidewalk, driveway, and pathway systems have been constructed in some residential areas. A few porous street systems have been constructed (e.g., in Phoenix and Portland).

For more information about porous asphalt

Contact Chris Williams, asphalt materials engineer at CTRE and assistant professor of civil, construction, and environmental engineering at ISU, 515-294-2140, rwilliam@iastate.edu.

See the National Asphalt Pavement Association's 2003 report *Design, Construction,*

popcorn ball pavement continued on page 4

Iowa LTAP Mission

To foster a safe, efficient, and environmentally sound transportation system by improving skills and knowledge of local transportation providers through training, technical assistance, and technology transfer, thus improving the quality of life for Iowans.

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popcorn ball pavement continued from page 3

and Maintenance Guide for Porous Asphalt Pavements, IS 131. To borrow a copy from the Iowa DOT library, contact Hank Zalatel, librarian, 515-239-1200, hank.zalatel@dot.state.ia.us. To order a copy from NAPA's website, see http://store.hotmix.org/index.php?productID=179&hasjavascript=yes.

For more information about pervious concrete

Contact Vernon Schaefer, 515-294-9540, vern@iastate.edu, or John Kevern, 515-294-2140, kevernj@iastate.edu.

See the American Concrete Institute's 2006 publication *Pervious Concrete*, ACI 522R–06. To borrow a copy from the Iowa DOT library, contact Hank Zalatel, librarian, 515-239-1200, hank.zalatel@dot.state.ia.us. To order a copy from the institute's website, see www.aci-int.net/PUBS/newpubs/522.htm. ■

Pervious concrete applications in Iowa

Figure 3. An ISU test lot of pervious concrete (Photo courtesy of John Kevern, ISU)

Limited courses of pervious concrete were placed as early as 1852 in the United States, but applications that have been successful in other countries, like pervious concrete overlays (wet-on-wet friction courses), generally have not been tried here.

Today, however, pervious concrete pavement systems are attracting attention as an effective storm water runoff management strategy. In 2005, an ISU research team led by Vern Schaefer, professor of civil, construction, and environmental engineering, studied the feasibility of cold-weather applications of pervious concrete. Conclusion: Specific mixes can be successful in specific applications, particularly parking lots.

John Kevern, a graduate research assistant at ISU's National Concrete Pavement Technology Center, researches pervious concrete applications in Iowa. At a pervious concrete system test lot in Ames (ISU parking lot 122, installed October 2006), he monitors storm water discharge. In the lab, he collects data on freeze-thaw cycles of various mixes of pervious concrete.

Kevern helped design and keeps tabs on several Iowa test applications of pervious concrete systems, including handicap-accessible areas and sidewalks around a parking lot at Arnold's Park in Okoboji, and the new North Liberty Middle School parking lot. These relatively new projects are performing as expected.

Work zone awareness

FHWAs National Work Zone Safety Week poster 2007

Nationally, it's April 2–6

But, if your shop is serious about worker and motorist safety, every week that your agency conducts road construction or maintenance activities should be Work Zone Safety Week.

Here are some ideas for enhancing work zone safety in your jurisdiction:

Engineering

- Plan and implement standard work zones per the *Manual on Uniform Traffic Control Devices* (and NCHRP 350, which contains federal standards and guidelines for work zone safety devices).
- Use Quickzone software to help you improve work zone safety and mobility (www.tfhrc.gov/its/quickzon.htm).
- Make sure emergency vehicles can access your work zones at all times.
- Work closely with law enforcement officials to identify appropriate countermeasures for high-risk work zone locations.
- Avoid construction delays.

Education

- Provide technical training about work zone safety for your staff. Examples:
  - Flagger safety training, available through Iowa's safety circuit rider, Tom McDonald, 515-294-6384, tmcdonal@iastate.edu.
  - *Model Traffic Management Program*, a self-evaluation guide to identify strengths and weaknesses of your work zone activities (www.fhwa.dot.gov/reports/evalgd.pdf).
  - *Best Practices Guidebook* highlights good work zone practices (www.ops.fhwa.dot.gov/wz/workzone.htm).
- Improve public awareness through public service announcements and/or articles in the newspaper. For possible content see
  - The "10 Tips" sidebar accompanying this article.
  - The National Work Zone Safety Week website, http://safety.fhwa.dot.gov/wz/wz_awareness.htm.
- Encourage your local schools and/or driver education programs to use *Moving Safely across America*, an interactive CD with information on how to drive safely through work zones. To borrow a copy contact Jim Hogan, Iowa LTAP library coordinator, 515-294-9481, hoganj@iastate.edu. To purchase a copy or for more information contact Timothy Barkley at FHWA, timothy.barkley@fhwa.dot.gov.

Enforcement

Work with local law enforcement to ensure their vigilance about drivers who speed or ignore work zone signs.

For more information

See FHWA's website, http://safety.fhwa.dot.gov/wz/wz_awareness.htm. ■

10 Tips for Driving Safely in Work Zones

You should . . .	Because in work zones . . .
Expect the unexpected.	Normal speed limits may be reduced, traffic lanes may be changed or merged, people may be working on or near the road, and other motorists may not be paying attention.
Slow down.	Speeding is one of the major causes of work zone crashes.
Don't tailgate.	Rear-end collisions are the most common crash in highway work zones. Keep a safe distance between your vehicle and the one ahead of you.
Maintain a safe distance between your vehicle and construction workers and their equipment.	Road workers and equipment may inadvertently move into your travel lane.
Observe posted signs.	Warning signs are there to help you and other drivers move safely through the work zone.
Obey the flaggers.	Flaggers have the same authority as regulatory signs. You can be cited for disobeying their directions.
Stay alert.	There's little room for error in work zones. If you get sleepy, stop at a rest area for some fresh air, a walk, or a nap.
Minimize distractions.	The slightest inattention—changing radio stations, using a phone, eating, reading maps, etc.—while you're behind the wheel makes it difficult to focus your attention on the road and work zone.
Keep up with the traffic flow.	Driving right up to a lane closure and then trying to enter the traffic lane can cause rear-end collisions. When warned of merging traffic ahead, merge as soon as possible.
Allow plenty of time.	Delays may occur. Ahead of your trip, check local TV and radio listings about work zones. Where road work is occurring, anticipate delays.
Be patient; stay calm.	Work zones aren't there to personally inconvenience you but to improve your future driving conditions.

Just for street and road workers

Editor's note: *The two articles on pages 6–8 are the latest in a series based on information in Iowa's new* Local Roads Maintenance Workers' Manual. *The manual was developed by CTRE and sponsored by the Iowa Highway Research Board (TR-514). The series began with the July–August 2006 issue of* Technology News. *Previous topics included maintaining gravel roads and identifying/repairing asphalt pavement distresses.*

Iowa One Call: It's the Law

Iowa law requires that anyone planning any form of excavation must contact the Iowa One Call notification system (1-800-292-8989) at least 48 hours in advance so that utilities can be located and marked. Always consult your supervisor before conducting any excavation like mud jacking and full-depth repair.

Rule of Thumb

Always check with your supervisor and follow your agency's policies and procedures for identifying distresses and performing maintenance or repair work.

Identifying concrete pavement distresses

Properly maintaining and repairing portland cement concrete (PCC, or simply concrete) pavements helps prevent, delay, and/or reduce the severity of distresses that can result in pavement deterioration. Random cracks, for example, can allow water to infiltrate the pavement base and subbase, potentially decreasing the pavement's load-carrying capacity. Some distresses grow, leading to pavement deformation and surface damage.

Every jurisdiction should have a system in place for regularly identifying distress(es) needing repair.

Cracks

Random cracks can occur in concrete pavement for many reasons:

Transverse cracks run across the pavement, perpendicular to the shoulder. Longitudinal cracks run parallel to the shoulder. These cracks may occur if joints are not sawed at the right time and in the right places to adequately relieve stresses in the restrained concrete due to drying shrinkage, curling and warping, etc.

D cracking occurs at slab corners where longitudinal and transverse joints intersect. The failure is due to poor quality aggregate in the original concrete mixture.

Map cracking is a pattern of interconnected random cracks that indicates the surface was over-finished or inadequately cured.

Joint deterioration/spalling

Joint deterioration like spalling is caused when water and/or debris in the joint freezes and expands, putting pressure on the concrete along the joint (figure 1).

Blowups

When concrete expands during hot weather, pressure can build up in the concrete along the joints until the panels rise at the joints and shatter. Blowups can be quick and violent, throwing pieces of concrete several feet.

Scaling

Scaling is the deterioration of the upper 1/8- to 1/2-inch of the concrete surface. It may be caused by deicing chemicals or inadequate curing.

Pavement settlement

Slabs sometimes settle, particularly bridge approach panels. Settlement generally indicates that subbase materials have migrated from beneath the slab.

Faulting

Faulting is a difference in elevation across a joint or crack caused by slab settlement on one or both sides of the crack/joint or by rocking of the slab at the crack/joint as traffic moves across it.

Pumping

Pumping is the seeping or ejection of water and subbase material from beneath the pavement through pavement cracks under heavy loads. Sometimes deposits of fine material are left on the pavement surface or stain it.

Corner breaks

A corner portion of the slab may separate along a crack that intersects adjacent transverse and longitudinal joints. Corner breaks can occur if loads are allowed on new pavement before it has gained adequate strength or where the subbase material is not uniform or has eroded away.

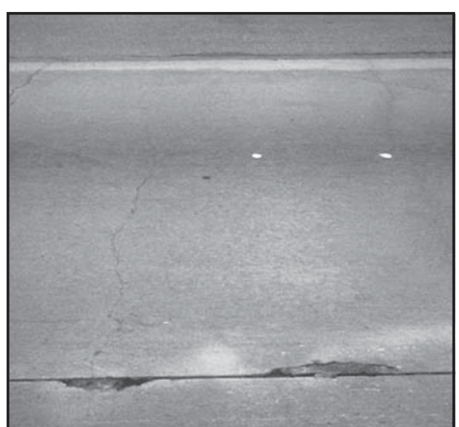

Figure 1. Spalling (FHWA)