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Industry News

Joint Sand Stabilization—
A Case Study

by Peter van Niekerk

Editor’s note: Peter van Niekerk has worked extensively in the concrete paver industry in South Africa and has been contributing to its growth in southern California. He discovered a new and improved joint stabilization material and was also keen to share his findings with his friends in the trade. Over the years, he has been one of the important figures in the concrete paver industry.

Remembering the Alamo

by Peter van Niekerk

A few years ago, Peter van Niekerk was visiting his friends in Texas. He heard about the Alamo, a historic site that played a significant role in American history. The Alamo is an old Spanish mission and military fortification.

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**SUMMER 2016**

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—from the National Infrastructure Advisory Council’s 2009 Critical Infrastructure Resilience Final Report and Recommendations

Procrastination seems endemic to human nature. However, there may be some evidence to the contrary. Most of us might recall Superstorm Sandy in October 2012. Millions in New Jersey and New York sure do. Local governments, insurance companies, businesses and homeowners also remember some $80 billion in destruction. And this event wasn’t a hurricane.

The evidence against procrastination appears to be emerging from within the highest levels of government and among business leaders. Katrina and Sandy were catalysts. Leaders are asking how to build better to reduce damage from storms and earthquakes and accelerate recovery. Most of the discussion is on making buildings stronger, i.e., more wind-, flood- and earthquake-resistant. The conversation must soon turn to how to better build things outside buildings such as parking lots, roads, utilities and communication infrastructure.

Even flooding from smaller storms, the ones with no names, are costing millions. While investments in resilient infrastructure solutions are long-term, we are seeing an emerging trend of using permeable interlocking concrete pavement (PICP) as a means to reduce flooding. Such is the case with the Southeast Atlanta Green Infrastructure Initiative that aims to capture seven million gallons under miles of PICP streets. The first six miles are already built. This exemplifies resilient infrastructure where roads also do flood control: They mitigate it rather than contribute to it.

Another little known aspect is resilience from interlocking concrete pavement. That type of segmental pavement isn’t designed to permeate due to sand joints, bedding, and a dense-graded aggregate or stabilized base. There are reports in Canada and Italy on the ability of this system to not crack when inundated, unlike monolithic asphalt or concrete. ICP doesn’t crack when flooded because it has “cracks” in it; joints between the paving units relieve the water pressure as it builds under the pavers. And the surface can be reinstated without requiring deliveries from a ready-mix concrete or asphalt plant. (They might be flooded, too.) Rapid recovery of roads from floods or earthquakes is a prerequisite to building repair.

While lots of beautiful patios are being built, the segmental concrete pavement industry is at the threshold of entirely different conversation and market opportunity. It is poised to more readily establish and institutionalize segmental pavements as part of resilient infrastructure that yields economic, environmental and social benefits to property owners, municipalities and wider society.
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And the Survey Says...

INTERLOCKING CONCRETE PAVEMENT INSTITUTE’S INDUSTRY SALES PROFILE SHOWS DOUBLE-DIGIT GROWTH

Thanks to continued construction growth, industry survey results from the Interlocking Concrete Pavement Institute (ICPI) indicate a repeat of last year’s double-digit growth. New home construction, acceleration in sales of existing homes, a rebound in public section construction spending, and an increase in commercial construction all contributed to strong growth last year for U.S. and Canadian segmental concrete pavement. Survey respondents, including 29 companies representing 141 paver-producing machines, report shipments across all segmental concrete pavement categories up 15.4% in the U.S. and 8.9% in Canada compared to 2014 figures.

The Industry Survey encompasses interlocking concrete pavers, permeable interlocking concrete pavers, concrete grid paving units, paving slabs, and related concrete paving products. In the principal category of concrete pavers as defined by ASTM and CSA, U.S. production increased 15.2% year-over-year from 517 million to 595 million square feet, while Canadian output grew 10.6% from 85 million to 94 million square feet. At just over 78% of all sales, the residential market continues to drive segmental concrete pavement. Commercial sales, including municipal and industrial projects, claimed almost 22% of the total 2015 market.

Robust year-over-year sales activity, notes ICPI Chairman and Oldcastle APG Northeast President Matt Lynch, “demonstrates continued demand for segmental concrete pavement systems with versatile design options, low maintenance and environmental benefits. The construction industry is experiencing an economic recovery that supports the expansion of our market share in residential and commercial applications.”

Order the survey report from icpi.org. $20 for ICPI members; $99 for non-members.

A HIGHER DEGREE OF ASSURANCE

The American Society for Testing and Materials International (ASTM) recently approved revisions to C936 Standard Specification for Solid Concrete Interlocking Paving Units that include an optional lower temperature for laboratory freeze-thaw durability testing while paver units are immersed in a 3% saline solution. For freeze-thaw durability testing, C936 references C1645 Standard Test Method for Freeze-thaw and De-icing Salt Durability of Solid Concrete Interlocking Paving Units. This test method includes a minimal freezing temperature of -5°C (23°F) though 49 freeze-thaw cycles. Mass lost is measured from the tested paver units and that loss is divided by the total surface area expressed in square meters to determine if the pavers meet the requirements in ASTM C936. This standard now includes the optional use of -15°C (5°F) as the lowest temperature in C1645. Deciding to use the -15°C option is supported by a map identifying geographic cold climate zones for project locations where the specifier might want to use this colder temperature in freeze-thaw durability testing per C1645. The reason for introducing this option is that some areas of the U.S. see colder temperatures than -5°C and use deicing materials. The colder temperature option of -15°C can help provide a higher degree of assurance for winter paver durability to manufacturers and specifiers.

A concrete paver test specimen immersed in a 3% saline solution in preparation for subjection to 50 freeze-thaw cycles per ASTM test methods.
New ICPI Authorized Instructors

ICPI held the Adult Educator Course and course-specific instructor training for the Concrete Paver Installer (CPI) Course and Permeable Interlocking Concrete Pavement Specialist (PICPS) Course at the ICPI headquarters in Chantilly from March 30-31. Attendees came from different regions. Authorized Instructors may be Contractor Instructors who are primary instructors and can teach solo, Technical Instructors who can be secondary instructors and Lead/Technical Instructors who have fulfilled stringent requirements and are allowed to be primary instructors. Since its introduction in 2009, over 1,200 contractors have taken the course.

L-R: Carlos Andrade, Alex Burke, Jim Beck, Joshua Dickey, Jordan Abernathy, Allen Carver, Dean Sandri, Rob Bowers (ICPI Director of Engineering), Jason Georgevich. Inset: Frank Bourque

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Burbank, California, may be the famous studio location for The Tonight Show with Johnny Carson, but the EcoCampus at Burbank Water and Power (BWP) broadcasts its own show worthy of a different fame. The project debuted as the only industrial category selectee among 150 national and international projects for the Sustainable Sites pilot program in 2012. BWP and its design partner, AHBE Landscape Architects in Los Angeles, transformed an aging power plant site into a regenerative green campus with aspirations toward net-zero water use.

At the heart of BWP’s EcoCampus, Centennial Courtyard features repurposed remnants of an electrical substation amidst a mixture of plank and Holland concrete pavers.
“Being good stewards, doing the work of service, our landscape is reflective of those values we have here,” said BWP Conservation Manager Joe Flores. BWP offers regular tours of its EcoCampus to educate visitors about several stormwater management technologies there which include permeable pavers and concrete planks. At the heart of the campus, Centennial Courtyard features 4 x 16 x 3 1/8 in. thick planks in a multi-colored array of pewter, amber, caramel, mocha and charcoal. While larger and longer paving units continue growing in popularity, this three-year-old project represents early pioneering with planks.

CONTEMPORARY COOL
Two distinct trends have emerged over the past few years including a shift from warm earth-tone colors to cooler shades of gray, and growing use of larger paver units, slabs and planks. AHBE designers wanted a modern, linear appearance for the courtyard, and once BWP saw samples of the planks from an ICPI member manufacturer, BWP fell in love with them. The decision was also influenced by the salvaged and repurposed structures BWP chose to retain from the original site. Though initially the plan was to remove everything, BWP envisioned a transformation rather than a complete demolition. Old generator pads became seating areas; utility tunnels became infiltration chambers; equipment plinths became garden sculptures; and a two-story steel skeleton substation became a trellis for a shade canopy. Multicolored planks provided the desired complement. “If we just poured concrete [for the courtyard], it wouldn’t be very visually interesting,” said Mr. Flores. “The pavers add a material richness you want in that kind of environment,” he added.

AS ABOVE, SO BELOW
From the outset, BWP wanted to develop a green campus with sustainable stormwater detention and filtration technologies. The Centennial Courtyard planks sloped to drain stormwater into a phytoextraction canal. Formerly a tunnel that carried power cables from

PROJECT CREDITS: Project Design: AHBE Landscape Architects; Owner: Burbank Water and Power; Paver Manufacturer: Acker-Stone; Paver Installer: KPRS

Continued on page 10
the power plant to the electrical substation, the six-foot deep tunnel floor was perforated and then backfilled with select soils and plants that filter stormwater runoff as it percolates down into aquifers. At each side of the canal, fountains of recycled water are circulated by solar-powered pumps.

A green street development spanning three city blocks along Lake Street includes an 8 ft wide permeable paver sidewalk and filtration planter bump-outs collecting and infiltrating water into concrete bioretention cells with trees. “With permeable pavers, you’re able to do stormwater capture and then direct the water to encourage trees and plants to grow roots downward, which is healthy for the landscape, and also alleviates problems of roots uplifting sidewalks,” Mr. Flores explained.

The visual qualities of the landscape are noteworthy, but what lies beneath—a campus-wide water filtration system—is truly remarkable. Five water filtration technologies were used: infiltration, flow-through, detention, tree root cells, and stormwater capture. According to BWP, this was the first time this number of sustainable landscape technologies were integrated into a single industrial site.

**PIXILATION AND PROGENY**

Three types of pavers were used for the courtyard and green street, according to AHBE Landscape Architects Principal Evan Mather, ASLA, RLA. “We used plank pavers for the courtyard, rectangular pavers where we didn’t want to infiltrate, for example, next to buildings, and permeable pavers where we wanted to infiltrate,” said Mr. Mather. “The overall look of the campus doesn’t present scored concrete; it’s more about the individual pixilation of the paver materials.”

Regarding maintenance, Mr. Flores said, “It’s not as much as you might think. We don’t have to do much other than blowing [leaves and debris] and cleaning up the
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GREEN STREET TECHNOLOGIES

Part of the BWP EcoCampus, a streetscape renovation project turned Lake Street, between Magnolia Blvd. and Olive Ave., into a Green Street showcasing five stormwater management systems.

PERMEABLE PAVERS & AN AGGREGATE RESERVOIR:
The permeable paver sidewalk infiltrates water through the joints into underground cells filled with planting soil, providing additional space for adjacent trees' roots to expand and grow.

TREE ROOT CELLS:
These cells create an underground frame that can bear traffic loads while creating space for tree roots to expand and grow.

TREE POD SYSTEM:
This unassuming tree box filters out ultrafine and dissolved pollutants normally found in stormwater runoff.

INfiltration planter bump-outs:
As stormwater flows down the street, it is diverted into flow-through planters containing plants selected to tolerate both winter rains and summer droughts.

Filtration planters:
These planters are structural landscaped reservoirs used to collect, filter and/or infiltrate stormwater runoff, allowing pollutants to settle and filter out as the water percolates through the planter soil before infiltrating into the ground.

GREEN STREET TECHNOLOGIES

occasional spill.” Because the pavers are multicolored, a few spots here and there aren’t nearly as noticeable as they would be on a continuous white concrete surface, Mr. Flores said.

CONGRUENT VALUES
The close collaboration among the project owners, landscape designers and the paver manufacturer resulted in a creative synergy where each drove the others toward greater excellence. “They were a fantastic partner,” Mr. Mather said of BWP. AHBE has been a leader in sustainable design for 30 years, Mr. Mather said, but an industrial power plant might be the last place one would think of when it comes to sustainability. With all its green merits, the BWP EcoCampus really is for the people. Human utilization of the campus and courtyard space drove the design from the outset according to Mr. Flores. “Using the space in this way creates a healthy work environment... because it’s congruent with the values of people who want to work here.”

To anyone mulling over a similar redevelopment project, Mr. Flores offers this advice: “Consider not just the physical elements but the human and cultural aspects that define the values of your organization. How can you express that through the use of your physical space?” Addressing these human aspects resurrected this site with support from carefully selected and placed concrete paving units.

If we just poured concrete [for the courtyard], it wouldn’t be very visually interesting. The pavers add a material richness you want in that kind of environment."

— Joe Flores, Conservation Manager, Burbank Water and Power

Holland pavers weave pathways around the ecocampus and its sculptural remnants of the old power station.
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CAN ONE MACHINE CLEAN UP WASHINGTON, DC?

Since the 1990s, municipalities and private property owners constructed millions of square feet of pervious concrete (PC), porous asphalt (PA) and permeable interlocking concrete pavements (PICP) in parking lots, alleys and streets. The number one question is about maintenance. The next questions typically are how often should the surface be cleaned and with what equipment?

The diesel-powered Cyclone CY5500 carries approximately 1,200 liters (300 gal) of water.
All permeable pavements require regular surface cleaning to remove embedded sediment and to maintain surface infiltration. Regenerative air machines used for routine cleaning are effective in removing loose sediment and debris. Low surface infiltration into highly clogged pavements with tracked-in or settled sediments can be raised with a true vacuum machine. Equipment availability, costs, personnel time or outsourcing costs for surface cleaning suggests a need for a single machine that provides routine maintenance cleaning, as well as restoration of clogged surfaces when maintenance is neglected.

A machine that might qualify for this role is the Cyclone CY5500. Originally developed to clean tire rubber from runways, this machine was tried in June 2015 on porous asphalt (PA), pervious concrete (PC), and permeable interlocking concrete pavement (PICP) in a residential neighborhood in Northwest Washington, DC. All of the permeable pavements were installed by the District of Columbia Department of Transportation (DDOT) as part of a combined sewer overflow mitigation program.

The sites included PC in two nearby on-street parking lanes. One was cast-in-place PC and the other was a precast PC panel, among several. These two areas received contributing run-on from the impervious center lane of the street. The PA and PICP were situated in alleys, with some or little run-on from impervious surfaces and instead received sediment from adjacent vegetated areas. All of the permeable pavements were subject to leaves and debris from a mature urban forest canopy. None of the pavements were older than a year in service.

The diesel-powered Cyclone CY5500 was brought to the site as shown in Figure 1. Cyclone manufactures a smaller walk-behind model and a larger truck-size version. The CY5500 is an off-road vehicle smaller than the truck-size equipment. This machine carries approximately 1,200 liters (300 gal) of water, much of which is drawn back into the machine, filtered and re-used.

The Cyclone machine relies on water applied under pressure in a circular motion within a surrounding chamber in close contact with the permeable pavement surface. The water pressure can be varied by the operator from 1,200 psi (8 MPa) to 4,350 psi (30 MPa). Water is blasted against the pavement surface and the speed of the rotating head applying the water provides some suction (hence the cyclone name) to pull most of the water back into the machine for reuse. The machine manufacturer claims cleaning rates as high as approximately 10,000 sf (935 m²) per hour on most permeable pavements.

Prior to conducting cleaning, ASTM C1701 Standard Test Method for Infiltration Rate of In Place Pervious Concrete and C1781 Standard Test Method for Surface Infiltration Rate of

Continued on page 18
The most notable observation is that the PICP only required two passes of the Cyclone machine rather than four to increase the infiltration rate from 20 in./hr (<508 mm/hr) to 327 in./hr (8,306 mm/hr).

Permeable Unit Pavement Systems was applied to each surface. The former test method is applicable to PC (and PA). Both test methods produce comparable results. This is illustrated in Figures 2 through 5.

The pre-wetting initial infiltration test measurement was conducted to determine the extent of clogging. All of the pavements were clogged with little or no infiltration within the ring. Then, the four areas were cleaned in the following order: cast-in-place PC, PICP, PA, then the precast PC panel. The Cyclone machine passed twice over the same area of permeable pavement almost immediately after the initial infiltration testing (called pre-wetting). Figure 6 shows the Cyclone machine making a typical pass of about 30 ft (10 m) in length on an alley.

After the second pass, the ASTM test ring was applied to the pavement surface and an additional (approximate) 8 lbs (5 kg) of water was applied (the surface infiltration rate was calculated per the ASTM standards). Both ASTM standards use the same surface infiltration calculation. If the surface infiltration rate was under 250 mm/hr (100 in./hour) the Cyclone machine made an additional two passes, the ring reapplied in the same location and an additional approximate 8 lbs (5 kg) of water applied into the ring. The table provides a summary of the surface infiltration test results.

○ Continued on page 20
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The table indicates increased infiltration rates after the first two passes on the PC, PICP and PA. Infiltration rates doubled for the PC and PA but could be considered low. There was little if any change in the infiltration rate of the precast PC panel after the first two passes. The second two passes yielded better results with PC infiltration rate doubling again and the PA almost reaching the same level. The precast panel saw a
PERMEABLE PAVEMENTS

<table>
<thead>
<tr>
<th>Permeable Interlocking Concrete Units Alley</th>
<th>Porous Asphalt Alley</th>
<th>Pervious Concrete Precast Panel On-Street Parking Lane</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;360 seconds</td>
<td>170 seconds</td>
<td>&gt;360 seconds</td>
</tr>
<tr>
<td>&lt;508 mm/hr (&lt;20 in./hr)</td>
<td>1,067 mm/hr (42 in./hr)</td>
<td>&lt;508 mm/hr (&lt;20 in./hr)</td>
</tr>
<tr>
<td>30 MPa (4,350 psi), 2 passes</td>
<td>19.3 MPa (2,800 psi), 2 passes</td>
<td>30 MPa (4,350 psi), 2 passes</td>
</tr>
<tr>
<td>22 seconds</td>
<td>180 seconds</td>
<td>360 seconds</td>
</tr>
<tr>
<td>8,306 mm/hr (327 in./hr)</td>
<td>1,016 mm/hr (40 in./hr)</td>
<td>&lt;508 mm/hr (&lt;20 in./hr)</td>
</tr>
<tr>
<td>17.2 MPa (2,500 psi) on second two passes on location about 10 feet away to test for aggregate removal; no infiltration test conducted due to high infiltration on first two passes in different location.</td>
<td>30 MPa (4,350 psi) 2 passes</td>
<td>30 MPa (4,350 psi) 2 passes</td>
</tr>
<tr>
<td>Not needed</td>
<td>100 seconds</td>
<td>55 seconds</td>
</tr>
<tr>
<td></td>
<td>1,829 mm/hr (72 in./hr)</td>
<td>3,302 mm/hr (130 in./hr)</td>
</tr>
</tbody>
</table>

The most notable observation is that the PICP only required two passes of the Cyclone machine rather than four to increase the infiltration rate from 20 in./hr (<508 mm/hr) to 327 in/hr (8,306 mm/hr). The joint widths in the PICP were narrow, approximately ¼ in. (6 mm) wide and many of the small aggregates were pulled out with the sediment after the first two passes. Some of the stones were left on the surface of the pavers after the second pass and these could be swept back into the joints. See Figure 7. Additional aggregate should be supplied given these results.

In this experiment, the Cyclone machine was assigned to clean highly clogged pavements. It can be set on a lower pressure setting to clean a less clogged condition, i.e., remove loose material from the pavement surface. In the case of this brief demonstration however, the PICP surrendering sediment with the jointing aggregate to the Cyclone machine explains the resulting high infiltration rate after two passes rather than four passes, as conducted on the other surfaces. This demonstrates the ability of clogged PICP to experience restored infiltration rates as compared to monolithic surfaces, even when heavily clogged.

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Geosynthetics can be grouped into several product categories; geotextiles, geogrids, geomembranes, geonets, geosynthetic clay liners, geopipes, geofoam, geocells and geocomposites. This article examines construction with geotextiles and future articles will cover construction using the other geosynthetics. The articles are excerpted from a soon-to-be released ICPI Tech Spec that provides a comprehensive view of geosynthetic materials, selection, and construction in various segmental concrete pavement assemblies.

When placing geotextile avoid wrinkles in the fabric. Follow the overlap recommendations specified in AASHTO M-288 Geotextiles for Highway Applications as noted in Table 1 below. Make sure the geotextile is placed in full contact with the surrounding soils or aggregates. Voids, hollows or cavities from wrinkles created under or beside the geotextile compromises its intended function.

**TABLE 1**

<table>
<thead>
<tr>
<th>Soil CBR, %</th>
<th>Overlap</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 3.0</td>
<td>1.0 ft [0.3 m] to 1.5 ft [0.45 m]</td>
</tr>
<tr>
<td>1.0 to 3.0</td>
<td>2.0 ft [0.6 m] to 3.0 ft [1.0 m]</td>
</tr>
<tr>
<td>0.5 to 1.0</td>
<td>3.0 ft [1.0 m] or sewn</td>
</tr>
<tr>
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<td>Sewn</td>
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<tr>
<td>All roll ends</td>
<td>3.0 ft [1.0 m]</td>
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Figure 1 illustrates a familiar detail, i.e., separating the compacted aggregate base from the soil subgrade with geotextile. This can help maintain consolidation of the base materials over time by preventing intrusion of fines in the bottom and sides. This slows the rate of rutting in the base and on the soil subgrade.

Geotextile placed under the bedding sand next to the curb provides a ‘flashing’ function. This separates the sand from the base and prevents sand loss into joints between the concrete curb and the compacted aggregate base, as they are two structures that can move independently from each other. Table 2 provides guidelines for geotextile selection depending on the soil and fabric functions required.

**FIGURE 1**

**GEOTEXTILE IN AN INTERLOCKING CONCRETE PAVEMENT OVER A FLEXIBLE BASE**

Concrete curb and foundation per local standards

Concrete pavers 3 1/8 in. (80 mm) thickness

1 in. to 1 ½ in. (25-40 mm) bedding sand

12 in. (300 mm) wide geotextile along perimeter turn up at curb

Geotextile as required

Compacted aggregate base

Compacted soil subgrade

12 in. (300 mm) wide geotextile along perimeter — turn up at curb (do not cover top of base)

Geotextiles separate compacted aggregate base from the soil subgrade to maintain consolidation of the base materials over time by preventing intrusion of fines in the bottom and sides.
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**Figure 2** illustrates geotextile on a concrete base in a crosswalk application. For new sidewalks, crosswalks and streets, 12 in. (300 mm) wide strips of geotextile are recommended over all joints in new concrete bases to prevent loss of bedding sand, as well as over weep holes. New asphalt generally should not require geotextile on it except at curbs, structures and pavement junctions where bedding sand might enter. For existing asphalt and concrete bases, the surface of each should be inspected for cracks, the severity and extent of which determines repairs. If cracks are few and minor (suggesting substantial remaining life in these bases), geotextile should be placed over the cracks to prevent potential future loss of bedding sand. Covering the entire asphalt or concrete surface with a loose-laid sheet of geotextile can present some risk of creating a slip plane for the bedding sand and paving units as a result of repeated vehicular traffic.

**Figure 3** illustrates a typical application of geotextile in PICP. Its application against the sides of the subbase and against the excavated soil is essential in all PICP projects that do not use full-depth concrete curbs to completely confine open-graded aggregates at the pavement perimeter. The design and selection of geotextiles for PICP is covered in detail in the ICPI manual, *Permeable Interlocking Concrete Pavements – Design, Specification, Construction, and Maintenance.*

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